



# California Rapid Assessment Method for Wetlands

Slope Wetlands  
Field Book  
ver. 6.2  
October 2017

This Slope Wetlands Field Book, version 6.2, dated October 2017 is the most current version available (as of October 2017). This module has completed both the Verification Phase and Validation Phase. See additional notes on Page 5 for Field Book status.

## Details regarding CRAM Version 6.1 and 6.2 Modules

September 1, 2018- Please note that CRAM Version 6.2 Fieldbooks have been released for the Slope and Vernal Pool modules, **without** accompanying support for data entry in eCRAM.

The current on-line data entry system for CRAM assessment data (eCRAM) accepts data collected for Slope and Vernal Pool wetlands using **ONLY Version 6.1** of those Fieldbooks. If you are required to enter assessment data for these wetland types into eCRAM, please use Version 6.1 of the appropriate fieldbook.

The Validation phase of development occurred during 2016 and 2017 for these modules, resulting in the development of Version 6.2 of the fieldbook, which incorporates updates and edits identified during the validation effort. The Level 2 Committee (the CRAM oversight committee) of the California Wetland Monitoring Workgroup (CWMW) is currently seeking funding for the development of the eCRAM data entry forms for Version 6.2. Once funding has been secured, and the data entry forms developed, Version 6.1 will be replaced with Version 6.2. Until that point in time, the L2 Committee is making both versions of the fieldbooks available. We advise practitioners to continue to utilize Version 6.1 and enter the assessment data into eCRAM as in previous years. However, for studies that anticipate collecting data in subsequent years, practitioners should consider using both modules -- Version 6.1 to enter and report data currently, and Version 6.2 so that score comparisons in the future can utilize the same version.

Please contact Sarah Pearce ([sarahp@sfei.org](mailto:sarahp@sfei.org)) with any questions.

## Basic Information Sheet: Slope Wetlands

<b>Assessment Area Name:</b>	
<b>Project Name:</b>	
<b>Assessment Area ID#:</b>	
<b>Project ID#:</b>	<b>Date</b>
<b>Assessment Team Members for This AA:</b>	
<b>Assessment Area Size:</b>	
<b>Surface water present during the assessment?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No <b>Flowing?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No	
<b>Briefly describe the hydrology of the AA (e.g., water sources, channels, swales, etc.)</b>  	
<b>AA Category:</b> <input type="checkbox"/> Pre-Restoration <input type="checkbox"/> Post-Restoration <input type="checkbox"/> Pre-Mitigation <input type="checkbox"/> Post-Mitigation <input type="checkbox"/> Pre-Impact <input type="checkbox"/> Post-Impact <input type="checkbox"/> Ambient <input type="checkbox"/> Reference <input type="checkbox"/> Training <input type="checkbox"/> Other:	
<b>Which best describes the type of wetland?</b> <input type="checkbox"/> Channeled Wet Meadow (assoc. with a fluvial channel) <input type="checkbox"/> Non-Channeled Wet Meadow <input type="checkbox"/> Channeled Forested Slope <input type="checkbox"/> Non-Channeled Forested Slope <input type="checkbox"/> Seep or Spring	
<b>Are peat soils present in the AA?</b> <input type="checkbox"/> Yes <input type="checkbox"/> No	
<b>AA Encompasses:</b> <input type="checkbox"/> entire wetland <input type="checkbox"/> portion of the wetland	
<b>Which best describes the dominant hydrologic state of the AA at the time of assessment?</b> <input type="checkbox"/> ponded/inundated <input type="checkbox"/> saturated soil, but no surface water <input type="checkbox"/> moist <input type="checkbox"/> dry	
<b>What is the apparent hydrologic regime of the wetland?</b>  <i>Perennial</i> slope wetlands contain surface water year-round, <i>seasonal</i> slope wetlands support surface water for 4-11 months of the year (in > 5 out of 10 years.) <i>Temporarily flooded</i> slope wetlands possess surface water between 2 weeks and 4 months of the year.  <input type="checkbox"/> perennial <input type="checkbox"/> seasonal <input type="checkbox"/> temporarily flooded	

**Photo Identification Numbers and Description:**

	Photo ID No.	Description
1		Looking North into the AA
2		Looking South into the AA
3		Looking East into the AA
4		Looking West into the AA
5		
6		
7		
8		
9		
10		

**Site Location Description** (including County and USGS Topographic Quadrangle if known):

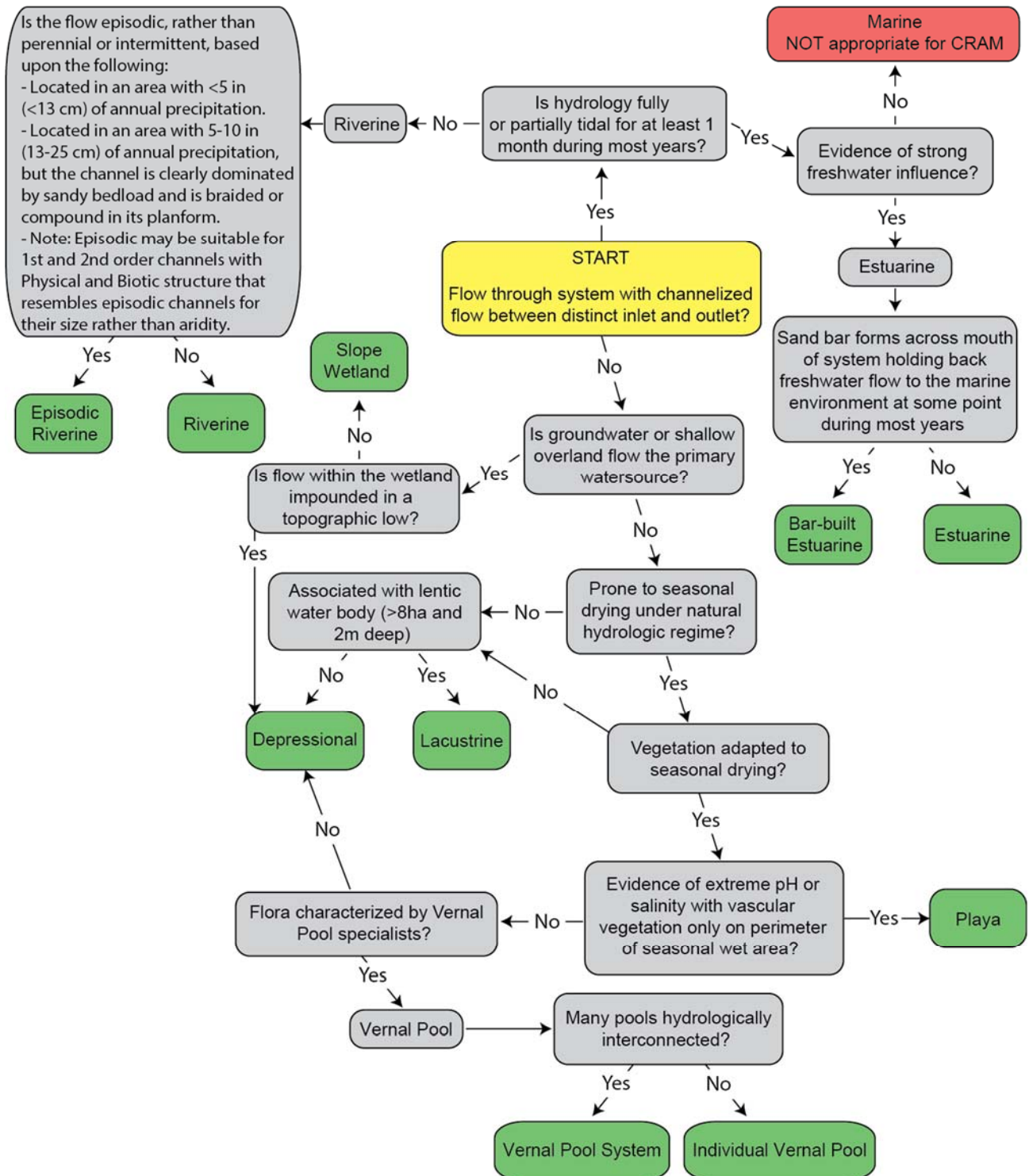
**Comments:**

### Scoring Sheet: Slope Wetlands

<b>AA Name:</b>				<b>Date</b>				
<b>Attribute 1: Buffer and Landscape Context</b>						<b>Comments</b>		
Aquatic Area Abundance (D)			Alpha		Numeric			
Buffer								
Buffer submetric A: Percent of AA with Buffer		Alpha					Numeric	
Buffer submetric B: Average Buffer Width								
Buffer submetric C: Buffer Condition								
<b>Raw Attribute Score</b> = $D + [C \times (A \times B)^{1/2}]^{1/2}$ (do not round)					<b>Final Attribute Score =</b> <b>(Raw Score/24) x 100</b>			
<b>Attribute 2: Hydrology</b>								
Water Source			Alpha		Numeric			
Hydroperiod								
Hydrologic Connectivity (all but Channeled)								
Hydro Connectivity submetric A: Bank Height Ratio		Alpha	Numeric					
Hydro Connectivity submetric B: Percent Dewatered								
Hydrologic Connectivity for Channeled ( <i>avg. of submetrics A-B</i> )								
<b>Raw Attribute Score</b> = sum of numeric scores					<b>Final Attribute Score =</b> <b>(Raw Score/36) x 100</b>			
<b>Attribute 3: Physical Structure</b>								
Structural Patch Richness			Alpha		Numeric			
Topographic Complexity								
<b>Raw Attribute Score</b> = sum of numeric scores					<b>Final Attribute Score =</b> <b>(Raw Score/24) x 100</b>			
<b>Attribute 4: Biotic Structure</b>								
Plant Community Composition (submetric A is not applicable for Non-Channeled meadows)								
Plant Community submetric A: Number of plant layers		Alpha	Numeric					
Plant Community submetric B: Number of Co-dominant species								
Plant Community submetric C: Percent Invasive species								
Plant Comm. Composition ( <i>avg. of submetrics A-C or B-C</i> )								
Horizontal Interspersion			Alpha		Numeric			
Plant Life Forms								
<b>Raw Attribute Score</b> = sum of numeric scores					<b>Final Attribute Score =</b> <b>(Raw Score/36) x 100</b>			
<b>Overall AA Score</b> (average of four final Attribute Scores)								



## Identify Wetland Type



**Figure 1:** Flowchart to determine wetland type.

## Slope Wetlands

Slope Wetland is a broad category of groundwater-dominated wetlands inclusive of Channeled and Non-channeled Wet Meadows, Channeled and Non-channeled Forested Slopes, and Seeps and Springs sub-types. In these wetlands groundwater may emerge into the root zone or across the ground surface seasonally or perennially, but mainly has unidirectional flow. The term “slope” refers to the uni-directional flow of ground and surface water within the wetland, rather than to a geomorphic feature (e.g. hillslope, toe-slope).

All five of the wetland sub-types have completed the Validation Phase of development (see <http://cramwetlands.org/about>). However, none of the sub-types have completed the sixth, and final phase of development, a statewide or regional Ambient Survey. This however does not preclude the use of this module.

The wetland sub-types have experienced different development pathways:

- Both the Channeled Wet Meadow and Non-Channeled Wet Meadow sub-types were included in Verification Phase assessments in 2012 in the Sierra Nevada and Modoc regions, 2013 in Santa Rosa, 2014 in Central and Southern California, and 2016 in statewide National Wetland Condition Assessments sites. The 2015 Validation Phase sites are distributed statewide.
- The Channeled Forested Slope and Non-channeled Forested Slope wetland sub-types were not included in the 2012 Verification Phase of module development. In 2013 and 2014 a limited number of field sites were tested in Santa Rosa, and Central and Southern California. The 2015 Validation Phase sites did include a small number of Forested Slope wetlands. Although this wetland sub-type has only been tested on a relatively small number of sites statewide (~20), this fieldbook represents the best currently available information for conducting assessments in Forested Slope wetlands. The division between Channeled and Non-channeled Forested Slope wetlands was enacted during the 2017 Version 6.2 update of the module.
- The Seeps and Springs wetland sub-type was not included in the 2012 Verification Phase of module development. In 2014 a limited number of field sites were tested during the Verification Phase of development in Central and Southern California. A limited number of sites were included in the 2015 Validation Phase fieldwork. As with the Forested Slope wetland sub-type, the Seeps and Springs sub-type has only been tested on a relatively small number of sites statewide (~8), but this fieldbook represents the best currently available information for conducting assessments in Seep and Spring wetlands.

## Wet Meadow

Wet meadows depend on groundwater rising to the surface or into the root zone for a period of time long enough to create hydric soil conditions that supports wetland vegetation.

According to the existing CRAM classification system for wetlands, a wetland should be classified as wet meadow if it meets all five of the following requirements:

- The overall hydrology of the meadow that contains the AA is dominated by groundwater, rather than dominated by channelized surface flow between distinct inlets and outlets, although a channel with surface flow may be present;
- Flow is not impounded in a topographic low;



- Variations in the moisture of the root zone of the AA are mainly controlled by variations in water-table height (i.e., minimum depth to saturated soil or minimum depth to the surface of the free-standing piezometric level, relative to the wetland surface);
- Less than 50% of the area is perennially or seasonally covered by standing (i.e., not flowing) and open (i.e., not supporting at least 5% cover of vegetation) surface water;
- Less than 30% of the AA is forested (over at least 0.2 ha).

A wet meadow AA can include a variety of geomorphic features or elements, including areas of bare mineral sediment, peat or highly organic soils, cobbles and boulders, fluvial channels, bedrock outcrops, natural levees, breaks in topographic slope, paleo shorelines, etc. They can have seasonal and perennial areas of standing open water that do not cover more than about 50% of the AA.

Wet meadows have fine-textured soil material (Weixelman et al 2011) which can be either mineral or peat soils, or a combination of both. While previous detailed studies and classifications have separated meadows with peat soils from those with mineral soils (e.g. Cooper and Wolf, 2005; Weixelman and Cooper, 2009; Weixelman et al, 2011), this module of CRAM does not make distinctions based upon the soil or mix of soil types present within the wetland. This module is appropriate to assess wet meadows of all soil types and mixes of types.

Groundwater can enter the root zone of a wet meadow by rising vertically or by flowing from adjacent uplands. For California as a whole, the natural moisture regimes of most wet meadows are mainly controlled by groundwater driven by local precipitation. In other words, precipitation (rain, snow, fog drip, etc) provides moisture to the groundwater basin that then feeds the wetland, through upwelling, emergence along toe slopes, or interactions with surface water. In alpine wet meadows, the melt water from wet meadow snowpacks strongly influences local water table heights (Laubhan et al 2004). In the Central Valley and sub-alpine Coast Ranges, fog drip can be an important source of groundwater for wet meadows (Dawson 1998, USNPS 2009).

Natural sources of water other than groundwater that can influence wet meadows include over-bank flooding from rivers and streams, surface runoff from adjacent uplands, and direct precipitation, which can include rainfall, snowfall, frost, dew, and fog drip. However, groundwater fluctuations dominate the moisture regime of the root zone of wet meadows, especially during the growing season. The plant community of wet meadows is highly correlated to spatial and temporal variability in groundwater height as well as average seasonal groundwater heights (Loheide et al 2008 and references cited therein).

Wet meadows associated with fluvial channels are influenced by the fluvial flow levels throughout the year, as well as the magnitude and frequency of overbank stream flooding. Groundwater recharge can occur during overbank flooding, while horizontal recharge can occur through channel banks during high flows that do not exceed the channel banks. In addition, beaver dams can impact local water levels, overbank flooding, and in-channel and floodplain sediment deposition.

Although wet meadows are dominated by groundwater in the root zone, some meadows are associated with fluvial riverine channels while others do not contain any distinct channel and have only sub-surface flow or surface sheet flow. The meadows with channels often have unique features that are not found in those without channels. These systems need to be assessed differently using CRAM, and so the CRAM classification splits wet meadows into two types: Channeled Wet Meadows and Non-channeled Wet Meadows.

### **Channeled Wet Meadow sub-type:**

Meadows associated with fluvial channels often have a zone of woody riparian vegetation such as willow or alder species, which other meadows may not have. They also have more complex topography than Non-channeled Wet Meadows due to the variation in elevation from channels, floodplain benches, oxbows, natural levees, or other riverine features. These types of meadows are sometimes called “riparian meadows” because they occur along streams or rivers (Weixelman et al. 2011). However, CRAM uses a more inclusive definition of the word riparian, which is based on the definition used by the Technical Advisory Team for the Procedures For Discharges Of Dredged Or Fill Material To Waters Of The State (formerly known as the California Wetland and Riparian Area Protection Policy) and the National Research Council, and thus does not use the word to describe wet meadows associated with a channel.

**Riparian:** Riparian areas exist between aquatic and non-aquatic areas and are distinguished by gradients in biophysical conditions, ecological processes, and biota. They are areas through which surface and subsurface hydrology interconnect aquatic areas and connect them with their adjacent non-aquatic areas. They can include wetland areas, non-wetland aquatic areas, and those portions of non-aquatic areas that significantly influence exchanges of energy and matter with aquatic areas (NRC 2001).

Riparian areas are the zone of transition between any aquatic feature and adjacent uplands, not just the area along riverine systems with woody vegetation. In order to remain consistent with this widely accepted use of the word riparian, the meadow type associated with riverine channels has been termed the Channeled Wet Meadow sub-type. However it should be clear that this refers to the same systems that are termed Riparian low, middle, and high gradient in the hydrogeomorphic classification of Weixelman et al. 2011 (Figure 2).

This sub-type includes meadows that have a channel through the majority of the meadow. Due to variations in water and/or sediment supply, groundwater upwelling or infiltration, concentration of surface flows, variations in slope, or disturbance, channels conveying surface water through a meadow can appear or disappear. In instances with a discontinuous channel through a meadow, the practitioner should decide if the majority of the meadow contains a distinct channel.

### **Non-channeled Wet Meadow sub-type:**

Many meadows do not contain a stream or river channel and are dominated by groundwater throughflow or surface water sheet flow. They may have ditches or rills but not complete channels. These usually have few or no woody species and the vegetation is dominated by graminoids and forbs. They sometimes have conifers or shrubs where part of the meadow is drying and upland species are encroaching, or when woody species adapted to wetland conditions are present. The gradient can range from very flat to steep, depending on the landscape position of the meadow (Figure 2). This wetland type can include meadows, broad swales, wide riverine floodplains or terraces with <30% woody vegetation cover, and marine terraces, among others.

