California Rapid Assessment Method
Vernal Pool Module Validation

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ABSTRACT. The California Rapid Assessment Method for wetlands (CRAM) is a field-based, cost-effective, and scientifically defensible tool for monitoring wetlands. It is organized to guide the user through the wetland's structure from landscape level to site-specific plant community composition. We validated CRAM for vernal pool wetlands by examining correlations between CRAM data and intensive field measures, including macroinvertebrate and vegetation surveys. We leveraged data collected by project partners throughout California. The study included sites in the Central Valley, San Francisco Bay area, Santa Rosa area, San Diego region, and the Central Coast. The Vernal Pool CRAM Index score was significantly correlated with large branchiopod species richness and the Shannon Evenness Index for vegetation. Individual CRAM Attributes were also correlated with invertebrates and vegetation. The Vernal Pool CRAM module provides a meaningful, repeatable, and accurate assessment of wetland condition across the state of California.

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INTRODUCTION

The California Rapid Assessment Method (CRAM) was developed to support wetland monitoring needs in the state. CRAM provides an overall Index score (ranging from 25 to 100) that indicates the general health of a wetland and its capacity to perform important functions and services. The Index score is an average of four "Attributes" of condition. Each Attribute is composed of two to five metrics and submetrics (Table 1). The assessment of each metric or submetric is based on visual indicators surveyed during a field visit of less than half a day.

CRAM has many modules, each tailored for a specific wetland type, one of which is vernal pools. The unique functions and services provided by vernal pools are assessed using CRAM metrics that are designed for vernal pool ecosystems. For example, one of the metrics scores the richness of vernal pool endemic plant species. Vernal pools have been lost or severely impacted by urban development and agricultural practices over the last century, resulting in many species of endemic flora and fauna becoming listed as endangered (Zedler, 1987). Due to vernal pools' unique ecological functions and their continued degradation, there is a need to chronicle the condition of these systems throughout California as well as document their presence and condition at regional and watershed scales (Jones, 2009).

There are six steps to CRAM module development, as described in Sutula et al. (2006) and outlined on the CRAM website (http://www.cramwetlands.org/about). These steps include:

1) Definition (describe the class of wetlands that the module is built to evaluate),
2) Basic design (develop metrics and attributes that reflect unique condition characteristics of the wetland class),

TABLE 1. CRAM Attributes and metrics, with summaries of each metric.

Attributes	Metrics/Submetrics	Metric Summary
Buffer and Landscape Context	Aquatic Area Abundance	Measures extent of wetlands within 500 m
	Percent with Buffer	Percent of area surrounded by at least 5 m of buffer land cover
	Buffer Width	Average of 8 buffer width measurements up to 250 m
	Buffer Condition	Vegetation quality (native vs. non-native), degree of soil disturbance, and impact of human visitation
Hydrology	Water Source	Anthropogenic influence on water sources (extractions or inputs) within local watershed up to 2 km
	Hydroperiod	Direct anthropogenic inputs or diversions
	Hydrologic Connectivity	Access to adjacent slopes without levees, road grades, or other obstructions
Physical Structure	Structural Patch Richness	Number of habitat structures present from a list of potential patch types for vernal pools
	Topographic Complexity	Complexity of micro- and macro-topographic features
Biotic Structure	Number of Co-dominant Species	Total number of living plant species that comprise at least 10% of any pool sampled
	Percent Non-native Species	The percent of the total number of co-dominant species that are not native according to Baldwin, et al., (2012)
	Endemic Species Richness	The total number of co-dominant species that are vernal pool endemics
	Horizontal Interspersion	The complexity of plant zones (species assemblages or mono-specific stands)

3) Verification (partner with local wetland experts to test the draft method for utility, representativeness and clarity),
4) Validation (affirm that the tool generates a condition score reflective of California wetlands of that class and that correlates as expected with site-specific data),
5) Module production (Complete method updates and post a CRAM Field Guide/Manual and online data upload system), and
6) Ambient survey (Use the validated tool to document distributions of condition scores for California wetlands).

Previous work completed phases one through three of the CRAM development process (CWMW, 2013). Vernal pool experts were convened to draft the vernal pool CRAM module and test the method in the field (i.e., verification). The verification process involved state and federal agency staff, academics, non-profits, and consultants in conceptualizing and field testing the method. The Depressional CRAM module was adapted to the unique characteristics of vernal pools, particularly the presence of unique vernal pool endemic plants and the characteristic clustering of groups of vernal pools. Until this current effort, the vernal pool CRAM module had not been validated, which involves documenting relationships between CRAM results and independent measures of condition in order to establish CRAM's defensibility as a meaningful and repeatable measure of wetland condition (Stein et al., 2009).

