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Montana Ecological Integrity Assessment Field Manual

MONTANA
Natural Heritage
Program

TABLE OF CONTENTS

Section 1: INTRODUCTION

The Ecological Integrity Assessment (EIA)

The Montana Natural Heritage Program (MTNHP) uses an Ecological Integrity Assessment (EIA) framework to assess the condition of wetlands with an emphasis on biological integrity. An EIA relies upon the physical collection of vegetation and soils data as well as the identification of key ecological indicators and stressors/disturbances that can be readily measured, monitored, or observed. In addition, several wetland classification systems are used to group similar types of wetlands during evaluations and for the different condition scoring methods.

The Ecological Integrity Assessment (EIA) method has been developed collaboratively over many years led by NatureServe, the umbrella organization over all 80+ Natural Heritage Programs in the U.S., Canada, and Latin America. This collaboration has culminated in two major reports (Faber-Langendoen et al. 2008; Faber-Langendoen et al. 2012a, Faber-Langendoen et al. 2012b). The EIA method uses concepts from the EPA's Level 1-2-3 Framework for Wetland Assessment to describe the level of intensity needed for data collection. Level 1 assessments are GIS-based landscape analyses using 1) digital wetland mapping to summarize information on wetland abundance, type, extent, and function across the watershed (Johnson 2005); and 2) a landscape characterization of the distribution of anthropogenic stressors such as roads and land use in relation to wetlands, as well as general wetland landscape context. Level 2 assessments are rapid, field-based assessments that evaluate the general condition of wetlands using a suite of easily collected and interpreted metrics. Level 3 assessments involve the most intensive, field-based protocol to collect detailed quantitative data and are considered the most accurate measure of wetland condition. The Montana EIA methods are a direct descendant of the NatureServe EIA Framework, although some methods and metrics have been modified to make it work best for wetlands in the mountains and plains of Montana.

Purpose of Montana's EIA method

Montana's EIA method can be used for a variety of purposes. Since 2008, the EIA method has been used to document the range of wetland condition across the state, often focusing on major river basins, watersheds, or wetland types. These studies have been funded by U.S. Environmental Protection Agency (EPA) Region 8 Wetland Program Development Grants and are intended to establish baseline conditions and to inform management, restoration and conservation goals. In addition, the process laid out in the EIA provides land and resource managers with a tool to measure the ecological integrity of wetlands under their jurisdiction. When carried out on a suite of wetlands, it could be used to target sites for restoration (those with lower scores) or further protection (those with higher scores). By focusing on biological integrity, the EIA method could be used to track change in species composition and structure over time after restoration projects have been conducted. Through its use of the stressor checklist, it could also be used to identify the most pressing stressors faced by wetlands in a given area, helping managers pinpoint and address the stressors under their control (Lemly 2016).

Ecological Integrity

Building on the related concepts of biological integrity and ecological health, ecological integrity is a broad and useful endpoint for ecological assessment and reporting. "Integrity" is the quality of being unimpaired, sound or complete. To have integrity, an ecosystem should be relatively unimpaired across a range of characteristics and spatial and temporal scales. Ecological integrity can be defined as the structure, composition and function of an ecosystem operating within the bounds of natural or historic disturbance regimes. Ecological integrity has also been defined as the ability of an ecosystem to support and maintain a full suite of organisms with species composition, diversity, and function comparable to similar systems in an undisturbed state. High ecological integrity is generally regarded as an ecosystem property where expected structural components are complete and all ecological processes are functioning optimally. Ecological integrity assessments, therefore, can be defined as a means of assessing the degree to which,

under current conditions, a system matches reference characteristics of similar systems with high ecological integrity (Lemly 2016).

Condition Category	Interpretation
At or Near Reference Standard Condition (No or Minimal Human Impact)	Wetland functions within the bounds of natural disturbance regimes. The surrounding landscape contains natural habitats that are essentially unfragmented with little to no stressors; vegetation structure and composition are within the natural range of variation, nonnative species are essentially absent, and a comprehensive set of key species are present; soil properties and hydrological functions are intact. Management should focus on preservation and protection.
Slight Departure from Reference Standard	Wetland predominantly functions within the bounds of natural disturbance regimes. The surrounding landscape contains largely natural habitats that are minimally fragmented with few stressors; vegetation structure and composition deviate slightly from the natural range of variation, nonnative species and noxious weeds are present in minor amounts, and most key species are present; soils properties and hydrology are only slightly altered. Management should focus on the prevention of further alteration.
Moderate Departure from Reference Standard	Wetland has a number of unfavorable characteristics. The surrounding landscape is moderately fragmented with several stressors; the vegetation structure and composition is somewhat outside the natural range of variation, nonnative species and noxious weeds may have a sizeable presence or moderately negative impacts, and many key species are absent; soil properties and hydrology are altered. Management would be needed to maintain or restore certain ecological attributes.
Severe Departure from Reference Standard	Wetland has severely altered characteristics. The surrounding landscape contains little natural habitat and is very fragmented; the vegetation structure and composition are well beyond their natural range of variation, nonnative species and noxious weeds exert a strong negative impact, and most key species are absent; soil properties and hydrology are severely altered. There may be little long term conservation value without restoration, and such restoration may be difficult or uncertain.

Scoring Methods

Key ecological indicators reflect both the structure and function of the wetland and are measured as metrics that consist of narrative ratings scaled along a gradient reflecting wetland condition relative to a natural or undisturbed state (i.e., reference standard). EIA metric ratings are integrated to produce overall scores for four attributes: 1) Landscape Context, 2) Vegetation, 3) Physicochemical (soils and water quality) and 4) Hydrology. The ratings for these four attributes are then combined into a multi-metric index (MMI) to produce an overall EIA wetland condition score.

The EIA form also contains a list of observed stressors or disturbances commonly found in Montana. Stressor lists can provide additional information when evaluating ecological integrity and can aid in further understanding overall wetland condition. The scope and severity of each stressor are estimated to define the proportion of the site and surrounding buffer expected to be affected by the stress as well as the estimated level of damage (Faber-Langendoen et al. 2012a, Faber-Langendoen et al. 2012b). Stressor scope and severity scores are rolled up into an overall stressor impact score, flagging sites that already are or may become degraded in the future as disturbances in and around a wetland take effect.

The Floristic Quality Assessment Index (FQAI) is a tool that uses plants to make standardized comparisons among open land areas, to set conservation priorities, to monitor project areas, and to restore habitats. The basic

component of the FQAI is the assignment of a coefficient of conservatism (C-value) by a panel of botanical and ecological experts to individual plant species that is specific to a defined geographical location. For a given geography, the C-value reflects the plant species' tolerance to natural and/or human disturbance and its fidelity to a habitat rated on a scale of 0 to 10. High C-values are assigned to species which are obligate to high-quality, specialized habitats and are intolerant of disturbance, while low C-values are assigned to habitat generalists with a wide tolerance or positive response to human disturbance. In Montana, C-values of 0 and 1 are reserved for non-native species. Montana has recently completed a series of C-value reevaluations specific to the state's flora (Pipp 2017). Several variations of FQA indices can be calculated, each of which provides a powerful and relatively easy assessment of the integrity of both biotic and abiotic processes and are indicative of the ecological integrity of a site (Wilhelm and Ladd 1988).

Section 2: APPLYING THE EIA METHOD

A. General Principles of AA Establishment:

Proper placement of the Assessment Area (AA) is crucial because it defines the area for most of the data collection, around which a buffer is established to evaluate landscape influences. Before heading into the field, crews should examine aerial photos of the sites and should strategize the most likely placement of the AA based on observed wetland features surrounding the target AA center coordinates. Once in the field and the area surrounding the point has been identified to be suitable for sampling, the crew will establish the AA boundaries. The AA should be established so that the entire wetland is represented, meaning that the AA should encapsulate the variety of plant communities, plant species, water regimes, soil types, etc… in the approximate ratio that they occur in the entire wetland. Field crews should also keep in mind that the AA should be located in the closest possible suitable area to the target coordinates. The crew should always document the process used to move the AA and accompanying vegetation zones or plot(s) when the target coordinates and/or standard AA are not used in the 'General AA Description' and/or 'Plot Representativeness' sections of the form.

Before establishing an AA, the field crew should write down the latitude (Y) and longitude (X) of the original target AA Center coordinates, noting the GPS unit make, model, and designated unit # on the field form.

Rules for the AA:

1. The AA should be 0.5 ha (5,000m^2) whenever possible, but can be as small as 0.1 ha (1,000 m^2) if necessary.
2. The maximum AA length is 200 meters, regardless of shape.
3. The minimum AA width is 20 meters, regardless of shape.
4. The AA should contain no more than 10% water > 1 meter in depth. This includes water in a stream channel.
5. The AA can cross and contain a stream channel that is < 1 meter in depth. The AA should not cross streams that are too deep or unsafe to wade.
6. If the wetland is < 25 meters in width and linear (e.g., riparian zone or lacustrine fringe), the AA will be a rectangle starting at the point and moving upstream no more than 200 m. The AA will be **smaller** than 0.5 ha. For example, if the wetland habitat is 20 m wide, the AA would be 20 x 200 = 4,000m^2 = 0.4 ha. Note: The AA should occur on only one side of the channel.
7. The AA must contain no more than 10% upland inclusions.
8. The AA center should be as close to the site s original target point as possible.
9. The AA should be established so that the entire wetland is represented, meaning that the AA should encapsulate the variety of plant communities, plant species, water regimes, soil types, etc... in the approximate ratio that they occur in the entire wetland.

Once the AA is established, take a waypoint at the established AA center ONLY if the original target coordinates have been moved to a new AA Center. Use the waypoint naming conventions outlined in Appendix M to name this and all other GPS waypoints. Write down

the waypoint ID, datum, zone, elevation (m), latitude (Y), longitude (X), and accuracy (m) on the form.

RECORD THE GPS COORDINATES OF ALL WAYPOINTS.

A. Establishing the Assessment Area (AA)

1. **Standard Layout of the AA:** Navigate to the original target coordinates using the GPS; this is the AA center. In open vegetation, pull a tape out 40 meters to the north and walk in a circle, flagging the boundary of the AA with pin flags or flagging tape. At least eight flags should be
used to mark the AA boundary, one in each of the four cardinal directions (N, S, E, W) and one in each of the ordinal directions (NE, SE, SW, NW). More flagging can be used if it is difficult to see all of the flagging. This 40-m radius circular plot (0.5 hectares) is the AA. If the total area of the wetland is smaller than 0.5 hectares, then the entire wetland is the AA. If the entire wetland can hold an AA with a 40-m radius, but the original target coordinates are too close to the wetland perimeter, then go to Alternate AA Layout 1, below. If the wetland is linear (e.g., riverine sites) and cannot hold an AA with a 40-m radius, then go to Alternate AA Layout 2, below. If the wetland area is smaller than 0.5 ha OR the wetland is larger than 0.5 ha but the wetland boundaries are such that a 0.5 ha AA cannot be established, then go to Alternate AA Layout 3, below.

2. **Alternate Layout 1 - Adjusting the AA for wetlands that can hold an AA with a 40-m radius:** If the entire wetland can hold an AA with a 40-m radius, but the original target coordinates for the AA center are too close to the wetland perimeter, then the center of the AA can be moved from the original coordinate location, but should be as close to the original target point as possible.

3. **Alternate AA Layout 2 - Rectangle:**

   Adjusting the AA for wetlands that are too narrow to hold an AA with a 40-m radius: If a 40-m radius circle does not fit within the wetland area, then field crews may decide to use a rectangular shape to define the AA. Rectangle dimensions should reflect the target AA size of
   0.5 ha (5,000 m^2). For example, a square AA should be 71 meters on each side (71 x 71 = 5041). If the wetland is 50 meters wide, the rectangle should be 50 x 100 m. The *maximum* length of a rectangular AA is 200 meters and the *minimum* width is 20 meters. Beyond 200 meters in length, the wetland may be highly variable and too difficult to assess in one visit. An AA less than 20 meters in width is too difficult to establish the vegetation plot. Rectangular
   AAs may be centered on the point. **Rectangular AAs should only be used where the wetland area is generally straight, and the size of the AA is not compromised by bends in the wetland boundary.** The boundary of the AA should be flagged as often as necessary so the boundary is easily visible. GPS waypoints should be taken at each of the four corners of
   rectangular AAs, and their coordinates should be recorded on page 1 of the field form under AA Corner #1, AA Corner #2, AA Corner #3, and AA Corner #4

   If the wetland is >25 m wide and linear, then the AA will be laid out beginning at the point and moving upstream the distance needed to produce a rectangular AA of 0.5 hectares . For
   example, if the wetland habitat along a river is 40 m wide, then the length of the AA would be 5,000 m^2/40 m^2 = 125 m.

4. **Alternate AA Layout 3 – AA Polygon:**

   If the wetland area is smaller than 0.5 ha OR the wetland is larger than 0.5 ha but the wetland boundaries are such that a 0.5 ha AA cannot be established, then the AA shape can be determined by the shape of the wetland itself. If the entire wetland is smaller than 0.5 ha, then the entire wetland becomes the AA. If the wetland is large enough but oddly shaped, the field crew must estimate the general dimensions of the wetland using the aerial photos provided and determine the best way to establish a 0.5 ha AA. The field crew will walk the AA perimeter with the GPS in TRACK mode, flagging the AA perimeter as they walk. Once the perimeter is walked and the shape is complete, the GPS unit will calculate the area of the shape and the crew can adjust it as needed to create a 0.5 ha AA. The GPS track is saved to the GPS unit and named by the point code (e.g., RV001AATRACK).

   The field crew should note any changes to the AA and the reasoning behind such selection (e.g., wetland too narrow, required a rectangular AA of 40 x 125 m).

B. General Assessment Area (AA) Information

Some of the information requested on the data forms may be provided on the Site Maps.

1. **Site ID:** This is the unique identifier assigned during the sample selection process. This identifier MUST be maintained throughout the project duration. Place the Site ID on each sheet of the data form.
2. **Site Name:** This is not required, but assigning a name to an assessment area may help organize different sites in the field and with site recollection later if questions arise.
3. **Visit Number:** Indicate whether this is the first, second, etc. visit to the site.
4. **Level of Assessment:** Indicate whether this is a Level 2 or a Level 3 assessment.
5. **Date**: Record the date the wetland was assessed written as month, day, year (e.g., 7/12/2018)
6. **Observers**: List the full names of all observers present during the wetland assessment.
7. **County:** This will help the Botanist hone their potential plant list (e.g., SOC list, Lesica 2012).
8. **Nearest Town:** This is helpful for organizing datasheets and recollecting site locations later.
9. **Land Ownership:** This should be on the Site Map and then filled in on the form during the assessment.
10. **Is This a Mitigation Wetland?** Select Yes or No. If yes, answer questions regarding pre- and post-construction visits.
11. **Slope and Aspect:** The field form contains three places to record slope and aspect for assessment areas that have two or three general slopes and aspects (e.g., a riverine wetland might slope down to the river channel and also with the general gradient and direction of the stream). Use a compass to measure both the slope and the aspect. Aspect should be measured while pointing downhill/down the slope.
12. **AA location relative to the target AA coordinates:** Check the appropriate case for the location of the AA relative to the original target coordinates. Determine if the AA is centered around the original target coordinates; the AA center is shifted and >60m from original target coordinates; shifted but ≤60 meters of the original target coordinates; or there were no original target coordinates.
13. **AA dimensions:** Check the appropriate case for the AA dimensions. The AA is a 40 meter radius circle; the AA is a rectangle (record width and length); the AA has an alternate layout.

C. GPS Coordinates at the AA Center

1. **Target AA Center Coordinates:** Record the original target coordinates of the selected AA center.
2. **GPS Unit Information and Unit Number:** Record the make and model of the GPS unit and, if applicable, the unit number.
3. **Actual Waypoint ID**: This is the ID assigned to the waypoint taken at the actual center of the AA. Rename the automatically assigned three digit number to a logical Waypoint ID as per Appendix M. Be certain to keep the waypoint ID consistent between the data form and the GPS.
4. **Accuracy**: Record the accuracy in meters given on the GPS unit. Consult the user's manual if it is necessary to change units from feet to meters.
5. **Datum**: This should be NAD83. Methods for changing the datum on the GPS will depend upon the model used. Consult the user's manual if necessary.
6. **Elevation**: Record the elevation in meters given on the GPS unit. Consult the user's manual if necessary to change units from feet to meters.
7. **Longitude (X) and Latitude (Y):** Since the AA Center can be moved from the original target coordinates, these may or may not be different from the target coordinates. Record coordinates in UTM. Changing the coordinate system on the GPS unit depends upon the model used. Consult the user's manual if necessary to change from degrees-minutes- seconds or from decimal degrees to UTM.
8. **GPS Coordinates for alternate AA layout:** Record each waypoint ID, coordinates, and accuracy for the AA corners (rectangular OR polygonal AA) or the name of the GPS track. Rename the automatically assigned three digit number to a logical Waypoint ID/Track Name as per Appendix M.

D. General Assessment Area Description

Include a general description of the assessment area and the surrounding uplands. Describe the wetland type, dominant vegetation, general location, and any notable features about the AA that may not have been captured in the classification or other information. Note surrounding vegetation (including uplands) and land use.

E. Directions to the Assessment Area and Access Comments

Detailed directions to the site can be written back at the office using the gazetteer. Note any issues that affected access to the AA.

F. Photos of the Assessment Area

Required photos of the AA include 4 photos looking in each cardinal direction (N,S,E,W) from the AA Center and an overview photo. Place the Photo Card in the lower corner of each photo (Figure 1).

Using a dry erase pen, fill in the Site ID, date, and bearing of the photo on the Photo Card. Be sure that the Photo Card takes up very little of the photo, but that the information on the Photo Card is visible in the photo.

Note: Watch for glare off of the Photo Card.

Record a description on the data form, when necessary. Record the number of the photo from the camera onto the form. Be certain that this number is maintained when the photos are downloaded onto the computer.

Take a GPS point at each overview and additional photo location. Rename the automatically assigned three digit number to a logical Waypoint ID as per Appendix M. Record each waypoint ID, coordinates, and accuracy on the data form.

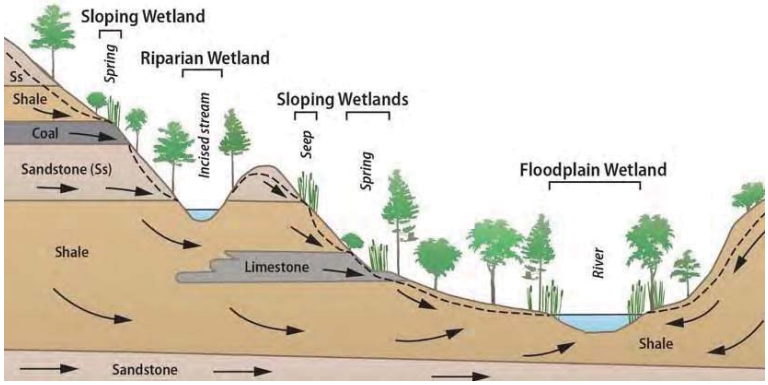
1. **Camera Information:** Record the camera make, model, and serial number.
2. **Photos from the AA Center:** From the AA center, take four photos; one in each cardinal direction.
3. **AA Overview:** Take <u>two</u> photos showing an overview of the entire AA. This may require standing at a distance or climbing a nearby hill to gain some perspective. The first overview should include the Photo Card, while the second overview should only include the AA landscape view. Record the bearing of both photos (should be the same) on both the form and the Photo Card (when used).
4. **Additional Photos**: Take any additional photos that you feel would provide additional information for the AA. Record the number of the photo from the camera onto the form. Be certain that this
number is maintained when the photos are downloaded onto the computer.

Figure 1. Examples of AA photos. Note placement of photo card in the corner of each photo.

G. Site Geography: Topographic Position and Water

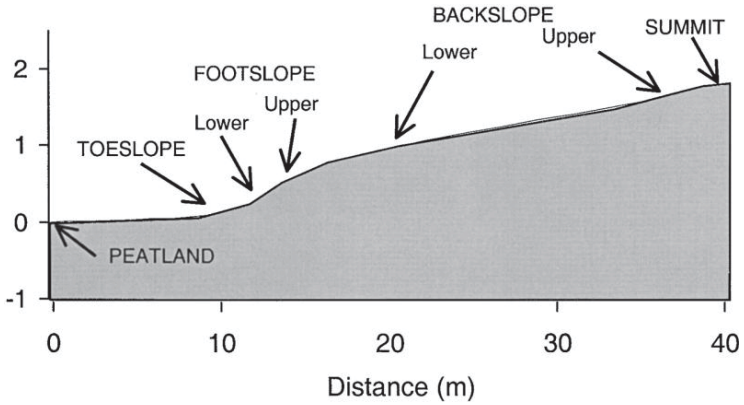
1. Topographic Position: Select the appropriate topographic position category based on the position of the AA in the landscape.

Slope- Intermediate slope position, not the toe of the slope but actually on a sloping face.



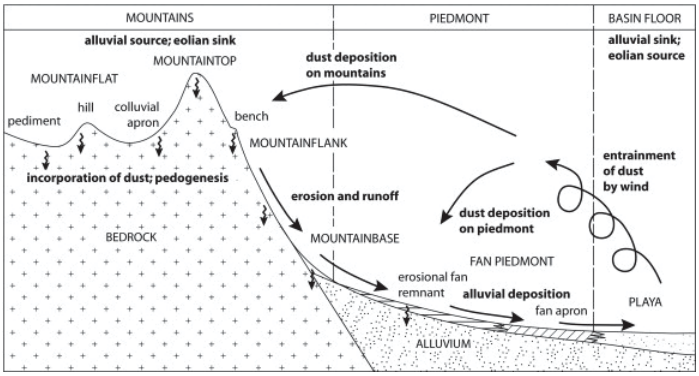
https://www.researchgate.net/figure/Depiction-of-sloping-floodplain-and-riparian-wetlands-across-the-Appalachian-Plateau fig4 316460315

Toeslope- Outermost gently inclined surface at base of a slope. In profile, commonly gentle and linear and characterized by alluvial deposition.



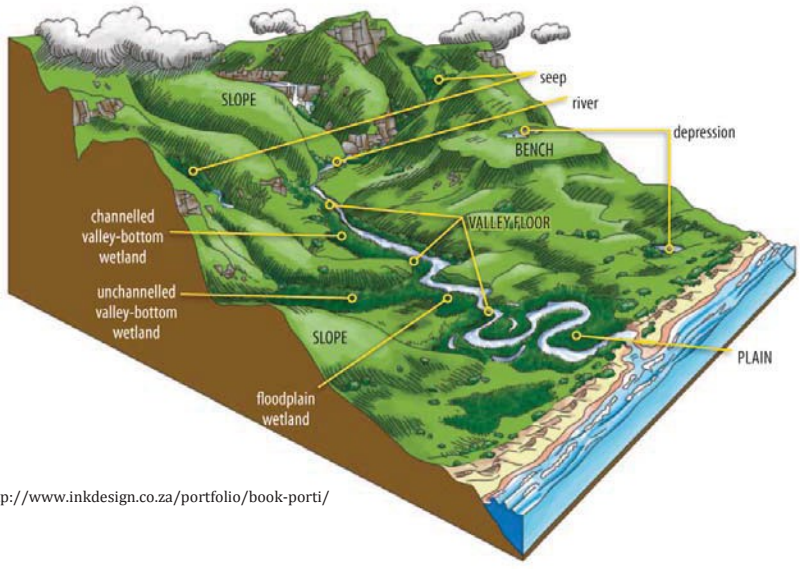
https://dl.sciencesocieties.org/publications/sssaj/abstracts/65/5/1559 show-t-%20%20f=tables&wrapper=no access=0&view=article

Basin floor- Nearly level to gently sloping, bottom surface of a basin.



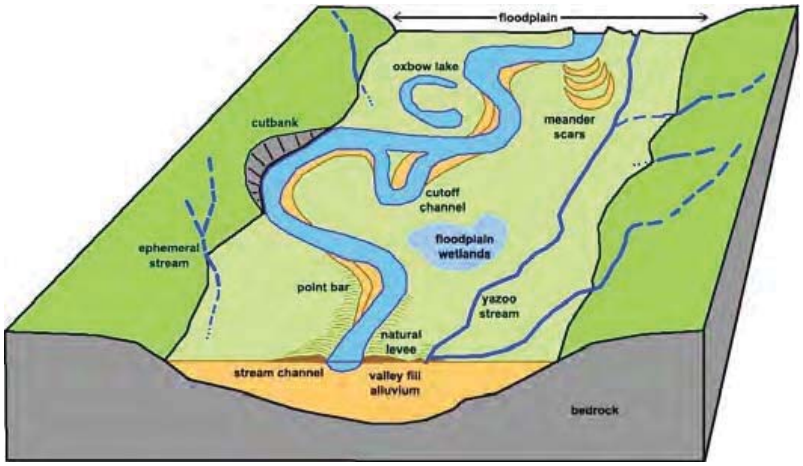
https://www.sciencedirect.com/science/article/pii/S0341816211001561

Valley bottom- Also called 'valley floor.' The nearly level to gently sloping, lowest surface of a valley.



http://www.inkdesign.co.za/portfolio/book-porti/

Floodplain - The nearly level alluvial plain that borders a stream and is subject to inundation under flood-stage conditions unless protected artificially. It is usually a landform built of sediment deposited during overflow and lateral stream migration



https://socratic.org/questions/what-is-the-flat-portion-of-a-valley-floor-adjacent-to-a-stream-channel-called

2. Amount of Assessment Area Covered by Standing Water: Select the appropriate cover of standing water in the AA.

3. Estimated Depth of Standing Water: Select the appropriate depth of standing water (averaged over the entire AA).

4. Surface Water Permanence: Based on vegetation, soil characteristics, and topographic position, select whether the AA is generally saturated during the growing season, or if the AA surface water is permanent, semipermanent, seasonal, or temporary during the growing season.

I. Classification of the Assessment Area

For EACH of the following classifications, select the appropriate Confidence Level for your selection and provide reasoning for your selection on the data form.

1. **Ecological System**:
   Select the appropriate Ecological System of the AA from the list using the Key to Wetland Ecological Systems of Montana (Appendix A). If none of the provided Ecological Systems seems appropriate, note it in the comments, providing a detailed explanation. Select only 1 dominant Ecological System.
2. **Hydrogeomorphic (HGM) Class**:
   Select the appropriate HGM class of the AA using the Key to the Hydrogeomorphic Classification of Wetlands in the Rocky Mountains (Appendix B). The AA should encompass only one dominant HGM class.

HGM Class (check one - use Key to Hydrogeomorphic Classes—then check with description below):

_____**Slope** – occurs on a slope (slope can be very gradual or nearly flat) where groundwater is the primary hydrologic input, and water flows in one direction, discharging as sheet flow or subsurface flow via seeps or springs with no channel formation. Small rivulets may form to direct water away from wetland, but no channel will convey surface flow into wetland and these rivulets are not subject to overbank flooding. Water does not pond except occasionally in small depressions or behind hummocks. Examples: fens, shrub-carrs, swales.

_____**Lacustrine Fringe** – occurs adjacent to large lakes (>8 ha/>20 acres) with >30% non-vegetated, open water (>2.5m/8.2 ft deep). Water elevation of lake maintains the water table in the wetland, though wetland may receive groundwater from upslope wetlands. Vegetation experiences bidirectional flow as result of vertical water level fluctuations of lake. Examples: fringe wetlands around Flathead Lake, Canyon Ferry Lake, Ennis Lake.

_____**Depressional** – occurs in topographic depression that allows for accumulation of surface water or surface is saturated at some time during the year. May or may not have an inlet or outlet. If outlet present, it will be higher than the bottom of the depression. Examples: prairie potholes, playas, vernal pools, oxbows that do not flood regularly.

_____**Flat** – occurs in broad, flat plains with precipitation the dominant source of water; groundwater and surface runoff are not major hydrologic sources. Usually underlain by a hardpan soil layer which prevents percolation of water into the soil. Example: greasewood flat.

_____**Riverine (floodplain)** – occurs in active valley or floodplain associated with a stream/river channel that is inundated by overbank flooding at least every two years. Dominant hydrologic sources are overbank flooding or hyporheic (subsurface flowing water adjacent/connected to stream) connections between the stream channel and wetlands. Oxbows and other wetlands in the floodplain receiving floodwaters or hyporheic water as their primary hydrologic source are Riverine. Examples: willow/alder thickets along streams, oxbows that flood regularly.

3. **Cowardin & Riparian Classification**:
   Record all appropriate Cowardin classification codes using the definitions provided in the Key to the Cowardin Systems and Classes of the Rocky Mountains (Appendix C; FGDC 2013). A Riparian key is not provided, but if the site does not appear to be wet enough to be a wetland and is located along a lake or river, it may be Riparian (see Appendx C -Cowardin & Riparian Classification System Definitions). Select the appropriate Subclass and Water Regime based on the descriptions on p.2 of the field form. Use Appendix C to determine the correct Subclass for each Cowardin Class to make sure it is compatible. Each complete Cowardin code (System + Class + Subclass + Water Regime + Special Modifier (optional)) should be applied to no less than 1% of the AA. The percentages of each Cowardin code + the % of Upland in the AA (from p.1) should equal 100% of the AA.

For each classification, select a confidence level and provide a reason why you chose that category (i.e., for a Riverine, Upper Perennial, Unconsolidated Shore, Temporarily Flooded, Cobble-gravel (R3USA3) you might write site is a gravel bar located along the bank of a fast-flowing stream and it has >30% vegetation growing on it. Do NOT write "because it keyed to that in the Cowardin Key."

Section 3. PLANT ZONE DESCRIPTION for the ASSESSMENT AREA

See Table 1 for the following scales and values used in this Section: Height Scale, Cover Scale, Stratum, Avg. Water Depth for Each Plant Zone, Plant Community (adapted from Eggers & Reed 2015).

A. Distinguishing Individual Plant Zones: Plant zones usually consist of more than one plant species, but some zones can be monospecific. Identify and describe the plant zones that occur within the assessment area. A plant zone should be described if it meets the following rules:

1. The plant zone is dominated by...
    a. A stratum distinctly different from the stratum that dominates other plant zones; OR
    b. The same stratum as other plant zones, BUT each plant zone is dominated by different species.
2. The plant zone makes up more than 5% of the AA (e.g., 250 m^2 for an AA of 0.5 ha).
3. Each individual patch of the plant zone is greater than 10m^2.

B. Summary of Each Plant Zone Within the AA:

1. **% of AA:** Estimate the percent cover of each plant zone within the AA using the cover class scales.
2. **Cowardin Code:** Assign a Cowardin code to each plant zone. The plant zone Cowardin codes and the % s in which they exist should correlate to the Cowardin codes and % s assigned on p.4 of the field form (See Section 1.I.3.). There can be multiple plant zones with the same Cowardin code, as long as they are distinguishable according to the rules outlined in Section 2.A. above. For example, if there is 50% PEMC and 50% PSSA recorded on p.4 in the Cowardin Classification section of the field form, then there should be at least two plant zones recorded in this Summary... section, e.g., Plant Zone #1 = 50% of the AA and is PEMC, Plant Zone #2 = 20% of the AA and is PSSA, and Plant Zone #3 =30% of the AA and is PSSA, where Plant Zone#2 may be dominated by C*ornus sericea* and Plant Zone #3 may be dominated by *A/nus incana.*
3. **Avg. H2O Depth:** Estimate the average water depth of each plant zone within the AA using the depth scale found in Table 1.
4. **Biophysical Setting:** Assign a biophysical setting to each plant zone using the Key to Wetland Biophysical Settings in Montana (Appendix E; adapted from Eggers & Reed (2015) and the values in Table 1). Make sure that the Cowardin Code assigned to a zone coordinates with the Biophysical Setting by using Appendix F.
5. **Comments:** Make any pertinent comments about each plant zone as needed.
6. **"Other":** Fill in the % of the AA that is composed of Cowardin codes listed on p.4 of the field form that are non-vegetated (e.g., Riverine System, Rocky Shore Class, etc...) + the sum of all plant zones that are <5%of the AA (these are usually NOT described Plant Zone #1-5)
7. **"Upland"**: The % of Upland in the AA (from p.1)

   The percentages of each plant zone + the % of "Other" + the % of Upland should equal 100% of the AA.

