English Meadow

California Rapid Assessment Method
Slope Wetland Assessment & Evaluation

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Introduction - Objectives

This paper details the findings of a biological assessment of slope wetlands at English Meadow conducted on behalf of Dr. Kevin Cornwell of the Geology Department at Sacramento State University, the Plumas Corporation, and Nevada Irrigation District. The wetlands consist of a matrix of relatively pristine mountain groundwater-fed meadows adjacent to the Yuba River; two small fens are included in the wetland assessment. The Sierra Nevada, which John Muir called "the Range of Light," occupies only 25% of California's state land area, and is the source area for more than 60% of California's developed water supply (Sierra Meadow Partnership 2016). Sierran meadows are hotspots for biodiversity. A pair of nesting Sandhill Cranes (*Grus Canadensis*) were observed while we were at English Meadow.

English Meadows consists of wet meadows and fens. Fens are an important and unique wetland type formed where the long-term rate of organic matter production by plants exceeds the rate of decomposition due to groundwater input and anoxic conditions. This process forms peat, which accumulates very slowly, measured elsewhere at 11 to 41 cm (4.3 to 16.2 inches) per thousand years. The integrity of peat and ecosystems is inherently tied to groundwater exchange supporting peat accumulation and micro-topographic complexity supporting unique plant assemblages. A variety of land uses and use features can affect the maintenance of these special areas, including water diversions, livestock grazing, ditches, and roads. Fens support a disproportionately large number of rare vascular and nonvascular plants species in the Sierra Nevada, underscoring the importance of these habitats for regional biological diversity. In addition, fens are a major sink for atmospheric carbon (Weixelman and Cooper, 2009). Portions of the English Meadow fens are impacted by drainage ditches, resulting in degradation of meadow biotic and hydrologic functions.

Data for this assessment was gathered using the California Rapid Assessment Method (CRAM) to establish baseline and reference conditions on the site, comparing undisturbed and disturbed portions of the meadow. The data collected in this project will serve as a long-term reference dataset to determine English Meadow's habitat quality and hydrologic function. It is also available to inform restoration and adaptive management decisions.

<u>English Meadow Location</u>

English Meadow (UTM 10S 713019mE, 4370815mN) is approximately 35 miles (56 km) north and west of Lake Tahoe and straddles the boundaries of Nevada and Sierra counties in northern California. The meadow is about 1.5 miles (2.4 km) upstream of the Jackson Meadows Reservoir and ranges in elevation throughout the meadow from a downstream low of 6149 feet (1874m) to an upstream high of 6201 feet (1890m). The meadow itself covers an approximate area of 0.27 miles^2 (0.72 km^2) and is about 1.24 miles (2.00 km) long and 0.23 miles (0.37 km) wide. The meadow is in the headwaters of the Yuba River watershed, with wetlands primarily nourished by precipitation, springs, and groundwater sources.

<u>What is the California Rapid Assessment Method?</u>

The U.S. Environmental Protection Agency (USEPA) has proposed a three-tiered monitoring paradigm (Level 1-2-3) that provides a structured framework for conducting more integrated assessments of wetland resources across multiple scales (Solek et al., 2008; Stein et al., 2009). CRAM is a Level 2 rapid assessment method used to provide rapid and scientifically defensible data regarding a given wetland's conditions at the time of its assessment. This method is approved by the California Water Quality

Monitoring Council and is subject to the peer review process of the California State Water Resources Control Board and California Environmental Protection Agency (EcoAtlas 2016). The "Water Quality Control Plan for Wetlands" clarifies the State Water Board's existing authority under both Porter Cologne and Section 401 certification of the Clean Water Act in protecting the beneficial uses of wetlands from pollution.

The CRAM framework of the is divided into three levels:

Landscape Assessment (Level 1) uses remote sensing data and field surveys to catalogue the wetlands of a region (EcoAtlas 2016).

Rapid Assessment (Level 2) uses field diagnostics and existing data to assess conditions at wetland sites (EcoAtlas 2016).