Specifically, this project used more intensive invertebrate and plant species data previously collected from the selected study sites to analyze the relationship between CRAM scores (which rely on less intensive species data) and more comprehensive species data to determine if CRAM scores accurately reflect actual site conditions. This study is Step 4, the validation process for the Vernal Pool Systems CRAM module, which establishes its scientific credibility for use in local, state, and federal programs.

METHODS

Vernal pools can be negatively impacted by adjacent land use, and landscape condition has been shown to be an effective predictor of wetland health (Roth et al., 1996; Micacchion and Gara, 2008). Adjacent land cover affects wetland condition through many processes, including impacts of polluted runoff, loss of adjacent habitat area and condition, movement of invasive species, and alteration of hydrologic dynamics. This study selected 29 sites along a gradient of development pressure, including some sites in open space preserves or parks, and others in cities and agricultural areas, to test the ability of the method to evaluate a broad range of vernal pool conditions.

The development team used existing vegetation and invertebrate data that had been collected by regional experts using similar but varied protocols. Using the compiled data, we were able to extract the following standard parameters for vegetation and invertebrate populations: invertebrate species richness; large branchiopod species richness; plant species richness; vernal pool endemic plant species richness; relative percent native plant cover; relative percent non-native plant cover; Shannon Diversity Index for plant species; and Shannon Evenness Index for plant species. Not all parameters were available for all of the sites, but the most detailed data available were used. See Table 2 for a tally of data types available for each site.

Where invertebrate data were available, methods and data varied, ranging from comprehensive counts of all species to presence/absence data for specific large branchiopods. Vernal pools can support special status large branchiopods such as vernal pool fairy shrimp (*Branchinecta lynchi),* and these threatened and endangered species are often the focus of vernal pool surveys. Many of the datasets were provided as a list of large branchiopods present rather than comprehensive macroinvertebrate counts. Some sites were surveyed with comprehensive dipnet sampling, while others were more cursory observations. Where there were complete samples of all invertebrates, the total species richness of all invertebrates was tallied (Table 2).

Plant data collection methods also vary widely. The relevé method is commonly used for plant surveys, and some of the sites were surveyed using the relevé protocol (Sawyer and Keeler-Wolf, 1995). Others were studied with less quantitative methods. Vernal pools support many threatened and endangered plants, such as Contra Costa goldfields (*Lasthenia conjugens).* These rare plants are often targeted in vernal pool monitoring. Many of the sites had intensive, but varying methods of plant surveys that enabled the calculation of several plant parameters. Raw data were not available at all sites. For some sites, percent native cover data were available but not cover values for individual species. Some sites did not have cover data but only species richness information. For this analysis, species-specific cover values were calculated relative to the total plant cover, excluding bare ground and litter. Relative percent cover of native and non-native plants were both calculated where those data were available. Parameters also included total plant species richness, that is a tally of the number of all plant

TABLE 2. Data types compiled for each site.

	Invert Spp Richness	Large Branchiopods	Plant Species Richness	VP Endemic Plant Richness	Native Cover	Non-native Cover	Shannon Index	Shannon Evenness
Carinelli								
Cocklebur		✓	✓	✓	✓	✓		
Dennery West		✓	✓	✓	✓	✓	✓	✓
Ft Hunter Liggett Borrow Pit Pools	✓	✓						
Ft Hunter Liggett Parking Lot Pools	✓	✓						
J26 Otay Mesa			✓	✓	✓	✓	✓	✓
Klotz AA1	✓	✓	✓	✓	✓	✓	✓	✓
Klotz AA2	✓	✓	✓	✓	✓	✓	✓	✓
Klotz AA3	✓	✓	✓	✓	✓	✓	✓	✓
Lazy K East AA	✓	✓	✓	✓	✓	✓	✓	✓
Lazy K West AA	✓	✓	✓	✓	✓	✓	✓	✓
Madera CalTrans Pools 48-55	✓	✓	✓	✓	✓	✓	✓	✓
Madera CalTrans Pools 77-86	✓	✓	✓	✓	✓	✓	✓	✓
Mass 3 Camp Pendleton	✓	✓	✓	✓				
Miramar Created Pools			✓	✓	✓	✓		
Miramar Natural Pools			✓	✓				
Montezuma Created Pools	✓	✓	✓	✓	✓	✓	✓	✓
Montezuma Natural Pools	✓	✓	✓	✓	✓	✓	✓	✓
Rancho Seco Created Pools	✓	✓	✓	✓	✓	✓	✓	✓
Rancho Seco Natural Pools	✓	✓	✓	✓	✓	✓	✓	✓
Roseville Reserve #12	✓	✓	✓	✓				
Roseville Preserve #2	✓	✓	✓	✓				
Roseville Preserve #9	✓	✓	✓	✓				
Stillwater Created Pools	✓	✓	✓	✓	✓	✓	✓	✓
Stillwater Natural Pools	✓	✓	✓	✓	✓	✓	✓	✓
Warm Springs Pasture 2			✓	✓	✓	✓	✓	✓
Warm Springs Pasture 7			✓	✓	✓	✓	✓	✓
Wire Mountain			✓	✓				
Woodbridge Santa Rosa			✓	✓	✓	✓	✓	✓

