CALIFORNIA'S WETLAND DEMONSTRATION PROGRAM PILOT

A Final Project Report to the California Resources Agency

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California Resources Agency

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EXECUTIVE SUMMARY

California's wetlands are an important natural resource, providing critical ecological services. Most of the State's threatened and endangered plants and animals depend on wetlands. The primary threats to wetlands are human activities that result in altered wetland hydrology, substrates, or biological communities; these activities include discharge of fill material, excavation, habitat fragmentation, and degradation from stressors (e.g., invasive species, excess sediment, altered hydrology, and contaminants). Over the last 20 years, billions of dollars have been invested in the protection and restoration of wetlands and riparian areas in California. Unfortunately, the effectiveness of these investments is uncertain because these areas are not systematically monitored. A comprehensive monitoring program is needed to sustainably manage these resources by: 1) creating tools that inform regulatory and management processes in order to make them more adaptive and performance based; 2) conducting ambient assessments to provide context for interpreting site-specific data and informing decision-making; 3) developing a consistent approach to project performance assessments; and 4) providing a common framework and platform for data management and dissemination.

In 2003, a consortium of scientists and managers began developing the conceptual framework and standardized methods to be used in a Statewide wetlands assessment program, modeled after the United States Environmental Protection Agency (USEPA) Level 1-2-3 framework for assessment of wetland resources (USEPA 2006). This toolkit includes standardized protocols to map wetlands and riparian areas (Level 1), the California Rapid Assessment Method (CRAM) for low-cost assessment of the overall condition of wetlands and riparian areas (Level 2), standardized intensive assessment protocols (e.g., indices of biological integrity, etc.) to validate CRAM and quantify functions of wetlands or particular aspects of their condition (Level 3), and public data management tools to track investments in wetlands and changes in their quantity and quality (www.wetlandtracker.org).

In 2006, the Resources Agency was awarded a three-year USEPA Wetland Demonstration Program (WDP) Pilot grant to begin phased implementation of a statewide wetland monitoring program, building on the Level 1-2-3 framework and the standardized wetland monitoring toolkit. The WDP project consisted of a series of major monitoring activities designed to demonstrate the toolkit as integral to the State's enhanced capacity to manage, regulate and conserve wetlands and riparian areas. These activities include:

- Create a Statewide Steering Committee to provide interagency coordination on approaches and strategies for wetland monitoring and assessment
- Demonstrate new wetland and riparian mapping standards for updating the State's wetland inventory as a base map for tracking change, including wetland projects and the effects of climate change
- Develop State Agency capacity to implement CRAM through standardized training
- Develop State Agency capacity to track projects and manage wetland-related data through a publicly accessible data portal called the Wetland Tracker
- Demonstrate the toolkit by assessing the condition of estuarine wetlands statewide and riverine wetlands condition in three demonstration watersheds
- Report on the State of the State's Wetlands, based in part on the above WDP activities

The WDP project demonstrates significant advances in the State's capacity to monitor wetlands and riparian areas. Progress on toolkit development and implementation is summarized in Table E-1. Results of WDP activities utilizing the wetland assessment toolkit are summarized below and presented in detail in Appendix 1.

Table E-1. Summary of the State's progress on implementing a comprehensive monitoring program, recommended next steps, and status of current funding to address these recommendations.

Area	Summary of Progress	Recommended Next Steps
Programmatic	• Improved coordination among agencies on wetland monitoring, now formalized through the State Wetland Monitoring Workgroup • Wetland and riparian protection policy under development: Phase I includes definition and proposed classification of wetlands and components of a statewide wetland monitoring program	• Implement a statewide wetland monitoring program, consistent with USEPA guidance (the "10 elements letter" of 2006) • Establish a long-term strategy to comprehensively assess wetlands ands riparian areas using existing programs • Support standard wetland and riparian definitions for all state agencies • Develop a funding strategy to support monitoring program implementation • Support periodic (e.g., every three years) programmatic evaluations of the effectiveness of the wetland monitoring program • Strengthen agency participation in the Statewide Wetland Monitoring Workgroup (SWMW) to provide ongoing mechanism for coordination and identification of common assessment needs and priorities • Develop regional teams for areas of the State currently underserved by early implementation efforts (i.e., areas of the Central Valley, Lahontan, and Colorado River Basin Regional Water Quality Control Boards)
Mapping	• Drafted standardized operating procedures for the mapping of wetland and riparian habitat • Continued update of statewide wetland inventory	• Vet and adopt state-sanctioned classification system and mapping standards for wetlands and riparian areas • Adopt the USFWS National Wetland Inventory Status and Trends approach to future updates of the wetland inventory • Clarify mechanism to cross-walk between state and federal classification systems for wetlands and riparian areas
Rapid Assessment	• Completed CRAM Users Manual for six wetland types • Validated estuarine and riverine CRAM modules • Developed publicly accessible eCRAM and statewide CRAM database • Prepared draft CRAM guidance document for agency implementation • Initiated SWRCB peer review of CRAM • Developed CRAM training modules for agency staff and practitioners	• Vet draft California Rapid Assessment Methods (CRAM) guidance within agencies and develop a position on implementation • Support the adoption and use of CRAM as a core component of all wetland monitoring • Support the integration of CRAM as a component of an integrated aquatic resource assessment framework for the Surface Water Ambient Monitoring Program (SWAMP) • Support the refinement or additional development as needed of all necessary CRAM modules consistent with results of the USACE peer review, the review underway by the State Water Resources Control Board (SWRCB), and any evaluations judged to be needed by the SWMW • Extend CRAM validation to include depressional wetlands and thereafter all other wetland types for which CRAM has not yet been validated • Establish full reference network for all wetland types statewide • Develop performance curves for restoration projects based on CRAM • Refine eCRAM to enhance data download and automated reporting features

Table E-1. Continued

Area	Summary of Progress	Recommended Next Steps
Project Tracking	• Developed statewide project tracking form • Piloted project tracking in SF RWQCB • Developing interagency guidance for implementation of tracking in South Coast	• Vet draft guidance for application of project tracking in agency programs • Adopt standardized tracking of wetlands and riparian areas across all relevant state agencies • Extend the project tracking tools to include "Notices of Intent" and other early documentation of projects proposed through CEQA
Quality Assurance	• Developed and met quality assurance standards for CRAM implementation in ambient surveys	• Develop a Quality Assurance (QA) process for using Wetland Tracker and CRAM for permitted and/or project-specific monitoring. • Create and maintain statewide technical CRAM oversight team and regional CRAM technical teams to implement QA process for project tracking and CRAM • Support implementation of CRAM and wetland tracking training programs
Data Management	• Developed and launched wetland data information management platform, operational in three coastal regions and populated with a total of 315 projects • Updated functionality of Tracker to enhance user experience	• Improve functionality of the Wetland Tracker (www.wetlandtracker.org) to serve as Statewide Wetland Data Portal • Support the creation and ongoing maintenance for data centers to manage, synthesize and disseminate updated Statewide Wetland Inventory, project tracking, habitat tracking, and CRAM data via the Wetland Tracker • Support data sharing between Wetland Tracker data and the existing databases of other federal and state agencies (e.g., USACE/EPA ORM-2 database)
Toolkit Proof of Concept	• Produced the State's first statewide report on estuarine wetlands • Engaged in ongoing demonstration of CRAM in statewide perennial stream assessment • Demonstrated toolkit for watershed assessment in three watersheds	• Continue to support the incorporation of CRAM into Statewide Perennial Stream Survey. • Fund watershed demonstration projects of the wetland toolkit in North Coast and inland regions of the State

Statewide Estuarine Wetland Assessment. A statewide assessment of estuarine wetlands was conducted in 2007, using the wetland monitoring toolkit. The assessment consisted of: 1) a Level 1 profile of the extent and geographic distribution of estuarine wetlands; 2) a Level 2 (CRAM) statewide probability-based survey of the ambient condition of saline, perennially tidal estuarine wetlands; and 3) a Level 2 assessment of 30 completed estuarine wetland restoration projects.