CRAM Classification	Channeled Wet Meadow	Non-Channeled Wet Meadow
Hydrogeomorphic Classification (Weixelman et al, 2011)	Riparian Low Gradient Riparian Middle Gradient Riparian High Gradient	Subsurface Low Gradient Subsurface Middle Gradient Subsurface High Gradient Basin Peatland Mound Peatland Discharge Slope Peatland Depressional Seasonal Depressional Perennial Lacustrine Fringe Dry Discharge Slope

**Figure 2.** Classification of Wet Meadow wetlands in CRAM and the relation to Hydrogeomorphic classification (Weixelman et al, 2011).

### Forested Slope

Forested Slope wetlands are separated from wet meadows, also called non-forested slope wetlands, by the percent coverage of trees. Forested Slope wetlands are slope wetlands larger than 0.5 acres (0.2 ha) that form due to a seasonal or perennial emergence of groundwater into the root zone and in some cases onto the ground surface, and that support more than 30% cover of tall woody vegetation (e.g. Lodgepole pines, willows, oaks, or other tree species), as evidenced in aerial imagery, a LiDAR-derived tree height hillshade, or other sources of plant height information (Cayce et al., 2012). These wetlands can adjoin non-forested slope wetlands (i.e., Wet Meadows) or other wetland types. They can include wetland areas with less than 30% woody cover (i.e., non-forested slope wetlands) that are not larger than 0.5 acres (0.2 ha). Mapping standards exist to define the boundary of forested slope wetlands within forested areas, where the boundary may not be obvious (see Cayce et al., 2012).

#### Channeled Forested Slope sub-type:

Forested Slope wetlands associated with fluvial channels often will have more complex vegetation directly adjacent to the channel, as well as more complex topography as compared to Non-channeled Forested Slope wetlands.

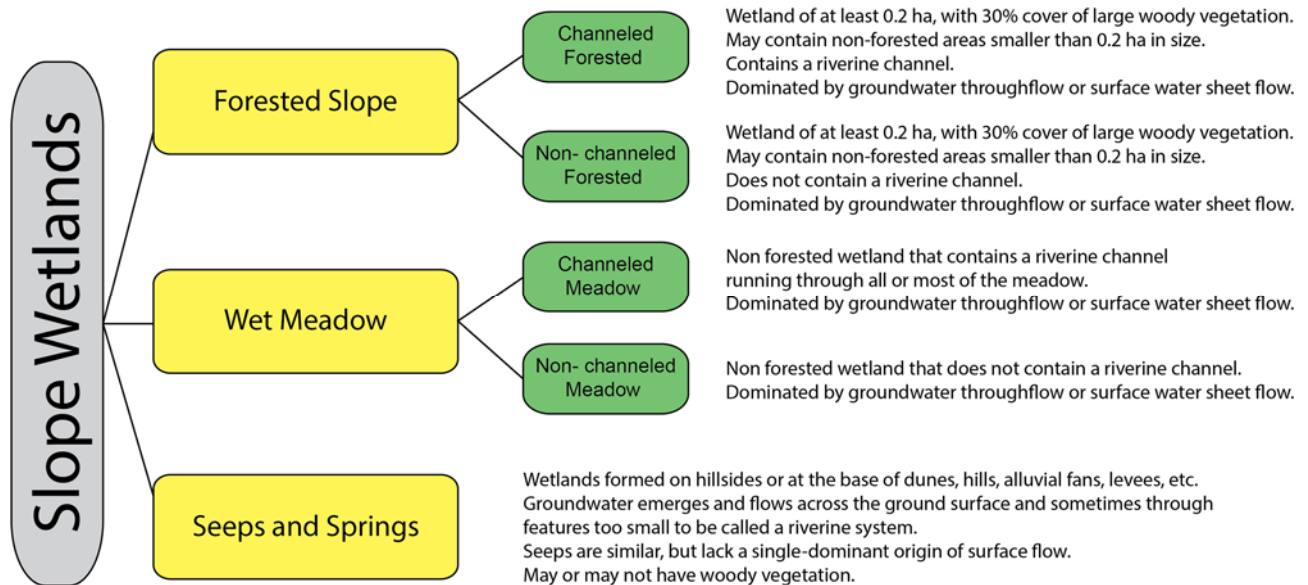
This sub-type includes forested slopes that have a channel through the majority of the wetland. Due to variations in water and/or sediment supply, groundwater upwelling or infiltration, concentration of surface flows, variations in slope, or disturbance, channels conveying surface water through a wetland can appear or disappear. In instances with a discontinuous channel through a wetland, the practitioner should decide if the majority of the wetland contains a distinct channel.

#### Non-channeled Forested Slope sub-type:

Many forested slope wetlands do not contain a stream or river channel and are dominated by groundwater throughflow or surface water sheet flow. They may have ditches or rills but not complete channels. The gradient can range from very flat to steep, depending on the landscape position of the wetland. This wetland type can include forested wetlands adjacent to wet meadows, or wide riverine floodplains or terraces that are located far away from the active riverine channel, among others.

## Seeps and Springs

These wetlands occur on hillsides or at the base of dunes, hills, alluvial fans, levees, etc. Springs are indicated by groundwater emerging and flowing across the ground surface and sometimes through indistinct or very small rivulets, runnels, and other features that are too small to be called a creek or riverine system. They often lack the features of riverine channels, such as a thalweg or floodplain. Seeps are similar to springs but lack a single-dominant origin of surface flow. Most of the flow is confined to the root zone and is not evident on the ground surface. Seeps and Springs may have, or may lack woody vegetation; no distinction is made in CRAM.



**Figure 3:** Slope wetland types and sub-types.

## Establish the Assessment Area (AA)

Selection of the Assessment Area (AA) will be based upon the purpose of the assessment. For example, for ambient assessments, the AA will be based upon the location randomly selected from the Sample Universe (the map of all of the wetlands of that class within the area of interest). For project assessments, the AA will be based upon the established Sample Frame (the map of the wetland class within the project footprint, filled completely with potential AAs). In both instances, the exact AA boundaries should be defined based upon field conditions and specific features (Tables 1 and 2).

For Wet Meadow and Forested Slope wetlands, the AA should at least encompass the gradient from the upland edge to the core, or lowest central elevation of the wetland. Seep and Springs slope wetlands should include from the source of groundwater seepage or emergence, downslope to the wetland boundary or to where a transition in wetland type occurs, inclusive of any overhanging riparian vegetation. The recommended AA size is 1 ha (Table 3), however variations on this size recommendation allow for assessment of all slope wetland systems.

For small slope wetlands of all types (1 ha or smaller), the AA should include the entire wetland (Figure 4) and any directly overhanging riparian vegetation. For medium sized wetlands, the AA should ideally be a 1 ha rectangle with one edge oriented perpendicular to the overall wetland flow direction. The rectangle should extend from the upland edge to either the channel centerline (Figure 5), the topographic low point of the meadow or wetland (Figure 6), or all the way across the wetland to the opposite upland edge (Figure 7). In larger wetlands, the AA size can be increased up to 2 ha so that it can include the upland edge and channel centerline or topographic low point. Variations in AA size for wetlands between 1 and 2 ha should consider the purpose of the assessment and maximize the variability within the wetland and the practitioners' ability to accurately assess the area defined. It is acceptable to include the entire wetland in the AA if it is smaller than 2 ha and the practitioner decides that it is appropriate. Alternatively, the AA can include a 1.0 ha portion of a wetland that is between 1 and 2 ha in total area, or such a wetland could be split into 2 AAs of equal size.

In very large meadows it may not be possible to create AAs that all include the upland edge. In these systems a random grid of 1 ha AAs can be placed within the boundaries of the wetland (Figure 8). One or more of these can be assessed, depending on the purpose of the assessment. Where the boundaries of the wetland overlap with the squares in the grid, those squares that have more than half of their area within the wetland boundary will be included in the Sample Frame for assessment. See the CRAM User's manual and the Technical Bulletin at [www.cramwetlands.org](http://www.cramwetlands.org) for additional guidance on assessing large areas for project evaluations.

The upland edge of all wetlands will include any woody riparian vegetation that directly overhangs the wetland. The entire footprint (i.e the dripline) of any particular tree or shrub that overhangs the wetland is included in the AA. If overhanging riparian vegetation does not exist, include an area 2 meters wide extending landward from the upland transition as part of the AA.





**Figure 4.** The AA in a small meadow encompasses the entire wetland, with boundary drawn at the upland transition edge, inclusive of overhanging vegetation.



**Figure 5.** The AA in a medium Channeled Wet Meadow extends from the upland edge (inclusive of overhanging vegetation) to the centerline of the riverine channel, and is oriented with long edge perpendicular to the overall direction of flow in the meadow.



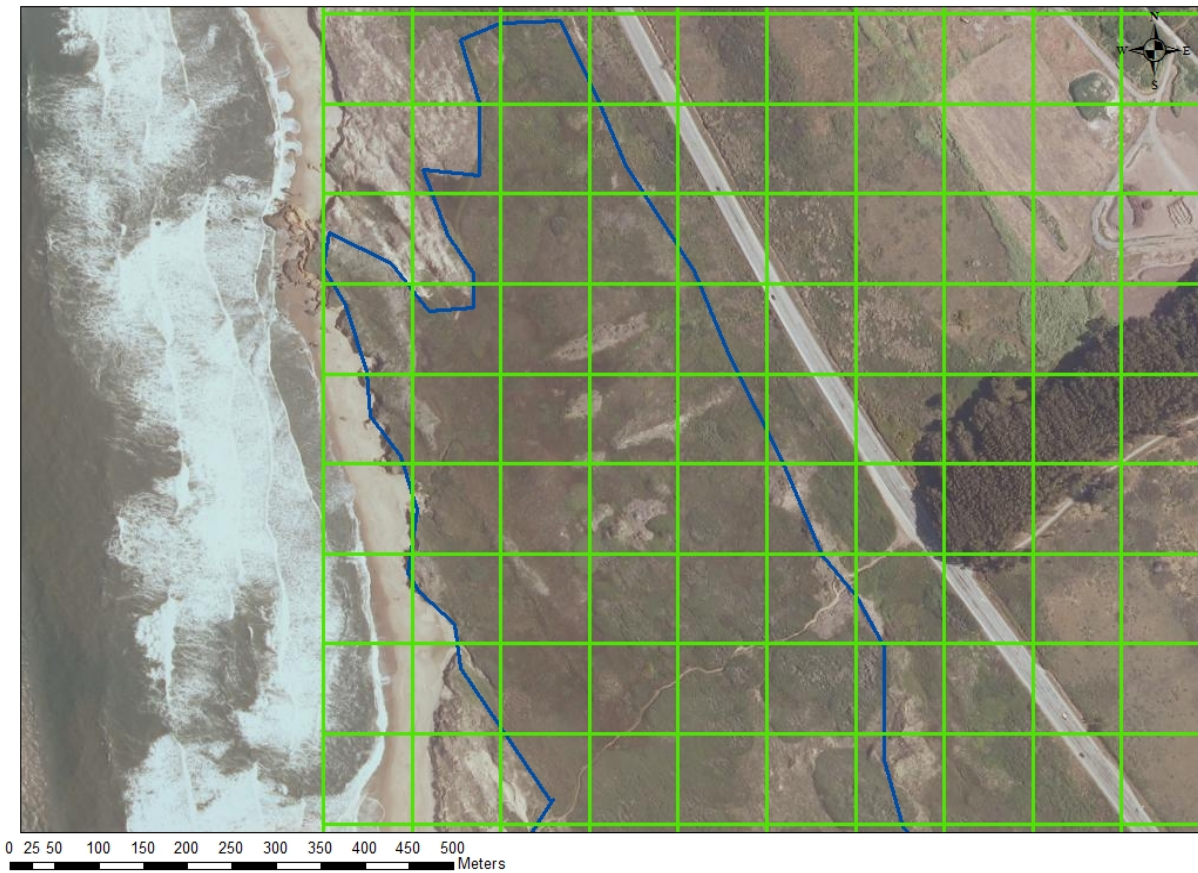


**Figure 6.** The AA in a medium Non-Channelled Wet Meadow extends from upland edge (inclusive of overhanging vegetation) to center low point of meadow.



**Figure 7.** The AA in a medium sized Wet Meadow that extends across the entire meadow, from upland edge to upland edge (inclusive of overhanging vegetation).





**Figure 8.** A random grid (green lines) placed over the extent of the wetland resource (blue polygon).

The upland transition zone should be identified by the practitioner, and is defined based upon a suite of geomorphic and vegetative indicators, such as breaks in slope, limit of stands of conifers, change in plant community, change in soil moisture, etc.

**Table 1: Examples of features that *should* be used to define AA boundaries for Slope Wetlands.**

*\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for photos of each of the following examples.*

- major changes in meadow confinement or slope
- major fluvial channel confluences
- diversion ditches
- end-of-pipe large discharges
- water falls
- open water areas more than 30 m wide on average or broader than the wetland
- transitions between wetland types (e.g. depressional, lacustrine, etc)
- weirs, culverts, dams, drop- structures, levees, and other flow control, grade control, or water height control structures
- frequently used paved roadways that threaten wildlife
- artificial berms, levees, dikes, dams, etc that direct or confine runoff
- uplands at least 10m wide
- Project boundaries (when the purpose is to assess a project- see guidance on CRAM website)

**Table 2: Examples of features that *should not* be used to define AA boundaries for Slope Wetlands.**

*\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for photos of each of the following examples.*

- **at-grade**, unpaved, single-lane, infrequently used roadways or crossings
- bike paths and jogging trails **at grade**
- bare ground within what would otherwise be the AA boundary
- equestrian trails
- fences (unless designed to obstruct the movement of wildlife)
- property boundaries, unless access is not allowed or the purpose is to assess a project within a boundary
- spatial changes in land cover or land use along the wetland border
- state and federal jurisdictional boundaries (unless required for the purpose of the assessment)

**Table 3: Recommended maximum and minimum AA sizes for Slope Wetlands.**

Note: Wetlands smaller than the recommended AA sizes can be assessed in their entirety.

Wetland Type	Recommended AA Size and Shape
Wet Meadow	<p>1.0 ha (e.g., a rectangle about 200m x 50m); no minimum size, maximum size is 2.0 ha (e.g. a rectangle about 200m x 100m).</p> <p>Shape should be a rectangle with edge oriented perpendicular to the overall meadow flow direction extending from at least the upland transition edge to the low point of the meadow (or channel centerline). If size allows, extend AA from upland transition edge across to the opposite upland transition edge. If the entire meadow fits within the size limitations, assess the entire meadow, with the AA boundary following the upland transition edge, plus any overhanging vegetation.</p>
Forested Slope	<p>1.0 ha (e.g., a rectangle about 200m x 50m); no minimum size, maximum size is 2.0 ha (e.g. a rectangle about 200m x 100m).</p> <p>Shape should be a rectangle with edge oriented perpendicular to the overall wetland flow direction extending from at least the upland transition edge to the low point of the wetland (or channel centerline). If size allows, extend AA from upland transition edge across to the opposite upland transition edge. If the entire wetland fits within the size limitations, assess the entire wetland, with the AA boundary following the upland transition edge, plus any overhanging vegetation.</p>
Seeps and Springs	<p>0.5 ha (e.g., a square 75m x 75m, but shape can vary); no minimum size, maximum size is 2.0 ha.</p>

As stated in the CRAM User's Manual (CWMW, 2013), a CRAM assessment area should only include a single wetland type. This has caused some confusion about how to define the AA for wet meadows and forested slopes that contain a riverine channel. For the Channeled Wet Meadow and Channeled Forested Slope sub-type, the assessment area may include the entire riverine channel within the wetland for assessment areas that span the entire wetland width, or a portion of the riverine channel (to the centerline) for assessment areas that only span part of the wetland width. This could potentially result in a slope wetland assessment area overlapping with a Riverine wetland assessment area, which is acceptable. The type of wetland that is the focus of the assessment determines where and how an AA is drawn. Whether the assessment is for a Slope or a Riverine wetland, a map of the wetland resource (the sample universe) will be the starting point for selecting potential assessment areas. If the Slope wetland is the focus, the map will show polygon areas representing the slope wetlands, from which a Slope wetland assessment area will be selected. If the Riverine wetland is the focus, the map will show a line (or sometimes a polygon for wide river systems) representing the channel, from which a Riverine wetland assessment area will be selected. Each of these assessment areas can include portions of the other wetland type, however those portions are not the focus of the assessment. For each wetland type module, the metrics focus upon the important aspects of that wetland type, with only minimal influence from the other wetland type.

## Attribute 1: Buffer and Landscape Context

CRAM includes two metrics to assess the Buffer and Landscape Context attribute of wetlands: the Aquatic Area Abundance metric and the Buffer metric. The Buffer metric is composed of three submetrics: (1) percentage of the AA perimeter that has a buffer; (2) the average buffer width; and (3) the condition or quality of the buffer.

### Metric 1: Aquatic Area Abundance

**Definition:** The aquatic area abundance of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. Wetlands close to each other have a greater potential to interact ecologically and hydrologically, and such interactions are generally beneficial.

