A photograph of a riverine wetland. The foreground and middle ground are dominated by water with numerous clumps of tall, thin, brownish-green grasses growing out of it. The water is dark and reflects the sky. In the background, a grassy bank rises, covered in green vegetation. The entire image is framed by a thin, dark border.

**California Rapid Assessment Method
for Wetlands**

version 5.0.2

**Riverine Wetlands
Field Book**

September 2008

Basic Information Sheet: Riverine Wetlands

Your Name:					
CRAM Site ID:					
Assessment Area Name:					
Assessment No.		Date (m/d/y)			
Assessment Team Members for This AA					
Average Bankfull Width:					
Approximate Length of AA (10 times bankfull width, min 100 m, max 200 m):					
Wetland Sub-type:					
<input type="checkbox"/> Confined <input type="checkbox"/> Non-confined					
AA Category:					
<input type="checkbox"/> Restoration <input type="checkbox"/> Mitigation <input type="checkbox"/> Impacted <input type="checkbox"/> Other					
Did the river/stream have flowing water at the time of the assessment? <input type="checkbox"/> yes <input type="checkbox"/> no					
What is the apparent hydrologic flow regime of the reach you are assessing?					
<p>The hydrologic flow regime of a stream describes the frequency with which the channel conducts water. <i>Perennial</i> streams conduct water all year long, whereas <i>ephemeral</i> streams conduct water only during and immediately following precipitation events. <i>Intermittent</i> streams are dry for part of the year, but conduct water for periods longer than ephemeral streams, as a function of watershed size and water source.</p>					
<input type="checkbox"/> perennial <input type="checkbox"/> ephemeral <input type="checkbox"/> intermittent					
Photo Identification Numbers and Description:					
	Photo ID No.	Description	Latitude	Longitude	Datum
1		North			
2		South			
3		East			
4		West			
5					
6					

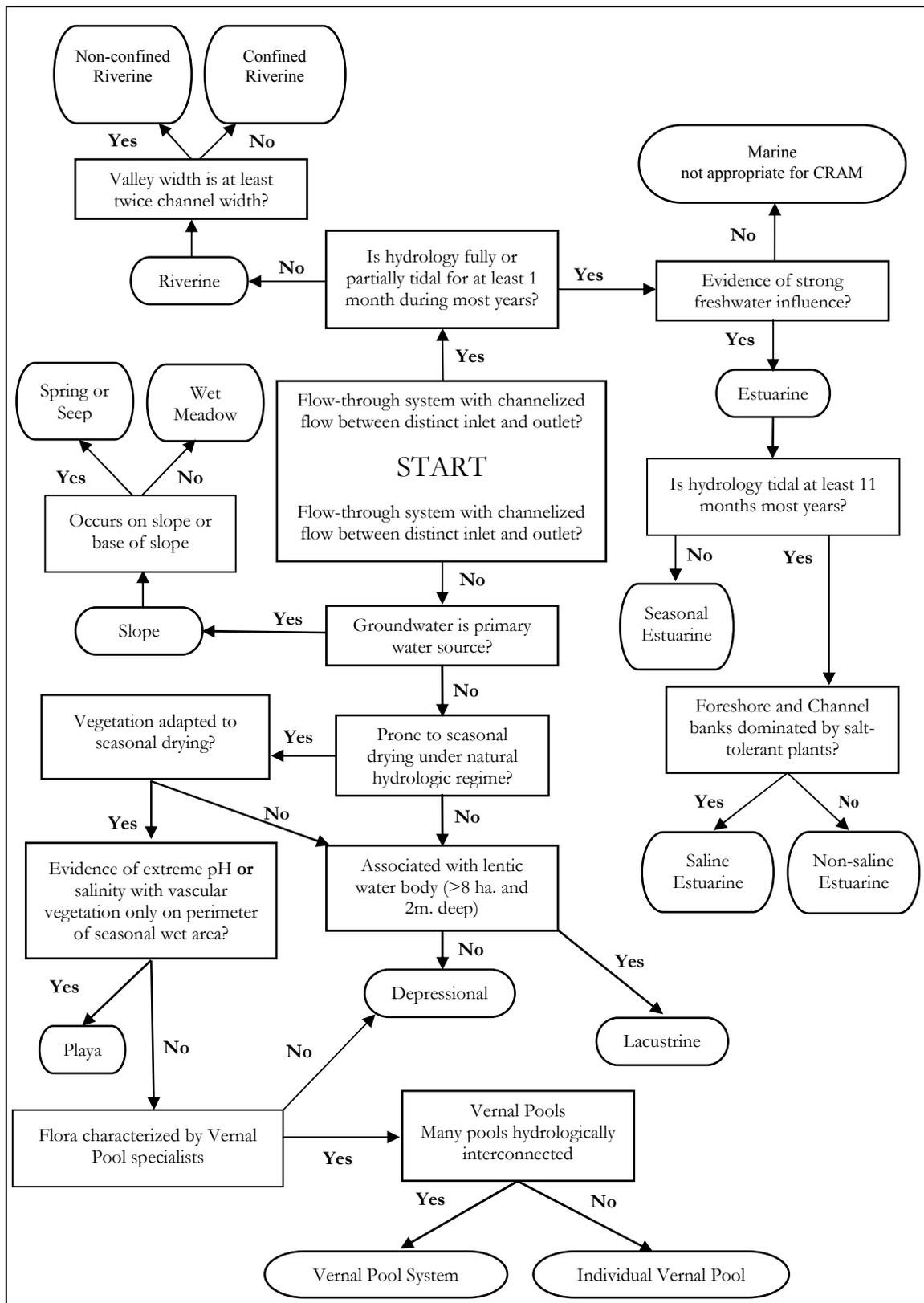
Comments:

Scoring Sheet: Riverine Wetlands

AA Name:		(m/d/y)			
Attributes and Metrics		Scores		Comments	
Buffer and Landscape Context					
Landscape Connectivity (D)					
<i>Buffer submetric A: Percent of AA with Buffer</i>					
<i>Buffer submetric B: Average Buffer Width</i>					
<i>Buffer submetric C: Buffer Condition</i>					
$D + [C \times (A \times B)^{1/2}]^{1/2} = \text{Attribute Score}$		Raw	Final	Final Attribute Score = (Raw Score/24)100	
Hydrology					
Water Source					
Hydroperiod or Channel Stability					
Hydrologic Connectivity					
Attribute Score		Raw	Final	Final Attribute Score = (Raw Score/36)100	
Physical Structure					
Structural Patch Richness					
Topographic Complexity					
Attribute Score		Raw	Final	Final Attribute Score = (Raw Score/24)100	
Biotic Structure					
<i>Plant Community submetric A: Number of Plant Layers</i>					
<i>Plant Community submetric B: Number of Co-dominant species</i>					
<i>Plant Community submetric C: Percent Invasion</i>					
Plant Community Metric (average of submetrics A-C)					
Horizontal Interspersion and Zonation					
Vertical Biotic Structure					
Attribute Score		Raw	Final	Final Attribute Score = (Raw Score/36)100	
Overall AA Score				Average of Final Attribute Scores	

Identify Wetland Type

Figure 3.2: Flowchart to determine wetland type and sub-type.



3.2.2.1 Riverine (Including Closely Associated Riparian Areas)

A riverine wetland consists of the riverine channel and its active floodplain, plus any portions of the adjacent riparian areas that are likely to be strongly linked to the channel or floodplain through bank stabilization and allochthonous inputs (see Section 3.5.3 below). An active floodplain is defined as the relatively level area that is periodically flooded, as evidenced by deposits of fine sediment, wrack lines, vertical zonation of plant communities, etc. The water level that corresponds to incipient flooding can vary depending on flow regulation and whether the channel is in equilibrium with water supplies and sediment supplies. Under equilibrium conditions, the usual high water contour that marks the inboard margin of the floodplain (i.e., the margin nearest the thalweg of the channel) corresponds to the height of bankfull flow, which has a recurrence interval of about 1.5 years. The active floodplain can include broad areas of vegetated and non-vegetated bars and low benches among the distributaries of deltas and braided channel systems. Vegetated wetlands can develop along the channel bottoms of intermittent and ephemeral streams during the dry season. Dry season assessment in these systems therefore includes the channel beds. However, the channel bed is excluded from the assessment when it contains non-wadeable flow. To help standardize the assessment of riverine wetlands, the assessments should be restricted to the dry season (see Sections 3.4 and 3.5.3).

There may be a limit to the applicability of CRAM in low order (i.e., headwater) streams in very arid environments that tend not to support species-rich plant communities with complex horizontal and vertical structure. CRAM may be systematically biased against such naturally simple riverine systems. Therefore, while CRAM can be used in these systems, the results will be tracked carefully to ascertain if CRAM should be revised in their regard.

Riverine wetlands are further classified as confined or non-confined, based on the ratio of valley width to channel width (see Figure 3.2 above). Channels can also be entrenched, based on the ratio of flood prone width to bankfull width (Figure 3.3 below). Entrenchment impacts hydrologic connectivity and is discussed more fully in Section 4.2.3. A channel can be confined by artificial levees and urban development if the average distance across the channel at bankfull is more than half the distance between the levees or more than half the width of the unurbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development.

