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SWS Research Brief

Diagnosing Wetland Health with Rapid Assessment Methods

Background

Metrics, indices, and report cards are commonly used in academia, economics, medicine, and other disciplines to synthesize complex diagnostic measurements into measures of overall health that are intuitively understandable and easy to communicate. Common indices of this kind include grade point averages, the Dow Jones Industrial average, and the Apgar score given to infants at birth to assess their overall vitality. Similar diagnostic indices can be applied to wetlands. Increased requirements for project specific monitoring and a growing need to evaluate the performance of wetland protection programs are compelling state and federal agencies to develop relatively rapid, cost-effective indices of wetland health. These indices are generically called RAMs (Rapid Assessment Methods). The intent of all RAMs is to evaluate the complex ecological condition of wetlands using a finite set of observable field indicators, such as plant community composition and structure, hydrology, physical structure, and buffers. RAMs are intended to provide a more structured approach to wetland assessment than qualitative evaluation based on best professional judgment.

Although attractive in their simplicity, there is justifiable concern about the ability of RAMs to accurately convey overall wetland health. RAMs are simple and intuitive, but training and calibration between users is necessary to achieve the precision required to inform management decisions. Skepticism over the meaning of RAM results has limited their use in ambient monitoring and regulatory programs. As a result, despite the stated preference of many wetland programs to consider overall function or condition in decision making processes, few do so in a rigorous manner.

One way to begin addressing concern over the meaning of RAM output is to establish its scientific defensibility by validating it against independent measures of wetland condition.

CRAM can be used to assess a diverse range of wetlands, including: (clockwise from top left) coastal lagoon, vernal pool, and riverine ecosystems: stream channel and adjacent wetlands.

Study Goal

The main study goal was to demonstrate a validation process that increases reliability and confidence in RAMs. We presented results from validation of the California Rapid Assessment Method (CRAM) for riverine and estuarine wetlands. We documented relationships between CRAM results and multiple independent, quantitative measures of condition. A secondary study goal was to demonstrate the benefits of validating RAMs using pre-existing data.

The preferred approach for validation is to simultaneously measure condition while conducting a RAM. However, cost and logistical constraints often make this difficult. As an alternative, we validated CRAM by applying it to sites where condition had been previously quantified using independent assessment methods that met strict qualification criteria.

CRAM Overview

CRAM assesses wetland condition with respect to four overarching "attributes": Buffer/Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Within each of these attributes are a number of "metrics" that address more specific aspects of wetland condition (Table 1). Metrics are customized by wetland class.

Table 1. CRAM attributes and metrics.

Attributes	Metrics
Buffer/Landscape Context	Landscape Connectivity
	Percent of AA with Buffer
	Average Width of Buffer
	Buffer Condition
Hydrology	Water Source
	Hydroperiod
	Hydrologic Connectivity
Physical Structure	Physical Patch Richness
	Topographic Complexity
Biotic Structure	Vertical Biotic Structure
	Interspersion and Zonation
	Number of Plant Layers
	Number of Co-dominants
	Percent Invasion
	Native Plant Species Richness

Level 1-2-3 Approach to Comprehensive Wetland Assessment

Aquatic resource management depends on a comprehensive understanding of watershed condition. Unfortunately, most monitoring and assessment is based on a single objective (such as regulatory compliance) or a single indicator (such as macroinvertebrates). To remedy this, the USEPA has proposed a three-level framework for wetland monitoring. The three levels address different types of management questions that emerge at different spatial scales; together they form an integrated, comprehensive assessment framework.

Level 3 measures, such as animal use can be used to validate rapid assessments.

Level 1: Resource Inventories and Maps that address questions about the general extent and distribution of wetlands and related resources.

Level 2: Rapid Wetland Assessments (RAMs) that address questions about the general condition or overall health of wetlands using relatively simple indicators. Level 2 assessments are usually based on field observations with relatively coarse resolution.