Wetlands are often important components of local mosaics of multiple types of habitat. The components of such mosaics tend to be inter-connected by the flow of water and movements of wildlife, such that they have additive influences on the timing and extent of many landscape-level processes, including flooding, filtration of pesticides and other contaminants, and wildlife support. In turn, these processes can strongly influence the form and function of wetlands. The functional capacity of a wetland is therefore determined not only by its intrinsic properties, but by its relationship to other habitats across the landscape. Several researchers have concluded that landscape-scale variables are often better predictors of stream and wetland integrity than localized variables (Roth *et al.* 1996; Scott *et al.* 2002). Wetlands that are close are better able to provide refuge and alternative habitat patches for metapopulations of wildlife, to support transient or migratory wildlife species, and to function as sources of colonists for primary or secondary succession of newly created or restored wetlands

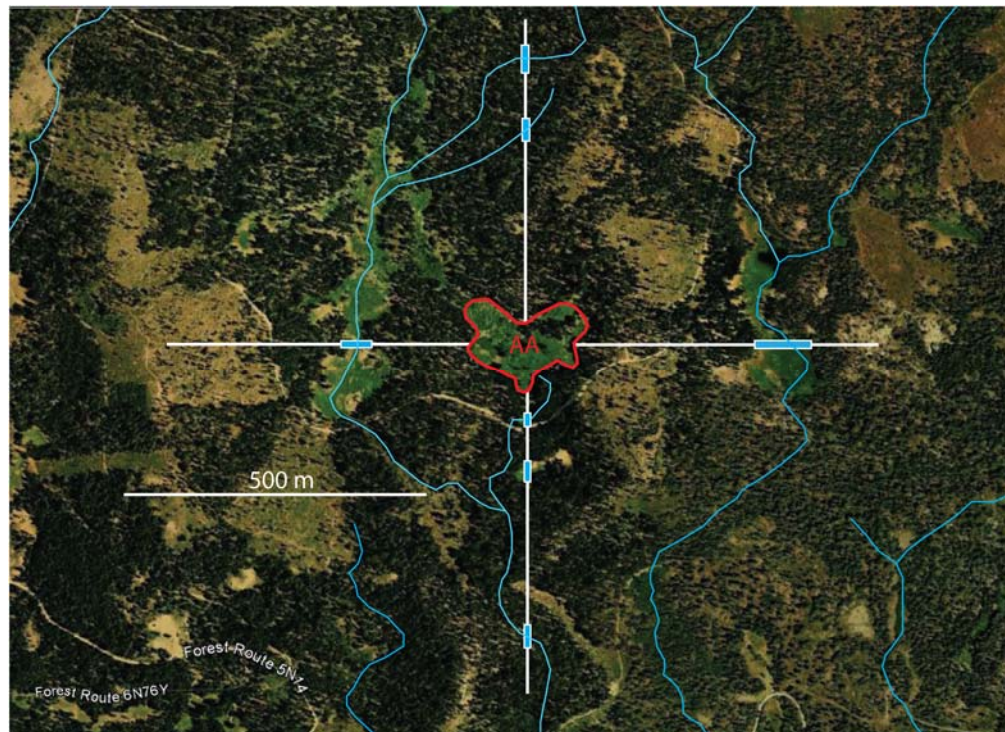
For the purposes of CRAM, 500 m is the maximum distance between wetlands and other water-dependent habitats that does not by itself function as a barrier to the easy regular movements of small mammals, birds, amphibians, or reptiles. Greater distances between the wetland of interest and neighboring habitats are considered breaks in landscape connectivity.

**Special Considerations for Isolated Wetlands:** Isolated wetlands will score lower in this metric than wetlands that are close to other aquatic resources. These wetlands may be highly functioning on an individual basis, but this metric measures the potential to connect to other areas of aquatic resources that can provide the landscape level functions outlined above. Within the landscape, wetlands occur within a hydrologic continuum between being completely “isolated” and connected with other aquatic areas. At its simplest, spatial isolation is the result of the distances between wetlands or other aquatic areas. For a particular landscape setting, the frequency distribution of these distances will be a function of both wetland density and the pattern of their distribution (i.e., dispersed or clumped). These spatially isolated wetlands tend to only receive inputs of water from direct precipitation, groundwater, and within-catchment runoff. Although wetlands can be geographically isolated in the landscape and completely surrounded by upland habitat (Tiner 2003b), hydrologic interactions between such wetlands and other waters can occur via ground-water connections or intermittent surface-water connections during flooding (e.g., spillage and/or through longer duration soil-water pathways). In some instances, these wetlands may have little opportunity for groundwater interactions with other wetlands due to the geometry of the watershed and groundwater basins. However, the same wetlands may be connected with other wetlands through wildlife interactions.

## Procedure to Assess this Metric for Slope Wetlands

Aquatic Area Abundance for slope wetlands should be assessed by measuring the proportion of aquatic resources along four transects in the cardinal directions in the landscape surrounding the AA.

On digital or hardcopy site imagery, draw a straight line extending 500 m from the AA boundary in each of the four cardinal compass directions, in lines originating from the approximate center point of the AA (Figure 9). Along each transect line, estimate the percentage of the segment that passes through wetland or aquatic habitat of any kind, including riverine wetlands or open water. Use the worksheet below to record these estimates.



**Figure 9.** Example of Aquatic Area Abundance measurement. Areas of aquatic habitat (here, either other wet meadow or riverine wetland) are highlighted in blue. This example has an average of 20% of the transects passing through aquatic habitat, and thus scores as a “C”.



### Worksheet for Aquatic Area Abundance Metric

Percentage of Transect Lines that Contains Wetland or Aquatic Habitat of Any Kind	
Segment Direction	Percentage of Transect Length That is an Aquatic Feature
North	
South	
East	
West	
Average Percentage of Transect Length That Is an Aquatic Feature	

**Table 4: Rating for Aquatic Area Abundance.**

Rating	Alternative States
<b>A</b>	An average of 46 – 100 % of the transects is an aquatic feature of any kind.
<b>B</b>	An average of 31 – 45 % of the transects is an aquatic feature of any kind.
<b>C</b>	An average of 16 – 30 % of the transects is an aquatic feature of any kind.
<b>D</b>	An average of 0 – 15 % of the transects is an aquatic feature of any kind.

### **Metric 2: Buffer**

**Definition:** The buffer is a zone of transition between the immediate margins of a wetland and its surrounding environment that is likely to help protect the wetland from anthropogenic stress and natural disturbance. For the purposes of CRAM, the buffer is an area adjoining the AA that is in a natural or semi-natural state and currently not dedicated to anthropogenic uses that would severely detract from its ability to entrap contaminants, discourage visitation into the AA by people and non-native predators, or otherwise protect the AA from anthropogenic stress and natural disturbance. Because regulation and protection of wetlands historically did not extend to adjacent uplands, these areas in some cases have been converted to recreational, urban, agricultural, or other human land uses and might no longer provide their critical buffer functions for wetlands. Areas adjoining wetlands that probably do not provide protection are not considered buffers.

Buffers can protect wetlands by filtering pollutants, providing refuge for wetland wildlife during times of high water levels, acting as barriers to disruptive incursions by people and pets into wetlands, and moderating predation by ground-dwelling terrestrial predators. Buffers can also reduce the risk of invasion by non-native plants and animals, by either obstructing terrestrial corridors of invasion or by helping to maintain the integrity and therefore the resistance of wetland communities to invasions. The ability of buffers to protect a wetland increases with buffer extent along the wetland perimeter. For some kinds of stress, such as predation by feral pets or disruption of plant communities by cattle, small breaks in buffers may be adequate to nullify the benefits of an

existing buffer. However, for most stressors, small breaks in buffers caused by such features as trails and small, unpaved roadways probably do not significantly disrupt the buffer functions.

### Procedure to Assess this Metric for Slope Wetlands

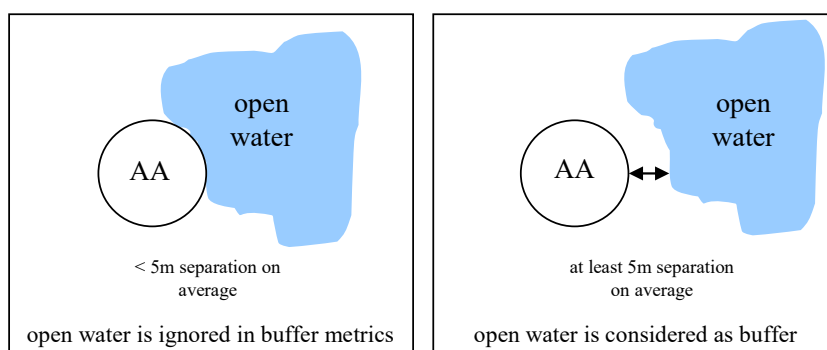
This metric is assessed by visually estimating the total percentage of the perimeter of the AA that adjoins land cover types that usually provide buffer functions, using appropriate scale aerial imagery and field observations (see Table 5). To be considered as buffer, a suitable land cover type must be at least 5 m wide and extend along the perimeter of the AA for at least 5 m. The maximum width of the buffer is 250 m. At distances beyond 250 m from the AA, the buffer becomes part of the landscape context of the AA.

#### Special Notes:

*\*Any area of open water at least 30 m wide that is directly adjoining the AA, such as a lake, large river, or large slough, is not considered in the assessment of the buffer (Figure 10). Such open water is considered to be neutral, and is neither part of the wetland nor part of the buffer. There are three reasons for excluding large areas of open water (i.e., more than 30 m wide) from Assessment Areas and their buffers.*

- 1) Assessments of buffer extent and buffer width are inflated by including open water as a part of the buffer.*
- 2) While there may be positive correlations between wetland stressors and the quality of open water, quantifying water quality generally requires laboratory analyses beyond the scope of rapid assessment.*
- 3) Open water can be a direct source of stress (i.e., water pollution, waves, boat wakes) or an indirect source of stress (i.e., promotes human visitation, encourages intensive use by livestock looking for water, provides dispersal for non-native plant species), or it can be a source of benefits to a wetland (e.g., nutrients, propagules of native plant species, water that is essential to maintain wetland hydroperiod, etc.).*

*\*However, any area of open water that is within 250 m of the AA but is not adjoining the AA is considered part of the buffer.*



**Figure 10:** Diagram showing when open water is considered in the Buffer metrics.

**Table 5: Guidelines for identifying wetland buffers and breaks in buffers.**

*\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for photos of each of the following examples.*

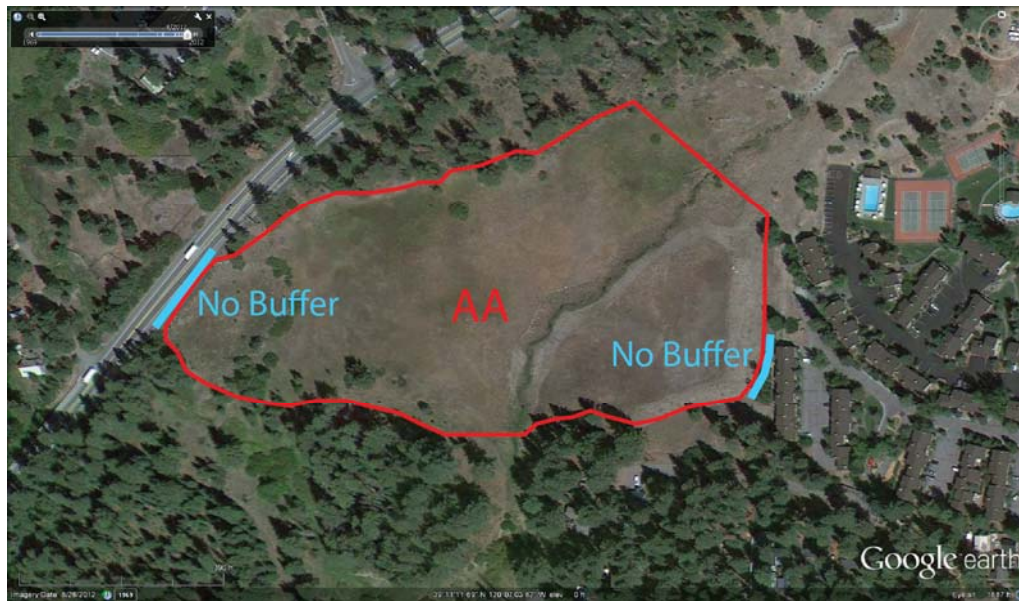
Examples of Land Covers Included in Buffers	Examples of Land Covers Excluded from Buffers
<ul style="list-style-type: none"> <li>• at-grade bike and foot trails, or trails (with light traffic)</li> <li>• horse trails</li> <li>• natural upland habitats</li> <li>• nature or wildland parks</li> <li>• range land and pastures</li> <li>• railroads (with infrequent use: 2 trains per day or less)</li> <li>• roads not hazardous to wildlife, such as seldom used rural roads, forestry roads or private roads</li> <li>• swales and ditches</li> <li>• vegetated levees</li> </ul>	<p>Notes: buffers do not cross these land covers; areas of open water adjacent to the AA are not included in the assessment of the AA or its buffer.</p> <ul style="list-style-type: none"> <li>• commercial developments</li> <li>• fences that interfere with the movements of wildlife (i.e. food safety fences that prevent the movement of deer, rabbits and frogs)</li> <li>• intensive agriculture (row crops, orchards and vineyards)</li> <li>• golf courses</li> <li>• paved roads (two lanes or larger)</li> <li>• active railroads (more than 2 trains per day)</li> <li>• lawns</li> <li>• parking lots</li> <li>• horse paddocks, feedlots, turkey ranches, etc.</li> <li>• residential areas</li> <li>• sound walls</li> <li>• sports fields</li> <li>• urbanized parks with active recreation</li> <li>• pedestrian/bike trails (with heavy traffic)</li> <li>• active logging operations</li> </ul>

### Submetric A: Percent of AA with Buffer

**Definition:** This submetric is based on the relationship between the extent of buffer and the functions they provide to aquatic areas. Areas with more buffer typically provide more habitat values, better water quality and other valuable functions. This submetric is scored by visually estimating from aerial imagery (with field verification) the percent of the AA perimeter that is surrounded by at least 5 meters of buffer land cover.

### Procedure to Assess this Metric for Slope Wetlands

In the examples below (Figure 11), most of the AA has buffer, however a portion of each perimeter does not have buffer, as it is directly adjacent to either a road, houses, or a golf course. The remaining portion of the perimeter does have at least 5 m of buffer land cover, in these examples either natural upland habitat, or other wetland area.



**Figure 11:** Diagrams of AAs with buffer and non-buffer land cover types. In the top example, the AA has approximately 90% buffer, with the road and the houses representing adjacent non-buffer land cover. In the lower example, the AA has approximately 65% buffer, with the road and the golf course representing adjacent non-buffer land cover.

### **Percent of AA with Buffer Worksheet.**

In the space provided on the datasheet, make a quick sketch of the AA, or perform the assessment directly on the aerial imagery; indicate where buffer is present, estimate the percentage of the AA perimeter providing buffer functions, and record the estimate amount in the space provided.

**Table 6: Rating for Percent of AA with Buffer.**

<b>Rating</b>	<b>Alternative States (excluding directly adjoining open-water areas)</b>
<b>A</b>	Buffer is 75 - 100% of AA perimeter.
<b>B</b>	Buffer is 50 – 74% of AA perimeter.
<b>C</b>	Buffer is 25 – 49% of AA perimeter.
<b>D</b>	Buffer is 0 – 24% of AA perimeter.

## Submetric B: Average Buffer Width

**Definition:** The average width of the buffer adjoining the AA is estimated by averaging the lengths of eight straight lines drawn at regular intervals around the AA from its perimeter outward to the nearest non-buffer land cover or 250 m, whichever is first encountered. It is assumed that the functions of the buffer do not increase significantly beyond an average width of about 250 m. The maximum buffer width is therefore 250 m. The minimum buffer width is 5 m, and the minimum length of buffer along the perimeter of the AA is also 5 m. Any area that is less than 5 m wide and 5 m long is too small to be a buffer. See Table 5 above for more guidance regarding the identification of AA buffers.

A wider buffer has a greater capacity to serve as habitat for wetland edge-dependent species, to reduce the inputs of non-point source contaminants, to control erosion, and to generally protect the wetland from human activities. Also see the buffer rationale presented above.

### Procedure to Assess this Metric for Slope Wetlands

This procedure is to be completed in the field using the appropriate scale aerial imagery. The procedure has four steps as presented in Table 7 below.

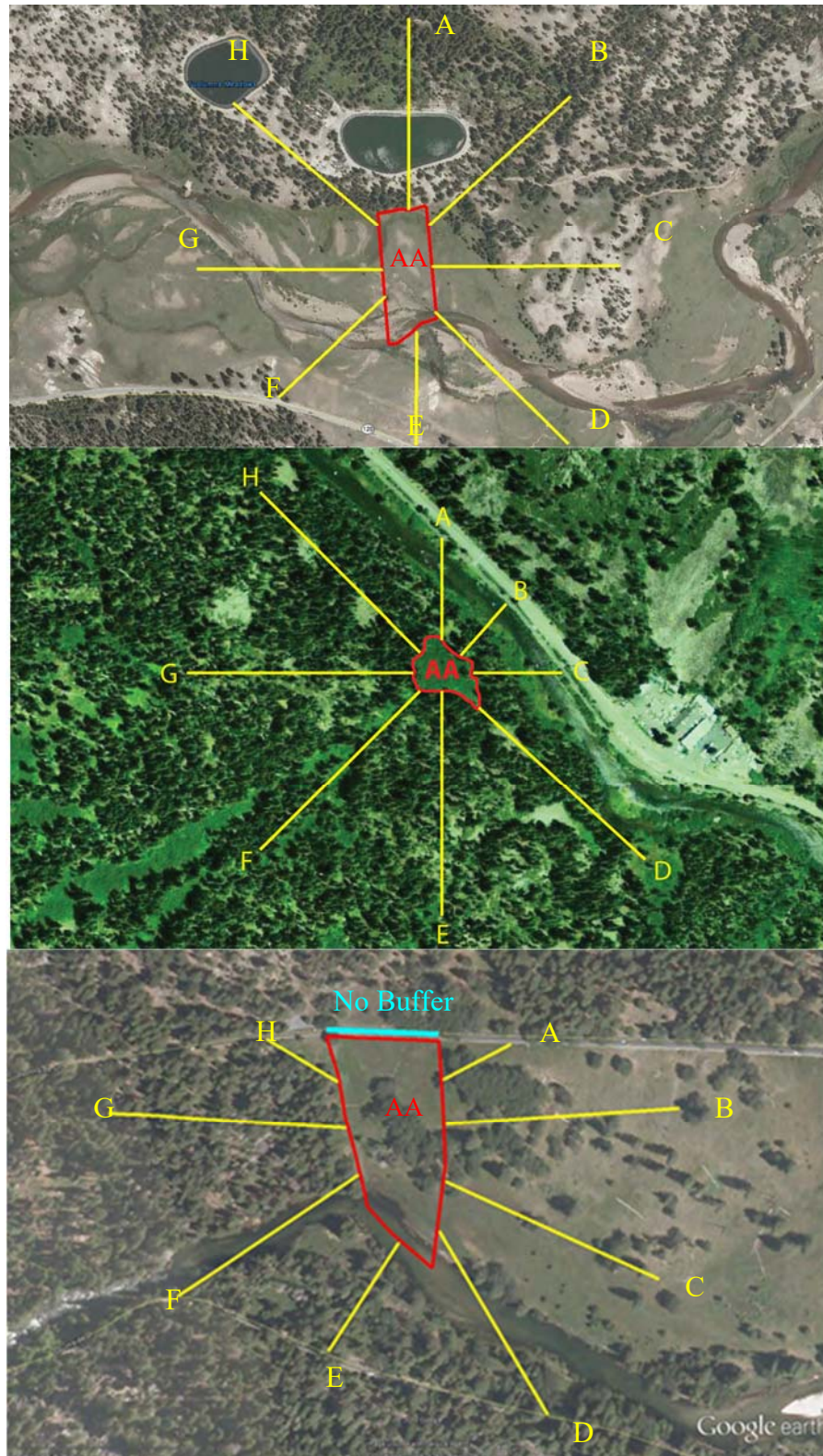
**Table 7: Steps to estimate Buffer Width.**

<b>Step 1</b>	Consider only the area around the AA perimeter previously identified as buffer.
<b>Step 2</b>	Draw 8 straight lines 250 m in length, starting at the AA boundary, and perpendicular to the AA boundary, for the areas identified as having buffer, radiating out in a starburst pattern (in the cardinal compass directions). Lines should stop when they intersect non-buffer land cover.
<b>Step 3</b>	Estimate the length of each line as they extend away from the AA. Record these lengths on the worksheet below.
<b>Step 4</b>	Calculate the average buffer width. Record this width on the worksheet below.