Intensive Site Assessment (Level 3) provides the field data necessary to validate the CRAM, characterizes reference condition, and tests hypotheses about the causes of wetland conditions as observed through Levels 1 and 2 using quantitative methods such as assessment of plant community composition and soils analysis (EcoAtlas 2016).

This report does not include a thorough description of CRAM; this information may be obtained from the CRAM website (www.cramwetlands.org), including CRAM's development, application, and implementation. In general, we should emphasize that CRAM is an assessment method for wetland conditions; CRAM is not a wetland identification/delineation methodology or a wetland functional assessment methodology.

Methods – English Meadow Slope Wetland CRAM Ambient Monitoring

We used CRAM to evaluate the health of English Meadow's ecosystem as a baseline assessment for restoration. CRAM is an efficient and cost-effective tool to assess the condition of a wetland ecosystem and the stressors that affect it (Stein et al., 2009). This methodology can be performed on scales ranging from an individual wetland to a watershed or a larger region (EcoAtlas 2016). Wetlands can also be evaluated to detect changes over periods of time. This information can then be used in planning wetland monitoring and restoration activities (EcoAtlas 2016).

The CRAM module focuses on characterizing the following attributes for each wetland class: 1) Buffer and Landscape Context, 2) Hydrology, 3) Physical Structure, and 4) Biotic Structure. Each CRAM module assesses these same four attributes, although the metrics used in each module vary to address class-specific relationships within a wetland. In each module, an "Index Score" is calculated as the average of the four attribute scores. Interpreting the results of a CRAM application requires the researcher to consider the effects of each attribute score. (CRAM metrics are subject to change as site conditions change over time, so they can be very sensitive indicators of change, such as those caused by restoration projects.) Indicators that make up the various sub-metrics of each attribute have been found to directly correlate to the overall condition of the ecosystem (Stein et al., 2009). The sub-metrics of each attribute are totaled into a raw score; then, a final score is calculated for each attribute. The final Index Score for the assessment area is calculated from the average of the four final attribute scores (CWMW 2013, Version 6.1). The scores for assessment areas in English Meadow range between 30 and 94 and are comparable to all slope wetlands scores in California.

1.0 Attribute 1: Buffer and Landscape Context

Aquatic Area Abundance

Aquatic Area Abundance is a measure of an assessment area's spatial association with other aquatic resources; it measures the distance of the closest aquatic feature to the study site in the four cardinal compass directions (Slope Wetland Guidebook, CWMW 2013, Version 6.1). This metric would increase if disturbed areas were restored, because areas connected to neighboring water features would be created, restored, and enhanced (see Table 2).

1.1 Percent of Assessment Area with Buffer

The *percent of assessment area with buffer* metric assesses the overall quality and presence of the buffer (CWMW 2013, Version 6.1). All assessment areas are surrounded by cover types that provide 100% buffer. This metric score would not change with implementation of proposed restoration alternatives.

1.2 Average Buffer Width

The *average buffer width* measures the ability of the buffer to serve as habitat for wildlife, to reduce the inputs of non-point source contaminants, to control erosion, and to protect the wetland from human activities (CWMW 2013, Version 6.1). This metric score would not change with implementation of proposed restoration alternatives

1.3 Buffer Condition

The *buffer condition* assesses the extent and quality of plant cover, the overall condition of the substrate (soil disturbance), and the amount of human visitation (CWMW 2013, Version 6.1). Metric scores would increase for EM-3 and EM-4, and EM-5 and EM-6 are likely to increase with proposed future restoration in terms of improved condition of plant cover and soil substrate. If the area was then grazed, both plant cover and soil substrate would likely be impaired.

2.0 Attribute 2: Hydrology

2.1 Water Source

The *water source* affects the extent, duration, and frequency of saturated or ponded conditions within an Assessment Area and assesses whether water inputs to the site are from natural or artificial sources (CWMW 2013, Version 6.1). This metric score is unlikely to change with proposed restoration alternatives.