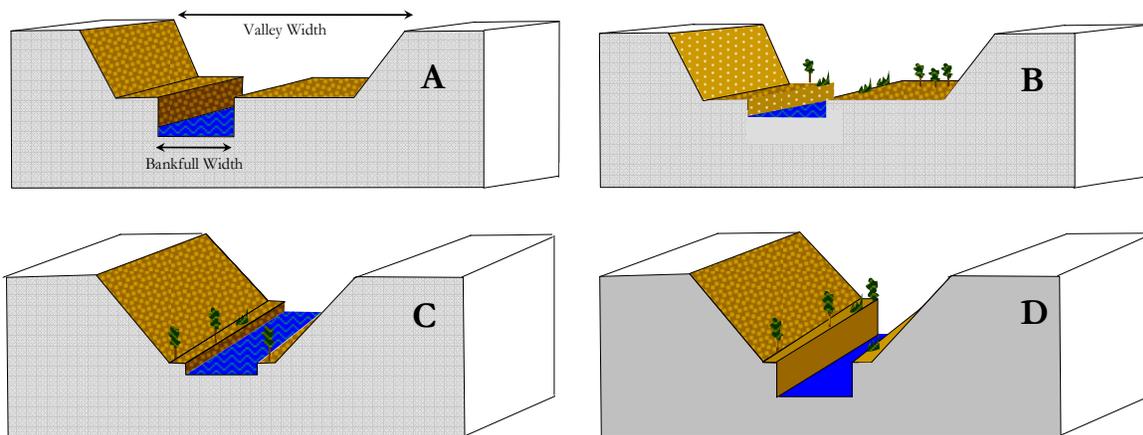


Figure 3.3: Illustrations of riverine confinement and entrenchment.

(A) non-confined entrenched, (B) non-confined not entrenched, (C) confined not entrenched, and (D) confined entrenched riverine sub-types.

3.2.2.1.1 Non-confined Riverine Sub-type

In non-confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, or other feature that is likely to prevent further migration is at least twice the average bankfull width of the channel. Non-confined riverine systems typically occur on alluvial fans, deltas in lakes, and along broad valleys. A channel can be confined by artificial levees and urban development if the average distance across the channel at bankfull is more than half the distance between the levees or more than half the width of the unurbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development. Confinement is unrelated to the channel entrenchment. Entrenched channels can be confined or non-confined.

3.2.2.1.2 Confined Riverine Sub-type

In confined riverine systems, the width of the valley across which the system can migrate without encountering a hillside, terrace, man-made levee, or urban development is less than twice the average bankfull width of the channel. A channel can be confined by artificial levees and urban development if the average distance across the channel at bankfull is more than half the distance between the levees or more than half the width of the unurbanized lands that border the stream course. This assumes that the channel would not be allowed to migrate past the levees or into the urban development. Confinement is unrelated to the channel entrenchment. Entrenched channels can be confined or non-confined.

Establish the Assessment Area (AA)

Table 3.5: Examples of features that *should* be used to delineate AA boundaries.

Flow-Through Wetlands	Non Flow-Through Wetlands	
Riverine, Estuarine and Slope Wetlands	Lacustrine, Wet Meadows, Depressional, and Playa Wetlands	Vernal Pools and Vernal Pool Systems
<ul style="list-style-type: none"> • diversion ditches • end-of-pipe large discharges • grade control or water height control structures • major changes in riverine entrenchment, confinement, degradation, aggradation, slope, or bed form • major channel confluences • water falls • open water areas more than 50 m wide on average or broader than the wetland • transitions between wetland types • foreshores, backshores and uplands at least 5 m wide • weirs, culverts, dams, levees, and other flow control structures 	<ul style="list-style-type: none"> • above-grade roads and fills • berms and levees • jetties and wave deflectors • major point sources or outflows of water • open water areas more than 50 m wide on average or broader than the wetland • foreshores, backshores and uplands at least 5 m wide • weirs and other flow control structures 	<ul style="list-style-type: none"> • above-grade roads and fills • major point sources of water inflows or outflows • weirs, berms, levees and other flow control structures

Table 3.6: Examples of features that should *not* be used to delineate any AAs.

<ul style="list-style-type: none"> • 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 • riffle (or rapid) – glide – pool transitions in a riverine wetland • spatial changes in land cover or land use along the wetland border • state and federal jurisdictional boundaries

Table 3.7: Recommended maximum and minimum AA sizes for each wetland type.
Note: Wetlands smaller than the recommended AA sizes can be assessed in their entirety.

Wetland Type	Recommended AA Size
Slope	
Spring or Seep	Maximum size is 0.50 ha (about 75 m x 75 m, but shape can vary); there is no minimum size.
Wet Meadow	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.1 ha (about 30 m x 30 m).
Depressional	
Vernal Pool	There are no size limits (see Section 3.5.6 and Table 3.8).
Vernal Pool System	There are no size limits (see Section 3.5.6 and Table 3.8).
Other Depressional	Maximum size is 1.0 ha (about 100 m x 100 m, but shape can vary); there is no minimum size.
Riverine	
Confined and Non-confined	Recommended length is 10x average bankfull channel width; maximum length is 200 m; minimum length is 100 m. AA should extend laterally (landward) from the bankfull contour to encompass all the vegetation (trees, shrubs vines, etc) that probably provide woody debris, leaves, insects, etc. to the channel and its floodplain (Figure 3.4); minimum width is 2 m.
Lacustrine	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.5 ha (about 75 m x 75 m).
Playa	Maximum size is 2.25 ha (about 150 m x 150 m, but shape can vary); minimum size is 0.5 ha (about 75 m x 75 m).
Estuarine	
Perennial Saline	Recommended size and shape for estuarine wetlands is a 1 ha circle (radius about 55 m), but the shape can be non-circular if necessary to fit the wetland and to meet hydro-geomorphic and other criteria as outlined in Sections 3.5.1-3. The minimum size is 0.1 ha (about 30 m x 30 m).
Perennial Non-saline	
Seasonal	

Attribute 1: Buffer and Landscape Context

Special Considerations for Riverine Wetlands Including Riparian Areas

For a riverine wetland, the AA should begin at a hydrological or geomorphic break in form or structure of the channel that corresponds to a significant change in flow regime or sediment regime, as guided by Tables 3.5 and 3.6. If no such break exists, then the AA can begin at any point near the middle of the wetland. For ambient surveys, the AA should begin at the point drawn at random from the sample frame. From this beginning, the AA should extend upstream or downstream for a distance ten times (10x) the average channel width, but at least 100 m, and no further than 200 m. In any case, the AA should not extend upstream of any confluence that obviously increases the downstream sediment supply or flow, or if the channel in the AA is obviously larger below the confluence than above it. The AAs should include both sides of wadeable channels, but only one side of channels that cannot be safely crossed by wading.

All types of wetlands can have adjacent riparian areas that benefit the wetlands. However, riparian areas play a larger role in the overall form and function of a riverine wetland than they do for the other wetland types. Riverine wetlands are generally more dependent on the allochthonous riparian input to support their food webs. Also, the large woody debris provided by riparian areas can be essential to maintain riverine geomorphology, such as pools and riffles, as well as the associated ecological services, such the support of anadromous fishes. Conservation policies and practices commonly associate riparian functions with riverine wetlands more than other wetland types.

Therefore, the riverine AA should extend landward from the backshore of the floodplain to include the adjacent riparian area that probably accounts for bank stabilization and most of the direct allochthonous inputs of leaves, limbs, insects, etc. into the channel including its floodplain. Any trees or shrubs that directly contribute allochthonous material to the channel should be included in the AA in their entirety (Figure 3.4). The AA can include topographic benches, interfluves, paleo-channels, terraces, meander cutoffs, and other features that are at least semi-regularly influenced by fluvial processes associated with the main channel of the AA or that support vegetation that is likely to directly provide allochthonous inputs.

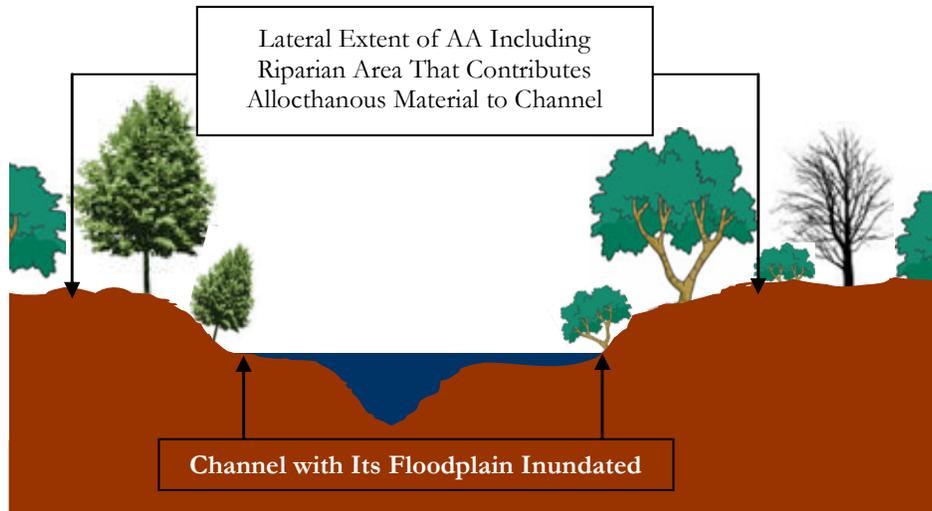


Figure 3.4: Diagram of the lateral extent of a riverine AA that includes the portion of the riparian area that can help stabilize the channel banks and that can readily provide allochthonous inputs of plant matter, insects, etc.