#### Special Note:

*\*Any area of open water that is within 250 m of the AA but is not directly adjoining the AA (separated from the AA boundary by 5m or more of upland or other wetland type) is considered part of the buffer, and thus Buffer Width lines should extend across the open water and be included in the buffer width.*





**Figure 12.** Examples of Buffer Width measurements. In the third example there is no buffer to the north, so the buffer lines are evenly distributed around areas that have buffer.

### Worksheet for calculating Average Buffer Width of AA

Line	Buffer Width (m)
A	
B	
C	
D	
E	
F	
G	
H	
Average Buffer Width	

**Table 8:** Rating for Average Buffer Width.

Rating	Alternative States
A	Average buffer width is 190 – 250 m.
B	Average buffer width 130 – 189 m.
C	Average buffer width is 65 – 129 m.
D	Average buffer width is 0 – 64 m.

### Submetric C: Buffer Condition

**Definition:** The condition or composition of the buffer, in addition to its width and extent around a wetland, determines the overall capacity of the buffer to perform its critical functions. The condition of a buffer is assessed according to the extent and quality of its vegetation cover, the overall condition of its substrate, and the amount of human visitation. Buffer conditions are assessed only for the portion of the wetland border that has *already been identified as buffer* (i.e., as in Figure 11). Thus, evidence of direct impacts (parking lots, buildings, etc.) by people are excluded from this metric, because these features are not included as buffer land covers; instead these impacts are included in the Stressor Checklist.

### Procedure to Assess this Metric for Slope Wetlands

Buffer condition must be assessed in the field. Prevalence of native vegetation, absence of exotic vegetation, absence of recent substrate disturbance, and absence of trash or debris are assumed to indicate good buffer conditions. Low impact human visitation includes activities like hiking, bird-watching, or other passive recreation. Moderate or intense human visitation could include activities such as off-road ATV use, 4WD parks, homeless encampments, construction of terrain parks for bikes, or other activities that disturb the soil or plant communities. For the purpose of assessing substrate condition in the buffer, evidence of problems more than 5 years old should not be

considered. Grazing should be considered for potential soil disturbance, rather than considered as human visitation. Indicators of potential soil disturbance from grazing include: bare ground > 10%, an obvious reduction in plant vigor or growth, > 20% of new growth is composed of woody plants that have been browsed on, and > 20% cover of disturbance indicator plant species (D. Weixelman, pers. comm.). Disturbance species include introduced or non-native herbaceous species as well as early successional native herbaceous species. Some examples include Kentucky bluegrass (*Poa pratensis*), primrose monkeyflower (*Mimulus primuloides*), tinker's penny (*Hypericum anagalloides*), and yarrow (*Achillea millefolium*). If any of these indicators of heavy grazing is present the practitioners should consider and discuss soil disturbance due to the grazing. Narratives for Buffer Condition ratings are provided in Table 9.

**Table 9: Rating for Buffer Condition.**

\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for photos of each of the following examples.

Rating	Alternative States
<b>A</b>	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
<b>B</b>	1) Buffer for AA is characterized by an intermediate mix of native and non-native vegetation (25-75%), but mostly undisturbed soils and is apparently subject to little or low impact human visitation.
	OR
	2) Buffer for AA is dominated by native vegetation, but shows some soil disturbance and is apparently subject to little or low impact human visitation.
<b>C</b>	Buffer for AA is characterized by substantial (>75%) amounts of non-native vegetation AND there is at least a moderate degree of soil disturbance/compaction, and/or there is evidence of at least moderate intensity of human visitation.
<b>D</b>	Buffer for AA is characterized by barren ground and/or highly compacted or otherwise disturbed soils, and/or there is evidence of very intense human visitation, or there is no buffer present.

## Attribute 2: Hydrology

Hydrology includes the sources, quantities, and movements of water, plus the quantities, transport, and fates of water-borne materials, particularly sediment as bed load and suspended load.

Hydrology is the most important direct determinant of wetland functions (Mitch and Gosselink 1993). The physical structure of a wetland is largely determined by the magnitude, duration, and intensity of water movement. For example, substrate grain size, depth of wetland sediments, and total organic carbon in sediments tend to be inversely correlated to duration of inundation in a lacustrine wetland. The hydrology of a wetland directly affects many physical processes, including nutrient cycling, sediment entrapment, and pollution filtration. For example, Odum and Heywood (1978) found that leaves in freshwater depressional wetlands decomposed more rapidly when submerged. The hydrology of a wetland constitutes a dynamic habitat template for wetland plants and animals.

### Metric 1: Water Source

**Definition:** Water Sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area. Water Sources include direct inputs of water into the AA as well as any diversions of water from the AA. Diversions influence the water source because they affect the ability of the AA to function as a source of water for other habitats while also directly affecting the hydrology of the AA.

A water source is direct if it supplies water mainly to the AA, rather than to areas through which the water must flow to reach the AA. Natural sources of direct water inputs for slope wetlands include groundwater, precipitation and surface water flows. Examples of unnatural, direct sources include stormdrains that empty directly into the AA or into an immediately adjacent area. Indirect sources that should not be considered in this metric include large regional dams that have ubiquitous effects on broad geographic areas of which the AA is a small part. However, the effects of urbanization on hydrological dynamics in the immediate watershed containing the AA (“hydromodification”) *are* considered in this metric; because hydromodification both increases the volume and intensity of runoff during and immediately after rain events and reduces infiltration that supports base flow discharges during the drier seasons later in the year.

Engineered hydrological controls such as weirs, flashboards, grade control structures, check dams, plug and pond restoration methods, etc., can serve to demarcate the boundary of an AA, but should not be considered in the assessment of this metric. These features may temporarily impound water, but they are not the source of the water. The water source metric looks beyond the scale of the AA to the upstream watershed within about 2 km.

Wetlands depend on constant or recurrent shallow inundation or saturation at or near the surface of the substrate (National Research Council 2001). Consistent, natural inflows of water to a wetland are important to their ability to perform and maintain most of their intrinsic ecological, hydrological, and societal functions and services. The flow of water into a wetland also affects its sedimentary processes, geo-chemistry, and basic physical structure. Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate or inappropriate hydrology.

## Procedure to Assess this Metric for Slope Wetlands

The assessment of this metric should be guided by an initial observation of the site imagery in the office, but scored during the field visit. This metric focuses on *direct* sources 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.

Aerial photograph observation should initially focus on the immediate margin of the AA and its wetland, and then expand to include the smallest watershed or storm drain system that directly contributes to the AA or its immediate environment, such as another part of the same wetland. Delineate the local watershed upstream of the AA using a topographic map or watershed GIS tools. Only consider the immediate watershed area 2 km upstream of the AA, or to the top of the drainage divide (if less than 2 km from the AA). Indicators of unnatural water sources include adjacent intensive development, irrigated agriculture, and wastewater treatment discharge.

Water Source should be evaluated based on conditions of the wetland during the dry season (e.g., post snowmelt peak of the water year, or during the summer in parts of California with a Mediterranean climate), and should not focus on the timing of water delivery to the wetland. The dry season is the most stressful time of the year for many wetland flora and fauna, and is when water source-related stresses will be most evident.

**Table 10: Guidelines for features to consider (left column) or that should not be considered (right column) for Water Source.**

<b>Examples of features to consider as negatively affecting Water Source</b>	<b>Examples of features that should not be considered as negatively affecting Water Source</b>
<ul style="list-style-type: none"><li>• adjacent developments</li><li>• stormdrains</li><li>• irrigated agriculture (including irrigated pasture), or direct irrigation in the meadow (e.g. sprinklers or flood irrigation)</li><li>• golf courses</li><li>• wastewater treatment discharge</li><li>• houses with septic systems</li><li>• surface water diversion</li><li>• ground water extraction</li><li>• dams or other artificially impounded water</li><li>• paved roads</li><li>• significant density of logging roads or clearcutting</li></ul>	<ul style="list-style-type: none"><li>• Large regional dams &gt;2 km upstream</li><li>• Plug and pond restoration</li><li>• Beaver dams</li><li>• Low intensity (selective) logging</li></ul>



**Table 11: Rating for Water Source.**

<b>Rating</b>	<b>Alternative States</b>
<b>A</b>	The freshwater sources that affect the dry season moisture regime of the AA, such as the extent and duration of groundwater-affected moisture in the root zone, are mainly natural groundwater fluctuations, but might also include direct precipitation, natural runoff, or natural flow from an adjacent freshwater body, or the AA naturally lacks water in the dry season. There is no indication that dry season conditions are substantially controlled by artificial or modified water sources.
<b>B</b>	The freshwater sources that affect the dry season moisture regime of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology, as evidenced by developed land or irrigated agricultural land that is likely to provide runoff or groundwater to the AA, but which comprises less than 20% of the immediate drainage basin within about 2 km upstream of the AA, or that is characterized by the presence of a few small stormdrains or scattered homes with septic systems adjacent to or nearby the AA.
<b>C</b>	<p>The freshwater sources that affect the dry season moisture regime of the AA are substantially affected by such factors as urban runoff, direct irrigation, pumped water, artificially impounded water, water remaining after diversions, regulated releases of water through a dam, artificial recharge, or other artificial hydrology. Indications of substantial artificial groundwater hydrology include developed or irrigated agricultural land that comprises more than 20% of the immediate drainage basin within about 2 km upstream of the AA.</p> <p style="text-align: center;">OR</p> <p>The groundwater in the root zone of the AA during the dry season is substantially controlled by injection wells, recharge basins, subsurface drains, upstream diversions of water or other artificial processes within, adjacent to, or nearby the AA.</p>
<b>D</b>	Natural groundwater sources that affect the dry season moisture regime of the AA have been eliminated, or nearly eliminated, based on presence of extraction wells, siphons, or artificial surface or subsurface drainage.

## **Metric 2: Hydroperiod**

**Definition:** Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year.

Natural slope wetlands typically experience daily, seasonal, and inter-annual variations in groundwater height that are governed by diurnal increases in evapotranspiration and longer term variability in groundwater recharge and movement that is governed by variability in rainfall and runoff. However, anthropogenic actions can also cause deviations in groundwater height, recharge, and movement. These deviations may increase or decrease the amount or duration of water supporting the wetland, and thus, have effects upon the condition of the wetland or the functions it provides.

### **Procedure to Assess this Metric for Slope Wetlands**

This metric considers deviations from the natural hydrograph of the wetland, based upon a suite of visible indicators of change in the patterns of filling and drying in the wetland. Table 12 lists some example indicators of altered hydroperiod; indicators such as ‘evidence of aquatic wildlife mortality’ may be present due to the climatic year, thus more than one indicator is typically desired to indicate an altered hydrograph.

Hydroperiod should be evaluated during the dry season (e.g., post snowmelt peak of the water year, or during the summer in parts of California with a Mediterranean climate), with indicators expected to vary based upon the amount of precipitation during the water year. This metric should take into account the type of water year during which the assessment is being conducted, but score the metric based upon a typical water year.

**Table 12: Field Indicators of Altered Hydroperiod.**

*\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for photos of some of the following examples.*

Direct Evidence	Indirect Evidence
Reduced Extent and Duration of Inundation or Saturation (“Less Water”)	
<ul style="list-style-type: none"> <li>• Upstream spring boxes</li> <li>• Impoundments that reduce the amount of water available to the meadow or wetland</li> <li>• Pumps, diversions, ditching that move water <i>from</i> the wetland</li> <li>• Berms or levees that prevents water from reaching the wetland</li> </ul>	<ul style="list-style-type: none"> <li>• Evidence of aquatic wildlife mortality</li> <li>• Encroachment of upland vegetation well into the wetland</li> <li>• Stress or mortality of hydrophytes or wetland plant species</li> <li>• Compressed or reduced plant zonation</li> <li>• Transition to fewer wetland obligate plant species, if known</li> <li>• Oxidation of peat substrate (however, may require additional knowledge beyond field observation)</li> <li>• Incision or widening of adjoining fluvial channels</li> </ul>
Increased Extent and Duration of Inundation or Saturation (“More Water”)	
<ul style="list-style-type: none"> <li>• Berms, dikes, levees delivering water or keeping water in the wetland</li> <li>• Pumps, diversions, ditching that move water <i>into</i> the wetland</li> <li>• Sprinklers</li> <li>• Flood irrigation</li> </ul>	<ul style="list-style-type: none"> <li>• Late-season vitality of annual vegetation, given the water year</li> <li>• Increase in extent and abundance of wetland obligate plant species, if known</li> <li>• Recently drowned wetland vegetation</li> <li>• Extensive fine-grained sediment deposits on the wetland surface</li> <li>• Formation of surface pools, pannes, etc</li> <li>• Increased wetness outside of non-channeled meadows due to overflow (e.g. into adjacent non-meadow areas)</li> <li>• Standing surface water that extends into the late summer months (e.g. July or August) beyond expected, and not associated with a recent storm event</li> <li>• Aggradation of adjoining fluvial channels</li> </ul>

**Table 13: Rating of Hydroperiod for Slope Wetlands.**

<b>Rating</b>	<b>Alternative States (based on Table 13)</b>
<b>A</b>	All indications are that the hydroperiod, or duration of shallow groundwater within the AA is characterized by natural patterns of rise and fall, without alterations  OR The amount and duration of shallow groundwater is altered so that the hydroperiod mimics the pattern of natural conditions.
<b>B</b>	The amount of water supplied to the wetland is enhanced compared to natural conditions, but thereafter, the AA is subject to natural drawdown or drying.  OR The duration of groundwater supply or inundation is extended later into the year than would be expected for natural conditions.
<b>C</b>	The amount of water supplied to the wetland is consistent with natural supply, but thereafter, the AA is subject to more rapid drawdown or drying  OR The duration of groundwater supply or inundation is shortened compared to what would be expected for natural conditions.
<b>D</b>	Both the patterns of groundwater rise and fall are altered compared to natural conditions, with alterations to the amount or timing of filling and drawdown of groundwater within the wetland  OR The groundwater is generally artificially lowered below the root zone for most of the AA due to pervasive artificial groundwater extraction or artificial drainage or diversions.

### **Metric 3: Hydrologic Connectivity**

**Definition:** For Slope Wetlands, Hydrologic Connectivity describes the ability of the wetland to slow the movement of surface runoff and shallow groundwater, and slowly release that water downstream. This metric assesses the degree to which the inflows of groundwater or surface runoff are likely to be retained and then released downstream in such ways that the outputs are filtered of particulate matter (although the outputs might be enriched with nutrients), downstream peak flows are reduced, and base flows in receiving channels are increased, extended downstream, and longer lasting.

This metric is scored differently for Channeled Wet Meadows and Channeled Forested Slopes versus all other Slope Wetlands. Channeled Wet Meadows and Channeled Forested Slopes (Method 1) are scored using two sub-metrics. Sub-metric A considers the degree of entrenchment of the fluvial channel, and Sub-metric B assesses the percentage of wetland surface affected by dewatering. For all other Slope Wetlands (Method 2), the metric only considers the percentage of wetland surface affected by dewatering. Some Non-Channeled Slope wetlands may be highly dissected by numerous small developing rills or channels; use the initial designation of Channeled or Non-Channeled to determine which rating table to use.

## **Method 1: Procedure to Assess this Metric for Channeled Wet Meadows and Channeled Forested Slopes**

For Channeled Wet Meadows and Channeled Forested Slopes, this metric assesses the potential for rising waters in the channel to reach the wetland surface and spill out of the channel banks. It also looks at the dewatering impacts to the wetland by assessing the percentage of the wetland showing indicators of dewatering. This metric is split into two sub-metrics, the Bank Height Ratio Sub-metric and the Percent Dewatered Sub-Metric. The Hydrologic Connectivity: Bank Height Ratio Sub-metric is scored by assessing the degree to which the lateral movement of floodwaters is restricted from flowing out onto the wetland surface due to incision of the channel. The sub-metric is assessed based on the bank height to bankfull depth ratio portion of the Bank Erosion Hazard Index (BEHI) (Rosgen 2001). This ratio is a field measurement calculated by making in-channel measurements at three representative locations in the AA (upstream, middle, downstream). Bank height is measured as the maximum height between the thalweg (the deepest point along the channel bed) and the top of the channel bank (the break in slope between the near vertical channel bank and the near horizontal wetland surface). The wetland surface is measured at the level of the primary horizontal wetland surface, and not at the height of any small inset floodplains that may be forming in an entrenched or incising system. Bankfull depth is measured as the height between the thalweg and the projected water surface at the level of bankfull flow (see special notes below for indicators). For AAs that include the wetland on both sides of the channel, measure the lowest elevation channel bank, regardless of which side of the channel it is found on. For assessments in large Channeled Wet Meadows or Channeled Forested Slopes that only include one half of the channel in the AA, the bankfull width and depth are still measured across the entire channel. However, measure bank height only on the side of the channel with the AA. A stadia rod and tape measure are recommended for making these measurements. In instances where the channel is too deep to wade and measure the bankfull depth, practitioners should discuss with the land owner/manager to see if any channel depth or cross section data exists. If no data exists, practitioners should make their best estimate of depth.