2.2 Hydroperiod

The *hydroperiod* is the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. Slope wetlands typically have a high degree of variation; this metric assesses the seasonal patterns of the water levels and how closely these levels correspond to natural inundation/drainage cycles (CWMW 2013, Version 6.1). This metric score will increase in disturbed areas with implementation of proposed restoration alternatives (see Table 2).

2.3 Hydrologic Connectivity

The *hydrologic connectivity* assesses water flowing into and out of the wetland and the wetland's ability to accommodate floodwaters (CWMW 2013, Version 6.1). This metric score will increase in disturbed areas with implementation of proposed restoration alternatives (see Table 2).

3.0 Attribute 3: Physical Structure

3.1 Structural Patch Richness

The *structural patch richness* metric is a surrogate for determining potential habitat types for both terrestrial and aquatic species and is evaluated using 17 different patch types (CWMW 2013, Version 6.1). Structural patch richness metric scores are lower in disturbed assessment site, and are likely to increase in disturbed areas with implementation of proposed restoration alternatives (see Table 2).

3.2 Topographic Complexity

This metric 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 of that influence the path of flowing water (CWMW 2013, Version 6.1). It is unknown if micro-topography or topographic complexity would change with restoration; such change would depend on the site conditions and restoration alternative selected for implementation.

4.0 Attribute 4: Biotic Structure

4.1 Number of plant layers

The CRAM methodology for assessing Biotic Structure is composed of the number of plant layers, the number of co-dominant plant species, and percent invasive species (CWMW 2013, Version 6.1). To be counted as a plant canopy layer (floating/canopy forming, short, medium, tall, and very tall), the layer must cover at least 5% of the assessment area and include only those plants within prescribed plant heights. Having more plant layers is important for habitat complexity and preventing encroachment of invasive species. Vegetation metric scores for the metric *Number of Plant Layers* are very high for reference Assessment Areas. This metric score is likely to increase in disturbed areas with implementation of proposed restoration alternatives.

4.2 Number of co-dominant species

Once a layer has been determined, the co-dominant plant species represent at least 10% relative cover of the assessment area (CWMW 2013, Version 6.1). The total numbers of co-dominant species are summed from each plant layer, and are counted only once. The *Number of Co-Dominant Plant Species* metric scores are very high for reference Assessment Areas. This metric score is likely to increase in disturbed areas with proposed restoration alternatives. The vegetation metric scores for Dominant Plant Species are very high for reference Assessment Areas. This metric score is likely to increase in disturbed areas with implementation of proposed restoration alternatives.

4.3 Percent invasion

The percent invasion calculates the percent of invasive plant species from the dominant plant species for all layers of plants in the assessment area (CWMW 2013, Version 6.1). The invasive status for many

California wetland and riparian plant species is based on the Cal-IPC list. The site is in very good shape when it comes to percent invasive species, and we don't anticipate much change with restoration in this metric score.

4.4 Number of Upland Encroachment Groups

This metric considers the presence of specific species groups within the assessment area, which indicate the degree of encroachment of upland vegetation into the wetland. CRAM assumes that encroachment of the wetland indicates succession into a drier regime, and in the case of English Meadow, this is certainly true where drainage ditches have been dug (CWMW 2013, Version 6.1). This metric does not seem very effective for the English Meadow wetlands, as all assessment areas had encroachment by Lodgepole Pine (*Pinus contorta*). It is facultative in the wetland plant indicator status for California, and is equally likely to occur in a wetlands or non-wetlands. Dewatering has created drier conditions in disturbed areas in the meadow, and this has led to greater encroachment by Lodgepole Pine. The drainage ditches are lined with Lodgepole Pines. It is likely that wetter conditions through restoration alternatives would increase metric scores for Number of Upland Encroachment Groups. This metric is not a very sensitive indicator of wetland condition.

