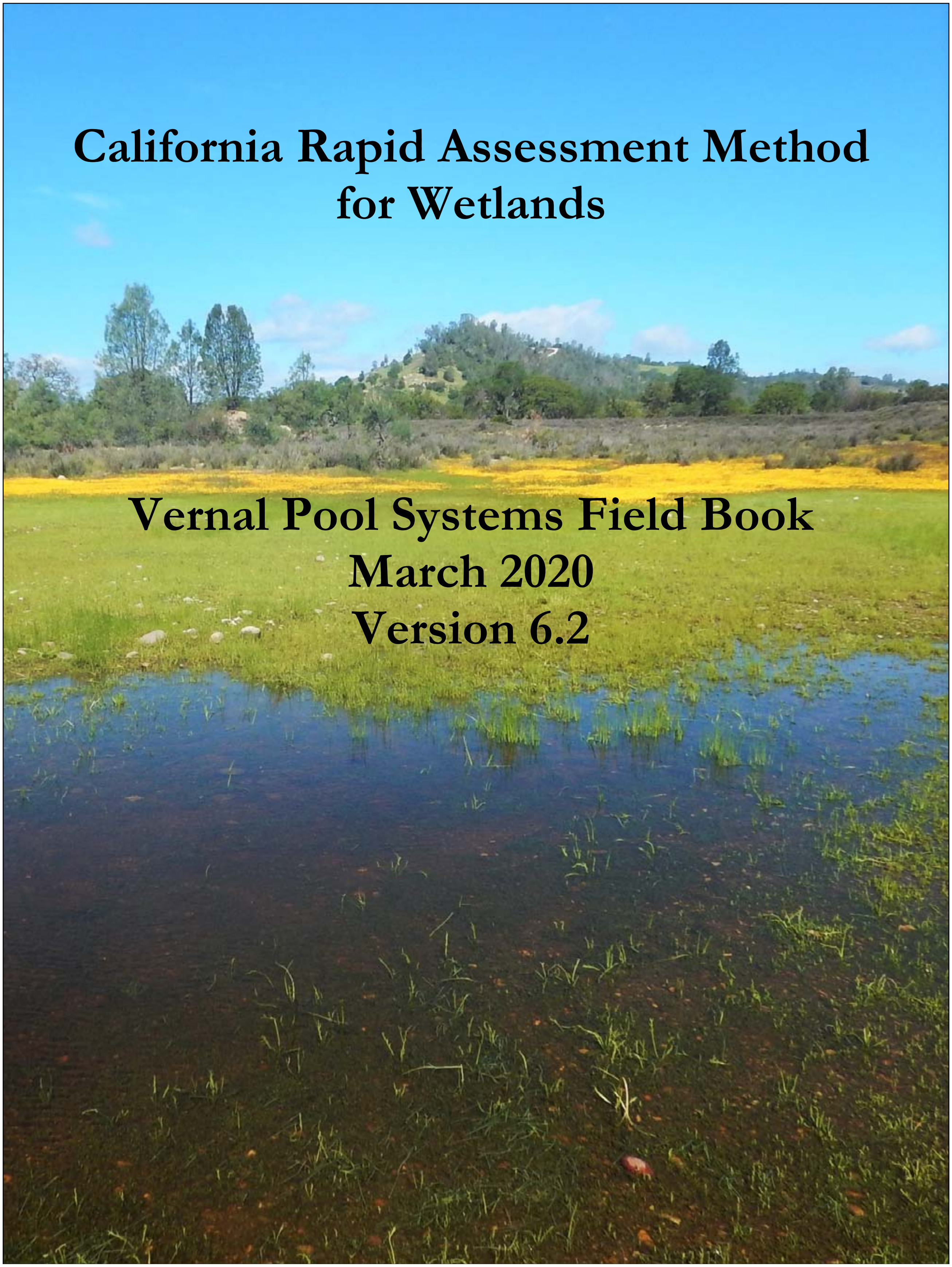
California Rapid Assessment Method for Wetlands



Vernal Pool Systems Field Book

March 2020

Version 6.2

Basic Information: Vernal Pool Systems

Assessment Area Name:	
Project Name:	
Assessment Area ID #:	
Project ID #:	**Date:**
Assessment Team Members for This AA	
AA Location: **Latitude:** **Longitude:** **Datum:**	
Wetland Category: □ Natural □ Constructed □ Restoration (Rehabilitation OR Enhancement)	
If Created or Restored, does the action encompass: □ entire wetland □ portion of the wetland	
What best describes the hydrologic state of the wetland at the time of assessment? □ ponded/inundated □ saturated soil, but no surface water □ dry	
Does the vernal pool system connect with the floodplain of a nearby stream? □ yes □ no	

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: Vernal Pool Systems

<table>
<tr><td colspan="4">AA Name:</td><td colspan="2">Date:</td></tr>
<tr><td colspan="2">Attributes and Metrics</td><td>Alpha.</td><td>Numeric</td><td colspan="2">Comments/Scores</td></tr>
<tr><td colspan="4">Attribute 1: Buffer and Landscape Context (pp. 8-15)</td><td colspan="2"></td></tr>
<tr><td colspan="2">(A) Aquatic Area Abundance</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>(B): Percent of AA with Buffer</td><td>Alpha. | Numeric</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(C): Average Buffer Width</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>(D): Buffer Condition</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="3">Initial Attribute Score $= A + [\,D \times (B \times C)^{½}\,]^{½}$</td><td></td><td>Final Attribute Score = (Initial Score/24) x 100</td><td></td></tr>
<tr><td colspan="4">Attribute 2: Hydrology (pp. 16-18)</td><td colspan="2"></td></tr>
<tr><td colspan="2">Water Source</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Hydroperiod</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Hydrologic Connectivity</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Initial Attribute Score= sum of metric scores</td><td colspan="2"></td><td>Final Attribute Score = (Initial Score/36) x 100</td><td></td></tr>
<tr><td colspan="4">Attribute 3: Physical Structure (pp. 19-28)</td><td colspan="2"></td></tr>
<tr><td colspan="2">Structural Patch Richness</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Pool and Swale Density</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Topographic Complexity</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Initial Attribute Score= sum of metric scores</td><td colspan="2"></td><td>Final Attribute Score = (Initial Score/36) x 100</td><td></td></tr>
<tr><td colspan="4">Attribute 4: Biotic Structure (pp. 29-34)</td><td colspan="2"></td></tr>
<tr><td colspan="2">Horizontal Interspersion and Zonation</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td>Plant Community submetric A: Number of Co-dominant species</td><td>Alpha. | Numeric</td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Plant Community submetric B: Percent Non Native</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td>Plant Community submetric C: Endemic Species Richness</td><td></td><td colspan="2"></td><td colspan="2"></td></tr>
<tr><td colspan="2">Plant Community Composition Metric
(numeric average of submetrics A-C)</td><td></td><td></td><td colspan="2"></td></tr>
<tr><td colspan="2">Initial Attribute Score= sum of metric scores</td><td colspan="2"></td><td>Final Attribute Score = (Initial Score/24) x 100</td><td></td></tr>
<tr><td colspan="4">Overall AA Score (Average of four Final Attribute Scores)</td><td colspan="2"></td></tr>
</table>

Details regarding the updated CRAM Version 6.2 Module

This CRAM Vernal Pool Systems Version 6.2 Field Book was originally released in November, 2019, reflecting updates and edits identified during the 2016 and 2017 Validation effort. Minor edits were made in March, 2020. The corresponding Version 6.2 data entry forms in eCRAM were also released in March, 2020. We advise practitioners to now collect Vernal Pool System data using this Version 6.2 Field Book, and enter data into eCRAM using the Version 6.2 data entry forms. After March, 2020, new Vernal Pool CRAM assessments can only be created using Version 6.2.

Please contact Sarah Pearce (sarahp@sfei.org) with any questions.