Indicate the location of each plant zone on the AA drawing and on the aerial photo.

Table 1. Classes and values for height, cover, stratum, average water depth for each plant zone, and biophysical setting for each plant zone (adapted from Eggers & Reed (2015)).

PLANT ZONES WITHIN ENTIRE ASSESSMENT AREA

Identify and describe the plant zones that occur within the assessment area. Identify the dominant plant species within each stratum. To be considered a separate plant zone, it must make up more than 5% of the AA (e.g., 250 m^2 for an AA of 0.5 ha).

Height Class				Cover Class			
1	<0.5 m	6	10-<15 m	1	Trace	6	10-<25%
2	0.5-1 m	7	15-<20 m	2	<1%	7	25-<50%
3	1-<2 m	8	20-<35 m	3	1-<2%	8	50-<75%
4	2-<6 m	9	35-<50 m	4	2-<5%	9	75-<95%
5	6-<10 m	10	≥50 m	5	5-<10%	10	≥95%

Stratum		Avg. Water Depth		Biophysical Setting for Each Plant Zone	
FO	Forest/Woodland (Trees/Shrubs >6 m)	1	Dry	AB	Aquatic Bed
SH	Shrubland (Shrubs 0.5-6 m)	2	Moist	ShMa	Shallow Marsh
H	Herbaceous (e.g., Graminoids, Forbs, Ferns)	3	Saturated	DeMa	Deep Marsh
DS	Dwarf Shrubland (<0.5 m)	4	< 5 cm	SeMe	Sedge Meadow
NV	Nonvascular (Bryophytes, cryptogamic crusts)	5	5-<10 cm	WeMe	Wet Meadow
SD	Standing Dead (>45° angle)	6	10-<20 cm	WWMP	Wet to Wet-Mesic Prairie
SV	Sparsely Vegetated (including bare ground)	7	20-<30 cm	SFM	Seasonally Flooded Mudflat
CW	Coarse Woody Debris (≥ 7.6 cm diameter)	8	30-<40 cm	SFBDF	Seasonally Flooded Basin/Depression/Flat
FW	Fine Woody Debris (≤ 7.5 cm diameter)	9	40-<50 cm	HF	Herbaceous Fen
V	Vines	10	0.5-<0.75 m	SSF	Scrub-Shrub Fen
Collecting unknown plant specimens: collect a specimen to press, assigning it a unique number (U1, U2, etc) and record that in the **Collect #** column for each Plant Zone.		11	0.75-<1 m	SSW	Coniferous Fen
		12	1-<1.5 m	CF	Coniferous Wetland
		13	1.5-<2.5 m	CW	Coniferous Fen
		14	≥2.5 m	FF	Floodplain Forest
				SD	Saline Depression

C. Identify and Describe Each Plant Zone Within the AA:

1. **Stratum:** Select the appropriate strata (e.g., forest, shrubland, herbaceous, etc.) from Table 1 that coordinates with each dominant species within each plant zone.
2. **Dominant Species:** Record the dominant species within each plant zone.
3. **Height Class & Cover Class:** Record the height and cover class of each plant species using the height and cover class scales in Table 1.
4. **Comments:** Make any pertinent comments about each plant species as needed.

Section 4. ASSESSMENT AREA DRAWING

Provide a drawing of the assessment area, including north arrow, plant zones, vegetation plot/module placement (Level 3 assessment only), soil pit placement (S1 & S2), direction of surface water inlets and outlets with solid arrows, and direction of groundwater/subsurface drainage with dashed arrows. Anthropogenic features like culverts, berms, or impoundments should also be included in the sketch.

Also indicate any major plant zones on the aerial photo of the AA.

Section 5. PHYSICAL PATCH TYPES within the ASSESSMENT AREA

Physical patches such as open water, mudflats, floating mats, etc. increase the structural complexity of wetlands as well as perform important ecological functions and can be important indicators of wetland function. Patch types are recorded on the datasheet by selecting all that apply from a checklist of different physical surfaces or features that may provide habitat for species. For patch types that occur within the AA, estimate the overall cover class of each in the AA.

List of Physical Patch Types within the Assessment Area

NO PHYSICAL PATCH TYPES PRESENT IN AA: ☐

PHYSICAL PATCH TYPE	Cover Class	Comments
Cover Classes **1**: trace **2**: <1% **3**: 1–<2% **4**: 2–<5% **5**: 5–<10% **6**: 10–<25% **7**: 25–<50% **8**: 50–<75% **9**: 75–<95% **10**: ≥95%		
Open water-pond or lake: Medium to large natural water body		
Open water -pools: Areas that hold stagnant or slow moving water from groundwater discharge but are not associated with a defined channel.		
Open water-river/stream: Areas of flowing water associated with a sizeable channel.		
Open water-small rivulet: Areas of flowing water associated with a narrow stream channel.		
Open water-oxbow/backwater channel: Areas holding stagnant or slow moving water that have been partially or completely disassociated from the primary river channel.		
Open water-tributary/secondary channel: Areas of flowing water entering the main channel from a secondary source.		
Open water-beaver pond: Areas that hold stagnant or slow moving water behind a beaver dam.		
Active beaver dam: Debris damming a stream clearly constructed by beaver (note gnawed ends of branches)		
Beaver canals: Canals cut through emergent vegetation by beaver.		
Braided river channel: River channel consisting of a network of small channels separated by small and often temporary islands or bars.		
Adjacent or onsite springs/seeps: Localized point of emerging groundwater, often on or at the base of a sloping hillside.		
Debris jams/woody debris: Aggregated woody debris in a stream channel deposited by high flows.		
Deadfall/woody debris: Aggregated clumps of coarse woody debris from dead or downed tree or large shrubs.		
Pool/riffle complex: Deep, slow-moving pools alternating with shallow, fast-moving riffles along the relatively straight course of a stream or river.		
Point bars: A low ridge of sediment (sand or gravel) formed on the inner bank of a meandering stream.		
Bank slumps or undercut banks: A bank slump is the portion of a stream or other wetland bank that has broken free from the rest of the bank but has not eroded away. Undercut banks are areas along a stream bank or shoreline of a wetland that have been excavated by waves or flowing water.		
Mudflats: An accumulation of mud at the edge of shallow waters, such as a lake or pond. Often intermittently flooded or exposed.		
Salt flat/alkali flat: Dry open area of fine-grained sediment and accumulated salts. Often wet in the winter months or with heavy precipitation.		
Animal mounds or burrows: Mounds or holes associated with animal foraging, denning, predation, or other behaviors.		
Plant hummocks: A mound composed of herbaceous plant material resulting in a raised pedestal of persistent roots or rhizomes.		
Tree hummocks: Raised mounds of tree roots surrounding a tree, often with soil and debris, on which various plants often grow.		
Water tracks/hollows: Depressions between hummocks or mounds that remain permanently saturated or inundated with slow moving surface water.		
Natural island: Naturally occurring islands surrounded by water. Island can be dominated by either wetland or upland vegetation.		
Anthropogenic island: Island created by artificial means, often for nesting waterfowl.		
Floating mat: Mats of peat held together by roots and rhizomes of sedges. Floating mats are underlain by water and /or very loose peat.		
Marl/limonite beds: Marl is a calcium carbonate precipitate often found in calcareous fens. Limonite forms in iron-rich fens when iron precipitates from the groundwater incorporating organic matter.		
Other:		

Section 6. LEVEL 2 ASSESSMENT METRICS

A. Landscape Context Metrics

1. Landscape Connectivity: This metric measures the percent of unfragmented landscape within a 200 m envelope around the AA perimeter (non-riverine) or the degree to which the riverine corridor above and below a floodplain area exhibits connectivity with adjacent natural systems (riverine). Fill in the correct bubble for the type of wetland being assessed, depending on the HGM class.

Metric Measurement Protocol:

a. Non-riverine**:** The intensity of human activity in the landscape often has a proportionate impact on the ecological processes of natural systems. The percentage of altered landscape (e.g., anthropogenic patches) provides an indirect estimate of connectivity among natural ecological systems. To assess this metric, estimate the percent unfragmented area within the 200 meter envelope. Dirt roads count as fragmentation, but hiking trails can be included in unfragmented blocks. Estimate the landscape connectivity using the following narrative descriptions:

b. Riverine: For Riverine wetlands (where the channel is within or adjacent to the AA), landscape connectivity is the continuity of the riparian corridor 200 m upstream and 200 m downstream of the AA. Of special concern is the ability of wildlife to enter the riparian area at any place within 200 m of the AA and to move easily through adequate cover along the riparian corridor from either upstream or downstream. Refer to maps and aerial photos provided to estimate the percent of anthropogenic, non-buffer patches within the riparian corridor (the width of the geomorphic floodplain) 200 m upstream and downstream of the AA. Anthropogenic patches include heavily grazed pastures, roads, bridges, urban/industrial development, agriculture fields, and utility right-of-ways. Estimate the landscape connectivity using the following narrative descriptions:

Use the following narrative descriptions to identify the landscape connectivity within 200m of the AA.

Landscape Connectivity within 200 m of the AA perimeter		
Type of Wetland (check one):	**Non-Riverine** ◯ **Riverine** ◯	
Use the site map to select the statement that best describes the landscape connectivity within a 200 m envelope around the AA perimeter (non-riverine wetlands) or within a 200 m envelope upstream and downstream of the AA perimeter (riverine wetlands).	Intact: AA embedded in >90-100% unfragmented, natural landscape.	**1**
	Variegated: AA embedded in >75-90% unfragmented, natural landscape.	**2**
	Fragmented: AA embedded in >50-75% unfragmented, natural landscape.	**3**
	Severely fragmented: AA embedded in 25-50% unfragmented, natural landscape.	**4**
	Relictual: AA embedded in <25 % unfragmented, natural landscape.	**5**

2. Buffer Index: Wetland buffers are vegetated, natural (non-anthropogenic) areas that surround a wetland (Table *2*). This metric calculates the overall area and condition of the buffer immediately surrounding the AA using three measures: percent of AA with buffer (buffer length), average buffer width, and buffer condition.

Metric Measurement Protocol:

a. Buffer Length**:** This metric can be assessed first using aerial photography but must be verified in the field. Visually estimate the total percentage of the AA perimeter that adjoins land cover types that provide buffer functions. To be considered as a buffer, a suitable land cover type must be at least 30 meters in width. For Riverine wetlands, do not include the area immediately upstream or downstream as part of the buffer. Only consider areas on one side of the channel or the other.

Buffer Length (Perimeter)		
Select the statement that best describes the buffer length around the AA perimeter.	A buffer of at least 30 m occurs around 76-100% of the AA perimeter.	**1**
	A buffer of at least 30 m occurs around 51-75% of the AA perimeter.	**2**
	A buffer of at least 30 m occurs around 25-50% of the AA perimeter.	**3**
	A buffer of at least 30 m occurs around <25% of the AA perimeter, OR NO BUFFER EXISTS.	**4**

Table 2. Examples of land cover that should be included and excluded from wetland buffer calculations.

Examples of Land Cover Included in Buffers	Examples of Land Cover Excluded from Buffers
• Additional wetland/riparian area • Natural upland habitats • Nature or wildland parks • Bike trails • Foot trails • Horse trails • Open rangeland with light grazing • Swales and ditches • Open water • Vegetated levees	• Commercial developments • Residential developments • Paved roads • Dirt roads • Railroads • Parking lots • Fences that interfere with the movements of wildlife • Sound walls • Intensive agriculture (row crops, orchards, vineyards) • Dryland farming • Horse paddocks, animal feedlots • Rangeland with intensive grazing • Lawns • Golf courses • Sports fields • Urbanized parks with active recreation • Paved or heavily used pedestrian/bike trails (frequent traffic) • Clearcuts/Intensive Logging

b. Buffer Width**:** This metric can be assessed first using aerial photography but must be verified in the field. Where buffers exist, visually estimate the average distance between the perimeter of the AA and the edge of the buffer at eight evenly spaced intervals up to 200 meters from the perimeter of the AA. For Riverine wetlands, do no include the area immediately upstream or downstream as part of the buffer. Only consider areas on one side of the channel or the other. See Table 3 for land covers included and excluded from buffers. Use the following narrative descriptions to estimate the buffer width:

Buffer Width: ***Select the statement that best describes the buffer width of the AA. Estimate width up to 200 m from AA perimeter at eight evenly spaced intervals. Draw a 'pie' on your aerial photo and determine buffer width for each section.***			
N	S	Average buffer width between edge of the AA and the edge of the buffer is >200 m.	**1**
NE	SW	Average buffer width between edge of AA and the edge of the buffer is >100-200 m.	**2**
E	W	Average buffer width between edge of the AA and the edge of the buffer is 50-100 m.	**3**
SE	NW	Average buffer width between edge of the AA and the edge of the buffer is <50 m, OR no buffer exists.	**4**
Average Buffer Width:_____			

c. Buffer Condition: Estimate the overall condition of the buffer within 200 meters of the AA perimeter based on plant species composition, extent of soil disturbance, and the extent of trash or evidence of human visitation or recreation using the narrative descriptions below. ONLY consider portions of the 200 m envelope considered buffer (i.e., exclude non-buffer areas such as roads).

Buffer Condition within 200 m of the AA perimeter		
Select the statement that best describes the plant species composition within a 200 m envelope around the AA perimeter.	Abundant (>95%) native vegetation cover and little or no (<5%) cover of non-native plants.	**1**
	Substantial (>75–95%) native vegetation cover and low (5–25%) cover of non-native plants.	**2**
	Moderate (50-75%) native vegetation cover.	**3**
	Low (<50%) cover of native vegetation, OR NO BUFFER EXISTS.	**4**
Select the statement that best describes the extent of soil disturbance composition within a 200 m envelope around the AA perimeter.	Soils are intact.	**1**
	Soils are slightly to moderately disturbed.	**2**
	Soils are moderately to extensively disturbed.	**3**
	Soils are highly disturbed OR ground is unnaturally bare, OR NO BUFFER EXISTS.	**4**
Select the statement that best describes the extent of trash or evidence of human visitation within 200 m of the AA perimeter.	No trash present OR no evidence of human visitation or recreation.	**1**
	Little trash OR evidence of minor human visitation or recreation.	**2**
	Moderate or greater amounts of trash OR evidence of moderate human visitation/recreation.	**3**
	Excessive amounts of trash OR evidence of high intensity human visitation/recreation, OR NO BUFFER EXISTS.	**4**

B. Vegetation Structure Metrics

1. Relative Cover of Native Plant Species: A measure of the relative percent cover of all plant species that are native to the region.

Metric Measurement Protocol
Estimate the percent of the vegetation cover within the AA that is comprised of native plant species. Note: If 50% of the AA is covered by water and 50% of the AA is covered by vegetation, then estimate the percent of the AA covered by vegetation that is comprised of native vegetation. Estimate the relative cover of native plant species in the AA based on the following narrative descriptions:

Relative cover of native plant species within the AA		
Select the statement that best describes the relative cover of native plant species within the AA.	>99% of the vegetation cover within the AA is comprised of native vegetation.	**1**
	95-99% of the vegetation cover within the AA is comprised of native vegetation.	**2**
	80-94% of the vegetation cover within the AA is comprised of native vegetation.	**3**
	50-79% of the vegetation cover within the AA is comprised of native vegetation.	**4**
	<50% of the vegetation cover within the AA is comprised of native vegetation.	**5**

2. Relative Cover of Listed Noxious Weed Species within the AA: A measure of the relative percent cover of listed noxious weed species and the distribution of noxious weed species in the AA.

Metric Measurement Protocol
Estimate the percent of the relative vegetation cover within the AA that is comprised of listed noxious weed species plant species from the Montana Noxious Weed List (Appendices G, H). If noxious weed species are present in the AA, then identify and rank the three most common species observed. Estimate the relative cover of listed noxious weed species and the distribution of noxious weed species in the AA based on the following narrative description:

Relative cover of listed noxious weed species within the AA (*see State/County Noxious Weed list*)		
Select the statement that best describes the relative cover of listed noxious weed species within the AA. *Identify and rank the three most common noxious weed species observed in the AA.* *1)*_____ *2)*_____ *3)*_____	No noxious weed species are present in the AA.	**1**
	<1-3% of the vegetation cover within the AA is comprised of noxious weed species. If weeds occur in patches, then patches are small and isolated (1-2 patches) within the AA.	**2**
	>3-10% of the vegetation cover within the AA is comprised of noxious weed species. If weeds occur in patches, then patches are moderate in size and common (3-5 patches) within the AA.	**3**
	>10% of the vegetation cover within the AA is comprised of noxious weed species. If weeds occur in patches, then patches are relatively large and abundant (>5 patches) within the AA.	**4**

3. Relative Cover of Aggressive Graminoids within the AA: For the purposes of this metric, aggressive graminoids include reed canarygrass (*Phalaris arundinacea*), common reed (*Phragmites australis*), cattail (*Typha* ssp.), smooth brome (*Bromus inermis*), Kentucky bluegrass (*Poa pratensis*), common timothy (*Phleum pratense*), and meadow foxtail (*Alopecurus pratensis*). Both native and non-native ecotypes of reed canarygrass and common reed occur in Montana. The nativity of these species often cannot be known with certainty because they are difficult to distinguish in the field. Similarly, two cattail species can occur in Montana, *Typha latifolia* is a native species, whereas *T. angustifolia* is native to the eastern U.S. Both species tend to increase and dominate sites with excessive nutrients. Smooth brome, Kentucky bluegrass, common timothy, and meadow foxtail are aggressive, non-native pasture grasses that often invade temporarily and seasonally flooded wetlands.

This metric is a measure of the absolute percent cover of graminoids that are aggressive competitors with other native plant species and are obviously changing the species composition of the wetland.

Metric Measurement Protocol
Estimate the absolute percent cover of aggressive graminoids within the AA. If aggressive graminoids are present in the AA, then identify and rank the three most common species observed. Estimate the absolute percent cover of aggressive graminoids within the AA using the following narrative descriptions:

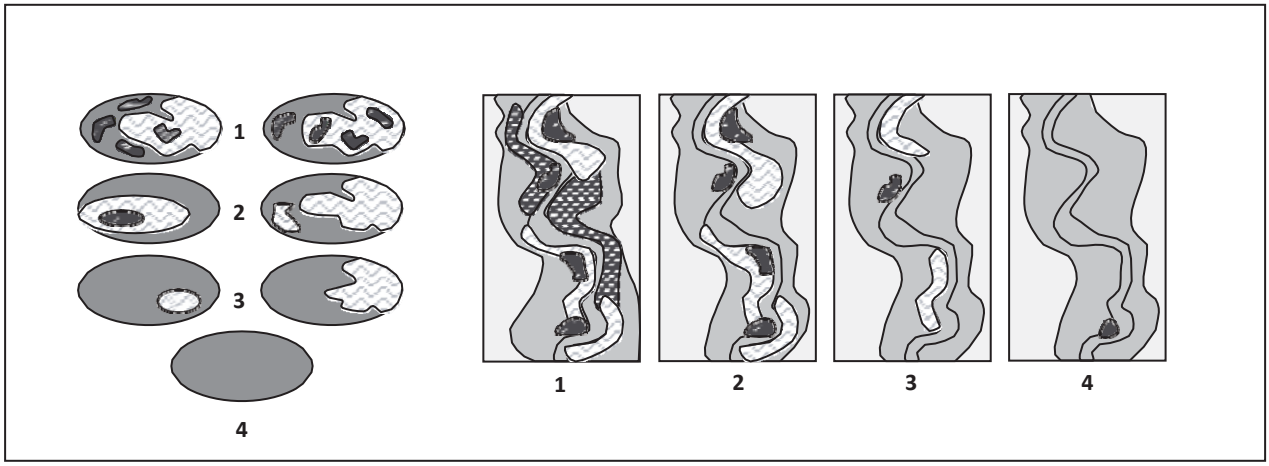
Relative cover of aggressive graminoids within the AA		
Select the statement that best describes the relative cover of aggressive graminoids within the AA. *Identify and rank the three most common aggressive graminoids observed in the AA.* *1)*_____ *2)*_____ *3)*_____	No aggressive graminoid species are present in the AA.	**1**
	Aggressive graminoids are present in the AA, but with low cover (<10% relative cover of cattails or <5% cover of reed canarygrass, common reed, smooth brome, Kentucky bluegrass, common timothy, or meadow foxtail).	**2**
	Aggressive graminoids are common in the AA (10-25% relative cover of cattails or 5-10% relative cover of reed canarygrass, common reed, smooth brome Kentucky bluegrass, common timothy, or meadow foxtail).	**3**
	Aggressive graminoids are abundant in the AA (>25-50% relative cover of cattails or 10-25% relative cover of reed canarygrass, common reed, smooth brome, Kentucky bluegrass, common timothy, or meadow foxtail).	**4**
	Aggressive graminoids are dominant in the AA (>50% relative cover of cattails or >25% relative cover of reed canarygrass, common reed, smooth brome, Kentucky bluegrass, common timothy, or meadow foxtail).	**5**

4. Herbaceous Litter/Woody Debris Accumulation: The accumulation of litter and/or woody debris is integral to a variety of wetland functions, such as surface water storage, percolation and recharge, nutrient cycling, and support of wetland plants. Intact litter layers and/or woody debris provide areas for primary production and decomposition that are important to maintaining functioning food chains. They nurture fungi essential to the growth of rooted wetland plants. They support soil microbes and other detritivores that comprise the base of the food web in many wetlands. The abundance of litter and/or woody debris on the substrate surface can significantly influence overall species diversity and food web structure. Fallen debris serves as cover for macroinvertebrates, amphibians, rodents, and even small birds. Litter is the precursor to detritus, which is a dominant source of energy for most wetland ecosystems. **Note: The site must have the potential to accumulate woody debris (i.e., woody plant species should be present at the site).**

Metric Measurement Protocol
Use the following narrative descriptions to describe the herbaceous litter/woody debris accumulation within the AA:

Herbaceous Litter/Woody Debris Accumulation within the AA		
Select the statement that best describes the herbaceous litter/woody debris accumulation of the site. ***Note:*** **Woody debris only applies to sites with shrubs/trees.**	Site has moderate amount of fine litter/woody debris. New growth is more prevalent than previous years' growth. Layers of litter in pools or areas of topographic lows are thin.	**1**
	Site is characterized by small amounts of litter/woody debris, little plant recruitment	**2**
	Litter/woody debris is somewhat excessive.	
	Site has scant litter/woody debris	**3**
	Litter/woody debris is excessive and is blocking plant recruitment.	

6. Interspersion of Plant Zones within the AA: Refer to the diagrams below and circle the number that best illustrates the interspersion of plant zones within the AA. Use the plant zones identified on pages 5 and 6 of the field form. Along with the plant zones, include zones of open water when evaluating interspersion.



Interspersion of Plant Zones within the AA		
Select the statement that best describes the patch interspersion of the site (use the associated schematics at the top of p. 11).	Horizontal structure consists of a very complex array of nested or interspersed irregular biotic patches with no single dominant type.	**1**
	Horizontal structure consists of a moderately complex array of nested or interspersed irregular biotic patches with no single dominant type.	**2**
	Horizontal structure consists of a simple array of nested or interspersed irregular biotic patches with no single dominant type.	**3**
	Horizontal structure consists of one dominant patch type with no interspersion.	**4**

7. Woody Species Establishment and Regeneration within the AA: Select the statement on the form that best describes the regeneration of native woody species establishment and regeneration within the AA.

Metric Measurement Protocol
Use the following narrative descriptions to describe the woody species establishment and regeneration within the AA:

Woody Species Establishment and Regeneration within the AA		
Select the statement that best describes woody species establishment and regeneration within the AA.	Woody species are naturally uncommon or absent.	1
	All age classes of native woody species present.	
	Middle age group(s) absent with all other well-represented	2
	Early successional saplings only.	
	Seedlings and saplings and middle age group(s) absent. The stand is comprised mainly of mature species.	3
	Woody species predominately consist of relict or dying individuals	4
	AA has a > 5% canopy cover of Russian Olive and/or Salt Cedar.	

8. Tree and Shrub Utilization Within the AA: Estimate the extent of browse on woody species within the AA.

Metric Measurement Protocol
Use the following narrative descriptions to describe the extent of browse on woody species within the AA:

Tree and Shrub Utilization within the AA		
Select the statement that best describes the utilization of trees and shrubs in the AA.	Woody species are naturally uncommon or absent.	1
	0-5% of the available second year and older stems are browsed.	
	>5%-25% of the available second year and older stems are browsed.	2
	>25%-50% of the available second year and older stems are browsed.	3
	More than 50% of the available second year and older stems are browsed.	4

C. Physicochemical Metrics

1. Soil Surface Integrity: An indirect measure of soil condition based on stressors that increase the potential for erosion or sedimentation, assessed by evaluating intensity of human dominated land uses on the site.

Metric Measurement Protocol: Use the narrative descriptions provided to describe the soil surface integrity of the AA.

Soil Surface Integrity within the AA		
Select the statement that describes the soil surface integrity within the AA.	Soil disturbance is limited to naturally caused disturbances such as flood deposition or game trails.	1
	Soil disturbance due to human causes (including livestock) is present but minimal. Depth of disturbance is limited to a few inches and does not show evidence of ponding or channeling water. Site will recover within a few years after disturbance removal.	2
	Soil disturbance due to human causes is common and will be slow to recover. Damage is not excessive and the site will recover with the removal of degrading human influences and moderate recovery times.	3
	Soil disturbance is widespread and substantially degrades the site. Water, if present, would be channeled or ponded. The site will not recover without restoration and/or long recovery times.	4

2. Water Quality: An assessment of water quality based on visual evidence of water clarity and eutrophic species abundance.

Metric Measurement Protocol: Use the narrative descriptions provided to describe the water quality of the AA.

Water Quality: ***Select the statements that best describe the following water quality indicators within the AA.***		
Algae	No water present in AA at time of visit.	**N/A**
	No visual evidence of degraded water quality. No potential source of water quality degradation observed. Water is clear with minimal algae growth.	**1**
	Some negative water quality indicators are present and/or some potential sources of water quality degradation observed. Algae are limited to small and localized areas within the wetland. Water may have a minimal greenish tint, cloudiness, or sheen.	**2**
	Algal growth occurs in large patches throughout the AA. Potential sources of water quality degradation are apparent. Water may have a moderate greenish tint or sheen.	**3**
	Algal mats may be extensive, blocking light to the bottom. Potential sources of water quality degradation are apparent. Water has strong greenish tint, sheen, or turbidity. The bottom is difficult to see during the growing season.	**4**
Turbidity	No water present in AA at time of visit.	**N/A**
	No visual evidence of degraded water quality. No potential source of water quality degradation observed.	**1**
	Water is slightly cloudy and/or some potential sources of water quality degradation observed, but there is no obvious source of sedimentation	**2**
	Water is cloudy, but the bottom is still visible. Potential sources of water quality degradation are apparent.	**3**
	Water is milky and/or muddy. The bottom is no longer visible. Potential sources of water quality degradation are apparent.	**4**
Sheen (petroleum-based) ***Note:* Sheens can be caused by bacteria. When disturbed, a bacterial sheen will break up into small platelets; petroleum sheens will quickly reform.**	No water present in AA at time of visit.	**N/A**
	No visual evidence of degraded water quality. No potential source of water quality degradation observed. Water is clear with no sheen.	**1**
	Some negative water quality indicators are present and/or some potential sources of water quality degradation observed. Sheen on the water is limited to small and localized areas within the AA.	**2**
	Sheen occurs in large patches throughout the surface water of the AA. Potential sources of water quality degradation are apparent. Water may have a moderate sheen.	**3**
	Sheen is extensive throughout the surface of the water in the AA. Potential sources of water quality degradation are apparent. Water has a strong sheen.	**4**

D. Hydrology

1. Water Inputs into the AA: Water inputs encompass the forms or places of direct inputs of water into the AA. Inputs of water affecting conditions during the growing season are especially important because these strongly influence the structure and composition of wetland plant and animal communities. The water inputs metric focuses on conditions affecting growing season hydrology.

Natural water sources include precipitation, ground water discharge, and flooding of the AA due to naturally high flows, seasonal runoff, etc. Examples of unnatural sources include storm drains that empty directly into the AA or into an immediately adjacent area. For seeps and springs that occur at the toe of an earthen dam, the reservoir behind the dam is an unnatural water source. Large reservoirs and lakes that do not drain directly into the AA should not be considered water sources, although they can have systemic, ubiquitous effects on the condition of the AA. Engineered hydrological controls, such as pumps, weirs, flashboards, grade control structures, check dams, etc., are not considered water sources.

Metric Measurement Protocol:
The assessment of this metric is the same for all wetland systems. For all wetlands, including fringe habitat, this metric focuses on *direct* inputs of water as defined above. The natural sources will tend to be more obvious than the unnatural sources. Evaluation of this metric should therefore emphasize the identification of the unnatural sources or diversions that directly affect the dry season conditions of the AA.

Use the narrative descriptions provided to describe the water inputs into the AA.

Metrics for Water Inputs into the AA.

Water Inputs into the AA		
Select the statement that best describes the water sources into the AA during the growing season.	Sources are precipitation, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the growing season.	**1**
	Sources are mostly natural but can include occasional or small effects of modified hydrology. No large point sources or dams control the overall hydrology.	**2**
	Sources are primarily from anthropogenic sources (e.g., urban runoff, pumped water, impoundments, regulated releases through a dam).	**3**
	Natural sources have been eliminated based on the following indicators: impoundment of all possible wet season inflows, diversions of all dry-season inflows, predominance of xeric vegetation, etc.	**4**

Identify all ***major*** water sources/inflow feeding the AA during the growing season in the table provided on the form. Rank the top sources (up to three) as 1, 2, 3. Mark all others present as 4 and those not present as NA. For discrete inlets (stream channels, springs, ditches, etc.), count the number of each within the AA and a 200 m envelope of the AA. Enter NA for those not present. Mark all inlets on the aerial photo and those within the AA on the site sketch. If there is an indication that inflow during the growing season is controlled by artificial water sources, please explain in comments.