species present at a site, and the number of vernal pool endemic species found at each site (Table 2).

The Shannon Diversity Index was calculated to characterize the diversity of plant species. It combines the overall number of plant species and the percent cover of each individual species (Spellerberg and Fedor, 2003). Higher values show higher diversity of plant habitats. The Shannon Diversity Index is calculated by defining the cover class midpoint or absolute cover value for each plant species and dividing that value by the total cover to calculate the statistic designated "P_i". The natural log (ln) of P_i was calculated and then multiplied by pi. The sum of the products for all species was calculated, and the absolute value of that summation is the Shannon Diversity Index, designated "H".

$$H = \sum_{i=1}^{s} - (P_i * \ln P_i)$$

Where:
H = the Shannon Diversity Index
P_i = relative percent cover of species i
S = number of plant species
∑ = sum from species 1 to species S

Shannon Evenness Index was calculated by dividing H by the natural log of species richness for the site. Low values of the Shannon Evenness Index indicate that one or a few species dominate the vegetation community, while high values indicate that the cover of vegetation is more evenly divided among multiple species (Morris et al., 2014).

$$E = H / (\ln S)$$

Where:
E = Shannon Evenness Index
H = the Shannon Diversity Index
S = number of plant species

Field sites were selected from across California's vernal pool regions where existing plant and invertebrate data were available. Sites were selected that had a range of ecological and adjacent land use conditions, and represented a broad geographic coverage across the state. Vernal pools are only found in areas with particular climatic and geologic conditions. Areas of California with abundant vernal pools include the Central Valley, the San Francisco Bay Area, inland regions of the Central Coast, Southern California from San Diego north to the Riverside area, and the Modoc plateau. We were able to identify sites throughout all of these areas, with the exception of the Modoc region, for inclusion in our study. A total of 29 vernal pool areas were sampled for the project (Figure 1).

Field assessments were conducted using the CRAM Vernal Pool Systems module (version 6.2) at 29 sites during spring 2016. The Vernal Pool Systems module is designed to assess a group of vernal pools with one assessment. There is also an Individual Vernal Pool CRAM module, but this project did not include individual pools as they are less common, and we had limited resources for field data collection. All assessments followed the quality assurance procedures outlined in the CRAM Quality Assurance (QA) Plan (CWMW, 2016) and the Quality Assurance Project Plan (QAPP) for this project (CCWG, 2014). These QA procedures require that the team conducting the assessments are trained in the method and thoroughly document each site visit.

Each CRAM Attribute was tested for normality using the Shapiro-Wilk test, and transformed, if necessary, to conform to a normal distribution. The Buffer and Landscape Context and Hydrology Attributes data were skewed. Normalization calculations were attempted (square root and log transformations) but did not result in normal distributions, so the non-transformed data were analyzed. The plant and invertebrate data were also tested for normality. The invertebrate species richness parameter was skewed and was successfully log transformed. The CRAM Index score and all four Attribute scores were tested for correlation with all plant and invertebrate metrics. The Pearson correlation test was used for the CRAM Index score

FIGURE 1. Map of vernal pool validation sites (N = 29).

and the Physical and Biotic Structure Attributes, and the Kendall's tau b test was used to test the Buffer and Landscape Context and Hydrology Attributes for correlation with all plant and invertebrate metrics. Kendall's tau b correlation is a non-parametric statistical test for correlation of ranked data that produces more accurate p-values with smaller sample sizes than Spearman's ranked correlation. Correlation coefficients higher than 0.7 are considered high values, and coefficients between 0.5 and 0.7 indicate a moderately strong correlation (Mukaka, 2012).

