An Evaluation of Wetland Restoration Projects in Southern California using the California Rapid Assessment Method (CRAM)

A Final Report to
the Southern California Wetlands Recovery Project

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EXECUTIVE SUMMARY

Determining the "success" of wetland restoration is one of the most important, yet most difficult, management decisions that are made. Challenges include deciding on appropriate assessment endpoints, consistent use of assessment tools, and providing context against which to judge to performance of individual projects. This study used the California Rapid Assessment Method (CRAM) for Wetlands to assess the condition of 25 wetland restoration projects in southern California. CRAM provides a standardized, semi-quantitative framework that resource managers can use to prioritize management activities for wetland restoration projects. The goal of this study was to demonstrate how rapid assessment can be an effective tool to inform decisions regarding restoration success and how ambient, probability-based surveys that employ rapid assessments can provide context for site-specific monitoring.

A fundamental finding of this study is that CRAM can be effectively used to evaluate restoration success and be a useful tool to guide decisions related to wetland project selection and siting. CRAM scores for restoration sites varied along a gradient related to onsite and adjacent stressors. Overall CRAM index scores for perennially tidal estuarine projects ranged from 40 to 75. Estuarine projects with the highest CRAM index scores were located in the largest wetlands by area, and projects with the lowest average index score were located in the smallest wetland by area. Mean attribute scores tended to be highest for Landscape/Buffer Context (65) and lowest for Physical Structure (44). For the five riverine restoration projects assessed with CRAM, overall index scores ranged from 89 to 62, and mean attribute scores were highest for the Physical Structure attribute (81). Overall index scores for perennial estuarine and riverine project sites were significantly negatively correlated with the number of stressors recorded at project sites ($r = -0.82$; $p = 0.0001$; Figure ES-1). The most frequent severe stressors to a site's overall condition (and corresponding CRAM Attribute), regardless of wetland type, included:

- Transportation corridors (Buffer and Landscape Context)
- Lack of treatment of invasive plant species adjacent (Biotic Structure)
- Presence of dikes and levees (Hydrology)
- Contaminant pollution in the form of nutrients, bacteria, heavy metals, pesticides (Physical Structure)

This study also demonstrates the value of having a regional context for evaluation of the performance of individual sites within a region. For the projects we evaluated, perennially tidal saline estuarine restoration projects are in generally lower condition than the median ambient condition, with most of these projects (80%) scoring below the 50th percentile of CRAM Index scores for the South Coast region. In contrast, riverine restoration projects are generally comparable to the median ambient condition, with most projects (77%) scoring above the 50th percentile of CRAM Index scores for perennial streams in the South Coast region.

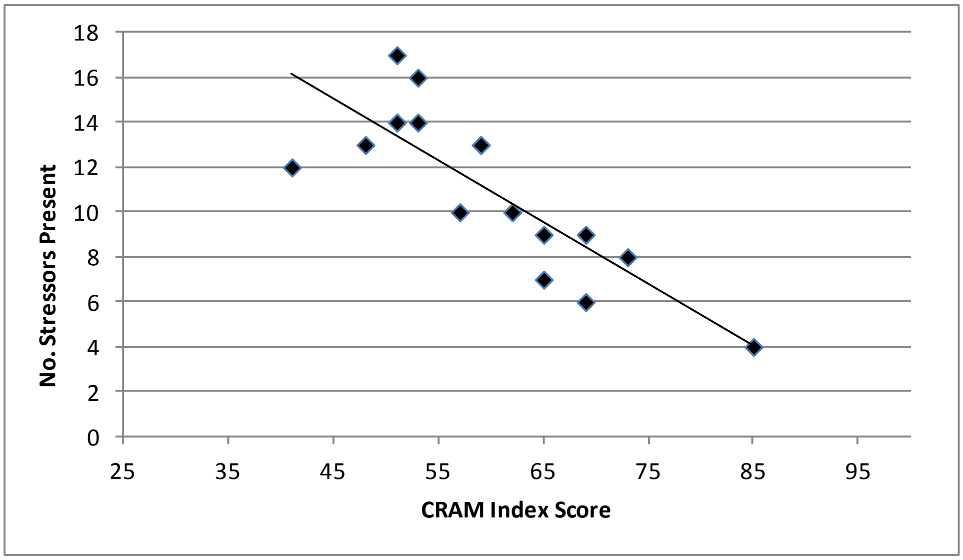

Figure ES-1. Relationship of mean CRAM Index scores with the number of stressors recorded at the 11 perennial estuarine and five riverine restoration projects assessed with CRAM.

Although CRAM scores were sensitive to differences in the condition of restoration sites, the results highlighted the challenge with determining success, i.e., the decision of what score is a reasonable expectation. For example, success can be determined by comparing CRAM scores at project sites to either statewide or regional ambient conditions (Figure ES-2). For example, if the Model Marsh (yellow dot) is viewed from the statewide ambient perspective (blue line), approximately 75% of estuarine saltmarsh area is of higher condition. However, in the context of a regional ambient distribution of CRAM scores, only 40 % of area of saltmarsh area is in better condition than the Model Marsh. Conclusions regarding relative performance will vary based on the distribution of CRAM scores (either statewide or regional) to which they are compared; therefore, managers need to determine the appropriate context by which to define the benchmark for comparison.

Regional differences in geomorphology, hydrology, ecology, and land use have the potential to affect the “reference” or “best attainable” wetland condition. Reference wetland networks, project performance curves, and watershed profiles provide additional ways to provide context for restoration planning and evaluation. Reference sites provide context for tracking the progress of restoration sites relative to natural variability and/or anthropogenic effects and can be used to gauge success and/or compliance with wetland regulations and policies. Used in combination with ambient survey data, reference sites can be used to establish science-based performance criteria and trajectories for projects that forecast how the condition of projects can be expected to improve over time.

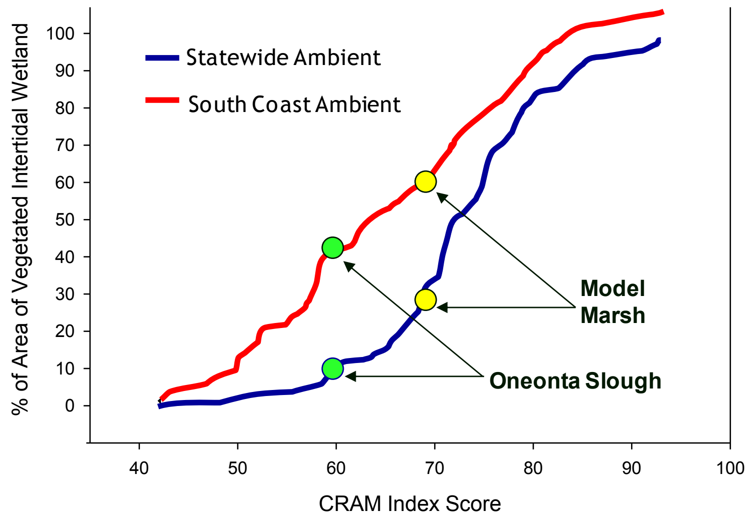

Figure ES-2. Interpreting mean CRAM Index scores for estuarine restoration projects in the context of statewide and regional conditions. In this example, the mean Index scores for the Model Marsh and Oneonta Slough projects (paired yellow and green dots) are plotted on the statewide (blue line) and South Coast (redline) ambient distribution of CRAM Index scores. Although scores are the same, their meaning differs based on the context in which they are viewed. In this example, the percentage of area of vegetated intertidal saltmarsh in better or poorer condition varies for the same project based on the distribution of CRAM scores to which that project is compared.

Watershed “profiles” can also be used to address management questions about watershed condition as a whole. These profiles provide an understanding of the distribution of wetland types within a watershed and their relationship to landscape position. In this context, they provide a means to set physiographically-defined benchmarks for each wetland type and gauge progress of restoration projects toward reaching those benchmarks. For example, CRAM data collected at restoration sites can be used in the development of performance curves for project sites. This would help to scale expectations for restoration or mitigation efforts. The expectations could then be calibrated for wetland size and shape, landscape position, surrounding land uses, hydrology, and the age of the project.

The relatively low CRAM scores for estuarine restoration projects relative to ambient condition may be attributable to several factors, including project age and original project objectives. However, the main factors that likely influenced the low CRAM scores are proximity of adjacent stressors and landscape position of the restoration area.

Based on the results of this analysis, managers should consider the following factors in future restoration planning and assessment:

1. The condition of a project site is influenced by the number and proximity of adjacent stressors operating at or near a site. Therefore, identification of the stressors impacting a site should be conducted in conjunction with any condition assessment of the site. A stressor checklist can be used to identify possible management actions that require attention.

2. The condition of a project site is intimately coupled with its landscape position. An analysis of the spatial patterns in regards to landscape position is critical to understand watershed-scale disturbances to a site, as well as inherent landscape-level limitations on improving condition via restoration activities. This analysis would be particularly useful in identifying project scenarios where landscape-scale attributes could be protected, maintained, or even improved via habitat acquisition, restoration or enhancement activities in other portions of the watershed.
3. It is important to collect quality pre-project data and information at a site. If using CRAM, condition assessments (including a stressor analysis) should occur both prior to restoration activities and after restoration activities are complete (i.e., when all project construction plans and designs have been implemented). The assessments should then be repeated as the project matures and the wetland(s) evolve. This would allow documentation of the net change in acreage and condition of the wetland due to construction activities and subsequent geomorphic and ecological succession.
4. If comparing CRAM scores between different projects or wetland sites, careful control on a project's age, landscape position, and pre- and post-construction condition is required to better assess the true differences in condition between projects or wetlands.
5. If wetlands on a project site have been converted from one wetland type to another due to restoration activities, the pre vs. post project CRAM scores will not be directly comparable if the data were collected using different CRAM modules. If CRAM is being used to help evaluate alternative designs or to provide baseline data for a restoration that anticipates changing wetland types, then the CRAM module for the anticipated future wetland type should be used, as well as the CRAM module for the current type. The CRAM module for the existing wetland type should be used to evaluate potential impacts to the current wetland.
6. Even if a project site receives a relatively high CRAM score, restoration activities may still be warranted at the site. Comparison of the site with appropriate reference conditions and regional ambient assessments of wetland condition will help to determine the true restoration potential of the site.

Incorporation of a tool like CRAM into project-based monitoring is an important step forward in the ability to make more informed wetland management decisions. However, CRAM is just one component of a broader toolkit that has been developed for wetland assessment in California and the inherent limitations of CRAM must be recognized. For example, CRAM is intended to assess vegetated wetlands and is not appropriate to assess projects that include significant subtidal or unvegetated intertidal flats. In most cases, CRAM will need to be used in conjunction with other, more intensive methods (e.g. surveys of benthic invertebrates, riparian birds, rare plant diversity) to support the assessment of wetland condition for decision- making purposes.

Although the inherent limitations of all rapid assessment methods must be recognized, their integration with probabilistic survey designs provides a means to make unbiased estimates of wetland condition. RAM results can also be used to help focus and prioritize the need and location for more intensive assessments. Thus, the relatively low cost of RAMs makes them useful for regional wetland assessments, as well as the mechanism through which regional wetland management and restoration program effectiveness can be evaluated.

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Report Objectives and Goals

The California Rapid Assessment Method for Wetlands (CRAM; Collins *et al.* 2008) was used to assess the condition of wetland restoration projects throughout southern California. CRAM was selected for this assessment because, to date, efforts to build State and regional capacity to assess the condition of wetlands in California have focused on CRAM as a standardized, cost-effective monitoring tool for routine assessment of wetland condition. The goals of this report are specifically to: 1) demonstrate how standardized rapid assessment methods can be an effective tool to inform upon restoration planning, measure recovery progress, and evaluate the anthropogenic stressors constraining recovery in southern California, and 2) discuss how probability-based, ambient surveys can provide context for regional project-based monitoring. This report is intended to assist members of the Wetland Managers Group (WMG) of the Southern California Wetland Recovery Project (WRP) in their work of identifying wetland projects and activities to implement the WRP regional wetland strategy, facilitating interagency coordination, and generating policy proposals for its Governing Board consideration

Introduction

Millions of dollars are spent annually in California by Federal, State, and local agencies to restore and protect wetlands and riparian resources; however, the State is unable to report on the health of wetlands and riparian areas because ambient conditions are not routinely or systematically assessed and projects are monitored in disparate ways. This limits data comparability between sites and the necessary context to interpret data obtained from site-specific assessments. Data of this kind are critical to enable state and regional wetland managers to track the effects of policies and programs, assess net wetland change in acreage and condition, report on the effectiveness of public investment in restoration, and support management decisions (NAS 2001).

A significant obstacle to developing adequate data about condition of wetlands has been the high costs of conventional assessment methods and lack of standardized assessment tools. Rapid assessment methods (RAMs) and are gaining popularity for use in a range of wetland monitoring and assessment applications (Stapanian *et al*. 2004, Cohen *et al.* 2005, Fennessy *et al.* 2007), and provide a straightforward, efficient, and cost-effective means of assessing overall wetland condition (Kentula 2007). RAMs are structured diagnostic tools that combine scientific understanding of process and function with best professional judgment in a consistent, systematic, and repeatable manner (Sutula *et al.* 2006). The basic assumption of most RAMs is that that ecological conditions vary predictably along gradients of stress, and that the conditions can be evaluated based on a fixed set of observable field metrics. These metrics are typically qualitative measures of a specific biological or physical attribute that reflects some element of ecological condition and can be related to key ecosystem functions (Stein *et al.* 2009).

RAMs can be used to extend the geographic application of understanding derived from expensive and geographically restrictive special studies and intensive assessments. In this way, they can be the cornerstone of a comprehensive regional monitoring program and make basic assessment of wetland projects affordable (Sutula *et al*. 2006). RAMs provide the ability to quantify the condition of wetland projects, to compare data among projects, to evaluate cumulative impacts of projects on wetlands resources. Used in conjunction with probability-based survey designs, wetland resource inventories, intensive monitoring, and special studies, RAMs provide a practical means by which to interpret wetland condition data obtained from site-specific assessments within the context of the larger watershed, regional, state, or nationwide scale (Smith *et al.* 1995; Stein and Ambrose 1998).

BACKGROUND

Southern California wetlands and watersheds have been dramatically altered by human activities over the past 150 years (Leet *et al.* 2001). Portions of many coastal wetlands have been filled for agricultural or urban development. In some coastal wetlands, oil extraction facilities have been erected, while in others, ponds have been created for salt extraction, sewage treatment, or duck hunting purposes. In addition, many of the creeks and rivers in Southern California's coastal watersheds have been significantly altered as a result of agricultural and urban development. Dams were built in the upper watersheds for water storage, flood control, and hydroelectric purposes. Creek and river systems have been highly engineered with channels moved, confined to concrete, and placed underground. Extensive urban development has replaced native vegetation with concrete. The resulting fragmentation and loss of habitat continue to threaten the extinction of numerous wetland-dependent species (Dobson 1997). Furthermore, development pressure in the region continues to be intense, with a doubling of the 1995 population expected by 2020 (San Diego Association of Governments 2000).

In 1997, the Southern California Wetland Recovery Project (WRP) was formed in response to a need for increased regional coordination of wetland preservation and management. The WRP is a partnership of 17 state and federal agencies that works with local government, environmental organizations, and scientists to develop and implement restoration projects within southern California. The WRP relies on a non-regulatory approach and restoration is viewed broadly to include any efforts that increase the quantity or quality of coastal wetland resources in the region. These efforts are typically termed "projects", and incorporate a range of activities from habitat preservation, enhancement and improvement. Preservation includes any action that facilitates protection of existing resources, including acquisition of property in fee by public agencies or through partnerships with private conservation organizations, acquisition of conservation easements, or implementation of best management practices on private property. Given the extent of historical wetland loss and the limited opportunities remaining in southern California, preservation and restoration of tidal wetlands and stream corridors in the region are a high priority for the WRP. Since its inception through March 2006, over $500,000,000 has been spent on WRP Work Plan projects, or an average of $50,000,000 per year (SCWRP 2001). These projects have encompassed a broad range of activities, from small enhancement efforts to large-scale reconstruction of wetland systems.

Public interest in (and funding for) conservation and restoration activities remains high in the southern California region even during recent times of slow economic growth or recession. To date, however, it has been difficult for the WRP to evaluate the net effects of its efforts because the extent and condition of wetland resources have not been routinely monitored in a consistent manner across the region. Recognizing this, the Board of Governors of the WRP endorsed the

Integrated Wetlands Regional Assessment Program (IWRAP) in 2002. IWRAP is modeled after USEPA's Level 1-2-3 framework that integrates of three tiers (or levels) of assessment activities (USEPA 2006):

Level 1: consists of standardized wetland, riparian, and vegetation mapping methodologies and inventories. Level 1 assessment answers questions about wetland and riparian extent and distribution;

Level 2: consists of standardized rapid assessment methods which use cost-effective field-based diagnostic tools to assess the condition of wetland and riparian areas. Level 2 assessment answers questions about general wetland health.

Level 3: consists of traditional, intensive assessment methods (e.g., standardized water chemistry and toxicity assessment methods) to provide data to validate rapid methods, characterize reference condition, and diagnose the causes of wetland condition observed in Levels 1 and 2. Level 3 assessments can be used to test hypothesis and provide insight into functions and processes.