CRAM assesses the condition of a standardized amount of wetland or riparian habitat called the Assessment Area (AA). Visible indicators of condition are used to score the AA for each of four attributes: Landscape Context (landscape connectivity and natural buffer), Hydrology (water source, hydroperiod, and hydrologic connectivity), Physical Structure (complexity of marsh topography and physical patch types), and Biological Structure (wetland plant community structure). All scores represent the percent of maximum possible, which represents the best achievable condition, based on statewide validation exercises. The attribute scores are summed into an overall index score for each AA. Likely sources of stress for each AA are recorded on a checklist that accompanies each attribute score.

The ambient survey design emphasized objective selection of each AA while accounting for the portion of total estuarine wetland area that the AA represents. This design is necessary because some AAs are part of large wetlands, therefore their scores represent a smaller portion of the total wetland area than an AA of the same size in smaller wetlands. The approach is called a probability-based survey. It depends on an accurate wetland map, which in this case was produced as part of the statewide Level 1 profile of estuarine wetlands. Based on this approach, 150 sites were distributed among four coastal regions: the North, Central, and South Coasts, and the San Francisco (SF) Estuary. Results were reported as the percentages of the total estuarine wetland area that fell within four categories of CRAM index or attribute scores: scores 82 to 100 = Category 1; scores 63 to 82 = Category 2; scores 44 to 63 = Category 3; and scores 44 to 25 = Category 4.

Land use practices along the California coastline have drastically decreased the amount of estuarine wetland and changed the sizes, shapes, and spatial relationships between wetlands. In urbanized estuaries, many wetlands are impacted by intensive land uses and bounded by levees, which diminish the hydrological and ecological connectivity among the wetlands and increase susceptibility to invasion and local catastrophic events. Based on the Level 1 profile, there are currently 44,456 acres of perennial, saline estuarine wetland in California. The statewide ambient survey results are strongly influenced by the SF Estuary, which has 77% of the State's estuarine wetlands. Eighty-five percent of the statewide acreage scored within the top 50% of CRAM index scores. Sixty-four percent had Landscape Context scores within the top category of possible scores, while 35% of acreage had scores for within the top category for Hydrology and Biological Structure attribute. Conversely, 62% of the acreage was found in the bottom two categories of CRAM physical structure scores. Anthropogenic modifications to the tidal and freshwater hydrology, sediment transport, and geomorphology of the marsh result in reduced integrity of marsh physical structure. CRAM index and attribute scores showed a general decrease from north to south. This difference was most pronounced for Hydrology and Physical Structure attributes (25 - 30 point difference from North to South Coast) and least for Landscape Context (<10 point difference North to South). This southward decrease in condition quality is related to a southward increase in coastal urbanization, which involves increasing amounts of diking and other fragmentation of estuarine wetlands. Dikes and levees, which restrict tidal exchange and extend the retention time of water in wetlands, were among the most frequent and most severe stressors identified statewide.

The CRAM index and attribute scores for restoration projects tended to be 5 - 20% lower than ambient scores for their region. Differences can be attributed to a number of factors including project age (i.e., how much time the restoration processes have been operating), and landscape context (the degree to which the project is embedded in urban land use). To understand the causes of low project scores relative to ambient condition, projects should be assessed with CRAM prior to impact or restoration, then re-assessed as the project matures. Data of this kind are essential to enabling wetland managers to track net change in wetland acreage and condition and to account for the large and ongoing public investment in wetland restoration.

CRAM scores and the accompanying stressor checklist suggest possible management actions to increase wetland condition within each coastal region. The stressors affecting the condition of estuarine wetlands originate in their watersheds or adjoining uplands. Altered runoff (increases due to urban drainage, decreases due to stream diversion or withdrawals, etc.) have changed estuarine salinity regimes. In some South Coast estuaries, erosion control or impoundment of sediment has significantly reduced the amount of sediment supply needed to sustain estuarine wetlands. In others areas, such as the North Coast, timber harvesting activities upstream have led to excessive sedimentation in stream reaches. In all regions, conversion of floodplains to developed land use has reduced their ability to filter runoff and buffer estuaries from upstream contaminants. Better management of urban and agriculture runoff through integration of Best Management Practices is necessary to reduce contaminant inputs to these systems, reduce toxicity of water and sediments, while assuring that sediment supplies are adequate to sustain estuarine wetlands, especially in the context of sea level rise.

Historical levees and dikes that have modified tidal circulation have caused a general decline in estuarine wetland condition. Careful removal, realignment, or re-engineering of operational and abandoned railroads and highways is required so that they no longer impede tidal circulation. Much of this infrastructure will need to be modified to accommodate rising sea levels and increased wave run-up; improved tidal exchange between estuarine wetlands and their estuaries should be a design criterion, coupled to plans for infrastructure repair and replacement. A statewide forecast of sea level rise across the coastal landscape would help preview estuarine wetland restoration constraints and opportunities.

Improving biotic conditions in the North Coast region requires controlling the invasive cordgrass *Spartina densiflora*. At the landscape scale, estuaries should be regarded as downstream extension of their watersheds. Improving the overall condition of estuarine wetlands will ultimately require changes in watershed management to 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 rise.

Use of the Wetland Toolkit for Watershed Assessment. Aquatic resource monitoring is a key component of watershed assessment. Wetlands, through use of the toolkit, can be seamlessly integrated into the assessment of all aquatic habitats within a watershed. With standard assessment methods, comparisons can be made among watersheds or to Statewide ambient condition. To demonstrate this, three watersheds were chosen representing South Coast (San Gabriel River watershed), Central Coast (Morro Bay Watershed), and the Bay Area (Napa River watershed). Assessment of riverine-riparian habitat within these watersheds consisted of, at minimum: 1) Level 1 inventory of wetlands; 2) Level 2 (CRAM) assessment of ambient condition of riverine-riparian habitat using; and 3) CRAM assessment of selected riverine-riparian projects. Each watershed had a distinct management community and baseline of existing data. These data are complemented by CRAM assessments of riverine-riparian habitat conducted as part of the 2007-08 Statewide Perennial Stream Assessment (PSA) of the State's Surface Water Ambient Monitoring Program (SWAMP). . Examples are used from each dataset to illustrate toolkit use for riverine-riparian assessment.

The Napa River Watershed had detailed maps of wetlands and riverine-riparian habitat for present-day and historical conditions (pre-dating local Euro-American contact). These data were used to show changes in wetland and riparian extent over time. In this watershed, most of the seasonal and perennial depressional wetlands have been drained or filled to support agriculture and urbanization, while the amount of lacustrine wetland has been greatly increased by the construction of reservoirs for flood control, recreation, irrigation, and other consumptive uses. The acreage of riverine-riparian habitat has slightly increased due to the addition of irrigation and drainage ditches. However, the amount of riparian area wide enough to support the full complement of riparian functions, including terrestrial and riparian wildlife support, has decreased by almost 90%.

The results of the ambient surveys can be compared among demonstration watersheds and to the Statewide PSA. Median CRAM index scores for Morro Bay watershed (72 ±3), Statewide and Napa River watershed (67 ±3) fall into Category 2 (medium-high condition), whereas the median score for the San Gabriel River watershed falls into Category 3 (44 ±3; medium-low). These index scores and their component attribute scores reflect a gradient of urbanization within these watersheds. Completed restoration projects in Morro Bay watershed were used to show how projects can be compared to ambient condition at the watershed scale, and to track restoration progress and to establish performance curves. Seven of 10 projects in the Morro Bay watershed scored below the 50^{th} percentile of the both the Morro Bay watershed and the statewide ambient survey. Data of these types illustrate the cost-effectiveness of using CRAM to interpret the condition of a project relative to the gradients in condition within a watershed and statewide.