If the lateral limits of allochthonous input are not discernable, then the AA should extend laterally from the backshore toward the uplands for a distance equal to twice the Site Potential Vegetation Height (SPVH). For example, if the dominant overstory along the backshore of a channel consists of alders about 5 m tall, then the AA would extend landward 10 m from the backshore. The minimum riparian width is 2 m. For a wadeable riverine system, the opposing sides of the AA can have different widths, based on differences in plant architecture.

Landscape Connectivity

Definition: The landscape connectivity 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. It is assumed that wetlands close to each other have a greater potential to interact ecologically and hydrologically, and that such interactions are generally beneficial.

For riverine wetlands, landscape connectivity is assessed as the continuity of the riparian corridor over a distance of about 500 m upstream and 500 m downstream of the AA. Of special concern is the ability of wildlife to enter the riparian area from outside of it at any place within 500 m of the AA, and to move easily through adequate cover along the riparian corridor through the AA from upstream and downstream. The landscape connectivity of riverine wetlands is assessed as the total amount of non-buffer land cover (as defined in Table 4.4) that interrupts the riparian corridor within 500 m upstream or downstream of the AA. Non-buffer land covers less than 10 m wide are disregarded in this metric.

Note that, for riverine wetlands, this metric considers areas of open water to provide landscape connectivity. For the purpose of assessing buffers, open water is considered a non-buffer land cover. But for the purpose of assessing landscape connectivity for riverine wetlands, open water is considered part of the riparian corridor. This acknowledges the role the riparian corridors have in linking together aquatic habitats and in providing habitat for anadromous fish and other wildlife.

Table 4.2: Steps to assess Landscape Connectivity for riverine wetlands.

Step 1	Extend the AA 500 m upstream and downstream, regardless of the land cover types that are encountered (see Figure 4.1).
Step 2	Using the site imagery, identify all the places where non-buffer land covers (see Table 4.4) at least 10 m wide interrupt the riparian area on at least one side of the channel in the extended AA. Disregard interruptions of the riparian corridor that are less than 10 m wide. Do not consider open water as an interruption.
Step 3	Estimate the length of each non-buffer segment identified in Step 2, and enter the estimates in the worksheet for this metric.

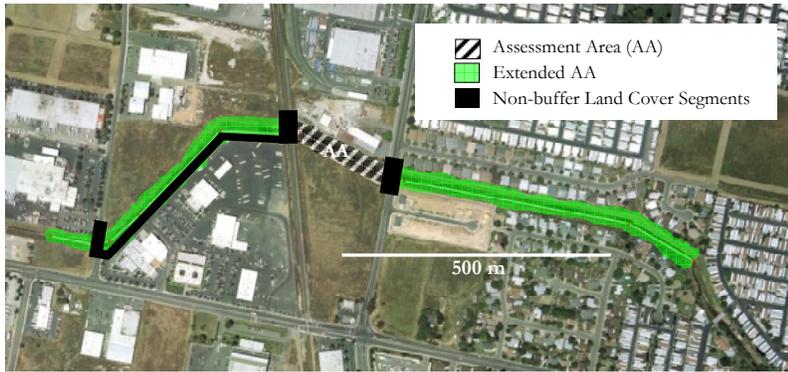


Figure 4.1: Diagram of method to assess Landscape Connectivity of riverine wetlands. This example shows that about 400 m of non-buffer cover crosses at least one half of the buffer corridor within 500 m downstream of the AA, and about 10 m crosses the corridor upstream of the AA.

Worksheet for Landscape Connectivity Metric for Riverine Wetlands

Lengths of Non-buffer Segments For Distance of 500 m Upstream of AA		Lengths of Non-buffer Segments For Distance of 500 m Downstream of AA	
Segment No.	Length (m)	Segment No.	Length (m)
1		1	
2		2	
3		3	
4		4	
5		5	
Upstream Total Length		Downstream Total Length	

Table 4.3: Rating for Landscape Connectivity for Riverine wetlands.

Notes:

- a. Assume the riparian width is the same upstream and downstream as it is for the AA, unless a substantial change in width is obvious for a distance of at least 100 m.
- b. Assume that open water areas serve as buffer (only for this metric as it applies to riverine wetlands).
- c. The minimum length for any non-buffer segment (measured parallel to the channel) is 10 m.
- d. To be a concern, a non-buffer segment must cross the riparian area on at least one side of the AA.
- e. For wadeable systems, assess both sides of the channel upstream and downstream of the AA.
- f. For systems that cannot be waded, only assess the side of the channel that has the AA, upstream and downstream of the AA.

Rating	For Distance of 500 m Upstream of AA:	For Distance of 500 m Downstream of AA:
A	The combined total length of all non-buffer segments is less than 100 m for wadeable systems (“2-sided” AAs); 50 m for non-wadeable systems (“1-sided” AAs).	The combined total length of all non-buffer segments is less than 100 m for wadeable systems (“2-sided” AAs); 50 m for non-wadeable systems (“1-sided” AAs).
B	The combined total length of all non-buffer segments is less than 100 m for “2-sided” AAs; 50 m for “1-sided” AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for “2-sided” AAs; 50 m and 100 m for “1-sided” AAs.
OR		
B	The combined total length of all non-buffer segments is between 100 m and 200 m for “2-sided” AAs; 50 m and 100 m for “1-sided” AAs.	The combined total length of all non-buffer segments is less than 100 m for “2-sided” AAs; is less than 50 m for “1-sided” AAs.
C	The combined total length of all non-buffer segments is between 100 m and 200 m for “2-sided” AAs; 50 m and 100 m for “1-sided” AAs.	The combined total length of all non-buffer segments is between 100 m and 200 m for “2-sided” AAs; 50 m and 100 m for “1-sided” AAs.
D	The combined total length of non-buffer segments is greater than 200 m for “2-sided” AAs; greater than 100 m for “1-sided” AAs.	any condition
OR		
D	any condition	The combined total length of non-buffer segments is greater than 200 m for “2-sided” AAs; greater than 100 m for “1-sided” AAs.

Percent of AA with Buffer

Definition: The buffer is the 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 forays into the AA by people and non-native predators, or otherwise protect the AA from stress and disturbance.

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.

Any area of open water at least 30 m wide that is adjoining the AA, such as a lake, large river, or large slough, is not considered in the assessment of the buffer. Such open water is considered to be neutral, 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. First, assessments of buffer extent and buffer width are inflated by including open water as a part of the buffer. Second, 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. Third, 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 hydroperiods, etc.). However, any area of open water at least 30 m wide that is within 250 m of the AA but is not adjoining the AA is considered part of the buffer.

In the example below (Figure 4.2), most of the area around the AA (outlined in white) consists of non-buffer land cover types. The AA adjoins a major roadway, parking lot, and other development that is a non-buffer land cover type. There is a nearby wetland but it is separated from the AA by a major roadway and is not considered buffer. The open water area is neutral and not considered in the estimation of the percentage of the AA perimeter that has buffer. In this example, the only areas that would be considered buffer is the area labeled “Upland Buffer”.



Figure 4.2: Diagram of buffer and non-buffer land cover types.

Table 4.4: Guidelines for identifying wetland buffers and breaks in buffers.

<p>Examples of Land Covers Included in Buffers</p>	<p>Examples of Land Covers Excluded from Buffers</p> <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"> • bike trails • dry-land farming areas • foot trails • horse trails • links or target golf courses • natural upland habitats • nature or wildland parks • open range land • railroads • roads not hazardous to wildlife • swales and ditches • vegetated levees 	<ul style="list-style-type: none"> • commercial developments • fences that interfere with the movements of wildlife • intensive agriculture (row crops, orchards and vineyards lacking ground cover and other BMPs) • paved roads (two lanes plus a turning lane or larger) • lawns • parking lots • horse paddocks, feedlots, turkey ranches, etc. • residential areas • sound walls • sports fields • traditional golf courses • urbanized parks with active recreation • pedestrian/bike trails (i.e., nearly constant traffic)

Table 4.5: Rating for Percent of AA with Buffer.

<p>Rating</p>	<p>Alternative States (not including open-water areas)</p>
<p>A</p>	<p>Buffer is 75 - 100% of AA perimeter.</p>
<p>B</p>	<p>Buffer is 50 – 74% of AA perimeter.</p>
<p>C</p>	<p>Buffer is 25 – 49% of AA perimeter.</p>
<p>D</p>	<p>Buffer is 0 – 24% of AA perimeter.</p>

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 4.4 above for more guidance regarding the identification of AA buffers.

**Table 4.6: Steps to estimate Buffer Width for all wetlands.
For Riverine wetlands, see text before Figure 4.4.**

Step 1	Identify areas in which open water is directly adjacent to the AA, with no vegetated intertidal or upland area in between. These areas are excluded from buffer calculations.
Step 2	Draw straight lines 250 m in length perpendicular to the AA through the buffer area at regular intervals along the portion of the perimeter of the AA that has a buffer. For one-sided riverine AAs, draw four lines; for all other wetland types, draw eight lines (see Figures 4.3 and 4.4 below).
Step 3	Estimate the buffer width of each of the lines as they extend away from the AA. Record these lengths on the worksheet below.
Step 4	Estimate the average buffer width. Record this width on the worksheet below.