Identify Wetland Type

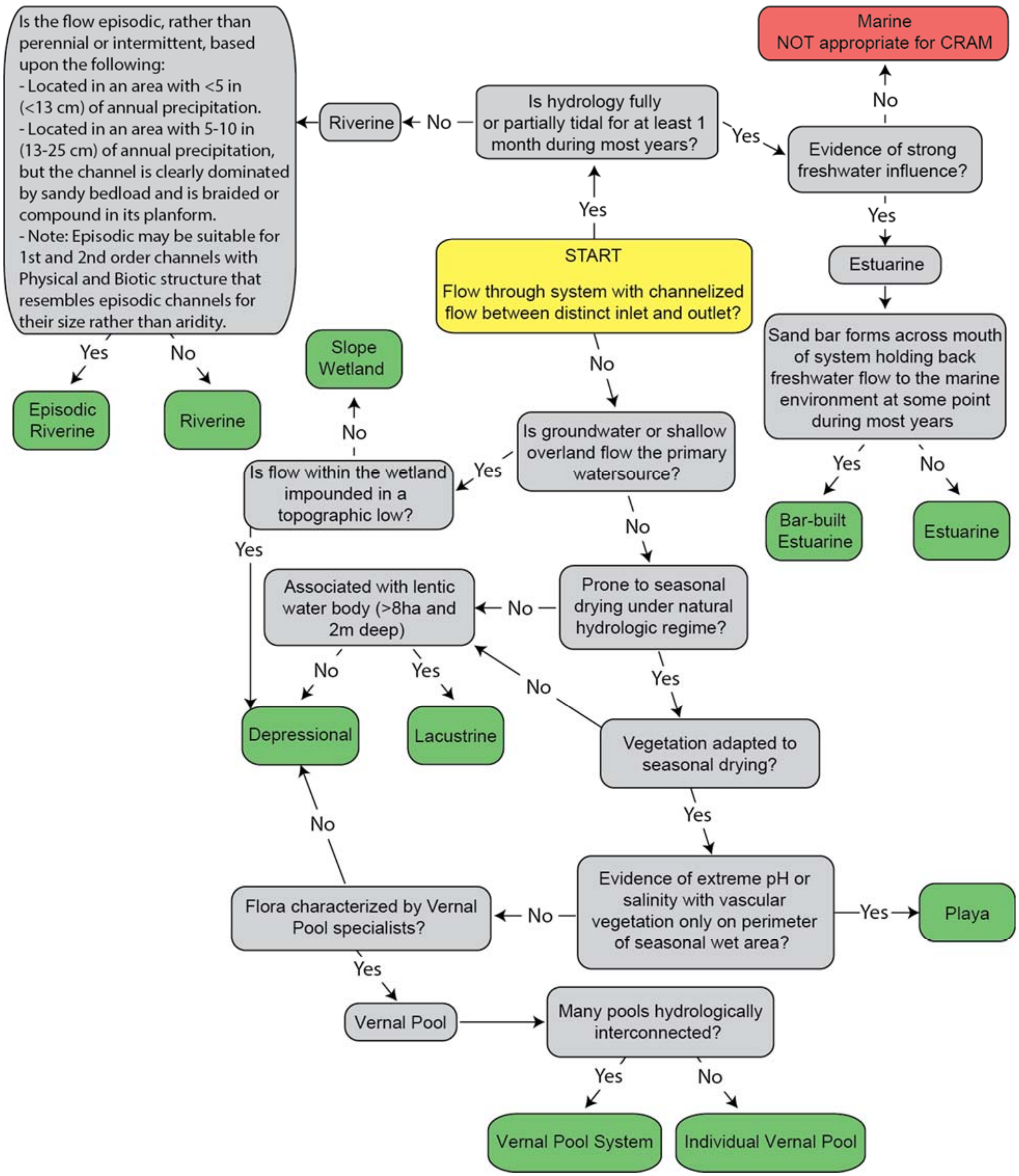


Figure 1: Flowchart to determine wetland type and sub-type

Vernal Pool Wetlands

Vernal pools are ephemeral wetlands that form in shallow depressions underlain by bedrock or by an impervious, near-surface soil horizon. These depressions fill with rainwater and runoff during the winter and may remain inundated until spring or early summer, sometimes filling and emptying repeatedly during the wet season. Vernal pools undergo four distinct annual phases: (1) the wetting phase with the onset of the first rains; (2) the aquatic phase when the peak rainfall and inundation occurs; (3) the drying phase when many plants flower and produce seed and many animals disperse; and finally (4) the drought phase when the soil dries and cracks, and the plants succumb to extreme dry conditions. Vernal pools typically support a minimum of 30% cover of native plant species during the aquatic or drying phase. Vernal pools in disturbed areas or subjected to abnormal rainfall patterns might not meet this criterion due to invasion by non-native plants. If the wetland is mostly characteristic of a vernal pool but also has characteristics of other kinds of wetlands, such that its classification as a vernal pool is not completely certain, then it should be considered a vernal pool.

Vernal Pool Systems and Individual Vernal Pools

Vernal pools often occur together and with vernal swales as vernal pool systems. These can have many pools of various sizes and shapes, varying floral and faunal composition, and various hydroperiods. Water can move between adjacent pools and swales through the thin soils above the underlying impervious substrate. The lack of surface flow between pools does not necessarily indicate that they are not hydrologically inter-connected. Unusual or extremely large vernal pools should be assessed using the Individual Vernal Pool Module.

Pools can be assessed individually or as parts of systems. **This CRAM module is designed to assess vernal pool systems.**

Vernal Pool Landscapes

Vernal pools and vernal pool systems are underlain by bedrock or by an impervious, near-surface soil horizon. These conditions can extend for many kilometers. Large areas having numerous individual vernal pools, swales, or multiple vernal pool systems are termed vernal pool landscapes.
In general, vernal pools and swales must comprise at least 10% of the land surface to define a vernal pool landscape. This definition can be revised as new data on pool density are assembled.

Other Depressional Wetlands

Depressional wetlands other than vernal pools can be seasonal or perennial, but their flora and fauna are mostly not characteristic of vernal pools, and ***they lack the impervious substrate that controls vernal pool hydrology***. They differ from lacustrine wetlands by lacking an adjacent area of open water at least 2 m deep and 8 ha total area. They differ from playas by lacking an adjacent area larger than the wetland of either alkaline or saline open water less than 2 m deep or non-vegetated, fine-grain sediments. Unlike slope wetlands (i.e., springs and seeps), depressional wetlands depend more on precipitation than groundwater as their water source.

Establish the Assessment Area (AA)

Table 1: Examples of features that *should* be used to delineate AA boundaries

- above-grade roads and fills
- major point sources of water inflows or outflows
- weirs, berms, levees and other flow control structures
- local watershed divide boundaries

Table 2: Examples of features that should *not* be used to delineate any AAs

- 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: Recommended maximum and minimum AA sizes for the Vernal Pool wetland type

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

Wetland Type	Recommended AA Size
Individual Vernal Pool	There are no size limits
Vernal Pool Systems	Preferred size is <10 ha (about 300m x 300m; shape can vary); there is no minimum size so long as there are at least 3 pools, maximum of 10 pools per AA.

Table 4: Steps to delineate a vernal pool system and its component pools

Step	Vernal Pool System Delineation Task
1	On the site imagery, draw the boundary around the system of vernal pools that are probably interconnected by surface or subsurface flow. To the extent possible, the AA boundary should follow the drainage divide or rim of the basin encompassing the selected vernal pool system, without extending further than about 30m from any pool and without extending into non-buffer land cover.
2	Delineate or circle and number all pools within the pool system from Step 1. Minimum of three pools and maximum of 10 pools. These pools comprise the AA.
3	Select three representative pools from the system. These should be one large pool, one small pool, and one pool of intermediate size. If the pools are all of similar size randomly select three of them. Pools to be assessed within the system should be of different sizes but similar in terms of vegetation, depth, etc. These pools will be assessed individually and their scores will be averaged using the Vernal Pool System CRAM module. If you have fewer than 3, assess each of them using the Individual Vernal Pool CRAM module. Additionally, if a pool looks substantially different than the others in the system (in terms of vegetation, depth, etc.), then it should be assessed as an individual vernal pool.

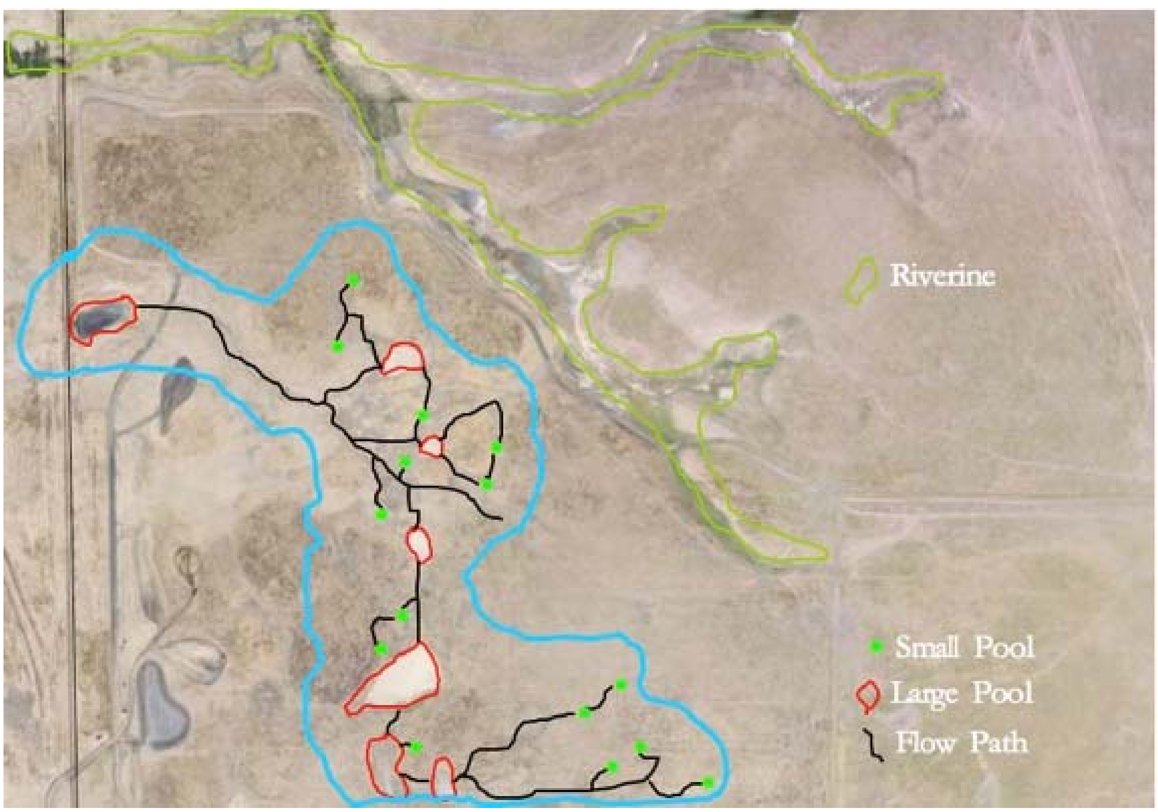


Figure 2: Example map of one vernal pool system and its component elements. The boundary around the system of vernal pools is shown as a blue line.