The San Gabriel River watershed provided the template to illustrate the merits of using the Level 1-2-3 toolkit (i.e., wetland resource extent/distribution, overall condition, and specific aspects of condition) to provide a complete assessment of wetland condition in the watershed. These data can help determine how policies and programs have affected conditions in a watershed and how they might influence future management actions. A comparison of Level 2 and Level 3 data indicates issues with contaminant loads and habitat impairment among three sub-regions based on watershed position. Information from Level 1 and Level 2 studies corroborates observations that watershed position is an important determinant of overall water quality in the San Gabriel River. A positive correlation between CRAM-benthic macroinvertebrate IBI scores and CRAM-SWAMP physical habitat scores provides weight of evidence indicating that biotic integrity is strongly dependant on habitat condition. By applying a hybrid sampling design that integrates probability-based surveys, overall condition assessment (Level 2), and more quantitative site assessments (Level 3), wetland status and trends assessment can be successfully incorporated into traditional water quality and biological monitoring programs to provide a more robust understanding of the relationship between ambient condition of aquatic resources and their beneficial uses.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

1. INTRODUCTION

California's wetlands are an important natural resource, providing a number of critical ecological services, including: habitat support for migratory and threatened and endangered species, fisheries support, flood control, water quality protection and enhancement, and ground water recharge. Physical features, climate, and hydrology, as well as plant and animal diversity, sharply distinguish the State's wetlands from any other in North America. Over the past 150 years, California wetlands, streams, and watersheds have been dramatically altered by human activities. Over the last 20 years, billions of public and private dollars have been invested in the protection, restoration, creation, and enhancement of wetlands and riparian areas throughout California. Unfortunately, information on the effectiveness of these investments, relative to ongoing degradation from changing land use, has not been readily available to resource managers, regulators, elected officials, non governmental organizations (NGO's), and the public because wetlands and riparian habitat are not being monitored systematically.

The primary threats to wetlands are human uses that alter wetland hydrology, substrate conditions, and plant communities; these uses include discharge of dredge or fill material, excavation, and habitat degradation from external stressors, such as point and non-point source (NPS) pollution. An illustration of the current scale of impacts can be seen the State Water Resources Control Board (SWRCB) listing in 2006 of over 100,000 acres of tidal wetlands and 23,000 miles of creeks and rivers as impaired under Section 303(d) of the Clean Water Act. In spite of such well-documented impairment, development pressure continues to be intense with a doubling of the 1995 population expected by 2020.

The Need for a Comprehensive Wetland and Riparian Monitoring Program

A comprehensive wetland and riparian monitoring program is needed to in order to address these stressors and sustainably manage wetland and riparian resources. The need for comprehensive wetland monitoring and assessment, illustrated above, is supported by the National Research Council's report on "Compensating for Wetland Losses under the Clean Water Act" (NRC 2002), which noted the need to: 1) conduct ambient monitoring and assessment; 2) create tools to better inform the regulatory and management processes to make them more adaptive and performance-based; 3) provide mechanisms to engage all regulatory programs via consistent approaches and tools; 4) conduct assessment to provide a regional context for decision-making, including evaluation of cumulative impacts; 5) develop a consistent approach to assessment project performance; and 6) provide a common framework and platform for data management and dissemination. More recently, the National Wetland Mitigation Action Plan and a State Water Resource Control Board (SWRCB) evaluation of the effectiveness of Clean Water Act Section 401 water quality certification recommends improvements in wetland monitoring, project tracking, and follow-through in evaluating compensatory mitigation in order to better track net change in wetland and riparian acreage and condition (Ambrose *et al*. 2006).

One challenge to developing an integrated statewide monitoring and assessment program is the fact that no single agency has authority over aquatic resources. Regulation and management of wetlands and streams falls under the authority of six state and federal agencies. To add to this complexity, multiple programs within an agency may have authority or regulatory control over wetlands. For example, wetlands and streams may be monitored or evaluated by a Regional Water Quality Control Board (RWQCB) under the Section 401, NPDES/MS4, and Surface Water Ambient Monitoring Program (SWAMP) efforts without any substantial intra-agency coordination. A need exists to implement standardized monitoring and assessment tools and approaches within state and federal agencies in California. The resulting data can be used to better manage wetland and riparian resources, evaluate program efficacy, and facilitate improved coordination and communication within and among agencies.

Conceptual Framework and State Wetland Monitoring Toolkit

In 2003, a consortium of scientists and managers from around the state began developing the conceptual framework and tools to be used in a Statewide wetlands assessment program, modeled after the United States Environmental Protection Agency (USEPA) Level 1-2-3 framework for the monitoring and assessment of wetland resources (USEPA 2006). The fundamental elements of this framework are as follows:

- Level 1 consists of wetland and riparian inventories, landscape profiles, and assessment of stressors from upstream and surrounding land uses.
- Level 2 consists of rapid assessment, which uses cost-effective field based diagnostic tools to assess the condition of wetland and riparian areas.
- Level 3 consists of intensive assessment to provide data to validate rapid methods, characterize reference condition, and diagnose the causes of wetland condition observed in Levels 1 and 2.

This framework is applicable to wetlands and riparian areas in their broadest sense, independent of any particular agency jurisdiction. A definition of "wetland" is now under development by the SWRCB. The current draft definition of "wetland" for SWRCB programs under the Porter-Cologne Act is similar to definitions long used by federal agencies, assuring essential compatibility among state and federal wetland programs; the draft definition also includes coverage for some non-vegetated areas that are not covered under the federal definition. Riparian areas include transitional areas adjacent to rivers, streams, estuaries, lagoon, lakes, depressional wetlands, and other waterbodies that characteristically have a high water table and are subject to periodic flooding and influence from these adjacent waterbodies. These transitional areas do not need to have riparian vegetation to be considered "riparian areas." The toolkit currently consists of the following tools:

- Standardized Methods to Map Present Day and Historical Wetland and Riparian Habitat (Level 1). Inventories are the most basic component of a comprehensive wetlands and riparian assessment program, and are essential for identifying the historical and present day spatial distribution and abundance of these habitats. Inventories are the primary mechanism through which the State can evaluate its "no net loss" of wetlands policy. Inventories also serve as sample frames for probabilistic surveys of wetland and riparian ambient condition.
- California Rapid Assessment Method (CRAM; Level 2). USEPA funded the development of the CRAM as a Level 2 tool for wetland and riparian monitoring and assessment (Collins *et al.* 2007). The overall goal of CRAM is to provide a rapid, scientifically defensible, and repeatable assessment methodology that can be used routinely in wetland monitoring and assessment programs throughout the state of California. The general framework of CRAM is consistent across wetland types and regions, yet allows for customization to address special characteristics of different regions and wetland classes. CRAM is designed for routine use in local, regional, and statewide programs to monitor wetlands and riparian areas. CRAM also features a "field to PC" data management tool (eCRAM) to ensure consistency and quality of data produced with the

method. CRAM has been validated against independent Level 3 measures of condition for estuarine and riverine wetlands (Stein *et al*. in press).

- Wetland Project Tracking and Wetland Information Management (Level 1 and 2). Wetland project tracking consists of standardized sets of data and maps to collect and share data among agencies and the public on projects that impact wetland and riparian habitat quantity and quality. In the coastal regions of California, project tracking is currently being implemented through a publicly accessible, GIS-based data management system called the Wetland Tracker (www.wetlandtracker.org). The Wetland Tracker serves as a shared resource for current and historical habitat maps, CRAM ambient survey and project data, and wetland projects among participating resource and regulatory agencies and the general public. It allows information about permitted or grant-funded wetland and riparian gains and losses to be tracked and analyzed over time relative to regional trends in wetland and riparian extent and condition. Wetland project tracking is one key mechanism through which the State is be able to track the impact of permitted wetland gains and losses. It also aids state agencies in evaluating the impact of their programs on wetland and riparian resources.
- Standardized Monitoring Protocols (Level 3). Regional teams in southern California and San Francisco (SF) Bay area continue to develop a suite of standardized Level 3 monitoring protocols that supplement CRAM and can be employed for both probability-based surveys and project-specific monitoring to address wetland management questions that require more precision than provided by CRAM alone. The state is currently implementing a benthic macroinvertebrate index of biological integrity (IBI) in streams. Also under development is a periphyton IBI for streams, as well as a host of Level 3 protocols to assess the physical and biological integrity of estuarine wetlands, rivers and streams.

Purpose and Intended Audience of Report

In 2006, the Resources Agency was awarded a USEPA Wetland Demonstration Program (WDP) Pilot grant to begin a phased implementation of a statewide wetland monitoring program, building on the existing conceptual framework and statewide wetland monitoring toolkit. Through grant activities, significant advancements have been made in the State's capacity to monitor wetlands and riparian areas through improved interagency coordination, a statewide wetland inventory, assessment standardization, information management tools, and project tracking, culminating in a demonstration of toolkit application through condition assessments in estuarine and riverine wetlands.