The development of IWRAP is important for the WRP in several ways. First, it provides a conceptual framework in which to evaluate recovery priorities and ensure that WRP use of public funds has a lasting regional impact. Second, it provides an integrated and cost effective regional approach to addressing the management information needs of WRP partners. Third, it streamlines reporting of monitoring data, making the data more accessible for routine scientific evaluation of restoration and management techniques. Fourth, it serves to verify the effectiveness of wetland regulatory and management policy, both at a regional level and for locations where site-specific monitoring is conducted.

THE CALIFORNIA RAPID ASSESSMENT METHOD FOR WETLANDS (CRAM)

In California, the California Rapid Assessment Method for Wetlands (CRAM) was developed, tested, and validated (Collins *et al.* 2008; Stein *et al.* 2009). CRAM is a structured, Level-2 diagnostic tool that combines scientific understanding of process and function with best professional judgment in a consistent, systematic, and repeatable manner (Sutula *et al.* 2006). CRAM assesses four overarching attributes of wetland condition: Buffer and Landscape Context, Hydrology, Physical Structure, and Biotic Structure (Collins *et al*. 2008). Each of these attributes is comprised of a number of metrics and submetrics that are evaluated in the field for a prescribed assessment area (Table 1). See Appendix 1 for a summary description of each of these metrics or Collins *et al*. (2008) for a more detailed description.

Table 1. Relationship between CRAM attributes, metrics (m), and submetrics (s). The four attributes are averaged to produce an overall CRAM index score (see Appendix 1 for a summary description of each metric).

Attribute	Metric and Submetrics
Buffer and Landscape Context	Landscape Connectivity (m)
	Buffer (m):
	Percent of AA with Buffer (s)
	Average Buffer Width (s)
	Buffer Condition (s)
Hydrology	Water Source (m)
	Hydroperiod or Channel Stability (m)
	Hydrologic Connectivity (m)
Physical Structure	Structural Patch Richness (m)
	Topographic Complexity (m)
Biotic Structure	Plant Community (m):
	Number of Plant Layers Present (s)
	Number of Co-dominants Plant Species (s)
	Percent Invasion (s)
	Horizontal Interspersion and Zonation (m)
	Vertical Biotic Structure (m)

CRAM metrics or submetrics are assessed in the field with a standardized set of mutually exclusive alternative states using narrative or schematic descriptions. Choosing the best-fit description for each metric generates a score for each attribute. The attribute scores are averaged to produce an overall index score. Final attribute and index scores are expressed as percent possible, and range from 25 (lowest possible) to a maximum of 100. These scores are based on an internal reference standard that represents the best achievable condition statewide for the type of wetland being assessed. Therefore, any two scores for the same type of wetland can be compared to each other because they are based on the same statewide standard. For example, a CRAM Assessment Area having an AA score of 50 can be interpreted as having lower ecological condition than another AA of the same wetland type having an AA score of 80. A similar interpretation can be made for Attribute scores.

In addition to producing condition scores, CRAM includes a list of 52 anthropogenic stressors within a wetland or its setting that are likely to negatively impact the functional capacity of the CRAM assessment area (Appendix 2). Each CRAM Attribute has a corresponding stressor checklist. Stressors for each Attribute are represented as categorical variables ranging from “0”, indicating no stressor is present; “1”, indicating that the stressor is present; and “2”, indicating that the stressor is severe and likely to cause a significant negative impact. The CRAM stressor checklist does not factor into the calculation of the CRAM overall or attribute scores, but can help to inform upon the scores and to identify possible management actions to improve condition.

CRAM validation efforts to date have indicated that CRAM is broadly applicable throughout the range of conditions commonly encountered. The method has undergone extensive technical review and iterative refinement for all CRAM wetland types. In addition, the riverine and estuarine classes have been validated against independent, more intensive measures of condition including benthic invertebrates, riparian birds, and estuarine plant richness and diversity (Stein *et al.* 2009). CRAM was <u>not</u> designed for use in the assessment of subtidal habitats and intertidal areas with less than 5% vegetated cover of emergent marsh. In addition, CRAM is under refinement for certain subclasses of wetlands, including ephemeral streams and seasonal depressional wetlands.

Using CRAM for Restoration Planning

There are generally two kinds of CRAM applications: assessments of ambient condition and assessments of project conditions. Ambient assessments are often conducted based on a probabilistic (random) sampling design where a statistically representative sample of wetlands is assessed and used to make inferences about the overall condition of the larger population of wetlands in the geographic area of interest. For example, an ambient survey might encompass all of the possible assessment areas for fringing wetlands of lakes (i.e., lacustrine wetlands) within an administrative region of an agency, congressional district, etc. CRAM may be used alone (or with other methods) to characterize ambient wetland condition at spatial scales ranging from the watershed (Solek *et al*. *in press*), regional (Mazor *et al. in press*), and statewide level (Sutula *et al.* 2008a). The ambient condition of any given wetland type can be displayed as the cumulative frequency distributions (CFDs) of overall scores (Figure 1a), or the ambient conditions of two different types of wetlands can be compared based on the frequency distributions of the overall scores (Figure 1b). These graphs can be produced for individual watersheds, regions, or an entire state.

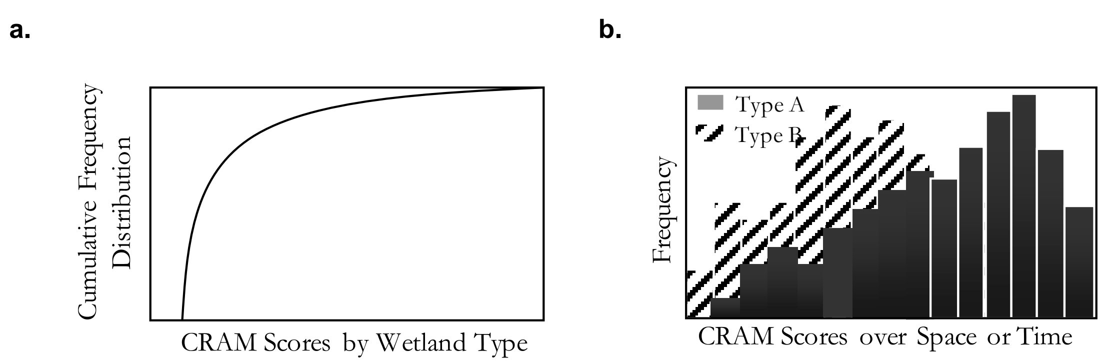


Figure 1. Graphical representations of CRAM data: frequency distributions of overall scores for a single wetland type using a CFD plot (a), and frequency distributions of the overall scores for two different types of wetlands using histograms (b).

A spatial consideration for ambient surveys is that the probability of any wetland within a given area being selected for assessment increases with its size, and weighting CRAM scores for the inclusion probabilities of their associated assessment areas depends on having a standard assessment area size range for each wetland type. Therefore, there are preferred and minimum CRAM assessment area sizes for each wetland type (Collins *et al.* 2008).

In the case of a project assessment, all of the possible areas for one kind of wetland are assessed with CRAM within the boundaries of one project area. The results are used to characterize the project. CRAM metric, attribute, and index scores from project sites can be compared to the distribution of comparable scores from statewide, regional, or watershed ambient survey data for the same wetland type using bar charts (Figure 2a) or with CFD plots. The CFD allows one to estimate what percent of the wetland area of that wetland type is less than or equal to a particular score. In this way, it can be determined how far the population departs from the reference standard or a score of interest. The progress of a restoration or mitigation project can also be shown as the change in average overall score relative to prescribed performance standards (Figure 2b).

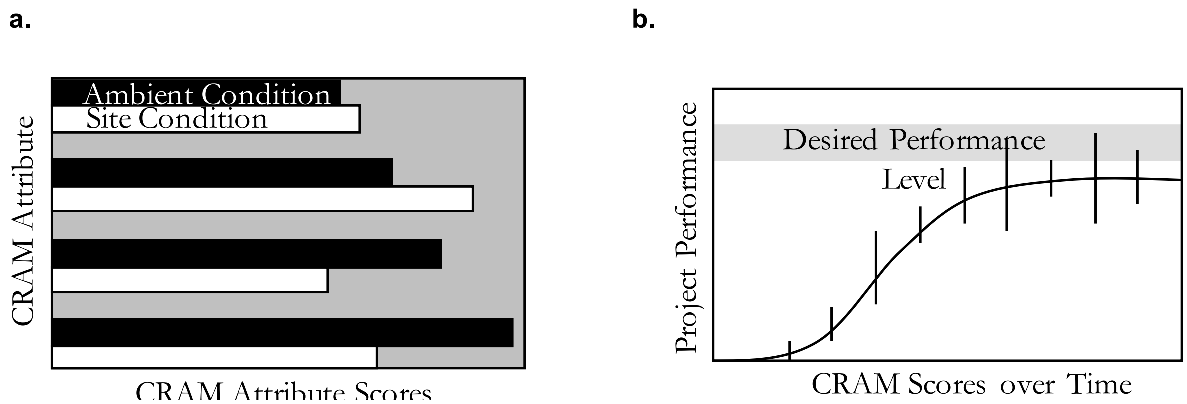


Figure 2. CRAM scores can be compared and analyzed using bar charts to compare site scores with ambient conditions (a) and examining changes in average overall score over time relative to prescribed performance standards (b).

CRAM may also be used to help assess change in wetland condition over time and track the relative improvement in wetland condition of a specific portion of wetland acreage post-restoration (Figure 3). In this hypothetical example, restoration project index scores are overlaid onto a cumulative distribution of CRAM scores for a hypothetical watershed. Movement of CRAM scores along the distribution shows a low initial score (1), followed by a drop in score due to land form changes, possibly due to grading of the project site (2), which is followed by a rapid rise in score due to vegetation recruitment (3). Invasion of non-native weeds lowers the score (5), but additional weed management and planting reverse this (6-7), and eventually, a final, stable wetland condition (8). At the end of the monitoring period, overall condition changed from 30th percentile to 70th percentile of wetlands within the watershed.

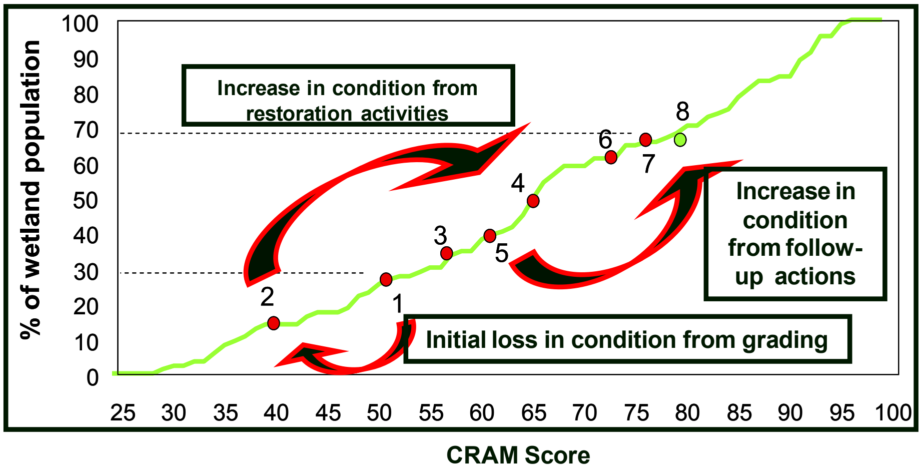


Figure 3. Hypothetical example of monitoring temporal change in CRAM scores within a wetland restoration project.

As with any assessment method, the ability of CRAM to detect change depends on the size of the change relative to the precision of CRAM. In general, based on the calibration and validation of CRAM for riverine systems and estuarine wetlands, the precision of CRAM is about 5 CRAM points for Attribute scores and about 10 CRAM points for overall AA scores. Therefore, only changes in condition that translate into differences in Attribute scores of at least 5 points or into differences in AA scores of at least 10 points will be detected using CRAM. This suggests that CRAM can be used frequently during the early stages of restoration and mitigation projects, when changes tend to be rapid and large, and less frequently later-on, when changes are more gradual. However, CRAM might prove to be useful in measuring trends or a “restoration trajectory” over the required monitoring period and comparing those results to Level-3 data (CWMW 2009).

Although the same guidelines for delineating assessment areas pertain to both ambient and project assessments, the number of assessment areas per wetland varies between these two applications. Whereas just one assessment area would be required in the same wetland if it were only being assessed as part of an ambient survey, multiple assessment areas are required to assess the average condition of a wetland project that is many times larger than one CRAM assessment area.

There are appropriate and inappropriate uses of CRAM for wetland regulatory and management purposes (CWMW 2009). Particular applications for specific projects will ultimately be at the discretion of each agency as part of its permitting or grant programs. For the WRP and its project-based monitoring, CRAM can be most useful in the evaluation of pre- and post-project conditions at restoration sites, the assessment of performance or success of restoration sites over time, and the comparison of proposed alternatives for restoration planning purposes. For example, an anticipated CRAM score can be generated based on one or more project design alternatives. This would involve a series of assumptions about the expected structure and composition following implementation of a proposed project. Such "forecasted" assessments can aid in the evaluation of the relative condition of several alternatives. CRAM, however, is not intended to be used as a "cook book" to provide a specific answer to a management question. Rather, the method is intended to be used to inform decisions that are made based on numerous considerations and may include other assessments in addition to CRAM.

In most cases, CRAM should not be used as the sole basis for making regulatory or project related decisions, but will need to be used in conjunction with Level 1 and 3 methods to support the assessment of wetland condition for these purposes. In some cases, appropriate Level 3 protocols already exist; in other cases additional Level 1 or 3 assessment tools may need to be developed for the assessment. California is still in the process of developing standardized Level-1 tools (wetland mapping, classification, delineation) and Level-3 protocols for its various programmatic needs and applications. To date, efforts to build State capacity to assess wetlands have focused on CRAM (Level-2) as a standardized wetland assessment method. The California Wetland Monitoring Workgroup (CWMW)[1] and IWRAP have both endorsed and recommended CRAM as a standardized wetland assessment tool.

METHODS

A total of 26 wetland projects throughout southern California were assessed with CRAM from January 2008-September 2008. From January-March, eleven (11) completed estuarine-based wetland restoration and mitigation projects were assessed with the perennial estuarine module of CRAM (ver. 5.0.2; Collins *et al*. 2008) in southern California (Table 2a). These ten projects were included as part of targeted assessment of completed estuarine projects that were conducted as part of a larger statewide demonstration of California wetland monitoring tool kit (Sutula *et al*. 2008a; 2008b). Four of these completed projects were on the WRP workplan.

From August-September 2008, 15 WRP restoration and acquisition projects were assessed with CRAM (Table 2b; Appendix 3). Because these projects represented different wetland types or had multiple wetland types present within the project footprint, various CRAM modules were used, including the seasonal estuarine, riverine, depressional, lacustrine, and playa modules (version 5.0.2; Collins *et al*. 2008). For ten (10) of the WRP projects, restoration had not yet been conducted on site at the time of the CRAM assessment, so only pre-restoration CRAM scores are available. For the other five (5) WRP projects, restoration had already been conducted at the time of the CRAM assessment, so only post-restoration CRAM scores are available. All projects were selected based in input of regional coastal zone managers and represent a range in locations, wetland types, sizes, ages. The lack of a comprehensive project inventory for southern California prevented the use of a randomized approach for selecting projects to assess for both surveys.

[1] The California Wetland Monitoring Workgroup (CWMW) is a subcommittee of the California Water Quality Monitoring Council (Senate Bill 1070; Kehoe 2006).

Table 2a. Summary information for the 11 estuarine restoration projects assessed with CRAM in 2008 in conjunction with the statewide survey of perennially tidal saline estuarine wetlands. The number of CRAM assessments areas conducted for a project are noted in parentheses after the project name. Project age is the approximate age of project (post-restoration) at time that the CRAM assessment was conducted.

Project Name	County	Size (acres)	Project Type	WRP Project	Project Age
Tijuana Slough Model Marsh (3)	San Diego	20	restoration	Yes	8
Oneonta Slough Tidal Linkage at Tijuana Slough (1)	San Diego	1.7	mitigation	No	11
West Point Loma Marsh Restoration at Famosa Slough (2)	San Diego	3.4	restoration	Yes	3
Marisma de Nacion Restoration at Sweetwater Marsh (2)	San Diego	17	mitigation	No	17
Connector Marsh Restoration at Sweetwater Marsh (4)	San Diego	12.1	mitigation	No	23
Talbert Marsh Restoration (2)	Orange	24	restoration	Yes	19
Lower Santa Ana River Marsh Restoration (3)	Orange	92	mitigation	No	18
Bolsa Chica Lowlands Restoration (3)	Orange	566	mitigation/ restoration	Yes	2
Ballona Wetlands Ballona Tide Gate Installation (1)	Los Angeles	540	restoration	No	6
Mugu Treatment Ponds Restoration (2)	Ventura	37	mitigation	No	8
Capinteria Salt Marsh Basin I (2)	Santa Barbara	34	restoration	No	1

Table 2b. Summary information for the 15 WRP projects assessed with CRAM in 2008. The number of CRAM assessments areas conducted for a project are noted in parentheses after the project name. Project age is the approximate age of project (post-restoration) at time that the CRAM assessment was conducted.