Attribute 1: Buffer and Landscape Context

Metric 1: Aquatic Area Abundance

The Aquatic Area Abundance of an Assessment Area is assessed in terms of its spatial association with other areas of aquatic habitat, 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.

On digital or hardcopy site imagery, at a scale between 1:6,000 and 1:8,000, identify the approximate center of the AA. In each of the four cardinal compass directions, draw a straight transect line from the edge of the AA boundary (in line with the center of the AA) to a point 500 m from the AA boundary. Estimate the percentage of the 500-m segment of each transect line outside the AA that passes through wetland or other aquatic habitat, including open water. Include a 30 m buffer around vernal pool systems and individual vernal pools in the estimation of aquatic habitat. For all other wetland types in the VP system (swales, etc.) include a 5 m buffer. Use Worksheet 1 below to record these estimates. Ignore any aquatic area that intercepts less than 5m of a line.

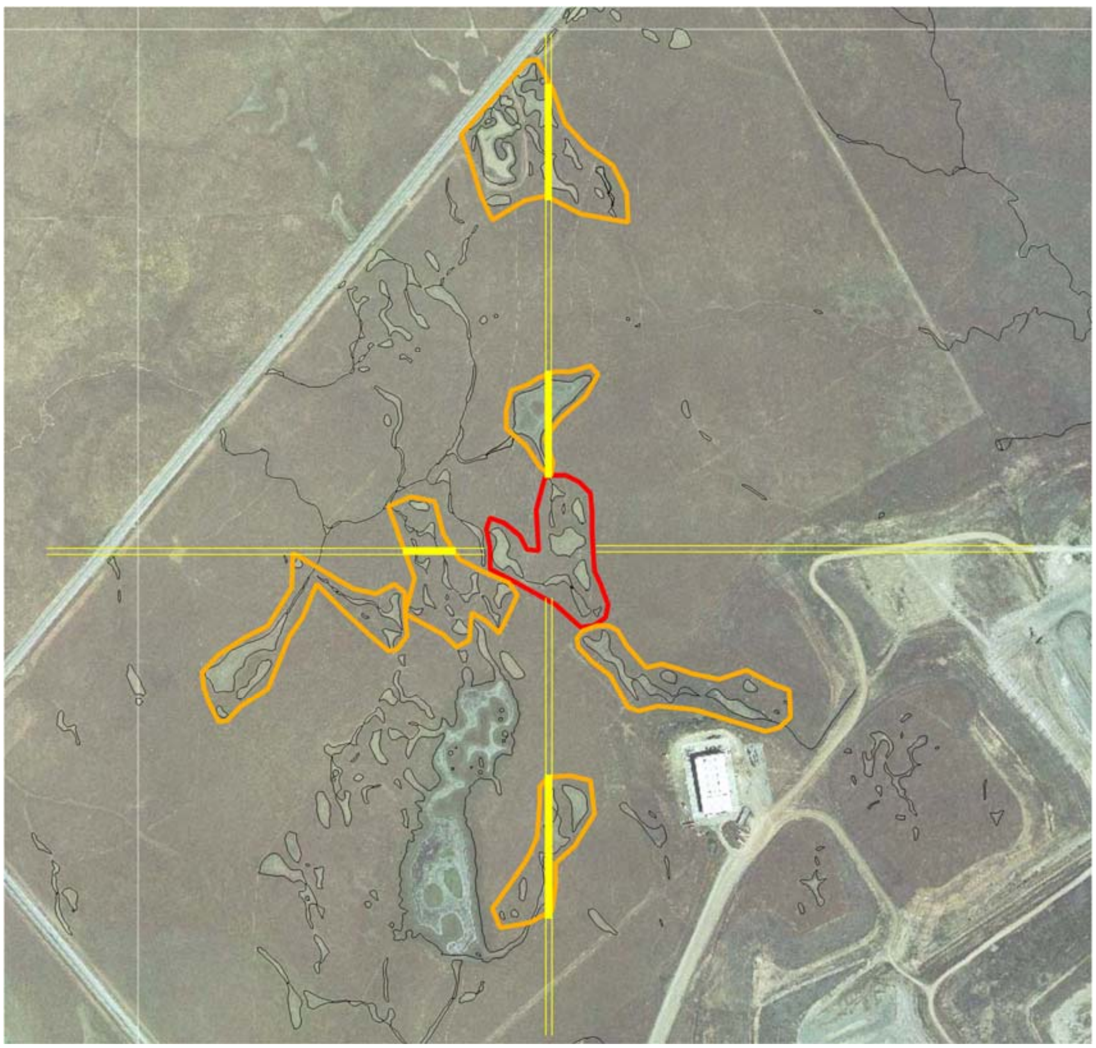


Figure 3. Aquatic Area Abundance. Double yellow lines show 500 m transects in cardinal directions. Orange polygons are potential VP AAs along the transects. Solid yellow indicates where the transect crosses through a VP AA. Black lines show individual pools and swales.

Worksheet 1: Aquatic Area Abundance for Vernal Pool Systems

Percentage of Each Transect Line Crossing Wetland or Other Aquatic Habitat	
Transect	Percent Crossing Aquatic Area
North	
East	
South	
West	
Average value for all Four Transects *Round to the nearest integer*	

Table 5: Rating for Aquatic Area Abundance for Vernal Pool Systems (enter rating in Scoring Sheet)

Rating	Alternative States
A	An average of 31 – 100 % of the transects pass through an aquatic feature of any kind.
B	An average of 21 – 30 % of the transects pass through an aquatic feature of any kind.
C	An average of 11 – 20 % of the transects pass through an aquatic feature of any kind.
D	An average of 0 – 10 % of the transects pass through an aquatic feature of any kind.

Metric 2: Buffer

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.

Table 6: Guidelines for identifying wetland buffers and breaks in buffers

Examples of Land Covers Included in Buffers	**Examples of Land Covers Excluded from Buffers** 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.
• at-grade bike and foot trails, or trails (with light traffic) • horse trails • natural upland habitats • nature or wildland parks • range land and pastures • railroads (with infrequent use: 2 trains per day or less) • roads not hazardous to wildlife, such as seldom used rural roads, forestry roads or private roads • swales and ditches • vegetated levees	• commercial developments • fences that interfere with the movements of wildlife (i.e. food safety fences that prevent the movement of deer, rabbits and frogs) • intensive agriculture (row crops, orchards and vineyards) • golf courses • paved roads (two lanes or larger) • lawns • active railroads (more than 2 trains per day) • parking lots • horse paddocks, feedlots, turkey ranches, etc. • residential areas • sound walls • sports fields • urbanized parks with active recreation • pedestrian/bike trails (with heavy traffic)

Submetric A: Percent of AA with Buffer

Definition: This submetric is based on the relationship between the extent of buffer and the functions provided by 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 that is surrounded by at least 5 meters of buffer land cover (Figure 4).

In the example below, the assessment area is surrounded by a mix of land cover types. Most of the area immediately adjacent to the AA is buffer (shaded in green). To the north and east is non-buffer urban development (shaded in red). To the west is an urban park with parking lots and sports fields, which is not considered buffer (shaded in orange).