The purpose of this technical report, submitted to the California Resources Agency on behalf of the WDP Regional Science Teams, is to document this progress, summarize the results of the assessments, and recommend next steps.

The intended audience for this technical report is state, federal and local agency technical staff and program managers responsible for managing, regulating, and conserving wetlands and riparian areas. The Resources Agency used this report and recommendations from the State Wetlands Monitoring Workgroup[1] to develop the State of the State's Wetland Report (California

[1] The State Wetlands Monitoring Workgroup is a subcommittee of the Water Quality Monitoring Council, a group formed by the Senate Bill SB1070 that calls for improved coordination of water quality monitoring across agency programs. The State Wetlands Monitoring Workgroup, chaired by the SWRCB and the

Resources Agency 2008a), based on this technical report and recommendations from the State Wetlands Monitoring Workgroup, a subcommittee of the WQMC. The State of the State's Wetland Report is intended for the legislature and the general public.

WDP Project Goals and Major Tasks

The goal of the WDP project was to improve State capacity to manage, regulate and conserve its wetlands and riparian habitat through the phased implementation of a comprehensive assessment program. The comprehensive assessment program utilizes the toolkit of standardized data collection and assessment methods to monitor wetlands and riparian habitat.

The WDP project sought to initiate the implementation of a Statewide Wetland Monitoring Program through a series of major activities, carried out over a three year period:

- Creation of a Statewide Steering Committee to oversee project activities to provide a mechanism for interagency coordination on wetland monitoring and assessment and refine the State's conceptual approach and strategy
- Standardization of wetland and riparian mapping methodologies and continued update of the State's comprehensive wetland inventory
- Development of state agency capacity to implement CRAM
- Development of state agency capacity to implement project tracking and manage wetlands related data through a publicly accessible data portal called the Wetland Tracker (www.wetlandtracker.org)
- Assessment of status and trends of estuarine wetlands statewide
- Assessment of status and trends of riverine wetlands and associated riparian areas in three demonstration watersheds
- Report on the State of the State's Wetlands

Report Organization

This report is organized into seven sections that follow the major activities outlined above.

The Executive Summary provides an overview of project findings and presents a series of recommendations and next steps for consideration of the Resources Agency and the State Wetland Monitoring Workgroup.

Section 1 summarizes the need for a comprehensive wetlands and riparian monitoring program, provides an introduction to the State's wetland monitoring toolkit, and outlines WDP project goals and major activities.

Section 2 describes how a statewide wetland monitoring program will address management information needs, and reports on the status of the State's effort to develop a program, using USEPA Elements letter as an organizing framework (USEPA 2006), and identifies key actions necessary for continued progress.

California Department of Fish and Game, was reconstituted from the WDP Steering Committee member agencies.

Section 3 details the status of the State Wetland and Riparian inventory, progress on standardization of wetland and riparian mapping protocols, and recommendation to cost-effectively assess the trends in wetland and riparian acreage statewide.

Section 4 discusses the status of CRAM development and implementation, as well as its utility to address agency management needs.

Section 5 provides an overview of the need and conceptual approach to project tracking as well progress to agree on a standard set of data to track projects. Progress on Wetland Tracker, the information management system for wetlands related data is also presented in this section.

Section 6 presents the findings of the State's first 305(b) report on the status of perennial estuarine wetlands.

Section 7 demonstrates the use of the Level 1-2-3 framework to assess wetlands and riparian habitat for wadeable streams in the Napa River, Morro Bay, and San Gabriel River watersheds.

2. CONCEPTUAL APPROACH AND BENEFITS OF STATEWIDE WETLAND MONITORING PROGRAM

The purpose of this section is to: 1) describe how these tools can be used to inform decisions regarding wetland and riparian resources, and improve coordination and efficiency of various State and Federal wetland programs; 2) summarize the State's progress in developing a statewide wetland monitoring program; and 3) identify key technical and administrative actions necessary to achieve further progress.

Meeting Management Information Needs via a Statewide Wetlands Assessment Program

Wetland regulation and management in California is covered by a multitude of agencies, programs, and guidance, including:

- Federal Regulatory Programs – Federal Clean Water Act, Sections 404, 401, 402 (NPDES), Coastal Zone Management Act
- State Regulatory Programs – Porter-Cologne Act, Section 1600 of the Fish and Game Code, California Coastal Act, McAteer-Petris Act
- Planning and Monitoring Programs – Surface Water Ambient Monitoring Program (SWAMP), Statewide Wetland Monitoring Program (WDP), State Water Board Watershed Management Initiative, USEPA Advanced Identification (ADID), United States Corps of Engineers Special Area Management Plans (SAMP), RWQCB Urban Runoff Management Plans (JURMP/WURMP/SUSMP)
- Restoration Programs administered by the California Coastal Conservancy, US Fish and Wildlife Service, Department of Fish and Game, Wildlife Conservation Board and others

There are several key needs within the diversity of programs focused on wetland regulation and management that can be addressed through implementation of a standardized wetland and riparian assessment toolkit. These needs include:

- Providing data to better inform management decisions, including the analysis of cumulative impacts
- Standardizing data protocols to improve coordination between agencies and programs. This includes common definitions of wetlands and riparian areas, approaches for classification, consistent assessment tools, and common data management platforms and standardized data transfer formats
- Generating information that can be used to assess the effectiveness of wetland programs and funding, including common performance measures for restoration and mitigation projects

The Level 1-2-3 framework and the associated tools developed under this framework can help address some of these needs by providing a coherent conceptual approach that provides information about wetlands and riparian areas to agencies and the general public.

Providing Data to Better Inform Management Decisions

Implementation of the monitoring toolkit within the Level 1-2-3 framework provides the means for cost-effective, holistic assessment of ambient extent and condition of aquatic resources and beneficial uses (see Sections 6 and 7). These tools can be applied at the state, regional, or watershed scale to inform management actions and prioritize recovery efforts.

Implementation of inventories, landscape assessment of stressors, and probability-based surveys utilizing rapid assessment tools and Level 3 protocols provide a comprehensive picture of ambient condition. Inventories show the geographic distribution and extent of resources. When coupled with an understanding of historical habitat distribution, inventories provide an understanding of how to prioritize recovery efforts. Landscape assessment of stressors can be used to characterize the impacts that anthropogenic land use practices have on resource condition; it can also be used as a coarse tool to predict wetland condition at a catchment scale. Probability-based surveys using CRAM and other Level 3 monitoring protocols provide an evaluation of ambient condition and data with which to formulate management actions. Application of these tools at the project scale then provides a means by which to interpret data obtained from site-specific assessments within the context of the overall ambient condition at the watershed, regional, or statewide scale. These tools can also be used to provide assessments of status and trends of wetland and riparian beneficial uses.

The State's SWAMP has in the past been limited to evaluation of the ambient condition of the rivers and streams, emphasizing water quality over aquatic life use. This emphasis is now shifting with the implementation of a benthic macroinvertebrate IBI in rivers and streams, and the identification of the importance of assessing wetland beneficial uses in the recently revised SWAMP strategy. Rapid assessment tools such as CRAM can be seamlessly integrated with other bioassessment tools to more comprehensively assess the status of aquatic life use in waters of the State. Similarly, CRAM provides a tool to help support emerging wetland ambient assessment programs, such as the WDP being developed by the California Resources Agency.

The Level 1-2-3 framework and the wetland monitoring toolkit also have tremendous potential for application at the watershed scale, where most management actions should be formulated. Inventories and probability-based surveys using CRAM allow a cost-effective estimate of general baseline conditions of wetlands and riparian areas in a watershed. These data can then be used to identify specific stressors that need to be managed, including: hydromodification, excessive sedimentation, invasive species, and human impacts. It can also be used as amechanism to prioritize degraded areas for recovery work or pristine areas for conservation. The combination of inventories, CRAM, and project tracking will allow agencies and the general public to spatially survey the locations of projects, including restoration projects, impact sites and mitigation sites. This will reduce the possibility of impacting past mitigation or restoration areas, and will promote watershed scale planning and management activities. Such watershed scale activities are consistent with pending Federal mitigation policies, which emphasize a watershed approach.