Project Name	County	Size (acres)	Project Type	CRAM Module	Project Age
Arroyo Burro Estuary and Mesa Creek Restoration (1)	Santa Barbara	1.2	restoration	riverine	1
Carpinteria Creek Watershed Restoration: Bliss Fish Passage Improvement (1)	Santa Barbara	0.06	restoration	riverine	completed 2008
Carpinteria Creek Watershed Restoration: Cate School Fish Passage Improvement (2)	Santa Barbara	3.3	restoration	riverine	completed 2008
Solstice Creek Fish Passage (3)	Los Angeles		restoration	riverine	2
Buena Vista Creek-Sherman Parcel (3)	San Diego	1.0	acquisition	riverine	NA
Buena Vista Lagoon Phase II Restoration Planning (10)	San Diego	200	planning	lacustrine	NA
UCSB Campus Lagoon Enhancement (1)	Santa Barbara	2.0	enhancement	lacustrine	completed
Coal Oil Point Reserve West Slough Margin Restoration at Devereux Slough (2)	Santa Barbara	1.25	restoration	seasonal estuarine	3
Los Cerritos Wetlands-Bryant Property Acquisition (5)	Los Angeles	87	acquisition	seasonal estuarine	NA
Malibu Lagoon Restoration Project (2)	Los Angeles	33	restoration	seasonal estuarine	NA
Ormond Beach Wetlands Acquisition-Part II (8)	Ventura	674	acquisition	depressional/seasonal estuarine playa	NA
Huntington Beach Wetlands Restoration (6)	Orange	107	restoration	depressional (estuarine)	completed 2010
San Joaquin Marsh Enhancement Phase II Implementation (3)	Orange		enhancement	depressional	5
West Storke Wetland Enhancement (1)	Santa Barbara	1.0	enhancement	depressional	1
Western Goleta Slough Wetland Restoration (4)	Santa Barbara	34.4	restoration	depressional	completed 2010

All surveys adhered to the preferred maximum and minimum assessment area sizes for each wetland type based on the guidance of Collins *et al*. (2008; Table 4). To the degree possible, the delineation of each assessment area was based on hydro-geomorphic considerations as described Collins *et al*. (2008). When these considerations were not applicable, assessment area delineations relied on the size guidelines in Table 4 only and the maximum size appropriate for that wetland type was always assessed. Since CRAM metrics vary between wetland types, each CRAM assessment area within a project represented only one type of wetland. For several projects, the wetlands present on a project site had been converted from their historic type to another wetland type (e.g. Brookhurst Marsh, Magnolia Marsh, and the wetlands on TNC parcel at the Ormond Beach). In these cases, the wetland was assessed using the CRAM module for both the current wetland type and the anticipated future wetland type.

Table 4. Recommended CRAM assessment area sizes for the wetland types assessed for this study (adapted from Collins *et al.* 2008).

Wetland Type	Recommended AA Size*
Perennial Saline and Seasonal Estuarine	Recommended size and shape for estuarine wetlands is a 2.5 acre circle (radius about 180 ft.). Shape can be non-circular to fit the wetland. Minimum size is 0.25 acres.
Depressional (vernal pools excluded)	Maximum size is 2.5 acres; no minimum size.
Riverine	Recommended length is 10x average bankfull channel width; maximum length is 656 ft.; minimum length is 328 ft. The assessment area should extend laterally (landward) from the bankfull contour to encompass all the vegetation that probably provide woody debris, leaves, insects, etc. to the channel and its floodplain; minimum width is 6.5 ft.
Lacustrine and Playa	Maximum size is 5.5.acres; minimum size is 1.2 acres.

In most cases, multiple assessment areas were required to assess the condition of projects many times larger than one standard CRAM assessment area. For these cases, procedures followed the guidelines in Collins *et al.* (2008) for determining the number of assessment areas per project and the attribute scores were averaged to generate an overall project index score. If the wetland was twice as large as the preferred assessment area size for a particular wetland type, two CRAM assessments were conducted and the results are reported for both assessment areas. If the wetland was at least three times as large as the preferred assessment area size for a particular wetland type, then three assessments areas were randomly selected from the array of all possible assessments areas for the wetland type and assessed with CRAM. If the overall score for the third assessment area differed from the average of the first two scores by more than 15%, then a fourth assessment area was randomly selected and assessed. This process was repeated until the overall score for the last randomly selected assessment area was no more than 15% different than the average of all previous scores.

Data Reporting and Analysis

Project CRAM scores are reported and analyzed in several ways. First, the average index and attribute scores were tabulated for each project. These scores represent the average condition of wetland(s) within each project footprint and are presented for inter-project comparative purposes. Second, summary statistics of index and attribute scores are reported by wetland type. Third, the stressor checklist data from the project sites are summarized.

It is very difficult to interpret the meaning of average values of several attribute scores or the significance of an average CRAM score for multiple assessment areas. Multiple combinations of metrics scores will yield the same Attribute score, and multiple combinations of Attribute scores will yield the same overall AA score. Each CRAM assessment area score can only be explained by its particular set of contributing metric scores. When multiple scores for an Attribute are averaged, or when multiple AA scores are averaged, the link to the explanatory metric scores is blurred, if not lost entirely (CWMW 2009).

Because of this, we assessed the overall condition for a site as the number of scores that fell into each quartile of the appropriate ambient data set of CRAM scores. At this time, statewide and regional ambient surveys of wetland condition using CRAM have been conducted only for perennially tidal saline estuarine wetlands and wadeable, perennial streams in California. In 2007, a statewide assessment of perennially tidal estuarine wetlands in California was conducted in 2007 to provide statistical estimates of the extent and condition of estuarine wetlands within four coastal regions of California (Sutula *et al*. 2008a; 2008b). Beginning in 2009, the Stormwater Monitoring Coalition (SMC), comprised of Southern California's major stormwater agencies and their state and federal regulatory counterparts, have conducted annual assessments of perennial wadeable streams in Southern California. CRAM is one of the indicators used by this program. At this time, ambient assessments for the other wetland types (depressional, lacustrine, playa) have not been conducted.[2]

CRAM index and attribute scores for perennial tidal estuarine wetlands and wadeable, perennial streams project assessment areas were separated into four equal score quartiles: (1) Quartile 1 (> 82); (2) Quartile 2 (64-82); (3) Quartile 3 (44-63); and (4) Quartile 4 (< 44). These four ranges of CRAM scores represent a theoretical continuum of condition along various stressor gradients, with 100 and 25 representing the highest and lowest possible scores possible, respectively, on each gradient (Sutula *et al*. 2006). Because this approach to summarizing multiple CRAM assessments does not involve any averaging of multiple scores, it avoids attending difficulties in interpretation. This approach has the added benefit of linking project assessment to ambient assessment in a way that clearly illustrates their interdependence.

RESULTS

The 26 wetland projects assessed with CRAM comprise five CRAM wetland types (estuarine, riverine, depressional, lacustrine, and playa). The estuarine projects included two subtypes (perennial saline and seasonal), the riverine projects two sub-types (confined and non-confined),

[2] An ambient survey of depressional wetlands in the South Coast region is planned for 2012.

and the depressional projects two sub-types (perennial and seasonal). Some projects contained multiple parcels that needed to be assessed independently (e.g. Ormond Beach) or contained more than one wetland type (e.g. Sherman Parcel at Buena Vista Creek). In total, 77 individual CRAM assessments were conducted in 2008 (Table 5). Metric, Attribute, and Index scores for all assessment areas for all projects are provided in Appendix 4A and 4B. A summary of the stressors recorded at the WRP project sites is presented in Appendix 5.

Table 5. Average Attribute and Index Scores for all projects assessed with CRAM in southern California in 2008. The number of individual CRAM assessments conducted at each site is noted in parentheses. Sites are ordered by highest to lowest CRAM Index score for each wetland type or subtype.

Project Name	CRAM Index	Buffer/Landscape	Hydrology	Physical	Biotic
Saline Perennial Tidal Estuarine:					
Tijuana Slough Model Marsh (3)	69	100	58	54	62
Mugu Treatment Ponds (2)	69	92	71	69	43
Oneonta Slough (1)	59	58	67	38	72
Capinteria Marsh Basin I (2)	58	73	50	38	71
Marissma de Nacion (2)	56	58	58	44	64
Bolsa Chica (3)	55	70	58	54	37
Ballona Wetlands (1)	53	79	42	38	53
Connector Marsh (4)	51	45	58	47	54
Santa Ana River Marsh (3)	50	63	42	38	60
Bryant Property-Los Cerritos Wetlands (5)	48	47	57	35	54
Talbert Marsh (2)	48	49	50	38	56
Famosa Slough (2)	41	30	50	25	58
Seasonal Estuarine:					
Malibu Lagoon (2)	65	63	75	44	81
Devereux Slough (2)	60	56	75	38	71
Riverine:					
Solstice Creek Steelhead Passage (3)	85	92	69	96	83
Mesa Creek (1)	65	67	83	50	61
Cate School Fish Passage (2)	65	77	63	63	57
Bliss Creek Fish Passage (1)	62	38	58	75	78
Buena Vista ER (2)	73	58	63	94	76
Depressional:					
West Storke Wetland (1)	75	54	67	88	92
Buena Vista ER (1)	66	48	100	38	81
Western Goleta Slough (4)	56	82	54	41	48
San Joaquin Marsh (3)	54	85	33	38	59
Depressional (type-converted):					
Huntington Beach-Brookhurst Marsh (3)	59	58	64	33	80
Huntington Beach: Magnolia Marsh (3)	57	63	75	33	58
Ormond Beach-TNC Parcel (5)	50	52	47	35	67
Lacustrine:					
UCSB Campus Lagoon (1)	61	45	50	75	75
Buena Vista Lagoon (10)	60	67	63	39	69
Playa:					
Ormond Beach- SCC parcel (3)	65	77	42	58	83

Estimates of Condition for South Coast Estuarine Projects

A total of 12 CRAM assessments were conducted at perennially tidal estuarine projects. CRAM index scores for these assessment areas ranged from 40 to 75 (Table 6). The two projects with the highest CRAM index scores (Model Marsh and Mugu Treatment Ponds) were also located in the largest wetlands by area (Tijuana Slough and Point Mugu Lagoon). The project with the lowest average index score (West Point Loma Marsh Restoration) was located in the smallest wetland in terms of area (Famosa Slough).

Table 6. Summary statistics of CRAM Overall Index and Attribute scores (by CRAM assessment area) for the completed South Coast estuarine restoration and mitigation projects assessed with CRAM (N=25).

CRAM Index and Attribute	Mean	Median	SE	SD	Maximum	Minimum
Overall Index Score	55	56	2	9	75	40
Landscape and Buffer Context	65	63	4	21	100	30
Hydrology	55	58	2	9	75	33
Physical Structure	44	38	3	13	75	25
Biotic Structure	57	56	2	12	75	36

Estimates of Condition for South Coast Riverine Projects

A total of nine (9) CRAM assessments were conducted at riverine restoration projects. CRAM index scores for these assessment areas ranged from 89 to 62 (Table 7). The Solstice Creek Fish Passage Project had the highest CRAM index and Attribute scores of all the projects assessed.

Table 7. Summary statistics of CRAM Overall Index and Attribute scores (by CRAM assessment area) for the 5 South Coast riverine assessed with CRAM in 2008 (N=9).

CRAM Index and Attribute	Mean	Median	SE	SD	Maximum	Minimum
Overall Index Score	73	66	4	11	89	62
Landscape and Buffer Context	73	73	7	20	93	38
Hydrology	67	67	3	8	83	58
Physical Structure	81	88	6	19	100	50
Biotic Structure	73	78	5	15	94	56

Estimates of Condition for South Coast Depressional Projects

A total of 11 CRAM assessments were conducted at depressional wetland restoration projects. CRAM index scores for these assessment areas ranged from 75 to 43 (Table 8). The Storke wetland restoration project had the highest CRAM index score of all the projects assessed. This site also scored the highest for the Physical and Biotic Structure Attributes of CRAM.

Table 8. Summary statistics of CRAM Overall Index and Attribute scores for the 4 South Coast depressional projects assessed with CRAM in 2008.

CRAM Index and Attribute	Mean	Median	SE	SD	Maximum	Minimum
Overall Index Score	58	58	3	10	75	43
Landscape and Buffer Context	62	55	6	19	100	42
Hydrology	58	58	7	24	100	33
Physical Structure	42	38	6	20	88	25
Biotic Structure	68	72	4	15	92	44

Estimates of Condition for Other South Coast Projects

Of the two lacustrine projects assessed with CRAM, the UCSB Campus Lagoon required a single CRAM assessment and received a CRAM Index score of 61. The other lacustrine site (Buena Vista Lagoon) was large in area and hydrologically separated into several sections. It, therefore, required ten (10) CRAM assessments were to assess its condition. Index scores for CRAM assessment areas at this site ranged from 66 to 46. The SCC parcel at the Ormond Beach site contained an area of wetland that was best characterized as a playa. Index scores for CRAM assessment areas at this site ranged from70 to 62. Note that for Playa CRAM, the Number of Plant Layers submetric and the Vertical Biotic Structure metric are not assessed.

Stressors at Project Sites

A total of 39 types of stressors were identified at all project CRAM assessment areas from the CRAM stressor checklist (Appendix 6). For all South Coast project sites, transportation corridors were the most frequent stressor (62% of sites; Appendix 6) and the most prevalent severe stressor (53% of sites) to the Buffer and Landscape Context Attribute. The lack of treatment of invasive plant species adjacent was the most frequent stressor (67% of sites) and the most prevalent severe stressor (46% of sites) to the Biotic Attribute. Dikes and levees were the most frequent stressor (63% of sites; Table) and the most prevalent severe stressor (54% of sites) to the Hydrology Attribute; contaminant pollution in the form of pesticides/organic compounds was the most frequent stressor (39% of sites; Table) and the most prevalent severe stressor to a site's Physical Structure (28% of sites), but other forms of contaminant pollution (bacteria, nutrient, and heavy metal impairment) were also common. Industrial/commercial development, excessive human visitation, non-point source discharges (urban runoff, farm drainage) were also identified as severe stressors at all project sites. These overall patterns of stressor occurrence and severity generally applied to all project sites regardless of wetland type, however dike and leeves were less frequently encountered at riverine project sites. In addition, flow obstructions (culverts, paved stream crossings) were most frequently associated with riverine project sites and never encountered at estuarine sites.

Trends in stressor presence and severity at estuarine project sites are similar to those observed at the probabilistically selected estuarine sites from the 2007 ambient survey of perennial estuarine wetland condition. Non-parametric ANOVA tests showed that the number of stressors and number of severe stressors did not significantly differ between large and small estuaries as assessed for the ambient survey (p-value = 0.98 and 0.78, respectively: Sutula *et al.* 2008).

The ambient survey also revealed that sites where dikes/levees or lack of treatment of invasive plants was identified as a severe stressor had on average a 10 point lower CRAM index score than other sites ($p < 0.02$). Sites with culverts or other flow obstructions had average CRAM index scores that were 15 points lower than other sites where this stressor was absent ($p = 0.001$).

Relationships of CRAM Scores with Project Age

CRAM index or attribute scores were not correlated with project age (the number of years since restoration at the site was completed).

Comparison of Projects to Ambient Condition

The condition of South Coast wetland projects was assessed as the percent of Index and Attribute scores that fell into each quartile of CRAM scores relative the ambient data set for the appropriate wetland type. Based on the results of the ambient survey of perennially tidal estuarine wetlands in the South Coast, 13% of the almost 4,000 acres of in the region is likely to have CRAM index scores in Quartile 1. The majority of the acreage would probably score in Quartiles 2 or 3 (55 and 39%, respectively), with just 3% scoring in Quartile 4 (Table 9).

Table 9. Distribution of South Coast intertidal wetland acreage among categories of condition. The first column presents the mean and standard error (in parentheses) of CRAM index and attribute scores for the South Coast region. The last four columns present the estimated percentage of estuarine wetland area to score within each quartile (Sutula et al. 2008).

CRAM Index and Attribute	South Coast Mean	Percent of Estuarine Wetland Area in Four Score Bins			
		Quartile 1 >82	Quartile 2 82-63	Quartile 3 63-44	Quartile 4 <44
CRAM Index	67 (1)	3	55	39	3
Landscape Context	82 (2)	51	38	11	0
Hydrology	61 (1)	5	28	49	0
Physical Structure	59 (3)	14	15	46	25
Biotic Structure	67 (2)	30	46	24	0

In comparison, 72% of assessment areas for estuarine projects scored in the 3rd Quartile for CRAM Index scores. No CRAM assessment areas scored the highest quartile of CRAM scores and 8% scored in the lowest quartile (Table 10).

Table 10. Distribution of South Coast estuarine wetland project CRAM scores among categories of condition (N = 25). The first column contains the mean and standard error (in parentheses) of CRAM index and attribute scores for estuarine wetlands in the South Coast region. The second column contains the mean and standard error (in parenthesis) of CRAM index and attribute scores for South Coast estuarine projects. The last four columns present the percentage of CRAM scores for this project within each quartile.

CRAM Index and Attribute	South Coast Mean	Project Mean	Percent of Estuarine Project AAs in Four Score Bins			
			Quartile 1 >82	Quartile 2 82-63	Quartile 3 63-44	Quartile 4 <44
CRAM Index	67 (1)	55 (2)	0	20	72	8
Landscape Context	82 (2)	65 (4)	16	24	48	12
Hydrology	61 (1)	55 (2)	0	12	76	12
Physical Structure	59 (3)	44 (3)	0	8	36	56
Biotic Structure	67 (2)	57 (2)	0	28	52	20

Mean CRAM index and attribute scores for estuarine restoration and mitigation projects in southern California tended to be 6 -17% lower than mean ambient scores for the South Coast region (Table 4). Buffer and Landscape Context scores for projects tended to be the lowest when compared to ambient scores. Most projects (48%) scored in the 3rd Quartile of this Attribute, and 24% scored in Quartile 2 for this Attribute.