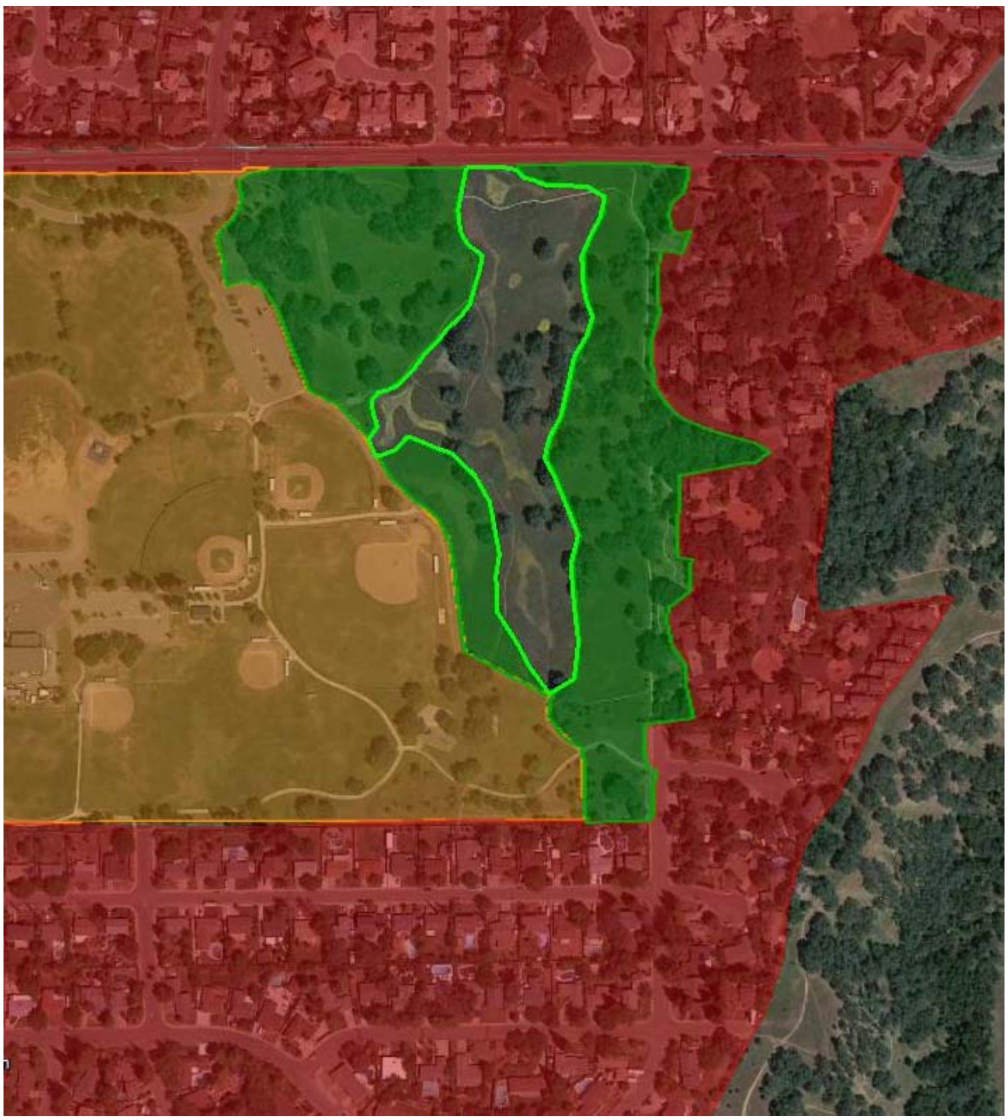


Figure 4. Diagram of buffer (green) and non-buffer (orange and red) land cover types

Worksheet 2: Percent of AA with Buffer

In the space provided below make a quick sketch of the AA, or on aerial the imagery, indicate where buffer is present, and record the total amount in the space provided.

Percent of AA with Buffer: ______ %

Table 7: Rating for Percent of AA with Buffer.
(enter rating in Scoring Sheet)

Rating	Alternative States
A	Buffer is 75 - 100% of AA perimeter.
B	Buffer is 50 – 74% of AA perimeter.
C	Buffer is 25 – 49% of AA perimeter.
D	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 6 above for more guidance regarding the identification of AA buffers.

Table 8: Steps to Estimate Buffer Width
(use Worksheet 2 or aerial to prepare sketch)

Step 1	For the area that has been identified as having buffer, draw eight straight lines 250 m in length perpendicular to the AA at regular intervals along the AA boundary. These lines should not cross.
Step 2	Estimate the buffer width of each of the lines as they extend away from the AA. Record these lengths on Worksheet 3 below.
Step 3	Calculate the average buffer width. Record this width on Worksheet 3 below.

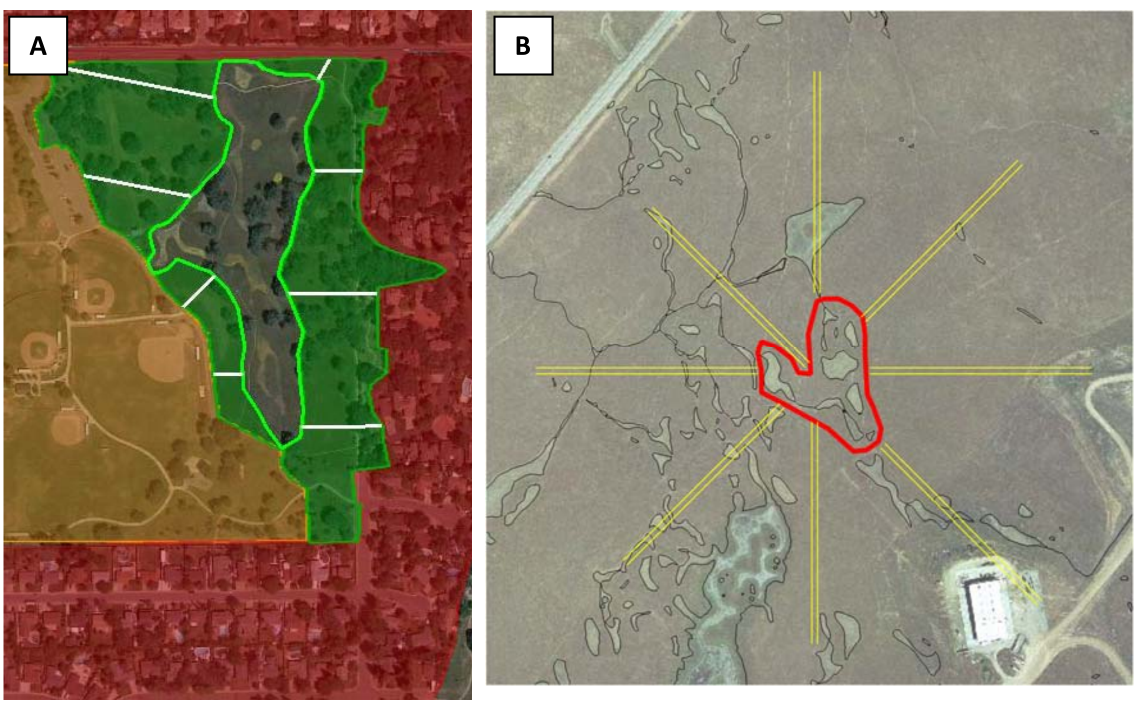


Figure 5. Examples of the method used to estimate Buffer Width. In example A, eight lines were drawn evenly distributed where buffer is present around the AA. The parts of the AA that are directly adjacent to non-buffer areas are excluded from the buffer width measurements. These are the north side of the AA that is directly next to the road, and a small part of the west side of the AA that is directly adjacent to the park. In example B seven of the eight buffer lines are a full 250 m, while the line to the southeast is interrupted by development. The width is based on the average length of eight lines A-H that extend around the perimeter of the AA where buffer is present.

Worksheet 3: Calculating average buffer width of AA

Transect	Buffer Width (m)
A	
B	
C	
D	
E	
F	
G	
H	
Average Buffer Width ***Round to nearest integer***	

Table 9: Rating for Average Buffer Width
(enter rating in Scoring Sheet)

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 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. Evidence of direct impacts (parking lots, buildings, etc.) 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 as buffer in the previous step**. If there is no buffer, assign a score of D.

Table 10: Rating for Buffer Condition
(enter rating in Scoring Sheet)

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 a mix of native and non-native vegetation, has no appreciable phytomass accumulation or invasive infestations, and has mostly undisturbed soils and is apparently subject to little or low impact human visitation.
C	Buffer for AA is characterized by non-native vegetation with little or no native component, or has appreciable phytomass accumulation or invasive infestations, or has a moderate degree of soil disturbance/compaction, or there is evidence of at least moderate intensity of human visitation.
D	Buffer for AA is characterized by barren ground or otherwise compacted or disturbed soils, or there is significant cover of invasive species, or there is evidence of very intense human visitation.

Attribute 2: Hydrology

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 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. Natural, direct sources include rainfall, and ground water discharge. Examples of unnatural, direct sources include stormdrains that empty directly into the AA or into an immediately adjacent area.

To score this metric use site aerial imagery and any other information collected about the watershed surrounding the AA to assess the water source within the immediate watershed contributing to your AA (Table 11). The maximum distance evaluated is 2 km, but most vernal pool systems have a much smaller local watershed. If the watershed is smaller than 2 km, assess only the area that is associated with the vernal pool system the AA is located in.

Table 11: Rating for Water Source
(enter rating in Scoring Sheet)

Rating	Alternative States
A	There is no indication that dry season conditions are substantially controlled by artificial water sources.
B	Freshwater sources that affect the dry season conditions 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 vicinity.
C	Freshwater sources that affect the dry season conditions of the AA are primarily urban runoff, direct irrigation, pumped water or other artificial hydrology. Indications are developed land or irrigated agriculture that comprise more than 20 % of the immediate vicinity.
D	Natural, freshwater sources that affect the dry season conditions of the AA have been eliminated, or all wet season inflows have been impounded or diverted.

Metric 2: Hydroperiod

Definition: Hydroperiod is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. Vernal pools are ephemeral wetlands that form in shallow depressions underlain by bedrock or by an impervious, near-surface soil horizon. These depressions fill with rainwater and runoff during the winter and may remain inundated until spring or early summer, sometimes filling and emptying repeatedly during the wet season.