Level 3: Intensive, Quantitative Assessments that address questions about functions, specific aspects of condition, and cause-and-effect relationships.

Level 1 tools often consist of GIS applications to track projects, habitats, and permits. Level 1 maps can be designed as sample frames to guide surveys of condition or function using Level 2 and Level 3 tools. Level 2 tools (RAMs) can be applied to survey wetland health at specific sites, across watersheds, and on a regional basis. Level 3 tools include Indices of Biological Integrity (IBIs), intensive measures of plant and animal community structure, and protocols for quantifying processes and functions.

For example, hydrologic connectivity is evaluated in riverine and estuarine CRAM, but the specific field indicators are designed based on features expected to occur in each wetland class. Each of the metrics is assigned a numeric score based on either narrative or schematic descriptions of condition. Metrics are scaled to capture characteristics across a range of conditions such that the highest score for each metric represents the theoretical optimum condition obtainable for the wetland feature being evaluated. In this context, "optimum" means very likely to support the functions associated with the metric (Fig. 1).

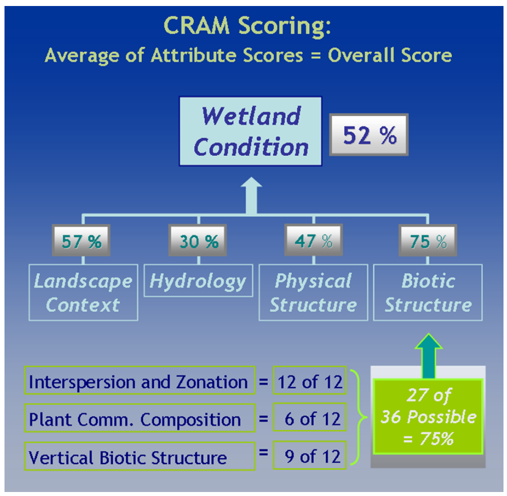


Figure 1. CRAM Scoring. Plant Community Composition represents Number of Plant Layers + Number of Co-dominants + Percent Invasion.

Methods

CRAM was validated by comparing scores to independent Level 3 field measurements of biotic community structure (see sidebar). Large scale measures of wetland functions, such as productivity or the maintenance of biological integrity, are very rare. However, measures of the instantaneous status of functions, such as biomass or species diversity were available. Because these data integrate over time and through space in ways analogous to the CRAM attributes, the evaluation of CRAM took place largely at the attribute level.

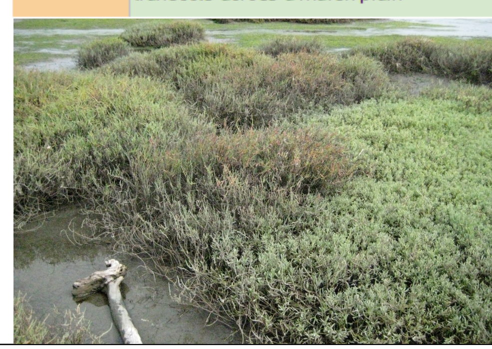
There are no "gold standard" measures of overall wetland function. There are many accepted methods to quantify individual wetland functions, such as avian community support, nutrient cycling, and flood stage desynchronization.