4.5 Horizontal Interspersion

Horizontal Interspersion refers to the variety and interspersion of plant "zones," or patches of monocultures or obvious multi-species association that are arrayed along gradients of elevation, moisture, or other environmental factors that seem to affect the plant community organization in a two-dimensional plan view. Interspersion is essentially a measure of the number of distinct plant zones or "communities AND the amount of edge between them (CWMW 2013, Version 6.1). The Horizontal Interspersion maps from each assessment area are included in these documents appendices. The metric for horizontal interspersion is lower in disturbed assessment areas, and is likely to improve with implementation of restoration (see Table 2). However, if restoration alternatives include removing the conifer "Patches," this score might actually decrease.

4.6 Plant Life Forms

The Plant Life Forms metric captures the number of different plant structure types that are present within the assessment area (CWMW 2013, Version 6.1). Each plant life forms provides unique functions for animal habitat as well as influencing hydrologic and physical processes. Metric scores for Plant Life Forms for all assessment areas are high, indicating that even in de-watered conditions, English Meadow supports multiple life forms and thus provides a greater diversity and complexity of biotic structure, which in turn provides the complexity of habitat for birds, mammals, amphibians, and insects.

CRAM Slope Module Assessment Areas

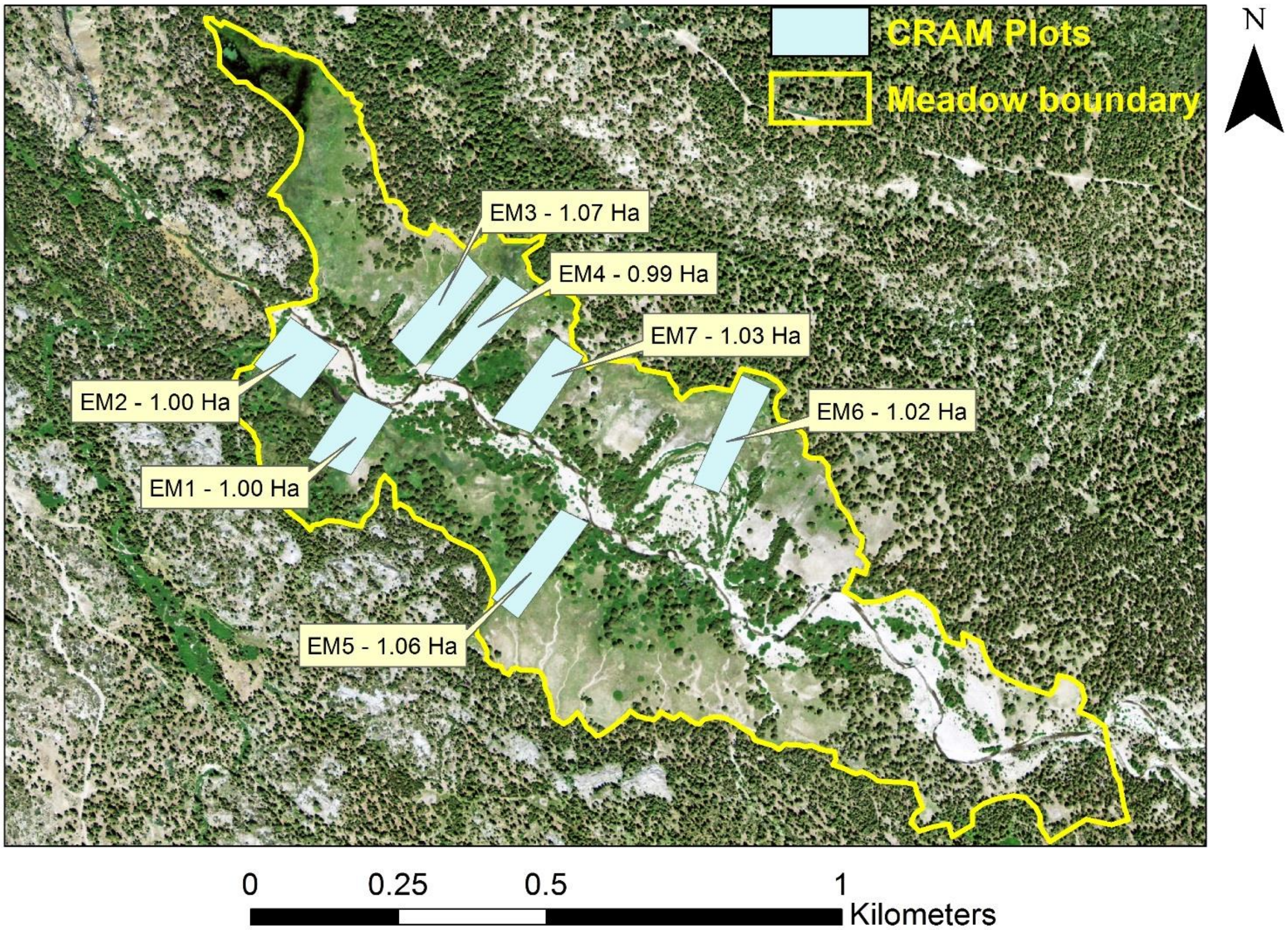
The CRAM field evaluation was conducted using the Slope Module (CWMW 2013, Version 6.1). Dr. Michelle Stevens, lead CRAM practitioner, and Chris Hersey, CRAM Practitioner, conducted the CRAM evaluation. Seven assessment areas, each measuring approximately 1 ha (2.5 acres), were selected for this study in order to accurately represent the whole site. The CRAM was conducted within each of the seven assessment areas between July 20 and 28, 2016.