Table 12: Field Indicators of Altered Hydroperiod

Direct Engineering Evidence	Indirect Ecological Evidence
Reduced Extent and Duration of Inundation or Saturation	
• Upstream spring boxes • Impoundments • Pumps, diversions, ditching that move water ***out of*** the wetland	• 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	
• Berms • Dikes • Pumps, diversions, ditching that move water ***into*** the wetland	• Late-season vitality of annual vegetation • Recently drowned riparian vegetation • Extensive fine-grain deposits

Table 13: Rating of Hydroperiod for Vernal Pool Systems.
(enter rating in Scoring Sheet)

Rating	Alternative States
A	Hydroperiod of the AA is characterized by natural patterns of filling, inundation, or saturation as well as natural patterns of and drying or drawdown with no indication of hydro-modification. There are no artificial controls on the hydroperiod.
B	The filling, inundation, or saturation patterns in the AA are of greater magnitude or longer duration than would be expected under natural condition (or compared to comparable natural wetlands), but thereafter, the AA is subject to natural processes and patterns of drawdown or drying.
C	The patterns of filling, inundation or saturation of the AA as well as the patterns of drawdown or drying of the AA are naturalistic but controlled by unnatural processes due to hydromodification.
D	The patterns of filling, inundation or saturation of the AA as well as the patterns of drawdown or drying of the AA significantly deviate from natural patterns due to hydromodification.

Metric 3: Hydrologic Connectivity

Definition: Hydrologic Connectivity describes the ability of water to flow into or out of the wetland, or to inundate their adjacent uplands. It provides for the ecotone caused by the moisture gradient between the vernal pool and its surrounding upland. For vernal pool systems, it is scored by assessing the degree to which hydrologic connectivity along the margin of the AA is restricted by unnatural features, such as levees and excessively high banks. **This metric applies to both within and immediately adjacent to the AA.**

Table 14: Rating of Hydrologic Connectivity for Vernal Pool Systems (enter rating in Scoring Sheet)

Rating	Alternative States
A	Rising water in the AA has unrestricted access to adjacent areas, without levees or other obstructions to the lateral movement of flood waters.
B	There are unnatural features such as levees or road grades that limit the amount of adjacent transition zone or the lateral movement of flood waters, relative to what is expected for the setting. But, the limitations exist for less than 50% of the boundary of the AA. Restrictions may be intermittent along margins of the AA, or they may occur only along one side of the AA. Flood flows may exceed the obstructions, but drainage back to the AA is obstructed.
C	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for 50-90% of the AA. Flood flows may exceed the obstructions, but drainage back to the AA is obstructed.
D	The amount of adjacent transition zone or the lateral movement of flood waters is limited, relative to what is expected for the setting, by unnatural features, such as levees or road grades, for more than 90% of the AA.

Attribute 3: Physical Structure

Metric 1: Structural Patch Richness

Patch richness is the number of different obvious types of physical surfaces or features that may provide habitat for aquatic (including wetland) or riparian species. This metric is different from topographic complexity in that it addresses the number of different patch types, whereas topographic complexity helps evaluate the spatial arrangement and interspersion of the types. Physical patches can be natural or unnatural.

Worksheet 4: Structural Patch Types for Vernal Pool Systems

Identify each type of patch that is observed in the AA and use the total number of observed patch types in Table 15. Each patch should occupy at least 3 m^2 of area in aggregate within the AA, with some exceptions (see definitions below).

Structural Patch Type	Check for Presence
Adjacent shrub or tree cover	
Animal mounds and burrows	
Bare soil	
Cobble and boulders	
Complexly-shaped pools	
Drainage branches (more than 1 drainage branch)	
Islands	
Large individual pools	
Large swales	
Mima mounds	
Patches of dense vegetation	
Pool Cluster	
Simply-shaped pools	
Small individual pools	
Small swales	
Soil cracks	
Within Pool Mounds	
Total Possible	**17**
No. Observed Patch Types (enter here and use in Table 15)	

Table 15: Rating of Structural Patch Richness
(enter rating in Scoring Sheet)

Rating	Vernal Pool Systems
A	≥ 12
B	9 – 11
C	7 – 8
D	≤ 6

Patch Type Definitions for Vernal Pool Systems

Adjacent shrub or tree cover. These are patches of shrubs or trees adjacent to pools. They provide shading, nutrient input, and potentially affect pool dry-down among other biogeochemical processes. This patch type can be found anywhere in the AA.

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 thus it 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. Animal mounds and burrows can be found both within the pools and in the surrounding upland that is included in the AA.

Bare soil. Bare soil is any area at least $3m^2$ in size within a vernal pool system that has less than 5% cover of vegetation during the peak of the growing season. Rock outcrops do not qualify as bare soil. Bare soil areas must be at least $3m^2$ in one discrete area, small patches of bare soil that add up to $3m^2$ in aggregate do not count. This patch type should be located within pools or swales, not in the upland portion of the AA.

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. 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. This patch type should be located within pools or swales, not in the upland portion of the AA.

Complexly-shaped pools. Vernal pool systems or complexes usually consist of many pools of different shapes. In general, pools can be separated into two shape classes; simply-shaped pools and complexly-shaped pools. Complexly-shaped pools do not resemble circles or ovals. They are much longer than wide, or they are kidney-shaped, or they vary in width in complex ways that are not well represented by either a circle or an oval.

Drainage confluence. Vernal pool systems usually consist of many pools that are interconnected by one or more shallow pathways of surface water flow called swales. In their downstream reaches, some swales develop obvious banks and beds and therefore can be called channels. The swales and/or channels and pools that drain to a common place comprise a drainage network. If the drainage network consists of two or more swales and/or channels that are clearly confluent with each other (i.e., they are connected to, and contribute to the flow of, another swale or channel), then the network has a confluence. There must be obvious overland flow (swales or channels), as opposed to groundwater flow, to be considered a confluence.

Islands. There are patches of upland vegetation located within pools and lying topographically above the maximum zone of pool inundation.

Large vernal pools. Vernal pool systems or complexes usually consist of many pools of different sizes. For the purpose of assessing pool systems using CRAM, two pool size classes are recognized – large and small. Large pools are defined for the purposes of this patch type checklist as pools that are at least 3 times the size of the smallest pool in the AA.

Large swales. Large swales transport water, but also generally contain wide, flat areas that pond similar to vernal pools. Large swales are fed by other large and small swales and are rarely directly connected to pools.

Mima mounds. Mima mounds are elliptical mounds of soil, usually 1-3 meters tall, and uniformly distributed across a landscape. The sizes of areas between mounds is often very similar to the mound sizes, such that the landscape, as viewed from a few thousand feet above, resembles the surface of a golf ball. Vernal pools tend to form in the low areas between mima mounds.

Patches of dense vegetation (Juncus, Eleocharis, bunchgrasses) – Patches of vegetation in which one or several species have significantly higher vegetative cover in comparison with the remainder of the pool. These patches should be visually distinguishable. This patch type should be located within pools or swales, not in the upland portion of the AA.

Pool Cluster. Vernal pool systems or complexes usually consist of many pools of different sizes. Some pools are interconnected by shallow pathways of surface water flow called swales. In their downstream reaches, some swales develop obvious banks and beds and therefore can be called channels. The swales and/or channels that drain to a common place comprise a drainage network. Three or more vernal pools of any size that exist in the same drainage network compose a vernal pool cluster.

Simply-shaped pools. Vernal pool systems or complexes usually consist of many pools of different shapes. In general, pools can be separated into two shape classes; simply-shaped pools and complexly-shaped pools. Simply-shaped pools resemble circles or ovals.

Small individual pools. Vernal pool systems or complexes usually consist of many pools of different sizes. For the purpose of assessing pool systems using CRAM, two pool size classes are recognized. The small pools in a system are less than half the size of the average size of pools in the system. There is no maximum size of small pools.

Small swales. Small swales are linear features that transport water between well defined pools or from pools to steam features.

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. This patch type should be located within pools or swales, not in the upland portion of the AA.

Within Pool Mounds. These are patches (of earth) located within pools and raised above the pool bottom at elevation that lies within the zone of maximum inundation. Mounds may be inundated periodically during the wet season or saturated by surrounding ponded water for sufficient duration to promote a dominance of hydrophytic vegetation characteristic of pool basins or edges.

Metric 2: Pool and Swale Density (Vernal Pool Systems ONLY)

One aspect of vernal pool system physical structure that emerges at the AA scale is the density of pools and swales, meaning their absolute percent cover across the AA. As density increases, the potential for each pool or swale to be hydrologically and ecologically interconnected also increases, as does the potential for density-independent disturbance and stress to be accommodated by the system as a whole.

Density is assessed by estimating the length of swales or pools that cross two transects within the AA. These transect lines are oriented along the long axis of the vernal pool system AA and perpendicular to that along the short axis. The method for establishing the transect lines is also provided here.

On digital or hardcopy site imagery, identify the approximate center of the AA. Then identify the longest axis that goes through the center of the AA. Draw a straight transect line along the long axis of the AA. Draw another straight transect line going through the center of the AA and perpendicular to the first transect. If the AA does not have one dominant long axis, the transects are drawn north-south and east-west by default. While viewing the site imagery at a scale of 1:1000 to 1:2000, estimate the length in meters of each of these two transect lines inside the AA. Then measure the length of each transect that passes through a pool or swale. Use worksheet 5 to record these estimates.