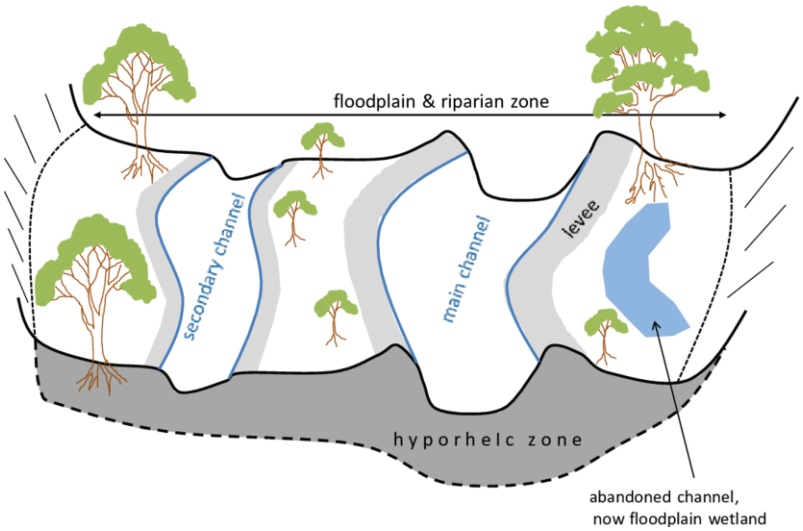
Identify the major sources of inflow to the wetland, using the definitions provided below and count the number of discrete inlets entering the wetland, both natural and manmade.

Water Inputs into the AA				
Select the statement that best describes the water sources into the AA during the growing season.	Sources are precipitation, groundwater, and/or natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the growing season.			**1**
	Sources are mostly natural but can include occasional or small effects of modified hydrology. No large point sources or dams control the overall hydrology.			**2**
	Sources are primarily from anthropogenic sources (e.g., urban runoff, pumped water, impoundments, regulated releases through a dam).			**3**
	Natural sources have been eliminated based on the following indicators: impoundment of all possible wet season inflows, diversions of all dry-season inflows, predominance of xeric vegetation, etc.			**4**
Rank major water sources observed in the AA, or observed to potentially impact the AA, starting with 1 being the most dominant through 3. Mark all others present with a 4 and those not present as NA.	**Natural Sources/Inflow**	**Rank**	**Discrete Inlets**	**Count**
	Overbank flooding		Channels	
	Alluvial storage/hyporheic flow		Spring	
	Throughflow (if yes, rank in Outputs)		Ditches	
	Non-channelized flow from contiguous wetland area		Culvert	
	Groundwater discharge		Pipes	
	Precipitation (ONLY if major hydrologic driver)		Pumps	
	Snowmelt (ONLY if major hydrologic driver)		Other/Comments:	
	Anthropogenic Sources/Inflow	**Rank**		
	Irrigation run-off/ditches			
	Urban run-off			
	Pipes directly feeding into wetland			
	Culvert			
	Pumps			
	Other:			

Definitions of Hydrologic Inflows and Outflows:

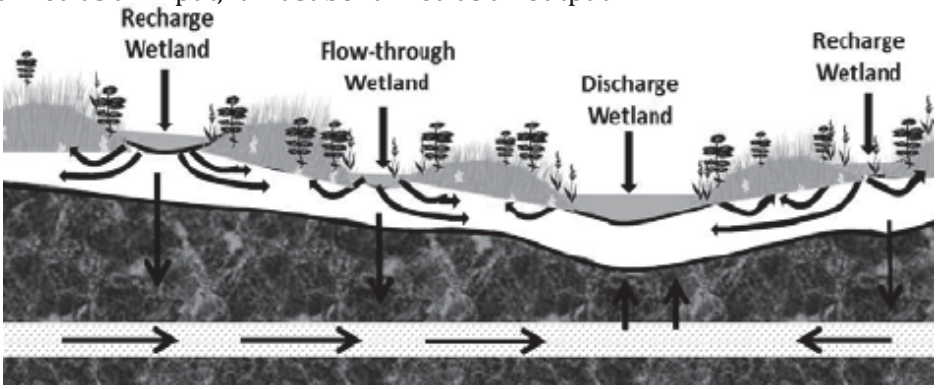
1. Overbank flooding -- overbank flooding occurs when the amount of water flowing in a channel exceeds the carrying capacity of that channel. Water spills over the top of the streambank and flows into the floodplain, carrying with it large amounts of sediments (rocks, gravels, sands, and silts) as well as organic matter (trees, branches, leaves, and sometimes fish and invertebrates). This happens during spring thaws when snowmelt occurs rapidly or it may happen after a large rainstorm.

2. Alluvial storage/hyporheic flow -- groundwater associated with loose floodplain substrates of streams and rivers. A wetland influenced by hyporheic inflows/outflows will lie in close proximity to a stream or river, likely in a large floodplain.



https://www.researchgate.net/figure/A-schematic-illustration-of-a-river-corridor-showing-the-lateral-extent-of-the fig29 312577782

3. Throughflow -- throughflow occurs when a wetland both receives and discharges surface water or groundwater. These wetlands receive water and pass it through to another wetland, stream, or waterbody at a lower elevation. Examples include some prairie potholes & slope wetlands. If throughflow is ranked as an input, it must be ranked as an output.



https://www.researchgate.net/figure/Diagram-showing-groundwater-flow-systems-associated-with-prairie-wetlands-Arrows fig4 281445419

4. Non-channelized flow to/from contiguous wetland -- may also be called overland flow or sheet flow. Surface water runs over the landscape outside of a defined channel, such as after rainfall or during spring thaw. May also occur on slopes where groundwater surfaces but there is not enough flow to cause the formation of a channel to collect water.

5. Groundwater discharge -- water leaves the wetland by seeping into the ground to feed a stream, wetland, or aquifer.

6. Precipitation -- rain is the primary source of water (i.e., prairie potholes). Not to be used unless it is one of the top 3 hydrologic sources to the wetland.

7. Snowmelt -- snow is the primary source of water. This is to be used primarily for wetlands in high elevation areas that receive nearly off of their hydrologic input from snow (i.e, wetlands in a headwall basin), but also includes prairie potholes (Vance, et al 2013).

8. Channelized flow (headwater wetland) -- there is enough surface flow leaving the wetland to form a defined channel to convey water away from the wetland.

9. Recharge to adjacent stream -- for wetlands in a floodplain that lose water via sheet flow or groundwater, not a defined channel, to the adjacent stream.

10. No natural outlet -- many depressional wetlands have no natural outlet for water to leave the wetland. Water leaves either via seepage into the ground (a form of groundwater discharge which may or may not be easily identified) or via evapotranspiration.

2. Water Outputs from the AA: Whether or not water can leave the wetland and where it goes can also influence the structure and composition of wetland plant and animal communities. Identify all major pathways through which water leaves the AA during the growing season in the table provided on the form. Rank the top pathways/outflow (up to three) as 1, 2, 3. Mark all others present as 4 and those not present as NA. For discrete outlets (stream channels, culverts, ditches, etc.), count the number of each within the AA and a 200 m envelope of the AA. Enter 'NA' for those not present. Mark all outlets on the aerial photo and those in the AA on the site sketch. If there is an indication that outflow is modified by anthropogenic disturbance, please explain in comments.

Metric Measurement Protocol:
The assessment of this metric is the same for all wetland systems. For all wetlands, including fringe habitat, this metric focuses on water outlets as defined above. Evaluation of this metric should therefore emphasize the identification of the unnatural outlets that directly affect the dry season conditions of the wetland/AA.

Use the narrative descriptions provided to describe the water outlets of the wetland/AA.

Water Outputs from the AA		
Select the statement that best describes the water outlet of the AA during the growing season.	Water leaves the site through natural runoff, natural flow, evaporation, or outlet is blocked by natural features (e.g., beaver dam), OR the site naturally lacks water in the growing season.	**1**
	Outflow is mostly natural, but there is some modification due to anthropogenic restrictions (e.g., filling or development, channelization).	**2**
	Withdrawals are primarily from anthropogenic sources, and outflow has been significantly altered by flow obstructions (culverts, paved stream crossings, impoundments, ditching).	**3**
	Natural outflow has been completely eliminated due to the following indicators: dike/levees, railroads, or roads with no culverts.	**4**

Identify the major sources of outflow from the wetland, using the definitions provided above and count the number of discrete outlets leaving the wetland, both natural and manmade.

Water Outputs from the AA				
Select the statement that best describes the water outlet of the AA during the growing season.	Water leaves the site through natural runoff, natural flow, evaporation, or outlet is blocked by natural features (e.g., beaver dam), OR the site naturally lacks water in the growing season.			**1**
	Outflow is mostly natural, but there is some modification due to anthropogenic restrictions (e.g., filling or development, channelization).			**2**
	Withdrawals are primarily from anthropogenic sources, and outflow has been significantly altered by flow obstructions (culverts, paved stream crossings, impoundments, ditching).			**3**
	Natural outflow has been completely eliminated due to the following indicators: dike/levees, railroads, or roads with no culverts.			**4**
Rank major water outlets observed in the AA, or observed to potentially impact the AA, starting with 1 being the most dominant through 3. Mark all others present with a 4 and those not present as NA.	**Natural Outflow**	**Rank**	**Discrete Outlets:**	**Count**
	Channelized flow (headwater wetland)		Channels	
	Recharge to adjacent stream		Culvert	
	Throughflow (if yes, rank in Sources/Inflow)		Ditches	
	Non-channelized flow to contiguous wetland area		Pumps	
	No natural outlet		Other/Comments:	
	Anthropogenic Outflow	**Rank**		
	Culverts under roadways / trails			
	Ditches established to drain wetland			
	Natural outlet blocked/bermed			
	Water is being pumped out of wetland			
	Other:			

3. Hydroperiod: An assessment of the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. Depressional, lacustrine, and riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration, and seasonal cycles that are governed by wet season rainfall and runoff. Slope wetlands (fens) that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Metric Measurement Protocol:

This metric evaluates recent changes in the hydroperiod, flow regime, or sediment regime of a wetland and the degree to which these changes affect the structure and composition of the wetland plant community. Common indicators are presented for the different wetland classes. This metric focuses on changes that have occurred in the last 2-3 years.

Depressional, Lacustrine, and Slope Wetlands OR Fens (You must choose one wetland type):
Assessment of the hydroperiod for these kinds of wetlands should be initiated with an office-based

review of diversions or augmentations of flows to the wetland. Field indicators for altered hydroperiod include pumps, spring boxes, ditches, hoses and pipes, encroachment of terrestrial vegetation, excessive exotic vegetation along the perimeter of the wetland, and desiccation during periods of the year when comparable wetlands are typically inundated or saturated. Use the following narrative description below to describe the hydroperiod of the AA:

Select the statement that best describes the hydroperiod of the AA. **CHOOSE ONE** of the following wetland types			
NON-FEN (Depressional, Lacustrine, Slope)		**FEN**	
Hydroperiod of the AA is characterized by natural patterns of filling or inundation and drying or drawdowns.	**1**	Hydroperiod of the AA is characterized by stable, saturated hydrology, or by naturally damped cycles of saturation and partial drying.	**1**
The filling or inundation patterns in the AA are of greater magnitude or duration than would be expected under natural conditions, but thereafter the AA is subject to natural drawdown or drying.	**2**	Hydroperiod of the AA experiences minor altered inflows or drawdown/drying, as compared to more natural wetlands (e.g., ditching).	**2**
Hydroperiod of the AA is characterized by natural patterns of filling or inundation, but thereafter, is subject to more rapid or extreme drawdown or drying, as compared to more natural wetlands. OR the filling or inundation patterns in the AA are of substantially lower magnitude or duration than would be expected under natural conditions, but thereafter, the AA is subject to natural drawdown or drying.	**3**	Hydroperiod of the AA is somewhat altered by greater increased inflow from runoff, or experiences moderate drawdown or drying, as compared to more natural wetlands (e.g., ditching).	**3**
Both the inundation and drawdown of the AA deviate from natural conditions (either increased or decreased in magnitude and/or duration).	**4**	Hydroperiod of the AA is greatly altered by increased inflow from runoff or experiences large drawdown or drying, as compared to more natural wetlands (e.g., ditching).	**4**

4. Surface Water Connectivity: An assessment of the ability of the water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals. You must choose one type of wetland, Depressional - Lacustrine - Slope OR Fen.

Metric Measurement Protocol:
Assessment of this metric is based solely on field indicators and is different by HGM class. Use the narrative below for guidance.

Select the statement that best describes the surface water connectivity of the AA. **CHOOSE ONE** of the following wetland types			
NON-FEN (Depressional, Lacustrine, Slope)		**FEN**	
Water, when present, has unrestricted access into or out of the wetland. There are no artificial obstructions to surface water flow.	**1**	No natural surface water connectivity with surrounding water bodies.	**1**
Artificial obstructions limit the access of surface water into or out of the wetland, but the limitations exist for < 50% of the AA perimeter.	**2**	Partial surface water connectivity with surrounding water bodies exists via artificial means (e.g., ditching or draining to dry the fen).	**2**
Artificial obstructions limit the access of surface water into or out of the wetland for 50–90% of the AA perimeter. Flood flows may exceed the obstructions, but drainage into or out of the AA is probably obstructed.	**3**	Substantial to full surface water connectivity exists via artificial means that has obvious drying effects on the peat body.	**3**
Artificial obstructions limit the access of surface water into or out of the wetland for >90% of the AA perimeter.	**4**		

Section 7. ONSITE and SURROUNDING DISTURBANCES

Definition: Document the scope and impact of disturbances observed ***and*** expected to impact the site both within a 200 m envelope around the AA perimeter and within the AA. Using Table 6 (provided below and on the field form), check each land use/disturbance that occurs and enter the total on the form. Note also the field indicator observed. Estimate the scope and impact of each disturbance using the ratings in the table below (page 16 on the form).

Level 3 Disturbance Evaluation is the column on the far right. It is only to be filled out if an intensive Level 3 protocol is being completed for the site. If only a Level 2 assessment is being completed, this column will remain blank.

Table 3. Scope and Impact Ratings

Scope of Disturbances		Impact of Disturbances	
5	Pervasive – Affects nearly all (>75%) of the envelope or AA.	4	Extreme – likely to extremely modify, degrade, destroy, or eliminate the wetland.
4	Large – Affects most (>50-75%) of the envelope or AA.	3	Serious – likely to seriously modify, degrade or reduce wetland function or condition.
3	Moderate – Affects much (>25-50%) of the envelope or AA.	2	Moderate – likely to moderately modify, degrade or reduce wetland function or condition.
2	Restricted – Affects some (>10-25%) of the envelope or AA.	1	Slight – likely to only slightly modify, degrade, or reduce wetland function or condition.
1	Small – Affects a small (>1-10%) portion of the envelope or AA.	**NOTE:** There is no 0 score for Impact. If you record a score for Scope you must record a score for Impact (i.e., a 0 Scope would get an Impact score of 1 at a minimum, though it could be higher).	
0	Nil – Affects little to none (≤1%) of the envelope or AA.		

Note: In filling out the Onsite and Surrounding Disturbances Table if a disturbance is not present, DO NOT fill in the table with zeros. Zero (O) is an indicator of a very minor presence of disturbance. If a O is recorded in the table, it MUST be accompanied by an Impact score.

Onsite and Surrounding Disturbances—Indicate Scope and Impact of disturbances (see tables p. 16).

Disturbances Observed *and* Expected to Impact the Site	Scope		Impact		Field Indicator Observed	LEVEL 3 EVALUATION ONLY
	200 m	AA	200 m	AA		
Only record a Scope/Impact rating if a disturbance is present. If there is no disturbance, leave the field blank.						
Transportation Disturbances						**Total length (m) within 200m buffer**
Paved surfaces (e.g., roads, parking lots)						
Unpaved roads						
Railroads						
Land Use Disturbances-Development or Recreation						**% 200m buffer affected**
Domestic or commercial development						
Intensively managed sports fields, golf courses						
Recreation or human visitation						
Filling or dumping of sediment or fill						
Trash or refuse dumping						
Land Use Disturbances-Agriculture						**% 200m buffer affected**
Dryland farming (e.g., wheat, barley, etc.)						
Open range livestock grazing						
Horse paddock or private barnyard						
Feedlot operation						
Irrigated cropland						
Irrigated hay pasture						
Irrigation ditches affecting wetland						
Permanent tree plantation						
Cropland treated with pesticides						
Disturbed fallow lands dominated by exotic species						
Haying of native grassland						
Fallow fields (no human use in past 10 years)						
Fields with recent plowing or discing						
Shelterbelts						
Fences (score for potential to impede wildlife movement/migration)						
Land Use Disturbances-Resource Extraction						**% 200m buffer affected**
Gravel pits, open pit mining						
Small scale mining activity or abandoned mines						
Abandoned oil/gas wells						
Oil/gas pump jacks (active)						
Injection wells, tank batteries, collection facilities, or other oil/gas-associated infrastructure						
Intensive logging (50-75% trees of >50 cm diameter removed)						
Selective logging (<50% of trees >50 cm diameter removed)						

Site ID_____

Disturbances Observed *and* Expected to Impact the Site	Scope		Impact		Field Indicator Observed	LEVEL 3 EVALUATION ONLY
	200 m	AA	200 m	AA		
Land Use Disturbances-Vegetation Removal/Conversion						**% 200m buffer affected**
Chemical vegetation control						
Evidence of intentional burning						
Mechanical vegetation removal						
Vegetation conversion (e.g., from shrubland to grassland)						
Natural or Environmental Disturbances						**% 200m buffer affected**
Beetle-killed *Pinus* species						
Other diseased conifers						
Evidence of recent fire (<5 years)						
Beaver activity						
Evidence of prolonged drought						
Browsing of woody vegetation by native ungulates						
Hydrologic Disturbances						**% 200m buffer affected**
Upstream spring box						
Impoundment of flowing water						
Potential for agricultural runoff						
Potential for urban runoff						
Culvert						
Upstream dam						
Reservoir/stock pond						
Weir or drop structure						
Dredged inlet/outlet channel						
Engineered channel (e.g., riprap)						
Pumps, diversions, or ditches that move water *into* wetland						
Pumps, diversions, or ditches that move water *out of* wetland						
Berms/Dikes/Levees						

For more detailed information about the impact of different types of fencing on wildlife, see Table 4.

Table 4. Impact of different fence types on wildlife. Deer, elk, moose, bighorn sheep, and pronghorn (in extreme cases) are all capable of jumping many fences, but smooth or barbed wire can snag animals and tangle legs. All ungulates jump with their hind legs pointing forward. If the top strands are too high, too close together, or are loose, they will often get hung up and sometimes are unable to pull free. Pronghorn nearly always look for a place to crawl under the fence, rarely jumping (Hanophy 2009, Paige 2012).

Generally from Most to Least Wildlife Friendly	Comments
Plastic mesh (e.g., snow fence)	If loose, easily entangled in antlers
3 strand wire	Ungulates can be ensnared while jumping or crawling under. If in open area, can impact grouse, hawks & owls swooping on prey. If across water, can impact ducks, geese, swans, & cranes.
4 strand wire	Ungulates can be ensnared while jumping or crawling under. If in open area, can impact grouse, hawks & owls swooping on prey. If across water, can impact ducks, geese, swans, & cranes.
Zig-zag/Worm fence	Often too low and with rails too close together for animals to cross or crawl through. Adults can usually jump over.
Post and rail (wooden, 1 dimensional)	Often too high, too many rails (4 or more), and with rails too close together for animals to cross or crawl through.
Jackleg/Buck and rail (wooden, 3 dimensional "triangle")	Often too high, too wide, and with rails or wires too close together for animals to negotiate easily. Very hard to leap over due to wide bases.
Woven wire	Barrier to fawns/calves
Woven wire + wire top strand	Barrier to animals incapable or unwilling to jump or are too large to slip through, including bears. Is the most lethal to wildlife; ungulate's legs are easily snared and tangled between the barbed-wire and rigid woven-wire.
Jackleg (wooden, 3 dimensional "triangle") + Adjacent woven wire OR Barbed wire OR On steep terrain	Nearly complete barrier to ungulates & other large animals.

Fences that cause problems are:	More wildlife friendly fences have:
Too high to jump	Smooth top and/or bottom wire
Too low to crawl under	High-visibility wire, flagging, PVC, a round top rail, or other visual markers for the top wire
Have loose wires	Flagging, PVC, reflective tape, or other visual markers throughout the fence, especially in open landscapes and over water (birds)
Have wires spaced too closely together	Open gates, sections, or holes in the fence to allow wildlife passage
Difficult for running animals or birds to see	Occasional raised sections of the lowest wire strand (≥18") or gullies/swales that provide a gap below the fence
On steep terrain (as slope increases, the distance an animal must jump increases)	Occasional dropped rails, lower sections of wire fencing (≤40"), or jump out ramps
Can impale or snag a leaping animal	Lack vertical "stays" connecting the strands of wire in between each set of posts
Create a 3-dimensional obstacle	High tensile wire that can be ratched to be tight
Create a complete barrier	Fewer posts and fewer strands/rails

Other Findings:

On average, one ungulate per year was found tangled for every 2.5 miles of fence.
On average, one ungulate was found dead next to, but not in, every 1.2 miles of fence; most were next to woven-wire. Most animals (69% of juveniles and 77% of adults) died by getting caught in the top two wires. Juveniles are eight times more likely to die in fences than adults.
Mortalities peaked during August, when fawns are weaned.
90% of carcasses found near fences were fawns separated from their mothers and unable to cross. 70% of all mortalities were on fences higher than 40".
Fence markers can reduce sage-grouse collisions with wire fences by 70% to >80%.

Section 8. SOIL PROFILE DESCRIPTIONS

A. Placement of the Soil Pit: Dig two soil pits within the AA. Make every attempt to place each soil pit in a different area of zonation. This will likely be evident from differences in vegetation. Whenever possible, place the soil pits in or near the vegetation plot.

1. **General soil pit information:**
   a. Record the Soil Pit #(1 or 2), circle whether the soil pit is located in a Level 2 Plant Zone or in a Level 3 Vegetation Module, and record either the Plant Zone # or the Veg Module #.
   b. Record the soil pit GPS coordinates and their accuracy.
   c. If standing surface water is present, record the depth of standing surface water. If no water is present, record NP (not present).
   d. Describe each soil layer and determine the soil texture.
   e. After digging the soil pit and removing the soil profile, record the depth to saturation in the pit. If no saturation is present, record NP (not present). Record the depth to free water in the pit. If there is no free water in the pit, record NP.
2. **Digging the soil pit:**
   a. Use the auger to dig a hole to a depth of 80 centimeters if possible; remove the soil and auger and carefully lay the soil on the ground. Slice open the entire soil core lengthwise to split the core into 2 long, parallel halves. This will expose the soil from the inside of the sample to ensure a clean sample is used.
   b. Changes in soil texture or soil matrix color are indicators of distinct soil layers. Insert golf tees at the intersections between each different soil layer. Lay a measuring tape along the side of the entire soil profile, with 0 cm at the top of the soil profile at what was once the surface of the soil pit.

      If an impenetrable layer is encountered at a depth of < 80 cm (e.g., bedrock, large rock, cemented layer, log, etc.), excavate the pit as deeply as possible, describe soils as the depth of the pit allows, and note the occurrence and depth to bedrock or the cemented layer (i.e., depth of refusal).
3. **Distinguishing among different soil layers**:
   For each soil layer, record the depth, texture, matrix color and hydric soil indicators on the field form that apply, as well as any % fibers, modifiers or redoximorphic features present. See Appendix I for Soil Profile Description Procedures.
   For each distinct soil layer, record the following:
   a. Soil Layer: Record the layer (e.g., 1, 2, etc.).
   b. Depth to the lower boundary of the layer in centimeters.
   c. Soil Texture for Mineral Soils (refer to Appendix I)
   d. Soil Texture Modifier (if appropriate, for mineral soils ONLY)
   e. Organic Layer: If an organic layer is present, indicate what type of organic material it is (definitions from NRCS (2017)):
      i. Peat (P): fibric organic soil material in which plant forms can be identified in virtually all of the organic material (>40% visible fibers after rubbing)
      ii. Muck (M): sapric organic soil material in which nearly all of the organic material is so decomposed that identification of plant forms is not possible (<20% visible fibers).
      iii. Mucky Peat (MP): hemic organic material, which is characterized by decomposition that is intermediate between that of fibric material and that of sapric material (20-40% visible fibers).
   f. Percent visible plant fibers, if applicable. This is for organic soils only.
   g. Soil Matrix Color: This is the Hue/Value/Chroma for the soil matrix that matches most closely from the Munsell Soil Color Chart. If soils are dry, slowly wet the sample until it no longer changes color. Always have the sun at your back when comparing the soil to the color chart to find the best match.

h. Redox Concentration Features: Redox concentrations are the result of iron and manganese oxidation as groundwater levels fluctuate throughout the growing season. These concentrations are orange/reddish-brown (because of iron) and dark reddish-brown/black (because of manganese).
   Redox concentrations can occur as:
   - nodules or concretions-firm irregularly shaped bodies with diffuse boundaries
   - masses-other bodies occurring throughout the matrix (also known as mottles)
   - pore linings-redox concentrations along root channels as a result of oxygen diffusion from the roots of plants into the surrounding soil matrix reacting with iron in the soil (also known as oxidized rhizospheres).

   i. Redox Concentration Abundance (%): Estimate the percentage of redox concentrations in each soil layer.
   ii. Hue/Value/Chroma of Redox Concentrations

i. Redox Depletions: Redox depletions occur when soils are flooded and iron and manganese are reduced to their soluble forms. These soluble forms of iron and manganese can be leached out of the soil, leaving the natural color (gray or black) of the parent sand, silt, or clay (i.e., the matrix) behind.
   i. Redox Depletion Abundance (%): Estimate the percentage of redox depletions in each soil layer.
   ii. Hue/Value/Chroma of Redox Depletions

j. Hydric Soil Indicators Observed: Check all that apply using the Hydric Soil Indicators checklist. If the Hydric Soil Indicator is not listed, write in the indicator that best describes the soil profile (See Hydric Soil Indicators of Montana, Appendix E).

Commonly Observed Hydric Soil Indicators (check all that apply):	
	A1. Histosol (≥40 cm of upper 80 cm is organic soil, i.e., P, MP, or M)
	A2. Histic Epipedon (Top layer is ≥20 cm of organic soil over mineral layer)
	A4. Sulfidic (rotten eggs) odor
	Gleyed or Low Chroma Colors
	Other:

k. Soil Profile Photos: Take photos of the entire soil core, complete with golf tees, measuring tape, and photo board with Site ID#, date, and Soil Pit #. Take additional photos of soil layers &/or features as appropriate.
l. Remarks: make any remarks or clarifications on the field form.
m. Depth to saturation/Depth to standing water: Allow approximately 30 minutes for equilibration of the soil pit. Measure the depth to standing water in the pit or to where water is seeping from the soil onto pit walls. If the pit contains standing water, measure the depth to the water surface and record on the form. If no standing water is present, record "NP" (not present) on the form. If soils at the margins of the pit are saturated with water, record the depth to the saturated layer. Saturation is indicated by a sheen or glistening of the soil. At or below the depth of soil saturation, water may also be oozing from the soil into the pit. Identify that it is not free water, but that the soil is saturated. Record "NP" if there is no saturation in the pit.
n. Backfill the excavation: Return the soil to the pit. Clean the Munsell Book using the provided toothbrush and bandana.

Section 9. ADJACENT UPLAND VEGETATION CHARACTERIZATION

Use the aerial photo of the AA to determine if upland vegetation occurs within 200 meters of the AA perimeter. If the AA is surrounded by wetland vegetation within 200 meters of the AA perimeter, then mark the bubble for NO UPLAND VEGETATION WITHIN 200 M OF THE AA for each quadrat on the field form. If upland vegetation does occur within 200 meters of the AA perimeter, then walk in each of the four cardinal directions until you enter upland vegetation. Once you enter upland vegetation, place a 1-m2 quadrat on the ground and record the stratum, height, and cover of all dominant species. Record ALL NON-NATIVE plant species observed in the quadrat, regardless of dominance.

Section 10. VEGETATION MEASUREMENTS for INTENSIVE WETLAND ASSESSMENT

Intensive assessments involve the collection of plant species cover and composition data. The vegetation plot is adapted from the flexible-plot method developed by Peet et al. (1998). The entire plot measures 20 m x 50 m (1,000 m2 = 0.1 ha). The plot is comprised of ten 10 m x 10 m modules (100 m2 = 0.01 ha). In general, an AA area consisting of a 0.5 ha circular plot will hold a standard vegetation plot, consisting of a two by five array of ten 10 m x 10 m modules (Figure 2). Vegetation is measured in four intensive modules.

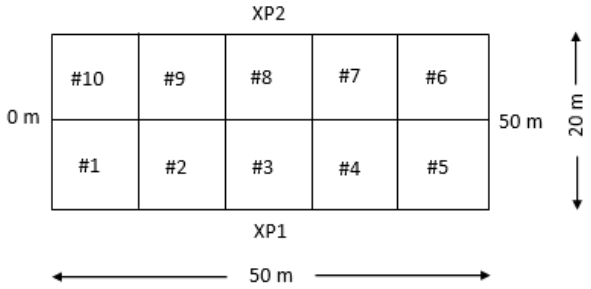


Figure 2. Schematic of the 20 m x 50 m vegetation plot with a two by five array of ten 10 m x 10 m modules.

The location and layout of the vegetation plot within the AA is based on the AA size and site characteristics. In most AAs, a single standard vegetation plot will be used to assess the vegetation of the AA. For situations where AAs are not 0.5 hectare circular plots, alternate plot configurations may be required, such as changing the shape of the plot array. Vegetation plots should be placed within the AA to maximize abiotic/biotic heterogeneity within the AA. Capturing heterogeneity of the AA ensures adequate representation of vegetation patterns and local variations in environment such as directional gradients, microtopography, natural disturbances such as flooding, and anthropogenic disturbances such as grazing. The following guidelines should be used to determine plot locations within the AA:

1. The plot should be located in a representative area of the AA that incorporates as much microtopographic variation as possible.
2. If the AA is homogeneous and there is no obvious direction or orientation for vegetation plot placement, then the plot should be centered within the AA and laid out either N to S or E to W. Use the second hand on a watch to determine the direction randomly (e.g., 00-29 seconds = N to S orientation; 30-59 seconds = E to W orientation).
3. If the AA is not homogeneous, is oddly shaped, or is directional (i.e., follows a stream), then the plot should be oriented to adequately represent the wetland features. In the case of a riverine wetland, the plot may be placed along the stream bank or cut across the stream.
4. If the wetland is an irregularly shaped polygon and the 20 m x 50 m plot does not fit within the AA, the 2 x 5 array of modules can be restructured to accommodate the shape of the AA. For example, a 1 x 5 array of 100 m^2 modules can be used for narrow, linear areas and a 2 x 2 array of 100 m^2 modules can be used for small, circular sites.

5. The plot should attempt to capture the range of diversity within the AA but should avoid crossing over into upland vegetation. No more than 10% of the plot should include upland vegetation beyond the wetland. NOTE: Modules that include upland should not be sampled as intensive modules.
6. If a small patch of another wetland type is present in the AA, then the plot should be placed so that at least a portion of the patch is in the plot.

The symbols depicted in the legend below are used in all of the plot placement diagrams (Figure 3). Detailed examples of how to place the vegetation plot based on the above rules are provided in Figures 4 through 9 to aid in decision making. These diagrams show examples of how to locate standard or alternate plots within different kinds of AAs. Note: ALTERNATE PLOT CONFIGURATIONS ARE ONLY USED WHEN THE STANDARD PLOT WILL NOT FIT INTO THE AA. All diagrams and accompanying text courtesy of Teresa Magee, US EPA Office of Research and Development, Corvallis, Oregon.