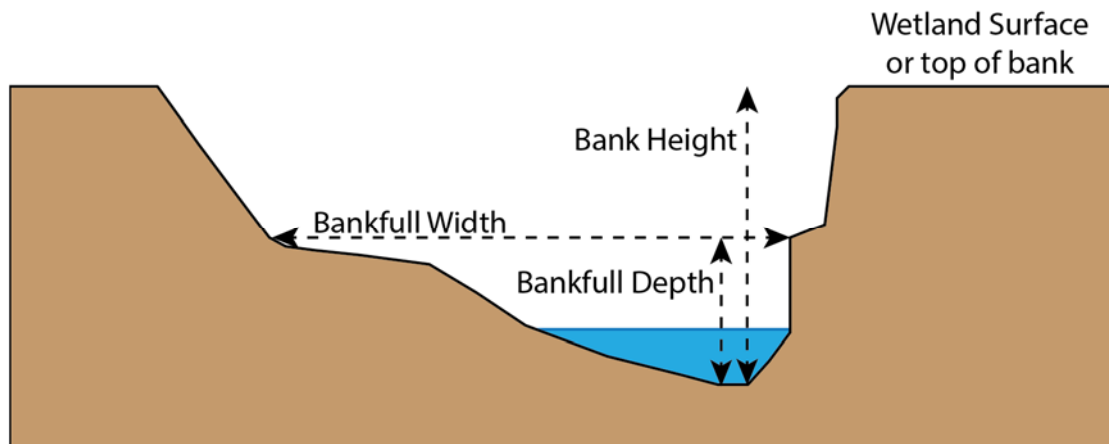


## Submetric A: Bank Height Ratio

### Channeled Wet Meadow and Channeled Forested Slope Wetland Bank Height Calculation Worksheet

The following 4 steps should be conducted for each of 3 cross-sections located in the AA at the approximate midpoints along straight riffles or glides, away from deep pools or meander bends. An attempt should be made to place them at the top, middle, and bottom of the AA.

Steps	Replicate Cross-sections →	TOP	MID	BOT
1 Estimate bankfull width.	This is a critical step requiring familiarity with field indicators of the bankfull contour. Measure the distance between the right and left bankfull contours.			
2: Estimate max. bankfull depth.	Imagine a level line between the right and left bankfull contours; measure the height of the line above the thalweg (the deepest part of the channel).			
3: Estimate max. bank height	Identify the location of the top of bank. Measure the height between the thalweg and the top of bank location.			
4: Calculate bank height ratio.	Divide the bank height (Step 3) by the bankfull depth (Step 2). Keep two significant figures.			
5: Calculate average bank height ratio.	Calculate the average results for Step 4 for all 3 replicate cross-sections. Enter the average result here and use it in Table 14. Keep two significant figures (hundredths).			



**Figure 13:** Diagram of bank height measurements. Bank height ratio is measured as maximum bank height divided by bankfull depth.

#### Special Notes:

##### \*Definitions:

- *Bankfull: the discharge that occurs on average every 1.5 years. This discharge is sufficiently frequent and sufficiently effective to form and maintain the channel dimensions (Leopold, 1994). In some systems, this represents the stage when water just begins to leave the channel and flow over the floodplain or meadow surface.*

- *Although numerous studies suggest that bankfull flow has a frequency of about 1.5 to 3 years, the definition of bankfull is not dependent upon flow frequency. Supplemental indicators of bankfull:*
  - *Break in slope of bank from vertical to horizontal depositional surface marking the edge of the channel*
  - *Lower limit of perennial species*
  - *In some cases, the presence and height of certain depositional features, especially point bars, can define lowest possible level for bankfull stage. However, point bar surfaces are usually below the bankfull height and are not reliable indicators of bankfull stage.*
- *Floodplain: relatively flat depositional surface adjacent to the river/stream that is formed by the river/stream under current climatic and hydrologic conditions. The floodplain is inundated on average every other year by flood waters. In some instances, the floodplain may be the meadow surface.*

*\*It may be necessary to conduct a short test on how uncertainty about the location of the bankfull contour affects the metric score. To conduct the sensitivity analysis, assume two alternative bankfull contours, one 10% above the original estimate and one 10% below the original estimate. Re-measure the bankfull depth using the alternative bankfull contours. Re-calculate the metric based on these alternative bankfull heights. If either alternative changes the metric score, then add three additional cross-sections to finalize the estimates of bankfull height.*

*\* In altered systems (e.g. urban systems affected by hydromodification, or reaches downstream from dams) the physical indicators of bankfull are often obscured.*

*\*For a video describing bankfull, please go to the Resources and Documents page of the CRAM website to see “A Guide for Field Identification of Bankfull Stage in the Western United States”*

**Table 14: Sub-metric A: Rating of Hydrologic Connectivity  
Bank Height Ratio for Channeled Wet Meadows and  
Channeled Forested Slopes.**

<b>Rating</b>	<b>Alternative States (based on the bank height calculation worksheet above)</b>
<b>A</b>	Bank height to bankfull depth is $\leq 1.49$
<b>B</b>	Bank height to bankfull depth is 1.50 to 2.49
<b>C</b>	Bank height to bankfull depth is 2.50 to 3.49
<b>D</b>	Bank height to bankfull depth is $\geq 3.50$

## Submetric B: Percent Dewatered

Slope wetlands that are dewatered, no matter what the cause, provide less wetland function than slope wetlands that are not dewatered. Dewatering is when the zone of saturation in the wetland drops below its previous elevation, so that the soils become drier and the plants become stressed due to reduced extent and duration of soil saturation in the root zone. The root zone is the upper-most soil stratum (the first 30 to 40 cm below the surface) where most of the biomass (80 to 90% by weight) of the herbaceous wetland plant roots exists.

Indicators of dewatering can be found in the channel as well as across the wetland plain. For slope wetlands with channels, dewatering can occur when the channel incises, reducing the overbank flow and groundwater recharge as water flows across the wetland surface, but also lowers the water table in the wetland. Indicators of channel incision include, but are not limited to: high bank height ratios, largely undercut banks with block failures, hanging or exposed roots, channel scoured to bedrock or dense clay, presence of active knickpoints, and active gully erosion or headcutting.

Dewatering can also occur due to causes other than channel incision, such as decreases in water supplied to the wetland, over-grazing, or influxes of sediment to the wetland, among others. In these instances, indicators of the dewatering can be found outside of the channel, across the wetland plain. Indicators of dewatering include, but are not limited to: stress or mortality of plants adjacent to the channel or in the wetland, presence of xeric/upland species (e.g. encroachment species) either across the wetland plain or sometimes in a zone adjacent to the channel as a channel incises and the wetland begins to dewater, development of rills and gullies on the wetland surface, large areas of bare soil on the wetland surface, and soil cracking of the wetland surface adjacent to the channel. Overall observations such as the decrease in plant vigor (especially hydrophytes), the change in plant and animal species or communities (e.g. the conversion from hydrophytes), and the changes in soil structure and moisture content are good indicators of dewatering.

The presence of specific plant species groups within the AA can indicate dewatering of the wetland, commonly known as the degree of encroachment of upland vegetation (i.e. primarily UPL or FACU rating in the Army Corps National Wetland Plant List) into the wetland. While encroachment of the wetland indicates succession into a drier regime, the practitioner may or may not be able to discern the causes (natural or not natural). Here, the encroachment by upland vegetation is used as an indicator of dewatering of the wetland, and thus reduced wetland function, regardless of the causes.

The practitioner should complete the Worksheet for Assessing Hydrologic Connectivity: Percent Dewatered for Slope Wetlands to determine if the wetland has intact hydrologic connectivity, or degraded hydrologic connectivity (dewatering). Then, determine the percentage of the wetland that is affected by dewatering by estimating the percentage of dewatering within the larger **wetland** that contains the AA. In other words, do not limit this metric only to the AA. Use aerial imagery and field observations to best estimate the percentage of the Slope Wetland that is dewatered. For very large wetlands, only consider the wetland area that is within 500 m of the AA boundary.

*Note- Lodgepole Pine (Pinus contorta) is facultative (FAC) in the wetland plant indicator status for California. It is equally likely to occur in wetlands or in non-wetlands. Lodgepole encroachment may be in the natural range of variability for a wetland between successive fire events or through landscape evolution after glaciation events. However, in many areas, particularly the Sierra Nevada, Lodgepole encroaches into wetlands after they become dewatered by human activities. Both drier conditions due to dewatering and also fire suppression may lead to greater encroachment by Lodgepole. In either case significant encroachment by Lodgepole may indicate reduced wetland function and is treated as such in the indicator list below.*

## Worksheet for Assessing Hydrologic Connectivity: Percent Dewatered for Slope Wetlands.

Condition	Field Indicators (check all existing conditions)
Indicators of Intact Hydrologic Connectivity	<input type="checkbox"/> No channel incision <input type="checkbox"/> Vigor of plant species, especially hydrophytes <input type="checkbox"/> Low or no cover of upland plant species <input type="checkbox"/> No rill or gully development <input type="checkbox"/> No areas of bare soil <input type="checkbox"/> No soil cracking <input type="checkbox"/> No changes in soil structure or moisture content <input type="checkbox"/> Surface water present on the wetland plain late into the summer season <input type="checkbox"/> Groundwater emerging <input type="checkbox"/> Moist peat soil <input type="checkbox"/> Floating fens <input type="checkbox"/> Evidence of regular inundation on floodplain slope wetlands (wrack etc.)
Indicators of Degraded Hydrologic Connectivity (dewatering)	<input type="checkbox"/> Evidence of channel incision, including low entrenchment ratios, undercut banks, block bank failures, sloughing banks, hanging or exposed roots, channel scoured to bedrock or dense clay, active knickpoints, active gully erosion, active headcutting <input type="checkbox"/> Stress or mortality of plants <input type="checkbox"/> Presence of xeric plant species <input type="checkbox"/> Development of rills or gullies on the wetland surface <input type="checkbox"/> Areas of bare soil <input type="checkbox"/> Areas of soil cracking <input type="checkbox"/> Drying of peat <input type="checkbox"/> Decrease in vigor of hydrophytes <input type="checkbox"/> Changes in plant or animal species or communities <input type="checkbox"/> Changes in soil structure or moisture content <input type="checkbox"/> More than 5% cover in the AA of upland conifer species (e.g. Douglas fir ( <i>Pseudotsuga menziesii</i> ), Lodgepole Pine ( <i>Pinus contorta</i> ), see special note) <input type="checkbox"/> More than 5% cover in the AA of upland broadleaf tree species (e.g. tanoak ( <i>Notholithocarpus densiflorus</i> ), coast live oak ( <i>Quercus agrifolia</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland shrub species (e.g. sagebrush ( <i>Artemisia tridentata</i> ), rabbitbrush ( <i>Ericameria nauseosa</i> ), French broom ( <i>Genista monspessulana</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland vines (e.g. English ivy ( <i>Hedera helix</i> ), Himalayan blackberry ( <i>Rubus armeniacus</i> ), field bindweed ( <i>Convolvulus arvensis</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland grasses (e.g. ripgut brome ( <i>Bromus diandrus</i> ), cheatgrass ( <i>Bromus tectorum</i> ), needlegrass ( <i>Stipa pulchra</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland herbs and forbs (e.g. ragweed ( <i>Ambrosia artemisiifolia</i> ), mustard ( <i>Brassica rapa</i> ), yellow star thistle ( <i>Centaurea solstitialis</i> )
Overall area of the wetland showing evidence of dewatering	<div style="display: flex; justify-content: space-around;"> <div> <input type="checkbox"/> No dewatering  <input type="checkbox"/> 25-50% dewatered             </div> <div> <input type="checkbox"/> &lt;25% dewatered  <input type="checkbox"/> &gt;50% dewatered             </div> </div>

**Table 15: Sub-metric B: Rating of Hydrologic Connectivity  
Percent Dewatered for Channeled Wet Meadows and  
Channeled Forested Slopes.**

<b>Rating</b>	<b>Alternative States</b>
<b>A</b>	<p>The wetland functions as variable source area for downstream surface flows, discharging water through springs, seeps, or a fluvial channel that is not incised. There is no observed dewatering of the wetland.</p> <p align="center">OR</p> <p>The wetland lacks any apparent surface discharge of water, although groundwater flow from the wetland is likely.</p>
<b>B</b>	The wetland functions as variable source area for downstream surface flows, discharging water through springs, seeps, or a fluvial channel (natural or artificial) that may be somewhat incised. Less than 25% of the wetland area is showing evidence of dewatering of the root zone.
<b>C</b>	The wetland functions as variable source area for downstream surface flows, discharging water through springs, seeps, or a fluvial channel (natural or artificial) that may be significantly incised. Between 25 and 50% of the wetland area is showing evidence of dewatering of the root zone.
<b>D</b>	The wetland functions as variable source area for downstream surface flows, discharging water through springs, seeps, or a fluvial channel (natural or artificial) that may be severely incised. More than 50% of the wetland area is showing evidence of dewatering of the root zone.

**Method 2: Procedure to assess this metric for all other Slope Wetlands (except Channeled Wet Meadows and Channeled Forested Slopes)**

Dewatering can also occur in Non-channeled meadows, Non-channeled Forested Slope wetlands, and Seeps and Springs. Dewatering is defined as when the zone of saturation in the wetland drops below its previous elevation, so that the soils become drier and the plants become stressed due to reduced extent and duration of soil saturation in the root zone. The root zone is the upper-most soil stratum (30 to 40 cm) where most of the biomass (80 to 90% by weight) of the herbaceous wetland plant roots exists.

Although these systems do not contain channels, dewatering can occur due to concentration of surface or groundwater flows in small rills that develop on the wetland surface, or due to ditching or excavation of the wetland. These features can concentrate and speed flows that previously moved more slowly across the wetland. The concentration of flow can also be erosive, sometimes incising a channel into the wetland surface, and further dewatering the wetland.

Multiple causative factors can cause dewatering, such as decreases in water supplied to the wetland, over-grazing, or influxes of sediment to the wetland, among others. Indicators of the dewatering can be found across the wetland plain, and include, but are not limited to: stress or mortality of plants adjacent to the channel or in the wetland, presence of xeric/upland species (e.g. encroachment



species) across the wetland plain, development of rills and gullies on the wetland surface, large areas of bare soil on the wetland surface, and soil cracking of the wetland surface adjacent to the channel. Overall observations such as the decrease in plant vigor (especially hydrophytes), the change in plant and animal species or communities (e.g. the conversion from hydrophytes), and the changes in soil structure and moisture content are good indicators of dewatering.

The practitioner should complete the Worksheet for Assessing Hydrologic Connectivity: Percent Dewatered for Slope Wetlands to determine if the wetland has intact hydrologic connectivity, or degraded hydrologic connectivity (dewatering). Then, determine the percentage of the wetland that is affected by dewatering by estimating the percentage of dewatering within the larger **wetland** that contains the AA. In other words, do not limit this metric only to the AA. Use aerial imagery and field observations to best estimate the percentage of the Slope Wetland that is dewatered. For very large wetlands, only consider the wetland area that is within 500 m of the AA boundary.

## Worksheet for Assessing Hydrologic Connectivity: Percent Dewatered for Slope Wetlands.

Condition	Field Indicators (check all existing conditions)
Indicators of Intact Hydrologic Connectivity	<input type="checkbox"/> No channel incision <input type="checkbox"/> Vigor of plant species, especially hydrophytes <input type="checkbox"/> Low or no cover of upland plant species <input type="checkbox"/> No rill or gully development <input type="checkbox"/> No areas of bare soil <input type="checkbox"/> No soil cracking <input type="checkbox"/> No changes in soil structure or moisture content <input type="checkbox"/> Surface water present on the wetland plain late into the summer season <input type="checkbox"/> Groundwater emerging <input type="checkbox"/> Moist peat soil <input type="checkbox"/> Floating fens <input type="checkbox"/> Evidence of regular inundation on floodplain slope wetlands (wrack etc.)
Indicators of Degraded Hydrologic Connectivity (dewatering)	<input type="checkbox"/> Evidence of channel incision, including low entrenchment ratios, undercut banks, block bank failures, sloughing banks, hanging or exposed roots, channel scoured to bedrock or dense clay, active knickpoints, active gully erosion, active headcutting <input type="checkbox"/> Stress or mortality of plants <input type="checkbox"/> Presence of xeric plant species <input type="checkbox"/> Development of rills or gullies on the wetland surface <input type="checkbox"/> Areas of bare soil <input type="checkbox"/> Areas of soil cracking <input type="checkbox"/> Drying of peat <input type="checkbox"/> Decrease in vigor of hydrophytes <input type="checkbox"/> Changes in plant or animal species or communities <input type="checkbox"/> Changes in soil structure or moisture content <input type="checkbox"/> More than 5% cover in the AA of upland conifer species (e.g. Douglas fir ( <i>Pseudotsuga menziesii</i> ), Lodgepole Pine ( <i>Pinus contorta</i> ), see special note) <input type="checkbox"/> More than 5% cover in the AA of upland broadleaf tree species (e.g. tanoak ( <i>Notholithocarpus densiflorus</i> ), coast live oak ( <i>Quercus agrifolia</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland shrub species (e.g. sagebrush ( <i>Artemisia tridentata</i> ), rabbitbrush ( <i>Ericameria nauseosa</i> ), French broom ( <i>Genista monspessulana</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland vines (e.g. English ivy ( <i>Hedera helix</i> ), Himalayan blackberry ( <i>Rubus armeniacus</i> ), field bindweed ( <i>Convolvulus arvensis</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland grasses (e.g. ripgut brome ( <i>Bromus diandrus</i> ), cheatgrass ( <i>Bromus tectorum</i> ), needlegrass ( <i>Stipa pulchra</i> ) <input type="checkbox"/> More than 5% cover in the AA of upland herbs and forbs (e.g. ragweed ( <i>Ambrosia artemisiifolia</i> ), mustard ( <i>Brassica rapa</i> ), yellow star thistle ( <i>Centaurea solstitialis</i> )
Overall area of the wetland showing evidence of dewatering	<div style="display: flex; justify-content: space-around;"> <div> <input type="checkbox"/> No dewatering  <input type="checkbox"/> 25-50% dewatered             </div> <div> <input type="checkbox"/> &lt;25% dewatered  <input type="checkbox"/> &gt;50% dewatered             </div> </div>

**Table 16: Rating of Hydrologic Connectivity for all other Slope Wetlands.**

<b>Rating</b>	<b>Alternative States</b>
<b>A</b>	<p>The wetland functions as a variable source area for downstream surface flows, and is not dissected by channels that convey the wetland discharges. There is no observed dewatering of the wetland.</p> <p style="text-align: center;">OR</p> <p>The wetland lacks any apparent surface discharge of water, although groundwater flow from the wetland is likely.</p>
<b>B</b>	<p>The wetland functions as a variable source area for downstream surface flows, but the wetland surface may be beginning to develop natural or artificial rills or channels that are actively eroding into the wetland. Less than 25% of the wetland area is showing evidence of dewatering of the root zone.</p>
<b>C</b>	<p>The wetland functions as a variable source area for downstream surface flows, but the wetland surface may be slightly dissected by natural or artificial rills or channels. Between 25 and 50% of the wetland area is showing evidence of dewatering of the root zone.</p>
<b>D</b>	<p>The wetland functions as a variable source area for downstream surface flows, but the wetland surface may be severely dissected by natural or artificial rills or channels. More than 50% of the wetland area is showing evidence of dewatering of the root zone.</p>

## Attribute 3: Physical Structure

Physical structure is defined as the spatial organization of living and non-living surfaces that provide habitat for biota (Maddock 1999). For example, the distribution and abundance of organisms in riverine systems are largely controlled by physical processes and the resulting physical characteristics of habitats (e.g., Frissell *et al.* 1986). Metrics of the Physical Structure attribute in CRAM therefore focus on physical conditions that are indicative of the capacity of a wetland to support characteristic flora and fauna. CRAM assumes that wetlands with greater physical complexity will support greater diversity and levels of ecological services. While some of the features in these metrics are sometimes associated with drying of slope wetlands or other negative impacts, the metrics aim to capture the overall amount of physical complexity within an AA, and thus the ability of the AA to support a diverse assemblage of flora and fauna.