Worksheet for calculating average buffer width of AA

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

For Riverine wetlands, do the steps of Table 4.6 with the following modifications. If the AA includes both sides of the channel (i.e., if the channel is wadeable), then draw four lines through the buffer areas on each side (see Figure 4.4 below). If the AA only exists on one side of the channel, then draw four lines through the buffer on one side (Figure 4.4). No lines should extend from the downstream or upstream ends of the riverine AA. Use the worksheet above to record the data for buffer width.

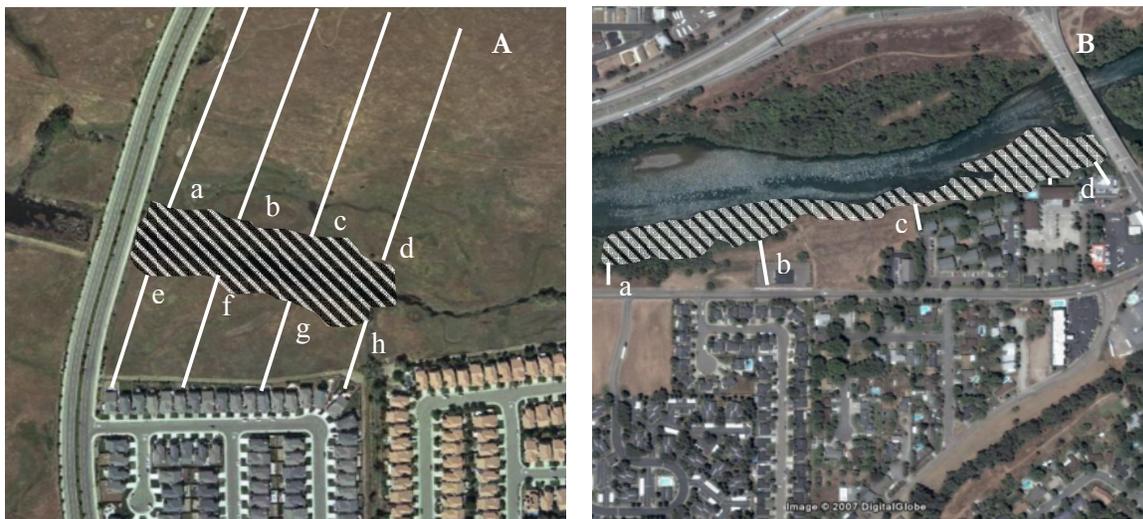


Figure 4.4: Diagram of approach to estimate Buffer Width for Riverine AAs. Widths are measured along lines a-h on both sides of a wadeable channel (A), and along lines a-d on one side of a non-wadeable channel (B).

Table 4.7: 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.

Buffer Condition

Definition: The condition of a buffer is assessed according to the extent and quality of its vegetation cover and the overall condition of its substrate. Evidence of direct impacts by people are excluded from this metric and included in the Stressor Checklist. Buffer conditions are assessed only for the portion of the wetland border that has already been identified or defined as buffer, based on Section 4.1.2 above. If there is no buffer, assign a score of D.

Table 4.8: Rating for Buffer Condition.

Rating	Alternative States
A	Buffer for AA is dominated by native vegetation, has undisturbed soils, and is apparently subject to little or no human visitation.
B	Buffer for AA is characterized by an intermediate mix of native and non-native vegetation, but mostly undisturbed soils and is apparently subject to little or no human visitation.
C	Buffer for AA is characterized by substantial 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.
D	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.

Attribute 2: Hydrology

Water Source

Definition: Water Sources directly affect the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area. Water Sources include the kinds of direct inputs of water into the AA as well as any diversions of water from the AA. Diversions are considered a 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, direct sources include rainfall, ground water discharge, and flooding of the AA due to high tides or naturally high riverine flows. Examples of unnatural, direct sources include stormdrains that empty directly into the AA or into an immediately adjacent area. For seeps and springs that occur at the toes of earthen dams, the reservoirs behind the dams are direct water source. Indirect sources that should not be considered in this metric include large regional dams or urban storm drain systems that do not drain directly into the AA but that have systemic, ubiquitous effects on broad geographic areas of which the AA is a small part. For example, the salinity regimes of estuarine wetlands in San Francisco Bay are indirectly affected by dams in the Sierra Nevada, but some of the same wetlands are directly affected by nearby discharges from sewage treatment facilities. Engineered hydrological controls, such as weirs, tide gates, flashboards, grade control structures, check dams, etc., can serve to demarcate the boundary of an AA (see Section 3.5), but they are not considered water sources.

The typical suite of natural water sources differs among the wetland types. Natural sources of water for riverine wetlands include precipitation, groundwater, and riverine flows. Whether the wetlands are perennial or seasonal, alterations in the water sources result in changes in either the high water or low water levels. Such changes can be assessed based on the patterns of plant growth along the wetland margins or across the bottom of the wetlands.

Table 4.9: Rating for Water Source.

Rating	Alternative States
A	Freshwater sources that affect the dry season condition of the AA, such as its flow characteristics, hydroperiod, or salinity regime, are precipitation, groundwater, and/or 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 water sources.
B	Freshwater sources that affect the dry season condition of the AA are mostly natural, but also obviously include occasional or small effects of modified hydrology. Indications of such anthropogenic inputs include developed land or irrigated agricultural land that 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. No large point sources or dams control the overall hydrology of the AA.
C	<p>Freshwater sources that affect the dry season conditions of the AA are primarily urban runoff, direct irrigation, pumped water, artificially impounded water, water remaining after diversions, regulated releases of water through a dam, or other artificial hydrology. Indications of substantial artificial 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, or the presence of major point source discharges that obviously control the hydrology of the AA.</p> <p style="text-align: center;">OR</p> <p>Freshwater sources that affect the dry season conditions of the AA are substantially controlled by known diversions of water or other withdrawals directly from the AA, its encompassing wetland, or from its drainage basin.</p>
D	Natural, freshwater sources that affect the dry season conditions of the AA have been eliminated based on the following indicators: impoundment of all possible wet season inflows, diversion of all dry-season inflow, predominance of xeric vegetation, etc.

Hydroperiod or Channel Stability

Definition: Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. The natural hydroperiod for estuarine wetlands is governed by the tides, and includes predictable variations in inundation regimes over days, weeks, months, and seasons. Depressional, lacustrine, playas, and riverine wetlands typically have daily variations in water height that are governed by diurnal increases in evapotranspiration and seasonal cycles that are governed by rainfall and runoff. Seeps and springs that depend on groundwater may have relatively slight seasonal variations in hydroperiod.

Channel stability only pertains to riverine wetlands. It is assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time), or degradation (i.e., net loss of sediment from the bed causing it to be lower over time). There is much interest in channel entrenchment (i.e., the inability of flows in a channel to exceed the channel banks) and this is addressed in the Hydrologic Connectivity metric.

For riverine systems, the patterns of increasing and decreasing flows that are associated with storms, releases of water from dams, seasonal variations in rainfall, or longer term trends in peak flow, base flow, and average flow are more important than hydroperiod. The patterns of flow, in conjunction with the kinds and amounts of sediment that the flow carries or deposits, largely determine the form of riverine systems, including their floodplains, and thus also control their ecological functions. Under natural conditions, the opposing tendencies for sediment to stop moving and for flow to move the sediment tend toward a dynamic equilibrium, such that the form of the channel in cross-section, plan view, and longitudinal profile remains relatively constant over time (Leopold 1994). Large and persistent changes in either the flow regime or the sediment regime tend to destabilize the channel and cause it to change form. Such regime changes are associated with upstream land use changes, alterations of the drainage network of which the channel of interest is a part, and climatic changes. A riverine channel is an almost infinitely adjustable complex of interrelations between flow, width, depth, bed resistance, sediment transport, and riparian vegetation. Change in any of these factors will be countered by adjustments in the others. The degree of channel stability can be assessed based on field indicators.

Table 4.10: Field Indicators of Altered Hydroperiod.

Direct Engineering Evidence	Indirect Ecological Evidence
Reduced Extent and Duration of Inundation or Saturation	
<ul style="list-style-type: none"> • Upstream spring boxes • Impoundments • Pumps, diversions, ditching that move water <i>into</i> the wetland 	<ul style="list-style-type: none"> • Evidence of aquatic wildlife mortality • Encroachment of terrestrial vegetation • Stress or mortality of hydrophytes • Compressed or reduced plant zonation
Increased Extent and Duration of Inundation or Saturation	
<ul style="list-style-type: none"> • Berms • Dikes • Pumps, diversions, ditching that move water <i>into</i> the wetland 	<ul style="list-style-type: none"> • Late-season vitality of annual vegetation • Recently drowned riparian vegetation • Extensive fine-grain deposits

Riverine: The hydroperiod of a riverine wetland can be assessed based on a variety of statistical parameters, including the frequency and duration of flooding (as indicated by the local relationship between stream depth and time spent at depth over a prescribed period), and flood frequency (i.e., how often a flood of a certain height is likely to occur). These characteristics plus channel form in cross-section and plan view, steepness of the channel bed, material composition of the bed, sediment loads, and the amount of woody material entering the channel all interact to create the physical structure and form of the channel at any given time.

The data needed to calculate hydroperiod is not available for most riverine systems in California. Rapid assessment must therefore rely on field indicators of hydroperiod. For a broad spectral diagnosis of overall riverine wetland condition, the physical stability or instability of the system is especially important. Whether a riverine system is stable (i.e., sediment supplies and water supplies are in dynamic equilibrium with each other and with the stabilizing qualities of riparian vegetation), or if it is degrading (i.e., subject to chronic incision of the channel bed), or aggrading (i.e., the bed is being elevated due to in-channel storage of sediment) can have large effects on downstream flooding, contaminant transport, riparian vegetation structure and composition, and wildlife support. CRAM therefore translates the concept of riverine wetland hydroperiod into riverine system physical stability.