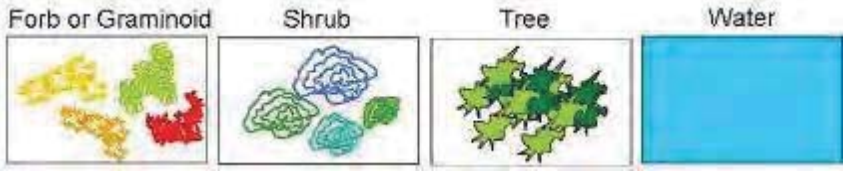


Figure 3. Legend for Figures 4 through 9.

Examples of Vegetation Plot Locations

Standard plot, centered in AA for homogeneous vegetation or mosaic. When the vegetation and abiotic features are homogeneous or distributed in a uniform or random mosaic pattern, a standard plot should be centered in the AA (Figure 4). For example, scrub-shrub, cattail marsh, grass-sedge wetlands, wet prairie, fen, forest communities, etc.

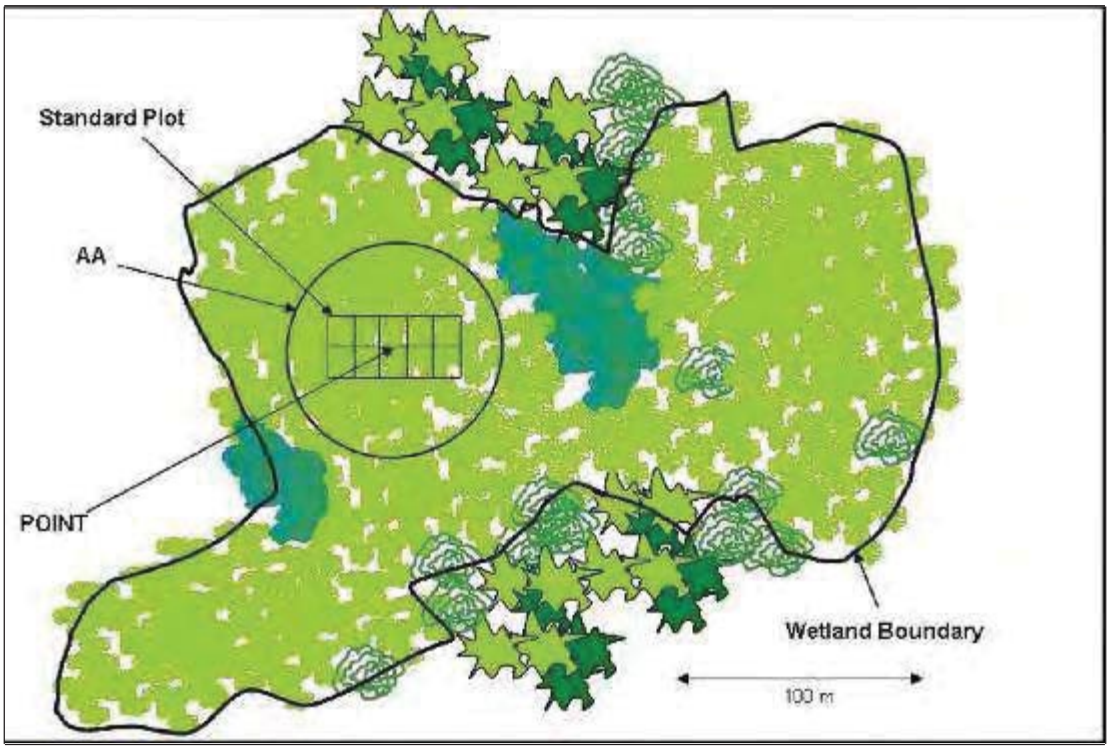


Figure 4. Standard plot centered in AA in homogeneous or mosaic vegetation.

Standard plot, placed within AA to include as many vegetation or community patch types as possible. When the vegetation is organized in distinct patches, lay out the plot so that it proportionally represents patch types for the AA as much as possible (Figure 5). Example situations include patches of scrub-shrub or trees in emergent wetlands, a variety of distinct emergent or shrub plant communities interspersed in the AA, etc.

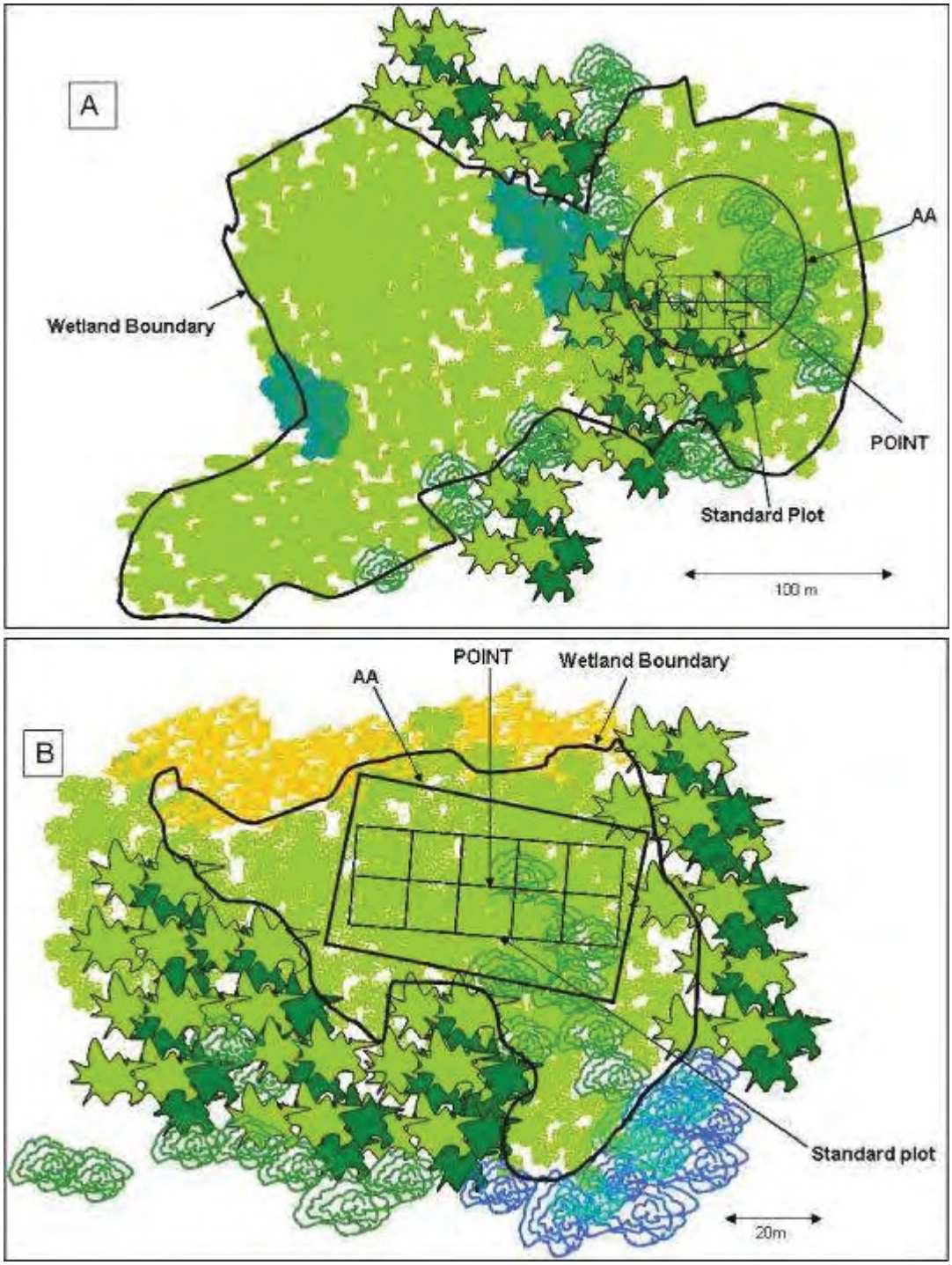


Figure 5. Standard plot placed in AA to include multiple vegetation or community patches. A = Circular AA, B= Rectangular AA.

Standard plot, placed within AA so long axis parallels primary environmental gradient or is perpendicular to vegetation zonation. If the AA occurs along an environmental gradient, like a lake shore or the zones of a marsh, lay out the standard vegetation plot so the long axis follows the gradient and cuts across multiple vegetation zones. In the examples below, the vegetation plot is laid out so the long axis captures the gradient from close to the lake edge to farther from the lake edge (Figure 6) or from high marsh to low marsh (Figure 7).

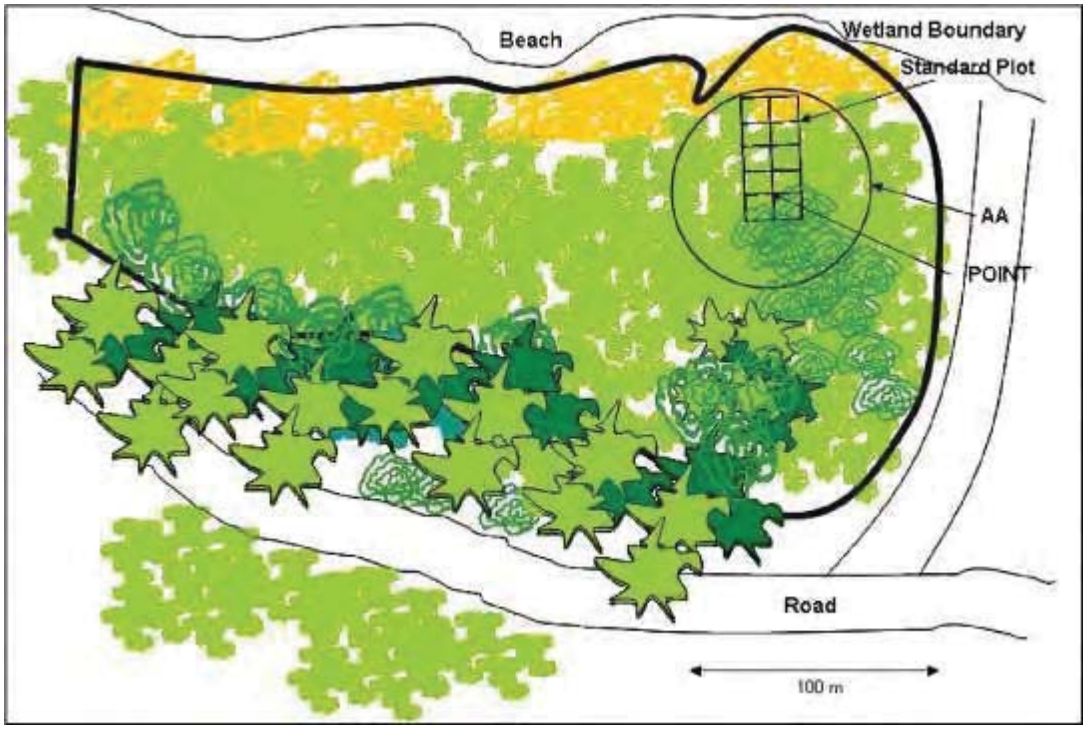


Figure 6. Standard plot placed in AA so long axis of plot parallels primary environmental gradient.

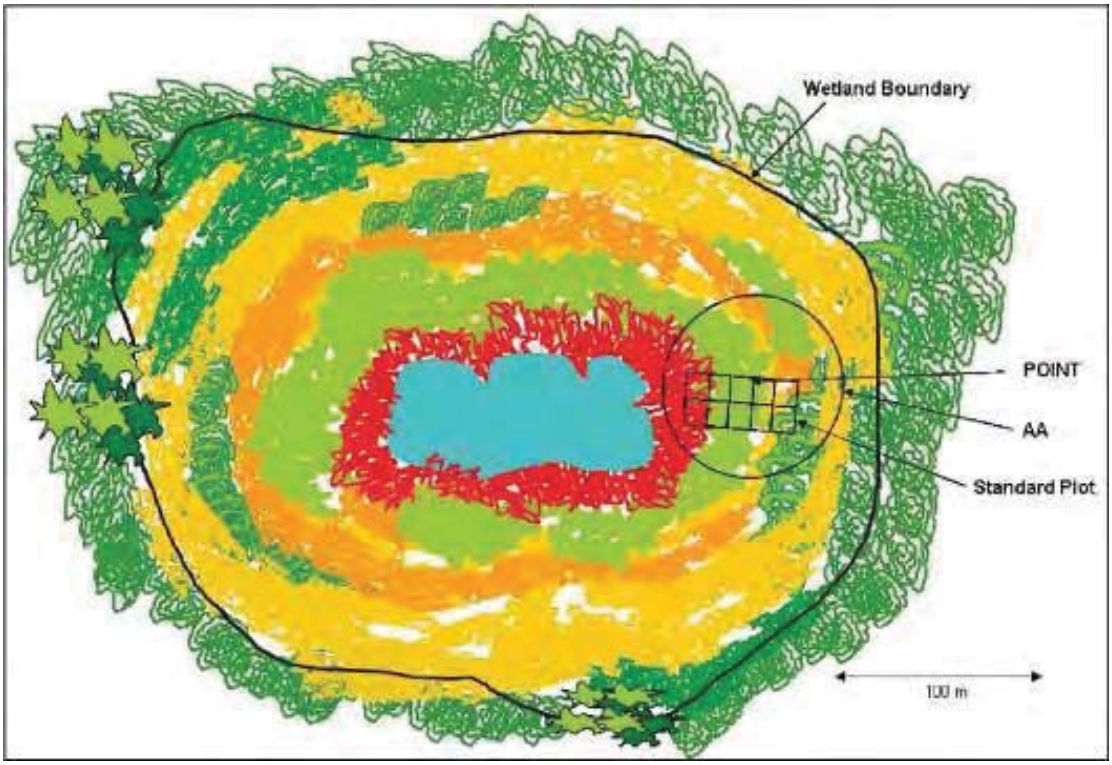


Figure 7. Standard plot placed in AA with long axis of plot perpendicular to vegetation zonation.

Placement of an alternate plot within the AA. If the AA has an irregular shape (e.g., long narrow riparian strip, lake edge, wetland smaller than 0.1 ha) that is incompatible with the standard plot configuration, an alternate plot configuration must be selected. For example, modules may be placed individually or in groupings other than the 2 x 5 array of the standard plot. Modules may be disarticulate to fit in a free-form shaped AA (Figure 8) or arranged as one long row in a narrow riparian area (Figure 9). To facilitate comparisons among AAs, the number of modules making up a standard plot or any alternate plot configuration should, normally, be the same (four 100-m^2 intensive modules and ten modules in total) so that equal levels of sample effort are maintained across AAs.

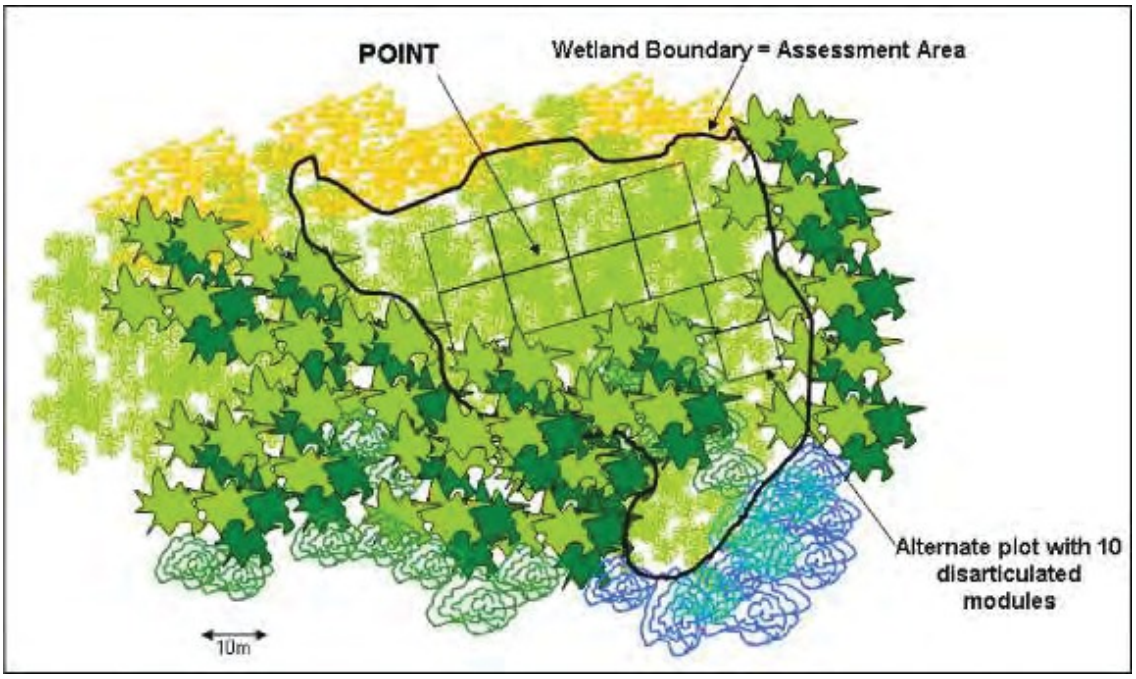


Figure 8. Alternate plot placed in AA that is the boundary of wetland < 0.1 ha. The alternate plot configuration is defined by arranging as many 100-m^2 modules as will fit into the shape of AA.

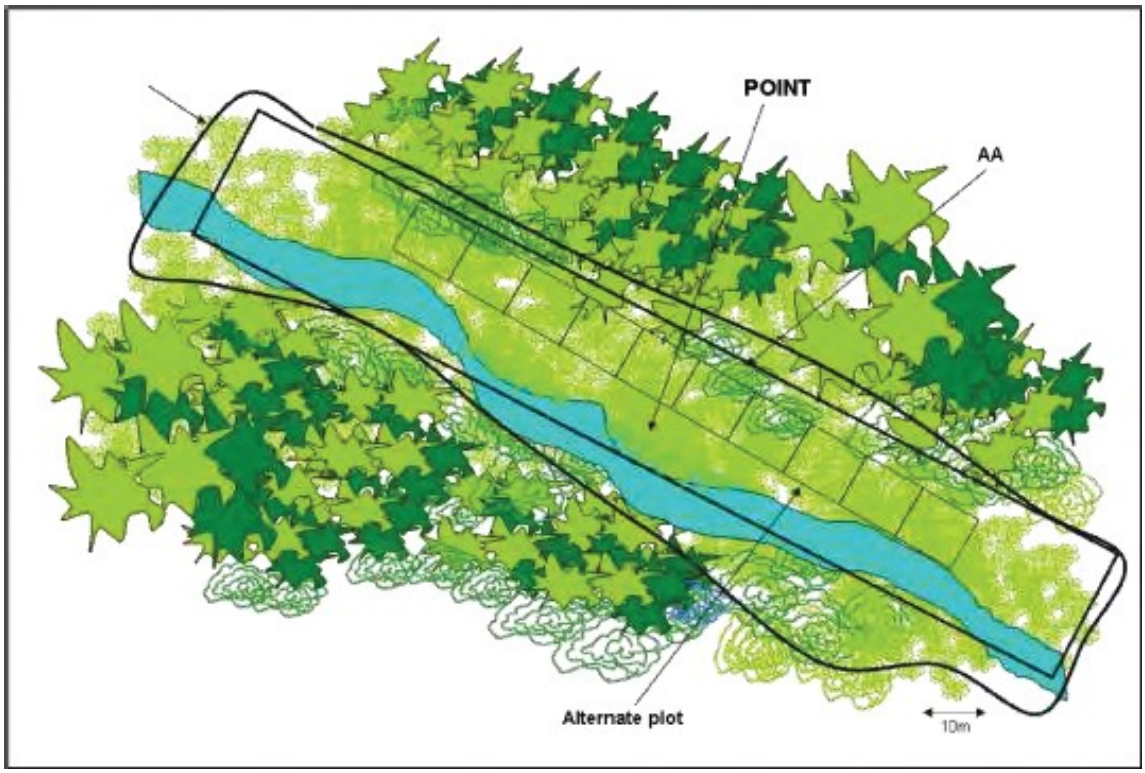


Figure 9. Alternate Plot placed in rectangular AA in a narrow riparian wetland.

1. Establishing and Documenting the Vegetation Plot

a. Vegetation Plot Set Up: Pull a tape out 50 meters and use a flagged pin to stake the tape. The tape functions as the centerline for the vegetation plot. If necessary, flag the centerline at 10 m intervals, so that the centerline is visible throughout data collection.

b. Using ropes or multiple 10-m tapes, lay out your first 10 x 10 meter modules. Starting at one end of the 50-m tape, one crew member holds the end of the 10-m rope on the center line while the other walks out perpendicular to the center line. Once at 10 meters, the second crew member will place a pin flag or use flagging tape to mark the corner of the plot. Repeat this at 10-m intervals alongthe center line, flagging the corners of each 10 x 10 meter module. After one side of the vegetation plot is established, the crew will walk back to the beginning of the 50-m tape and repeat the previous steps on the opposite side of the center line.

c. GPS Waypoints: Collect a GPS waypoint at both the 0 m (plot origin) and the 50-m end point to capture the location of the beginning and the end of the plot. Alternate module arrays may result in the plot being broken up into multiple parts or clumps of modules, in which case, collect a GPS waypoint at both ends of the multiple plots. For example, there may be a first plot with 6 modules arranged 2 wide x 3 long, starting at 0m and ending at 30m AND a second plot with 4 modules arranged 2 wide x 2 long, starting at a different 0m location and ending at a different 20m point.

d. Vegetation Plot Photos: Take a photo of the entire vegetation plot from the plot origin (0 m) and from the 50-m end and record the photo number and bearing. Note that the bearings/aspects should be exactly 180° apart. In the case of multiple plots due to alternate module arrays, take photos from both ends of both plots.

e. Selecting Modules for Intensive Vegetation Sampling: If the vegetation is homogenous, intensive modules will be modules 3, 7, 9, and either 1 or 5, giving the broadest spread of modules across the vegetation plot. If the vegetation is heterogeneous, the crew can decide which modules should be sampled to best capture the variability of the vegetation.

f. Intensive Vegetation Module Photos: Take a photo of each intensive vegetation module sampled, standing at the centerline.

g. Vegetation Plot Comments: Circle the location of the intensive modules and note any changes made to the layout of the plot.

h. Plot Representativeness: Discuss the decisions made for plot placement and/or whether the plot is representative of the AA. This often involves discussing the nature of each intensively sampled module and how it represents the AA and even particular plant zones.

i. Flora References used for Vegetation Identification: Standard floras are listed on the form. Mark a '1' next to the primary flora used for vegetation identification and a '2' next to any other secondary flora used to key and identify plants in the field. Write in additional floras used as necessary.

2. Vegetation Plot Ground Cover

Within each of the four intensive vegetation modules, record the following ground cover information:

a. Cover of deep water >20 cm: Using the cover classes provided on the field form, estimate the cover of deep water within the module.

b. Cover of shallow standing water <20 cm: Using the cover classes provided on the field form, estimate the cover of shallow standing water within the module.

c. Depth of deep standing water (cm): Take up to four measurements of deep standing water (in centimeters) and record the average depth.

d. Depth of shallow standing water (cm): Take up to four measurements of shallow standing water depth (in centimeters) and record the average depth.

e. Cover of bare ground: Using the cover classes provided, estimate the cover of bare ground within the module for three separate categories: 1) soil, sand, or sediment; 2) gravel or cobble 2mm-25 cm; and 3) bedrock, rock, or boulders >25 cm in diameter.

f. Cover of litter: Using the cover classes provided on the field form, estimate the cover of litter within the module. Include litter underneath vegetation.

g. Depth of litter: Take up to four measurements of litter depth (in centimeters) and record the average depth. Do NOT include standing dead herbaceous vegetation. Do not compress litter when taking depth measurements.

h. Coarse woody debris: Using the cover classes provided on the field form, estimate the cover of coarse woody debris. Coarse woody debris consists of fallen trees and large branches ≥ 7.6 cm in diameter. Do NOT include standing dead.

i. Fine woody debris: Using the cover classes provided on the field form, estimate the cover of fine woody debris. Fine woody debris consists of small branches and twigs ≤ 7.5 cm in diameter. Do NOT including standing dead.

j. Cover of nonvascular species: Using the cover classes provided on the field form, estimate the cover of nonvascular plant species, including beneath litter and vegetation.

k. Cover of algae: Using the cover classes provided on the field form, estimate the cover of algae.

3. Vegetation Plot Species Measurements

a. Floristic measurements: Record the presence, stratum, and percent canopy cover of all vascular plant species within each of the four intensive modules. Examples of canopy cover percentages can be found in Figure 10. Within each of the four intensive vegetation modules, denote the presence of each species that is encountered in the module with a check (✓) or a one (1) in the "Presence" column. All species will be recorded on the field form by their complete scientific name (e.g., *Carex utriculata*). **For woody species,** identify and estimate the cover of seedlings, saplings, and mature individuals separately, if they occur in different strata. This helps determine the extent of regeneration.

b. Unknown Species: Any **unknown species** will be entered on the field form with a descriptive name. If the genus of the species is known, the descriptive name should include the genus name (e.g., *Carex* sp. or *Aster* sp.). The descriptive name should also include some identifiable characteristics to distinguish multiple unknown species from the same genus (*Carex* sp. elongate black head or *Carex* sp. clustered brown head). If the genus is not known, the descriptive name should include any descriptors necessary (fuzzy round basal leaves or purple tubular corolla). All unknown species will be collected by the field crew when the species is encountered. Give each collected specimen a unique code (U1, U2, etc.) in the Collect # column on the left side of the Vegetation Plot Species Table.
All unknown species should be collected, even if the species appears to be unidentifiable. The crew may find the same species further developed at a later site and can compare the further developed specimen with the earlier voucher. *The only species the crew should not collect are those identified as or suspected to be* ***listed as threatened or endangered under the U.S Endangered Species Act.*** **(Appendix J)*.*** All crew members should be aware of the listed species in Montana and should document occurrences with photographs.

c. Residual Species: After the four intensive modules have been sampled, walk the remaining modules (usually six) and record additional species found in the residual "R" column. Estimate percent cover for each species across the remaining 6 modules.

4. **Plant Specimen Collection: see Appendix K for detailed Plant Collection Protocol.**

5. **Quality Assurance (QA) of Plant Specimens**
   a. Use a random number generator or a random number table to select one species identified from each vegetation module. Do not include Unknown specimens.

   b. Count the first known species listed on the field form for a particular module as number 1.

   c. If a species has been selected as a QA specimen, it cannot be selected as a QA specimen from another vegetation module in the same AA.

   d. After Unknown Species have been identified, 10% of these should be submitted to the botanist for QA.

Section 11. SITE WRAP UP and OTHER CONSIDERATIONS

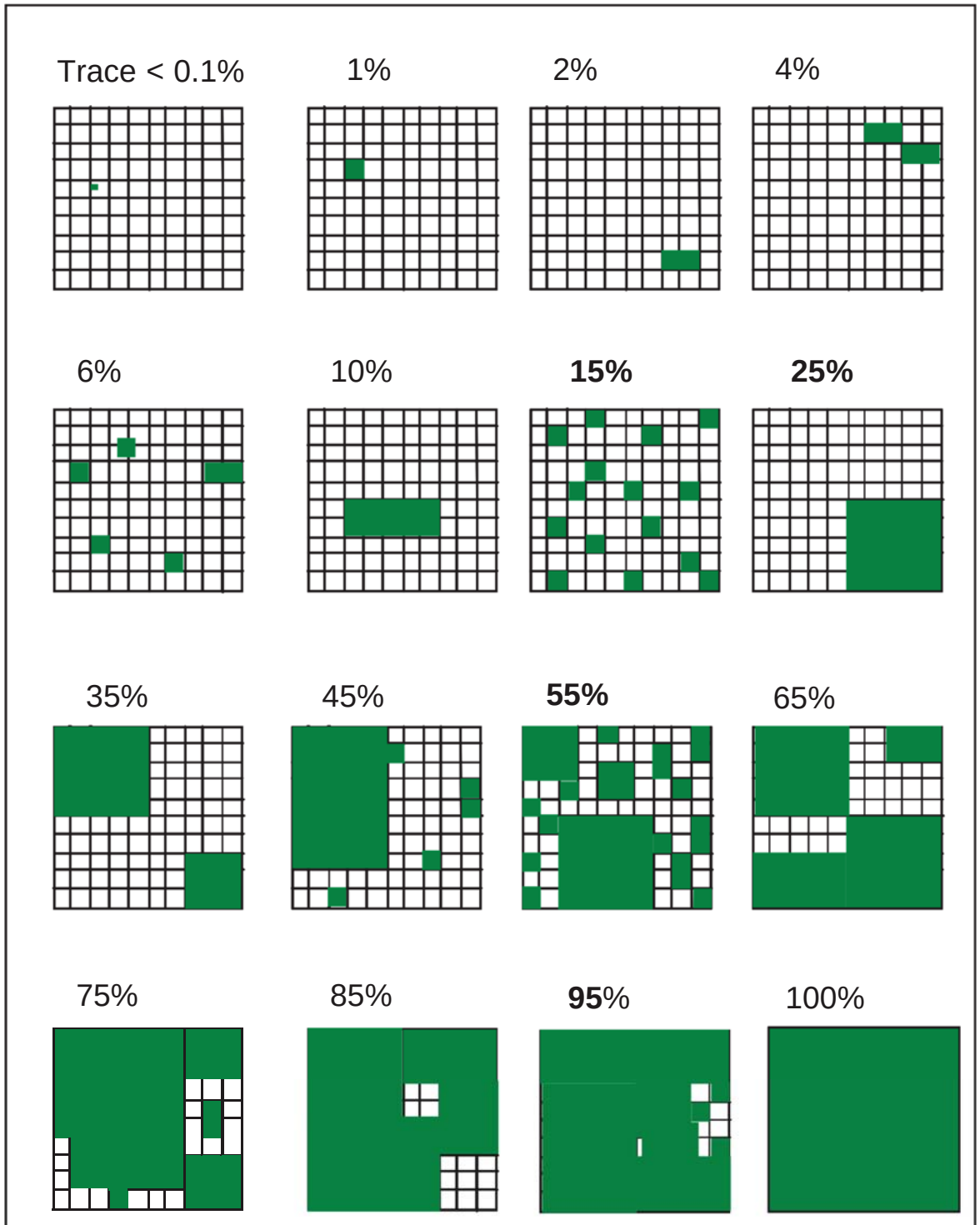
A. Site Clean up

Field personnel will make sure all soil samples are returned to the soil pits, all gear/tools and field guides are accounted for, and all flagging and/or flag pins are removed from the site before leaving.

B. Preventing the spread of invasive species

Field personnel will check clothing, boots, shoes and equipment to ensure that no plant materials, noxious weed seeds or aquatic invasives are transmitted from one assessment location to another. All water will be eliminated from equipment prior to transport. Prior to being used again, everything that has come in contact with water will be cleaned and thoroughly dried and/or sprayed with a bleach solution.

Figure 10. Percent cover estimate chart.



Percent cover estimates for 10m x 10m vegetation modules where each small grid square = 1 square meter (i.e. 1% cover in a module. Shaded areas represent % cover of a vegetation stratum or individual species.