The assessment of cumulative impacts at the watershed scale is another application for these tools. Cumulative impacts are an important aspect of regulatory programs that is seldom adequately addressed. Previous studies have documented that in many cases, the majority of total impacts to a watershed (or region) can occur as a result of the cumulative effect of numerous small actions over space and time (Holland and Kentula 1992, Allen and Feddema 1996, Stein and Ambrose 1998). Use of CRAM and Project Tracking would make it easier to assess and track these small projects and hence address cumulative impact issues.

Several projects are underway to demonstrate how CRAM can be implemented in an ambient survey at spatial scales ranging from the watershed to statewide level: 1) a statewide estuarine assessment, planned for 2007, which combines a Level 1 assessment of wetland extent, a Level 2 ambient survey of estuarine condition, and a CRAM assessment of the status of estuarine restoration projects; 2) implementation of CRAM along with the benthic macroinvertebrate IBI in a statewide assessment of rivers and streams; and 3) demonstration of how CRAM and the Level 1-2-3 framework can be implemented in three demonstration watersheds throughout the state (Solek et al. 2008, O'Connor et al. 2008, Appendix 1).

Standardizing Data Protocols to Improve Coordination and Outreach

Wetland and riparian inventories, CRAM, and Project Tracking provide a common set of tools and assessment language that all agencies can use to articulate wetland change due to permitted impacts on an ongoing basis, compensatory mitigation, and non-regulatory restoration, and to provide public access to this information. Using this common language can facilitate improved coordination and data sharing between programs. It will help agencies implement a variety of stated objectives, such as establishing beneficial use standards for wetlands, developing common performance measures, and evaluating "no net loss" policies. In particular, distribution of wetland condition based on CRAM scores (relative to specific wetland type or landscape/land use context) can be used to develop wetland and riparian protection policies, and to assess wetland beneficial uses and impairments of those beneficial uses.

In particular, Project Tracking provides an easy way to cross-reference agency actions (and file numbers) and provides an online mechanism for agency coordination on projects. Such information sharing has the potential to improve program efficiency across agencies by reducing redundancy in data processing and evaluation and providing for shared permit evaluation and compliance data. ·It also makes it easier and less time consuming for regulatory agency staff and others to track the status, success, and regional context of tidal and inland wetland projects by providing an online source for detailed information about individual wetland restoration, creation, and enhancement projects. It promotes easy exchange and archiving of project monitoring or descriptive information. It also provides a means to consistently update the public regarding the status of wetland and riparian areas.

Generating Information to Assess the Effectiveness of Wetland Programs

Over the last 20 years, billions of public and private dollars have been invested in the protection, restoration, creation, and enhancement of wetlands and riparian areas throughout California. Unfortunately, information on the effectiveness of these investments is not readily available to resource managers, regulators, elected officials, NGO's, and the public because the condition of wetlands and riparian habitat is not being monitored systematically. Incorporation of the Level 1-2-3 framework into agency programs will provide an opportunity to evaluate the effectiveness of public and private investment in the conservation and restoration of these resources. This will help agencies be accountable to the California legislature with respect to the impact of public investment in agency programs to conserve, restore, manage, and regulate wetland and riparian resources.

Recent reviews of both the State and Regional Water Board water quality certification programs have identified poor record keeping and data inaccessibility as barriers to program review and evaluation, and to compliance assessments (Ambrose *et al*. 2006). Use of Project Tracking would help remedy this situation by providing a central repository of data on impact, mitigation, and restoration sites in a format that is easy to update/query, and accessible to all agencies. Incorporation of common, structured tools, such as CRAM, will facilitate Quality Assurance (QA) and Permit compliance processes. Use of a common assessment tool can generate consistent data formats that in turn facilitate internal agency reviews. It can also make it easier for outside (or third party) reviewers to assist in the process, in addition to allowing agencies with overlapping jurisdiction to more readily share QA and compliance responsibilities. Thus, use of these tools will aid agencies in striving to meet "no net loss" goals.

Elements of a Comprehensive State Wetland Monitoring Program

In 2006, USEPA provided guidance to States recommending elements of a comprehensive wetland monitoring program (a.k.a. EPA Wetlands Elements Letter; USEPA 2006). This document was prepared to assist State program managers plan and implement a wetland assessment program within the context of the March 2003 EPA document, *Elements of a State Water Monitoring and Assessment Program* (EPA 841-B-03-003). It provides clarification and further information on how the original *Elements* document applies to wetlands. The Wetland Elements Letter (EPA 2006) recommends 10 basic elements of a comprehensive wetland assessment program that meet the requirements of Clean Water Act Section 106(e)(1):

1. Monitoring Program Strategy
2. Monitoring Objectives
3. Monitoring Design
4. Core and Supplemental Indicators
5. Quality Assurance
6. Data Management
7. Data Analysis
8. Reporting
9. Programmatic Evaluation
10. General Support and Infrastructure Planning

The follow summarizes the status of the State's progress on monitoring program development with respect to these 10 elements and identifies key actions to ensure continued progress.

Monitoring Program Strategy and Objectives

The cornerstone of a wetland monitoring program is a strategy which lays out the components of the program, the gaps in funding and infrastructure, and specifies the priority actions and timeframe to achieve them. It is strongly recommended that the State develop a wetland monitoring program strategy. This effort has been initiated by developing draft recommendations for the technical and programmatic components of a statewide wetland monitoring program (Appendix 1). The SWMW should review and revise this draft technical plan and create a strategy to implement this program.

The Monitoring Strategy should detail wetland monitoring programmatic objectives, assessment questions and integration into existing State water quality monitoring program will be detailed in this strategy. Each individual objective will control the nature of wetland sampling design, the selection of assessment indicators and sampling methods, field deployment, QA, data analysis, data management, reporting, and the cost of wetland monitoring activity.

Monitoring objectives must address the key wetland management questions throughout the state. Over the past 7 years, the WDP technical team has identified a set of key management questions that are common across agencies and programs. These questions, and examples of monitoring program objectives that correspond to these questions, are given in Table 2-1. The Statewide Wetland Monitoring Workgroup (SWMW) should consider identifying these management questions, and establishing monitoring program objectives to address these needs.

Table 2-1. List of common management questions across agencies and program and examples of monitoring program objectives that address these questions.

<table>
<tr><th>Key Management Questions</th><th>Example Monitoring Program Objectives</th></tr>
<tr><td>Where are the State's wetlands, how abundant are they, and how are they changing over time?</td><td rowspan="4">Establish a baseline of wetland condition and/or report changes in condition in a State's Clean Water Act (CWA) Section 305(b) report or Integrated Report

Refine or create wetland specific water quality standards pursuant to CWA Section 303, including the development of appropriate reference conditions</td></tr>
<tr><td>What is the ambient condition of wetlands statewide, how does their condition vary by region and wetland type, and how is this condition changing over time?</td></tr>
<tr><td>What are the major stressors on wetlands and how are they impacting condition?</td></tr>
<tr><td>Are wetlands beneficial uses impaired?</td></tr>
<tr><td rowspan="3">What is the impact of projects on wetland acreage and ambient condition?

Are "no net loss" policies being met?</td><td>Evaluate the environmental consequences of wetland policy or programs, including the effectiveness of compensatory wetland mitigation, under the provisions of CWA Section 404/401 and the National Environmental Policy Act (NEPA)</td></tr>
<tr><td>Evaluate the cumulative effects of wetland loss and/or restoration</td></tr>
<tr><td>Evaluate the performance of wetland restoration projects, including CWA Section 319 nonpoint source pollution control projects</td></tr>
</table>

To understand the context for this strategy, some explanation is required of the California's current and forthcoming wetland and riparian protection policies, the SWRCB's SWAMP water quality monitoring strategy, and the recently created Water Quality Monitoring Council (WQMC).