Every stable riverine channel tends to have a particular form in cross section, profile, and plan view that is in dynamic equilibrium with the inputs of water and sediment. If these supplies change enough, the channel will tend to adjust toward a new equilibrium form. An increase in the supply of sediment can cause a channel to aggrade. Aggradation might simply increase the duration of inundation for existing wetlands, or might cause complex changes in channel location and morphology through braiding, avulsion, burial of wetlands, creation of new wetlands, spray and fan development, etc. An increase in discharge might cause a channel to incise (i.e., cut-down), leading to bank erosion, headward erosion of the channel bed, floodplain abandonment, and dewatering of riparian areas.

There are many well-known field indicators of equilibrium conditions for assessing the degree to which a channel is stable enough to sustain existing wetlands. To score this metric, visually survey the AA for field indicators of aggradation or degradation (listed in the worksheet). After reviewing the entire AA and comparing the conditions to those described in Table 4.14, decide whether the AA is in equilibrium, aggrading, or degrading, then assign a rating score using the alternative state descriptions in Table 4.14.

Worksheet for Assessing Hydroperiod for Riverine Wetlands.

Condition	Field Indicators (check all existing conditions)
Indicators of Channel Equilibrium	<ul style="list-style-type: none"> <input type="checkbox"/> The channel (or multiple channels in braided systems) has a well-defined bankfull contour that clearly demarcates an obvious active floodplain in the cross-sectional profile of the channel throughout most of the AA. <input type="checkbox"/> Perennial riparian vegetation is abundant and well established along the bankfull contour, but not below it. <input type="checkbox"/> There is leaf litter, thatch, or wrack in most pools. <input type="checkbox"/> The channel contains embedded woody debris of the size and amount consistent with what is naturally available in the riparian area. <input type="checkbox"/> There is little or no active undercutting or burial of riparian vegetation. <input type="checkbox"/> There are no mid-channel bars and/or point bars densely vegetated with perennial vegetation. <input type="checkbox"/> Channel bars consist of well-sorted bed material. <input type="checkbox"/> There are channel pools, the bed is not planar, and the spacing between pools tends to be regular. <input type="checkbox"/> The larger bed material supports abundant mosses or periphyton.
Indicators of Active Degradation	<ul style="list-style-type: none"> <input type="checkbox"/> The channel is characterized by deeply undercut banks with exposed living roots of trees or shrubs. <input type="checkbox"/> There are abundant bank slides or slumps, or the lower banks are uniformly scoured and not vegetated. <input type="checkbox"/> Riparian vegetation is declining in stature or vigor, or many riparian trees and shrubs along the banks are leaning or falling into the channel. <input type="checkbox"/> An obvious historical floodplain has recently been abandoned, as indicated by the age structure of its riparian vegetation. <input type="checkbox"/> The channel bed appears scoured to bedrock or dense clay. <input type="checkbox"/> Recently active flow pathways appear to have coalesced into one channel (i.e. a previously braided system is no longer braided). <input type="checkbox"/> The channel has one or more nick points indicating headward erosion of the bed.
Indicators of Active Aggradation	<ul style="list-style-type: none"> <input type="checkbox"/> There is an active floodplain with fresh splays of coarse sediment. <input type="checkbox"/> There are partially buried living tree trunks or shrubs along the banks. <input type="checkbox"/> The bed is planar overall; it lacks well-defined channel pools, or they are uncommon and irregularly spaced. <input type="checkbox"/> There are partially buried, or sediment-choked, culverts. <input type="checkbox"/> Perennial terrestrial or riparian vegetation is encroaching into the channel or onto channel bars below the bankfull contour. <input type="checkbox"/> There are avulsion channels on the floodplain or adjacent valley floor.

Table 4.14: Rating for Riverine Channel Stability.

Rating	Alternative State (based on worksheet above)
A	Most of the channel through the AA is characterized by equilibrium conditions, with little evidence of aggradation or degradation (based on the field indicators listed in worksheet).
B	Most of the channel through the AA is characterized by some aggradation or degradation, none of which is severe, and the channel seems to be approaching an equilibrium form (based on the field indicators listed in worksheet).
C	There is evidence of severe aggradation or degradation of most of the channel through the AA (based on the field indicators listed in worksheet), or the channel is artificially hardened through less than half of the AA.
D	The channel is concrete or otherwise artificially hardened through most of AA.

Hydrologic Connectivity

Definition: Hydrologic Connectivity describes the ability of water to flow into or out of the wetland, or to inundate their adjacent uplands. This metric pertains only to Riverine, Estuarine, Vernal Pool Systems, individual Vernal Pools, and Playas.

This metric is scored by assessing the degree to which the lateral movement of flood waters or the associated upland transition zone of the AA and/or its encompassing wetland is restricted by unnatural features such as levees, sea walls, or road grades.

For riverine wetlands, Hydrologic Connectivity is assessed based on the degree of channel entrenchment (Leopold *et al.* 1964, Rosgen 1996, Montgomery and MacDonald 2002). Entrenchment is a field measurement calculated as the flood-prone width divided by the bankfull width. Bankfull depth is the channel depth at the height of bankfull flow. The flood-prone channel width is measured at the elevation equal to twice the maximum bankfull depth. The process for estimating entrenchment is outlined below. A 100 m tape measure can be helpful.

Riverine Wetland Entrenchment Ratio Calculation Worksheet

The following 5 steps should be conducted for each of 3 cross-sections located in the AA at the approximate mid-points along straight riffles or glides, away from deep pools or meander bends.				
Steps	Replicate Cross-sections \longrightarrow	1	2	3
1 Estimate bankfull width.	This is a critical step requiring familiarity with field indicators of the bankfull contour. Estimate or 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; estimate or measure the height of the line above the thalweg (the deepest part of the channel).			
3: Estimate flood prone depth.	Double the estimate of maximum bankfull depth from Step 2.			
4: Estimate flood prone width.	Imagine a level line having a height equal to the flood prone depth from Step 3; note where the line intercepts the right and left banks; estimate or measure the length of this line.			
5: Calculate entrenchment ratio.	Divide the flood prone width (Step 4) by the bankfull width (Step 1).			
6: Calculate average entrenchment ratio.	Calculate the average results for Step 5 for all 3 replicate cross-sections. Enter the average result here and use it in Tables 4.15 a, b.			

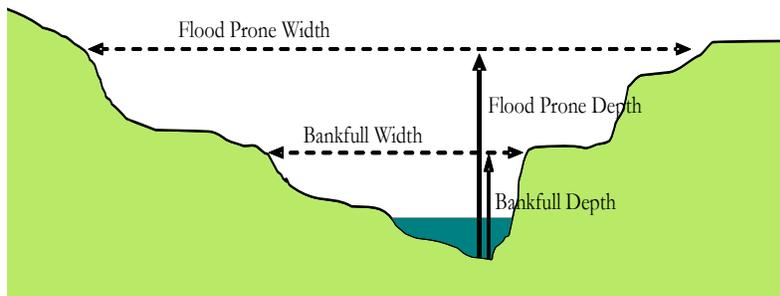


Figure 4.5: Diagram of channel entrenchment parameters.

Flood prone depth is twice maximum bankfull depth. Entrenchment is measured as flood prone width divided by maximum bankfull width.

Note: 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-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.

Table 4.15a: Rating of Hydrologic Connectivity for Non-confined Riverine wetlands.

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 2.2.
B	Entrenchment ratio is 1.9 to 2.2.
C	Entrenchment ratio is 1.5 to 1.8.
D	Entrenchment ratio is <1.5.

Table 4.15b: Rating of Hydrologic Connectivity for Confined Riverine wetlands.

Rating	Alternative States (based on the entrenchment ratio calculation worksheet above)
A	Entrenchment ratio is > 2.0.
B	Entrenchment ratio is 1.6 to 2.0.
C	Entrenchment ratio is 1.2 to 1.5.
D	Entrenchment ratio is < 1.2.

Attribute 3: Physical Structure

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.

Patch Type Definitions:

Animal mounds and burrows. Many vertebrates make mounds or holes as a consequence of their foraging, denning, predation, or other behaviors. 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.

Bank slumps or undercut banks in channels or along shorelines. A bank slump is a portion of a depressional, estuarine, or lacustrine 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.

Cobble and boulders. Cobble and boulders are rocks of different size categories. The long axis of cobble ranges from about 6 cm to about 25 cm. A boulder is any rock having a long axis greater than 25 cm. Submerged cobbles and boulders provide abundant habitat for aquatic macroinvertebrates and small fish. Exposed cobbles and boulders provide roosting habitat for birds and shelter for amphibians. They contribute to 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.

Concentric or parallel high water marks. Repeated variation in water level in a wetland can cause concentric zones in soil moisture, topographic slope, and chemistry that translate into visible zones of different vegetation types, greatly increasing overall ecological diversity. The variation in water level might be natural (e.g., seasonal) or anthropogenic.

Debris jams. A debris jam is an accumulation of drift wood and other flotsam across a channel that partially or completely obstructs surface water flow.