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APPENDICES

Appendix A. Field Key to Wetland and Riparian Ecological Systems of Montana, Omernik Level III Ecoregions, and NatureServe Ecological Divisions

Appendix B. Hydrogeomorphic (HGM) Classification of Wetlands in the Rocky Mountains

Appendix C. Key to the Cowardin Systems and Classes of the Rocky Mountains, Descriptions of Cowardin Water Regimes, & NWI Water Regime Restriction Table

Appendix D. Cowardin and Riparian Classification System Definitions

Appendix E. Keys to Wetland Biophysical Settings in Montana

Appendix F. Coordination of Montana Wetland Biophysical Settings with Classification of Wetland & Deepwater Habitats of the U.S., Cowardin, 2.0

Appendix G. Montana Noxious Weeds List

Appendix H. Montana County Listed Noxious Weeds

Appendix I. Soil Profile Description Procedures

Appendix J: Montana's Threatened or Endangered Plant Species

Appendix K. Plant Collection Protocol

Appendix L. Field Equipment and Trip Preparation Checklist

Appendix M. GPS Instructions

Appendix N. Hanna pH Meter User's Manual

Appendix A: Field Key to Wetland and Riparian Ecological Systems of Montana

(Comer et al. 2OO3, NatureServe 2OO9}

1a. Wetland defined by groundwater inflows and peat (organic soil) accumulation of at least 40 cm (unless underlain by bedrock). Vegetation can be woody or herbaceous. If the wetland occurs within a mosaic of non-peat forming wetland or riparian systems, then the patch must be at least 0.1 hectares (0.25 acres). If the wetland occurs as an isolated patch surrounded by upland, then there is no minimum size criteria .... **Rocky Mountain Subalpine-Montane Fen**

1b. Wetland does not have at least 40 cm of peat (organic soil) accumulation or occupies an area less than 0.1 hectares (0.25 acres) within a mosaic of other non-peat forming wetland or riparian systems **2**

2a. Total woody canopy cover generally 25% or more within the overall wetland/riparian area. Any purely herbaceous patches are less than 0.5 hectares and occur within a mosaic of woody vegetation. Note: Relict woody vegetation such as standing dead trees and shrubs are included here .... **..... GO TO KEY A: Woodland and Shrubland Ecological Systems**

2b. Total woody canopy cover generally less than 25% within the overall wetland/riparian area. Any woody vegetation patches are less than 0.5 hectares and occur within a mosaic of herbaceous wetland vegetation .... **GO TO KEY B: Herbaceous Ecological Systems**

KEY A: Woodland and Shrubland Ecological Systems

1a. Woody wetland associated with any stream channel, including ephemeral, intermittent, or perennial (Riverine HGM Class) **2**

1b. Woody wetland associated with the discharge of groundwater to the surface or fed by snowmelt or precipitation. This system often occurs on slopes, lakeshores, or around ponds. Sites may experience overland flow but no channel formation. (Slope, Flat, Lacustrine, or Depressional HGM Classes)..... **8**

2a. Riparian woodlands and shrublands of the montane or subalpine zone **3**

2b. Riparian woodlands and shrublands of the plains, foothills, or lower montane zone **4**

3a. Montane or subalpine riparian woodlands (canopy dominated by trees), occurring as a narrow streamside forest lining small, confined low- to mid-order streams. Common tree species include *Abies lasiocarpa*, *Picea engelmannii*, *Pseudotsuga menziesii*, and *Populus tremuloides*.....

..... **Rocky Mountain Subalpine-Montane Riparian Woodland**

3b. Montane or subalpine riparian shrublands (canopy dominated by shrubs with sparse tree cover), occurring as either a narrow band of shrubs lining the streambank of steep V-shaped canyons *or* as a wide, extensive shrub stand (sometimes referred to as a shrub carr) on alluvial terraces in low-gradient valley bottoms. Beaver activity is common within the wider occurrences. Species of *Salix*, *Alnus*, or *Betula* are typically dominant .... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

4a. Riparian woodlands and shrublands of the foothills or lower montane zones of the Northern and Middle Rockies and the Wyoming Basin..... **5**

4b. Riparian woodlands and shrublands of the Northwestern or Western Great Plains of eastern Montana **6**

5a. Foothill or lower montane riparian woodlands and shrublands associated with mountain ranges of the Northern Rockies in northwestern Montana. This type *excludes* island mountain ranges east of the Continental Divide in Montana. *Populus balsamifera* ssp. *trichocarpa* is typically the canopy dominant in woodlands. Other common tree species include *Populus tremuloides*, *Betula papyifera*, *Betula occidentalis*, and *Picea glauca*. Shrub understory species include *Cornus sericea*, *Acer glabrum*, *Alnus incana*, *Oplopanax horridus*, and *Symphoricarpos albus*. Areas of riparian shrubland and open wet meadow are common .... **Northern Rocky Mountain Lower Montane Riparian Woodland and Shrubland**

5b. Foothill or lower montane riparian woodlands and shrublands associated with mountain ranges of the Middle Rockies and the Wyoming Basin. This type also includes island mountain ranges in central and eastern Montana. Woodlands are dominated by *Populus* spp. including *Populus angustifolia*, *Populus balsamifera* ssp. *trichocarpa*, *Populus deltoides*, and *Populus fremontii*. Common shrub species include *Salix* spp., *Alnus incana*, *Crataegus* spp., *Cornus sericea*, and *Betula occidentalis*. .... **Rocky Mountain Lower Montane-Foothill Riparian Woodland and Shrubland**

6a. Woodlands and shrublands of draws and ravines associated with permanent or ephemeral streams, steep north-facing slopes, or canyon bottoms that do not experience flooding. Common tree species include *Fraxinus* spp., *Acer negundo*, *Populus tremuloides*, and *Ulmus* spp. Important shrub species include *Crataegus* spp., *Prunus virginiana*, *Rhus* spp., *Rosa woodsii*, *Symphoricarpos occidentalis*, and *Shepherdia argentea*. .... **Western Great Plains Wooded Draw and Ravine**

6b. Woodlands and shrublands of small to large streams and rivers of the Northwestern or Western Great Plains. Overall vegetation is lusher than above and includes more wetland indicator species. Dominant species include *Populus balsamifera* ssp. *trichocarpa*, *Populus deltoides*, and *Salix* spp. **7**

7a. Woodlands and shrublands of riparian areas of medium and small rivers and streams with little or no floodplain development and typically flashy hydrology .....**Northwestern/Western Great Plains Riparian**

7b. Woodlands and shrublands of riparian areas along medium and large rivers with extensive floodplain development and periodic flooding ..... **Northwestern/Western Great Plains Floodplain**

8a. Woody wetland associated with small, shallow ponds in northwestern Montana. Ponds are ringed by trees including *Populus balsamifera* ssp. *trichocarpa*, *Populus tremuloides*, *Betula papyrifera*, *Abies grandis*, *Abies lasiocarpa*, *Picea engelmannii*, *Pinus contorta*, and *Pseudotsuga menziesii*. Typical shrub species include *Cornus sericea*, *Amelanchier alnifolia*, and *Salix* spp..... **Northern Rocky Mountain Wooded Vernal Pool**

8b. Woody wetland associated with the discharge of groundwater to the surface, or sites with overland flow but no channel formation **9**

9a. Coniferous woodlands associated with poorly drained soils that are saturated year round or seasonally flooded. Soils can be woody peat but tend toward mineral. Common tree species include *Thuja plicata*, *Tsuga heterophylla*, and *Picea engelmannii*. Common species of the herbaceous understory include *Mitella* spp., *Calamagrostis* spp., and *Equisetum arvense*..... **Northern Rocky Mountain Conifer Swamp**

9b. Woody wetlands dominated by shrubs. **10**

10a. Subalpine to montane shrubby wetlands that occur around seeps, fens, and isolated springs on slopes away from valley bottoms. This system can also occur within a mosaic of multiple shrub- and herb-dominated communities within snowmelt-fed basins. This example of the system has the same species composition as the riverine example of this system and is dominated by species of *Salix*, *Alnus*, or *Betula*. ..... **Rocky Mountain Subalpine-Montane Riparian Shrubland**

10b. Lower foothills to valley bottom shrublands restricted to temporarily or intermittently flooded drainages or flats and dominated by *Sarcobatus vermiculatus* ..... **Inter-Mountain Basins Greasewood Flat**

KEY B: Herbaceous Wetland Ecological Systems

1a. Herbaceous wetlands of the Northwestern Glaciated Plains, Northwestern Great Plains, or Western Great Plains regions of eastern Montana **2**

1b. Herbaceous wetlands of other regions **5**

2a. Wetland occurs as a complex of depressional wetlands within the glaciated plains of northern Montana. Typical species include *Schoenoplectus* spp. and *Typha latifolia* on wetter, semi-permanently flooded sites, and *Eleocharis* spp., *Pascopyrum smithii*, and *Hordeum jubatum* on drier, temporarily flooded sites.....

....**Great Plains Prairie Pothole**

2b. Wetland does not occur as a complex of depressional wetlands within the glaciated plains of Montana..... **3**

3a. Depressional wetlands in the Western Great Plains with saline soils. Salt encrustations can occur on the surface. Species are typically salt-tolerant such as *Distichlis spicata*, *Puccinellia* spp., *Salicornia* spp., and *Schoenoplectus maritimus*..... **Western Great Plains Saline Depression Wetland**

3b. Depressional wetlands in the Western Great Plains with obvious vegetation zonation dominated by emergent herbaceous vegetation, including *Eleocharis* spp., *Schoenoplectus* spp., *Phalaris arundinacea*, *Calamagrostis canadensis*, *Hordeum jubatum*, and *Pascopyrum smithii*..... **4**

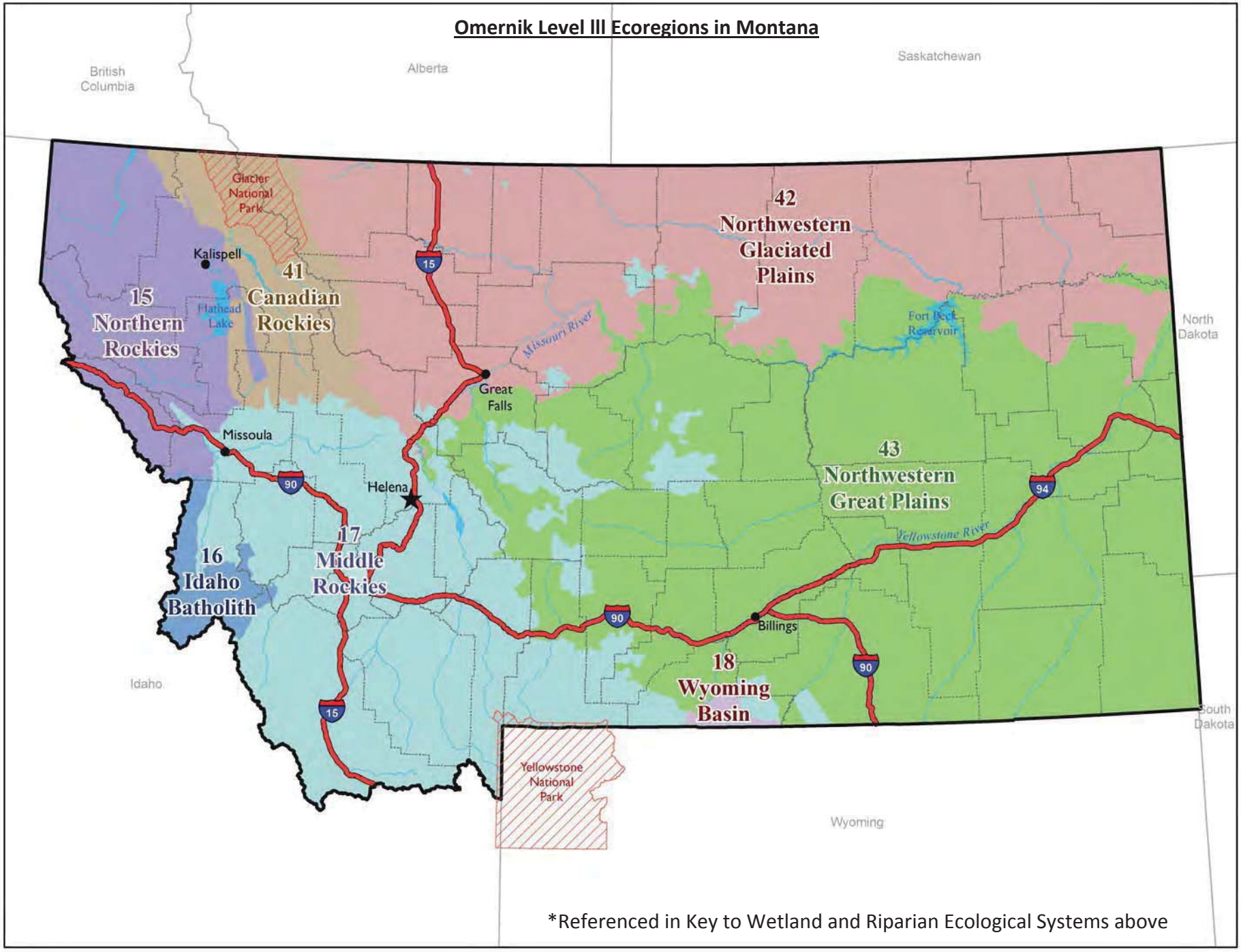
4a. Depressional wetlands in the Western Great Plains associated with open basins that have an obvious connection to the groundwater table. This system can also occur along stream margins where it is linked to the basin via groundwater flow. Typical plant species include species of *Typha*, *Carex*, *Schoenoplectus*, *Eleocharis*, *Juncus*, and floating genera such as *Potamogeton*, *Sagittaria*, and *Ceratophyllum*.....

..... **Western Great Plains Open Freshwater Depression Wetland**

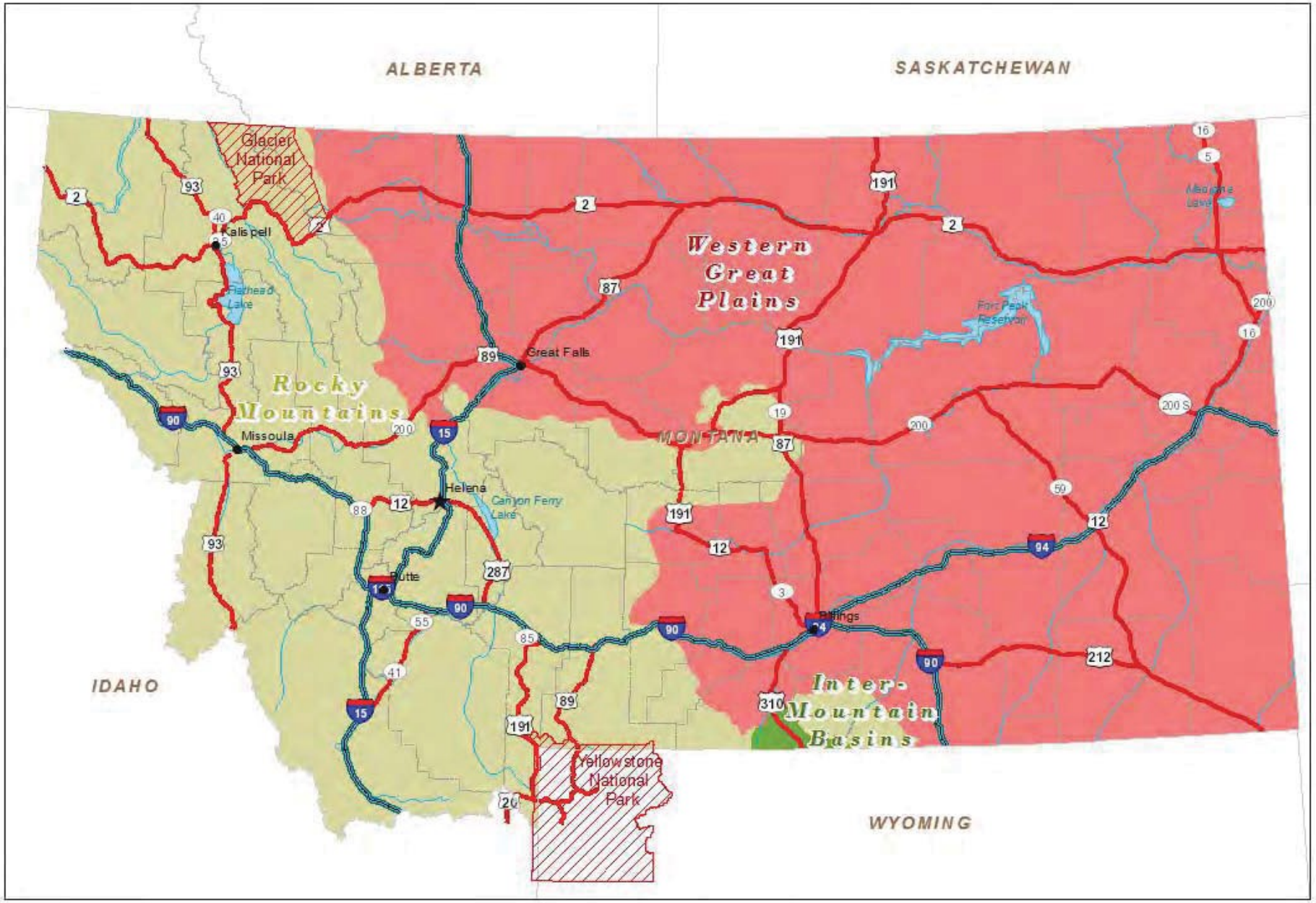
4b. Depressional wetlands in the Western Great Plains primarily within upland basins having an impermeable layer such as dense clay. Recharge is typically via precipitation and runoff, so this system typically lacks a groundwater connection. Wetlands in this system tend to have standing water for a shorter duration than Western Great Plains Open Freshwater Depression Wetlands. Common species include *Eleocharis* spp., *Hordeum jubatum*, and *Pascopyrum smithii* ..... **Western Great Plains Closed Depression Wetland**

Sa. Wetlands with a permanent water source throughout all or most of the year. Water is at or above the surface throughout the growing season, except in drought years. This system can occur around ponds, as fringes around lakes and along slow-moving streams and rivers. The vegetation is dominated by common emergent and floating leaved species including species of *Scirpus*, *Schoenoplectus*, *Typha*, *Juncus*, *Carex*, *Potamogeton*, *Polygonum*, and *Nuphar*..... **Western North American Emergent Marsh**

Sb. Herbaceous wetlands associated with a high water table or overland flow, but typically lacking standing water. Sites with *no channel formation* are typically associated with snowmelt and not subjected to high disturbance events such as flooding (Slope HGM Class). Sites *associated with a stream channel* are more tightly connected to overbank flooding from the stream channel than with snowmelt and groundwater discharge and may be subjected to high disturbance events such as flooding (Riverine HGM Class). Vegetation is dominated by herbaceous species; typically graminoids have the highest canopy cover including *Carex* spp., *Calamagrostis* spp., and *Deschampsia cespitosa* ..... **Rocky Mountain Alpine-Montane Wet Meadow**


Omernik Level lll Ecoregions in Montana
British Columbia
Alberta
Saskatchewan
North Dakota
South Dakota
Wyoming
Idaho
Glacier National Park
Kalispell
Flathead Lake
15 Northern Rockies
41 Canadian Rockies
42 Northwestern Glaciated Plains
Missouri River
Fort Peck Reservoir
Great Falls
Missoula
Helena
43 Northwestern Great Plains
Yellowstone River
16 Idaho Batholith
17 Middle Rockies
Billings
18 Wyoming Basin
Yellowstone National Park
15
90
94
*Referenced in Key to Wetland and Riparian Ecological Systems above

NatureServe's Ecological Divisions in Montana



*Referenced in Key to Wetland and Riparian Ecological Systems above

**Comer (2OO3} adapted this from Bailey's Ecoregions at Division scale

Appendix B: Hydrogeomorphic (HGM) Classification of Wetlands in Montana

If the hydrologic criteria listed in each question do not apply to the entire wetland unit being rated, you probably have a wetland with multiple HGM classes. In this case, identify which hydrologic criteria in Questions 1-5 apply, and go to Question 6.

1a. Entire wetland unit is flat and precipitation is the primary source (>90%) of water. Groundwater and surface water runoff are not significant sources of water to the unit ..... **Mineral Soil Flats HGM Class**

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

2a. Entire wetland unit meets ***all*** of the following criteria: a) the vegetated portion of the wetland is on the shores of a permanent open water body at least 8 ha (20 acres) in size; b) at least 30% of the open water area is deeper than 2.5 m (8.2 ft); c) vegetation in the wetland experiences bidirectional flow as the result of vertical fluctuations of water levels due to rising and falling lake levels.....

..... **Lacustrine Fringe HGM Class**

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

3a. Entire wetland unit meets ***all*** of the following criteria: a) wetland unit is in a valley, floodplain, or along a stream channel where it is inundated by overbank flooding from that stream or river; b) overbank flooding occurs at least once every two years; and c) wetland does not receive significant inputs from groundwater. **NOTE:** *Riverine wetlands can contain depressions that are filled with water when the river is not flooding such as oxbows and beaver ponds*..... **Riverine HGM Class**

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

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

4b. Wetland does not meet all of the above criteria..... **5**

5a. Entire wetland unit is located in a topographic depression in which water ponds or is saturated to the surface at some time during the year. **NOTE:** *Any outlet, if present, is higher than the interior of the wetland.*..... **Depressional HGM Class**

5b. Wetland does not meet the above criteria **6**

6. If the wetland is difficult to classify, then it probably contains multiple HGM classes. For example, seeps at the base of a slope may grade into a riverine floodplain, or a small stream within a depressional wetland may have a zone of flooding along its sides. GO BACK AND IDENTIFY WHICH OF THE HYDROGEOMORPHIC CLASSES DESCRIBED IN QUESTIONS 1-5 APPLY TO DIFFERENT AREAS IN THE UNIT (make a rough sketch to help you decide).

If you have two HGM classes present within your wetland, then identify the HGM class that represents 10% or more of the assessment area using the following table.

HGM Classes observed within the wetland being assessed	**HGM Class to use in assessment (must represent** 10% or more **of the assessment area)**
Slope + Riverine	***Riverine***
Slope + Depressional	***Depressional***
Slope + Lacustrine Fringe	***Lacustrine Fringe***
Depressional + Riverine along stream within assessment area boundary	***Depressional***
Depressional + Lacustrine Fringe	***Depressional***

NOTE: If the HGM class listed in column 2 represents less than 10% of the assessment area, then classify the wetland using the HGM class that represents more than 90% of the total assessment area. If you are still unable to determine which of the above criteria apply to your wetland, or if you have more than 2 HGM classes within an assessment area, classify the wetland as *Depressional* ***for the assessment and note reasoning.***

Modified from: Hruby, Tom, (2004). *Washington State Wetland Rating System for Eastern Washington - Revised.* Publication #04-06-15. Washington State Department of Ecology, Olympia, Washington.

Appendix C: Key to the Cowardin Systems and Classes of Montana

Cowardin 2.O (FGDC 2O13, adapted from Appendix B}

Key to the Cowardin Systems

1a. Persistent emergent herbaceous vegetation, trees, shrubs, or emergent mosses cover 30% or more of the wetland. If the wetland occurs within a mosaic of systems, then the patch must be at least 0.1 hectares (O.25 acres)..... **PALUSTRINE**

1b. Persistent emergents, trees, shrubs, or emergent mosses cover less than 30% of substrate, but nonpersistent emergents may be widespread during some portions of the year **2**

2a. Situated in a channel; water, when present, usually flowing..... **RIVERINE**

2b. Situated in a basin, catchment, or on level or sloping ground; water usually not flowing **3**

3a. Area 8 ha (20 acres) or greater ....**LACUSTRINE**

3b. Area less than 8 ha **4**

4a. Wave-formed or bedrock shoreline feature present or water depth 2.5 m (8.2 feet) or more.....**LACUSTRINE**

4b. No wave-formed or bedrock shoreline feature present and water less than 2.5 m deep.....**PALUSTRINE**

Key to the Cowardin Classes

1a. During the growing season of most years, areal cover by vegetation is less than 30%. **2**

1b. During the growing season of most years, percentage of area covered by vegetation 30% or greater. **6**

2a. Water regime permanently flooded (H}, intermittently exposed (G}, or semipermanently flooded (F}..... **3**

2b. Water regime seasonally flooded (C}, temporarily flooded (A}, intermittently flooded (J}, seasonally flooded-saturated (E}, or artificially flooded (K}..... **4**

3a. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area..... ..... **ROCK BOTTOM**

3b. Substrate of organic material, mud, sand, gravel, or cobbles with less than 75% areal cover of stones, boulders, or bedrock..... .....**UNCONSOLIDATED BOTTOM**

4a. Contained within a channel that does not have permanent/continuously flowing water (i.e., Intermittent Subsystem of Riverine System).....**STREAMBED**

4b. Contained in a channel with perennial/continuously flowing water or along the shore of a lake/pond **5**

5a. Substrate of bedrock, boulders, or stones occurring singly or in combination covers 75% or more of the area (RIVERINE OR LACUSTRINE ONLY). .....**ROCKY SHORE**

5b. Substrate of organic material, mud, sand, gravel, or cobbles; with less than 75% of the cover consisting of stones, boulders, or bedrock .....**UNCONSOLIDATED SHORE**

6a. Vegetation composed of pioneering annuals or seedling perennials, often not hydrophytes, occurring only at time of substrate exposure **7**

6b. Vegetation composed of algae, mosses, liverworts, lichens, or vascular plants that are usually hydrophytic perennials **8**

7a. Contained within a channel that does not have permanent flowing water..... **STREAMBED {VEGETATED)**

7b. Contained within a channel with permanent water, or not contained in a channel .... **UNCONSOLIDATED SHORE (VEGETATED)**

8a. Vegetation composed predominantly of nonvascular species **9**

8b. Vegetation composed predominantly of vascular species..... **10**

9a. Vegetation macrophytic algae, mosses, or lichens growing in water or the splash zone of shores. .... **AQUATIC BED**

9b. Vegetation mosses or lichens usually growing on organic soils and always outside the splash zone of shores..... **MOSS-LICHEN WETLAND**

10a. Vegetation herbaceous **11**

10b. Vegetation trees or shrubs..... **12**

11a. Vegetation emergents ..... **EMERGENT WETLAND**

11b. Vegetation submergent, floating-leaved, or floating ..... **AQUATIC BED**

12a. Dominants less than 6 m (20 feet) tall..... **SCRUB-SHRUB WETLAND**

12b. Dominants 6 m tall or taller ..... **FORESTED WETLAND**

*In addition, if neither the cover of trees or the cover of shrubs are individually ≥3O%, but the summation of their percentages IS ≥3O%..... **SCRUB-SHRUB WETLAND**

From FGDC {2013) Appendix A: Glossary

- Boulder = Rock fragment larger than 6O.4 cm (24 inches} in diameter.
- Stone = Rock fragment larger than 25.4 cm (1O inches} but less than 6O.4 cm (24 inches}.
- Cobble = Rock fragment 7.6 cm (3 inches} to 25.4 cm (1O inches} in diameter.
- Gravel = Mixture composed primarily of rock fragments 2 mm (O.O8 inch} to 7.6 cm (3 inches} in diameter. Usually contains much sand.
- Sand = Unconsolidated mineral sediment composed predominantly of particles >O.O74 mm & <2 mm.
- Mud = Wet soft earth composed predominantly of clay- and silt-sized mineral particles <O.O74 mm.

From FGDC {2013) Appendix E: Criteria for Differentiating between Mineral Soils and Organic Soils

"If a soil has both organic and mineral horizons, the relative thickness of the organic and mineral soil materials must be considered. [M]ineral soils [are] those that have both thick mineral soils layers and no more organic material than the amount permitted in the Histic Epipedon [(surface horizon ≥2Ocm}]. [A]ny O horizon at the surface is considered an organic horizon if it meets the requirements of organic soil material...and its thickness is added to that of any other organic horizons to determine the total thickness of organic soil materials. It is a general rule that a soil is classified as an organic soil (Histosol} if more than half of the upper 8O cm (32 in} of the soil is organic or if organic soil material of any thickness rests on rock or on fragmental material having interstices filled with organic materials."

Descriptions of Cowardin Water Regimes
(FGDC 2O13, Sec.3.3}

For MINERAL SOILS:

Permanently Flooded (H) - Water covers the substrate throughout the year in all years.

Intermittently Exposed (G) - Water covers the substrate throughout the year except in years of extreme drought.

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 (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 depth to substrate saturation may vary considerably among sites and among years.

Temporarily Flooded (A) - 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 ground surface for the most of the season.

Intermittently Flooded (J) - The substrate is usually exposed, but surface water is present for variable periods without detectable seasonal periodicity. Weeks, months, or even years may intervene between periods of inundation. The dominant plant communities under this Water Regime may change as soil moisture conditions change. Some areas exhibiting this Water Regime do not fall within our definition of wetland because they do not have hydric soils or support hydrophytes. This Water Regime is generally limited to the arid West.

For ORGANIC SOILS:

Seasonally Flooded-Saturated (E) - Surface water is present for extended periods (generally for more than a month} during the growing season, but is absent by the end of the season in most years. When surface water is absent, the substrate typically remains saturated at or near the surface.

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.

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.