### Metric 1: Structural Patch Richness

**Definition:** Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic, wetland, or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity evaluates the spatial arrangement and interspersions of the types. Physical patches can be natural or unnatural. The minimum size for most patches to be counted is 3 m<sup>2</sup>.

The richness of physical, structural surfaces, and features in a wetland reflects the diversity of physical processes, such as energy dissipation, water storage, and groundwater exchange, which strongly affect the potential ecological complexity of the wetland. The basic assumption is that natural physical complexity promotes natural ecological complexity, which in turn generally increases ecological functions, beneficial uses, and the overall condition of a wetland. We acknowledge that, particularly in large meadows, the physical complexity present within a single AA may or may not add significant ecological value to the entire meadow. Although some patch types may sometimes indicate processes that are detrimental to the wetland, they still contribute to overall complexity and diversity of functions in the wetland. The natural physical complexity is assessed by noting the visible patches of physical structure that occur any place within the AA.

### Procedure to Assess this Metric for Slope Wetlands

Using the Structural Patch Worksheet below, note the presence of each of the patch types found in the AA. For AAs in large Channeled Wet Meadows or Channeled Forested Slope wetlands that only include one of the channel banks, include patches that occur anywhere within the entire channel length along the AA. Table 17 contains guidance for scoring the Structural Patch Richness.

*\*Refer to the CRAM Slope Wetland Photo Dictionary for photos of each of the following examples.*

### Patch Type Definitions:

Abundant wrack or organic debris in channel or across wetland plain. Wrack is an accumulation of natural or unnatural floating debris along the high water line of a wetland. Organic debris is loose plant material (leaves, twigs, cones, brush tangles, etc) that has accumulated anywhere within the AA.

Active fluvial channel(s). A channel is a linear feature that conveys flowing surface water, and has defined bed and banks.

Animal mounds and burrows, sediment disturbance, or vole trails. Many vertebrates make mounds or holes as a consequence of their foraging, denning, predation, or other behaviors (e.g. gophers, voles). The resulting soil disturbance helps to redistribute soil nutrients and

influences plant species composition and abundance. To be considered a patch type there should be evidence that a population of burrowing animals has occupied the Assessment Area. A single burrow or mound does not constitute a patch. Other animals (e.g. feral pigs) may root in the soil, turning it over and causing a patch of disturbed soil.

*Bank slumps or undercut banks in channels or along shorelines.* A bank slump is a portion of a fluvial channel bank that has broken free from the rest of the bank but has not eroded away. Undercuts are areas along the bank or shoreline of a wetland that have been excavated by waves or flowing water.

*Beaver dams or lodges.* Beavers create dams or lodges across fluvial channels using sticks, logs, mud, and stones. The dams provide protection for the beavers and ready access to food. Dams also cause a backwater pond upstream of the dam, causing deposition of sediment and allowing infiltration of water.

*Boulders or bedrock outcrop.* Boulders are rocks with a middle axis larger than 256mm. Bedrock outcrop can be various shapes and sizes, but represents exposed in-place bedrock.

*Cutoff channels or oxbows.* Cutoff channels or oxbows are inactive parts of old channels that have been bypassed by the continued meandering of the current fluvial channel. These channels have bed and banks, but do not convey surface flow. They often pond surface water or upwelling ground water, and provide important habitat and refugia for many species.

*Filamentous macroalgae and algal mats.* Macroalgae occurs on benthic sediments and on the water surface. Macroalgae are important primary producers, representing the base of the food web in some wetlands. Algal mats can provide abundant habitat for macro-invertebrates, amphibians, and small fishes. Algae that has dried can also be considered.

*Gravel, cobble, or sand.* Gravel, cobble and sand are rocks of different size categories. The middle axis of gravel ranges between 2mm and 64mm, whereas cobble ranges between 64 and 256mm, and sand ranges between 0.06 and 2 mm. Submerged gravel and cobbles provide abundant habitat to aquatic macroinvertebrates. Exposed sand, gravel and cobble can provide shelter for amphibians, contribute to the patterns of shade and light and air movement near the ground surface that affect local soil moisture gradients, deposition of seeds and debris, and overall substrate complexity.

*Large woody debris.* Large woody debris (LWD) is an indicator of dynamic hydrology and ecology. LWD is any woody fragment greater than 10 cm diameter and 0.5 meters long. It provides basking habitat for turtles, which use wood perches preferentially over rock substrates. LWD is a source of food for invertebrates, and increases overall topographic heterogeneity. It can provide structure to create scour pools or eddies with dynamic hydrology. It can be a refuge to hide from predators in a low-relief landscape. Only one piece of LWD is required for this patch type.

*Moss.* Bryophytes such as sphagnum moss or other mosses can form the base of the substrate in some wetlands, and this substrate is necessary for peat formation.

*Non-vegetated flats (sandflats, mudflats) or bare ground.* A flat is a non-vegetated area of silt, clay, or sand and is a potential resting and feeding area for birds or other species and is habitat for ground-dwelling insects and invertebrates (e.g. solitary bees, beetles, etc). For example, in meadows, these can be alkaline areas, zones of recent siltation, or animal foraging areas, or non-vegetated patches of bare mineral soil. The area can be one large contiguous area, or a number of smaller patches that together meet the minimum size criteria.



Pannes or pools on wetland surface. A panne is a dry, shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain. Pannes become pools when they fill with water at least seasonally. They commonly serve as foraging sites for birds and as breeding sites for amphibians.

Plant hummocks or tussocks. Hummocks are mounds created by plants along floodplains, terraces or springs, created by the collection of sediment and organic material around wetland plants, or by freeze-thaw processes. Hummocks are typically less than 1m high. Tussocks are grasses that grow in clumps, tufts, or bunches, rather than forming a sod or lawn, and are depositional features that accumulate sediment.

Sediment mounds around the bases of trees or shrubs. Sediment mounds are similar to hummocks but lack plant cover. They are depositional features formed from repeated flood flows depositing sediment on the floodplain.

Sediment splays. Sediment splays are areas of coarse sediment (sand or larger) deposited across the wetland surface, typically during a flood event.

Soil cracks. Repeated wetting and drying of fine grain soil that typifies some wetlands can cause the soil to crack and form deep fissures that increase the mobility of heavy metals, promote oxidation and subsidence, while also providing habitat for amphibians and macroinvertebrates. Cracks must be a minimum of 2.5 cm (1 inch) deep to qualify.

Springs or upwelling groundwater. Springs are discrete locations where ground water intersects the land surface and emerges. Springs typically occur at breaks in slope (e.g. at the base of a slope) or along the banks of a fluvial channel, but they may also occur anywhere across the wetland surface where upwelling occurs. They include artesian springs and weeping ground. Upwelling groundwater typically is more diffuse in area as compared to springs.

Standing snags. Tall, woody vegetation, such as trees and tall shrubs, can take many years to fall to the ground after dying. These standing “snags” provide habitat for many species of birds and small mammals (e.g. insects, cavity nesters, perch for birds of prey, etc.). Any standing, mostly dead woody vegetation, including a large dead branch of a living tree, that is at least 3 m tall with at least a 10 cm diameter is considered a snag. Only one snag is required for this patch type.

Submerged vegetation. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea), that are rooted in the sub-aqueous substrate but do not usually grow high enough in the overlying water column to intercept the water surface. Submerged vegetation can strongly influence nutrient cycling while providing food and shelter for fish and other organisms.

Swales. Swales are broad, elongated, vegetated, shallow depressions that can sometimes help to convey flood flows to and from vegetated marsh plains or floodplains. But, they lack obvious banks, regularly spaced deeps and shallows, or other characteristics of channels. Swales can entrap water after flood flows recede. They can act as localized recharge zones and they can sometimes receive emergent groundwater.

Thatch. Thatch is dead plant material that builds up at the base of plants while still attached to the parent plant, which shades the wetland surface and helps to maintain soil moisture.

Variegated or crenulated upland edge. As viewed from above, the upland edge of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated upland edge resembles a meandering pathway. Variegated edges provide greater contact between the upland and the wetland.

### Structural Patch Type Worksheet for Slope Wetlands

Check each type of patch that is observed in the AA and use the total number of observed patches in Table 17 below.

<b>STRUCTURAL PATCH TYPE (circle for presence)</b>	<b>Slope Wetland</b>
<b>Minimum Patch Size</b>	<b>3 m<sup>2</sup></b>
Abundant wrack or organic debris in channel, or across wetland plain	
Active fluvial channel(s)	
Animal mounds and burrows, sediment disturbance, or vole trails	
Bank slumps or undercut banks in channels	
Beaver dams or lodges	
Boulders or bedrock outcrop	
Cutoff channels or oxbows	
Filamentous macroalgae or algal mats	
Gravel, cobble, or sand	
Large woody debris	
Moss	
Non-vegetated flats or bare ground	
Pannes or pools on wetland surface	
Plant hummocks and/or tussocks	
Sediment mounds around the bases of shrubs or trees	
Sediment splays	
Soil cracks	
Springs or upwelling groundwater	
Standing snags (at least 3 m tall)	
Submerged vegetation (in channels or open water)	
Swales	
Thatch	
Variegated, convoluted, or crenulated upland edge (not broadly arcuate or mostly straight)	
<b>Total Possible</b>	<b>23</b>
<b>No. Observed Patch Types (enter here and use in Table 17 below)</b>	

**Table 17: Rating of Structural Patch Richness.**

<b>Rating</b>	<b>Number of Patch Types Observed in the AA</b>
<b>A</b>	<b><math>\geq 12</math></b>
<b>B</b>	<b>9 – 11</b>
<b>C</b>	<b>6 – 8</b>
<b>D</b>	<b><math>\leq 5</math></b>

## **Metric 2: Topographic Complexity**

**Definition:** Topographic complexity refers to the variety of elevations within a wetland due to physical and biological materials and processes occurring within the AA.

Topographic complexity promotes variable hydroperiods and associated moisture gradients that, in turn, promote ecological complexity by increasing the spatial and temporal variability in energy dissipation, surface water storage, groundwater recharge, particulate matter detention, cycling of elements and compounds, and habitat dynamics. Areas that are aerated due to water movements through and across complex surfaces may promote volatilization of compounds, or re-suspension and export of water-borne material.

### **Procedure to Assess this Metric for Slope Wetlands**

Topographic complexity is assessed by noting the overall variability in topographic features, physical patches, and vegetation roughness (Table 18 and Figure 14). For Slope wetlands, topographic complexity can be evaluated by observing the amount of macro- and micro-topographic relief and physical plant structure that affect moisture gradients or that influence the path of water movements along a transect across the AA. Note that in Slope wetlands, the macro- and micro-topographic features may be on the order of  $\leq 1$  m relief. In fens, the features may be on the order of centimeters. Topographic gradients may be indicated by plant assemblages with different inundation/saturation or salinity tolerances. Tables 19 a and b provide narratives for each component of Topographic Complexity for Slope wetlands, while Table 19c provides the rating table for the metric.

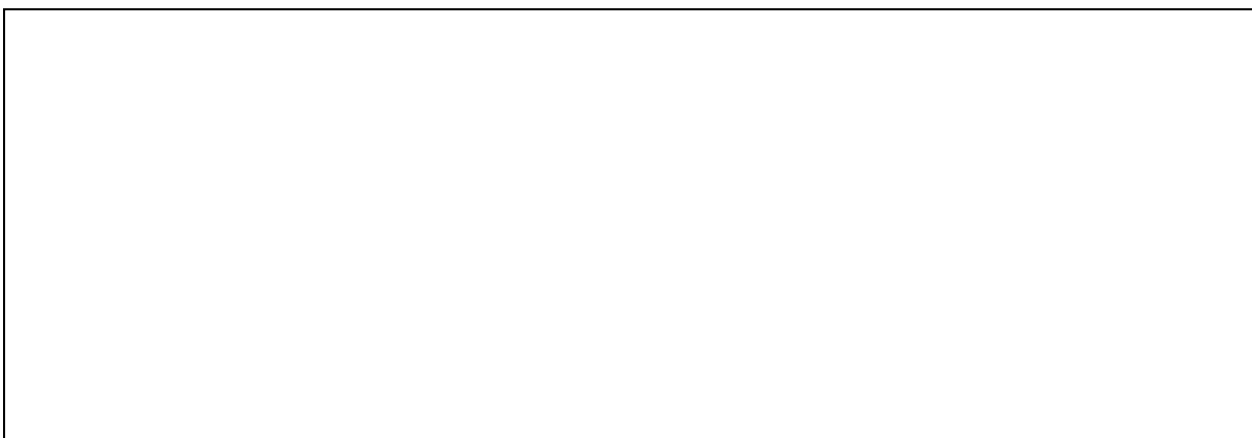
**Table 18: Typical indicators of Topographic Complexity.**

<b>Wetland Type</b>	<b>Examples of Topographic Features</b>
<b>Non-channeled Wet Meadows and Non-channeled Forested Slopes</b>	Swales, oxbows, plant hummocks, tree fall locations (i.e. tip up mound and cavity), large woody debris, cobbles or boulders, bedrock outcrops, pannes/pools on wetland surface, irregular upland edge, a wide variety of surfaces and slopes, animal mounds or burrows, and soil cracks.
<b>Channeled Wet Meadows and Channeled Forested Slopes</b>	Fluvial channels large and small, bank slumps, secondary channels, swales, oxbows, natural levees, plant hummocks, tree fall locations (i.e. tip up mound and cavity), large woody debris, cobbles or boulders, bedrock outcrops, pannes/pools on meadow surface, irregular upland edge, a wide variety of surfaces and slopes, animal mounds or burrows, and soil cracks.
<b>Seeps and Springs</b>	Swales, rivulets and outflow pathways, plant hummocks, tree fall locations (i.e. tip up mound and cavity), large woody debris, cobbles or boulders, bedrock outcrops, irregular upland edge, a wide variety of surfaces and slopes, animal mounds or burrows, and soil cracks.

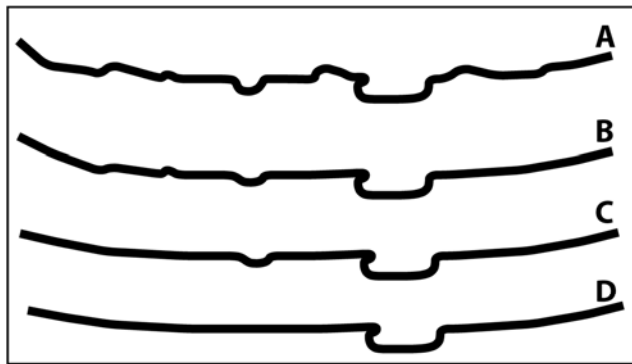
To complete this metric, walk through the AA perpendicular to (i.e., across) the overall wetland topographic slope (from upland edge to topographic low, and to the opposite upland edge if the AA extends to that edge). As you walk, sketch the topographic profile of the ground surface within the AA along the way, indicating the locations of any macro and micro-topographic relief. In addition, also sketch the vegetation roughness that occurs on top of the ground surface (worksheet below). Once the sketch is complete, compare it to the template of common cross-section profiles (Figure 14). Based on the comparison between the worksheet sketch and Figure 14, plus the rating tables (Table 19 a, b, and c), score the AA.

### **Worksheet for AA Topographic Complexity**

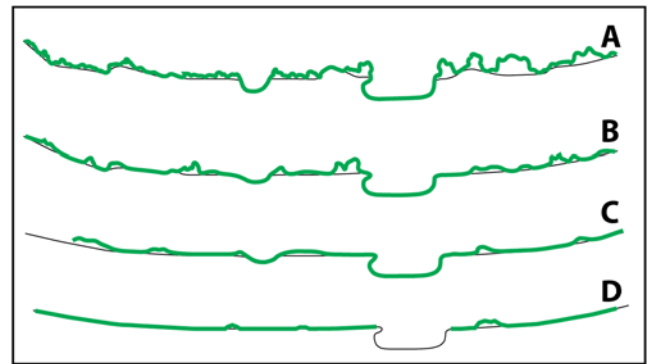
Complete a sketch of the topographic profile of the AA along a cross section perpendicular to the overall slope of wetland within the AA. Draw the section to include both AA boundaries. Include both the ground surface and the vegetation roughness. Indicate the letter grade for each component in the space below the sketch. Note the AA boundaries and important topographic features.