RESULTS

The CRAM tool generates a minimum value of 25 and a maximum value of 100. The CRAM Index scores collected for this project ranged from 55 to 92, with a median score of 75 (Figure 2). We determined that the resulting CRAM Index scores for the 29 validation sites were not biased towards high or low values (skewness = -0.02). A broad range of scores were measured for each CRAM Attribute (Buffer and Landscape Context 45-93, Physical Structure 33-100, and Biotic Structure 25-96), except the Hydrology Attribute (67-100) (Figure 3).

The overall CRAM Index score and each Attribute score were tested for significant correlations with invertebrate and plant data. Tables 3 and 4 list the results of all analyses. The CRAM Index score was significantly correlated with large branchiopod species richness (Figure 4) and the Shannon Evenness Index for plants (Figure 5). Physical and Biotic Structure were both significantly correlated with large branchiopod species richness and the Shannon Diversity Index for plant species, while Biotic Structure was also correlated with Shannon Evenness Index for plants. Buffer and Landscape Context was correlated with large branchiopod species richness. The Hydrology Attribute was negatively correlated with plant species richness (counter to expected results), likely the result of site selection challenges which limited the distribution of Hydrology Attribute scores and compromised statistical correlation analysis with data sets.

The individual CRAM Attributes were also correlated with several of the vegetation and invertebrate indicators, including large branchiopod species richness (Figure 6), plant species richness, and the Shannon Diversity Index for plants).

DISCUSSION

The goal of this project was to validate the CRAM module for vernal pool wetlands in California. To ensure that the CRAM method meets established CRAM development guidelines (Stein et al., 2009), the CRAM Validation team set out to confirm that a CRAM module for vernal pool systems could generate scores which appropriately represent a full range of wetland conditions found within the state. The tool should also be repeatable and correlate

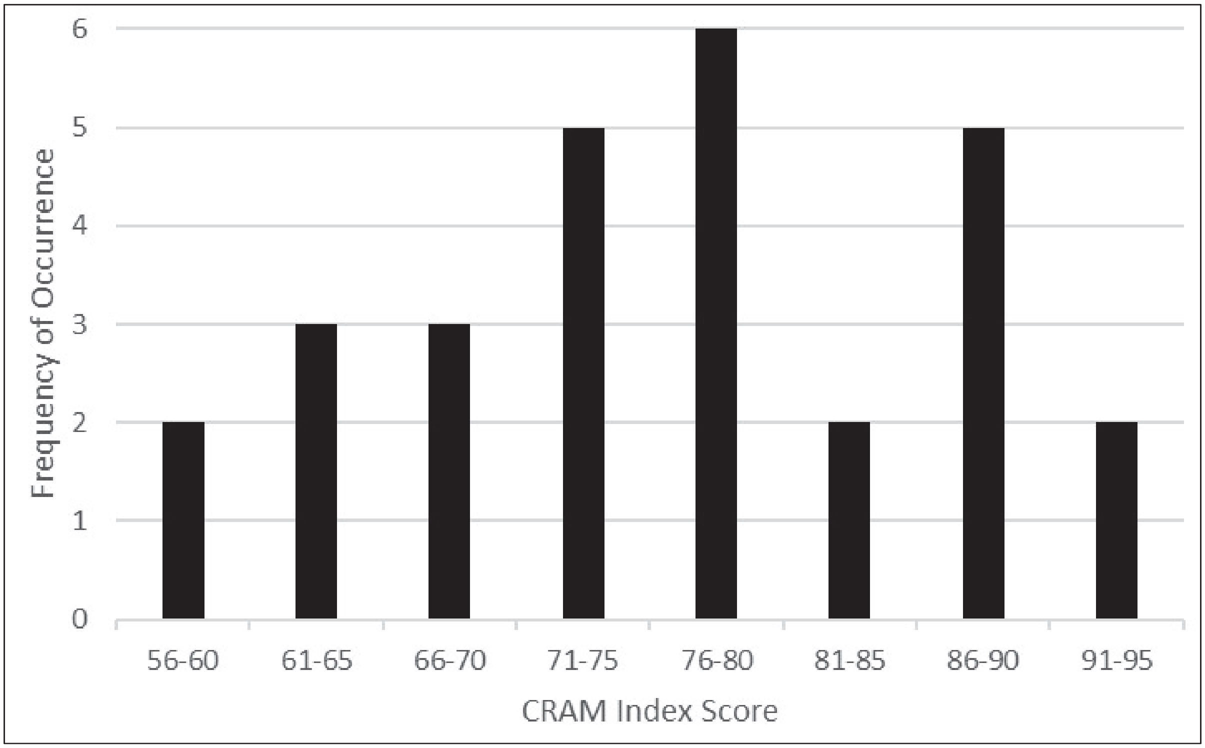

FIGURE 2. Histogram of CRAM Index scores (n = 29).

with other trophic or function-specific indicators of condition.