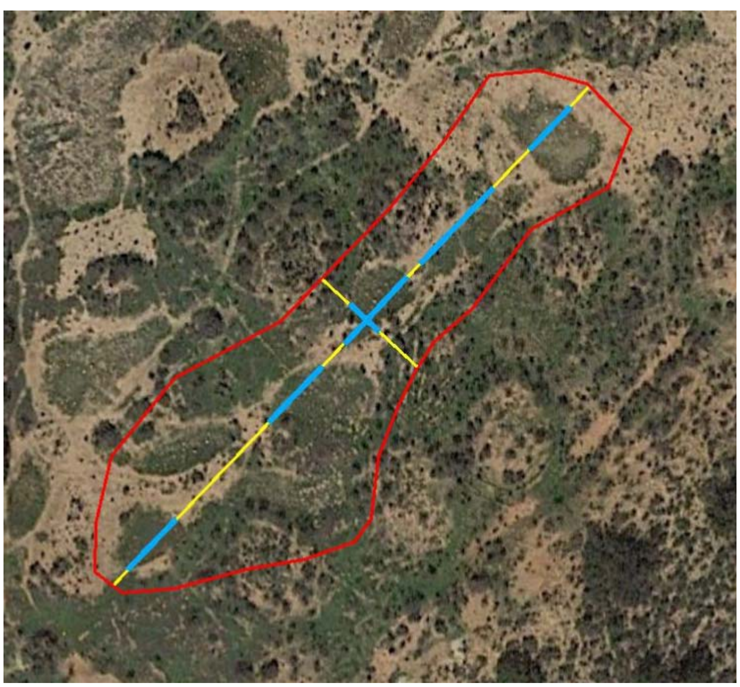


Figure 6. Example of method to assess pool and swale density in a vernal pool system. Yellow lines are transects along the long axis and perpendicular axis, and blue lines indicate where the transect crosses a pool or swale.

Worksheet 5: Pool and Swale Density for Vernal Pool Systems

Pool and Swale Density Worksheet		
Transect	Transect Length (m)	Length Crossing Pool or Swale (m)
Long Axis		
Short Axis		
Sum of Length (m)		
Percent Pool and Swale (Sum of Pools & Swales/Sum of Transect Lengths)*100 *Round to nearest integer*		

Table 16: Rating for Pool and Swale Density for Vernal Pool Systems (enter rating in Scoring Sheet)

Rating	Alternative States
A	An average of 36– 100 % of the transects crosses pools or swales.
B	An average of 26 – 35 % of the transects crosses pools or swales.
C	An average of 16 – 25 % of the transects crosses pools or swales.
D	An average of 0 – 15 % of the transects crosses pools or swales.

Metric 3: Topographic Complexity

Topographic complexity refers to the micro- and macro-topographic relief and variety of elevations within a wetland due to physical and abiotic features and elevation gradients that affect moisture gradients. This metric is assessed by noting the overall variability in physical patches and topographic features (Table 17 and Figures 7 and 8). Care must be taken to distinguish indicators of topographic complexity or habitat features within a wetland. Topographic complexity can be evaluated by observing the number of elevational features that affect moisture gradients along a transect across the AA, and the amount of micro-topographic relief along the transect. Moisture gradients at various elevational features may be indicated by plant assemblages with different inundation/saturation tolerances. It is helpful to walk a representative transect along the pool and sketch the changes in slope and elevation as well as smaller features that contribute to micro-topographic relief. Breaks in slope from shallower to steeper gradients and vice versa are particularly important because they affect the timing of inundation and resulting moisture niches within the pool. This metric is assessed for each of the 3 pools selected from the Vernal Pool System. Cross sections of the individual pools are recorded in Worksheet 6a for each pool. Scores for each pool are then recorded in Worksheet 6 based on the practitioner's drawings, the indicators listed in Table 17, the scale-independent schematic profiles in Figure 9, and the ratings in Table 18.

Table 17: Typical Indicators of Micro-topographic Complexity

Type	Examples of Topographic Features
Vernal Pools and Pool Systems	soil cracks, mounds, rivulets, cobbles, plant hummocks, cattle or sheep tracks

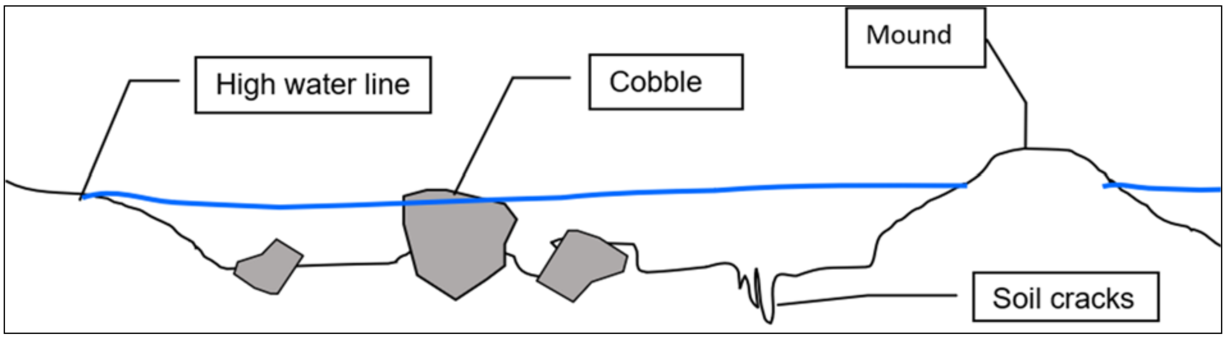


Figure 7: Scale-independent cross-section of macro and micro features that contribute to topographic complexity

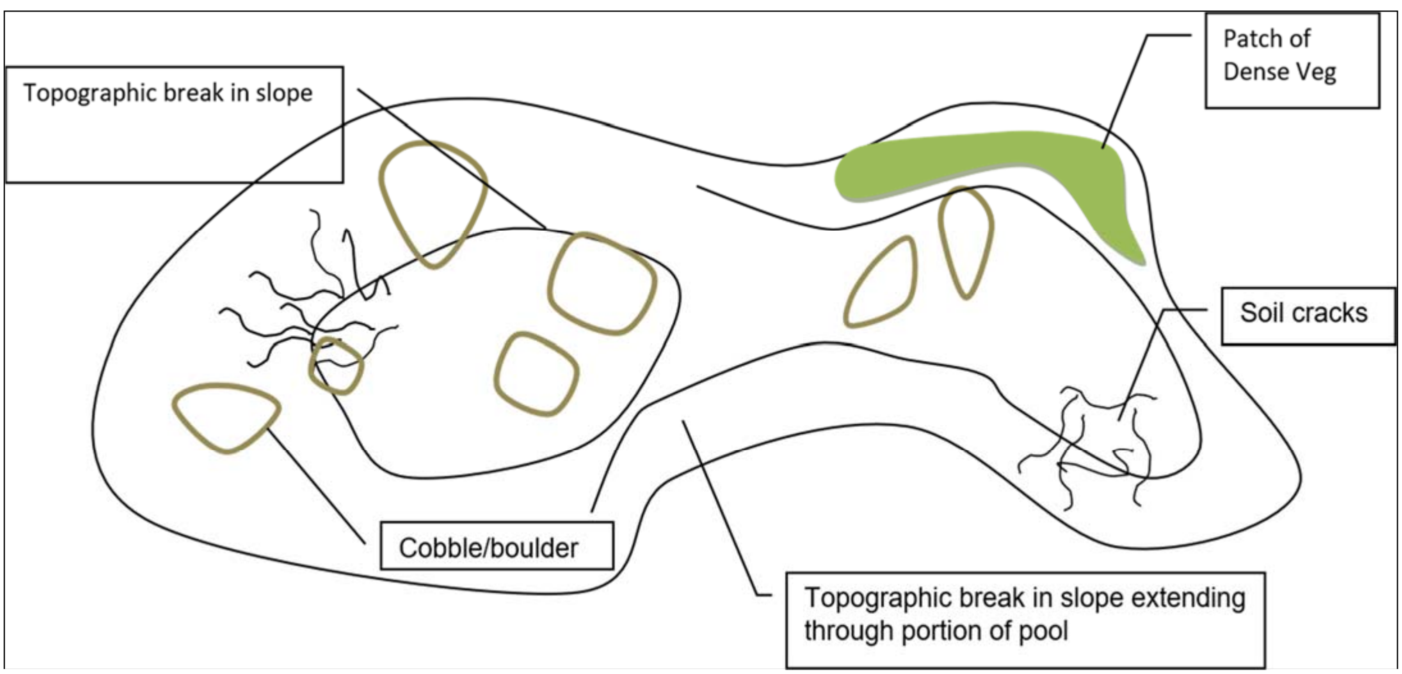


Figure 8: Scale-independent plan-view diagram of a pool with topographic breaks in slope and macro and micro features that contribute to topographic complexity