The Wetlands Conservation Policy of 1993 is the primary policy governing wetlands protection. The primary goal of this policy is to "…ensure no overall net loss and achieve a long-term net gain in the quantity, quality, and permanence of wetlands acreage and values in California…"

The recently passed Senate Bill SB 1070 (Chapter 750, statutes of 2006) created the California WQMC. The purpose of the Council is to review existing water quality monitoring, assessment, and reporting efforts, and to recommend specific actions and funding needs necessary to coordinate and enhance these efforts. The Council is charged with developing a comprehensive monitoring program strategy that utilizes and expands upon the state's existing statewide, regional, and other monitoring capabilities, and describes how the state will develop an integrated monitoring program that will serve all of the State's water quality monitoring needs and address all of the State's waters over time. The Council has designated the Statewide Wetlands Monitoring Workgroup (SWMW), reconstituted from the WDP Steering Committee, to provide information and recommendations on integrating wetlands into the State's water quality monitoring program. Table 2-2 gives a list of the SWMW member agencies. Therefore, the timing is appropriate to develop a strategy to implement a comprehensive wetland monitoring program. Note that this program must not only incorporate wetlands into existing Section 106 ambient monitoring of surface waters, but also implement components that address other important management questions (Table 2-1).

Table 2-2. List of Statewide Wetlands Monitoring Workgroup (SWMW) member agencies.

CA Coastal Commission (CCC)
CA Dept. of Parks and Recreation
CA Department of Fish and Game
CA Department of Water Resources
CA Resources Agency
CA State Lands Commission
CA Department of Fish and Game
Humboldt Bay Harbor District
Moss Landing Marine Laboratory
NOAA National Marine Fisheries Service
NRCS
RWQCB, Central Coast
RWQCB, Central Valley
RWQCB, Los Angeles
RWQCB, San Francisco
RWQCB, Santa Ana
SCCWRP
SFEI
SWRCB
USACE, Los Angeles District
USACE, Sacramento District
USACE, San Francisco District
USEPA
USFWS, NWI

An important component of a wetland monitoring program design is the assessment of ambient condition. The SWRCB has developed a water quality monitoring strategy for its SWAMP program. Wetlands monitoring is specifically mentioned in this strategy and the State is working to begin incorporating wetlands into SWAMP through a series of pilot projects. One such project is the statewide ambient assessment of estuarine wetlands; funded through the WDP grant, this project produced the State's first 305(b) report utilizing the wetland monitoring toolkit Section 7 (SWAMP 2008). A second pilot project involves the incorporation of CRAM into the statewide bioassessment program for rivers and stream (California Monitoring and Assessment Program; CMAP). A more complete integration of wetlands into a comprehensive aquatic resources monitoring framework is a logical outcome of the WQMC's work to coordinate water quality monitoring across the state.

In addition, the SWRCB is developing a new wetlands and riparian protection policy that includes, currently in draft form, a new definition for wetlands, a standardized classification system for mapping and assessment, methods for delineating wetlands, and requirements for project tracking and assessment using CRAM or an equivalent rapid method. The definition of wetlands and the proposed classification system are the foundation of the monitoring program strategy and will influence the design elements of its components.

Monitoring Design and Core/Supplemental Indicators

The design of a wetland monitoring program must be developed to specifically address the objectives. The monitoring design and sample sites selected must be those that best serve its monitoring objectives. The State of California has embraced the USEPA Level 1-2-3 assessment framework and the standardized wetland assessment toolkit as means of addressing these programmatic objectives. Figure 2-1 gives a conceptual picture of how the Level 1-2-3 assessment framework addresses the key management questions listed in Table 2-2. .

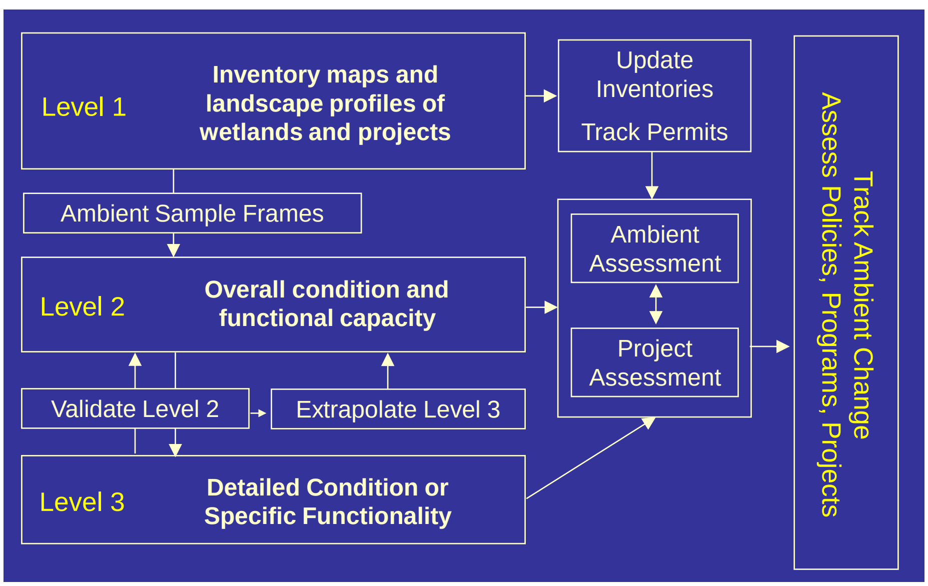


Figure 2-1. Basic assessment framework for California's comprehensive wetland monitoring program.

The State is developing and refining the Level 1 (mapping and landscape assessment) and Level 2 (CRAM) tools for implementation (see Sections 3 and 4 respectively for details). The WDP assessments demonstrated how Levels 1 and 2 can be used as core indicators to answer key management questions in a cost-effective manner (Sections 6 and 7). Level 3 indicators should be included to answer specific management questions that require greater level of precision. These core indicators should be included as a consistent component of all monitoring (ambient and project-specific) in order to ensure the ability to provide integrated reporting across agencies and programs statewide.

The State monitoring program design should integrate several monitoring designs (census, probability-based, and targeted sampling) as well as all three assessment levels to meet a full range of decision needs. The Statewide estuarine wetland assessment (Section 6) and watershed demonstration projects (Section 7) demonstrate how census (Level 1 inventory), and probability-based surveys, and targeted assessments (in Level 2 assessment) can be used for making inferences about the condition of wetlands in different geographic settings.

Reference networks are a fundamental component of a wetland monitoring program (see Section 4 for details). This reference network should reflect a gradient of human-induced disturbance, include least-impacted and other sites, and be used to verify the accuracy of wetland assessment methods, including CRAM. Long term sampling conducted within the reference network will provide information needed to characterize wetland variability over time and space, particularly with respect to climate change. Targeted sampling will be used in the development of a reference network for estuarine wetlands through a current EPA Section 104(b) Wetland Development Grant. Additional work is required to develop reference networks for other wetland types.

Quality Assurance

Wetland monitoring program quality assurance and quality control (QAQC) needs to be developed to specifically address monitoring program objectives. However, the WDP technical team has broad recommendations for the major components that must be considered as the Level 1-2-3 framework is implemented. Implementation of Level 1-2-3 methods and tools require training, reference sites, and quality assurance measures implemented through regional teams, but coordinated statewide through the SWMW. Figure 2-2 provides a schematic of the basic programmatic components needed for quality assurance. Training and data QAQC will be coordinated through a proposed regional data center that has been already established for SWAMP data collection, QAQC, and management. Training for Level 1-2-3 methods and tools must be provided for staff and practitioners. This work involves the development of manuals, tutorials, and curricula. As currently conceived, the University of California extension service could provide the mechanism through which training is administered.

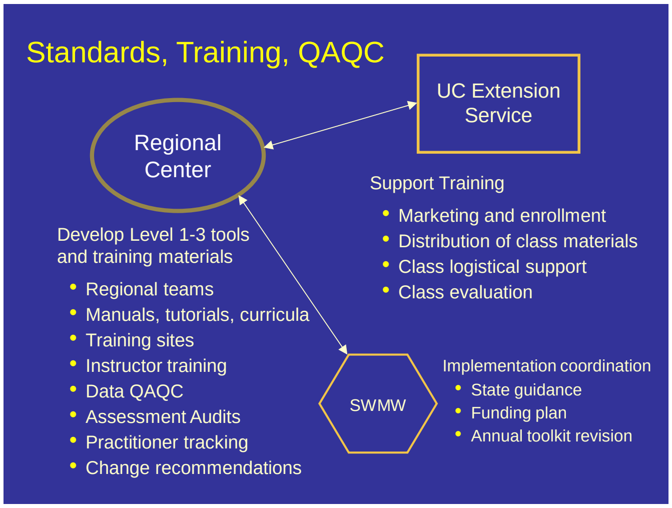


Figure 2-2. Schematic of components of wetland monitoring program quality assurance.