The site selection process ensured that sampled wetlands represented a broad range of climatic and ecological conditions found in California. Because vernal pools are clustered geographically in certain parts of the state, the selected sites were concentrated in those areas. Selected sites spanned a range of latitude from San Diego (32.5 degrees North) to the northern Sacramento valley (40.5 degrees North). Selected vernal pools ranged east to west in longitude from -116.9 degrees in San Diego to -122.8 degrees in Santa Rosa (Figure 1). Selected sites exhibited a range of condition and adjacent landscape disturbance, with some sites located in open space preserves and other sites within urban areas and higher intensity rural land uses (off-road vehicle use, etc.). By partnering with wetland scientists throughout the state with extensive experience in California vernal pools, we have developed a tool that can be used successfully by California wetland practitioners.

An effective rapid assessment method must be responsive to a range of conditions and be sensitive to human disturbance (Sutula et al., 2006; Stein et al., 2009). The CRAM Index score is a composite of the four Attribute scores and is intended to represent the overall ecological condition of the wetland. The broad range of Index scores calculated from a population of vernal pools reflected the site selection process which actively sought a range of condition, documenting the responsiveness of the Vernal Pool CRAM module.

Both the Buffer and Landscape Context and Hydrology Attributes scores were skewed towards higher scores for this CRAM module. Due to the constraints for site selection within this validation exercise (limited to sites with available data), we were unable to select sites with a complete range of Hydrology scores. Both the Buffer and Landscape Context and Hydrology Attributes tend to be skewed towards higher scores for most CRAM modules, because they are only reduced in score when