Scores for the Hydrology Attribute were 6% lower for project sites than mean ambient sites in the South Coast. The project sites also had more urbanized water sources than the ambient sites, resulting in most sites scoring in the 3rd Quartile of CRAM scores for water source, where most ambient sites scored in the 2nd Quartile for this metric. Physical structure was the attribute for which the South Coast estuarine projects scored the lowest, with 15% of project scoring lower than mean ambient sites. Biotic Structure scores were 10% lower for project sites than ambient sites in the South Coast. The overall condition of South Coast stream-based (riverine) restoration projects was assessed as the number of projects that fell into each quartile of scores relative to the ambient data set for wadeable, perennial streams (Table 11.) Based on the results of the ambient survey of stream condition, 28% of perennial streams in the region are likely to have CRAM index scores in Quartile 1. The majority of stream miles would probably score in Quartiles 2 or 3 (39 and 19%, respectively), with 15% scoring in Quartile 4.

Table 11. Distribution of South Coast perennial stream miles among categories of condition. The first column presents the mean and standard error (in parentheses) of CRAM index and attribute scores for the South Coast region. The last four columns present the estimated percentage of stream miles in the South Coast to score within each quartile (SMC 2009).

CRAM Index and Attribute	South Coast Ambient Mean	Percent of Stream Miles in Four Score Bins			
		Quartile 1 >82	Quartile 2 82-63	Quartile 3 63-44	Quartile 4 <44
CRAM Index	68 (2)	28	39	19	15
Landscape Context	78 (2)	51	25	14	10
Hydrology	66 (2)	26	32	22	19
Physical Structure	63 (2)	23	23	31	22
Biotic Structure	64 (2)	19	43	19	19

In comparison, 44% of CRAM assessment areas for riverine projects scored in the 2rd Quartile for CRAM Index scores. Thirty-three percent of CRAM assessment areas scored the highest quartile of CRAM scores and no projects scored in the lowest quartile (Table 12). One project (Solstice Creek Fish Passage project) scored in the highest quartile of CRAM Index scores.

Table 12. Summary of CRAM index and attribute scores for WRP riverine project assessment areas (N = 9). The first column contains the mean and standard error of CRAM index and attribute scores for wadeable, perennial streams in the South Coast region. The second column contains the mean and standard error of CRAM index and attribute scores for South Coast riverine projects. The last four columns present the estimated percentage of South Coast riverine projects to score within each quartile of CRAM scores.

CRAM Index and Attribute	South Coast Ambient Mean	Project Mean	Percent of Riverine AAs in Four Score Bins			
			Quartile 1 >82	Quartile 2 82-63	Quartile 3 63-44	Quartile 4 <44
CRAM Index	68	73	33	44	22	0
Landscape Context	78	73	44	33	11	11
Hydrology	66	67	11	56	33	0
Physical Structure	63	81	56	11	33	0
Biotic Structure	64	73	33	22	44	0

Mean CRAM Index scores for riverine projects in southern California were 5% higher than the ambient mean score for the South Coast region. The Buffer and Landscape Context Attribute for projects tended to score the lowest of all the CRAM Attributes; scores for this attribute were 5% lower for projects when compared to ambient scores. Scores for the Hydrology Attribute for riverine project sites was comparable to that of ambient sites. Biotic Structure scores were 9% higher for riverine project sites than ambient condition. Physical Structure scores for riverine projects were 18% higher than ambient sites. Physical structure was also the attribute for which South Coast riverine project sites scored the highest.

DISCUSSION

South Coast Restoration Projects and Relationship to Ambient Condition

Evaluation of the overall ecological benefit associated with restoration activities requires application of standard approaches and tools that allow compilation and synthesis of findings across many wetlands and broad geographic areas. The use of rapid assessment in both probability-based surveys and as an element of individual restoration project monitoring provides a cost-effective mechanism to report on restoration effectiveness at a regional level. This integration can also generate important baseline information on condition of wetlands in a region to provide valuable context for site-specific monitoring and assessment.

The results of the probabilistic survey of the ambient condition of estuarine wetlands in the South Coast region showed that the Buffer and Landscape Context was the attribute for which the region's salt marshes scored the highest. This result was driven by the fact that a statistical design that reports on area percentages will most likely select sites from larger wetlands, even if that design is spatially balanced (Stevens and Olsen 1999). South Coast estuarine wetlands are characterized by small lagoons and river mouth estuaries that are more fragmented (by roads, railroads, levees, and developed areas). These sites tend to have muted tidal hydrology which typically results in lower species richness (Noss and Csuti 1994). This is reflected in the low Hydrology, Physical, and Biotic Structure scores for South Coast salt marshes compared to other regions of the State. There is a strong correlation between both Landscape Context and Biotic Structures scores with size, reflecting decreases in percent developed lands adjacent to wetlands as well as a well-established relationship between habitat area and plant species richness (Rosenzweig 1995).

In comparison, CRAM Index and attribute scores for South Coast estuarine project sites were 6 - 17% lower than mean ambient scores for the South Coast region. These differences can be attributed to a number of factors, including the size of project, its landscape context, and project age (maturity). For small restoration projects that are completely embedded in urbanized landscapes (e.g. Famosa Slough), it can be expected that these projects will receive low Buffer and Landscape Context scores in comparison to ambient sites. Because of the probability-based ambient survey design, ambient sites tend to be located in larger wetland patches, which would tend to elevate their Buffer and Landscape Context scores relative to projects. Furthermore, most ambient sites are probably "older" with more developed and complex plant communities and would score higher for the Biotic Structure attribute of CRAM. True differences are difficult to tease out without control of these confounding factors as well as a pre- and post-restoration baseline assessment. However, this study demonstrates the concept of how the use of low-cost rapid assessments as a mechanism to evaluate restoration program effectiveness. Future incorporation of rapid assessment into pre and post project monitoring at restoration sites, along with monitoring over time through the restoration trajectory will provide greater insight into the net effect of restoration actions relative to permitted wetland losses.

It is known that the size of wetlands (as well as their location and their shape) strongly influence all of the services that can provide. In general, as the size of a wetland increases, the amounts and kinds of services it can provide also increase. As wetlands become more abundant, their collective service capacity tends to increase, and the overall risk that their services will decline tends to decrease. This is because the negative effects of declining services in one wetland can be offset by other wetlands that provide the same services. The shapes of wetlands affect their services in a variety of ways. In essence, the more edge a wetland has relative to its aerial extent, the more it tends to interact with adjoining environments.

Increasing the amount of edge of an estuarine wetland, for example, tends to increase its chances to filter sediment and pollutants from incoming tides, to supply nutrients to outgoing tides, and to be colonized by species of intertidal plants and animals. Some species prefer to inhabit wetland edges, while others prefer interior areas of wetlands away from edges. Some of these species will not inhabit wetlands that have more edge than interior areas. In practical terms, any wetland is large enough and has the right shape if it tends to sustain the services expected of it despite the usual natural and unnatural threats. Wetlands are abundant when the threats against their services are more than offset by the amount of those services that they can collectively provide. There are many factors that control the particular kinds and levels of services provided by a particular wetland type. However, to provide all the services that are appropriate and needed, the ideal estuarine landscape is likely to have abundant, large, round, wetlands.

The results of the probabilistic survey of the ambient condition of perennial streams in the South Coast region also showed that the Buffer and Landscape Context was the attribute for which the region's streams scored the highest, but in comparison, riverine project sites scored low for this attribute. This probably a direct result of most projects being located in urbanized areas where the riparian continuity of the stream and its buffer has been compromised or fragmented. Mean CRAM Index and Attribute scores for riverine projects were either comparable to or higher than mean ambient condition. The project sites scored higher for all attributes with the exception of the Buffer and Landscape Context attribute. Again, this is probably related to the fact the riverine projects tend to be located in urbanized landscapes where riparian connectivity and buffer characteristics have been impacted by development. The low sample size of riverine project sites assessed with CRAM limits the ability to interpret the data and make further comparisons between project and ambient conditions.

Condition of South Coast Restoration Projects and Relationship to Stressors

Physical Structure was the attribute for which the South Coast's estuarine marshes scored the lowest. A wetland's physical structure can be affected by anthropogenic modifications to the tidal and freshwater hydrology, sediment transport, and geomorphology of the marsh, which results in reduced integrity of marsh physical structure (Day *et al.* 1989). Not surprisingly, dikes/levees were the most frequent and most severe stressor identified at all project sites. Dikes and levees can act to impound the wetland, restricting tidal exchange and extending the retention time of water on the wetland (Brockmeyer *et al.* 1997). This can lead to decreased topographic complexity, decreased plant diversity, increased retention of contaminants (Zedler and Callaway 2000, Fell *et al.* 1991, Fetscher *et al.* 2010). Sites bounded by levees or other water control structures that reduce the wetland tidal action can be expected to have lower scores for almost all metrics relative to other sites. For example, South Coast estuarine sites where this stressor was present had on average 15 point lower CRAM scores than sites where this stressor was absent.

While numerous historic and current land use impacts have led to reduced condition of South Coast wetlands, the results of the CRAM stressor checklist indicate three main management actions could potentially enhance region-wide wetland condition. As indicated earlier, historical levees and dikes that have modified tidal circulation have caused a general decline in estuarine wetland condition. In many cases, after new intertidal areas have developed outboard of one set of levees, new levees have been built to capture the newly formed areas. Much of the infrastructure that adjoins estuaries, including operational and abandoned railroads and highways, occupies levees or other engineered fills that cross intertidal areas. Careful removal, realignment, or re-engineering of these crossings so they no longer impede tidal circulation could be considered. Many of these crossings may require modification to accommodate rising sea levels and increased wave run-up; improved tidal exchange between estuarine wetlands and their estuaries could be considered as a design criterion, balanced with the cost of infrastructure improvements required for such projects.

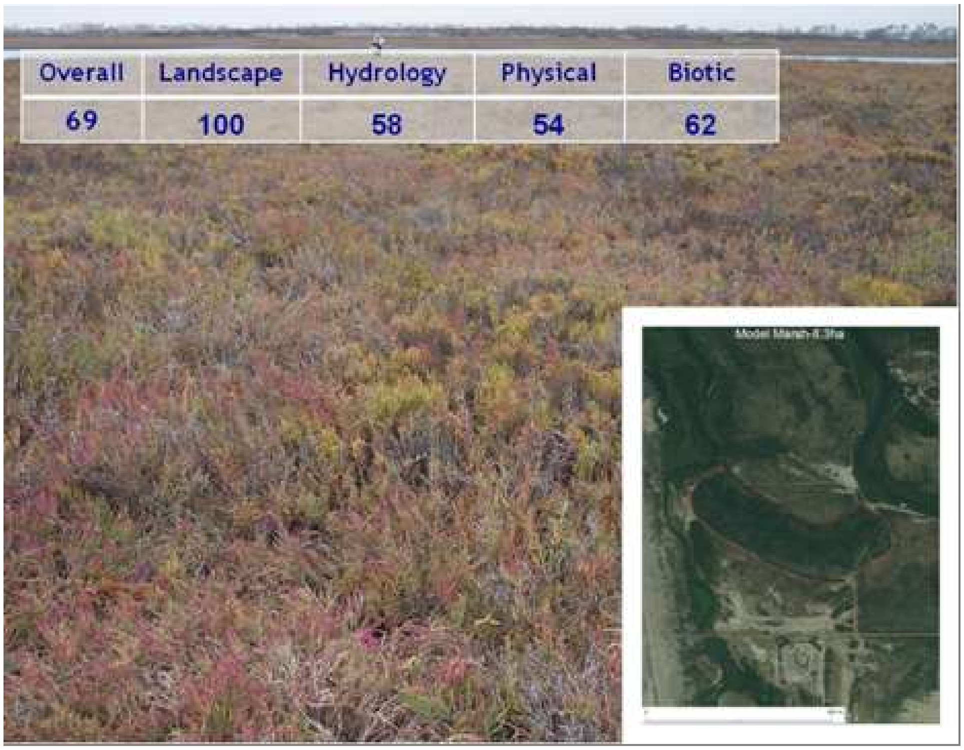
Numerous stressors affecting the condition of saline estuarine wetlands may originate in their watersheds or adjoining uplands. Results of the CRAM stressor checklist (coupled with office-based investigation and on-site observation) include the potential for excessive sediment supplies; excessive nutrients, pesticides and other chemical pollutants; and excessive predation. Decreases in water supplies due to upstream withdrawals and diversion or increases due to urban and agricultural runoff have the potential to alter the salinity regimes of many estuarine wetlands. Conversion of floodplains to agriculture and other development can reduce their ability to filter runoff and buffer estuaries from upstream contaminants (Grewell *et al*. 2007). Better management of urban and agriculture runoff through integration of Best Management Practices within and downstream of these lands has been documented to reduce contaminant inputs to these systems, reduce toxicity of water and sediments and to improve flood control (Day 1989). At the landscape scale, estuaries should be regarded as downstream extension of their watersheds. Changes in watershed management will help assure adequate supplies of clean water and sediment, improved tidal circulation between the wetlands and their estuaries, and adequate lands to accommodate estuarine transgression due to sea level (Grewell *et al*. 2007).

Using CRAM for Restoration Planning and Project Management

Results from South Coast project assessments with CRAM may be used for a variety of wetland project management purposes, including, but not limited to: 1) comparison of scores from different projects of the same wetland type, 2) pre-project surveys to identify the general management issues of a site before a project is undertaken, and, 3) periodic surveys at restoration and enhancement sites to document the changes in condition that occur on the site through time. When conducting project-based CRAM assessments, there are a number of important issues to consider (Appendix 7), especially if conducting CRAM at large project sites that require multiple CRAM Assessment Areas (Appendix 8).

One of the main values of using CRAM for project-based assessment is that it provides the ability to compare scores from different projects of the same wetland type. This ability to make comparisons based on a standardized assessment tool like CRAM provides context for interpretation of scores for specific projects. This concept can be illustrated through example using the two estuarine wetland projects, the Model Marsh restoration (Tijuana Slough, San Diego County) and the Mugu Treatment Ponds (Point Mugu Naval Air Weapons Station, Ventura, County; Figure 4 a and b).

a.



b.

Figure 4. CRAM scores for two estuarine wetland projects (Model Marsh (a) and Mugu Treatment Ponds(b)) illustrating how attribute scores can be interpreted inform wetland management discussions.

These two sites are approximately the same age and have similar CRAM index scores (69), but different CRAM attribute scores that immediately convey understanding about their condition. In the context of the ambient survey of estuarine wetlands, both sites fall into the second quartile of CRAM Index scores for the South Coast region. However, the causes of impairment for the two sites differ, and these management-relevant factors can be elucidated by examining the attribute scores. This comparison also reinforces the concept that identical CRAM index scores can be derived from different combinations of attribute scores, and it will often be necessary to refer to attribute scores (and sometimes individual metric scores) to interpret the meaning of the CRAM assessment.

The Model Marsh earned an overall index score of 69; but had higher scores for the Buffer and Landscape Context Attribute than Mugu because of its location within the larger Tijuana Slough Ecologic Reserve and the high condition of the surrounding buffer. Although the site is located adjacent to the estuarine waters of the Tijuana River, not far from the Pacific Ocean, it scored in the intermediate range for the Hydrology Attribute due to the source of the water (anthropogenic inputs), evidence of tidal muting, and hydrological restrictions in the form of levees encircling the restoration site. This site was found to have very low structural patch richness and topographic complexity, which was interpreted to be a consequence of excessive flood-borne runoff and sedimentation. However, the site received a higher score for the Biotic Structure attribute than the Mugu site, a consequence of the site's high percentage of native plant species, and marsh vegetation with more structural variation and complexity.

The Mugu Treatment Pond site also received an overall index score of 69, but received a slightly lower score for the Buffer and Landscape Context Attribute due to the slightly degraded condition of its buffer. It scored higher for the Hydrology mainly due to less tidal muting of the site. The Physical Structure Attribute also scored higher owing to the retention of substantial structural patch richness and moderate topographic complexity (probably related to the greater tidal prism experienced by the site). However, the Biotic Structure Attribute of the site was much lower than that of the Model Marsh, with lower plant diversity and less structural variation in biotic conditions.

Appropriate management concerns for these two sites might be identified based on the findings of the CRAM assessment and the stressor checklist. The Model Marsh site might include management of the stressors to site's hydrology while increasing efforts to protect water quality in its vicinity and to prevent sedimentation from upstream land uses. An additional management focus might be to protect the site from invasion by exotic plant species while removing the few individuals of exotic species that have colonized the site so far, while protecting the ecological dynamics that support native species. Appropriate management direction for the Mugu Treatment Ponds probably would not include substantial efforts to protect the site from additional sedimentation, and there would be less focus to enhance the site's overall hydrology. Management goals might include efforts to increase biotic complexity, such as through additional vegetation management and planting efforts. Management actions might well include efforts to remove some or all of the dominant invasive species in combination with efforts to establish native salt marsh species on and near the site.