NWI Water Regime Restriction Table for Montana

System		RIVERINE			LACUSTRINE		PALUSTRINE
Subsystem		**Lower Perennial**	**Upper Perennial**	**Intermittent**	**Limnetic**	**Littoral**	**Palustrine**
Class/Subclass	**Code**	R2	R3	R4	L1	L2	P
ROCK BOTTOM	RB		F G H		G H K	F G H K	F G H K
Bedrock	RB1		F G H		G H K	F G H K	F G H K
Rubble	RB2		F G H		G H K	F G H K	F G H K
UNCONSOLIDATED BOTTOM	UB	F G H	F G H		G H K	F G H K	F G H K
Cobble-gravel	UB1	F G H	F G H		G H K	F G H K	F G H K
Sand	UB2	F G H	F G H		G H K	F G H K	F G H K
Mud	UB3	F G H	F G H		G H K	F G H K	F G H K
Organic	UB4	F G H			G H K	F G H K	F G H K
AQUATIC BED	AB	C F G H	C F G H		G H K	C F G H K	C F G H K
Algal	AB1	F G H	F G H		G H K	F G H K	F G H K
Aquatic moss	AB2	F G H	F G H		G H K	F G H K	F G H K
Rooted vascular	AB3	C F G H	C F G H		G H K	C F G H K	C F G H K
Floating vascular	AB4	C F G H	C F G H		G H K	C F G H K	C F G H K
STREAMBED	SB			A C J			
Bedrock	SB1			A C J			
Rubble	SB2			A C J			
Cobble-gravel	SB3			A C J			
Sand	SB4			A C J			
Mud	SB5			A C J			
Organic	SB6			C			
Vegetated	SB7			A C J			
ROCKY SHORE	RS	A C	A C			A C J K	
Bedrock	RS1	A C	A C			A C J K	
Rubble	RS2	A C	A C			A C J K	
UNCONSOLIDATED SHORE	US	A C E J	A C E J			A C E J K	A C E J K
Cobble-gravel	US1	A C J	A C J			A C J K	A C J K
Sand	US2	A C J	A C J			A C J K	A C J K
Mud	US3	A C J	A C J			A C J K	A C J K
Organic	US4	E	E			E	E
Vegetated	US5	A C J	A C J			A C J K	A C J K
MOSS-LICHEN	ML						B C D E
Moss	ML1						B C D E
Lichen	ML2						B C D E
EMERGENT							
Persistent	EM1						A B C D E F J K
Non persistent	EM2	F G H				F G H K	F G H K
Phragmites australis	EM5						A B C D E F J K
SCRUB-SHRUB							
Broad-leaved deciduous	SS1						A B C D E F J K
Needle-leaved deciduous	SS2						A B C D E F J K
Broad-leaved evergreen	SS3						A B C D E K
Needle-leaved evergreen	SS4						A B C D E K
Dead	SS5						F G H K
Deciduous	SS6						A B C D E F J K
Evergreen	SS7						A B C D E K
FORESTED							
Broad-leaved deciduous	FO1						A B C D E F K
Needle-leaved deciduous	FO2						A B C D E F K
Broad-leaved evergreen	FO3						A B C D E K
Needle-leaved evergreen	FO4						A B C D E K
Dead	FO5						F G H K
Deciduous	FO6						A B C D E F K
Evergreen	FO7						A B C D E K

APPENDIX D
COWARDIN & RIPARIAN CLASSIFICATION SYSTEM DEFINITIONS

SYSTEM	DEFINITION		
RIVERINE (R)	The Riverine System includes all wetlands and deepwater habitats contained within a channel, UNLESS the wetland is dominated by trees, shrubs, persistent emergent vegetation, emergent mosses, or lichens		
SUBSYSTEMS	**LOWER PERENNIAL (2)**	**UPPER PERENNIAL (3)**	**INTERMITTENT (4)**
	Characterized by: • Low gradient • Water flows all year, except during extreme drought • Substrate is primarily sand & mud • Oxygen deficiencies may occur • Fauna includes many true planktonic species • Well-developed floodplain	Characterized by: • High gradient • Water flows all year, except during extreme drought • Substrate is mostly rock, cobbles, or gravel with occasional patches of sand • Dissolved oxygen is normally near saturation • Fauna characteristic of running water; few planktonic forms, if any • Little floodplain development	Characterized by: • High or low gradient • Channel contains flowing water only part of the year and may dry completely or may retain isolated pools of surface water • Substrate is variable and may be vegetated
LACUSTRINE (L)	The Lacustrine System includes all wetlands and deepwater habitats with ALL of the following characters: 1) Situated in a topographic depression or dammed river channel 2) Lacking tree, shrubs, persistent emergent, emergent mosses or lichens with 30% or greater areal coverage 3) Total area is at least 8 hectares (20 acres) *May include similar habitats <8 hectares if 1) an active wave-formed or bedrock shoreline makes up all or part of the boundary OR 2) the water depth is >2.5 m at low water.		
SUBSYSTEMS	**LIMNETIC (1)**	**LITTORAL (2)**	
	Characterized by: • All deepwater habitats ≥2.5 m (8.2 ft) deep • Not all Lacustrine systems have a Limnetic Subsystem	Characterized by: • All wetland habitats ≤2.5 m (8.2 ft) deep • Extends from the shoreline to the maximum extent of nonpersistent emergent vegetation (typically 2.5m below water)	
PALUSTRINE (P)	The Palustrine System includes all wetlands dominated by trees, shrubs, persistent emergent, emergent mosses, or lichens. Also includes non-vegetated wetlands with ALL of the following characters: 1) Area <8 hectares 2) No active wave-formed or bedrock shoreline 3) Water depth is <2.5m at low water *There are no Palustrine Subsystems		

CLASS	DEFINITION				
AQUATIC BED (AB)	Aquatic Bed includes wetlands & deepwater habitats where the dominant vegetation (≥30% areal coverage) is plants that grow on or below the surface of the water				
SUBCLASSES	**Algal (1)**	**Aquatic moss (2)**	**Rooted vascular (3)**	**Floating vascular (4)**	
	Includes algae that looks similar to vascular plants (*Chara, Nitella*) as well as filamentous algae	Occurs primarily in Riverine & Lacustrine Systems; includes *Fissidens, Depanocladus, Fontinalis* and aquatic liverworts	Includes plants that are completely submerged (*Ruppia, Elodea*) as well as rooted plants with floating leaves (*Nuphar*, some *Potamogeton*)	Includes vascular plants that float freely on the water surface (*Azolla, Lemna*) or just below the water surface (*Utricularia, Ceratophyllum, Wolffia*).	
ROCKY SHORE (RS) & ROCK BOTTOM (RB)	Rocky Shore is characterized by bedrock, stones, or boulders which singly or in combination have areal coverage ≥75% and vegetation coverage <30% (if aquatic mosses &/or liverworts cover ≥30% of the substrate, then it is Aquatic Bed)				
	Rock Bottom has stones, boulders, or bedrock substrates with coverage ≥75% and vegetation coverage <30% and is limited to water regimes F, G, H				
SUBCLASSES	**Bedrock (1)**		**Rubble (2)**		
	Bedrock covers ≥75% of the surface and vegetation coverage is <30%		Rubble has ≥75% bedrock, but stones & boulders alone or in combination with bedrock covers ≥75% of the area and there is ≥30% vegetation		
UNCONSOLIDATED SHORE (US)	Unconsolidated Shore includes wetlands with the following characteristics: 1) Unconsolidated substrates with ≥75% cover of stones, boulders, or bedrock 2) ≥30% cover of vegetation EXCEPT for pioneer species				
UNCONSOLIDATED BOTTOM (UB)	Unconsolidated Bottom includes wetlands with >25% cover of particles smaller than stones and vegetative cover <30% (there is no Vegetated subclass for UB—wetter water regime = no chance for pioneering species)				
SUBCLASSES	**Cobble-gravel (1)**	**Sand (2)**	**Mud (3)**	**Organic (4)**	**Vegetated (5)**
	Unconsolidated particles smaller than stones but larger than sand; May have some larger stones or boulders scattered on cobble-gravel shores	Consists primarily of particles smaller than gravel, but may be intermixed with some coarser fragments of gravels, cobbles, stones, or boulders	Dominant particles are silts and clay, with some intermixing of larger particles or organic material possible; anaerobic conditions often exist below the surface	Dominant substrate type is organic material in varying stages of decomposition; there is no minimum depth requirement	**FOR US ONLY:** Pioneer species that are usually killed by rising water levels (i.e., not wetland plants), such as weedy mesophytes or xerophytes like *Xanthium*,must have areal coverage of ≥30%

CLASS	DEFINITION						
MOSS-LICHEN (ML)	Moss-Lichen includes areas where mosses or lichens cover ≥30% of substrate OTHER THAN ROCK & where emergent vegetation, shrubs, and trees alone or in combination make up ≥30% coverage; limited to B, D water regimes & uncommon in Montana						
SUBCLASSES	**Moss (1)**		**Lichen (2)**				
	Areal coverage of mosses exceeds that of lichens; also includes liverworts		Areal coverage of lichens exceeds that of mosses				
STREAMBED (SB)	Streambed is for use ONLY with the Intermittent Subsystem (R4)						
SUBCLASSES	**Bedrock (1)**	**Rubble (2)**	**Cobble-gravel (3)**	**Sand (4)**	**Mud (5)**	**Organic (6)**	**Vegetated (7)**
	Bedrock substrate covers ≥75% of the stream channel; common in high mountain areas	Stones, boulders, and bedrock cover ≥75% of the channel; common in mountainous areas	≥25% of the substrate is particles smaller than stones	Sand-size particles dominate but may be interspersed with mud or cobble-gravel areas	Dominant substrate is silt or clay; common in arid areas where intermittent flow is characteristic of streams with low gradient	Characterized by channels that from in peat or muck; rare	Streambed is exposed long enough for pioneer species to colonize before being killed by rising water levels; must have ≥30% coverage of pioneer plants & may include *Panicum capillare, Xanthium*
EMERGENT (EM)	Tallest dominant lifeform is erect, rooted, herbaceous hydrophytes with ≥30% areal coverage; vegetation is present for most of the growing season & is usually dominated by perennial plants						
SUBCLASSES	**Persistent (1)**			**Nonpersistent (2)**			
	Emergent stems and leaves are evident above the surface of the water all year, or above the soil surface if water is absent; includes *Carex, Scirpus, Typha, Glyceria, Juncus*			Emergent stems and leaves are evident only during the growing season; during the dormant season there is no sign of emergent vegetation because ice/scour will remove these species, which includes *Pontederia, Sagittaria, Peltandra*			
SCRUB-SHRUB (SS) & FORESTED (FO)	Tallest dominant life form is woody plants ≥6 m (20 ft) tall with ≥30% coverage; includes shrubs, young trees, and stunted trees due to adverse environmental conditions (if SS and FO ≥30% cover each, but ≥30% combined, wetland is SS)						
	Tallest dominant lifeform is ≥6 m (20 ft) tall with ≥30% coverage						
	Broad-leaved deciduous (1)	**Needle-leaved deciduous (2)**	**Broad-leaved evergreen (3)**	**Needle-leaved evergreen (4)**	**Dead (5)**		
	SS: includes *Alnus, Cornia, Salix, Betula* FO: includes *Ulmus, Franxinus* (Eastern MT)	SS: includes young or stunted *Larix* FO: incudes mature *Larix*	SS: includes *Ledum, Kalmia* FO: probably none in Montana	SS: includes young or stunted *Abies, Picea, Tsuga* FO: includes *Abies, Picea, Tsuga*	SS: stands of woody plants ≥6 m tall, regardless of density, with <30% cover living vegetation; dead vegetation may result from prolonged rise in water levels due to impoundment via landslides, humans, or beaver, fire, insect infestation, air pollution, herbicides FO: stands of woody plants ≥6 m tall, regardless of density, with <30% cover living vegetation; factors are same as for SS		

SYSTEM	DEFINITION					
RIPARIAN (Rp)	Plant communities adjacent to & affected by surface/subsurface hydrologic features of perennial or intermittent rivers, streams, lakes, or drainageways that are usually transitional areas between wetlands and uplands; vegetation has different species than adjacent areas or similar species exhibiting more robust growth					
SUBSYSTEMS	**LOTIC (1)**		**LENTIC (2)**			
	Flowing water: streams, rivers		Lakes: natural and dammed			
CLASSES	**Emergent (EM)**		**Scrub-Shrub (SS)**		**Forested (FO)**	
	Erect, rooted vegetation with herbaceous stems		Woody vegetation ≥6m tall		Woody vegetation ≥6 m tall	
SUBCLASSES	**Dead (5)**	**Deciduous (6)**	**Evergreen (7)**	**Mixed deciduous/evergreen (8)**		
	Any dead standing tree or shrub	Includes *Populus, Elaeagnus, Alnus, Salix, Tamarix, Sarcobatus*	Includes *Juniperus, Picea, Artemisia*	Used only if cannot distinguish between dominant SS/FO type, reserved for remote mapping		

Appendix E. Key to Wetland Biophysical Settings of Montana (adapted from Eggers & Reed (2015))

*Note: ALL Wetland Biophysical settings described here are found in <2.5 m deep water, measured during the lowest part of the year, and usually have ≥30% vegetation.

1A. Plant community with ≥30% cover woody trees and/or shrubs, usually >1m tall, but includes dwarf shrubs <1m tall… **2**

1B. Plant community usually with ≥30% cover herbaceous vegetation, either emergent, submerged, floating, or floating-leaved… **6**

2A. Trees >6 m tall dominate community **3**

2B. Shrubs and young trees <6 m tall dominate community **5**

3A. Located in floodplains that are temporarily inundated during flood events, but are relatively well-drained for much of the growing season; primarily dominated by cottonwoods, but may also have a large coniferous component, particularly in western Montana…….. ……...….**FLOODPLAIN FOREST**

3B. Located in or near lake basins, slopes, depressions, flats, or high elevation meandering streams that have longer term inundation/saturation during the growing season; dominated by conifers such as Engelmann spruce, western hemlock, and/or subalpine fir **4**

4A. 0rganic soils present with at least a Histic Epipedon (surface horizon ≥20 cm organic (O) horizon) if not a Histosol (≥40 cm peat, muck, or mucky peat in the upper 80 cm); soils saturated at or near the surface for the duration of the growing season, commonly with pockets of standing water in depressions.…..……..…..…….....**CONIFEROUS FEN**

4B. Dominated by mineral soils, if organic then neither a Histic Epipedon nor a Histosol; standing water may be present in depressions for a short period during the growing season, but typically drying out during the latter half of the growing season.....**CONIFEROUS WETLAND**

5A. Organic soils present with at least a Histic Epipedon (surface horizon ≥20 cm organic (O) horizon) if not a Histosol (≥40 cm peat, muck, or mucky peat in the upper 80 cm); soils saturated at or near the surface for the duration of the growing season, commonly with pockets of standing water in depressions; often occurring on slopes fed by groundwater.....**SCRUB-SHRUB FEN**

5B. Dominated by mineral soils, if organic then neither a Histic Epipedon nor a Histosol; water levels and inundation period vary widely; geographically widespread, often along streams, lakes, reservoirs, or springs…….....**SCRUB-SHRUB WETLAND**

6A. Uppermost layer of vegetation is ≥30% cover of true aquatic plants including submerged, floating, and/or rooted floating-leaved plants or algae; if early in the growing season, submerged and rooted floating-leaved communities may have <30% cover .....**AQUATIC BED**

6B. Uppermost layer of vegetation is ≥30% cover of emergent herbaceous plants, true aquatic plants may or may not be present; standing water may or may not be present. **7**

7A. Plant community dominated by salt-tolerant graminoids and/or forbs; mineral soils have high salinity and salt encrustations may form on soil surface as water evaporates; inundation occurs early in the growing season or after rainfall; herbaceous plant cover <30% not uncommon; approximately restricted to the eastern 2/3 of Montana..…**SALINE DEPRESSION**

7B. Plant community dominated by freshwater graminoids and/or forbs; soils may be mineral or organic; inundation and saturation varies widely **8**

8A. Herbaceous plant cover may be <30% due to seasonal inundation resulting in exposed mudflats for part of the growing season; plant community consists of pioneering emergent annuals or may be cultivated for row crops or hay fields; soils usually mineral…..... **9**

8B. Herbaceous plant cover always ≥30%; soils may be mineral or organic…..... **10**

9A. Located on the edges of reservoirs, lakes, ponds, or large wetlands; plant community usually consists of pioneering emergent annuals, including non-native/invasive species; plant cover <30% common due to regularly fluctuating water levels or drawdown occurring late in growing season; soils almost always mineral…..……**SEASONALLY FLOODED MUDFLAT**

9B. Shallow depression or flat located in broad basins; early season inundation and drawdown exposes mudflats which become colonized by pioneering annual and perennials, including non-native/invasive species; plant cover usually ≥30% unless early season; often cultivated for row crops or hay fields; mineral soils; most common in eastern Montana……...
……..…….....**SEASONALLY FLOODED BASIN/DEPRESSION/FLAT**

10A. Plant community dominated by ≥50% cover of sedges, primarily *Carex* spp., but also including *Eriophorum* spp., *Trichophorum* spp., and other members of the Family Cyperaceae; typically found in organic soils; saturation at or near the soil surface; inundation varies…….
…….....**SEDGE MEADOW**

10B. Plant community with <50% cover of sedges; soils may be mineral or organic; inundation and saturation vary **11**

11A. Plant community dominated by emergent vascular plants, mosses, liverworts, and/or lichens; organic soils present with at least a Histic Epipedon (surface horizon ≥20 cm organic (O) horizon) if not a Histosol (≥40 cm peat, muck, or mucky peat within the upper 80 cm); soils typically saturated to surface throughout growing season with standing water in depressions common; floating mat of sedges and mosses may be present.……..…...…**HERBACEOUS FEN**

11B. Plant community dominated by emergent vascular plants and/or true aquatic plants; dominated by mineral soils, if organic then neither a Histic Epipedon nor a Histosol; inundation and water depth vary **12**

12A. Inundated by water depths ≥20 cm (up to 2.5 m) throughout the growing season in most years; community often a mixture of aquatic emergents, floating, floating-leaved and/or submergent plants, although true aquatic plants are <30% of cover……..**DEEP MARSH**

12B. Water depth usually <20 cm or absent later in the growing season; community dominated by aquatic emergents or drier plants that tolerate seasonal inundation; floating, floating-leaved and/or submergent plants often absent…. **13**

13A. Inundated by water depths <20 cm for more than a month in most years; aquatic emergent layer is dominant; floating, floating-leaved, and/or submergent layers may be present but a minor component…….……**SHALLOW MARSH**

13B. Often inundated early in the growing season, although not always, drying within a few months, the water table lies from the surface to well below the ground surface most of the season; community consists of aquatic emergent and/or drier plants; floating, floating-leaved and/or submergent plants absent…. **14**

14A. Plant community may be dominated by wetland emergents, although plant composition is often a mixture of a wide range of plants adapted to a variety of moisture requirements, centering around facultative graminoids and/or forbs; disturbed areas may be dominated by non-native or invasive species such as Canada thistle; inundation/saturation persists for a couple of months most years, usually drying out by latter half of growing season; geographically widespread…….. …….……..**WET MEADOW**

14B. Plant community dominated by moist prairie graminoids and forbs with some facultative or drier wetland emergents (i.e., Baltic rush, *Equisetum* spp.) present; disturbed areas may be dominated by non-native or invasive species such as Canada thistle; inundation/saturation very brief in early spring most years; mineral soils; often cultivated for row crops or hay fields…… .....……..**WET TO WET-MESIC PRAIRIE**

Appendix F. Coordination of Montana Wetland Biophysical Seetings with Classification of Wetland & Deepwater Habitat of the U.S., Cowardin 2.0 (FGDC 2013)

Montana Wetland Biophysical Settings	Classification of Wetlands & Deepwater Habitats of the U.S., Cowardin 2.0 (FGDC 2O13)		
	System/ Subsystem	Class	Water Regime
Aquatic Bed	P, L2	AB	C, F, G, H, K
Deep Marsh	P, L2	EM	F, G (L2 only}, K
Shallow Marsh	p	EM, ML	C, F (EM only), K (EM only)
Sedge Meadow	p	EM	A, B, C, D, E, F, K
Wet Meadow	p	EM	A, C, K
Wet to Wet-Mesic Prairie	p	EM	J, A, K
Seasonally Flooded Basin/Depression/Flat	p	EM, US	J, A, C, K
Seasonally Flooded Mudflat	P, L2	US	J, A, C, K
Saline Depression	P, L2 (US only)	EM, US	J, A, C, K
Herbaceous Fen	p	EM, ML	B, D, E
Scrub-Shrub Fen	p	SS	B, D, E
Scrub-Shrub Wetland	p	SS	J, A, C, F, K
Coniferous Fen	p	FO	B, D, E
Coniferous Wetland	p	FO	A, C, F
Floodplain Forest	Rp1, Rp2, P	FO	A (PFO only)

Appendix G. Montana Noxious Weed List

Montana Department of Agriculture (http://agr.mt.gov/Weeds), effective February 2017

PRIORITY 1A: These weeds are not present or have a very limited presence in MT. Management criteria require eradication if detected, education, & prevention	
Yellow starthistle	*Centaurea solstitialis*
Dyer's woad	*Isatis tinctoria*
Common reed	*Phragmites australis ssp. australis*
Medusahead	*Taeniantherum caput-medusae*

PRIORITY 1B: These weeds have limited presence in MT. Management criteria require eradication or containment, & education	
Knotweed complex	*Polygonum cuspidatum* (syn: *Fallopia japonica, Reynoutria japonica*) *P. sachalinense* (syn: *F. sachalinensis, R. sachalinensis*) *P. x bohemicum* (syn: *F. x bohemica, R. x bohemica*)
Purple loosestrife	*Lythrum salicaria*
Rush skeletonweed	*Chondrilla juncea*
Scotch broom	*Cytisus scoparius*
Blueweed	*Echium vulgare*

PRIORITY 2A: These weeds are common in isolated areas of MT. Management criteria require eradication or containment where less abundant. Management prioritized by local weed districts.	
Tansy ragwort	*Senecio jacobaea* (syn: *Jacobaea vulgaris*)
Meadow hawkweed complex	*Hieracium caespitosum, H. praealturm, H. floridundum, Pilosella caespitosa*
Orange hawkweed	*Hieracium aurantiacum* (syn: *Pilosella aurantiaca*)
Tall buttercup	*Ranunculus acris*
Perennial pepperweed	*Lepidium latifolium*
Yellowflag iris	*Iris pseudacorus*
Eurasian watermilfoil	*Myriophyllum spicatum, M. spicatum x M. sibiricum*
Flowering rush	*Rutomus umbellatus*
Commom buckthorn	*Rhamnus carthartica*

PRIORITY 2B: These weeds are common in isolated areas of MT. Management criteria require eradication or containment where less abundant. Management prioritized by local weed districts.	
Canada thistle	*Cirsium arvense*
Field bindweed	*Convoluvulus arvensis*
Leafy spurge	*Euphorbia esula*
Whitetop	*Cardaria draba* (syn: *Lepidium draba*)
Russian knapweed	*Acroptilon repens (syn: Rhaponticum repens)*
Spotted knapweed	*Centaurea stoebe* (syn: *C. maculosa*)
Diffuse knapweed	*Centaurea diffusa*
Dalmatian toadflax	*Linaria dalmatica*
St. Johnswort	*Hypericum perforatum*
Sulfur cinquefoil	*Potentilla recta*
Common tansy	*Tanacetum vulgare*
Oxeye daisy	*Leucanthemum vulgare*
Houndstoungue	*Cynoglossum officianale*
Yellow toadflax	*Linaria vulgaris*
Saltcedar	*Tamarix* spp.
Curlyleaf pondweed	*Potamogeton crispus*
Hoary alyssum	*Berteroa incana*

PRIORITY 3: These weeds are common in isolated areas of MT. Management criteria require eradication or containment where less abundant. Management prioritized by local weed districts.	
Cheatgrass	Bromus tectorum
Hydrilla	*Hydrilla verticillata*
Russian olive	*Elaeagnus angustifolia*
Brazilian waterweed	*Egeria densa*
Parrot feather watermilfoil	*Myriophylum aquaticum* (syn *M. brasiliense*)

Appendix H. Montana County Listed Weeds

Montana Weed Control Association (http://mtweed.org/), updated January 30, 2015

	Beaverhead	Big Horn	Blaine	Broadwater	Carbon	Chouteau	Daniels	Deer Lodge	Fallon	Flathead	Gallatin	Jefferson	Judith Basin	Lake	Lewis & Clark	Liberty	Lincoln	Madison	Meagher	Mineral	Missoula	Pondera	Powder River	Powell	Ravalli	Richland	Rosebud	Sanders	Sheridan	Silver Bow	Stillwater	Teton	Toole	Yellowstone
Baby's Breath *Gypsophila paniculata*			X	X		X	X	X		X		X													X			X	X				
Bellflower *Campanula rapunculoides*										X																							
Black henbane *Hyoscyamus niger*	X	X		X				X							X				X				X	X	X						X		
Common bugloss *Anchusa officinalis*																									X								
Bladder campion *Silene vulgaris*																			X														
White campion *Silene latifolia*										X																							
Chicory *Cichorium intybus*										X							X																
Common burdock *Arctium minus*		X	X	X					X						X		X					X								X			
Common crupina *Crupina vulgaris*																	X																
Common mullein *Verbascum thapsus*	X							X							X					X										X			X
Common teasel *Dipsacus fullonum*	X																							X									X
Curly dock *Rumex crispus*								X																									
Dwarf snapdragon *Antirrhinum majus*																	X																
Field scabious *Knautia arvensis*	X										X	X						X						X									
Halogeton *Halogeton glomeratus*	X																																
Kochia *Kochia scoparia*								X		X							X									X							
Matrimony vine *Lycium barbarum*																													X				
Mayweed chamomile *Anthemis cotula*																				X													
Meadow knapweed *Centaurea debeauxii*											X																						
Poison hemlock *Conium maculatum*		X				X			X		X						X						X			X							X

Montana County Listed Weeds

	Beaverhead	Big Horn	Blaine	Broadwater	Carbon	Chouteau	Daniels	Deer Lodge	Fallon	Flathead	Gallatin	Jefferson	Judith Basin	Lake	Lewis & Clark	Liberty	Lincoln	Madison	Meagher	Mineral	Missoula	Pondera	Powder River	Powell	Ravalli	Richland	Rosebud	Sanders	Sheridan	Silver Bow	Stillwater	Teton	Toole	Yellowstone
Puncturevine *Tribulus terrestris*																							X				X							X
Scentless chamomile *Tripleurospermum*	X										X						X			X													
Scot's broom *Cytisus scoparius*																	X																
Common speedwell *Veronica officianlis*																	X																
Germander speedwell *Veronica chamaedrys*																	X																
Cypress spurge *Euphorbia cyparissias*	X																																
Myrtle spurge *Euphorbia myrsinites*	X																																
Swainsonpea *Sphaerophysa salsula*	X																																
Musk thistle *Carduus nutans*	X			X				X			X				X	X	X	X				X									X	X	
Perennial sow thistle *Sonchus arvensis*				X				X								X						X											
Plumeless thistle *Carduus acanthoides*																	X																
Russian thistle *Salsola tragus*										X																							
Scotch thistle *Onopordum acanthium*				X	X						X						X		X								X						
Western water hemlock *Cicuta douglasii*																					X												X
Wild caraway *Carum carvi*																								X									
Absinth wormwood *Artemisia absinthium*					X												X		X														
Yellow mignonette *Reseda lutea*													X						X														
Medusahead *Taeniatherum caput-medusae*														X													X						

Appendix I. Soil Profile Description Procedures

SOIL PROFILE DESCRIPTION PROCEDURES

EXPOSE SOIL PROFILE BY TAKING SOIL CORE OR DIGGING SOIL PIT

DELINEATE SOIL HORIZONS OR LAYERS

FOR EACH HORIZON/LAYER, DETERMINE MATRIX COLOR

IF REDOX CONCENTRATIONS OR DEPLETIONS ARE PRESENT,
DETERMINE PERCENT SURFACE AREA OF SOIL MATRIX
AND COLOR FOR EACH

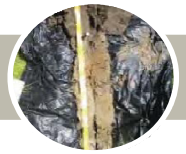
DETERMINE IF SOIL PROFILE HAS ORGANIC OR MINERAL SOIL
HORIZONS/LAYERS

DISTINGUISH BETWEEN MINERAL SOIL LAYERS WITH MUCKY MINERAL MODIFER
AND
ORGANIC SOIL LAYERS

IF SOIL HAS ORGANIC HORIZONS/LAYERS,
DISTINGUISH ORGANIC MATTER DECOMPOSITION STAGE
OF THOSE HORIZONS/LAYERS

DETERMINE SOIL TEXTURE FOR ALL MINERAL SOIL HORIZONS/LAYERS
(INCLUDING THOSE HORIZONS/LAYERS WITH MUCKY MINERAL MODIFIER)

DETERMINE IF A TEXTURE MODIFIER
IS APPROPRIATE TO USE FOR SOIL HORIZONS/LAYERS OF ROCKY SOILS



DELINEATE SOIL HORIZONS OR LAYERS

Distinguishing Soil Horizons. ***Left top:*** Soil slab diagram with horizons marked. ***Left bottom:*** Soil slab photo (Eric Vance, EPA). *Right :* Example soil profiles illustrating horizons distinguished by different colors, structure, or texture. Profile photos from USDA, NRCS (2010).

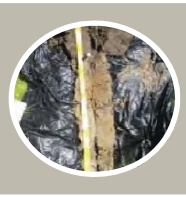
- Take your sunglasses off!
- First, eliminate smearing of the profile from auger or shovel. If you have a soil pit take a clean slice from an uncompact side of the pit with the sharpshooter. If sharpshooter smears profile, use a putty knife to "clean up" profile to expose clear layer boundaries. If you are using auger, carefully break open your soil to get clean, non-smeared profile.
- Place marker (e.g., golf tee} at bottom of each layer. Number layer in order from the top of the profile (see figure at left}.
- Take a photo of the profile.
- Measure depth from the top of the soil profile to the bottom of each layer in centimeters (a metric fiberglass seamstress tape works well}. Record the depth to the lower boundary of each layer.

Note: This may be an iterative process as sometimes visual clues may be difficult to differentiate . As you examine the soil texture, you may have to adjust the placement of soil layer markers but always start by separating layers based on differences in color and other visual cues.

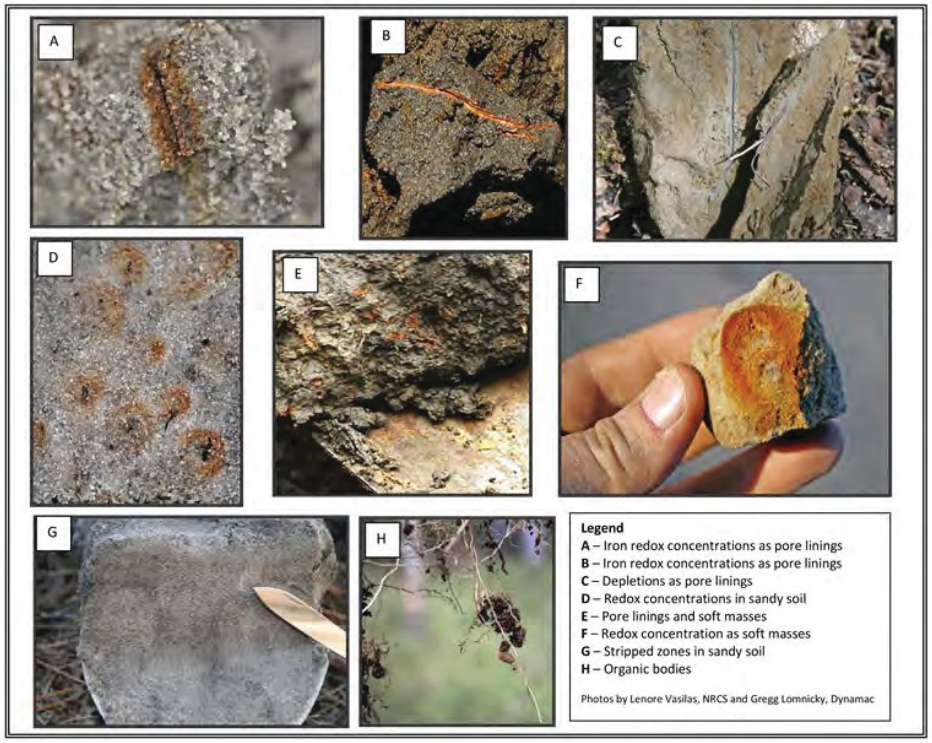
FOR EACH HORIZON/LAYER
DETERMINE MATRIX COLOR

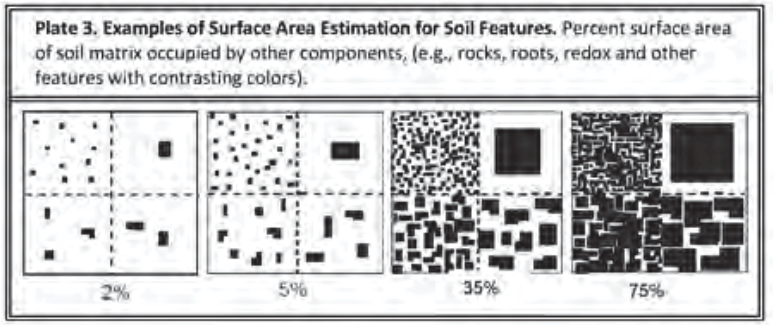
Photo courtesy of Vermont Department of Environmental Conservation

- Take off your sunglasses!
- For each layer, record the Soil Matrix Color using the Munsell Soil Chart. Soil Matrix Color is recorded as the Hue/Value/Chroma that matches most closely to the chips of the Munsell Soil Color Chart.
- If soils are dry, wet the sample until moist (not saturated}, and until sample no longer changes color.
- Soil samples may start to dry quickly when exposed to air, re-wet the sample as needed.
- Always have the sun at your back so that the soil sample is well lit when comparing the soil to the color chart to find the best match.