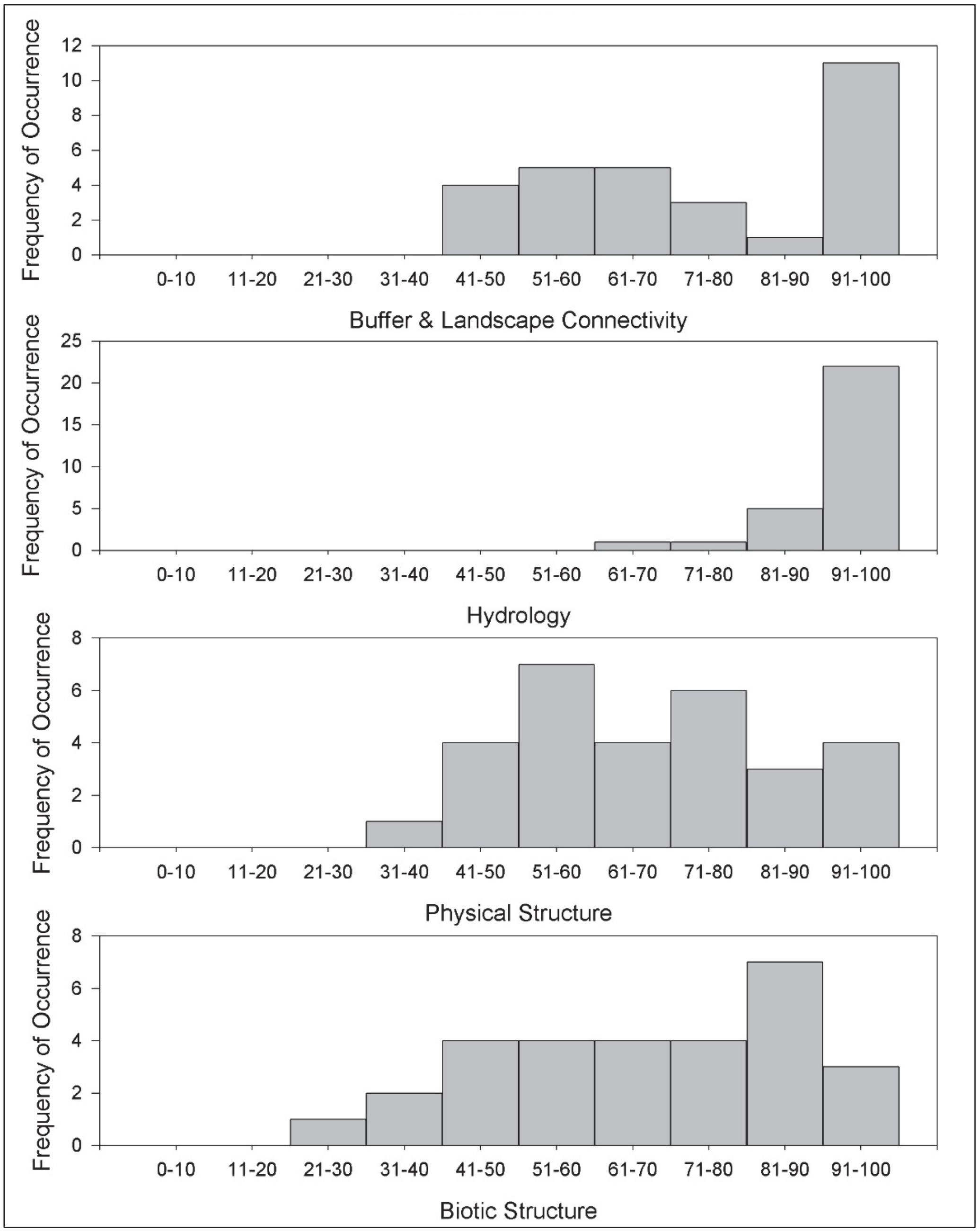

FIGURE 3. Distribution of data for each CRAM Attribute.

there is a direct impact in the immediately adjacent area. Hydrology Attribute scores may also be skewed positively due to development that converted one wetland class to another, for example where urban runoff extended the hydroperiod of a vernal pool and converted it to a depressional wetland. Many California vernal pools with severely altered hydrology are no longer classified as vernal pools and therefore are removed from the sample population. In other cases, landscape alterations such as deep tilling or water diversion have altered vernal pool landscapes so that they are no longer wetlands at all. Under these conditions the low end of the population drops out of the distribution, resulting in skewness towards higher scores. Through conversations among team experts, we determined that each Attribute (including

TABLE 3. Pearson correlations (bold values indicate significant correlation with α ≤ 0.05).

	Invert Species Richness	**Large Branchio-pods**	**Plant Species Richness**	**VP Endemic Plant Richness**	**Native Cover**	**Non-native Cover**	**Shannon Diversity Index**	**Shan-non Even-ness Index**
CRAM Index	0.34	**0.77**	0.16	0.23	0.34	-0.24	0.33	**0.52**
p-value	0.16	**<0.0001**	0.44	0.27	0.14	0.30	0.18	**0.03**
n	19	21	26	26	20	20	18	18
Physical Attribute	0.22	**0.57**	0.11	0.09	0.08	-0.14	**0.55**	0.30
p-value	0.36	**0.01**	0.60	0.64	0.73	0.55	**0.02**	0.22
n	19	21	26	26	20	20	18	18
Biotic Attribute	0.33	**0.52**	0.26	0.30	0.41	-0.24	**0.55**	**0.68**
p-value	0.16	**0.02**	0.20	0.13	*0.07*	0.31	**0.02**	**0.001**
n	19	21	26	26	20	20	18	18

TABLE 4. Kendall's Tau b correlations (bold values indicate significant correlation with α ≤ 0.05).

	log trans-formed Invert Species Rich-ness	**Large Branchio-pods**	**Plant Species Richness**	**VP En-demic Species Rich-ness**	**Native % Cover**	**Non-native % Cover**	**Shannon Diversity Index**	**Shan-non Even-ness Index**
Buffer and Landscape Attribute	0.28	**0.64**	0.14	0.20	0.10	-0.05	-0.26	0.02
p-value	0.13	**0.0003**	0.36	0.19	0.55	0.75	0.17	0.90
n	19	21	26	26	20	20	18	18
Hydrology Attribute	-0.11	0.02	**-0.33**	-0.19	0.06	-0.03	-0.21	-0.12
p-value	0.57	0.92	**0.04**	0.22	0.75	0.86	0.27	0.54
n	19	21	26	26	20	20	18	18

the Hydrology Attribute) is responsive to varying conditions and that scores represent the range of condition for these wetlands. Vernal pools that score very low for the Hydrology Attribute do exist; they just were not included in this study due to the restrictions on site selection.

The negative correlation between the Hydrology Attribute and the plant species richness indicator is likely an artifact of the skewed nature of the hydrology condition of selected sites. Of the 26 sites analyzed for correlation between Hydrology and plant species richness, over half of the sites received scores of 100 for Hydrology and only two sites had scores less than 80.