CRAM assessment can also be used to document the improvement in acreage and condition that a restoration project provides (Figure 5). Talbert Marsh, formerly a remnant estuarine wetland, was restored to full tidal action in 1989, providing 27 acres of estuarine habitat, including 15 acres of estuarine wetland. The post-restoration CRAM assessment of this project provided an average index score of 56. Since a pre-restoration CRAM baseline was not available for this project, an office based CRAM assessment of an adjoining piece of remnant wetland comparable to the pre-project conditions of the Talbert site (Brookhurst Marsh) was conducted. Assuming that the Talbert marsh pre-restoration baseline was equivalent to that of the adjacent remnant wetland, Talbert Marsh has likely experienced a 31 percentage point increase in condition due to the restoration of full tidal action.

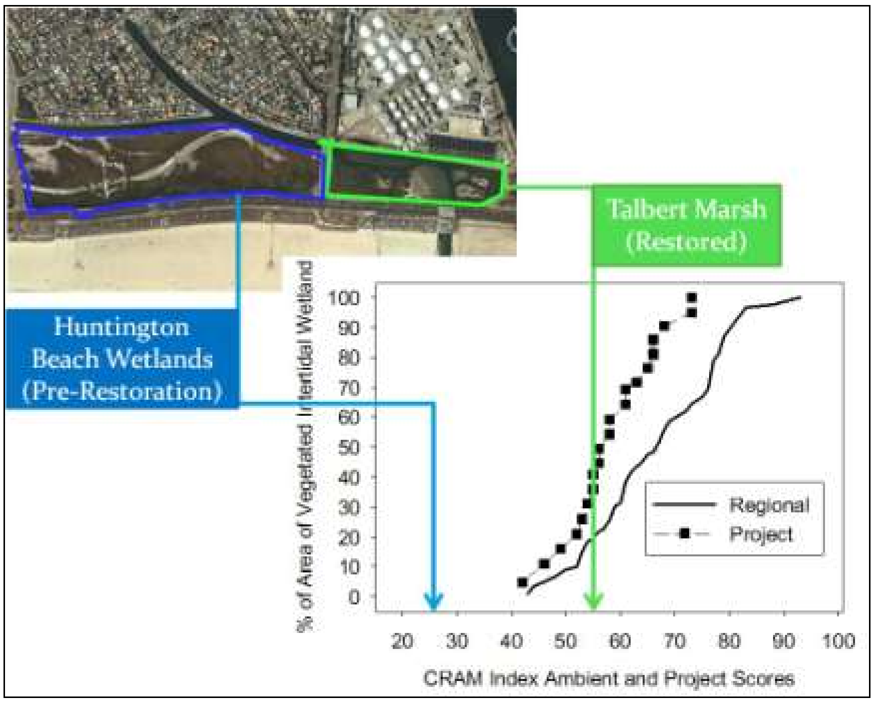


Figure 5. Improved condition of an estuarine wetland due to restoration of full tidal action. The pre-project CRAM index score for Talbert Marsh Restoration Project is presented by the score for Brookhurst Marsh because both sites were historically part of the same larger estuarine wetland.

Using CRAM for Pre-Project Assessment of Condition

Pre-project CRAM surveys can identify general management issues before a project is undertaken. Pre-restoration CRAM assessments were conducted at several large WRP project acquisition sites (e.g., Buena Vista Lagoon, Ormond Beach, Bryant Property at Los Cerritos Wetlands). The results of these assessments provide valuable baseline information on baseline conditions that can be referenced as restoration activities are initiated and changes in CRAM scores tracked through the restoration process.

As an example, the Ormond Beach property is a large acquisition for the WRP. The wetlands here once totaled 1,000 acres, but due to conversion from agriculture and development, approximately 250 acres remain (Josselyn and DeGraff 2007). These wetland areas historically were part of a salt marsh and brackish water lagoon system. These lagoons were located behind a narrow sandy barrier beach of low dunes and were fed by water from creeks and surface flow over the plain, and inundated by salt water during high tides or storms. Periodically, the barrier beach was breached by discharge of meandering river flows or the action of winter storm waves. Some of the lagoons likely remained open to the ocean for a period after the breaching event. Tidal connections have likely always been muted by a beach sill. Some hyperhaline or euryhaline wetlands may have formed naturally. The site probably received most of its water as runoff from inland sources and from the site's high water table (Josselyn and DeGraff 2007).

Wetland habitat was present on the two separate parcels that were assessed with CRAM, the 309-acre Nature Conservancy (TNC) parcel and the 265-acre State Coastal Conservancy (SCC) parcel south of Southland Sod and bordering Ormond Beach (other parcels with wetland habitat had not been acquired at the time of the CRAM assessments). Drainage and development have left these wetlands hydrologically isolated, significantly reduced in size, and type converted from their historic condition. General wetland types assessed with CRAM included formerly tidal salt marshes, and seasonally inundated brackish and freshwater marsh. Most areas may suffer from hypersalinity due to the lack of tidal flushing.

CRAM scores for most of the sites assessed fell into the two lowest quartiles of CRAM scores. Based on the low condition scores, it is clear that the site could benefit from specific types of restoration activities. Biologically, the remaining wetlands onsite suffer from a general lack of vegetation management to conserve natural resources (including lack of management to control invasive plants). On the TNC parcel, there was substantial evidence of pesticide application or vector control activities. Dike/levees, mosquito control ditches, and flow diversions/obstructions were recorded as sever stressors to the site's hydrology. From a physical standpoint, some of the CRAM assessment areas suffered from grading/ compaction and there was indication that sites may be impaired due to pesticides or trace organics from runoff.

Using CRAM to Assess Change in Wetland Condition Over Time

The Carpinteria Creek Bliss Fish Passage Project (Santa Barbara County) illustrates how CRAM can be used to evaluate the performance of a fish passage improvement project for stream-based restoration. In 2008, a pre-restoration CRAM assessment was conducted along Carpinteria Creek located north of the City of Carpinteria. This WRP stream restoration project involved the removal of a low-flow or "Arizona" crossing, considered one of the most significant migration barriers to endangered southern steelhead (*Oncorhynchus mykiss*) in the Carpinteria Creek watershed. Restoration activities at this site also included various types of channel stabilization activities, grading and filling of the stream bed with native cobble and creation of pools and riffles, and the installation of a bridge.

This project received a pre-restoration CRAM index score of 62, which places it in the third quartile of possible CRAM index scores for perennial wadeable streams. The site was characterized by severe evidence of channel degradation, including the presence of a large nick point at the Arizona crossing where active headward (upstream) erosion of the bed was observed.

Restoration commenced at this site a soon after the CRAM assessment was conducted. Although a CRAM assessment was not conducted at this site post-restoration, it is possible to forecast CRAM scores for this site. Because this project removed an instream flow barrier, and improved the channel' physical structure and overall stability, the CRAM metrics comprising the Hydrology Attribute (i.e., Channel Stability and Hydrologic Connectivity) and Physical Structure Attribute (Physical Patch Types and Topographic Complexity) would be the metrics most likely to be influenced by these types of restoration activities. Pre-restoration, this site received a 58 and 75 for the Hydrology and Physical Structure attribute, respectively. Given the type of restoration activities that were conducted at the Bliss site, an immediate change in CRAM scores for these metrics would not be expected to occur immediately (1 year post-restoration). However, over time (2 - 3 years post-restoration), it is not unreasonable to predict changes in the scores. For example, removal of the Arizona crossing would potentially reduce the amount of channel degradation/ incision and eventually lead to an improvement of the topographic complexity through the assessment area. In this way, CRAM can be a valuable tool to set realistic restoration goals or targets by prioritizing projects based on their likelihood of achieving some measurable standard of "success".

When using CRAM for restoration planning purposes, it is important to consider the potential challenges of conducting CRAM in wetlands that have been modified from their historic type (i.e., type conversion). If a wetland has been converted from one wetland type to another via restoration activities, the pre- and post-project CRAM scores will not be directly comparable because they are based on different CRAM modules. If CRAM is being used to help evaluate alternative designs or to provide baseline data for a restoration that anticipates changing wetland types (e.g., a riverine system has been converted to a depressional wetland), then the CRAM module for the anticipated future wetland class should be used, as well as the CRAM module for the current type. The CRAM module for the existing wetland type should be used for evaluation of potential impacts to the current wetland (CWMW 2009).

The CRAM assessments conducted at the Huntington Beach Wetlands (Orange County) highlight this issue of wetland type conversion and the inherent complexities of conducting CRAM in highly modified wetland systems.. When CRAM assessments were conducted on Brookhurst Marsh in 2008, it was a remnant estuarine wetland where all tidal hydrology had been eliminated. Brookhurst Marsh essentially functioned as a depressional system, even though typical salt marsh plants still dominated the vegetated portion of the wetland. The site received a CRAM index score of 60 based on the CRAM depressional module (Table 13a). However, because the ultimate restoration goal was to restore the wetland to full tidal action (as was done for nearby Talbert Marsh), a parallel assessment using the perennial tidal estuarine CRAM module was also conducted. Using this module, the site received the slightly lower CRAM Index score of 53. In 2010, Brookhurst Marsh was restored to full tidal action. Although an assessment using the CRAM module for perennial tidal estuaries has not been conducted post-restoration, CRAM metric scores can be forecasted to determine the site's condition since being restored (Table 13b).

Table 13a. Example of using CRAM for restoration planning: Brookhurst Marsh (Orange County). Pre-project CRAM assessment scores for the wetland's current type (pre-restoration) and anticipated type (post-restoration).

CRAM Attribute	CRAM Metric and Submetrics	Pre-restoration (depressional)	Pre-restoration (estuarine)
Buffer and Landscape Context	Landscape Connectivity	6	6
	Buffer :		
	Percent of AA with Buffer	12	12
	Average Buffer Width	9	9
	Buffer Condition	9	9
Hydrology	Water Source	3	3
	Hydroperiod	12	3
	Hydrologic Connectivity	6	6
Physical Structure	Structural Patch Richness	3	3
	Topographic Complexity	6	6
Biological Structure	Plant Community:		
	No. of Plant Layers Present	6	9
	No. of Co-dominants Plant Species	3	9
	Percent Invasion	12	12
	Horizontal Interspersion and Zonation	9	6
	Vertical Biotic Structure	12	12
Overall Index Score		**60**	**53**

Table 13b. Example of using CRAM for restoration planning: Brookhurst Marsh (Orange County). Projected CRAM assessment score scenarios (post-restoration). Yellow cells indicate forecasted improvement of metrics over time.

CRAM Attribute	CRAM Metric and Submetrics	1 year forecasted post-restoration (estuarine)	3-5 year forecasted post-restoration (estuarine)
Buffer and Landscape Context	Landscape Connectivity	6	6
	Buffer :		
	Percent of AA with Buffer	12	12
	Average Buffer Width	9	9
	Buffer Condition	9	**12**
Hydrology	Water Source	**6**	6
	Hydroperiod	**9**	9
	Hydrologic Connectivity	6	6
Physical Structure	Structural Patch Richness	**6**	**9**
	Topographic Complexity	6	**9**
Biological Structure	Plant Community:		
	No. of Plant Layers Present	6	**9**
	No. of Co-dominants Plant Species	**6**	**9**
	Percent Invasion	12	12
	Horizontal Interspersion and Zonation	9	**12**
	Vertical Biotic Structure	12	**12**
Overall Index Score		**64**	**73**

The above example demonstrates how CRAM metrics can be used to help inform restoration progress. The best achievable alternative state for each metric (i.e., the "A" condition) represents the theoretical optimum condition for a specific wetland type. However, certain metrics may be more sensitive to restoration. Furthermore, the time required post-restoration in which to observe an improvement in condition will vary based on the activities conducted on a site. For example, the Number of Co-dominant Plant Species on a site could be immediately affected by restoration or enhancement activities if plant species richness is increased through revegetation efforts. Likewise, a restoration that specifically targets invasive plant removal could immediately impact the number of invasive co-dominant species. It should be noted that a complete removal of all plants at a project site (including invasive species) would lower most of the metrics comprising the Biotic Structure Attribute of CRAM, so restoration activities should be conducted with this in mind if CRAM is being used to assess the progress of the restoration.

Improvement in CRAM scores for the other CRAM metrics or submetrics may not be immediately apparent for newly completed restoration projects. For example, the Number of Plant Layers Present and the other metrics of the Biotic Structure Attribute (Horizontal Interspersion/Zonation and Vertical Structure) may require a longer time period for an improvement in scores to be observed. . Similarly, the vertical complexity of a wetland's vegetation tends to increase over time as a site's vegetation matures. Therefore, it could be expected that older, more established restoration or enhancement sites would score higher for this metric than recently restored sites.

Hydrology is considered the most important direct determinant of wetland functions (Mitch and Gosselink 1993). Therefore, any opportunities to improve aspects of the CRAM Hydrology attribute (e.g., water source, hydroperiod, hydrologic connectivity), should be prioritized for restoration activities. The physical structure of a wetland is largely determined by the magnitude, duration, and intensity of water movement. In tidal marshes, for example, the spatial distribution of plants and animals closely corresponds to patterns of tidal inundation or exposure (Sanderson *et al*. 2000). The statewide ambient survey of estuaries demonstrated that sites where dikes, levees, culverts or other flow obstructions were identified as a severe hydrological stressors had on average 10-15 point lower CRAM index scores than sites where these stressors were was absent (Sutula *et al.* 2008). Sudol and Ambrose (2002) found that one of the greatest causes of failed wetland mitigation or restoration projects is inadequate or inappropriate hydrology.

The Buffer and Landscape Context and Hydrology attributes of CRAM are particularly influenced by landscape patterns. The metrics comprising these attributes may be immutable with restoration in highly urbanized landscapes where limited opportunities exist to increase the size or extent of a project's surrounding buffer or its connectivity with other wetland areas. Therefore, the analysis of spatial patterns in regards to these two metrics is critical to understand watershed-scale disturbances that affect these characteristics of a site, as well as landscape limitations on improving their condition. This analysis would particularly help to identify opportunities (typically rare in highly urbanized areas) in which the Buffer/Landscape Context and Hydrology attributes could be protected, maintained, or even improved via habitat acquisition, restoration or enhancement activities in other portions of the watershed.

THE FUTURE OF CRAM FOR WETLAND RESTORATION PLANNING

The statewide ambient assessment of perennially tidal estuaries demonstrated that differences in CRAM scores within and among regions must be interpreted with the understanding that natural gradients in geomorphology, hydrology, ecology, and anthropogenic land uses, will influence to some extent the "reference" or "best attainable" wetland condition for a region (Brinson and Rheinhardt 1996). Inter-regional comparisons of CRAM scores should be made with this distinction in mind. For regions like the highly urbanized South Coast, a restoration project may appear to score low with CRAM from the statewide context, but from the perspective of the South Coast region, the condition of these projects could be interpreted differently (Figure 6). This is a particularly germane for determining if a restoration is "successful" and results in an improvement of wetland condition.

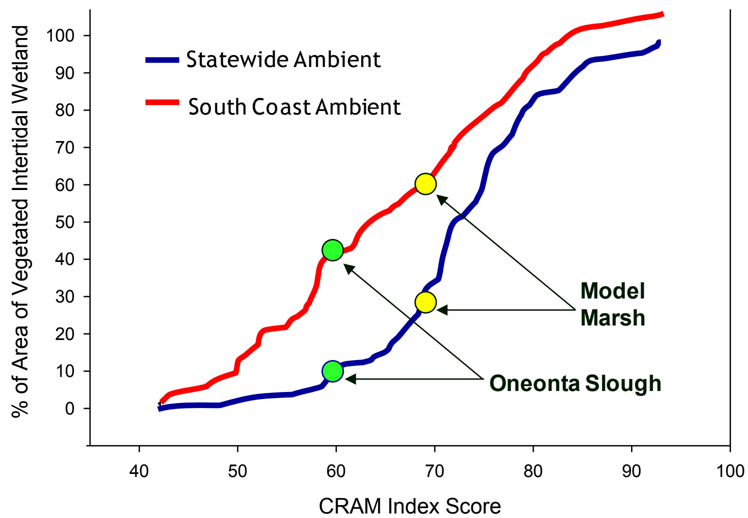


Figure 6. Interpreting mean CRAM Index scores for estuarine restoration projects in the context of statewide and regional conditions. In this example, the mean Index scores for the Model Marsh and Oneonta Slough projects (paired yellow and green dots) are plotted on the statewide (blue line) and South Coast (redline) ambient distribution of CRAM Index scores. Although scores are the same, their meaning differs based on the context in which they are viewed.

In order for these differences to be clearly understood for restoration planning, it is crucial to incorporate reference networks, performance curves, and watershed profiles into the planning and design of mitigation and restoration projects. These are all essential elements for understanding the potential trajectory" of a wetland project. Reference sites provide context for tracking the progress of restoration sites relative to natural variability and/or anthropogenic effects and can be used to gauge success and/or compliance with wetland regulations and policies. Used in combination with ambient survey data, reference sites can be used to establish science-based performance criteria and trajectories for projects. Phase 1 of the development of a network of reference wetlands will be complete by the end of 2011. This phase will have identified a small number of reference standard sites for various wetland types for various regions of California. This network of regionally-based reference sites will help to establish realistic targets for wetland restoration and mitigation efforts, interpret site-specific monitoring data, compare impacted and degraded sites, and make cross-project comparisons. Over time, the regional networks will illustrate the full range of conditions for each CRAM metric, including the best attainable condition for a region.