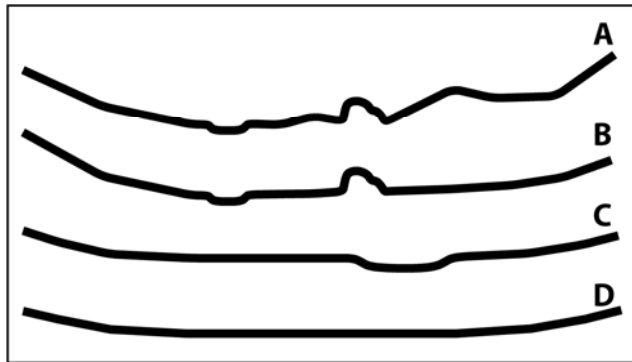
Physical topographic complexity score \_\_\_\_\_ Vegetation roughness score \_\_\_\_\_



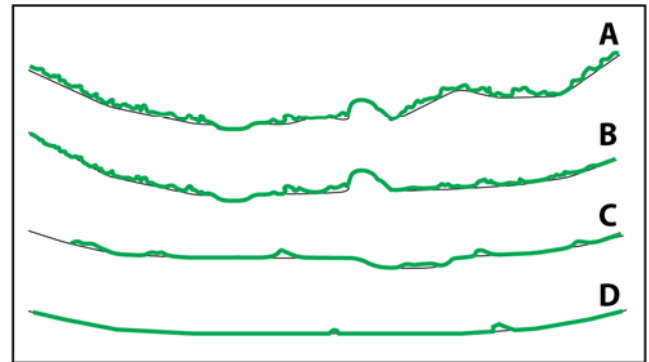
Channeled Wet Meadow and Channeled Forested Slope:  
Physical Topographic Complexity



Channeled Wet Meadow and Channeled Forested Slope:  
Vegetation Roughness



All Other Slope Wetlands: Physical Topographic Complexity



All Other Slope Wetlands: Vegetation Roughness

**Figure 14:** Cross sectional profile templates for an AA perpendicular to its overall slope. These diagrams are exaggerated wetland cross sections, with the ground surface shown in black, and the vegetation in green. The top row is for Channeled Wet Meadows and Channeled Forested Slopes, while the bottom row is for all other slope wetlands. The left-hand diagram represents the physical ground surface of the wetland. The right-hand diagram represents the vegetation roughness within the wetland. Both components should be scored separately (Tables 19 a and b). Next, average the scores for both components, and use Table 19c to score the metric. Note that these diagrams are conceptual representations of the morphology of a wetland, and any particular wetland may have a steeper or shallower slope than these models.

**Table 19a: Rating of Physical Topographic Complexity for Slope Wetlands.**

<b>Rating</b>	<b>Alternative States (based on diagrams in Figure 14 above)</b>
<b>A</b>	Cross-sectional profile of AA contains abundant physical macro and micro topographic features such as swales, oxbows, pannes/pools, or a wide variety of slopes. The profile is at least as complex as the line labeled “A” in Figure 14.
<b>B</b>	Cross-sectional profile of AA contains moderate physical macro and micro topographic features such as swales, oxbows, pannes/pools, or a wide variety of slopes. The profile resembles the line labeled “B” in Figure 14.
<b>C</b>	Cross-sectional profile of AA contains minor physical macro and micro topographic features such as swales, oxbows, pannes/pools, or a wide variety of slopes. The profile resembles the line labeled “C” in Figure 14.
<b>D</b>	Cross-sectional profile of AA lacks physical macro and micro topographic features such as swales, oxbows, pannes/pools, or a wide variety of slopes. The profile resembles the line labeled “D” in Figure 14.

**Table 19b: Rating of Vegetation Roughness for Slope Wetlands.**

<b>Rating</b>	<b>Alternative States (based on diagrams in Figure 14 above)</b>
<b>A</b>	Cross-sectional profile contains abundant vegetation roughness. The profile is at least as complex as the line labeled “A” in Figure 14.
<b>B</b>	Cross-sectional profile of AA contains at least moderate vegetation roughness. The profile resembles the line labeled “B” in Figure 14.
<b>C</b>	Cross-sectional profile of AA contains at least minor vegetation roughness. The profile resembles the line labeled “C” in Figure 14.
<b>D</b>	Cross-sectional profile of AA lacks any vegetation roughness. The profile resembles the line labeled “D” in Figure 14.

**Table 19c: Rating of Topographic Complexity.**

<b>Rating</b>	<b>Average of physical topographic complexity and vegetation roughness scores</b>
<b>A</b>	<b>10 – 12</b>
<b>B</b>	<b>7 – 9</b>
<b>C</b>	<b>4 – 6</b>
<b>D</b>	<b>3</b>



## Attribute 4: Biotic Structure

This attribute is assessed differently depending on the type of Slope wetland that is being assessed. Wet meadows with fluvial channels (Channeled Wet Meadows), Forested Slope wetlands, and Seeps and Springs often have woody vegetation that is usually not present in Non-Channeled Wet Meadows, so the biotic structure is separated into different methods for some of the metrics.

### Method 1: For Channeled Wet Meadows, Channeled Forested Slope Wetlands, Non-channeled Forested Slope Wetlands, and Seeps and Springs

#### Metric 1: Plant Community Metric for Channeled Wet Meadows, Forested Slope Wetlands, and Seeps and Springs

The Plant Community Metric for Channeled Meadows, Forested Slope wetlands, and Seeps and Springs is composed of three submetrics: Number of Plant Layers, Number of Co-dominant Plant Species, and Percent Invasive Species.

##### Submetric A: Number of Plant Layers

A “plant” is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forb, or fern, whether submerged, floating, emergent, prostrate, decumbent, or erect, including non-native (exotic) plant species. Algae and bryophytes (including mosses and liverworts) are not included among the species identified in the plant community assessment. For the purposes of CRAM, a plant “layer” is a stratum of vegetation indicated by a discreet canopy at a specified height that comprises at least 5% of the area of the AA *where the layer is expected* (e.g. floating layer is expected only in areas that have a water column; no species are expected in areas of bedrock outcrop).

Non-native species owe their occurrence in California to the actions of people since the time of Euroamerican contact. Many non-native species are now *naturalized* in California, and may be widespread in occurrence, but are not considered invasive. “Invasive” species are non-native species that “(1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes” (CalIPC 2012). CRAM uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, *with augmentation by regional experts*.

##### Layer definitions:

*Floating Layer.* This layer includes rooted aquatic macrophytes such as *Ruppia cirrhosa* (ditchgrass), *Ranunculus aquatilis* (water buttercup), and *Potamogeton foliosus* (leafy pondweed) that create floating or buoyant canopies at or near the water surface that shade the water column. This layer also includes non-rooted aquatic plants such as *Lemna* spp. (duckweed) and *Eichhornia crassipes* (water hyacinth) that form floating canopies.

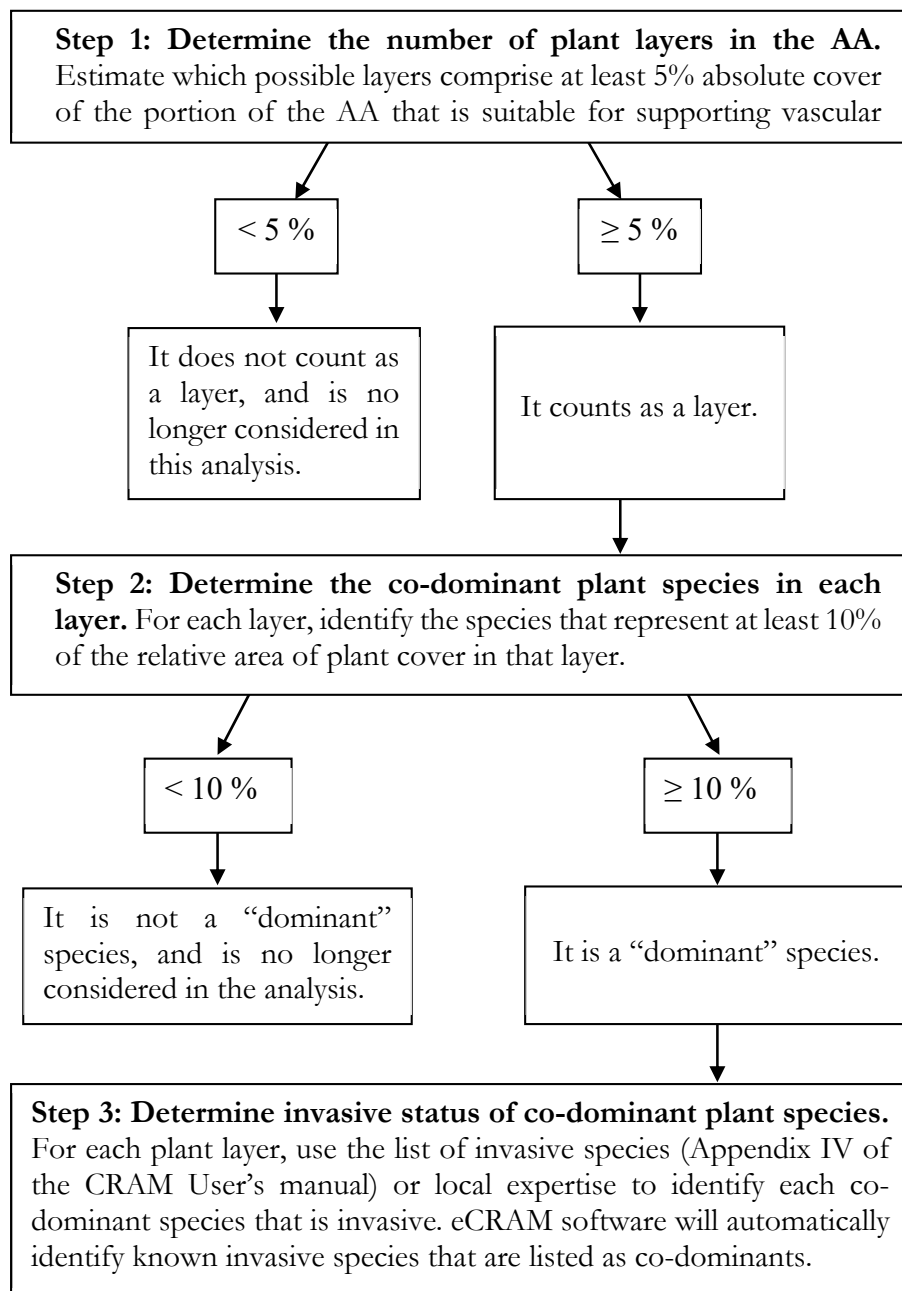
*Short Vegetation.* This layer is never taller than 30 cm. It includes small emergent vegetation and plants. It can include young forms of species that grow taller. Vegetation that is naturally short in its mature stage includes *Polygonum bistortoides* (bistort), *Solidago canadensis* (goldenrod), *Distichlis spicata* (saltgrass), *Eleocharis* spp. (spikerush) and *Hordeum marinum* (barley).

*Medium Vegetation.* This layer ranges from 30 cm to 1.0 m in height. It commonly includes rushes (*Juncus* spp.), sedges (*Carex* spp.), *Deschampsia cespitosa* (tufted hairgrass), *Scirpus microcarpus* (bulrush), *Rubus ursinus* (blackberry), *Lupinus* spp. (Lupin), and *Artemisia californica* (mugwort).

*Tall Vegetation.* This layer ranges from 1.0 m to 3.0 m in height. It usually includes the tallest emergent vegetation, larger shrubs, and small trees. Examples include *Typha latifolia* (broad-leaved cattail), *Glyceria elata* (mannagrass), *Veratrum californicum* (corn lily), *Baccharis pilularis* (coyote brush) and *Salix exigua* (narrow-leaf willow).

*Very Tall Vegetation.* This layer includes shrubs, vines, and trees that are greater than 3.0 m in height. Examples may include *Sambucus mexicanus* (blue elderberry), *Salix lemmonii* (Lemmon's willow), *Salix lasiolepis* (arroyo willow), *Pinus contorta* (lodgepole pine), and *Alnus rhombifolia* (white alder).

**Figure 15: Flow Chart to Determine Plant Dominance**



**Table 20. Plant Layer Height Classes for Channeled Wet Meadow, Forested Slope Wetlands, and Seeps and Springs.**

<b>Height Class</b>	<b>Floating</b>	<b>Short</b>	<b>Medium</b>	<b>Tall</b>	<b>Very Tall</b>
	On water surface	<0.3 m	0.3 – 1.0 m	1.0 - 3.0 m	> 3.0 m

**Special Note:**

*\*Standing (upright) dead or senescent vegetation from the previous growing season can be used in addition to live vegetation to assess the number of plant layers present. However, the lengths of prostrate stems or shoots are disregarded. In other words, fallen vegetation should not be “held up” to determine the plant layer to which it belongs. The number of plant layers must be determined based on the way the vegetation presents itself in the field.*

**Submetric B: Number of Co-dominant Species**

For each plant layer in the AA, every species represented by living vegetation that comprises at least 10% relative cover within the layer is considered to be dominant in that layer, and should be recorded in the appropriate part of the Plant Community Metric Worksheet. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded. When identifying the total number of dominant species in an AA, count each species only once; do not count a species multiple times if it is found in more than one layer.

**Special Notes:**

*\*If there are unknown plant species that are considered dominant in the AA, take a close-up photograph and a voucher specimen sample back to your office for identification (provided you have permission to remove samples from the landowner or managing agency). Make sure to collect any flowers, fruit, or seeds that are present to help in the identification process.*

*\*Please refer to the CRAM Photo Dictionary at [www.cramwetlands.org](http://www.cramwetlands.org) for a list of plant identification websites.*

**Plant Community Metric Worksheet: Co-dominant species richness for Channeled Wet Meadow, Channeled Forested Slope Wetlands, Non-channeled Forested Slope Wetlands, and Seeps and Springs**  
(A dominant species represents  $\geq 10\%$  relative cover)

Special Note:

*\* Combine the counts of co-dominant species from all layers to identify the total species count. Each plant species is only counted once when calculating the Number of Co-dominant Species and Percent Invasion submetric scores, regardless of the numbers of layers in which it occurs.*

Floating or Canopy-forming	Invasive?	Short (<0.3 m)	Invasive?
Medium (0.3-1.0 m)	Invasive?	Tall (1.0-3.0 m)	Invasive?
Very Tall (>3.0 m)	Invasive?	Total number of co-dominant species for all layers combined (enter here and see Table 21)	
		Percent Invasion (enter here and see Table 21)	

**Submetric C: Percent Invasive Species**

A list of invasive species is provided as Appendix IV of the User's Manual and can also be accessed directly from the California Invasive Plant Council's website (<http://cal-ipc.org/paf/>). Any species not on this list is not considered to be invasive, although it might be non-native, unless there is a strong rationale from local experts to designate a particular plant as invasive for a region. Expertise is required to assure that species are correctly identified as native, non-native, or invasive.

**Table 21: Ratings for Plant Community Sub-metrics for Channeled Wet Meadows, Forested Slope Wetlands, and Seeps and Springs.**

Rating	Submetric A: Number of Plant Layers Present	Submetric B: Number of Co- dominant Species	Submetric C: Percent Invasion
<b>A</b>	4-5	$\geq 10$	0 – 10%
<b>B</b>	3	7 – 9	11 – 20%
<b>C</b>	2	5 – 6	21 – 30%
<b>D</b>	0-1	0 – 4	31 – 100%

## Method 2: For Non-Channelled Meadows

### Metric 1: Plant Community for Non-Channelled Meadows

The Plant Community Metric for Non-Channelled Meadows is composed of two submetrics (submetrics B and C): Number of Co-dominant Species, and Percent Invasive Species. Submetric A: Number of Plant Layers Present is not applicable.

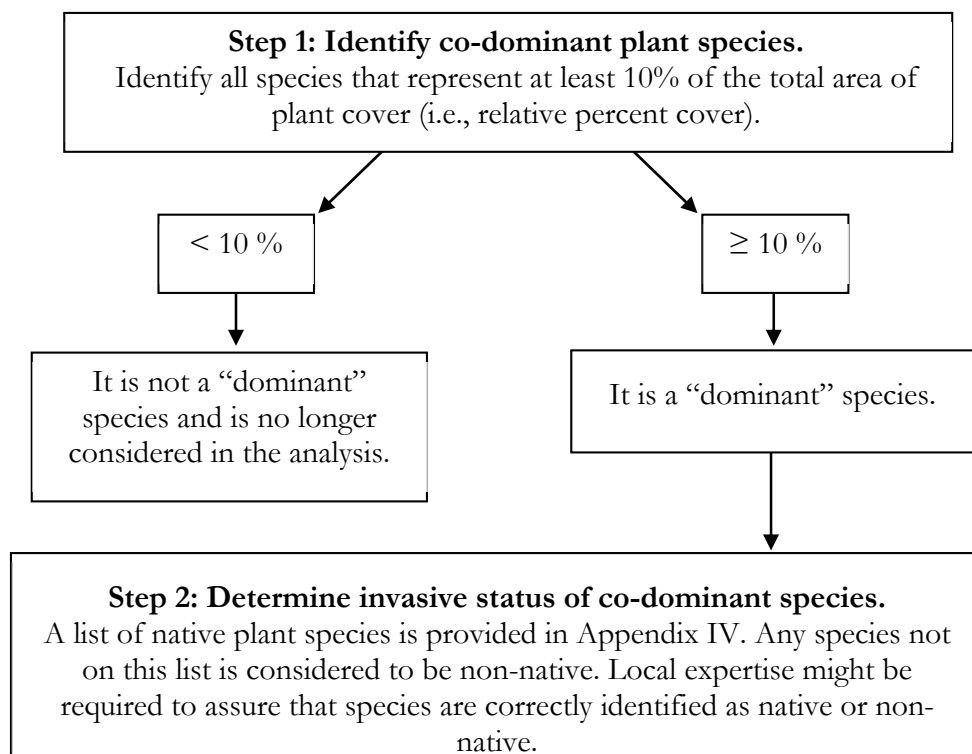
A “plant” is defined as an individual of any vascular macrophyte species of tree, shrub, herb/forb, or fern, whether submerged, floating, emergent, prostrate, decumbent, or erect, including non-native (exotic) plant species. Algae and bryophytes (including mosses and liverworts) are not included among the species identified in the assessment of the plant community.

Non-native species owe their occurrence in California to the actions of people since the time of Euroamerican contact. Many non-native species are now *naturalized* in California, and may be widespread in occurrence, but are not considered invasive. “Invasive” species are non-native species that “(1) are not native to, yet can spread into, wildland ecosystems, and that also (2) displace native species, hybridize with native species, alter biological communities, or alter ecosystem processes” (CalIPC 2012). CRAM uses the California Invasive Plant Council (CalIPC) list to determine the invasive status of plants, *with augmentation by regional experts*.

#### Submetric B: Number of Co-dominant Species

All plant species that comprise at least 10% relative cover of the AA are considered to be dominant. Only living vegetation is considered in this metric. Dead or senescent vegetation is disregarded. Bare areas and areas of open water areas are also disregarded.

**Figure 16: Steps to Determine Number of Co-dominants**



**Table 22: Worksheet for Co-dominant Plant Species.**

**Note:** A dominant species represents  $\geq 10\%$  *relative* cover. Count species only once when calculating any Plant Community sub-metric. Invasive species are listed in Appendix IV of the User's Manual.