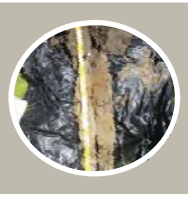
IF REDOX CONCENTRATIONS OR DEPLETIONS ARE PRESENT, DETERMINE PERCENT SURFACE AREA OF SOIL MATRIX AND COLOR FOR EACH





- For each Layer, record the Hue/Value/Chroma of Redox Concentrations. Redox concentrations are the result of iron oxidation as groundwater levels fluctuate throughout the growing season. These concentrations are orange/reddish-brown (due to iron} or dark reddish brown/black (due to manganese}. Redox concentrations can occur as:
  - Nodules or concretions: firm irregularly shaped bodies with diffuse boundaries
  - Masses: other bodies occurring throughout the matrix (also known as mottles}
  - Pore linings: redox concentrations along root channels as a result of oxygen diffusion from the roots of plants into the surrounding soil matrix reacting with iron in the soil (also known as oxidized rhizospheres}
- Record Redox Concentration Abundance (%}: Estimate the percentage of redox concentration in each soil layer (see Plate 3}.

Photos and Figures courtesy of NRCS



DETERMINE IF SOIL PROFILE HAS ORGANIC OR MINERAL SOIL HORIZONS/LAYERS

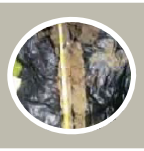
Step 1.
Determine whether the horizon/layer is an organic or mineral soil

- For each layer, take a dime-sized chunk of moist soil in your hand and gently rub the wet soil between forefinger and thumb 10 times.
  - If the soil feels greasy and leaves a light to dark stain on your hand, then the soil is either mucky mineral or organic soil (Go to Step 2.)
  - If soil does not feel greasy, the soil is a mineral soil (Go to Step 4.)

Mineral Soil

Organic Soil

Photos accessed at http://soils.usda.gov/technical/classification/orders/images/ultisol.jpg and http://soils.usda.gov/technical/classification/orders/images/histosol.jpg



DISTINGUISH BETWEEN MINERAL SOIL LAYERS WITH MUCKY MINERAL MODIFER AND ORGANIC SOIL LAYERS

Step 2.
Texturing Soils with High Organic Matter Content- Distinguishing between mucky mineral and organic layers

- For each organic soil layer, distinguish between mucky mineral or organic. Squeeze a chunk of wet soil and determine which of the following best describes the layer:
  - Organic - The soil has an organic texture if, when squeezed, it either extrudes liquid or much of the soil material does not stick to your hand. Identifiable plant parts are common (Go to Step 3}.
  - Mucky Mineral (modifier) - The soil has a mucky mineral modifier if it is gritty or sticks to your hand when squeezed and rubbed. Identifiable plant fibers are rare to none (Go to step 4 and determine soil texture. It will be more difficult to determine soil texture of mucky mineral soils than mineral soils, but do your best).

IF SOIL HAS ORGANIC HORIZONS/LAYERS, DISTINGUISH ORGANIC MATTER DECOMPOSITION STAGE OF THOSE HORIZONS/LAYERS

Step 3.
Distinguishing among organic matter decomposition stages for organic soil layers

- Organic textures include Peat, Mucky-Peat, or Muck. The three textures are based on differences in percent volume of plant fibers visible with a hand lens after rubbing between thumb and forefinger 10 times.

  - To distinguish between the organic soils, take a fresh dime-sized chunk of moist soil. Rub that sample between your thumb and forefinger 10 times, and then visually estimate the percent volume of plant fibers and dead roots. Use the chart below to determine the organic matter decomposition state of the organic soil layer.

Organic Soil	% Fibers Visible with Hand Lens after Rubbing
Peat	≥ 40 %
Mucky Peat	16.6 - < 40 %
Muck	< 16.6 %

United States Department of Agriculture, Natural Resources Conservation Service. 2017. *Field Indicators of Hydric Soils in the United States*, Version 8.1. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.}. USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

DETERMINE SOIL TEXTURE FOR ALL MINERAL SOIL HORIZONS/LAYERS (INCLUDING THOSE HORIZONS/LAYERS WITH MUCKY MINERAL MODIFIER)

Step 4:
Determine the texture of the mineral soil

- For each mineral soil layer, use the soil texture flow chart (**p.71**) to determine the texture of the mineral soil.

  NOTE: Mineral Soil Texture encompasses only the fine earth fraction that is ≤ 2 mm (i.e., clay, silt or sand), not coarse fragments (gravel, coble, stone, boulders) or organics (see tables to right for particle/fragment size definitions).

Fine Particle/ Grain Type	Particle Size (Grain Size)
Clay	< 0.002 mm
Silt	0.002 - 0.05 mm
Sand	0.05 - 2 mm

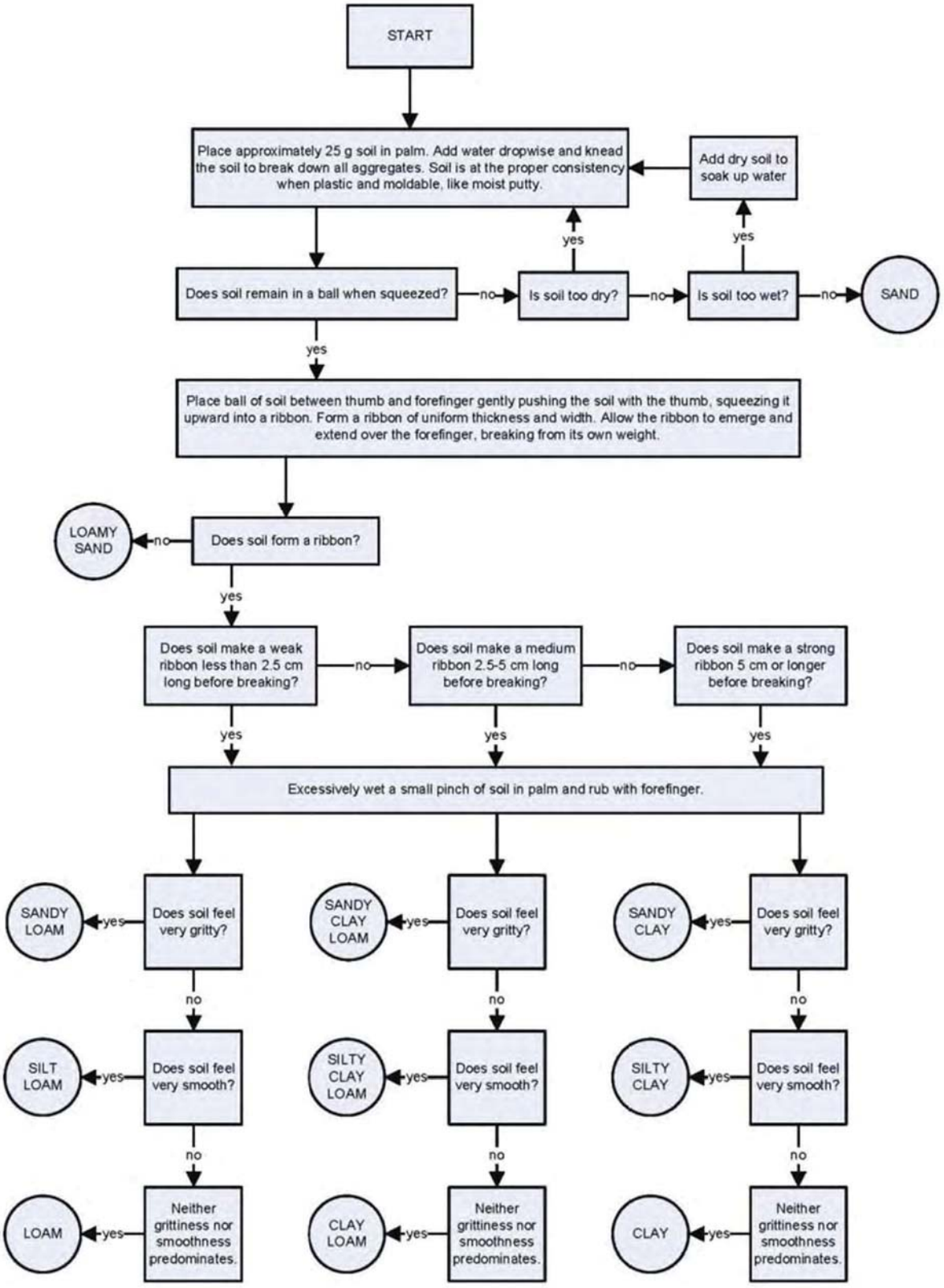
- If the soil layer has coarse fragments (>2 mm) or you hit water, go to Step 5 to determine if texture modifiers are appropriate for the soil layer.

- If, *AFTER YOU HAVE DETERMINED SOIL TEXTURE USING THE SOIL TEXTURE CHART*, you are still unsure of your soil texture results, check your results against the general descriptions of soil texture (**p.72**).

Coarse Fragment Type	Fragment Size
Gravel	>2 mm - 7.6 cm
Cobbles	>7.6 - 25 cm
Stones	>25 - 60 cm
Boulders	>60 cm

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Soil Texture Flow Chart



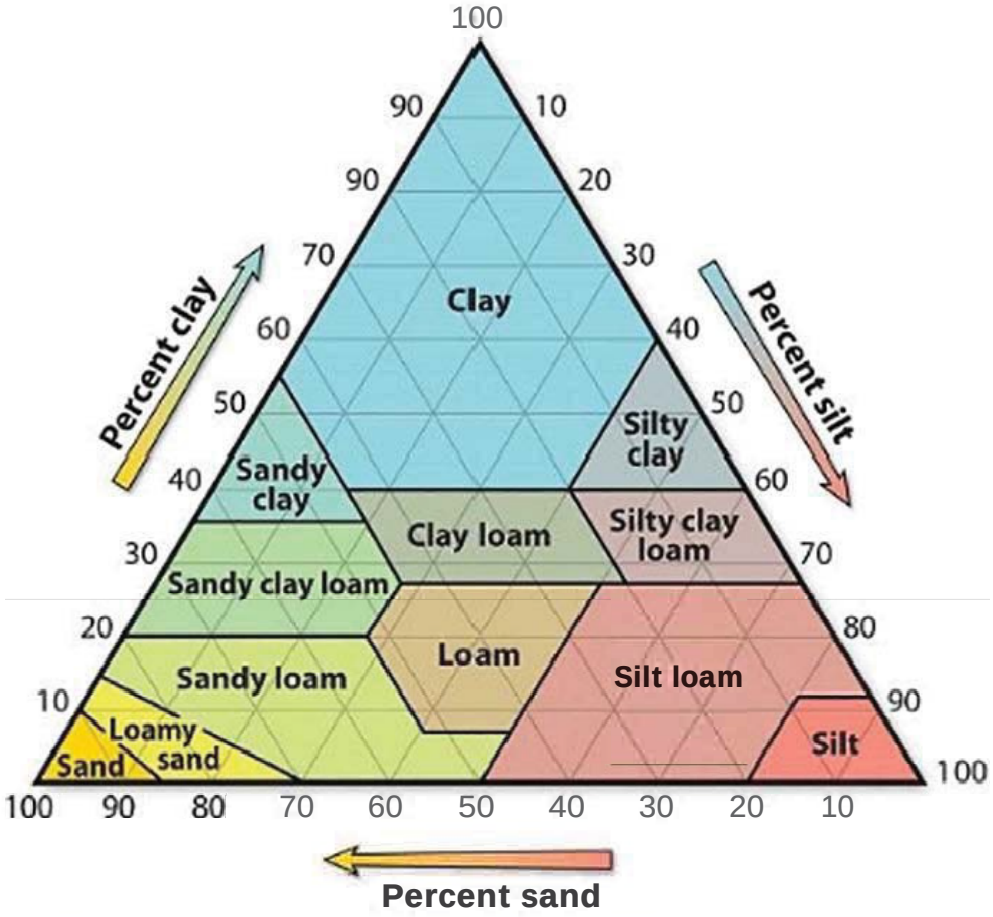
https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311

Modified from S.J. Thien. 1979. A flow diagram for teaching texture by feel analysis. Journal of Agronomic Education. 8:54-55.

General Description of Soil Textures				
Soil Texture	Visual detection of particle size and general appearance of the soil	Squeezed in hand and pressure released		Soil ribboned between thumb and finger when moist
		When air dry	When moist	
Sand	Soil has a granular appearance in which the individual grain sizes can be detected. It is free-flowing when in a dry condition.	Will not form a cast and will fall apart when pressure is released.	Forms a cast which will crumble when lightly touched.	Cannot be ribboned.
Sandy Loam	Essentially a granular soil with sufficient silt and clay to make it somewhat coherent. Sand characteristics predominate.	Forms a cast which readily falls apart when lightly touched.	Forms a cast which will bear careful handling without breaking.	Cannot be ribboned.
Loam	A uniform mixture of sand, silt and clay. Grading of sand fraction quite uniform from coarse to fine. It is mellow, has somewhat gritty feel, yet is fairly smooth and slightly plastic.	Forms a cast which will bear careful handling without breaking.	Forms a cast which can be handled freely without breaking.	Cannot be ribboned.
Silt Loam	Contains a moderate amount of the finer grades of sand and only a small amount of clay. Over half of the particles are silt. When dry, it may appear quite cloddy and can be readily broken and pulverized to a powder.	Forms a cast which can be freely handled. Pulverized it has a soft flourlike feel.	Forms a cast which can be freely handled. When wet, soil runs together and puddles.	It will not ribbon, but it has a broken appearance; it feels smooth and may be slightly plastic.
Silt	Contains over 80% of silt particles with very little fine sand and clay. When dry, it may be cloddy, readily pulverizes to powder with a soft flourlike feel.	Forms a cast which can be handled without breaking.	Forms a cast which can freely be handled. When wet, it readily puddles.	It has a tendency to ribbon with a broken appearance, feels smooth.
Clay Loam	Fine textured soil breaks into very hard lumps when dry. Contains more clay than silt loam. Resembles clay in a dry condition; identification is made on physical behavior of moist soil.	Forms a cast which can be freely handled without breaking.	Forms a cast which can be handled freely without breaking. It can be worked into a dense mass.	Forms a thin ribbon which readily breaks, barely sustaining its own weight.
Clay	Fine textured soil breaks into very hard lumps when dry. Difficult to pulverize into a soft flourlike powder when dry. Identification based on cohesive properties of the moist soil.	Forms a cast which can be freely handled without breaking.	Forms a cast which can be handled freely without breaking.	Forms long, thin flexible ribbons. Can be worked into a dense, compact mass. Considerable plasticity.
Organic Soils	Identification based on the high organic content. Muck consists of thoroughly decomposed organic material with considerable amount of mineral soil finely divided with some fibrous remains. When considerable fibrous material is present, it may be classified as peat. The plant remains or sometimes the woody structure can easily be recognized. Soil color ranges from brown to black. They have high shrinkage upon drying.			

Table taken from United States Department of Labor. Accessed at http://www.osha.gov/doc/outreachtraining/htmlfiles/soiltex.html

Soil Texture Triangle



https://www.nrcs.usda.gov/wps/portal/nrcs/detail/soils/edu/?cid=nrcs142p2_054311

DETERMINE IF A TEXTURE MODIFIER IS APPROPRIATE TO USE FOR SOIL HORIZONS/LAYERS OF ROCKY SOILS

Step 5:

Determine if a coarse fragment texture modifier is appropriate for soils with large volumes of coarse fragments.

- When a soil layer has >15% coarse fragments (>2 mm), the soil texture needs a modifier, possibly also an adjective.
  - Go to **Table A.** and determine whether a coarse texture modifier (e.g., cobbly), adjective prefix (e.g., "very"), or term in lieu of a soil texture (e.g., stones) should be used. Use Figure 10. on p.40 for surface area estimates.
  - IF modifier is being used, go to **Table B.** to determine the appropriate coarse fragment modifier term, which varies by size class.
  - IF ≥ 90% of the fragment content is a certain rock fragment, use **Table C.** for term to be used instead of a fine earth soil texture, modifier, OR adjective! e.g., the soil texture would be "stones" with no modifier or adjective.

A. Modifier & Adjective Usage

Fragment Content % By Volume	Rock Fragment Modifier & Adjective Usage
<15	No texture adjective or modifier (soil texture only; e.g., loam}
15 to < 35	Use modifier for appropriate size; e.g. gravelly loam (Go to B)
35 to < 60	Use "very" adjective with the appropriate size modifier; e.g., very gravelly loam (Go to B)
60 to < 90	Use "extremely" adjective with modifier; e.g., extremely gravelly loam (Go to B)
≥ 90	No adjective or modifier. ONLY use the appropriate noun for the dominant size class, e.g., gravel. Use Terms in Lieu of Texture (Go to C).

B. Coarse Fragment Size Class Modifier Term

Coarse Fragment Type	Fragment Size
Gravelly	>2 mm - 7.6 cm
Cobbly	>7.6 - 25 cm
Stony	>25 - 60 cm
Bouldery	>60 cm

C. Terms Used in Lieu of Fine Earth Soil Texture

Terms Used in Lieu of Soil Texture
Gravel
Cobbles
Stones
Boulders

Tables modified from Schoeneberger, P.J., D.A. Wysocki, E.C. Benham, and Soil Survey Staff. 2012. Field book for describing and sampling soils, Version 3.0. Natural Resources Conservation Service, National Soil Survey Center, Lincoln, NE.

Hydric Soil Indicators of Montana

	Hydric Soil Indicators	LRR	Description (See Hydric Soils Field Indicators (2017) for full descriptions)
A1	Histosol	D E F G	Organic soil material ≥40 cm thick within the top 80 cm. Peat, mucky peat, & muck.
A2	Histic Epipedon	D E F G	Organic soil material ≥20 cm thick above a mineral soil layer with chroma ≤2. Aquic conditions or artifical drainage required, but can be assumed if hydrophytic vegetation and wetland hydrology are present.
A3	Black Histic	D E F G	Very dark organic soil material ≥20 cm thick that starts within 15cm of soil surface AND lies above mineral soil with chroma ≤2. Color: Hue = 10YR or yellower; value ≤3; chroma ≤1. Aquic conditions or artificial drainage NOT required.
A4	Sulfidic Odor	D E F G	Rotten egg odor within 30cm of soil surface due to reduction of sulfur. Most commonly found in areas that are permanently saturated or inundated; almost never at a wetland boundary.
A5	Stratified Layers	F	Several stratified layers starting within 15 cm of soil surface. At least one layer have value ≤3 and chroma ≤1 (with ≥70% soil particles masked with organic material) OR it is muck, mucky peat, peat, or mucky modified mineral. Remaining layers have chroma ≤2. Not an indicator of soil deposition, as in a floodplain.
A9	1cm Muck	D F	Layer of muck ≥1 cm thick with value ≤3 and chroma ≤1 starting within 15 cm of soil surface.
A11	Depleted Below Dark Surface	D E F G	Depleted or gleyed matrix ≥15cm thick starts within 30cm of the soil surface. Color: chroma ≤2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark.
A12	Thick Dark Surface	D E F G	Depleted layer ≥15cm thick starts below 30cm of the soil surface. Color: chroma ≤2. Redox features required if color = 4/1, 4/2, 5/2. Layers above must be dark.
	For the remaining Indicators (except S6 & F8) all mineral layers above a layer meeting any hydric soil indicator must have dominant chroma ≤2 OR the thickness of the layer(s) with chroma ≥2 must be less than 15 cm (6 in) thick.		
S1	Sandy Mucky Mineral	D E F G	Layer of mucky modified sandy soil ≥5 cm starting within 15 cm of the soil surface.
S2	2.5cm Mucky Peat or Peat	G	Layer of peat or mucky peat ≥2.5cm thick with value ≤4 and chroma ≤3 starting with 15cm of soil surface on top of sandy soil.
S3	5cm Mucky Peat or Peat	F	Layer of peat or mucky peat ≥5cm thick with value ≤3 and chroma ≤2 starting with 15cm of soil surface on top of sandy soil.
S4	Sandy Gleyed Matrix	D E F G	Gleyed matrix making up ≥60% of layer starting within 15cm of soil surface. No minimum thickness required. Gley colors are found only on the Gley pages.
S5	Sandy Redox	D E F G	Must have ≥2% redox features in a depleted matrix ≥10 cm that starts within 15 cm of soil surface. Most common near wetland boundaries.
S6	Stripped Matrix	D E F G	Layer starting within 15 cm of surface in which iron/manganese oxides &/or organic matter has been stripped and the base color of the soil is exposed. Evident by faint, diffuse splotchy patterns of 2 or more colors. Stripped zones are ≥10% of soil volume, rounded, and ~1-3 cm in diameter.
F1	Loamy Mucky Mineral	D E F G	Layer of mucky modified loamy or clayey soil ≥10 cm starting within 15 cm of soil surface.
F2	Loamy Gleyed Matrix	D E F G	Gleyed matrix making up ≥60% of layer starting within 30 cm of soil surface. No minimum thickness required. Gley colors are found only on the Gley pages.
F3	Depleted Matrix	D E F G	Depleted matrix ≥5 cm thick starting within 10 cm of soil surface OR ≥15 cm thick starting within 25 cm of soil surface. Redox features required if color 4/1, 4/2, 5/2. Common near wetland boundaries.
F6	Redox Dark Surface	D E F G	Dark surface layer with redox concentrations ≥10 cm thick starting within 20 cm of soil surface. Matrix value must be ≤3. Chroma may be ≤1 if ≥2% redox concentrations OR chroma may be ≤2 if ≥5% redox concentrations. Difficult to see due to dark matrix.
F7	Depleted Dark Surface	D E F G	Dark surface layer with redox depletions ≥10 cm thick starting within 20 cm of soil surface. Redox depletions must have have value ≥5 and chroma ≤2. Matrix value must be ≤3. Chroma may be ≤1 if ≥10% redox concentrations OR chroma may be ≤2 if ≥20% redox concentrations.
F8	Redox Depressions	D E F G	Layer ≥5 cm thick starting within 10 cm of soil surface with ≥5% redox concentrations. Applies only to closed depressions.

Notes:

A# indicators are for ALL soil textures, S# indicators are for SANDY soils, F# indicators are for LOAMY or CLAYEY soils

Gleyed matrix is an indication of nearly continuous saturation (water regime D, E)

Depleted matrix = Value ≥4 and Chroma ≤2
All redox features must be distinct or prominent (not faint)

Glossary

Depleted matrix. For loamy and clayey material , a depleted matrix refers to the volume of a soil horizon or subhorizon in which the processes of reduction and translocation have removed or transformed iron, creating colors of low chroma and high value . A, E, and calcic horizons may have low chromas and high values and may therefore be mistaken for a depleted matrix; however, they are excluded from the concept of depleted matrix unless the soil has common or many distinct or prominent redox concentrations occurring as soft masses or pore linings. In some areas the depleted matrix may change color upon exposure to air (see Reduced matrix}; this phenomenon is included in the concept of depleted matrix.

Fibric. See Peat.

Gleyed matrix. Soils with a gleyed matrix have the following combinations of hue, value, and chroma (the soils are not glauconitic}: 1. 10Y, 5GY, 10GY, 10G, 5BG, 10BG, 5B, 10B, or 5PB with value of 4 or more and chroma of 1; or 2. 5G with value of 4 or more and chroma of 1 or 2; or 3. N with value of 4 or more; or In some places the gleyed matrix may change color upon exposure to air. (See Reduced matrix}. This phenomenon is included in the concept of gleyed matrix .

*Hemic. See Mucky peat

Horizon. A layer, approximately parallel to the surface of the soil, distinguishable from adjacent layers by a distinctive set of properties produced by soil-forming processes.

Layer(s). A horizon, subhorizon, or combination of contiguous horizons or subhorizons sharing at least one property referred to in the indicators

Matrix. The dominant soil volume that is continuous in appearance and envelops microsites. When three colors occur, such as when a matrix, depletions, and concentrations are present, the matrix may represent less than 50 percent of the total soil volume.

*Muck. Sapric organic soil material in which virtually all of the organic material is so decomposed that identification of plant forms is not possible. Bulk density is normally 0.2 or more. Muck has less than one-sixth fibers after rubbing, and its sodium pyrophosphate solution extract color has lower value and chroma than 5/1, 6/2, and 7/3.

*Mucky modified mineral soil material. A USDA soil texture modifier, e.g., mucky sand. Mucky modified mineral soil material that has 0 percent clay has between 5 and 12 percent organic carbon. Mucky modified mineral soil material that has 60 percent clay has between 12 and 18 percent organic carbon. Soils with an intermediate amount of clay have intermediate amounts of organic carbon. Where the organic component is peat (fibric material}

*Mucky peat. Hemic organic material, which is characterized by decomposition that is intermediate between that of fibric material and that of sapric material. Bulk density is normally between 0.1 and 0.2 g/cm3. Mucky peat does not meet the fiber content (after rubbing} or sodium pyrophosphate solution extract color requirements for either fibric or sapric soil material.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

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. If the soil is never saturated for more than a few days, it contains 20 percent or more organic carbon. Organic soil material includes muck, mucky peat, and peat.

*Peat. Fibric organic soil material. The plant forms can be identified in virtually all of the organic material. Bulk density is normally <0.1. Peat has three-fourths or more fibers after rubbing, or it has two-fifths or more fibers after rubbing and has sodium pyrophosphate solution extract color of 7/1, 7/2, 8/2, or 8/3.

Redox concentrations. Bodies of apparent accumulation of Fe-Mn oxides . Redox concentrations include soft masses, pore linings, nodules, and concretions. For the purposes of the indicators, nodules and concretions are excluded from the concept of redox concentrations unless otherwise specified by specific indicators.

Redox depletions. Bodies of low chroma (2 or less} having value 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.

Redoximorphic features. Features formed by the processes of reduction, translocation, and/or oxidation of Fe and Mn oxides; formerly called mottles and low-chroma colors.

Reduced matrix. A 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.

*Sapric. See Muck

Soil texture. The relative proportions, by weight, of sand, silt, and clay particles in the soil material less than 2 mm in size.

*** All definitions taken from United States Department of Agriculture, Natural Resources Conservation Service. 2017. Field Indicators of Hydric Soils in the United States, Version 8.1. L.M. Vasilas, G.W. Hurt, and J.F. Berkowitz (eds.}. USDA, NRCS, in cooperation with the National Technical Committee for Hydric Soils.

Appendix J: Montana's Threatened or Endangered Plant Species

Spiranthes diluvialis
Ute Ladies' Tresses-Listed Threatened

Distribution in Montana
Spiranthes diluvialis is known from only a handful of occurrences in southwest and south-central Montana in the Missouri, Jefferson, Beaverhead, Ruby and Madison River drainages. *S. diluvialis* is restricted in area by specific hydrologic requirements. Many populations have less than 100 individuals, though a couple have over 500 plants. Sites are susceptible to hydrologic changes and weed invasion. Large areas of habitat have been converted to agricultural uses. Livestock grazing is also a common use of these habitats. Two populations occur along highway right-of-ways. Most populations occur on private lands and no occurrences are currently protected or managed for their conservation value.

General Description
Ute Ladies' Tresses is a perennial orchid with usually 1 stem that is 20-50 cm tall and arising from tuberously thickened roots. Its narrow leaves are 1 cm wide, can reach 28 cm long, are longest at their base, and persist during flowering. The inflorescence consists of few to many white or ivory flowers clustered in a spike of 3-rank spirals at the top of the stem. The sepals and petals are ascending or perpendicular to the stem. The lateral sepals often spread abruptly from the base of the flower, and sepals are free or only slightly connate at the base. The lip petal is somewhat constricted at the median.

Phenology
Flowering in August-early September. Species is often not in full flower until mid-August.

Diagnostic Characteristics
S. diluvialis is intermediate between its putative progenitors, *S. romanzoffiana* and *S. magnicarporum*; the latter is not known from Montana. *S. diluvialis* is distinguished from *S. romanzoffiana* by its whitish, stout, ringent (gaping at the mouth) flowers, by its lip petal being exposed in lateral view, and by its sepals being free or connate at the base for a short distance rather than fused to form a hood above the lip. Additionally, the 2 species occupy different habitats, S. romanzoffiana almost always in mesic montane and subalpine settings, only rarely occurring in lower valley locations, whereas, S. diluvialis occurs in alkaline wetlands in the valley bottoms

Silene spaldingii
Spalding's Catchfly

Silene spaldingii Spalding's Catchfly

Distribution in Montana

Silene spaldingii exists in only a few locations in the northwest corner of the state. Extant occurrences are known in the following areas: Tobacco Plains area, Lost Trail National Wildlife Refuge, the Niarada area and on Wild Horse Island. The majority of occurrences have less than 100 individuals, though the largest population range-wide occurs in the state and is estimated to contain several thousand plants. One historical occurrence exists from the Columbia Falls area. Several threats affect the long-term viability of the species in the state. Invasive weeds are the most widespread threat and are negatively impacting the bunchgrass habitat occupied by *S. spaldingii.* Housing development and subdivision are directly impacting one occurrence and has the potential to further isolate other populations. Cattle grazing is affecting five populations and two other occurrences have apparently been extirpated recently from the severe impacts associated with llama grazing. Fire exclusion and the successive build-up of litter compared to historical conditions appears to be having negative impacts on survival and reproduction. Populations are also at risk due to the small numbers of individuals and their isolated nature, which reduces the chances of cross-pollination and gene flow between populations.

Long- and short-term trends are difficult to gauge due to the lack of survey and monitoring data. Estimates of trends and population size are also compounded by *S. spaldingii* plants exhibiting summer dormancy at rates that vary widely from year to year.

General Description

Spalding's Campion is a perennial with a simple or branched rootcrown. There are 4-7 pairs of sessile, broadly lance-shaped leaves that are 6-7 cm long below and gradually reduced in size upward. Herbage is long-hairy and very sticky. There are few to many flowers in a leafy, somewhat open inflorescence. The tubular calyx is ca. 15 mm long, has 10 nerves on its surface, and is very sticky. The corolla has 5 separate, white petals, each composed of a narrow claw that is ca. 15 mm long expanding into a broadened blade above. Only the entire or shallowly-lobed blade with 4 tiny wings at the base protrudes beyond the mouth of the calyx. The fruit is a capsule that is 10-15 mm long and filled with numerous tiny seeds.

Phenology

Flowering in July and usually continuing through August. Dried flower/fruiting stalks are often visible into the Fall.

Diagnostic Characteristics

This species can be distinguished from other perennial *Silene* spp. by its very sticky foliage and by its petals that are entire or only shallowly lobed.

Howellia aquatilis Water Howellia

Distribution in Montana
Water howellia is restricted in Montana to depressional wetlands in the Swan Valley, typically occupying small basins where the water level recedes partially or completely by the Fall. Montana contains the largest number of occupied ponds and wetlands though population numbers are generally small and the occupied habitat is clustered in a very small portion of the state, making it vulnerable to localized events and management actions. Reed canary grass (*Phalaris arundinacea*) has invaded into some wetlands in the Swan Valley and it has the potential to form dense monocultures, thereby decreasing the amount of available habitat. Additionally, water howellia is an annual species which is solely dependent on recruitment from seed and it has very narrow habitat and moisture requirements which leaves it vulnerable to extirpation as a result of consecutive years of unfavorable growing conditions.