Performance curves forecast how the condition of projects can increase over time. Although the State has developed the tools necessary for creating performance curves (i.e., EPA's Level 1-2-3 Wetland Assessment Framework), the curves themselves have not been built. A project to develop performance curves based on CRAM for perennial estuarine (San Francisco Bay region) and coastal riverine wetlands (South Coast region) was initiated in the summer of 2011. Regional reference sites will be incorporated to assess the curves with respect to best attainable condition.

Landscape or watershed "profiles can be developed using CRAM in combination with Level 1 and 3 data. These profiles can be used to address management questions about landscape or watershed condition as a whole. Landscape and watershed profiles provide a better understanding of the distribution of wetland types within a watershed and their relationship to landscape position. In this context, they could provide a means to determine the location and type of wetlands found in unimpacted landscapes (i.e., the location potential reference wetland sites). There are three primary applications of the landscape/watershed profile concept. One is to assess the ambient overall condition (or "health") of a landscape, in which case the profile is usually restricted to Level 1 data plus ambient surveys of overall condition based on Level 2 data. Other applications include setting landscape-level performance standards and planning for restoration or mitigation activities. For example, CRAM data collected at WRP restoration sites can be used in the development of performance curves for restoration sites. This would help to scale expectations for restoration or mitigation efforts. The expectations could then be calibrated for wetland size and shape, landscape position, surrounding land uses, hydrology, and the age of the project.

It is important to reiterate that CRAM is just one component of a broader wetland assessment toolkit that has been developed in California. Although CRAM was applied as a stand-alone monitoring tool for the purposes of this demonstration, in most cases it will need to be used in conjunction with other, more intensive methods to support the assessment of wetland condition for decision-making purposes. Although the inherent limitations of all RAMS must be recognized, their integration with probabilistic survey designs provides a means to make unbiased estimates of wetland condition. RAM results can also be used to help focus and prioritize the need and location for more intensive assessments. Thus, the relatively low cost of RAMs makes them useful for regional wetland assessments, as well as the mechanism through which regional wetland management and restoration program effectiveness can be evaluated (Kentula 2007).

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APPENDIX 1. SUMMARY OF INDIVIDUAL CRAM METRICS

CRAM Attributes and stressor checklists are the same for all wetland types and regions of the State. However, because these wetland types are very different from each other in terms of their form and structure, some CRAM Metrics vary based on wetland type to reflect these differences. Below is a summary definition of each CRAM Metric. For a complete description, rationale, and an indication of the metric's sensitivity to seasonal variability in wetland condition refer to Collins *et al*. (2008) or the appropriate field book for the particular wetland type. All documents are available at www.cramwetlands.org.

Buffer and Landscape Context Attribute

Landscape Connectivity

Assesses an area's spatial association with other areas of aquatic resources, such as other wetlands, lakes, streams, etc. For riverine systems, this metric is scored as the continuity of the riparian corridor over a prescribed distance upstream and downstream of the CRAM Assessment Area (AA).

Buffer

Assesses as the amount (percent), size (width), and condition of the buffer surrounding the assessment area, or for riverine systems, on both sides of the channel. Condition is assessed according to the extent and quality of its vegetation cover and the overall condition of its substrate.

Hydrology Attribute

Water Source

Assesses the kinds of direct inputs of fresh water into the AA during the dry season. This metric also accounts for diversions of water from the AA that affect the extent, duration, and frequency of saturated or ponded conditions within the AA.

Hydroperiod or Channel Stability

Assesses the characteristic frequency and duration of inundation or saturation of a wetland during a typical year. For riverine systems, this is a measure of channel stability and assessed as the degree of channel aggradation (i.e., net accumulation of sediment on the channel bed causing it to rise over time) or degradation (i.e., net loss of sediment from the bed causing it to be lower over time) using a checklist of indicators.

Hydrologic Connectivity

Assesses the ability of water to flow into or out of the wetland, or to accommodate rising flood waters without persistent changes in water level that can result in stress to wetland plants and animals. This Metric is scored by assessing the degree to which the lateral movement of flood waters or the associated upland transition zone of the AA and its encompassing wetland is restricted by unnatural features such as levees, sea walls, or road grades. For riverine systems, this Metric is assessed based on the degree of channel entrenchment, or the inability of flows in a channel to exceed the channel banks.

Physical Structure Attribute

Structural Patch Richness

Assessed as the number of different obvious types of physical surfaces or features that may provide habitat for aquatic species. The rating for this metric is based on the percent of total expected patch types for a given type of aquatic resource type.

Topographic Complexity

Assessed as the variety of elevations within a site due to physical, abiotic features and elevations gradients (macro-complexity) and the spatial arrangement and interspersion of individual patch types within these elevations (micro-complexity).

Biotic Structure Attribute

Plant Community Composition

Scored as the average of three submetrics: the number of plant layers, dominant plant species richness, and the percent of co-dominant species that are invasive.

Horizontal Interspersion and Zonation

Assesses the variety and interspersion of plant zones (i.e., plant monocultures or multi-species associations arrayed along gradients of elevation, moisture, etc.). Interspersion is essentially a measure of the amount of edge between plant zones.

Vertical Biotic Structure

Assessed as the overall number of plant layers, their spatial extent, and their vertical overlap relative to the expected conditions. The same plant layers used to assess the Plant Community Composition Metric are used to assess Vertical Biotic Structure.

APPENDIX 2. LIST OF ALL POSSIBLE STRESSORS FOR EACH OF THE FOUR ATTRIBUTES IN THE CRAM STRESSOR CHECKLIST (COLLINS *ET AL.* 2008)

HYDROLOGY ATTRIBUTE:
Point Source discharges (publicly owned treatment works, other non-stormwater discharge)
Non-point Source discharges (urban runoff, farm drainage)
Dredged inlet/channel
Dike/levees
Groundwater extraction
Weir/drop structure, tide gates
Dams (reservoirs, detention basins, recharge basins)
Flow diversions or unnatural inflows
Flow obstructions (culverts, paved stream crossings)
Engineered channel (riprap, armored channel bank, bed)
PHYSICAL STRUCTURE ATTRIBUTE:
Filling or dumping of sediment or soils*
Plowing/discing*
Grading/ compaction*
Resource extraction (sediment, gravel, oil and/or gas)
Excessive sediment or organic debris from watershed
Vegetation management
Excessive runoff from watershed
Pesticides or trace organics impaired**
Heavy metal impaired **
Nutrient impaired**
Bacteria and pathogens impaired**
Trash or refuse
BIOTIC STRUCTURE ATTRIBUTE:
Predation and habitat destruction by non-native vertebrates
Biological resource extraction or stocking (fisheries, aquaculture)
Treatment of non-native and nuisance plant species
Removal of woody debris
Tree cutting/sapling removal
Mowing, grazing, excessive herbivory (within assessment area)
Pesticide application or vector control
Excessive human visitation
BUFFER AND LANDSCAPE CONTEXT ATTRIBUTE:
Urban residential
Industrial/commercial
Dryland farming
Intensive row-crop agriculture
Dairies
Rangeland (livestock rangeland also managed for native vegetation)
Military training/Air traffic
Commercial feedlots
Ranching (enclosed livestock grazing or horse paddock or feedlot)
Orchards/nurseries
Transportation corridor
Active recreation (off-road vehicles, mountain biking, hunting, fishing)
Sports fields and urban parklands (golf courses, soccer fields, etc.)
Passive recreation (bird-watching, hiking, etc.)
Physical resource extraction (rock, sediment, oil/gas)
Biological resource extraction (aquaculture, commercial fisheries)

*not applicable to restoration areas ** includes point-source or non-point source pollution

APPENDIX 3. SUMMARY INFORMATION OF SOUTH COAST WRP PROJECT SITES ASSESSED WITH CRAM

Project Name: Arroyo Burro Estuary and Mesa Creek Restoration

County: Santa Barbara

WRP Tier: 1

Local Lead: City of Santa Barbara

Status: Restoration completed in 2008

Description: Restoration of Arroyo Burro Estuary and Mesa Creek expanded coastal estuary wetland habitat by over 6,000 square feet and will daylight a section of Mesa Creek that is currently in a culvert resulting in over 6,000 square feet of additional wetland habitat. The project will remove a number of invasive non-native plants including arundo and pampas grass and will increase plant diversity through the installation of 5,000 native plants and trees. In addition, the project will enhance habitat for the Tidewater goby and Southern Steelhead trout. Trails and a footbridge over Mesa Creek will also be installed improving access, wildlife viewing and educational opportunities.

Project Name: Carpinteria Creek Watershed Restoration: Bliss and Cate School Fish Passage Improvements

Location: Carpinteria Creek, Santa Barbara County

Coastal Conservancy Program Category: Resource Enhancement

WRP Tier: 1

Coastal Conservancy Staff Recommendation:
http://www.scc.ca.gov/webmaster/ftp/pdf/sccbb/2005/0506/0506Board13a_Carpinteria_Creek_Watershed.pdf

Local Lead: Community Environmental Council (CEC)

Status: Completed in 2008

Description: Project involved the removal of two low-flow or "Arizona" crossings at two locations along Carpinteria Creek to improve steelhead migration and habitat. These improvements served as the first phase of a comprehensive effort to restore and promote steelhead recovery in the Carpinteria Creek watershed.

Project Name: Devereux Slough Restoration

Location: Coal Oil Point Reserve, Santa Barbara County

Coastal Conservancy Program Category:

WRP Tier: 1

Coastal Conservancy Staff Recommendation:

Local Lead: University of California, Santa Barbara

Status: Project completed in September 2004

Description: The project will implement a restoration plan that is included in the Coal Oil Point Reserve Management Plan. The project will remove exotic plant species, revegetate habitat areas and develop a monitoring protocol for seasonally tidal wetlands. The project includes restoration of uplands adjacent to the Devereux Slough.

Project Name: West Storke Wetland Restoration
Location: Santa Barbara County
Coastal Conservancy Program Category:
WRP Tier: Small grants program
Coastal Conservancy Staff Recommendation: Resource Enhancement
Local Lead: University of California, Santa Barbara
Status: Project completed in 2007
Description: In 2006-2007, with funding provided by the Wetland Recovery Project and Environmental Now, CCBER sought to restore an area within the West Storke Wetlands that had become degraded by added fill. Soils in this area were re-graded to a lower, more natural elevation that would restore natural hydrology, thus providing resistance to non-native invasions and allowing native wetland species to thrive. Following grading, the area was planted with native salt marsh and freshwater wetland species.

Project Name: Ormond Beach Wetlands Acquisition, Part 2
Location: City of Oxnard, Ventura County
Coastal Conservancy Program Category: Resource Enhancement
WRP Tier: 1
Local Lead: Coastal Conservancy
Status: In June 2002, the Coastal Conservancy acquired 265 acres formerly owned by Southern California Edison. In June 2006, the Nature Conservancy completed purchase, with state funding, of 275 acres from Metropolitan Water District (MWD).
Description: Acquire in fee or through conservation easements, the privately owned portions of the Ormond Beach wetlands for restoration of wetlands and related habitat.

Project Name: UCSB Campus Lagoon Enhancements
Location: UCSB Campus Lagoon, Santa Barbara County
Coastal Conservancy Program Category:
WRP Tier: 2
Coastal Conservancy Staff Recommendation:
Local Lead: University of California, Santa Barbara
Status: Project completed.
Description: Enhance approximately 2 acres of salt marsh and sand dune habitat adjacent to the UCSB Campus Lagoon, and prepare restoration plans for three additional areas around the lagoon. Primary activities include removal of exotic species, revegetation, and trail and road improvements.

Project Name: Malibu Lagoon Habitat Enhancement Program
Location: Malibu Lagoon State Park, City of Malibu, Los Angeles County
Coastal Conservancy Program Category: Resource enhancement
WRP Tier: 1
Coastal Conservancy Staff Recommendation:
Local Lead: Resource Conservation District of the Santa Monica Mountains
Status: Phase 1 completed in 2008
Description: Enhance tidal circulation and enhancing wildlife habitat at Malibu Lagoon by enhancing as recommended in the 1999 Malibu Lagoon enhancement plan. Heal the Bay and the RCD of the Santa Monica Mountains will work with State Parks to implement the project. The first actions involved preparation of restoration designs to reconfigure tidal channels in two areas of Malibu Lagoon to enhance tidal circulation, including 1.2 acres on the east side of the lagoon and 16.1 acres on the west side of the lagoon.

Project Name: Bryant Property Acquisition Los Cerritos Wetlands
Location: City of Long Beach, Los Angeles County
Coastal Conservancy Program Category: Resource Enhancement and Public Access
WRP Tier: 1
Coastal Conservancy Staff Recommendation:
http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2006/0604/0604Board03_Bryant_Property_Acquisition.pdf
Local Lead: Trust for Public Lands
Status: Property purchased in 2006.
Description: Acquisition the 85-acre Bryant property which straddles the San Gabriel River.

Project Name: Huntington Beach Wetlands Restoration
Location: Huntington Beach Wetlands, City of Huntington Beach, County of Orange
Coastal Conservancy Program Category: Resource Enhancement
WRP Tier: 2
Coastal Conservancy Staff Recommendation:
http://www.scc.ca.gov/webmaster/ftp/pdf/sccbb/2004/0403/0403Board08_Huntington_Beach.pdf
Local Lead: Huntington Beach Wetlands Conservancy
Status: Restoration of full tidal influence to Talbert marsh was completed in 1989. Brookhurst Marsh restoration and channel dredging projects were completed in 2009. Recreation of the historical marsh channels and restoration of full tidal influence to Magnolia Marsh were completed in March 2010.
Description: The purpose of the project is to evaluate the engineering, environmental, and economic feasibility of restoration alternatives within the Huntington Beach Wetlands ecosystem, and then develop a framework for coordinated restoration within the entire wetland ecosystem.

Project Name: San Joaquin Marsh Enhancement - Phase II Implementation
Location: San Joaquin Marsh, City of Irvine, Orange County
Coastal Conservancy Program Category:
WRP Tier: 2
Coastal Conservancy Staff Recommendation:
Local Lead:
Status: Project completed in 2010.
Description: Enhancement of the approximately 120 acres of a perennial depressional marsh.

Project Name: Goleta Slough Tidal Restoration Demonstration Project
Location: Goleta Slough Ecological Reserve, City of Goleta, Santa Barbara County
Coastal Conservancy Program Category: Resource Enhancement
WRP Tier: 2
Coastal Conservancy Staff Recommendation:
http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2006/0405/0405Board04_Goleta_Slough.pdf
Local Lead: Land Trust for Santa Barbara County
Status: Project completed in 2006.
Description: This project will enhance and expand wetland habitat value throughout the 34.41 acres owned by CDFG in the Goleta Slough Ecological Reserve by removing non-native plant species; improving hydrologic conditions to sustain wetlands; removing man-made features; enhancing upland habitats adjacent to wetlands and providing for future tide circulation opportunities. It will be designed to accommodate restored tidal action as part of a subsequent phase.

Project Name: Buena Vista Lagoon Restoration Plan
Location: Cities of Carlsbad and Oceanside in northern San Diego County
Coastal Conservancy Program Category: Resource Enhancement.
WRP Tier: 1
Coastal Conservancy Staff Recommendation:
http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2004/0606Board17_Buena_Vista_Lagoon.pdf
Local Lead: Department of Fish and Game
Status: DFG selected the tidal alternative as the proposed action for the purposes of CEQA based on review of the feasibility study. Preliminary engineering design is underway.
Description: Develop consensus on the preferred alternative for restoration of Buena Vista Lagoon and preliminary design plans for the restoration. The Buena Vista Lagoon Restoration Feasibility Study outlined three basic options for lagoon restoration:1) maintain the lagoon primarily as a freshwater system; 2) restore tidal circulation to the maximum extent possible; or 3) restore tidal circulation to the lagoon’s western basin. The Feasibility Study was completed in spring of 2006 and the next phase is to develop preliminary engineering and conducting the environmental impact analysis on the proposed restoration.

Project Name: Buena Vista Creek Acquisition, Sherman Parcel
Location:
Coastal Conservancy Program Category:
WRP Tier: 2
Coastal Conservancy Staff Recommendation:
Local Lead: County of San Diego
Status: Property acquired in 2006.
Description: Acquire approximately 133.8 acres of land along Buena Vista Creek.

Project Name: Solstice Creek

Location: Solstice Creek Canyon, a portion of the Santa Monica Mountains National Recreation Area in the City of Malibu, Los Angeles County

Coastal Conservancy Program Category: Resource Enhancement

WRP Tier: 1

Coastal Conservancy Staff Recommendation:
http://scc.ca.gov/webmaster/ftp/pdf/sccbb/2006/0604/0604Board18G_Solstice_Creek_Fish_Passage.pdf

Local Lead: National Park Service

Status: The seven fish passage barriers located on the stream within the Santa Monica Mountains National Recreation Area were removed in fall 2006.

Description:. Project to remove fish passage barriers and restore habitat conditions to facilitate passage for southern steelhead trout in the Solstice Creek.

Project Name: Malibu Lagoon Restoration and Enhancement

Location: Malibu Lagoon State Park, City of Malibu

WRP Tier: 1

Local Lead: California Department of Parks and Recreation

Status: Implementation of the first phase, relocation of the existing parking lot, was completed in April 2008. Final design and permitting for Phase 2 is expected to be complete in spring 2010. Implementation of the second phase, lagoon restoration, will be ready to begin in summer 2011 depending on availability of funds.