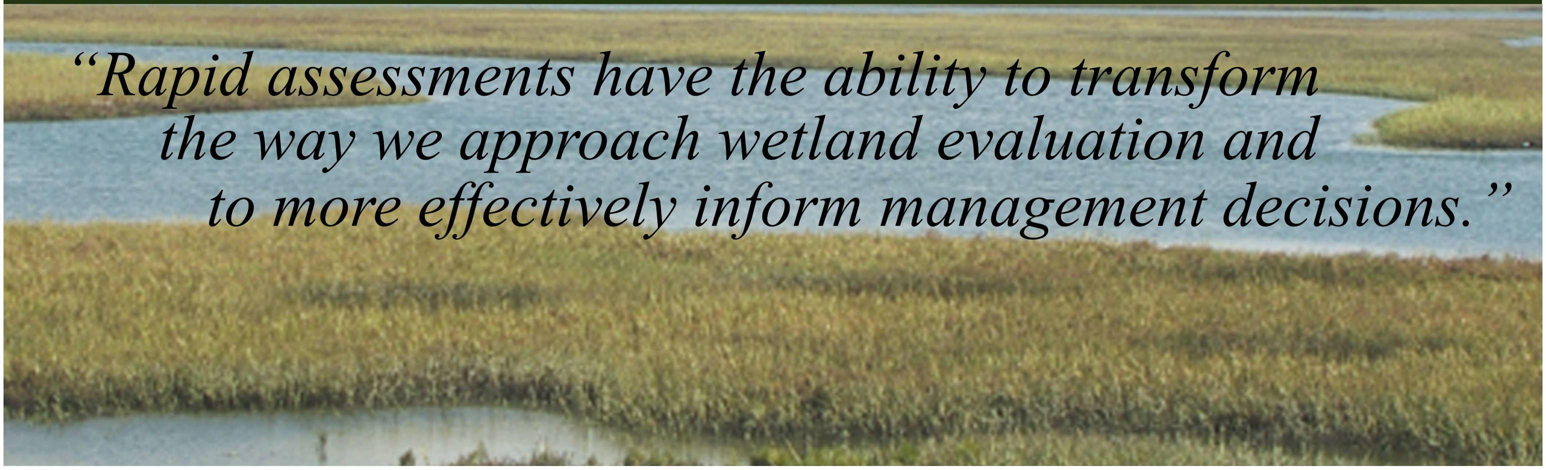
However, other than RAMs, there are no practical methods that assess overall health by integrating across functions or attributes of condition. Therefore, we used a "weight-of-evidence" approach in which CRAM scores were compared to multiple independent measures of wetland function or condition.

Three suitable data sources were identified for use in CRAM validation: Monitoring Avian Productivity and Survivorship (MAPS) program, which provided avian community support data; California wadeable stream bioassessment program, which provided stream benthos and IBI (BMI IBI) data; and the USEPA Environmental Monitoring and Assessment Program (EMAP) West Coast Pilot, which provided plant community composition data (Table 2).

Table 2: Data sets used for CRAM validation.

Level-3 Metric	Description
BMI IBI	Benthic Macroinvertebrate Index of Biotic Integrity for riverine wetlands
MAPS 1	Species richness all birds
MAPS 2	Species richness riparian-associated species
MAPS 3	Species richness nonriparian-associated species
MAPS 4	Reproductive index (ratio young:adults) all species
MAPS 5	Reproductive index (ratio young:adults) riparian-associated species
MAPS 6	Reproductive index (ratio young:adults) nonriparian-associated species
EMAP 1	Relative percent cover non-native plants across a marsh plain
EMAP 2	Relative percent cover invasive plants across a marsh plain
EMAP 3	Total number native plant species along transects across a marsh plain
EMAP 4	Relative percent cover non-native plants along the backshore border of an assessment area
EMAP 5	Total number all plant species along transects across a marsh plain





The validation process included the following performance factors:

- Responsiveness: a measure of CRAM's ability to discern good vs. poor condition (such as between sites with complex community structure and sites with simple structure)
- Range and Representativeness: the ability of CRAM to appropriately capture the distribution of conditions
- Integration: the effect of different combinations of CRAM's component condition metrics to generate an overall score
- Reproducibility: the ability of independent CRAM users to produce comparable results and the proportion of the total variance of scores attributable to user error

The Level 3 data used to validate CRAM were selected based on strict criteria designed to avoid regional biases and minimize variability due to differences in methodology, data collectors, and time interval between data collection and used for validation.

Criteria for suitable validation data sets are presented in Table 3. As part of the validation process, metrics and algorithms for combining metric scores were modified to improve correlations between the independent Level 3 measures of community structure and CRAM attribute scores.