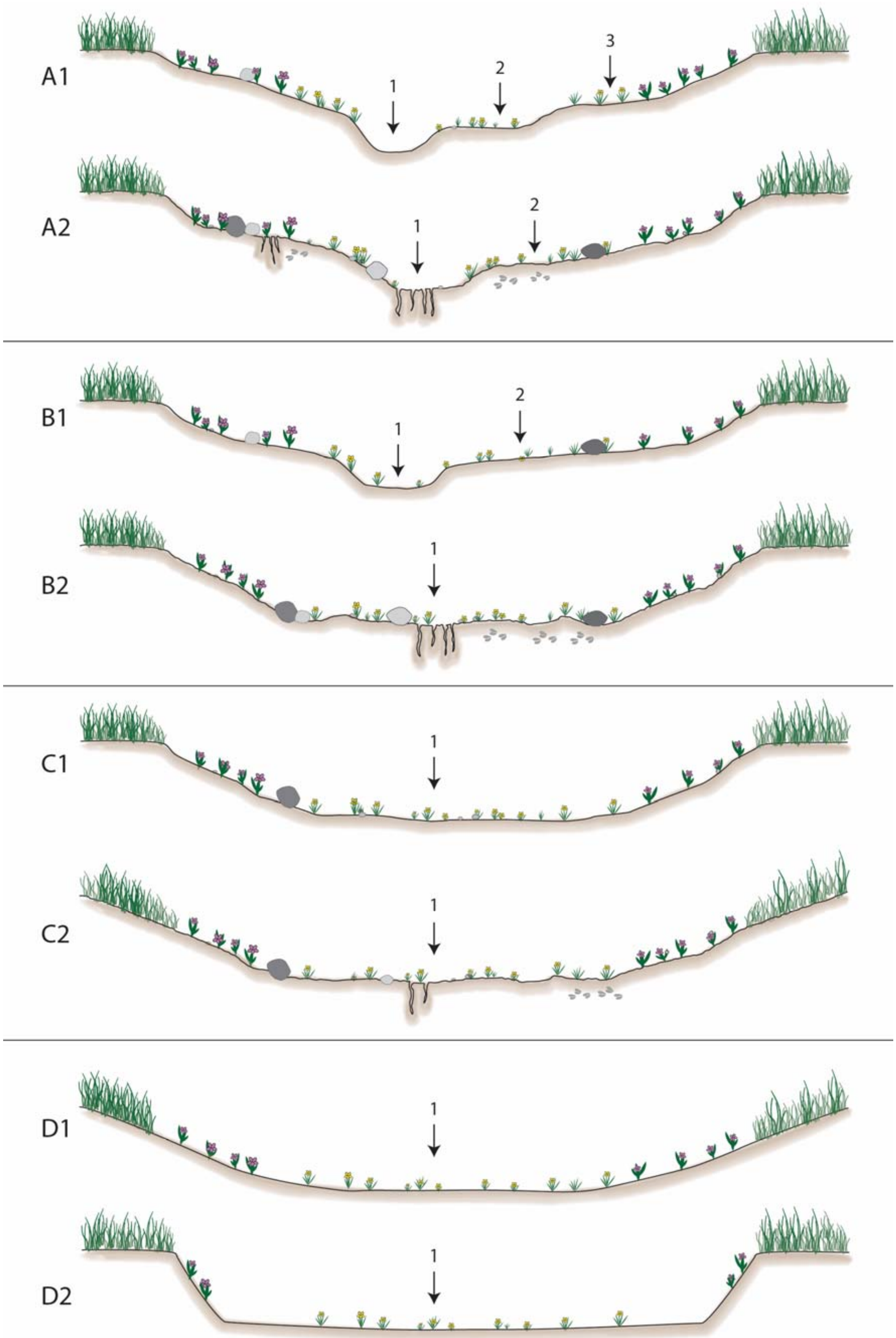


Figure 9: Scale-independent schematic profiles of Topographic Complexity.

Pool Replicates

Worksheet 6a: Sketches of Vernal Pool Profiles for Topographic Complexity
Worksheet 6a: Sketches of Vernal Pool Profiles for Topographic Complexity Along the long axis of the pool and perpendicular to the long axis across the middle, make a sketch of the profile of each of the three pools from its outside edge (1-3m landward or away from the saturated zone of the pool) to its deepest areas then back out to the outside margin. Try to capture the major breaks in slope and the intervening micro-topographic relief. Based on the sketches, choose a single profile from Figure 9 that best represents the pool overall.
Long Axis
Perpendicular to Long Axis

Table 18: Rating Topographic Complexity for Vernal Pool Systems
(enter results in Worksheet 6 below)

Rating	Alternative States
A	There are three obvious breaks in slope with or without abundant micro-topographic relief along most of the average profile. When the pool is full there are three distinct depth zones. One of the breaks in slope occurs at the transition to upland. OR There are two breaks in slope with abundant micro-topographic relief. When the pool is full there are two distinct depth zones. One of the breaks in slope occurs at the transition to upland.
B	There are two breaks in slope with limited micro-topographic relief. When the pool is full there are two distinct depth zones. One of the breaks in slope occurs at the transition to upland. OR There is one break in slope with abundant micro-topographic relief. When the pool is full the depth changes gradually without distinct depth zones, and the break in slope occurs at the transition to upland.
C	There is one break in slope with limited micro-topographic relief. When the pool is full the depth changes gradually without distinct depth zones, and the break in slope occurs at the transition to upland. OR There is a single slope with at least moderate micro-topographic relief.
D	There is a single slope with limited micro-topographic relief. OR There is a uniform slope with one break in slope at the upland edge, which is unusually steep and short for a natural profile. When the pool is full the depth changes gradually without distinct depth zones, and the break in slope occurs at the transition to upland.

Worksheet 6: Rating of Topographic Complexity for Vernal Pool Systems

Replicate Number	Replicate Score (A = 12; B = 9; C = 6; D = 3)	
	Alpha.	***Numeric***
Replicate 1		
Replicate 2		
Replicate 3		
Overall Average Score for All Pool Replicates ***Round to nearest integer*** **(enter here and use in Table 19)**		

Table 19: Rating for Overall Topographic Complexity for Vernal Pool Systems (enter rating in Scoring Sheet)

Rating	Vernal Pool Systems
A	≥ 10
B	8 – 9
C	7
D	≤ 6

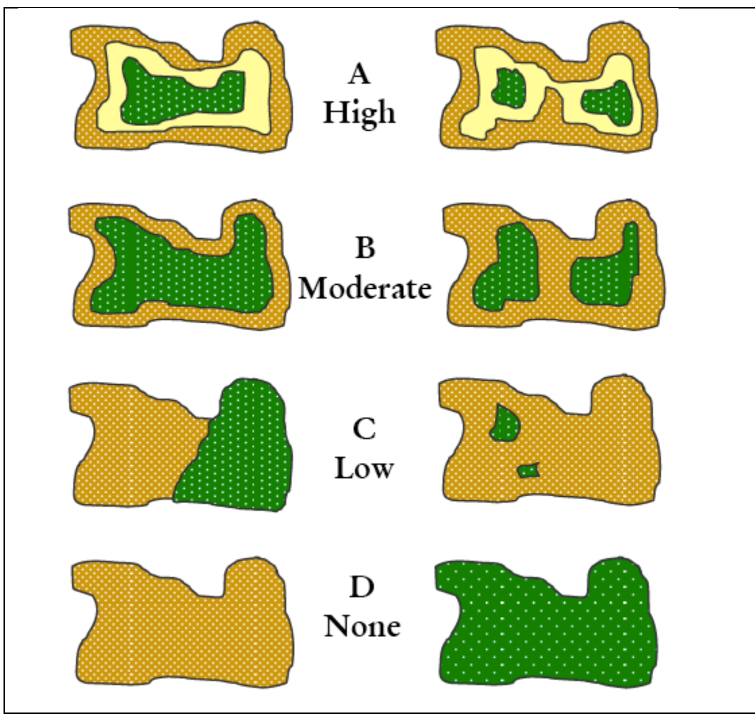
Attribute 4: Biotic Structure

Metric 1: Horizontal Interspersion and Zonation

Horizontal biotic structure refers to the variety and interspersion of plant "zones," plant monocultures or obvious multi-species association that are arrayed along gradients of elevation, moisture, or other environmental factors. Interspersion is essentially a measure of the number of distinct plant zones and the amount of shared edge between them.

This metric is assessed for each of the 3 pools selected from the AA. Drawings of the individual pools are recorded in Worksheet 7a for each pool. Make special note of the amount of shared edge. Scores for each pool are then recorded in Worksheet 7 based on the practitioner's drawings, the scale-independent images in Figure 10, and the narrative in Table 20.

Each zone must comprise at least 5% of the pool area. The white area in this figure surrounding each pool represents the upland matrix; the orange area represents the marginal saturation zone. All pools, even as shown for score "D", therefore have at least 1 zone. It is helpful to assign names of plant species or associations of species to the colored patches and to make special note of amount of shared edge. Note that if islands are present in the pool the upland portion of the island is not included in the interspersion assessment, but the increased complexity from the ecotone within the pool surrounding the island can add to interspersion for this metric.



A High	Pool has 3 plant zones and ***much shared edge***
B Moderate	Pool has 2 plant zones and ***much shared edge***
C Low	Pool has 2 plant zones and ***little shared edge***
D None	Pool has 1 plant zone and ***no interspersion***

Figure 10: Degrees of interspersion of plant zones for Individual Vernal Pools.