Project Description: Restore and enhance the ecological structure and function of Malibu Lagoon by increasing circulation and enhancing wetland habitat. Phase 1 of the Restoration and Enhancement Plan included relocation and redesign of the existing public parking and staging areas to maximize habitat restoration area in Phase 2 and to improve water quality in the Lagoon through implementation of BMPs. Phase 2 involves restoration of the lagoon, including re-contouring western lagoon channels, enhancing circulation in the lagoon, habitat enhancement and providing improved educational and recreational opportunities for the public.

Project Name: Ballona Wetlands Restoration Planning

Location: Ballona Wetlands, City of Play del Rey

WRP Tier: 1

Local Lead: Department of Fish and Game

Status: Feasibility analysis of the conceptual restoration alternatives was recently completed. Baseline data collection is underway and environmental analysis of the proposed project alternatives will begin when bond funding is available.

Project Description: Develop and evaluate restoration alternatives for all of the Ballona lands owned by the State of California (600 acres). Consistent with the WRP Regional Strategy, planning will include connected wetlands within the landscape context. The restoration plan will develop and analyze a range of alternatives to restore and enhance a mix of wetland habitats that will benefit endangered and threatened species as well as other migratory and resident species. This project will collect baseline data, develop project alternatives, conduct feasibility analysis and complete environmental impact analysis for restoration of the state owned property.

Project Name: San Joaquin Marsh Enhancement - Phase II Implementation

Location: Irvine, CA

WRP Tier: 2

Local Lead: University of California, Irvine

Status: Planning and permitting are completed. Construction will be phased based on available funding and may commence in summer 2010.

Project Description: Enhancement of approximately 120 acres of perennial marsh. Historically, the perennial marsh contained open water areas and channels. The extent and depth of the open water areas has significantly decreased due to gradual accumulation of sediment and organic matter and subsequent encroachment of cattails. Except for a few remaining open water areas, the marsh has become predominantly a monoculture of cattails.

APPENDIX 4A. SUMMARY OF CRAM METRICS, ATTRIBUTES, AND INDEX SCORES FOR THE 15 WRP PROJECTS BY ASSESSMENT AREA.

	Buffer and Landscape Context						Hydrology					Physical Structure				Biotic Structure							Index Score
Site Name and AA No.	Landscape Connectivity	% Buffer	Average Buffer Width	Buffer Condition	Raw Attribute	Final Attribute	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Attribute	Final Attribute	Structural Patch Richness	Topographic Complexity	Raw Attribute	Final Attribute	No. Plant Layers	No. Plant Co-dominant Species	Percent Co-dominant Invasive	Horizontal Interspersion Zonation	Vertical Biotic Structure	Raw Attribute	Final Attribute	
Mesa Creek 001 (R)	9	12	6	6	16	67	9	9	9	27	75	6	6	12	50	9	12	12	6	6	23	64	65
Bliss 001 (R)	3	6	3	9	9	38	9	6	6	21	58	12	6	18	75	12	6	12	9	9	28	78	62
Cate School 001(R)	9	12	9	6	17	70	9	9	6	24	67	9	6	15	63	12	6	6	6	6	20	56	64
Cate School 002(R)	12	12	9	6	20	83	9	6	6	21	58	9	6	15	63	12	6	9	6	6	21	58	66
Devereux 001 (STE)	3	12	12	6	11	48	6	12	12	30	83	3	6	9	38	9	6	12	6	12	27	75	61
Devereux 002 (STE)	6	12	12	9	16	68	6	12	12	30	83	3	6	9	38	9	6	12	6	9	24	67	64
West Storke Wetland (PE)	6	12	6	6	13	55	6	9	9	24	67	9	12	21	88	9	6	12	12	12	33	92	75
UCSB Campus Lagoon (L)	3	12	9	6	11	45	6	3	9	18	50	12	6	18	75	6	9	12	12	6	27	75	61
Goleta Slough 004 (PD)	3	12	6	6	10	42	6	9	6	21	58	6	3	9	38	9	3	12	9	12	29	81	55
Goleta Slough 005 (PD)	6	12	12	9	16	68	3	3	6	12	33	3	3	6	25	6	3	12	3	6	16	44	43
Goleta Slough 003 (PD)	6	12	6	6	13	55	6	9	6	21	58	9	6	15	63	9	6	12	9	9	27	75	63
Goleta Slough 002 (PD)	3	12	6	6	10	42	6	9	6	21	58	3	3	6	25	6	3	6	3	12	20	56	45
Ormond Beach 18W (SD)	6	12	12	9	16	68	6	9	6	21	58	3	3	6	25	6	3	12	6	9	22	61	53
Ormond Beach 18W (PTE)	6	12	12	9	16	68	6	3	6	15	42	3	3	6	25	6	3	12	6	9	22	61	49
Ormond Beach 22W (SD)	6	12	12	6	16	68	6	9	6	24	67	3	6	9	38	6	3	12	12	9	28	78	61
Ormond Beach 22W (PTE)	6	12	12	9	16	68	6	3	9	18	50	3	6	9	38	9	9	12	12	9	31	86	58
Ormond Beach 005W (D)	3	12	9	3	9	36	3	6	3	12	33	6	6	12	50	6	3	9	9	9	24	67	46
Ormond Beach 005W (STE)	3	12	9	3	9	36	3	3	3	9	25	3	3	6	25	9	9	9	9	9	27	75	40
Ormond Beach 18E (STE)	6	12	12	9	16	68	3	3	9	15	42	9	6	15	63	6	6	12	9	12	29	81	63
Ormond Beach 18E (P)	6	12	12	9	16	68	3	3	9	15	42	9	6	15	63		6	12	9		18	75	62
Ormond Beach 22E (STE)	9	12	12	12	21	88	3	3	9	15	42	9	6	15	63	6	6	12	12	9	29	81	68
Ormond Beach 22E (P)	9	12	12	12	21	88	3	3	9	15	42	9	6	15	63		6	12	12		21	88	70
Ormond Beach 21E (STE)	6	12	12	12	18	75	3	3	9	15	42	6	6	12	50	6	9	12	12	9	30	83	63
Ormond Beach 21E (P)	6	12	12	12	18	75	3	3	9	15	42	6	6	12	50		9	9	12		21	88	64
Ormond Beach 004W (D)	3	12	12	3	9	38	3	6	3	12	33	3	6	9	38	6	3	12	12	9	28	78	47
Ormond Beach 004W (STE)	3	12	12	3	9	38	3	3	3	9	25	3	6	9	38	6	6	12	9	9	26	72	43
Ormond Beach 006W (D)	6	12	9	6	14	58	6	3	6	15	42	3	3	6	25	6	3	12	9	3	19	53	44
Ormond Beach 006W (STE)	6	12	9	6	14	58	6	3	6	15	42	3	3	6	25	6	3	12	6	3	16	44	42
Malibu Lagoon 001 (STE)	6	12	6	6	13	55	6	9	12	27	75	6	3	9	38	6	9	12	9	9	27	75	61
Malibu Lagoon 002 (STE)	9	12	12	6	17	73	6	9	12	27	75	6	6	12	50	9	12	9	12	9	31	86	71
Solstice Creek 001 (R)	12	12	12	9	22	93	9	6	9	24	67	12	12	24	100	9	9	12	12	9	31	86	87
Solstice Creek 002(R)	12	12	12	9	22	93	9	6	9	24	67	9	12	21	88	12	6	12	9	9	28	78	81
Solstice Creek 003 (R)	12	12	12	9	22	93	9	9	9	27	75	12	12	24	100	12	6	12	9	12	31	86	89

	Buffer and Landscape Context						Hydrology					Physical Structure				Biotic Structure							
Site Name and AA No.	Landscape Connectivity	% Buffer	Average Buffer Width	Buffer Condition	Raw Attribute	Final Attribute	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Attribute	Final Attribute	Structural Patch Richness	Topographic Complexity	Raw Attribute	Final Attribute	No. Plant Layers	No. Plant Co-dominant Species	Percent Co-dominant Invasive	Horizontal Interspersion Zonation	Vertical Biotic Structure	Raw Attribute	Final Attribute	**Index Score**
Los Cerritos-Bryant 003	3	12	9	3	9	36	3	3	6	12	33	3	3	6	25	3	3	12	3	3	12	33	**32**
Los Cerritos-Bryant 002 (Zedler Marsh)	6	12	6	3	11	46	6	9	3	18	50	6	9	15	63	9	12	6	12	9	26	72	**60**
Los Cerritos-Bryant 006	6	12	9	3	12	48	3	3	6	12	33	3	6	9	38	9	9	6	12	6	26	72	**48**
Los Cerritos Bryant 005	9	12	9	3	15	61	3	3	6	12	33	3	6	9	38	6	3	12	3	3	13	36	**39**
Los Cerritos Bryant 004	6	12	6	3	11	46	3	3	6	12	33	3	3	6	25	6	6	12	6	3	17	47	**38**
San Joaquin Marsh 037 (SD)	6	12	12	9	16	68	6	3	3	12	33	3	3	6	25	9	3	12	6	6	20	56	**55**
San Joaquin Marsh 013 (SD)	9	12	12	12	21	88	6	3	3	12	33	3	3	6	25	6	3	12	9	3	19	53	**50**
San Joaquin Marsh 023 (SD)	12	12	12	12	24	100	6	3	3	12	33	3	3	6	25	9	3	12	12	6	26	72	**58**
Buena Vista ER (PD)	3	12	12	6	11	48	12	12	12	36	100	3	6	9	38	9	3	12	9	12	29	81	**66**
Buena Vista Creek 001 (R)	9	12	12	6	17	73	6	12	6	24	67	12	12	24	100	12	9	9	12	12	34	94	**83**
Buena Vista Creek 002(R)	3	12	9	6	11	45	6	6	9	21	58	12	9	21	88	9	6	12	6	6	21	58	**62**
Buena Vista Lagoon 010 (L)	6	12	6	6	13	55	6	9	9	24	67	3	3	6	25	6	3	12	3	3	13	36	**46**
Buena Vista Lagoon 002 (L)	6	12	9	6	14	58	6	9	6	21	58	3	9	12	50	6	3	12	9	12	28	78	**61**
Buena Vista Lagoon 003 (L)	9	9	9	6	16	68	6	9	6	21	58	3	9	12	50	12	6	12	9	12	31	86	**66**
Buena Vista Lagoon 001 (L)	9	12	6	6	16	67	6	9	6	21	58	3	9	12	50	6	3	12	9	12	28	78	**63**
Buena Vista Lagoon 011 (L)	6	12	12	12	18	75	6	9	9	24	67	3	3	6	25	6	3	12	6	12	25	69	**59**
Buena Vista Lagoon 009 (L)	9	12	12	12	21	88	6	9	9	24	67	3	3	6	25	6	3	12	3	12	22	61	**60**
Buena Vista Lagoon 017 (L)	6	12	9	9	16	65	6	9	9	24	67	3	9	12	50	6	3	12	3	12	22	61	**61**
Buena Vista Lagoon Berm(L)	6	12	6	6	13	55	6	9	3	18	50	3	3	6	25	6	3	12	6	9	22	61	**48**
Buena Vista Lagoon 023 (L)	6	12	9	9	16	65	6	9	9	24	67	3	9	12	50	6	3	12	6	12	25	69	**63**
Buena Vista Lagoon 018 (L)	6	12	9	12	17	72	6	9	9	24	67	3	6	9	38	6	3	12	12	12	31	86	**65**
Magnoila Marsh 001 (PTE)	6	12	6	9	15	61	12	3	3	18	50	3	6	9	38	9	9	12	6	12	28	78	**57**
Magnoila Marsh 001 (SD)	6	12	6	9	15	61	12	12	3	18	50	3	6	9	38	6	3	12	9	12	28	78	**63**
Magnoila Marsh 002 (PTE)	6	12	9	9	16	65	12	3	3	18	50	3	6	9	38	6	3	12	6	9	23	63	**54**
Magnoila Marsh 002 (SD)	6	12	9	9	16	65	12	3	3	18	50	3	6	9	38	6	3	12	6	9	22	61	**60**
Magnoila Marsh 003 (PTE)	6	12	6	9	15	61	12	3	3	18	50	3	3	6	25	9	3	12	3	3	14	39	**44**
Magnoila Marsh 003 (SD)	6	12	6	9	15	61	12	12	3	27	75	3	3	6	25	6	3	12	3	3	13	36	**49**
Brookhurst Marsh 009 (STE)	6	12	9	9	16	65	3	3	6	12	33	3	6	9	38	9	9	12	6	12	28	78	**53**
Brookhurst Marsh 009 (D)	6	12	9	9	16	65	3	3	3	9	25	3	6	9	38	6	3	12	9	12	28	78	**60**
Brookhurst Marsh 008 (D)	6	12	6	12	16	67	3	12	12	27	75	3	6	9	38	9	6	12	9	9	27	75	**68**
Brookhurst Marsh 001 (STE)	3	12	6	6	10	42	3	3	6	12	33	3	3	6	25	9	3	12	9	9	26	72	**43**
Brookhurst Marsh 001 (D)	3	12	6	6	10	42	3	12	6	21	58	3	3	6	25	6	3	12	9	9	25	69	**49**

APPENDIX4B. SUMMARY OF CRAM METRIC, ATTRIBUTE AND, INDEX SCORES FOR PERENNIALLY TIDAL SALINE ESTUARINE PROJECT ASSESSMENT AREAS.

	Buffer and Landscape Context						Hydrology					Physical Structure				Biotic Structure							Index Score
Site Name and AA No.	Landscape Connectivity	% Buffer	Average Buffer Width	Buffer Condition	Raw Attribute	Final Attribute	Water Source	Hydroperiod or Channel Stability	Hydrologic Connectivity	Raw Attribute	Final Attribute	Structural Patch Richness	Topographic Complexity	Raw Attribute	Final Attribute	No. Plant Layers	No. Plant Co-dominant Species	Percent Co-dominant Invasive	Horizontal Interspersion Zonation	Vertical Biotic Structure	Raw Attribute	Final Attribute	
Model Marsh 000	12	12	12	12	24	100	9	9	3	21	58	9	9	18	75	9	6	12	6	9	24	67	**75**
Model Marsh 006	12	12	12	12	24	100	9	9	3	21	58	3	6	9	38	9	9	12	6	6	22	61	**64**
Model Marsh 008	12	12	12	12	24	100	9	9	3	21	58	3	9	12	50	9	6	12	6	6	21	58	**67**
Oneonta Slough 001	9	12	12	6	14	58	6	12	6	24	67	6	3	9	38	9	12	12	12	3	26	72	**59**
Famosa Slough 001	3	12	3	3	7	30	6	9	3	18	50	3	3	6	25	9	6	12	9	3	21	58	**41**
Famosa Slough 002	3	12	3	3	7	30	6	9	3	18	50	3	6	9	38	9	9	12	6	9	25	69	**47**
Capinteria Marsh 015	9	12	12	9	19	81	6	9	3	18	50	3	6	9	38	9	6	12	6	12	27	75	**56**
Capinteria Marsh 012	6	12	12	9	16	68	6	9	3	18	50	3	6	9	38	9	6	12	6	9	24	67	**56**
Marissma de Nacion 011	6	12	12	6	14	58	6	12	3	21	58	6	6	12	50	9	12	12	6	3	20	56	**56**
Marissma de Nacion 088	6	12	12	6	14	58	6	12	3	21	58	3	6	9	38	9	12	12	9	6	26	72	**57**
Connector Marsh South 001	6	12	6	3	11	46	6	12	3	21	58	6	6	12	50	9	9	12	6	3	19	53	**52**
Connector Marsh South 003	6	12	6	3	11	46	6	12	3	21	58	3	6	9	38	9	9	12	6	3	19	53	**49**
Connector Marsh North 003	3	12	6	6	10	42	6	12	3	21	58	6	6	12	50	9	12	12	6	3	20	56	**51**
Connector Marsh North 004	3	12	9	6	11	46	6	12	3	21	58	6	6	12	50	9	12	12	6	3	20	56	**52**
Bolsa Chica 023	9	12	12	6	17	73	6	12	3	21	58	3	6	9	38	6	3	12	3	3	13	36	**51**
Bolsa Chica 011	9	19	9	6	16	68	6	12	3	21	58	6	9	15	63	6	3	12	3	3	13	36	**56**
Bolsa Chica 007	9	9	9	6	16	68	6	12	3	21	58	6	9	15	63	9	3	12	3	3	14	39	**57**
Ballona Wetlands	3	12	3	3	7	30	6	9	3	18	50	3	3	6	25	9	6	9	9	3	21	58	**41**
Santa Ana River Marsh 032	6	12	12	6	14	58	6	3	3	12	33	3	6	9	38	9	6	12	6	9	24	67	**49**
Santa Ana River Marsh 015	9	12	9	3	15	63	6	3	3	12	33	3	3	6	25	6	6	12	3	3	14	39	**40**
Santa Ana River Marsh 079	6	12	12	9	16	67	6	9	6	21	58	3	9	12	50	9	6	12	9	9	27	75	**63**
Talbert 003	3	9	3	12	11	45	6	9	3	18	50	3	6	9	38	9	6	12	6	3	18	50	**46**
Talbert 003a	3	9	6	12	12	52	6	9	3	18	50	3	6	9	38	9	9	12	9	3	22	61	**50**
Mugu Treatment Ponds 034	12	12	12	9	22	92	9	12	6	27	75	9	9	18	75	9	3	12	3	6	17	47	**72**
Mugu Treatment Ponds 016	12	12	12	9	22	92	9	12	3	24	67	6	9	15	63	9	3	12	3	3	14	39	**65**

APPENDIX 5. SUMMARY OF CRAM AVERAGE CRAM INDEX AND ATTRIBUTE SCORES AND STRESSORS RECORDED AT WRP PROJECTS.