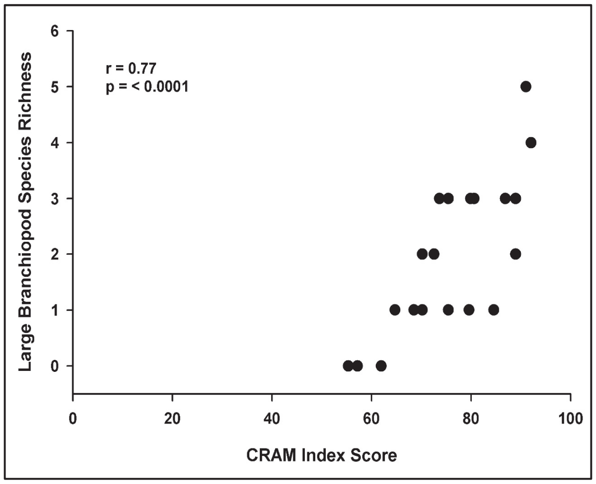

FIGURE 4. Correlation plot of CRAM Index Score vs. Large Branchiopod Species Richness.

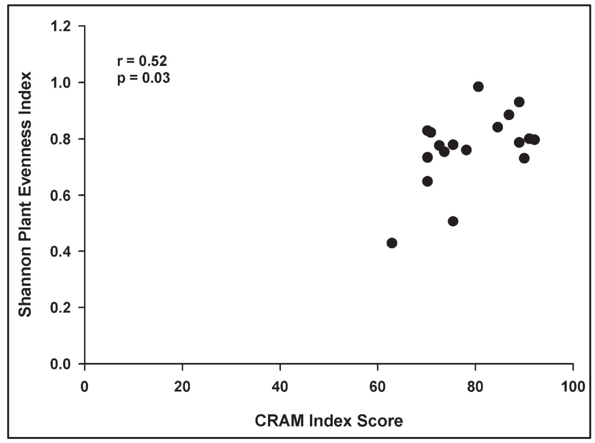

FIGURE 5. Correlation plot of CRAM Index Score vs. Shannon Plant Evenness.

Two sites with the highest plant species diversity had moderate Hydrology scores of 83, which likely drove unrepresentative negative correlations.

Higher diversity of plants and animals is associated with better-condition wetlands (Lopez and Fennessy, 2002). Large branchiopod diversity was strongly positively correlated with the CRAM Index score and three of the CRAM Attributes (Tables 3 and 4). This was an expected relationship, because CRAM was specifically designed to respond to environmental factors that promote or inhibit populations of these invertebrates, many of which are special-status. These correlations support the intent of CRAM validation to generate an assessment tool that is responsive to variation in ecological functions and trophic level communities.

The Shannon Diversity and Evenness Indices were also positively correlated with the CRAM Index score and two of the CRAM Attributes, Physical and Biotic Structure. The Shannon Diversity Index is a mathematical measure of species diversity that takes into account the relative abundance of the species found. The Shannon Evenness Index indicates whether plant cover is dominated by one or few species, or more evenly distributed among species. The correlation with Biotic Structure is expected as this Attribute relies on species richness. The Physical Structure Attribute likely correlated with the intensive plant parameters because this Attribute detects diversity of habitats within the pools, which leads to greater plant diversity. CRAM is sensitive to impacts on plant communities and assigns higher scores to sites that have intact plant habitats.

CRAM validation aims to document predicted correlations with multiple parameters that represent a range of ecological functions and services. CRAM is meant to measure multiple potential wetland functions rather than a single function. This study verified that CRAM scores correlate positively, as predicted, with indicators of plant and invertebrate diversity.

The CRAM Vernal Pool Systems Field Book Version 6.2 is considered validated and meets the goals for the validation process. Our analysis shows that there is a significant correlation between CRAM Index and Attribute scores and intensive measures of condition and function. Therefore, we conclude that the Vernal Pool CRAM module provides a meaningful, repeatable, and accurate assessment of vernal pool system condition across the state of California. All CRAM materials can be found on the CRAM website: www.cramwetlands.org.

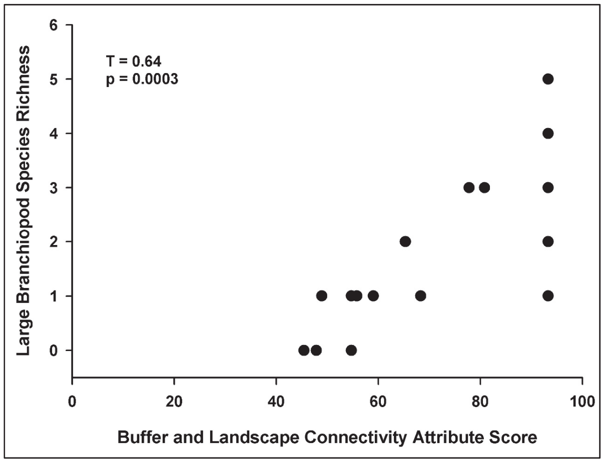

FIGURE 6. Correlation plot of CRAM Buffer and Landscape Score vs. Large Branchiopod Species Richness.