According to the existing CRAM classification system for wetlands (CRAM Slope Wetlands Field Book 2013, Version 6.1), the slope wetland module is appropriately classified as a wetland meadow if it meets four criteria:

1) The overall hydrology of the meadow that contains the assessment area is dominated by groundwater;
2) Variations in the moisture of root zone of the assessment area are mainly controlled by variations in water-table height;
3) Less than 50% of the area is covered by standing water; and
4) Less than 30% of the assessment area is forested.

To establish the assessment areas, we created a sample frame using a 1 ha random grid placed within the boundaries of English Meadow. Where the boundaries of the wetland overlapped with the squares in the grid, those squares that have more than half of their area within the wetland boundary are included in the sample frame for assessment. The upland edge for wetlands was the lodgepole pine forest ecotone on the upland edge. Assessment area boundaries were delimited using the diversion ditches; consistent with the CRAM methodology, we did not include them. The assessment area shape is a rectangle with edges oriented perpendicular to the overall direction of the meadow flow, extending from at least the upland transition edge to the low point of the meadow. We did not include the Yuba River in the assessment areas, as we considered it to be covered by a different CRAM module, and not integral to the project goals. If future restoration incorporates Yuba River riverine wetlands directly, we recommend sampling those areas using the riverine module. Six assessment area sites were randomly selected, with two of them in the disturbed areas adjacent to drainage ditches. We continued to select assessment areas in a stratified random manner from our sampling frame until our scores differed less than 15% (CWMW 2013, Version 6.1). Upon completion of EM-6 (5379), Index Scores between assessment areas were more than 6 points different, so we randomly selected another assessment area (EM-7) to sample.

CRAM Assessment Plots



CRAM Results and Discussion

CRAM results varied within each of the seven assessment areas and relative to the extent the areas have been disturbed by drainage ditches constructed in the meadows to enhance grazing. EM-1, EM-2, EM-5, and EM-6 are high-quality reference wetlands.

EM-2 Wetlands

The CRAM Scores vary significantly between the undisturbed sites (EM-1, EM-2, and EM-6) and the disturbed sites (EM-3 , EM-4,and EM-5) and to a lesser EM-7. While index scores for many slope wetlands on a Statewide basis have not yet been compiled on eCRAM, scores above 80 are in reference wetland condition (Sarah Pearse, personal communication, October 28, 2016).

EM-3 and EM-4 were affected by adjacent drainage ditch construction, and EM-7 is adjacent to the drained meadow area. These sites have encroachment of Lodgepole Pine, and would benefit from restoration.