Project Name	**Mean CRAM Index or attribute scores**					**Stressors Recorded at CRAM assessment areas** S = significant negative stressor
	Index	BLC	H	PS	BS	
Arroyo Burro Estuary and Mesa Creek	65	67	83	50	61	H- Engineered channel , levees (s) PS-Vegetation management BS-Excessive human visitation (s) BLC-Transportation corridor (s), urban residential, passive recreation
Bliss Fish Passage Improvement	62	38	58	75	78	H- Non-point-source discharges, flow obstructions (s), engineered channel (s) PS- Excessive runoff from watershed (s), pesticide or trace organics impaired BS- lack of vegetation management (s), lack of treatment of invasive plants (s) BLC-Orchards/nurseries (s), Transportation corridor (s)
Cate School Fish Passage Improvement	65	77	63	63	57	H- Non-point-source discharges, flow obstructions (s) PS- Excessive runoff from watershed (s), pesticide or trace organics imapired BS- lack of vegetation management (s), lack of treatment of invasive plants (s) BLC-Orchards/nurseries (s), Transportation corridor (s), urban residential
Devereux Slough Restoration	60	56	75	38	71	H- Non-point-source discharges PS- none recorded BS- none recorded BLC-Sports field/urban parkland (golf course), urban residential
Ormond Beach (TNC parcel)	50	52	47	35	67	H- Flow diversions, dikes levees (s), ditches (mosquito control, agricultural drainage)(s) PS- Pesticide or trace organics impaired (s), grading/compaction (s), plowing/disking (s) BS- pesticide application/vector control (s), lack of vegetation management (s), lack of treatment of invasive plants (s) BLC-Industrial/commercial, intensive row agriculture (s)
Ormond Beach (SCC parcel)	65	77	42	58	83	H- none recorded PS- Pesticide or trace organics impaired (s) BS- lack of vegetation management (s), lack of treatment of invasive plants (s) BLC intensive row agriculture (s)
UCSB Campus Lagoon	61	45	50	75	75	H- Non-point-source discharges, flow diversions(s), flow obstructions (s) , dredged inlet/channel (s), actively managed hydrology (s) PS- Grading/compaction (s), excessive runoff from watershed(s), nutrient impaired BS- Excessive human visitation (s), lack of treatment of invasive plants BLC- Urban residential (s), passive recreation(s)

Project Name	Mean CRAM Index or attribute scores					Stressors Recorded at CRAM assessment areas S = significant negative stressor
	Index	BLC	H	PS	BS	
Storke Wetland	75	54	67	88	92	H- Non-point-source discharges, flow diversions, flow obstructions , dikes/levees (s) PS- none recorded BS- Excessive human visitation, predation and habitat destruction by non-native vertebrates BLC- Urban residential (s), transportation corridor (s) passive recreation(s), sports field or urban parkland
Malibu Lagoon	65	63	75	44	81	H- Non-point-source discharges (s) PS- Nutrient, heavy metal, and bacteria impaired (s) BS- Excessive human visitation (s), predation and habitat destruction by non-native vertebrates, pesticide application/vector control BLC- Urban residential (s), industrial/commercial, transportation corridor (s), passive recreation(s), sports field or urban parkland (s)
Solstice Creek	85	92	69	96	83	H- Flow obstructions (s) PS- none recorded BS- Excessive human visitation, lack of treatment of invasive plants BLC- Passive recreation
Los Cerritos Wetlands	65	46	67	63	83	H- flow obstructions (s), engineered channels (s) PS- Resource extraction: oi) (s) BS- Lack of treatment of invasive plants (s) BLC- Industrial/commercial (s), transportation corridor (s), physical resource extraction (oil)(s)
Los Cerritos Wetlands-Bryant 002 only						H- Non-point-source discharges (s), flow obstructions (s), engineered channel, dikes/levees (s) PS- Resource extraction: oil (s), Nutrient, heavy metal, pesticides, and bacteria impaired (s), trash/refuse (s) BS- Excessive human visitation (s), lack of treatment of invasive plants (s) BLC- Industrial/commercial(s), transportation corridor (s), passive recreation
Huntington Beach Wetlands: Brookhurst	59	58	64	33	80	H- Non-point-source discharges (s), dikes/levees (s) PS- Filling or dumping of sediment or soils BS- Lack of treatment of invasive plants (s) BLC- Urban residential (s), industrial/commercial(s), transportation corridor (s)
Huntington Beach Wetlands: Magnolia	57	63	75	33	58	H- Non-point-source discharges (s), dikes/levees (s) PS- none recorded BS- none recorded BLC- Urban residential, industrial/commercial(s), transportation corridor (s)
San Joaquin Marsh	54	85	33	38	56	H- Dikes/levees (s) PS- Heavy metal impaired, grading/compaction BS- Pesticide application/vector control(s), lack of treatment of invasive plants BLC- Industrial/commercial, air traffic, transportation corridor (s)

Project Name	Mean CRAM Index or attribute scores					Stressors Recorded at CRAM assessment areas S = significant negative stressor
	Index	BLC	H	PS	BS	
Goleta Slough	51	52	52	38	64	H- Flow diversions (s), flow obstructions, dikes/levees (s) PS- Grading/compaction (s) BS- pesticide application/vector control, lack of treatment of invasive plants, predation and habitat destruction by non-native vertebrates BLC- Urban residential, industrial/commercial (s), air traffic, transportation corridor
Buena Vista Lagoon (Coast Hwy Basin AA 010 and upper basin AAs 011)	60	67	63	39	69	H- Non-point-source discharges (s), flow obstructions (s) Flow diversions (s), flow obstruction, dikes/levees (s) PS- Excessive sediment and runoff from watershed (s) , Nutrient, pesticides, and bacteria impaired (s) BS- Excessive human visitation (s), predation and habitat destruction by non-native vertebrates, pesticide application/vector control, lack of vegetation management (s), lack of treatment of invasive plants, BLC- Urban residential (s) , transportation corridor (s), sports field/urban parkland (s), passive recreation
Buena Vista Lagoon (all Railroad Basin AAs (001, 002, 003)						H- Non-point-source discharges (s), engineered channel (s) Flow diversions (s), flow obstruction, dikes/levees (s) PS- Excessive sediment and runoff from watershed (s) , Nutrient, pesticides, heavy metal, and bacteria impaired (s), trash/refuse (s) BS- Excessive human visitation (s), pesticide application/vector control, lack of vegetation management (s), lack of treatment of invasive plants, BLC- Urban residential (s) , major flow regulation or disruption (s) transportation corridor (s), passive recreation
Buena Vista Lagoon (berm AA)						H- Non-point-source discharges (s), flow obstructions(s) flow diversions (s), tide gates (s), dikes/levees (s) engineered channel (s) PS- Grading/compaction (s), excessive sediment and runoff from watershed (s) , nutrient, pesticides, heavy metal, and bacteria impaired (s), trash/refuse (s) BS- Pesticide application/vector control, predation and habitat destruction by non-native vertebrates, lack of vegetation management (s), lack of treatment of invasive plants, BLC- Urban residential (s), transportation corridor (s), passive recreation
Buena Vista Creek (riverine AAs)	73	59	63	94	76	H- Point-source discharges, non-point-source discharges (s) PS- Trash/refuse (s) BS- Tree/cutting, treatment of non-native and nuisance plant species, predation and habitat destruction by non-native vertebrates (s), lack of vegetation management (s), lack of treatment of invasive plants, BLC- Urban residential (s), transportation corridor (s), passive recreation
Buena Vista Creek (depressional AA)						H- non-recorded PS- non-recorded BS- non-recorded BLC- Transportation corridor

APPENDIX 6. PERCENT OF PROJECT ASSESSMENT AREAS WITH RECORDED STRESSORS (PRESENT) AND SEVERE STRESSORS (SIGNIFICANT), BASED ON THE CRAM STRESSOR CHECKLIST. (N=77).

Stressor Name	Present	Significant Negative Effect
Hydrologic Stressors:		
Dike/levees	63	54
Non-point Source (NPS) discharges	55	39
Flow diversions or unnatural inflows	32	25
Flow obstructions (culverts, paved stream crossings)	25	24
Ditches (borrow, agricultural drainage, mosquito control)	9	8
Engineered channel (riprap, armored channel bank, bed)	14	9
Actively managed hydrology	9	8
Weir/drop structure, tide gates	8	8
Dredged inlet/channel	7	5
Point Source (PS) Discharges (POTW, other non-storm water discharge)	4	0
Physical Structure Stressors:		
Pesticides or trace organics impaired	39	28
Heavy metal impaired	37	25
Nutrient impaired	38	29
Bacteria and pathogens impaired	34	28
Excessive runoff from watershed	22	18
Trash or refuse	16	12
Excessive sediment or organic debris from watershed	16	13
Grading/ compaction (N/A for restoration areas)	12	12
Filling or dumping of sediment/soils (N/A -restoration areas)	4	0
Plowing/Disking (N/A for restoration areas)	3	3
Vegetation management	3	1
Resource extraction (sediment, gravel, oil and/or gas)	7	7
Biotic Structure Stressors:		
Lack of treatment of invasives adjacent to AA/ buffer	64	46
Pesticide application or vector control	39	14
Excessive human visitation	38	28
Predation & habitat destruction by non-native vertebrates	34	17
Lack of vegetation management to conserve natural resources	33	30
Treatment of non-native and nuisance plant species	5	5
Tree cutting/sapling removal	1	0
Buffer and Landscape Stressors:		
Transportation corridor	62	53
Industrial/commercial	46	32
Urban residential	43	26
Passive recreation (bird-watching, hiking, etc.)	32	14
Military training/Air traffic	21	11
Intensive row-crop agriculture	11	11
Sports fields and urban parklands (golf courses, soccer fields, etc.)	12	13
Physical resource extraction (rock, sediment, oil/gas)	8	8
Orchards/nurseries	4	4
Dams (or other major flow regulation or disruption)	4	4
Median Number of Stressors Per Site		

APPENDIX 7. CONSIDERATIONS AND RECOMMENDATIONS FOR PROJECT-BASED ASSESSMENT WITH CRAM

The following are important considerations for conducting CRAM at wetland restoration or enhancement project sites. For additional guidance, see the Technical Bulletin "Using CRAM to Assess Wetland Projects as an Element of Regulatory and Management Programs" available at www.cramwetlands.org.

1. A project should be assessed with the CRAM module appropriate for its current wetland types(s) and anticipated wetland type(s).

2. CRAM assessments should occur both prior to restoration activities and after restoration activities are complete (e.g. when all project construction plans and designs have been implemented). CRAM should then be repeated as the project matures and the wetlands evolve. This would allow documentation of the net change in acreage and condition of the wetland due to construction activities and subsequent geomorphic and ecological succession. In the early stages of post-restoration monitoring, a CRAM assessment should be conducted at least twice a year, once at the beginning of the growing season and once at the end of the growing season to provide data on the inter-annual variability of CRAM scores for project sites.

3. If comparing CRAM scores between different projects, careful control on project age, landscape position, and pre- and post-construction condition is required to better assess the true differences in condition between projects.

4. If wetlands on a project site have been converted from one wetland type to another due to restoration activities, the pre vs. post project CRAM scores will not be directly comparable if the data were collected using different CRAM modules. If CRAM is being used to help evaluate alternative designs or to provide baseline data for a restoration that anticipates changing wetland types, then the CRAM module for the anticipated future wetland class should be used, as well as the CRAM module for the current type. The CRAM module for the existing wetland type should be use for evaluation of potential impacts to the current wetland.

5. CRAM is designed to assess vegetated wetlands, meaning wetlands that support at least 5% cover of vegetation during the peak growing season. Therefore, CRAM is not appropriate to use for the assessment of projects that include significant subtidal or unvegetated intertidal flats (e.g., Colorado Lagoon; mudflat portions of San Elijo Lagoon).

6. While there may be positive correlations between wetland stressors and the quality of open water, quantifying water quality generally requires laboratory analyses beyond the scope of CRAM. Even if a project site receives a relatively high CRAM score, restoration activities may still be warranted at the site. The stressor checklist can be used to identify possible management actions that require attention.

APPENDIX 8. SAMPLING CONSIDERATIONS FOR LARGE PROJECTS THAT REQUIRE MULTIPLE CRAM ASSESSMENT AREAS

Probabilistic survey approach

If the objective of a sampling program for a particular project is to capture the range of wetland conditions present within the project area, an effective way to achieve this is to assess a statistically representative subset of the total number of possible assessment areas via a probabilistic sampling design. For extremely large projects that require a potentially large number of assessment areas, sampling areas may need to be probabilistically selected out of programmatic and logistical necessity. An advantage of using the full complement of sites as the sample frame is that equal inclusion probabilities can be assigned to each site, which allows for a much simpler sample draw.

A statistical feature of a probabilistic design is that you can achieve a representative sample (or in the case of CRAM, a representative distribution of scores), with a minimum of 30 sites irrespective of the size of the total sample population, as long as they are randomly selected. The replication for the samples in built into the design. Fifty (50) sites would be preferred, but 30 is generally agreed to be the minimum in order to have confidence in the representativeness of the sample (McDonald *et al*. 2002).

A probabilistic survey approach is useful for comparing a population of mostly independent impacts sites to a population of non-impact sites, where either or both populations consist of sites having unequal probabilities of being selected for assessment. Consider a project, that consists of many road crossings through a stream with each crossing represents a unique impact site and there is mostly one CRAM assessment areas per crossing. Using the probabilistic survey approach, the population of impact sites could be compared to the population of non-impact sites based on independent probabilistic surveys of each population. Without knowing a priori whether or not the CRAM scores for either population are normally distributed (and without knowing how to normalize these scores), each survey should consist of at least 30 assessment areas, and each must be weighted by its probability of being selected from its population. According to the probabilistic approach, all pre-project candidate assessment areas are delineated in a GIS, and 30 (or more) of these are randomly selected and assessed to create a pre-project cumulative frequency distribution (or CFD). This process is repeated after a site is "restored", and the two CFDs are compared based on their median values and/or overall shape.

Ideally, there would be an eco-regional CFD of the wetland type in question with which to compare the pre- and post project CFDs in order to determine if the project is generally comparable to the regional ambient condition. Because this approach to summarizing multiple CRAM assessments does not involve any averaging of scores, it avoids the attending difficulties in data interpretation and has the added benefit of linking a site assessment to ambient conditions in a way that clearly illustrates the interdependence of the datasets (CWMW 2009). However, in the absence of the regional CFD, pre- and post-project conditions can be compared to each other to assess project impacts.

Considerations for sample stratification

If the goal of a study is to make specific comparisons among sub classes of sites, a stratified approach is needed. This is a critically important question in the context of probability-based surveys for impact assessment (impacts should be assessed separately for each stratum of interest). If using a stratified approach, at least 30 sites will need to be randomly selected for each stratum. This could result in a large number of sites and related costs depending on how many strata need to be compared. In some cases, post-stratification of data for an overall set of sites is possible (i.e., for the 30+ sites randomly selected from the entire sample), but the tractability of this would depend on how many sites from each stratum were included by chance in the probabilistic draw. Another approach is to intentionally distribute some of the 30+ assessment areas into each stratum, and account for this using the different inclusion probabilities of the different strata. This does not allow any characterization of the strata per se, but it allows for the CFD to reflect conditions among the strata.

In general, there is no need for strata unless they represent systematic differences in condition or function. Using CRAM as an example, if it is known that CRAM scores systematically differ between first-order and all other orders of channels, stratification based on channel order would be appropriate. First-order channels could be placed in their own stratum, and then either excluded from the sample, or a separate CFD could be developed for them. Alternatively, some assessment areas could be "forced" into the first-order stratum to increase representation in the non-stratified sample.

Targeted survey approach

The targeted survey approach focuses on one or more sites that are not part of a random or probabilistic sample draw, but are intentionally selected in their own regard. This approach is obvious when there is only one or a few impact sites, each of which can only have one or two assessment areas. In this case, pre- and post-project scores can be compared for each site, but they should be compared to a regional or watershed-specific ambient CFD to determine if the impacts are reducing the overall ambient condition.

Hybrid sampling approach for assessing impacts

Sampling could also employ a hybrid between a probabilistic and targeted approach. Under this hybrid approach, each randomly selected impact site is paired with an upstream non-impact site. The test of impact is then a test of the significance between mean scores for impacted and non-impacted sites. This approach requires either normalizing the scores (a study unto itself) or using a non-parametric test (most of these have limited power to detect differences).

When considering which sampling approach to undertake, it is of paramount importance to consider the scope and goals of the particular project (e.g. regulatory versus scientific purposes) when developing the sample frame. An advantage of using the full complement of sites as the sample frame is that equal inclusion probabilities can be assigned to each site, which allows for a much simpler sample draw. If grouping sites based on their size within the sample frame, inclusion probabilities would need to be assigned to each group (if each group is not the same size with the same number of individual sites).