Hummocks or sediment mounds. Hummocks are mounds created by plants in slope wetlands, depressions, and along the banks and floodplains of fluvial and tidal systems. Hummocks are typically less than 1m high. Sediment mounds are similar to hummocks but lack plant cover.

Islands (exposed at high-water stage). An island is an area of land above the usual high water level and, at least at times, surrounded by water in a riverine, lacustrine, estuarine, or playa system. Islands differ from hummocks and other mounds by being large enough to support trees or large shrubs.

Macroalgae and algal mats. Macroalgae occurs on benthic sediments and on the water surface of all types of wetlands. 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.

Non-vegetated flats (sandflats, mudflats, gravel flats, etc.). A flat is a non-vegetated area of silt, clay, sand, shell hash, gravel, or cobble at least 10 m wide and at least 30 m long that adjoins the wetland foreshore and is a potential resting and feeding area for fishes, shorebirds, wading birds, and other waterbirds. Flats can be similar to large bars (see definitions of point bars and in-channel bars below), except that they lack the convex profile of bars and their compositional material is not as obviously sorted by size or texture.

Pannes or pools on floodplain. A panne is a shallow topographic basin lacking vegetation but existing on a well-vegetated wetland plain. Pannes fill with water at least seasonally due to overland flow. They commonly serve as foraging sites for waterbirds and as breeding sites for amphibians.

Point bars and in-channel bars. Bars are sedimentary features within intertidal and fluvial channels. They are patches of transient bedload sediment that form along the inside of meander bends or in the middle of straight channel reaches. They sometimes support vegetation. They are convex in profile and their surface material varies in size from small on top to larger along their lower margins. They can consist of any mixture of silt, sand, gravel, cobble, and boulders.

Pools in channels. Pools are areas along tidal and fluvial channels that are much deeper than the average depths of their channels and that tend to retain water longer than other areas of the channel during periods of low or no surface flow.

Riffles or rapids. Riffles and rapids are areas of relatively rapid flow and standing waves in tidal or fluvial channels. Riffles and rapids add oxygen to flowing water and provide habitat for many fish and aquatic invertebrates.

Secondary channels on floodplains or along shorelines. Channels confine riverine or estuarine flow. A channel consists of a bed and its opposing banks, plus its floodplain. Estuarine and riverine wetlands can have a primary channel that conveys most flow, and one or more secondary channels of varying sizes that convey flood flows. The systems of diverging and converging

channels that characterize braided and anastomosing fluvial systems usually consist of one or more main channels plus secondary channels. Tributary channels that originate in the wetland and that only convey flow between the wetland and the primary channel are also regarded as secondary channels. For example, short tributaries that are entirely contained within the CRAM Assessment Area (AA) are regarded as secondary channels.

Shellfish beds. Oysters, clams and mussels are common bivalves that create beds on the banks and bottoms of wetland systems. Shellfish beds influence the condition of their environment by affecting flow velocities, providing substrates for plant and animal life, and playing particularly important roles in the uptake and cycling of nutrients and other water-borne materials.

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 1 inch deep to qualify.

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” they provide habitat for many species of birds and small mammals. Any standing, dead woody vegetation that is at least 3 m tall is considered a snag.

Submerged vegetation. Submerged vegetation consists of aquatic macrophytes such as *Elodea canadensis* (common elodea), and *Zostera marina* (eelgrass) 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 on floodplain or along shoreline. 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.

Variiegated or crenulated foreshore. As viewed from above, the foreshore of a wetland can be mostly straight, broadly curving (i.e., arcuate), or variegated (e.g., meandering). In plan view, a variegated shoreline resembles a meandering pathway. variegated shorelines provide greater contact between water and land.

Wreckline or organic debris in channel or on floodplain. Wrack is an accumulation of natural or unnatural floating debris along the high water line of a wetland.

Structural Patch Type Worksheet for All Wetland Types, Except Vernal Pool Systems

Circle each type of patch that is observed in the AA and enter the total number of observed patches in Table 4.16 below. In the case of riverine wetlands, their status as confined or non-confined must first be determined (see section 3.2.2.1).

STRUCTURAL PATCH TYPE (check for presence)	Riverine (Non-confined)	Riverine (Confined)	All Estuarine	Depressional	Slope Wetlands	Lacustrine	Individual Vernal Pools	Playas
Minimum Patch Size	3 m²	3 m²	3 m²	3 m²	1 m²	3 m²	1 m²	3 m²
Secondary channels on floodplains or along shorelines	1	0	1	0	1	1	0	1
Swales on floodplain or along shoreline	1	0	0	1	1	1	1	1
Pannes or pools on floodplain	1	0	1	0	1	1	1	1
Vegetated islands (mostly above high-water)	1	0	0	1	0	0	1	1
Pools or depressions in channels (wet or dry channels)	1	1	1	0	0	0	0	0
Riffles or rapids (wet channel) or planar bed (dry channel)	1	1	0	0	0	0	0	0
Non-vegetated flats or bare ground (sandflats, mudflats, gravel flats, etc.)	0	0	1	1	1	1	1	1
Point bars and in-channel bars	1	1	1	0	0	0	0	0
Debris jams	1	1	1	0	0	1	0	0
Abundant wrackline or organic debris in channel, on floodplain, or across depressional wetland plain	1	1	1	1	0	1	0	0
Plant hummocks and/or sediment mounds	1	1	1	1	1	1	1	1
Bank slumps or undercut banks in channels or along shoreline	1	1	1	1	0	1	0	0
Variegated, convoluted, or crenulated foreshore (instead of broadly arcuate or mostly straight)	1	1	0	1	0	1	0	0
Animal mounds and burrows	0	0	1	1	1	0	1	1
Standing snags (at least 3 m tall)	1	1	1	1	1	1	0	0
Filamentous macroalgae or algal mats	1	1	1	1	1	1	1	1
Shellfish beds	0	0	1	0	0	1	0	0
Concentric or parallel high water marks	0	0	0	1	1	1	1	1
Soil cracks	0	0	1	1	0	1	1	1
Cobble and/or Boulders	1	1	0	0	1	1	1	0
Submerged vegetation	1	0	1	1	0	1	0	0
Total Possible	16	11	15	13	10	16	10	10
No. Observed Patch Types (enter here and use in Table 4.16 below)								

Table 4.16: Rating of Structural Patch Richness (based on results from worksheets).

Rating	Confined Riverine, Playas, Springs & Seeps, Individual Vernal Pools	Vernal ,Pool Systems and Depressional	Estuarine	Non-confined Riverine, Lacustrine
A	≥ 8	≥ 11	≥ 11	≥ 12
B	6 – 7	8 – 10	8 – 10	9 – 11
C	4 – 5	5 – 7	6 – 7	6 – 8
D	≤ 3	≤ 4	≤ 5	≤ 5

Topographic Complexity

Definition: Topographic complexity refers to the variety of elevations within a wetland due to physical, abiotic features and elevations gradients.

Table 4.17: Typical indicators of Macro- and Micro-topographic Complexity for each wetland type.

Type	Examples of Topographic Features
Depressional and Playas	pools, islands, bars, mounds or hummocks, variegated shorelines, soil cracks, partially buried debris, plant hummocks, livestock tracks
Estuarine	channels large and small, islands, bars, pannes, potholes, natural levees, shellfish beds, hummocks, slump blocks, first-order tidal creeks, soil cracks, partially buried debris, plant hummocks
Lacustrine	islands, bars, boulders, cliffs, benches, variegated shorelines, cobble, boulders, partially buried debris, plant hummocks
Riverine	pools, runs, glides, pits, ponds, hummocks, bars, debris jams, cobble, boulders, slump blocks, tree-fall holes, plant hummocks
Slope Wetlands	pools, runnels, plant hummocks, burrows, plant hummocks, cobbles, boulders, partially buried debris, cattle or sheep tracks
Vernal Pools and Pool Systems	soil cracks, “mima-mounds,” rivulets between pools or along swales, cobble, plant hummocks, cattle or sheep tracks

Figure 4.6: Scale-independent schematic profiles of Topographic Complexity.

Each profile A-D represents one-half of a characteristic cross-section through an AA. The right end of each profile represents either the buffer along the backshore of the wetland encompassing the AA, or, if the AA is not contiguous with the buffer, then the right end of each profile represents the edge of the AA.

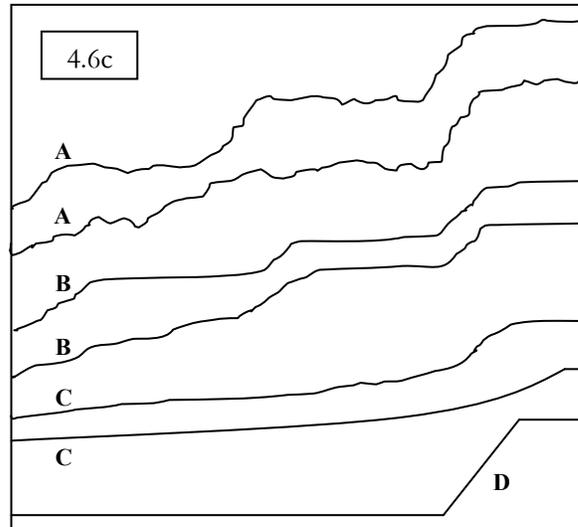


Table 4.18c: Rating of Topographic Complexity for all Riverine Wetlands.