Regional data centers will provide the mechanism through which data QAQC is conducted, practitioner assessments are audited, and detailed data about reference sites are maintained. These centers will also act as the conduit through which technical recommendations for improving methods and guidance can be delivered to the SWMW.

Standardized operating procedures and quality assurance program plans (QAPPs) should be developed for each tool and its programmatic application. Standard Operating Procedures (SOPs) will be standardized statewide for each type of tool or method; QAPPs may change as a function of a particular project or application and must reflect the level of data quality appropriate for specific uses of data (e.g., reporting status and trends, prioritizing restoration activity and assessing the performance of compensatory mitigation projects). SOPs are currently available for wetland and riparian mapping and use of CRAM (see CRAM Users Manual at www.cramwetland.org). Examples of QAPPs for application of Levels 1 and 2 in ambient and project-specific assessment are available on the CRAM website.

Data Management, Analysis, and Reporting

Conceptually, a comprehensive wetland monitoring program requires an electronic information management system for water quality, toxicity, sediment chemistry, habitat, and biological data; the system should feature timely data entry and public access. These data need to follow appropriate metadata and State/Federal geo-locational standards. Also, the monitoring program should also have the capability of managing available wetlands geospatial data for use in Geographical Information System (GIS) applications (e.g., Level 1 wetland assessment). Monitoring and assessment should be conducted with the intent that collected data and analyzed data will be archived to allow for its use in future studies. The selection of a data management system should be part of the initial planning phases of a monitoring project/program.

In California, the information management system under development is one in which the wetland monitoring and assessment data can be integrated with CWA Section 404/401 permit tracking systems (www.wetlandtracker.org; Section 5). The Wetland Tracker features a web-based user-friendly Google-Earth interface that allows users to view data related to historical and current wetland and riparian habitats, projects, and ambient assessment efforts. Upgrades to the Wetland Tracker enhance the functionality of electronic data querying and reporting, streamline quality assurance, and produce additional tools to simplify project submission (see Section 5) are planned. Wetland Tracker functionality should include means to access raw data, automated reports, published grey literature reports, and data syntheses, such as 305(b) reports (e.g., Sutula *et al*. 2008).

The Wetland Tracker is under consideration by the WQMC to serve as the State's Wetland Data Portal. In order to realize the Tracker's full potential as a means for the public to access wetlands related data, the State should engage in the process of determining what types of data are appropriate for the Tracker and fully fund its development and maintenance. This will likely involve the creation of regional data centers which serve as the local respository and manager of wetlands-related data.

Many agencies have existing databases used for project tracking. Ultimately, a process should be developed to allow data sharing among existing agency databases and data harvesting from Project Tracking and other agency databases. This would prevent the need for duplicate data entry while allowing agencies to supplement individual databases. This would also allow for information collected by Project Tracking to be uploaded to State or Federal databases for reporting purposes.

Programmatic Evaluation

Another essential component of a comprehensive wetland monitoring program is the periodic evaluation of the program. The State of California conducts periodic reviews of each aspect of its monitoring program to determine how well the program serves water quality decision needs for all State waters, including all waterbody types. Internal audits will identify gaps in information production that can be filled as a program matures. Such reviews also provide the opportunity to identify contingencies that will allow wetland monitoring and assessment activity to continue in the event of a funding shortfall.

The SWRCB has recently conducted an evaluation of compensatory monitoring under its CWA Section 401 Water Quality Certification Program (Ambrose *et al*. 2006). This assessment identified poor record keeping and data inaccessibility as barriers to program review and evaluation, and to compliance assessments. Use of Project Tracking would help remedy this situation by providing a central repository of data on impact, mitigation, and restoration sites in a format that is easy to update/query and accessible to all agencies.

Regular evaluations are critical to improving reporting on the performance of restoration and compensatory mitigation projects, including CWS Section 319 NPS pollution control projects, on a systematic basis to relevant state agencies, commissions, and departments, as well as federal agencies, including: the United States Army Corps of Engineer (USACE), USEPA, National Resources Conservation Service (NRCS), National Oceanic and Atmospheric Administration (NOAA), and United States Fish and Wildlife Service (USFWS). These evaluations should be disseminated to the public via the Wetlands Data portal.

General Support and Infrastructure Planning

Agency coordination and leadership is essential to meeting the challenge of developing a comprehensive monitoring program through improved coordination and identification of common assessment needs and priorities This leadership and interagency coordination has been initiated through the SWMW and cooperative regional management program such as the Southern California Wetland Recovery Project (www.scwrp.org) and the San Francisco Bay Wetlands Regional Monitoring Program (www.wrmp.org). These initial efforts need to be strengthened by continued support for staff participation and leadership in the SWMW.

The start-up of California's wetland monitoring and assessment program has occurred primarily in the coastal regions -- geographical locations where there are wetlands at risk, discretionary dollars, interested people and existing data. It is critical that the State move to develop regional teams for areas of the State currently underserved by the implementation effort. In particular, additional staff support for RWQCBs outside the coastal zone is needed. This would include the Central Valley, Lahontan, and Colorado River Basin Regional Boards.

A critical step in monitoring program development is the assessment of resources required for program development and implementation. The State should support the development and implementation of a funding strategy for prioritized implementation of a statewide wetland monitoring plan; this strategy may include development of a funding bill for the legislature as needed.

3. STATUS OF WETLAND AND RIPARIAN AREA MAPPING PROTOCOLS AND IMPLEMENTATION IN STATEWIDE WETLAND INVENTORY

There are three primary goals for mapping wetland and riparian areas in California. The first goal is to track changes in their distribution and abundance; this is essential to determining if the State's policies and programs for protecting these resources are working. The second goal is to assist land use planning for flood control, pollution control, water supplies, and wildlife conservation efforts that benefit from wetland and riparian areas. The third goal is to guide the assessment of wetland and riparian areas by geographic location. Mapping wetland and riparian areas is essential to assessing these areas' ability to provide needed benefits and services.

The purpose of this section is to: 1) give an update on the status of the State's wetland and riparian inventory, 2) describe proposed data quality goals that should guide future mapping efforts, 3) summarize the status of efforts to refine or create wetland and riparian mapping standards, and 4) provide recommended next steps.

Status of Statewide Wetland Inventory and Draft Inventory Data Quality Goals

The State has initiated a statewide, map-based inventory of wetlands, and is exploring ways to map riparian areas. Most of the wetland mapping is being done by the National Wetlands Inventory (NWI) of the USFWS by digitizing some existing maps, scanning others, and creating new maps. The mapped wetlands are classified as habitats using the NWI classification system (Cowardin *et al.* 1979).

Status of the State's Wetland Inventory

At this time, the State Wetland Inventory covers approximately 80% of the State, including all areas subject to rapid change due to urbanization or land use (Figure 3-1). The inventory includes digital data based on imagery from the 1980s or later. Table 3-1 summarizes the total acreage of NWI mapped wetlands for the State of California.

Table 3-1. Summary wetland habitat acreage. which by the NWI classification includes subtidal or open water, intertidal or flats, and vegetated wetland habitats (courtesy of T. Dahl, MDB, September 2008).