Pool Replicates

Worksheet 7a: Sketch of Vernal Pool Horizontal Interspersion and Zonation	
	Assigned Zones: 1) 2) 3) 4) 5)

Table 20: Rating of Horizontal Interspersion and Zonation of Plant Zones for Vernal Pools (enter results in Worksheet 7 below)

Rating	Alternative States
A	Pool has a high degree of plan-view interspersion.
B	Pool has a moderate degree of plan-view interspersion.
C	Pool has a low degree of plan-view interspersion.
D	Pool has essentially no plan-view interspersion.

Worksheet 7: Rating of Horizontal Interspersion for Vernal Pool Systems

Replicate Number	Replicate Score (A = 12; B = 9; C = 6; D = 3)	
	Alpha.	***Numeric***
Replicate 1		
Replicate 2		
Replicate 3		
Overall Average Score for All Pool Replicates ***Round to nearest integer*** **(enter here and use in Table 21)**		

Table 21: Rating for Horizontal Interspersion for Vernal Pool Systems (enter rating in Scoring Sheet)

Rating	Vernal Pool Systems
A	≥ 11
B	9 – 10
C	7 – 8
D	≤ 6

Metric 2: Plant Community

The Plant Community Metric is composed of three submetrics. The first submetric, Number of Co- dominant Species, is assessed for each of the 3 pools selected from the AA. The second and third submetrics, Percent Non-native and Endemic Species Richness, are not assessed for each replicate pool. Rather, a list of all species is compiled for all replicate pools combined. Worksheet 8 contains all of the data necessary to score all three submetrics.

Submetric A: Number of Co-dominant Species

For the pool as a whole, all plant species that comprise at least 10% relative cover are considered to be dominant. Only living vegetation in growth position is considered in this metric. Dead or senescent vegetation is disregarded. If upland islands are present they are excluded from consideration for this metric, and the plants present on the islands are not counted in the cover estimates. The number of co-dominant species from each replicate pool are averaged.

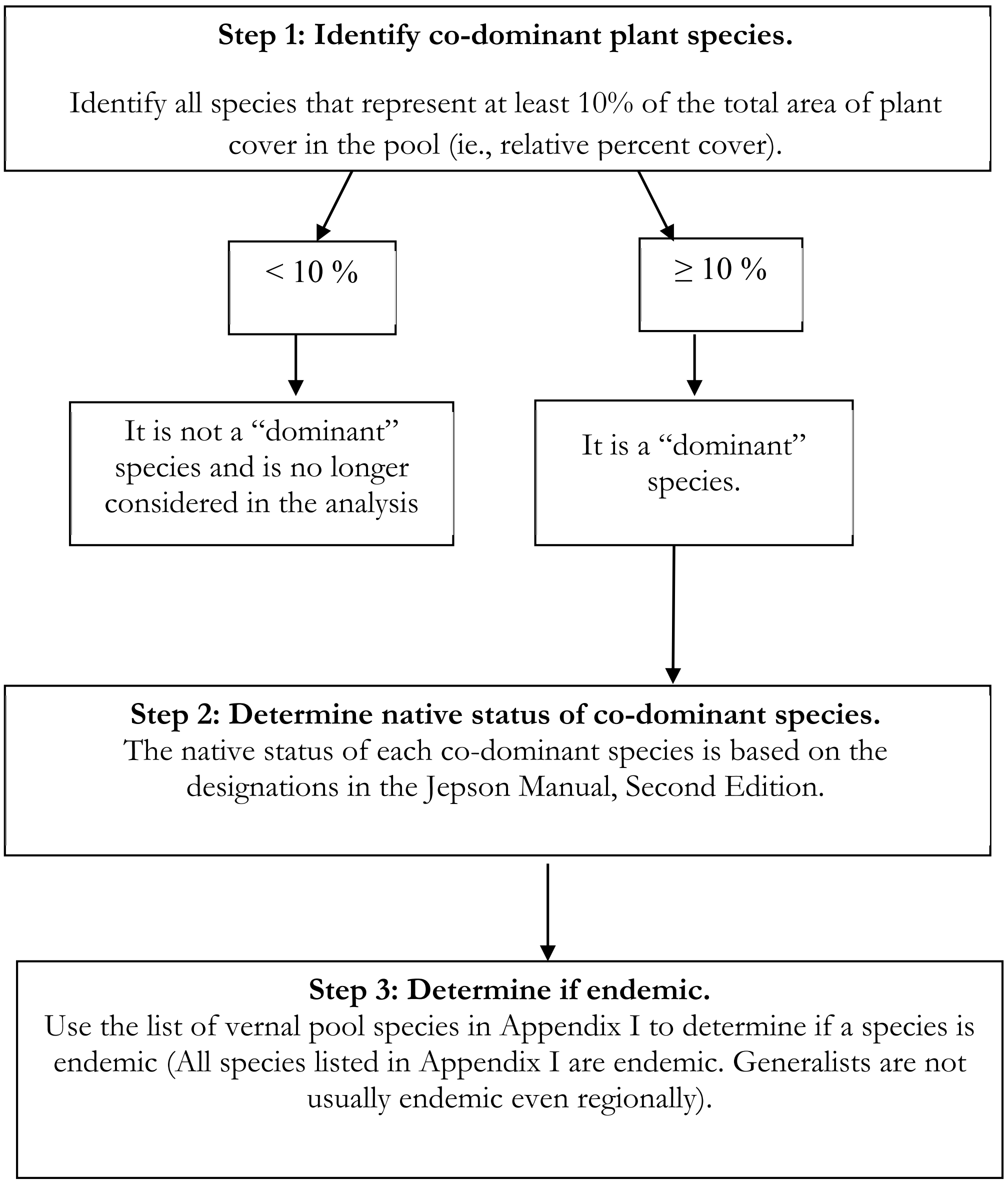
Submetric B: Percent Non-native

The percent of the co-dominant species that are non-native is calculated by dividing the number of non-native co-dominant species by the total number of co-dominant species. Native status is based on the Jepson Manual, Second Edition. Expertise is required to assure that species are correctly identified.

Submetric C: Endemic Species Richness

This submetric is based on the total number of co-dominant native plant species endemic to vernal pools that occur in the AA. All species listed in Appendix I are endemic. Generalists are not usually endemic even regionally. For Vernal Pool Systems, this metric is assessed for all the replicate pools combined.

Figure 11: Flow Chart to Determine Plant Dominance



Worksheet 8: Plant Community Metric –
List of Unique Co-dominant Plant Species from all Vernal Pools Combined

Plant Name	Check if non-native	Check if in Appendix I	Pool 1	Pool 2	Pool 3
Total number of co-dominant species in each pool					
Average number of co-dominant species *round to nearest integer* Enter here and use in Table 22					
Total number of co-dominant species (A)					
Total number of co-dominant species that are non-native (B)					
Percent non-native (B/A) x 100 *Round to nearest integer* Enter here and use in Table 23					
Total number of co-dominant species that are endemic Enter here and use in Table 24					

Table 22: Ratings for Submetric A: Average Number of Co-dominant Species (enter rating in Scoring Sheet)

Rating	Average number of Co-dominants
A	≥ 5
B	4
C	3
D	0 – 2

Table 23: Ratings for Submetric B: Percent Non-native species (enter rating in Scoring Sheet)

Rating	Percent Non-native
A	0 - 15%
B	16 – 30%
C	31 – 45%
D	46 – 100%

Table 24: Ratings for Submetric C: VP Endemic Species Co-Dominants (enter rating in Scoring Sheet)

Rating	VP Endemic Species Co-dominants
A	≥ 7
B	5 – 6
C	3 – 4
D	0 – 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 25: Wetland disturbances and conversions

<table>
<tr><td>Has a major disturbance occurred at this wetland?</td><td>Yes</td><td colspan="2">No</td><td colspan="2"></td><td></td></tr>
<tr><td>If yes, was it a flood, fire, landslide, or other?</td><td>flood</td><td colspan="2">fire</td><td colspan="2">landslide</td><td>other</td></tr>
<tr><td>If yes, then how severe is the disturbance?</td><td colspan="2">likely to affect site next 5 or more years</td><td colspan="2">likely to affect site next 3-5 years</td><td colspan="2">likely to affect site next 1-2 years</td></tr>
<tr><td rowspan="4">Has this wetland been converted from another type? If yes, then what was the previous type?</td><td colspan="2">depressional</td><td colspan="2">vernal pool</td><td colspan="2">vernal pool system</td></tr>
<tr><td colspan="2">non-confined riverine</td><td colspan="2">confined riverine</td><td colspan="2">bar-built estuarine</td></tr>
<tr><td colspan="2">perennial saline estuarine</td><td colspan="2">perennial non-saline estuarine</td><td colspan="2">wet meadow</td></tr>
<tr><td colspan="2">lacustrine</td><td colspan="2">seep or spring</td><td colspan="2">playa</td></tr>
</table>

Worksheet 9: 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		
Comments		

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		
Comments		

BIOTIC STRUCTURE ATTRIBUTE (WITHIN 50 M OF AA)	Present	Present and Likely to Have Significant negative effect on AA
Mowing, grazing, excessive herbivory (within AA)		
Excessive human visitation		
Predation and habitat destruction by non-native vertebrates (e.g., *Virginia opossum* 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	Present and likely to have 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		