Rating	Alternative States (based on diagrams in Figure 4.6 above)
A	AA as viewed along a typical cross-section has at least two benches or breaks in slope, including the riparian area of the AA, above the channel bottom, not including the thalweg. Each of these benches, plus the slopes between the benches, as well as the channel bottom area contain physical patch types or features such as boulders or cobbles, animal burrows, partially buried debris, slump blocks, furrows or runnels that contribute to abundant micro-topographic relief as illustrated in profile A of Figure 4.6c.
B	AA has at least two benches or breaks in slope above the channel bottom area of the AA, but these benches and slopes mostly lack abundant micro-topographic complexity. The AA resembles profile B of Figure 4.6c.
C	AA has a single bench or obvious break in slope that may or may not have abundant micro-topographic complexity, as illustrated in profile C of Figure 4.6c.
D	AA as viewed along a typical cross-section lacks any obvious break in slope or bench. The cross-section is best characterized as a single, uniform slope with or without micro-topographic complexity, as illustrated in profile D of Figure 4.6c (includes concrete channels).

Attribute 4: Biotic Structure

Plant Community Metric

Definition: The Plant Community Metric is composed of three submetrics for each wetland type. Two of these sub-metrics, Number of Co-dominant Plants and Percent Invasion, are common to all wetland types. For all wetlands except Vernal Pools and Vernal Pool Systems, the Number of Plant Layers as defined for CRAM is also assessed. For Vernal Pools and Pool Systems, the Number of Plant layers submetric is replaced by the Native Species Richness submetric. A thorough reconnaissance of an AA is required to assess its condition using these submetrics. The assessment for each submetric is guided by a set of Plant Community Worksheets. The Plant Community metric is calculated based on these worksheets.

A “plant” is defined as an individual of any species of tree, shrub, herb/forb, moss, fern, emergent, submerged, submergent or floating macrophyte, including non-native (exotic) plant species. 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.

Non-native species owe their occurrence in California to the actions of people since shortly before Euroamerican contact. “Invasive” species are non-native species that tend to dominate one or more plant layers within an AA. CRAM uses the California Invasive Plant Council (Cal-IPC) list to determine the invasive status of plants, with augmentation by regional experts.

Number of Plant Layers Present

To be counted in CRAM, a layer must cover at least 5% of *the portion of the AA that is suitable for the layer*. This would be the littoral zone of lakes and depressional wetlands for the one aquatic layer, called “floating.” The “short,” “medium,” and “tall” layers might be found throughout the non-aquatic areas of each wetland class, except in areas of exposed bedrock, mudflat, beaches, active point bars, etc. The “very tall” layer is usually expected to occur along the backshore, except in forested wetlands.

It is essential that the layers be identified by the actual plant heights (i.e., the approximate maximum heights) of plant species in the AA, regardless of the growth potential of the species. For example, a young sapling redwood between 0.5 m and 0.75 m tall would belong to the “medium” layer, even though in the future the same individual redwood might belong to the “very tall” layer. Some species might belong to multiple plant layers. For example, groves of red alders of all different ages and heights might collectively represent all four non-aquatic layers in a riverine AA. Riparian vines, such as wild grape, might also dominate all of the non-aquatic layers.

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 varies in maximum height among the wetland types, but is never taller than 50 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 *Rorippa nasturtium-aquaticum* (watercress), small Isoetes (quillworts), *Distichlis spicata* (saltgrass), *Jaumea carnosa* (jaumea), *Ranunculus flamula* (creeping buttercup), *Alisma* spp. (water plantain), *Sparganium* (burweeds), and *Sagittaria* spp. (arrowhead).

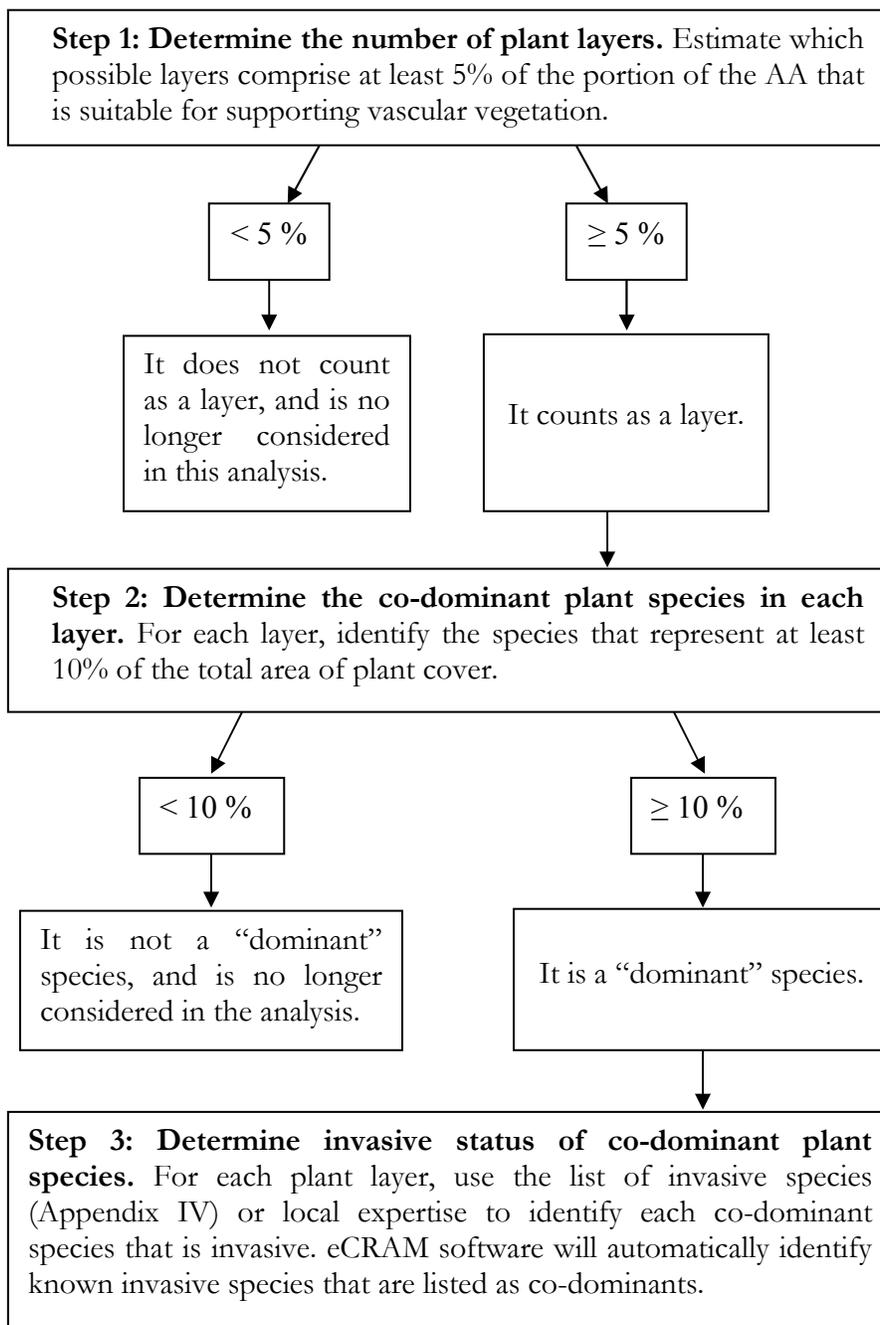
Medium Vegetation. This layer never exceeds 75 cm in height. It commonly includes emergent vegetation such *Salicornia virginica* (pickleweed), *Atriplex* spp. (saltbush), rushes (*Juncus* spp.), and *Rumex crispus* (curly dock).

Tall Vegetation. This layer never exceeds 1.5 m in height. It usually includes the tallest emergent vegetation and the larger shrubs. Examples include *Typha latifolia* (broad-leaved cattail), *Scirpus californicus* (bulrush), *Rubus ursinus* (California blackberry), and *Baccharis pilularis* (coyote brush).

Very Tall Vegetation. This layer is reserved for shrubs, vines, and trees that are taller than 1.5 m. Examples include *Plantanus racemosa* (western sycamore), *Populus fremontii* (Fremont cottonwood), *Alnus rubra* (red alder), *Sambucus mexicanus* (Blue elderberry), and *Corylus californicus* (hazelnut).

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.

Appendix I: Flow Chart to Determine Plant Dominance



Plant Community Metric Worksheet 1 of 8: Plant layer heights for all wetland types.

Wetland Type	Plant Layers				
	Aquatic	Semi-aquatic and Riparian			
	Floating	Short	Medium	Tall	Very Tall
Perennial Saline Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Perennial Non-saline Estuarine, Seasonal Estuarine	On Water Surface	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Lacustrine, Depressional and Non-confined Riverine	On Water Surface	<0.5 m	0.5 – 1.5 m	1.5 - 3.0 m	>3.0 m
Slope	NA	<0.3 m	0.3 – 0.75 m	0.75 – 1.5 m	>1.5 m
Confined Riverine	NA	<0.5 m	0.5 – 1.5 m	1.5 – 3.0 m	>3.0 m

Number of Co-dominant Species

For each plant layer in the AA, all species represented by living vegetation that comprises at least 10% relative cover within the layer are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded.

Percent Invasion

The number of invasive co-dominant species for all plant layers combined is assessed as a percentage of the total number of co-dominants, based on the results of the Number of Co-dominant Species sub-metric. The invasive status for many California wetland and riparian plant species is based on the Cal-IPC list (Appendix IV). However, the best professional judgment of local experts may be used instead to determine whether or not a co-dominant species is invasive.