EM-4 Drained meadow with encroaching pines

For the Nevada Irrigation District, restoring the disturbed portions of the meadow is likely to improve wetland condition and function, particularly groundwater supply and storage. Wet meadows are highly sensitive to climate-driven changes that impact hydrology. This includes changes in snowmelt, precipitation, and groundwater and particularly changes in the amplitude, duration, and timing of surface and subsurface flows (Loheide et al., 2009). In addition, many sensitive Sierran meadows and fens are in a degraded condition from water diversions, grazing, recreation and fire suppression (Hauptfeld and Kershner, 2014).

The capacity of wet meadows and fens to adapt or maintain resiliency in the face of climate change is greatly compromised by their dependence on groundwater, fragmented distribution, and state of degradation. Meadows and fens are among the rarest and most isolated habitat types in the region, and comprise only approximately 1% of the land base (ibid.). These watershed-level results suggest that the economic benefits from water-yield increases may be an important argument in favor of additional forest restoration investments (Podolak et al., 2015). Restoring the original hydrology of this meadow would enhance wet meadows and fens through a restored water table, more effective groundwater exchange, erosion control, and enhanced general ecology (Neff 2005). Studies indicate that approximately half of the Sierran meadows are degraded. Climate change is shown to reduce snowmelt and groundwater recharge into headwater aquifers, reducing available water supply to downstream users (Armandine 2014; Podolak et al., 2015; Sofaer 2016).

Several organizations are prioritizing restoration of Sierran Meadows, including:

- State Water Action Plan – calls for 10,000 acres of meadow restoration;
- Sierra Nevada Conservancy's Watershed Improvement Program Regional Strategy – supports meadow restoration and meadow health;
- National Fish and Wildlife Foundation, Sierra Meadows Restoration Business Plan, calls for 20,000 acres of meadow restoration;
- United States Forest Service, Region 5, Ecological Restoration Leadership calls for restoration of 50 percent of accessible degraded meadows.

How does CRAM contribute to statewide meadow conservation priorities? For one, incorporation of the CRAM evaluation can help with long-range planning and monitoring for conservation and restoration of mountain meadows in the Sierra Nevada. Mark Drew, of Trout Unlimited, spoke about the Sierran Meadow strategy and prioritization framework (Natural Areas Conference, Davis, CA, October 2016). He pointed out that often the regulatory and permitting process can delay restoration for years longer than the actual planning, designing and implementation of the restoration projects themselves. For example, the Lahontan Water Quality Control Board will require CRAM for all future projects and most of the conference speakers on mountain meadows were unaware of the CRAM, or new slope wetland module for mountain meadows. Organizers of the Sierra Meadows Strategy Group meeting scheduled for February 2017 have asked for more information from myself, Sarah Pearce (lead CRAM trainer at San Francisco Estuarine Institute) and Dave Weixelman (USFS) on the CRAM methodology for mountain meadows at their February 2017 annual meeting. The English Meadows CRAM is a good demonstration project for other meadow and forest restoration projects in the Sierra Nevada.

Conclusion

The English Meadow wetlands are a unique blend of pristine and disturbed reference sites to model future restoration work in the Tahoe Meadows. A long-term study of these meadows, and their changes affected by both restoration and climate change, will be extremely beneficial. Index scores in the range of the 80s and 90s indicate very high quality onsite reference conditions and potential for the drained areas to be restored to an improved wetland condition. EM-1 and EM-2 have Index scores in the 90's, indicating high quality reference condition. Index scores of other assessment areas are also in the mid 80's, which are also considered good indicators of reference condition. Index scores for EM-6 is 85, and EM-7 is 82. The Disturbed sites adjacent to drainage ditches have scores in the low 80's or 70's; these include EM-3 at 75, EM-4 at 80 and EM-5 at 77. This level of index score and attribute difference is considered significant (see Table 1 and 2). The following Metrics - Aquatic Area Abundance, Hydroperiod, Hydrologic Connectivity, Structural Patch Richness and Horizontal Interspersion - will be sensitive indicators of positive change due to restoration activities (see Table 2).