Findings

CRAM attributes generally corresponded well to multiple, independent Level 3 measures of landscape-level and site-specific physical and biological condition. These results indicate that CRAM is an effective tool for assessing general wetland condition.

To improve this correspondence, CRAM was carefully modified. The biggest improvement was achieved by providing users with more method guidance and by clarifying some narrative metrics. To a lesser degree, performance was improved by rescaling metrics, eliminating or combining metrics, and creating new submetrics.

Our analysis demonstrates how existing data can be used to validate RAMs using a weight-of-evidence approach. Specific aspects of the validation results are summarized below. Results can be used to infer performance of CRAM; however, such investigations can never control for natural variability, seasonal and regional differences, and the inherent complexity of wetlands. Therefore, the correlations between Level 2 and 3 data will always include a relatively high amount of scatter.

Table 3. Criteria for suitable validation data sets.

Offer statewide coverage to allow validation using the same data sources across diverse study area
Represent a range of conditions across a gradient of disturbance
Address survey site locations that are accessible to assessment crews
Be reflective of defined element(s) of wetland function that can be related to specific attributes of the rapid assessment method
Be readily available and include metadata describing the original purpose and objectives of the data set, sampling methods, location, procedures for data collection, and analyses
Provide access to original data providers for consultation about issues such as missing data, meaning of outliers, and any limitations of the data set
Be scientifically credible and clear of any controversy regarding validity, integrity, ownership, and distribution restrictions based on legal or proprietary concerns
Conform to standard consistent data collection, analysis methods, and quality assurance procedures
Be recently constructed so that data sets relect existing field conditions; sites where major impacts are known to have occurred during the intervening time period should be excluded

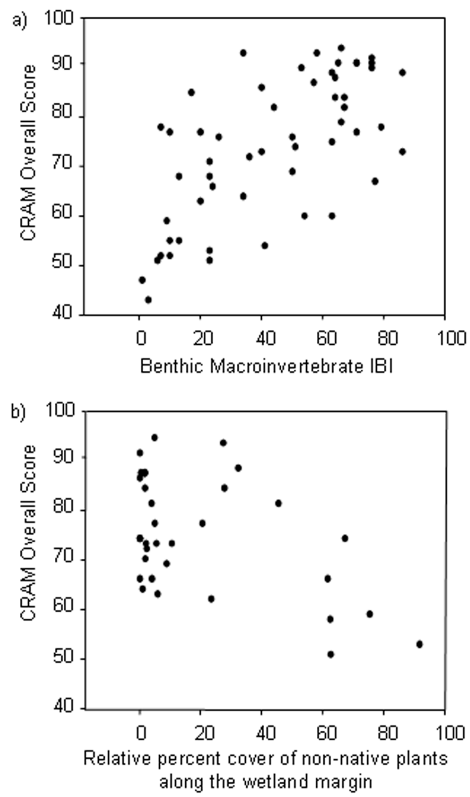


Figure 2: Relationship between CRAM overall scores and the BMI Index of Biotic Integrity for riverine wetlands (a) and relative percent cover of non-native plants along the estuarine wetland margin (b).

"Rapid assessment methods should not be viewed as endpoints, but as valuable tools that enhance implementation of monitoring and assessment programs."

- Responsiveness. There were many correlations between CRAM scores and the independent measures of biological community structure at both the attribute and metric level (Fig. 2). For example, there were consistent, significant negative correlations between measures of landscape stress and CRAM, and there were consistent positive correlations between CRAM and plant and animal native biodiversity.
- Range and Representativeness. The distributions of most CRAM attribute scores were consistent with the distributions of the validation data, suggesting that CRAM scores represent the actual range of condition at the validation sites. The distributions of attribute scores for Buffer and Landscape Context was originally positively skewed toward high scores. Adjustments to the scaling of these attributes based on the validation data remedied this problem (Fig. 3).
- Integration. There were no significant differences between the validation results based on a neutral method for combining metric scores (simple addition) and more complex algorithms based on CRAM's underlying conceptual models. The neutral method was therefore selected to make the scores easier to calculate and to interpret across a broad range of practitioners.
- Reproducibility. An essential part of the validation effort was the quantification of precision among validation teams. Overall CRAM scores for different teams at common test sites initially differed by as much as 23%. Training, clarifying field manuals and other support materials reduced inter-team variability to 10% for the overall index score and 5% for attribute scores. Quantification of precision can help decision makers determine when differences in CRAM scores likely represent significant differences in condition vs. variability of the assessment method.