Co-dominant Species	Check if Invasive
<b>Total Number of Co-dominants</b>	
<b>Total Number of Invasive Co-dominant species</b>	
<b>Percent Invasive Species (round to nearest integer)</b>	

### Submetric C: Percent Invasive Species

A list of invasive species is provided as Appendix IV of the User's Manual. Any species not on this list is not considered to be invasive, although it might be non-native, unless there is a strong rationale from local experts to designate a particular plant as invasive for a region. Expertise is required to assure that species are correctly identified as native, non-native, or invasive.



**Table 23: Ratings for Plant Community Submetrics for  
Non-Channelled Wet Meadows.**

<b>Rating</b>	<b>Submetric A: Number of Plant Layers Present</b>	<b>Submetric B: Number of Co-dominant Species</b>	<b>Submetric C: Percent Invasion</b>
<b>A</b>	n/a	$\geq 6$	0 – 10%
<b>B</b>	n/a	5	11 – 20%
<b>C</b>	n/a	4	21 – 30%
<b>D</b>	n/a	0 – 3	31 – 100%

### **Metric 2: Horizontal Interspersion**

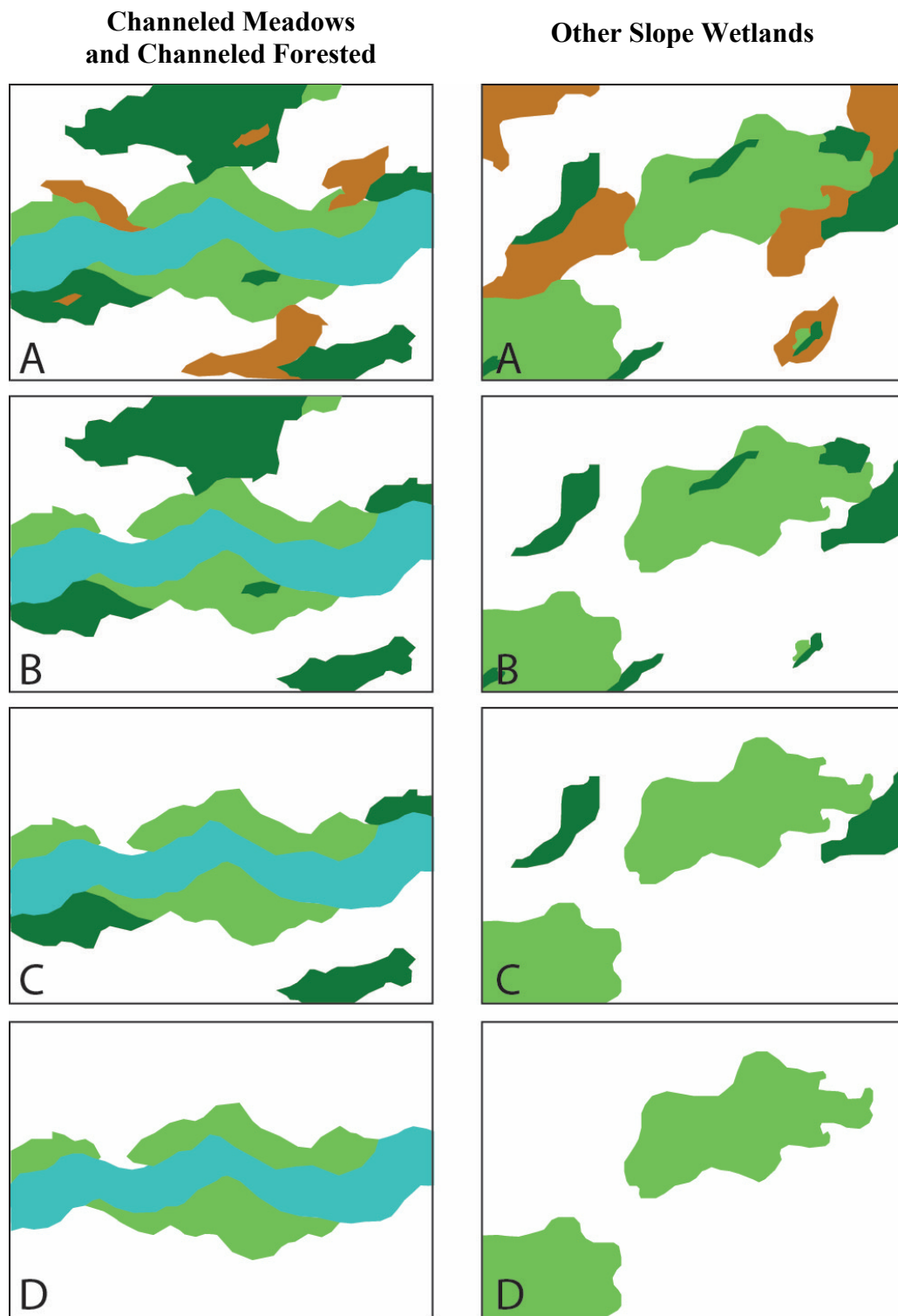
Horizontal Interspersion refers to the variety and interspersion of plant “zones,” or patches of monocultures or obvious multi-species association that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in a two-dimensional plan view. Interspersion is essentially a measure of the number of distinct plant zones or patches AND the amount of edge between them. Each zone must comprise 5% or more of the AA. It is important to note that the number of zones can be surprisingly high in some areas, and this metric cannot be scored by simply “counting” the number of zones. An "A" condition means BOTH more zones AND a greater degree of interspersion, and the departure from the "A" condition is proportional to BOTH the reduction in the numbers of zones AND their interspersion.

Examples may include multi-layered “riparian forest” composed of alders and pines above a willow understory; a shrub thicket dominated solely by arroyo willow; “meadow plain” composed of a consistent mix of three *Carex* and two *Juncus* species; or a “grass zone” with a widely varying composition of numerous Eurasian and/or native grasses. In all cases, the plant “zones” are defined by a relatively unvarying combination of physiognomy and species composition. Think of each plant zone as a vegetation complex of relatively non-varying composition extending from the top of the tallest trees down through all of the vegetation to ground level. A zone may include groups of species of multiple heights, and this metric is not based on the layers established in the Plant Community Submetric A.

### Horizontal Interspersion Worksheet

Use the spaces below to make a quick sketch of the AA in plan view, outlining the major plant zones (this should take no longer than 10 minutes). Assign the zones names and record them on the right. Based on the sketch, choose a single profile from Figure 17 that best represents the AA overall.

	<b>Assigned zones:</b>
	1)
	2)
	3)
	4)
	5)
	6)



**Figure 17:** Illustration of alternative patch mosaics for Horizontal Interspersion. Each row represents a different degree of interspersions and zonation among the patches. The first column represents Channeled Wet Meadows and Channeled Forested Slope wetlands, and the second column represents all other Slope wetlands. Colors represent obviously different plant zones. The white area within represents the matrix or background vegetation type.

### Metric 3: Plant Life Forms

The Plant Life Forms metric captures the number of different plant structure types that are present within the AA. Each plant life form provides unique functions for animal habitat as well as influencing hydrologic and physical processes. Wetlands with multiple life forms provide a greater diversity and complexity of biotic structure, which in turn provides the complexity of habitat for birds, mammals, amphibians and insects. Each life form must be present over at least 5% relative cover of the AA to be counted.

**Table 24. Plant Life Forms Metric.**

<b>Life Form</b>	<b>Present in &gt; 5% of AA?</b>
Bryophytes (mosses, liverworts, hornworts)	
Coniferous Trees	
Deciduous Broadleaf Trees	
Evergreen Broadleaf Trees	
Ferns	
Grasses	
Herbs/Forbs	
Lichens or Fungi	
Sedges/Rushes	
Shrubs	
Vines	
<b>Total Number of life forms</b>	

#### Life Form Definitions:

*Bryophytes:* Non-vascular land plants, consisting of a large group of seedless, flowerless, fruitless green plants including the mosses, liverworts, and hornworts. Bryophytes lack the specialized tissues xylem and phloem that circulate water and dissolved nutrients in the vascular plants. Bryophytes generally live on land but are mostly found in moist environments, for they have free-swimming sperm that require water for transport (Dictionary.com). Mosses and most liverworts have clearly recognizable leaves on stems, but totally lack a root system, while hornworts and some liverworts lack a leaf-stem differentiation (Norris, 2003). For example, *Sphagnum sp.*, *Marchantia polymorpha*, *Kindbergia oregana*.

*Coniferous trees:* Gymnosperms that have reproductive structures in cones. They are typically evergreen, and have drought-resistant leaves that are needle-shaped or scalelike. This group includes pines, firs, spruces, hemlocks, cypresses, junipers, yews, and redwoods. (Dictionary.com). For example, *Sequoia sempervirens*, *Pinus contorta*, *Abies concolor*.

*Deciduous Broadleaf trees:* Trees that have leaves that fall seasonally. (Jepson e-flora) For example, *Salix sp.*, *Acer macrophyllum*, *Alnus rhombifolia*.

*Evergreen Broadleaf trees:* Evergreen trees that are never leafless; usually pertaining to leaves that remain green and on the plant for more than one season, and that do not fall seasonally, or to plants that are never leafless. (Jepson e-flora) Broadleaf trees are angiosperms that have flat leaves and produce seeds inside of fruits. For example, *Quercus agrifolia*, *Notholithocarpus densiflorus*, *Umbellularia californica*.

*Ferns:* A vascular plant that reproduces via spores. Ferns do not have seeds or flowers. For example, *Polystichum californicum*, *Dryopteris expansa*, *Adiantum aleuticum*.

**Grasses:** Monocotyledonous plants of the family Poaceae, which can be perennial or annual.

Characterized by narrow, blade shaped leaves with sheaths, and jointed stems (biology-online.org). For example, *Poa pratensis*, *Deschampsia cespitosa*, *Bromus tectorum*.

**Herbs/Forbs:** Plants that, at least above ground, are generally non-woody and of less than one year or growing season in duration. (Jepson e-flora) For example, *Lupinus polyphyllus*, *Achillea millefolium*, *Persicaria punctata*.

**Lichens or fungi:** Lichen is a symbiosis of algae or cyanobacteria living among fungi. Fungi is a eukaryotic organism that does not photosynthesize. They are the principal decomposers of organic matter. For example, *Ramalina menziesii*, *Parmelia sulcata*, *Letharia vulpina*.

**Sedges/Rushes:** Sedges are graminoid flowering plants that have stems with triangular cross sections. Rushes are graminoid flowering plants that have round stems. For example, *Carex nebrascensis*, *Carex barbarae*, *Juncus mexicanus*, *Juncus effusus*.

**Shrubs:** Woody plant of relatively short maximum height, with generally many branches from the base (Jepson e-flora). For example, *Rosa californica*, *Grindelia stricta*, *Baccharis pilularis*.

**Vines:** Trailing, twining, or climbing plant, usually attached to its support by the twisting or coiling of stems, tendrils, or other structures (Jepson e-flora). For example, *Toxicodendron diversilobum*, *Rubus ursinus*, *Vitis californica*.

Special Notes:

*\*Dead or senescent vegetation does not count towards life forms present.*

**Table 25: Ratings for Number of Life Forms Present.**

Rating	Number of Co-dominant Life Forms
A	$\geq 6$
B	4-5
C	3
D	$\leq 2$

## Guidelines to Complete the Stressor Checklists

A stressor, as defined for the purposes of the CRAM, is an anthropogenic perturbation within a wetland or its environmental setting that is likely to negatively impact the condition and function of the CRAM Assessment Area (AA). A disturbance is a natural phenomenon that affects the AA.

There are four underlying assumptions of the Stressor Checklist: (1) deviation from the best achievable condition can be explained by a single stressor or multiple stressors acting on the wetland; (2) increasing the number of stressors acting on the wetland causes a decline in its condition (there is no assumption as to whether this decline is additive (linear), multiplicative, or is best represented by some other non-linear mode); (3) increasing either the intensity or the proximity of the stressor results in a greater decline in condition; and (4) continuous or chronic stress increases the decline in condition.

The process to identify stressors is the same for all wetland types. For each CRAM attribute, a variety of possible stressors are listed. Their presence and likelihood of significantly affecting the AA are recorded in the Stressor Checklist Worksheet. For the Hydrology, Physical Structure, and Biotic Structure attributes, the focus is on stressors operating within the AA or within 50 m of the AA. For the Buffer and Landscape Context attribute, the focus is on stressors operating within 500 m of the AA. More distant stressors that have obvious, direct, controlling influences on the AA can also be noted.

**Table 26: Wetland disturbances and conversions**

Has a major disturbance occurred at this wetland?	Yes	No		
If yes, was it a flood, fire, landslide, or other?	flood	fire	landslide	other
If yes, then how severe is the disturbance?	likely to affect site next 5 or more years	likely to affect site next 3-5 years	likely to affect site next 1-2 years	
Has this wetland been converted from another type? If yes, then what was the previous type?	depressional	vernal pool	vernal pool system	
	non-confined riverine	confined riverine	seasonal estuarine	
	perennial saline estuarine	perennial non-saline estuarine	wet meadow	
	lacustrine	seep or spring	playa	

### Worksheet: Stressor Checklist

HYDROLOGY ATTRIBUTE (WITHIN 50 M OF AA)	Present	Present and likely to have significant negative effect on AA
Point Source (PS) discharges (POTW, other non-stormwater discharge)		
Non-point Source (Non-PS) discharges (urban runoff, farm drainage)		
Flow diversions or unnatural inflows		
Dams (reservoirs, detention basins, recharge basins)		
Flow obstructions (culverts, paved stream crossings)		
Weir/drop structure, tide gates		
Dredged inlet/channel		
Engineered channel (riprap, armored channel bank, bed)		
Dike/levees		
Groundwater extraction		
Ditches (borrow, agricultural drainage, mosquito control, etc.)		
Actively managed hydrology		
<b>Comments</b>		

PHYSICAL STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present	Present and likely to have significant negative effect on AA
Filling or dumping of sediment or soils (N/A for restoration areas)		
Grading/ compaction (N/A for restoration areas)		
Plowing/Discing (N/A for restoration areas)		
Resource extraction (sediment, gravel, oil and/or gas)		
Vegetation management		
Excessive sediment or organic debris from watershed		
Excessive runoff from watershed		
Nutrient impaired (PS or Non-PS pollution)		
Heavy metal impaired (PS or Non-PS pollution)		
Pesticides or trace organics impaired (PS or Non-PS pollution)		
Bacteria and pathogens impaired (PS or Non-PS pollution)		
Trash or refuse		
<b>Comments</b>		



<b>BIOTIC STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)</b>	<b>Present</b>	<b>Present and Likely to Have Significant negative effect on AA</b>
Mowing, grazing, excessive herbivory (within AA)		
Excessive human visitation		
Predation and habitat destruction by non-native vertebrates (e.g., <i>Virginia opossum</i> and domestic predators, such as feral pets)		
Tree cutting/sapling removal		
Removal of woody debris		
Treatment of non-native and nuisance plant species		
Pesticide application or vector control		
Biological resource extraction or stocking (fisheries, aquaculture)		
Excessive organic debris in matrix (for vernal pools)		
Lack of vegetation management to conserve natural resources		
Lack of treatment of invasive plants adjacent to AA or buffer		
<b>Comments</b>		

<b>BUFFER AND LANDSCAPE CONTEXT ATTRIBUTE (WITHIN 500 M OF AA)</b>	<b>Present</b>	<b>Present and likely to have significant negative effect on AA</b>
Urban residential		
Industrial/commercial		
Military training/Air traffic		
Dams (or other major flow regulation or disruption)		
Dryland farming		
Intensive row-crop agriculture		
Orchards/nurseries		
Commercial feedlots		
Dairies		
Ranching (enclosed livestock grazing or horse paddock or feedlot)		
Transportation corridor		
Rangeland (livestock rangeland also managed for native vegetation)		
Sports fields and urban parklands (golf courses, soccer fields, etc.)		
Passive recreation (bird-watching, hiking, etc.)		
Active recreation (off-road vehicles, mountain biking, hunting, fishing)		
Physical resource extraction (rock, sediment, oil/gas)		
Biological resource extraction (aquaculture, commercial fisheries)		
<b>Comments</b>		

## CRAM Score Guidelines

**Table 27: Steps to calculate attribute scores and AA scores.**

<b>Step 1:</b> Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
<b>Step 2:</b> Calculate raw Attribute Score	<p>For each Attribute, calculate the Raw Attribute Score as the sum of the numeric scores of the component Metrics, except in the following cases:</p> <ul style="list-style-type: none"> <li>For Attribute 1 (Buffer and Landscape Context), the submetric scores relating to buffer are combined into an overall buffer score that is added to the score for the Aquatic Area Abundance metric, using the following formula:</li> </ul> $\left( \boxed{\text{Buffer Condition}} \times \left( \boxed{\% \text{ AA with Buffer}} \times \boxed{\text{Average Buffer Width}} \right)^{\frac{1}{2}} \right)^{\frac{1}{2}} + \boxed{\text{Aquatic Area Abundance}}$ <ul style="list-style-type: none"> <li>For Attribute 2, the Hydrologic Connectivity metric is split into two sub-metrics for Channeled Wet Meadows and Channeled Forested Slopes. Prior to calculating the Raw Attribute Score, average the 2 sub-metrics. Then sum the result with the other two Hydrology metrics. For all other Slope wetlands, simply sum the three Hydrology metrics.</li> <li>For Attribute 4 (Biotic Structure), prior to calculating the Raw Attribute Score, average the two or three Plant Community submetrics (A-C for Channeled Wet Meadows, Forested Slopes and Seeps and Springs, B-C for Non-Channeled Meadows). Then sum this result with the other two Biotic Structure metrics for the Raw Attribute Score.</li> <li><b>Do not</b> round the Raw Attribute scores to the nearest integer.</li> </ul>
<b>Step 3:</b> Calculate final Attribute Score	For each Attribute, divide its Raw Attribute Score by its maximum possible score, which is 24 for Buffer and Landscape Context, 36 for Hydrology, 24 for Physical Structure, and 36 for Biotic Structure. <b>Do not</b> round the final Attribute scores to the nearest integer before calculating the AA Index Score. You may round the final Attribute score to the nearest integer for reporting purposes.
<b>Step 4:</b> Calculate the AA Index Score	Calculate the AA Index score by averaging the Final Attribute Scores (with all significant figures: not rounded). Round this average to the nearest integer to get the AA Index Score (0.5 or greater rounds up, less than 0.5 rounds down).

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