Long-term reference datasets are a critical resource in determining the habitat quality and hydrologic function of English Meadow over time. The English Meadow site has exceptionally high CRAM scores in the undisturbed portions of the wetland, and could serve as a reference template for the conservation, management, and restoration of other Sierra Nevada meadows and headwaters.

Table 1: English Meadow Summary Assessment – CRAM Index Scores

Assessment Area (AA) Disturbance	*Reference*	*Reference Fen*	*Reference Fen*	*Reference*	*Adj Disturbed*	*Disturbed*	*Disturbed*
Attribute	**EM-1**	**EM-2**	**EM-6**	**EM-5**	**EM-7**	**EM-3**	**EM-4**
`9	**5374**	**5375**	**5379**	**5378**	**5380**	**5376**	**5377**
Buffer and Landscape	87.5	75.00	80.79	87.79	100.00	80.79	87.79
Hydrology	100.00	100.00	66.67	83.33	75.00	66.67	66.67
Physical	100.00	100.00	100.00	50.00	62.50	62.50	75.00
Biotic	95.83	95.83	94.44	94.44	88.89	88.89	97.22
Score:	**96**	**93**	**85**	**77**	**82**	**75**	**80**

Table 2: English Meadow Summary Assessment – CRAM Attributes, Metrics and Index Scores

Assessment Area (AA) Disturbance	*Reference*	*Reference Fen*	*Reference Fen*	*Reference*	*Adj Disturbed*	*Disturbed*	*Disturbed*
Attribute	**EM-1**	**EM-2**	**EM-6**	**EM-5**	**EM-7**	**EM-3**	**EM-4**
CRAM AA #	**5374**	**5375**	**5379**	**5378**	**5380**	**5376**	**5377**
Buffer and Landscape	**87.5**	**75.00**	**80.79**	**80.79**	**100.00**	**80.79**	**80.79**
Aquatic Area Abundance	B/9	C/6	B/9	B/9	A/12	B/9	B/9
A. Percent Buffer	A/12	A/12	A/12	A/12	A/12	A/12	A/12
B. Average Buffer Width	A/12	A/12	A/12	A/12	A/12	A/12	A/12
C. Buffer Condition	A/12	A/12	B/9	B/9	A/12	B/9	B/9
Hydrology	**100**	**100.00**	**66.67**	**83.33**	**75.00**	**66.67**	**66.67**
A. Water Source	A/12	A/12	A/12	A/12	A/12	A/12	A/12
B. Hydroperiod	A/12	A/12	C/6	C/6	C/6	C/6	C/6
C. Hydrologic Connectivity	A/12	A/12	C/6	A/12	B/9	C/6	C/6
Physical Structure	**100.00**	**100.00**	**100.00**	**50.00**	**62.50**	**62.50**	**75.00**
Structural Patch Richness	A/12	A/12	A/12	C/6	C/6	C/6	B/9
Topographic Complexity	A/12	A/12	A/12	C/6	B/9	B/9	B/9
Biotic Structure	**95.83**	**95.83**	**94.44**	**94.44**	**88.89**	**88.89**	**97.22**
A. Number of Plant Layers	A/12	A/12	A/12	A/12	A/12	A/12	A/12
B. # Co-Dominant Species	B/9	B/9	A/12	B/9	A/12	A/12	A/12
C. % Invasive Species	A/12	A/12	A/12	A/12	A/12	A/12	A/12
D. # Encroachment Groups	B/9	B/9	C/6	B/9	A/12	B/9	B/9
Horizontal Interspersion	A/12	A/12	A/12	A/12	B/9	B/9	A/12
Plant Life Forms	A/12	A/12	A/12	A.12	A/12	A/12	A/12
INDEX SCORE	**96**	**93**	**85**	**77**	**82**	**75**	**80**

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