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LITERATURE CITED

BALDWIN, B.G., D.H. GOLDMAN, D.J. KEIL, R. PATTERSON, T.J. ROSATTI, and D.H. WILKEN. 2012. The Jepson Manual: Vascular Plants of California. University of California Press, Berkeley, CA

CENTRAL COAST WETLANDS GROUP (CCWG). 2014. Quality Assurance Project Plan for Support for L2 Committee Priority Tool Development: Validation of Three CRAM Modules Task 4: Validation of the Vernal Pool Wetland CRAM Module. Funding Number: CD-99T05801-0

CALIFORNIA WETLANDS MONITORING WORKGROUP (CWMW). 2016. Data Quality Assurance Plan: California Rapid Assessment for Wetlands. Sacramento, CA. http://www.cramwetlands.org/sites/default/files/CRAM%20data%20QA%20plan%20v7-2016.9.19.pdf [accessed 11/30/2017]

CALIFORNIA WETLANDS MONITORING WORKGROUP (CWMW). 2013. California Rapid Assessment Method for Wetlands. Version 6.1, https://www.cramwetlands.org/sites/default/files/2013-04-22_CRAM_manual_6.1%20all.pdf [accessed 10/14/2017]

CALIFORNIA WETLANDS MONITORING WORKGROUP (CWMW). 2016. Data Quality Assurance Plan: California Rapid Assessment for Wetlands. Sacramento, CA. http://www.cramwetlands.org/sites/default/files/CRAM%20data%20QA%20plan%20v7-2016.9.19.pdf [accessed 11/30/2017]

JONES, P. 2009. A conceptual approach to vernal pool monitoring under Clean Water Act Section 404 permits. Presentation at the Vernal Pool Forum, January 29, 2009. Sacramento, CA. http://www.vernalpools.org/vpforum/jones.pdf [accessed 12/20/17]

LOPEZ, R.D., and M.S. FENNESSY. 2002. Testing the floristic quality assessment index as an indicator of wetland condition. Ecological Applications 12:487-497.

MICACCHION, M., and B. GARA. 2008. An Ecological and Functional Assessment of Urban Wetlands in Central Ohio. Volume 3: Comparisons of the Amphibian Communities of Urban and Reference Wetlands using Level 1, 2, and 3 Assessment Tools. Ohio EPA Technical Report WET/2008-1. Ohio Environmental Protection Agency, Wetland Ecology Group, Division of Surface Water, Columbus, OH.

MORRIS, E.K., T. CARUSO, F. BUSCOT, M. FISCHER, C. HANCOCK, T. MEIER, T. MINERS, C. MULLER, E. OBERMAIER, D. PRATI, S. SOCHER, I. SONNEMAN, N. WASCHKE, T. WUBET, S. WURST, and M. RILLIG. 2014. Choosing and using diversity indices: insights for ecological applications from the German Biodiversity Exploratories. Ecology and Evolution 4:3514-3524.

MUKAKA, M.M. 2012. A guide to appropriate use of Correlation coefficient in medical research. Malawi Medical Journal 24:69-71.

ROTH, N.E., J.D. ALLAN, and D.L. ERICKSON. 1996. Landscape influences on stream biotic integrity assessed at multiple spatial scales. Landscape Ecology 11:141-156.

SAWYER, J.O., and T. KEELER-WOLF. 1995. A Manual of California Vegetation. California Native Plant Society. Sacramento, CA.

SPELLERBERG, I.F., and P.J. FEDOR. 2003. A tribute to Claude Shannon (1916-2001) and a plea for more rigorous use of species richness, species diversity, and the "Shannon-Wiener" Index. Global Ecology and Biogeography 12:177-179.

SUTULA, M.A., E.D. STEIN, J.N. COLLINS, A.E. FETSCHER, and R. CLARK. 2006. A practical guide for the development of a wetland assessment method: The California experience. Journal of the American Water Resources Association 42:157-175.

STEIN E.D., A.E. FETSCHER, R.P. CLARK, A. WISKIND, J.L. GRENIER, M. SUTULA, J.N. COLLINS, and C. GROSSO. 2009. Validation of a wetland rapid assessment method: Use of EPA's level 1-2-3 framework for method testing and refinement. Wetlands 29:648-665.

ZEDLER, P.H. 1987. The ecology of southern California vernal pools: A community profile. U. S. Fish and Wildlife Service Biological Report 85 (7.11).