General Description
Water Howellia is a glabrous, much-branched, annual, aquatic herb with fragile, submerged and floating stems that are up to 100 cm tall. The simple, alternate or occasionally opposite or whorled stem leaves are narrowly linear, 1-5 cm long, and entire-margined. Beneath the surface of the water, small flowers that produce seeds without opening are solitary in the leaf axils. Once the stems reach the surface, small, white flowers are borne in a narrow, terminal, leafy-bracted inflorescence. The white corolla is 2-3 mm long. Flowering occurs on the surface of the water. The fruit, which forms below the attachment of the petals, is a capsule that is 1-2 cm long containing elongate seeds that are up to 2-4 mm long.

Phenology
A winter annual which germinates in the Fall, overwinters, and continues growing in the Spring when conditions are favorable. Chasmogamous (flowers that open and allow for pollination) flowers bloom at the surface in late July-early August; the submerged cleistogamous (flowers that do not open and are self-pollinated) flowers begin in late June.

Diagnostic Characteristics
Vegetatively, this species resembles a small-leaved pondweed (*Potamogeton*) or a water starwort (*Callitriche*), but the flowers in these two groups lack petals, and they have much smaller seeds.

Appendix K. Plant Collection Procedures

When selecting plants, collectors need to be sensitive to whether the plant to be collected is rare, and whether the population will be adversely affected by having one or several individuals removed. A rule of thumb sometimes given is the "1 to 20" rule---for every plant collected, there should be at least 20 others left in the population.

Ideally, the entire plant, including roots or other underground structures, should be collected or, in the case of trees, shrubs, vines, or other large species, ample material representative of the plant should be obtained. The best specimens have both flowers and fruits---while this may not always be possible, all specimens should have some reproductive structures (e.g., spores, cones, flowers, or fruits). **This is necessary for positive identification to species.** Because most taxonomic keys are based on reproductive characters, specimens consisting of vegetative parts only are often of little use. For example, some plants may not be flowering in early summer. In this case, with some effort, you may be able to locate specimens that may have remnant flowering stems or fruits from the previous year still present.

Rare and Uncommon Species

It is best to document the occurrence of a Species of Concern (SOC), with a specimen if it meets the "1 to 20" rule OR with several very high quality photographs.

The Manual of Montana Vascular Plants (Lesica 2012) has our most current plant species distribution to date. If an identified specimen does not have an occurrence represented for the county in which you have identified it, then collect the specimen (if it meets the "1 to 20" rule) or take several high quality photographs.

If a species has few occurrences documented in the Manual (< 6 counties), then collect the specimen (if it meets the "1 to 20" rule) or take several high quality photographs.

Other Special Circumstances:

Aside from the common *Botrychium* spp. (*B. multifidum* or *B. virginianum*), any *Botrychium* encountered should be collected (if it meets the "1 to 20" rule) or otherwise documented with several high quality photographs.

Label Data Form for Plant Specimens:

1. Assign each unknown specimen with a unique specimen number. For example, a combination of the Site ID and the order the specimen was collected.
2. Assign each unknown specimen with a descriptive name that refers to identifying characteristics of the specimen.
3. Scientific name of the specimen if known.
4. Collector's name
5. Collection date.
6. Site ID
7. Plant habit (e.g., tree, shrub, perennial bunchgrass, etc.).
8. Any plant characteristics that may be lost upon drying (e.g., flower color, fragrance, etc.).

Collection Protocol:

1. For each specimen to be collected, select one or more healthy plants that are typical of its population within the assessment area.
2. Collect at least enough plant material for species identification and to fill a standard herbarium sheet (11.5 x 16.5 inches). Each specimen should consist of a stem with attached leaves, flowers, fruits, and if possible, roots.
3. Flowers and/or fruits are particularly important as they are generally needed to determine species identity.
4. If the plant is small enough, collect the entire plant including the roots.

5. If the plant is too large to fit on a herbarium sheet, collect 1) sufficient leaves and stems to illustrate leaf shape and size, opposite or alternate branching, and buds; 2) some of the root or rhizome; and 3) the inflorescence (flowering stem).
6. For grasses and grass-like plants, try to include roots or rhizomes. Also place part of the mature inflorescence in a small envelope to protect it from damage. Mature fruits are important for identification of these species, especially for *Carex* (sedge) species.
7. In the case of trees, shrubs, or vines, material should be selected to illustrate the overall characteristics of the plant and the range of variation in flowers, leaves, and other structures.
8. If the species has separate male plants and female plants or male and female flowers on the same plant, collect specimens from both sexes whenever possible, e.g., *Salix* (willow) spp. and some *Carex* (sedge) spp.
9. If it is not possible to provide a complete specimen for an unknown species (e.g., the plant is immature or senescent), collect a sample that illustrates as many key diagnostic parts of the plant as possible. In many cases, this may be sufficient for a regional expert botanist to identify the species.

Transporting and Storage of Specimens:

1. Place each specimen in a separate Ziplock or plastic bag of appropriate size and label with appropriate information referenced above
2. If a plant press is available and logistics and time permits, press the plants immediately before leaving the Assessment Area and label newspaper with appropriate collection information. Otherwise, place the filled Ziplock or plastic bags in a large cooler for transport. Plants should be pressed within one or two days of collection.

Pressing Plant Specimens:

Standard Plant Press 12 X 18 inches:

1. A rigid, breathable wooden frame
2. Corrugated cardboard ventilators to allow air flow through the press
3. Blotter paper to absorb moisture
4. Folded newsprint to contain the plant material
5. Straps with buckles to tighten the press

Assembling the Press:

1. Each newspaper specimen folder with plant material is sandwiched between 2 moisture-absorbing blotters.
2. The "blotter-newsprint sandwiches" are sandwiched between corrugated cardboard.
3. The corrugations of the cardboard should run parallel to the shorter dimension for best air circulation.

Pressing Plant Specimens:

1. On the bottom wooden frame of the press, place a piece of cardboard, blotter paper, folder newsprint on top of the blotter paper.
2. Place plant material between the folded newsprint. Remove as much dirt as possible from the plant before placing it in the newsprint folder.
3. For each plant specimen, write on the outside of the newsprint folder using waterproof ink (a "Sharpie" marker works well). Record all of the specimen information (above).
4. Arrange the plant material on the bottom fold of the newsprint to display diagnostic features. Lay the plants flat and avoid overlapping plant parts. Spread flowers, leaves, and fruits so they can be easily observed from different perspectives. Show upper and lower surfaces of the leaves and flowers. If possible, arrange pressed material to show some flowers with the blossom open, and some flowers and fruits are pressed in longitudinal and transverse views.
5. Multiples of smaller plants should be pressed together.
6. For specimens that are larger than the page, bend stems sharply into a V, N, or W shape so they fit within the press frame. Do not curve or twist the stems.
7. Thick stems or large fruits may require additional newspaper or blotter paper.

8. Small lose plant parts such as seeds should be placed in a small envelope inside of the newsprint with the rest of the plant.
9. Once the specimen is arranged, close the newsprint, add another piece of blotter paper, then a piece of cardboard.
10. To add another specimen, place blotter paper over the cardboard, add a folded piece of newsprint and repeat steps 1-9 until all plants are collected or the press is full.
11. Use the two adjustable straps to firmly hold the plant press and its contents. The plant press must be kept tight to prevent shrinkage and wrinkling of the plant material. It should not be possible to move the blotter paper or cardboard from the side in a properly tightened press.

Essential to collect:

Reproductive Structures. All specimens must have reproductive structures (flowers and/or fruits on flowering plants; or cones (conifers), or spores (ferns and their relatives). If fruits are not yet formed, then it is essential to collect a specimen with flowers.

Fruits. Specimens of several families are difficult or impossible to identify unless fruits, or fruits and flowers, are obtained. Fruits are required or strongly recommended for specimens of the following families: Cyperaceae (sedge family), Juncaceae (rush) family, Salicaceae (Willow family), Ranunculaceae (Buttercup family), Apiaceae (Carrot family), Poaceae (Grass Family).

Leaves and Stems. Leaves from the flowering stem as well as basal leaves are needed.

The plant specimen itself. The best specimens are whole plants, including roots, basal and cauline leaves, and reproductive structures. All diagnostic morphological features should be observable without having to disturb the mount. The best herbarium specimens have been pressed carefully, and then are neatly mounted with no material hanging off the sheet. Both sides of structures like leaves should be visible.

Appendix L. Field Equipment & Trip Preparation Checklist

Wetland Assessment Projects

Personal (supplied by MTNHP)
___Bear spray
___Clipboard
___Compass
___Emergency blankets
___Eraser, big
___Field vest
___Hand lens, 10X – 20X
___Mosquito head net (optional)
___Mechanical pencils
___Rite 'n Rain notebook
___Ruler, 6in.
___Sharpies

Utility
___File box with field equipment/supplies
___File box with protocols, forms and references
___Bleach spray bottle
___Bucket, 5-gal.
___Cargo box
___Duct tape
___Electricians tape
___Fire extinguisher
___Garbage bags
___Masking tape

Navigation & Assessment Area Set-up
___1O0m measuring tape (2}
___AA batteries (~20)
___Digital camera
___Dry erase board & markers
___Flagging tape
___GPS units
___Pin flags (~35)
___SD memory cards for camera

Soil Sampling
___Auger
___Gloves (optional)
___Golf tees
___Hanna Instruments Combo pH & EC Tester
___pH & EC Tester Solutions: calibration (1), cleaning (1), storage (1), buffer (3)
___Knife/putty knife
___Measuring tape (seamstress, fabric)
___Munsell Color Chart
___Plastic container for calibrating
___Plastic sheeting (black; 6mil; 4' x 5')
___Rags/Handkerchief
___Shovel: standard & sharpshooter
___Spray bottle

Vegetation Sampling/Collecting
___Baggies – Ziploc Gallon & Quart
___Dissection equipment
___Envelopes (for loose plant parts)
___Garbage bags
___Hori hori
___Plant press w/blotters, cardboard, newspaper, straps
___Rope (10m)

Personal clothing/camping gear (not supplied by MTNHP)
___Boots* or other footwear for wet conditions
___Bug dope
___Cold weather clothing
___Frame backpack*
___Headlamp
___Lighter and/or matches
___Mug
___Rain gear
___Sleeping bag*
___Sleeping pad*
___Sun block
___Sunglasses
___Sun hat
___Tent*
___Two-way radio
___Waders*
*Limited supply available from MTNHP if needed

Group camping/safety gear (supplied by MTNHP)
___Bowls, plates, mugs and silverware
___Cooking pots
___Crazy Creek chairs
___Camping stove (2 burner for car-camping)
___Emergency beacon (if in wilderness/no cell service)
___Emergency first aid kit
___Fuel canister for stove & adapter/connector
___Tarp & ropes (for rain)
___Water jug (7 gal).
___Water purifier & filters

Site Information, Protocols & Forms
___MT Ecological Integrity Assessment Field Manual
___MT Ecological Integrity Assessment Field Forms (Level 2)
___MT Ecological Integrity Assessment Field Forms (Level 3)
___MTNHP Plant Collection protocol
___pH & EC Tester instruction manual
___Site coordinates and directions
___Site maps
___Species of Concern Observation Forms

References & Field Guides

___Road atlas
___SOC lists per county
___MTNHP List of Fen Species and/or Frequent GDE species
___Field Guide to MT's Wetland Vascular Plants (Lesica & Husby 2015) (one per person)
___Field Guide to Intermountain Sedges (USFS 1998)
___Field Guide to Intermountain Rushes (USFS 1994)
___Field Guide to Sedges of Pacific NW (Wilson et al. 2008)
___Field Guide to Willows of E.Central ID (Brunsfeld & Johnson 1985)
___Field Indicators of Hydric Soils (NRCS 2016)
___Grasses of Montana (Lavin & Seibert 2011)
___Grassland Plants of SD & NGP (Johnson & Larson 2007)
___Guide to the Willows of Shoshone NF (USFS 2001)
___Manual of Montana Vascular Plants (Lesica 2012)
___Plants of Black Hills/Bear Lodge Mtns (Larson et al. 1999)
___Plants of the Rocky Mtns. (Kershaw et al. 1998)
___Vascular Plants of Montana (Dorn 1984)
___Vascular Plants of West-Central MT (Lackschewitz 1991)
___Weeds of the West (Burrill et al. 2009)

Contact information:

MTNHP/1515 E. 6th Ave./Helena, MT 59620-1800
mtnhp@mt.gov
Phone: 406.444.5354/Fax: 406.444.0266

Motor Pool (Work hours)	406-444-2705
Motor Pool (After hours)	406-461-5371

Before leaving for a field trip:

___RAT (Request for Authorization to Travel): Sign and give your current trip RAT to Secretary (RATs are emailed to you).
___TER (Travel Expense Report): Sign and give previous trip TER to Secretary (TERs are emailed to you).
___Motor Pool Trip Ticket: Print & have Senior Ecologist or Ecologist sign before you pick up the vehicle (Tickets either in field boxes &/or emailed to you).
___GPS & Camera: Verify they are working.
___Extra AA batteries: Verify you have some.
___Site Maps, Coordinates, and Directions: This should be in supervisor's cubicle.
___Blank Field Forms: Make sure you have enough (or print from appropriate year: K:\ECOLOGY\Projects\WETLAND_PROJECTS\Wetland_EIA_FieldMaterials\EIAForms).
___pH & EC Tester: Check battery status; Have extras (4 x 1.5v) when the status is 20% or less.
___pH & EC Tester Solutions: Make sure you have enough 4.01/7.01/10.01 Buffer, Conductivity Calibration, Cleaning & Storage Solution.
___Plant Press: Ensure there are no specimens from the previous trip & that they are clearly labeled; Add more blotter paper & newspaper.

Returning from a field trip:

___Field Forms: Place completed forms in a folder and leave them in supervisor's cubicle.
___GPS Units & Cameras: Download & organize all data to appropriate K drive folder before next field trip.
___Dishes: Clean/dry dishes & other equipment.
___Field Gear and File Boxes: Re-organize!!! How you leave them is how you will find them prior to the next field trip.
___Fuel tanks: Store at a team member's house.
___Decide as a team how to complete veg ID (& Field Form updates) before the next field trip.
___Leave specimens to be identified/verified by MTNHP Botanist in her cubicle; make sure they are clearly labeled.

Appendix M. GPS Instructions

Before going to the field:

1. Check that you have the user's manual for the unit you are using. If not, download it here:
   Model 76S: http://static.garmin.com/pumac/GPSMAP76S_QuickStartGuide.pdf
   Model 76: http://static.garmin.com/pumac/GPSMAP76_OwnersManual.pdf
2. In the Setup Menu, under the Location Tab, make sure that:
   a. Location Format is set to"UTM UPS"
   b. Datum is set to "NAD83"
   c. North is set to "True."

   Consult the user's manual if any of these need to be changed.
3. Collect at least 6 spare AA batteries and put them in the case with the GPS unit.

To upload waypoints from your computer to your GPS unit:

1. Connect the GPS to the cable connected to your computer and turn the GPS on.
2. Open ArcMap.
3. Open ArcMap project with the shapefile of the points you want to load.
4. Select the layer that you want to upload in the Table of Contents.
5. Open DNR GPS. This should be installed on your computer. If not, download from http://www.dnr.state.mn.us/mis/gis/DNRGPS/DNRGPS.html
6. It should say 'Connected' at the bottom of the screen.
7. Go to File➔Load From ArcMap.
8. In the 'ident' field, select 'siteID'.
9. Then to upload points to your GPS, Waypoints➔Upload. The GPS will beep when it has finished uploading all of the points. DNRGPS will say "transfer complete" and the number of waypoints it has uploaded. Make sure it has uploaded all of them.

Renaming the "Waypoint ID" on the GPS unit <u>in the field</u>:

The following are suffixes that should be used when renaming Waypoint IDs, all of which should be preceded by the site name. For example, label the AA Center for site GDE101 as "GDE101AAC".

1. AA Center: "...AAC"
2. Alternate AA Layout
   Polygon with corners: "..AAN", "...AAE", "...AAS", "...AAW" (N, E, S, & W corners; or use whatever direction is appropriate). If polygon has many corners, or if it becomes too complex to use directions, could use "…AA1", "…AA2", etc.
3. Alternate AA Layout - Track: "...AATRACK"
4. Overview Photo:
   a. "...OV"
   b. if there is a 2nd Overview photo location, use "OV2"
5. Soils: "...S1" & "...S2" (2 soil samples per site)
6. Veg Plot:
   a. "...0M" & "...50M" (0m and 50m end of each plot). If alternate module array results in plot being broken up into multiple parts, use for example, "...0MP1" and "...30MP1" for first plot (6 modules) and "...02MP2" and "...20MP2" for the second plot (4 modules).
   b. If there are 'free-floating' modules which are NOT along any transect line and therefore do not have any GPS reference coordinates of any kind (usually photos are taken from the transect line 5 m from both corners of the module, facing towards the module), then pick the best corner of the module to take a GPS point and photo from that best represents the plant communities. Note both the module number and the corner's direction, for example: "...M6SW" (for module #6, GPS point taken in the southwest corner) or "...M2N" (module #2, point taken on the northern corner).
7. Inlet(s) & Outlet(s): "IN" & "OUT", respectively. If there are multiple inlets/outlets, label as "...IN1", "...IN2", etc...
8. Driving Directions: Indicate the direction you need to turn (R=right, L=left): "...RTURN", "...LTURN". if there are multiple right or left turns: "...RTURN#", "...LTURN#".
9. Parking Location: "...CAR". This is helpful for access purposes.
10. Other Photos: Label appropriately, e.g., "...ROAD" or "...SEEP"
11. Trail Junctions/Intersections: "…TR#JCT#"

To download waypoints from your GPS unit to your computer:

1. Connect the GPS to the cable connected to your computer and turn the GPS on.
2. Open DNR GPS
3. It should say 'Connected' at the bottom of the screen.
4. To download your GPS waypoints, go to Waypoint➔ Download. The GPS will beep when it has finished downloading all of the points. Make sure it has downloaded all of them.
5. To save your waypoints, go to File➔ Save to➔ File. You can save it as a text file (.txt).

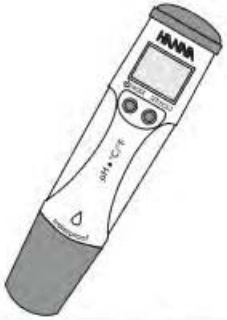
Appendix N. HANNA HI 98127 pH Meter User Manual

Download full manual from http://shop.hannainst.com/products/testers/hi98127-phep4-ph-tester.html

Instruction Manual

HI 98127 • HI 98128

Waterproof pH Testers with Replaceable Electrode



HANNA instruments

www.hannainst.com

WARRANTY

HI 98127 and **HI 98128** are **warranted for one year** against defects in workmanship and materials when used for their intended purpose and maintained according to instructions. **The electrode is warranted for a period of six months.** This warranty is limited to repair or replacement free of charge.

Damages due to accident, misuse, tampering or lack of prescribed maintenance are not covered.

If service is required, contact the dealer from whom you purchased the instrument. If under warranty, report the model number, date of purchase, serial number and the nature of the failure. If the repair is not covered by the warranty, you will be notified of the charges incurred. If the instrument is to be returned to Hanna Instruments, first obtain a Returned Goods Authorization Number from the Customer Service department and then send it with shipment costs prepaid. When shipping any instrument, make sure it is properly packaged for complete protection.

Hanna Instruments reserves the right to modify the design, construction and appearance of its products without advance notice.

Dear Customer,

Thank you for choosing a Hanna product.
This manual will provide you with the necessary information for correct operation. Please read it carefully before using the meter.
If you need additional technical information, do not hesitate to e-mail us at tech@hannainst.com.

These instruments are in compliance with the CE directives.

PRELIMINARY EXAMINATION

Remove the instrument from the packing material and examine it carefully. If any damage has occurred during shipment, immediately notify your Dealer or the nearest Hanna Customer Service Center.

Each meter is supplied with:

- **HI 73127** pH electrode
- **HI 73128** electrode removal tool
- batteries (4 x 1.5V) and instructions

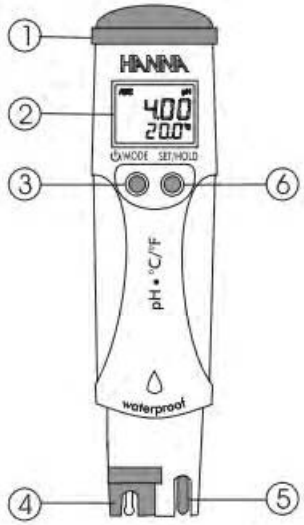
Note: Conserve all packing material until the instrument has been observed to function correctly. Any defective item must be returned in its original packing.

US DESIGN PATENT D462,024

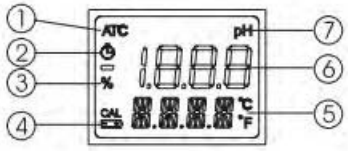
GENERAL DESCRIPTION

HI 98127 and **HI 98128** are waterproof pH and temperature meters. The housing has been completely sealed against humidity and designed to float.
All pH readings are automatically temperature compensated (ATC), and temperature values can be displayed in °C or °F units.
The meters can be calibrated at one or two points with auto-buffer recognition and against five memorized buffer values.
Measurements are highly accurate with a unique stability indicator right on the LCD.
These meters are also provided with battery level indication at start-up, and with a low battery symbol which warns the user when the batteries need to be replaced. In addition the Battery Error Prevention System (BEPS) avoids erroneous reading caused by low voltage level by turning the meter off.
The **HI 73127** pH electrode, supplied with the meters, is interchangeable and can be easily replaced.
The stainless steel encapsulated temperature sensor facilitates faster and more accurate temperature measurement and compensation.

FUNCTIONAL DESCRIPTION



1. Battery compartment
2. Liquid Crystal Display (LCD)
3. ON/OFF/MODE button
4. **HI 73127** pH electrode
5. Temperature sensor
6. SET/HOLD button



1. ATC (Automatic Temperature Compensation) indicator
2. Stability indicator
3. Battery life percentage indicator
4. Low battery indicator
5. Secondary display
6. Primary display
7. Measuring unit for primary display

CE DECLARATION OF CONFORMITY

HANNA instruments

CE

DECLARATION OF CONFORMITY

HI 98127 and HI 98128

EN 50082-1: Electromagnetic Compatibility - Generic Immunity Standard
IEC 61000-4-2 Electrostatic Discharge
IEC 61000-4-3 RF Radiated

EN 50081-1: Electromagnetic Compatibility - Generic Emission Standard
EN 55022 Enclosure, Class B

EN61010-1: Safety requirements for electrical equipment for measurement, control and laboratory use.

Recommendations for Users
Before using this product, make sure that it is entirely suitable for the environment in which it is used.
The glass bulb at the end of the electrode is sensitive to electrostatic discharges. Avoid touching the glass bulb at all times.
Any variation introduced by the user to the supplied equipment may degrade the instrument's EMC performance.
To avoid electrical shock, do not use this instrument when voltages at the measurement surface exceed 24 Vac or 60 Vdc. To avoid damages or burns, do not perform any measurement in microwave ovens.

ACCESSORIES

HI 73127	Replaceable pH electrode
HI 73128	Electrode removal tool
HI 70004P	pH 4.01 solution, 20 mL sachet (25 pcs)
HI 70006P	pH 6.86 solution, 20 mL sachet (25 pcs)
HI 70007P	pH 7.01 solution, 20 mL sachet (25 pcs)
HI 70009P	pH 9.18 solution, 20 mL sachet (25 pcs)
HI 70010P	pH 10.01 solution, 20 mL sachet (25 pcs)
HI 77400P	pH 4 & 7 solutions, 20 mL sachet (5 each)
HI 7004M	pH 4.01 solution, 230 mL bottle
HI 7006M	pH 6.86 solution, 230 mL bottle
HI 7007M	pH 7.01 solution, 230 mL bottle
HI 7009M	pH 9.18 solution, 230 mL bottle
HI 7010M	pH 10.01 solution, 230 mL bottle
HI 7061M	Electrode cleaning solution, 230 mL bottle
HI 70300M	Electrode storage solution, 230 mL bottle

IST98127R5 07/05

SPECIFICATIONS

Range	-2.0 to 16.0 pH (HI 98127) -2.00 to 16.00 pH (HI 98128) -5.0 to 60.0°C / 23.0 to 140.0°F
Resolution	0.1 pH (HI 98127) 0.01 pH (HI 98128) 0.1°C / 0.1°F
Accuracy (@20°C/68°F)	±0.1 pH (HI 98127) ±0.05 pH (HI 98128) ±0.5°C / ±1°F
Typical EMC Deviation	±0.1 pH (HI 98127) ±0.02 pH (HI 98128) ±0.3°C / ±0.6°F
Temp. Compensation	Automatic
Environment	-5 to 50°C (23 to 122°F); RH 100%
Calibration	1 or 2 points with 2 sets of memorized buffers (pH 4.01/7.01/10.01 or 4.01/6.86/9.18)
Electrode	HI 73127 pH electrode (included)
Battery	4 x 1.5V with BEPS / approx. 300 hours
Auto-off	after 8 minutes of non-use
Dimensions	163 x 40 x 26 mm (6.4 x 1.6 x 1.0")
Weight	100 g (3.5 oz)

OPERATIONAL GUIDE

To turn the meter on and check the battery status

Press and hold the ⏻/MODE button until the LCD lights up. All the used segments on the LCD will be visible for 1 second (or as long as the button is pressed), followed by the percent indication of the remaining battery life (E.g. % 100 BATT).

Taking measurements

Submerge the electrode in the solution to be tested while stirring it gently. The measurements should be taken when the stability symbol ▯ on the top left of the LCD disappears.

The pH value automatically compensated for temperature is shown on the primary LCD while the secondary LCD shows the temperature of the sample.

To freeze the display

While in measurement mode, press the SET/HOLD button. HOLD appears on the secondary display and the reading will be frozen on the LCD (E.g. pH 5.78 HOLD).

Press any button to return to normal mode.

To turn the meter off

While in normal mode, press the ⏻/MODE button. OFF will appear on the secondary display. Release the button.

Notes:

- Before taking any measurements make sure the meter has been calibrated (CAL tag present on the LCD).
- If measurements are taken in different samples successively, rinse the probe thoroughly to eliminate cross-contamination; and after cleaning, rinse the probe with some of the sample to be measured.

CALIBRATION

For better accuracy, frequent calibration of the instrument is recommended. In addition, the instrument must be recalibrated whenever:

a) The pH electrode is replaced.
b) After testing aggressive chemicals.
c) Where high accuracy is required.
d) At least once a month.

Calibration procedure

From normal measuring mode, press and hold the ⏻/MODE button until OFF on the secondary LCD is replaced by CAL. Release the button. The LCD enters the calibration mode displaying "pH 7.01 USE" (or "pH 6.86 USE" if the NIST buffer set was selected).

After 1 second the meter activates the automatic buffer recognition feature. If a valid buffer is detected then its value is shown on the primary display and REC appears on the secondary LCD. If no valid buffer is detected, the meter keeps the USE indication active for 12 seconds, and then it replaces it with WRNG, indicating the sample being measured is not a valid buffer.

For a **single-point calibration** with buffers pH 4.01, 9.18 or 10.01, the meter automatically accepts the calibration when the reading is stable; the meter displays the accepted buffer, with the message "OK 1". After 1 second the meter automatically returns to the normal measuring mode.

If a single-point calibration with buffer pH 7.01 (or pH 6.86) is desired, then after the calibration point has been accepted the ⏻/MODE button must be pressed in order to return to normal mode. After the button is pressed, the meter shows "7.01" (or "6.86") - "OK 1" and, after 1 second, it automatically returns to the normal measuring mode.

Note: It is always recommended to carry out a two-point calibration for better accuracy.

For a **two-point calibration**, place the electrode in pH 7.01 (or pH 6.86) buffer. After the first calibration point has been accepted, the "pH 4.01 USE" message appears. The message is held for 12 seconds, unless a valid buffer is recognized. If no valid buffer is recognized, then the WRNG message is shown. If a valid buffer (pH 4.01, pH 10.01, or pH 9.18) is detected, then the meter completes the calibration procedure. When the buffer is accepted, the LCD shows the accepted value with the "OK 2" message, and then the meter returns to the normal measuring mode.

Note: When the calibration procedure is completed, the CAL tag is turned on.

To quit calibration and to reset to the default values

- After entering the calibration mode and before the first point is accepted, it is possible to quit the procedure and return to the last calibration data by pressing the ⏻/MODE button. The secondary LCD displays "ESC" for 1 second and the meter returns to the normal measuring mode.
- To reset to the default values and clear a previous calibration, press the SET/HOLD button after entering the calibration mode and before the first point is accepted. The secondary LCD displays "CLR" for 1 second, the meter resets to the default calibration and the CAL tag on the LCD disappears.

SETUP

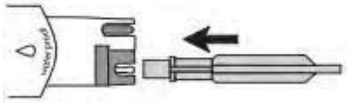
Setup mode allows the selection of temperature unit and pH buffer set.

To enter the Setup mode, press the ⏻/MODE button until CAL on the secondary display is replaced by TEMP and the current temperature unit (E.g. TEMP °C). Then:

- *for °C/°F selection*: Use the SET/HOLD button. After the temperature unit has been selected, press the ⏻/MODE button to enter the buffer set selection mode; press the ⏻/MODE button twice to return to the normal measuring mode.
- *to change the calibration buffer set*: After setting the temperature unit, the meter will show the current buffer set: "pH 7.01 BUFF" (for 4.01/7.01/10.01) or "pH 6.86 BUFF" (for NIST 4.01/6.86/9.18). Change the set with the SET/HOLD button, then press ⏻/MODE to return to normal measuring mode.

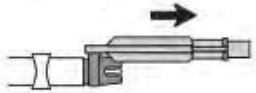
pH ELECTRODE MAINTENANCE

- When not in use, rinse the electrode with water to minimize contamination and store it with a few drops of **HI 70300** storage solution in the protective cap. DO NOT USE DISTILLED OR DEIONIZED WATER FOR STORAGE PURPOSES.
- If the electrode has been left dry, soak in storage solution for at least one hour to reactivate it.
- To prolong the life of the pH electrode, it is recommended to clean it monthly by immersing it in the **HI 7061** cleaning solution for half an hour. Afterwards, rinse it thoroughly with tap water and recalibrate the meter.
- The pH electrode can be easily replaced by using the supplied tool (**HI 73128**). Insert the tool into the electrode cavity as shown below.



- Rotate the electrode counterclockwise.

- Pull the electrode out by using the other side of the tool.



- Insert a new pH electrode following the above instructions in reverse order.

BATTERY REPLACEMENT

The meter displays the remaining battery percentage every time it is switched on. When the battery level is below 5%, the ▭ symbol on the bottom left of the LCD lights up to indicate a low battery condition. The batteries should be replaced soon. If the battery level is low enough to cause erroneous readings, the meter shows "0%" and the Battery Error Prevention System (BEPS) will automatically turn the meter off.

To change the batteries, remove the 4 screws located on the top of the meter.

Once the top has been removed, carefully replace the 4 batteries located in the compartment while paying attention to their polarity.

Replace the top, making sure that the gasket is properly seated in place, and tighten the screws to ensure a watertight seal.