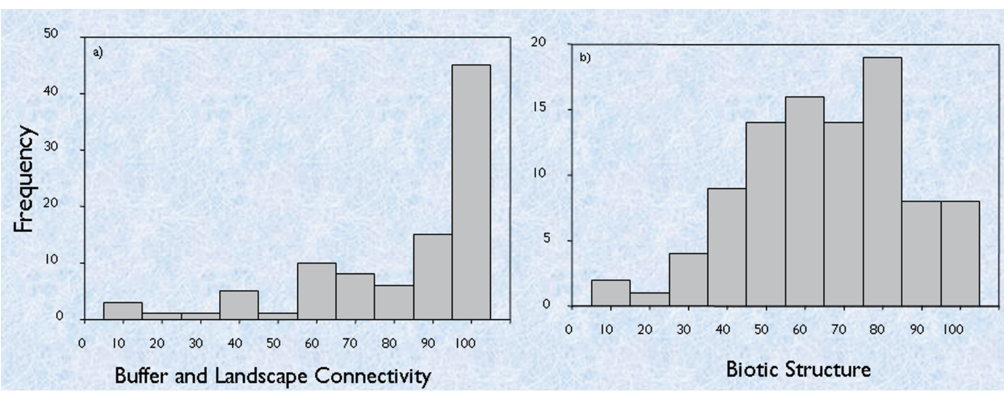


Figure 3: Distribution of CRAM scores for some attributes was initially skewed (a) prior to modification, while other attributes showed a relatively normal distribution (b).

- Redundancy. Correlation among metrics within an attribute was generally high, particularly for the Buffer and Landscape Context and Physical and Biotic Structure attributes. Although not unexpected, such correlations can result in implicit weighting of certain aspects of wetland condition by "double counting" them via several metrics. Ordination results indicate that the level of redundancy inherent in CRAM does not reduce the method's ability to detect gradients in wetland health or to correctly classify wetland areas along the gradients.

Significance

Validated RAMs fill a valuable niche in monitoring and assessment programs when used in combination with landscape scale and intensive assessments. Because they correlate well with more quantitative measures of condition, RAMs can be used as an initial diagnostic tool to guide more intensive assessment. They are valuable because they provide accessible, timely, and cost effective information that can be routinely and rapidly applied in a consistent manner across a range of wetland types.

RAMs can be used for ambient assessment of wetland health, assessment of projects in the context of ambient surveys, screening level evaluations, and assessment of program performance. RAMs are not intended to provide detailed information on wetland functions, health of particular species or communities, nor are they intended to be the only source of information about the success of mitigation or restoration projects. RAMs should not be viewed as the "silver bullet" of wetland assessment, rather as an important tool that scientists and managers can use to assess the overall condition or health of wetlands.

Confidence in the meaning of RAM results can be greatly increased through rigorous validation using independent measures of condition or function, in much the same way that rapid medical diagnostics, such as measures of blood pressure, have been validated with selected measures of human health, such as the risk of heart attacks. The power of RAMs is their ability to communicate general health in a broadly accessible manner. As RAMs are more broadly used, the results will hopefully encourage additional validation and method refinement. If broad use of RAM indices results in more direct consideration of wetland condition (or function) in the decision making process, then the science of wetland assessment will have taken a successful step forward.

Level 3 intensive field measures used for CRAM validation.

Additional Information

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CRAM Assessment of a vernal pool in Santa Barbara, CA

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