Plant Community Metric Worksheet 2 of 8: Co-dominant species richness for all wetland types, except Confined Riverine, Slope wetlands, Vernal Pools, and Playas
(A dominant species represents $\geq 10\%$ *relative* cover)

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Floating or Canopy-forming	Invasive?	Short	Invasive?
Medium	Invasive?	Tall	Invasive?
Very Tall	Invasive?		
		Total number of co-dominant species for all layers combined (enter here and use in Table 4.19)	
		Percent Invasion (enter here and use in Table 4.19)	

Plant Community Metric Worksheet 3 of 8: Co-dominant species richness for Confined Riverine and Slope wetlands
(A dominant species represents $\geq 10\%$ *relative* cover)

Note: Plant species should only be counted once when calculating the Number of Co-dominant Species and Percent Invasion metric scores.

Short	Invasive?	Medium	Invasive?
Tall	Invasive?	Very Tall	Invasive?
		Total number of co-dominants for all layers combined (enter here and use in Table 4.19)	
		Percent Invasion (enter here and use in Table 4.19)	

Table 4.19: Ratings for submetrics of Plant Community Metric.

Rating	Number of Plant Layers Present	Number of Co-dominant Species	Percent Invasion
Lacustrine, Depressional and Non-confined Riverine Wetlands			
A	4 – 5	≥ 12	0 – 15%
B	3	9 – 11	16 – 30%
C	1 – 2	6 – 8	31 – 45%
D	0	0 – 5	46 – 100%
Confined Riverine Wetlands			
A	4	≥ 11	0 – 15%
B	3	8 – 10	16 – 30%
C	1 – 2	5 – 7	31 – 45%
D	0	0 – 4	46 – 100%

Horizontal Interspersion and Zonation

Definition: Horizontal biotic structure refers to the variety and interspersion of plant “zones.” Plant zones are plant 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 plan view. Interspersion is essentially a measure of the number of distinct plant zones and the amount of edge between them.

Figure 4.9: Schematic diagrams illustrating varying degrees of interspersion of plant zones for all Riverine wetlands. Each zone must comprise at least 5% of the AA.

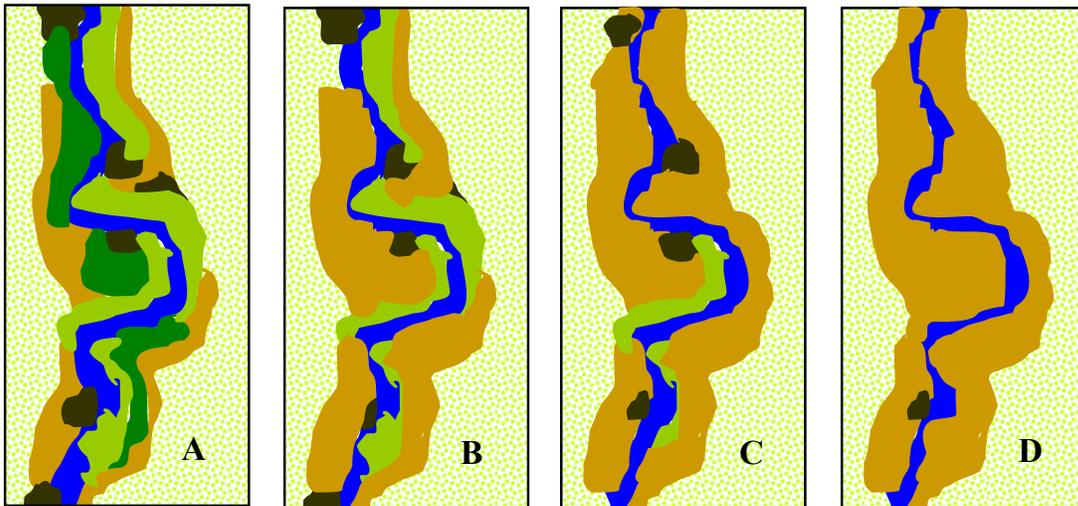


Table 4.20b: Rating of Horizontal Interspersion of Plant Zones for Riverine AAs.

Rating	Alternative States (based on Figure 4.9)
A	AA has a high degree of plan-view interspersion.
B	AA has a moderate degree of plan-view interspersion.
C	AA has a low degree of plan-view interspersion.
D	AA has essentially no plan-view interspersion.

Note: When using this metric, it is helpful to assign names of plant species or associations of species to the colored patches in Figure 4.9.

Vertical Biotic Structure

Definition: The vertical component of biotic structure consists of the interspersed and complexity of plant layers. The same plant layers used to assess the Plant Community Composition Metrics (see Section 4.4.2) are used to assess Vertical Biotic Structure. To be counted in CRAM, a layer must cover at least 5% of the portion of the AA that is suitable for the layer. This metric does not pertain to Vernal Pools, Vernal Pool Systems, or Playas.

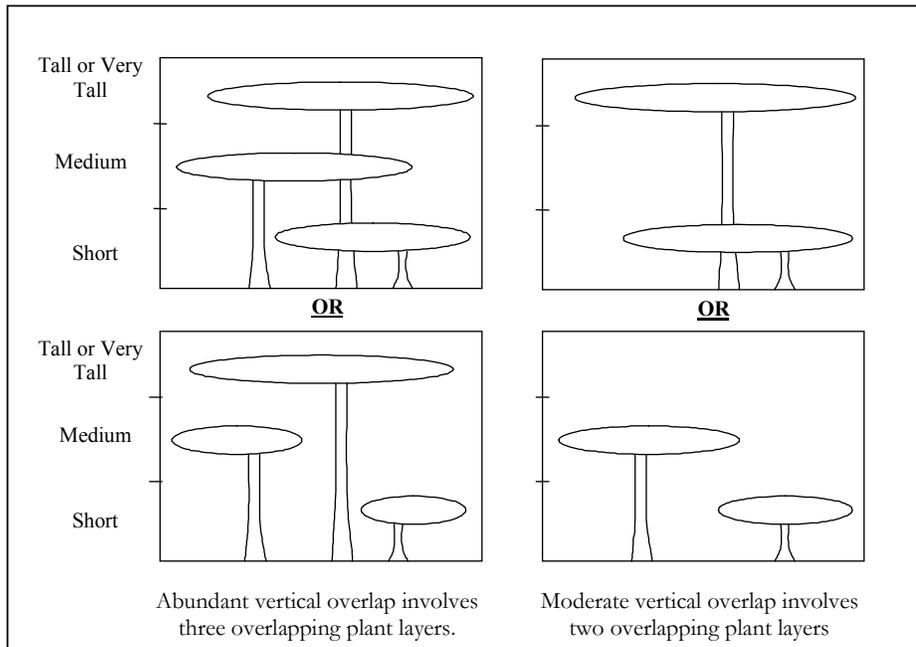


Figure 4.11: Schematic diagrams of vertical interspersed of plant layers for Riverine AAs and for Depressional and Lacustrine AAs having Tall or Very Tall plant layers.

Table 4.21: Rating of Vertical Biotic Structure for Riverine AAs and for Lacustrine and Depressional AAs supporting Tall or Very Tall plant layers (see Figure 4.11).

Rating	Alternative States
A	More than 50% of the vegetated area of the AA supports abundant overlap of plant layers (see Figures 4.11).
B	More than 50% of the area supports at least moderate overlap of plant layers.
C	25–50% of the vegetated AA supports at least moderate overlap of plant layers, or three plant layers are well represented in the AA but there is little to no overlap.
D	Less than 25% of the vegetated AA supports moderate overlap of plant layers, or two layers are well represented with little overlap, or AA is sparsely vegetated overall.

Guidelines to Complete the Stressor Checklists

Definition: 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 5.1: 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	

Stressor Checklist Worksheet

HYDROLOGY ATTRIBUTE (WITHIN 50 M OF AA)	Present and likely to have negative effect on AA	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		
Comments		

PHYSICAL STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present and likely to have negative effect on AA	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		
Comments		

BIOTIC STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present and likely to have negative effect on AA	Significant negative effect on AA
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		
Comments		

BUFFER AND LANDSCAPE CONTEXT ATTRIBUTE (WITHIN 500 M OF AA)	Present and likely to have negative effect on AA	Significant negative effect on AA
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)		
Comments		

CRAM Score Guidelines

Table 3.11: Steps to calculate attribute scores and AA scores.

Step 1: Calculate Metric Score	For each Metric, convert the letter score into the corresponding numeric score: A=12, B=9, C=6 and D=3.
Step 2: 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"> • 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 Landscape Connectivity metric, using the following formula: $\left(\boxed{\text{Buffer Condition}} \times \left(\boxed{\% \text{ AA with Buffer}} \times \boxed{\text{Average Buffer Width}} \right)^{\frac{1}{2}} \right)^{\frac{1}{2}} + \boxed{\text{Landscape Connectivity}}$ <ul style="list-style-type: none"> • Prior to calculating the Biotic Structure Raw Attribute Score, average the three Plant Community sub-metrics. • For vernal pool systems, first calculate the average score for all three Plant Community sub-metrics for each replicate pool, then average these scores across all six replicate pools, and then calculate the average Topographic Complexity score for all six replicates.
Step 3: 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.
Step 4: Calculate the AA Score	Calculate the AA score by averaging the Final Attribute Scores. Round the average to the nearest whole integer.