Cowardin System Level	Extent of Habitat (Acres)
Marine	14,600
Estuarine	125,755
Palustrine	1,689,410
Lacustrine	1,516,720
Riverine	223,734
Sum	**3,570,220**

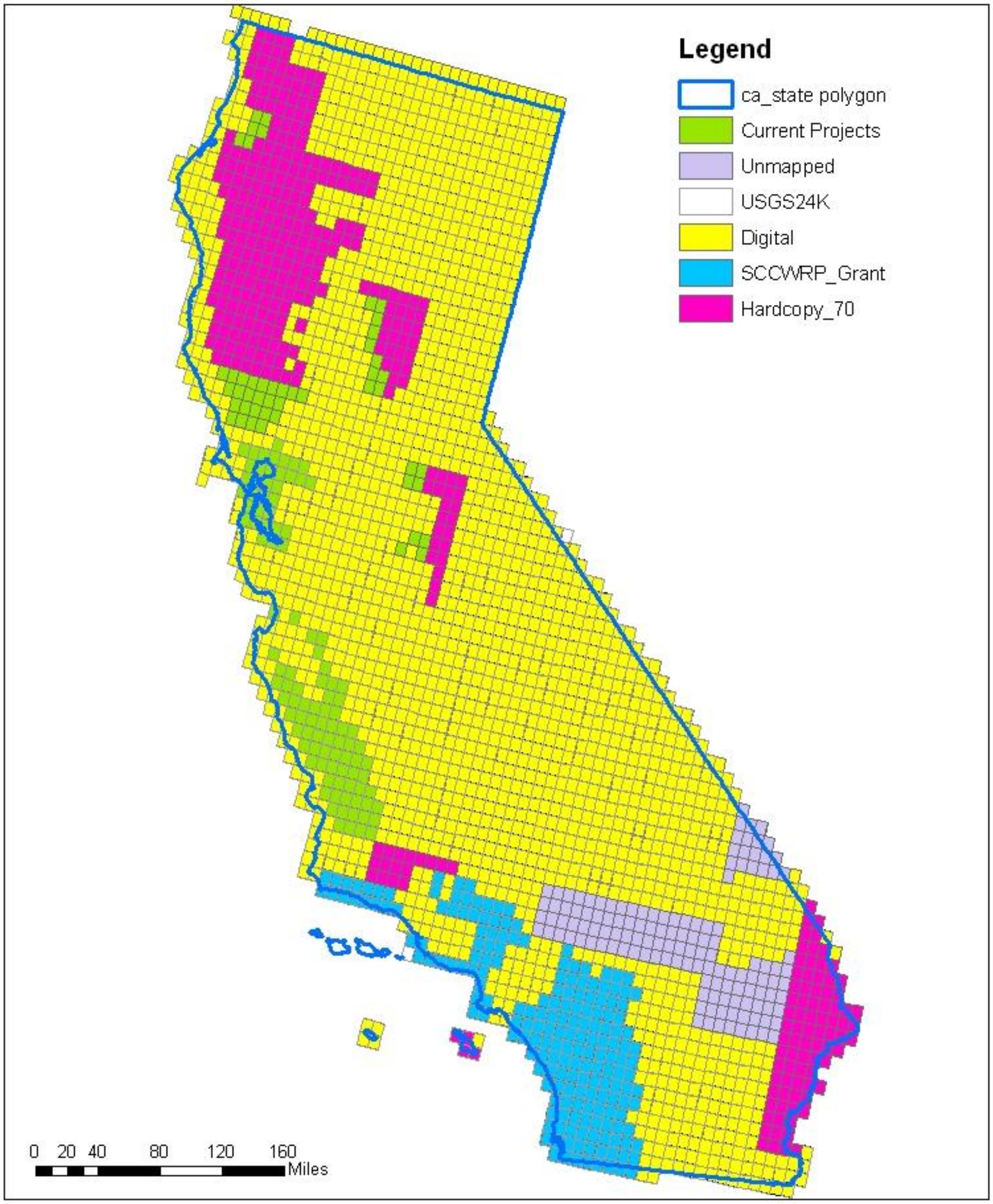


Figure 3-1. Status of the State's wetland inventory.

Draft Inventory Data Quality Goals

In order to assure that the wetland and riparian maps provide the intended benefits and services, the mapping methods must meet aset of data quality goals that are driven by intended uses. Discussions with agency staff and local wetland managers have revealed that NWI data currently available may not be meeting those needs. To clarify issues and guide future mapping efforts, data quality goals have been developed. These criteria are likely to evolve as experience is gained. The status of the existing inventory data relative to these criteria is discussed below.

A variety of methods for mapping riparian areas have been studied (Collins *et al* 2007), and a new approach is being piloted in southern California and the SF Bay area to meet these data quality goals.

Be consistent with federal standards for wetland and riparian mapping

The Federal Geographic Data Committee (FGDC) recently drafted new standards for wetland mapping (FGDC 2008) to be implemented through the NWI. The State inventory does not yet me*et al*l of these standards. Compliance varies across the inventory due to differences in the vintage and resolution of the imagery upon which the inventory is based, and due to differing levels of digital production. Some portions of the inventory are based on imagery that is older and less resolute than what the FGDC recommends.

The draft federal standards consider, but do not require, augmenting wetland maps by classifying wetlands in terms of their hydrogeomorphology (HGM; Brinson 1993), as well as habitat type. Through an agreement with the USFWS Region 1 office, recent NWI mapping within the State has included some HGM classification co-developed by the WDP Technical Team and NWI region 1 staff (Sutula *et al*. 2006). Thus the amount of HGM classification varies across the State inventory because it was initiated after the inventory began. The NWI is now considering augmenting its maps by also classifying wetlands in terms of their landscape position, landform, water flow path, and waterbody type (LLWW; Tiner 2003). There has been no LLWW classification of the State inventory. To comply with the finalized FGDC standards and/or NWI standards, the State should consider adopting the LLWW classification system, in part because these HGM data help to describe the anticipated functions of the mapped wetland.

The draft federal standards also consider, but do not require, riparian mapping. The only method of riparian mapping developed by the NWI mostly pertains to the arid southwest and may not pertain to broad range in climate that characterizes California. The FGDC recognizes this limitation of the NWI method. The new riparian mapping method that is being tested in California is being proposed by the WDP Technical Team as the preferred alternative.

Support California wetland and riparian protection policies and programs

The State inventory as currently produced cannot be used to assess net statewide change in wetland extent as required under the State's Wetland Conservation Policy, or meet its reporting requirements for all wetland types under the Clean Water Act (CWA) Section 305b. The main reason is that the State is too large and its wetlands are too variable relative to the funding and time required for comprehensive statewide mapping. Furthermore, much of the change in wetland acreage is due to wetland impacts, mitigation, and restoration projects that have not been mapped as part of the State inventory. As a result, the State inventory cannot be used to assess the performance of the State's 401 program, Waste Discharge Requirements program, or other wetland protection programs. Climate change is likely to affect rainfall amounts and timing, as well as sea level, which in turn will affect the distribution and abundance of wetlands. Mapping and re-mapping must happen faster to track the relative effects of climate change and government policies on the distribution and abundance of wetlands.

The State inventory does not yet include riparian areas. The State's procedure for mapping vegetation recognizes riparian vegetation types, but not riparian areas per se (Sawyer and

Keeler-Wolf 1995). The NWI has adopted a riparian definition and mapping methodology for the arid Southwest that are more restrictive than what has been proposed for the State's Wetland and Riparian Protection Policy.

Inform local land use planning and decisions

Local agencies have not be systematically polled, but those involved with updating the State inventory in Southern California and the Bay Area have commonly stated that the existing inventory is not accurate enough or precise enough to inform local land use planning. Some agencies have undertaken independent efforts to meet their wetland inventory needs (e.g., Holland 1998, Schirokauer, 2004, Humboldt Bay HRCD 2007).

Local and State agencies have a growing interest in historical information about wetlands and riparian areas as a basis for assessing restoration targets and design scenarios (Grossinger *et al*. 2008). The historical information supports classification of wetlands according to many systems, including the habitat classification used by NWI. However, the local interests that drive the historical ecology projects have preferred nomenclature that better reflects local policies and planning documents.

Serve as the sample frame to assess wetland and riparian condition and function

The State inventory has been produced through NWI using its mapping methods and habitat classification system (Cowardin *et al*. 1979). NWI was established to assess decadal and longer-term changes in wetland acreage across the nation, but not to provide sample frames for ambient surveys within states, where more detail and accuracy may be needed than NWI typically provides. The existing State inventory was found to be less accurate than required to serve as the sample frame for the recent statewide survey of estuarine wetland condition (see Section 6). It had to be updated based on recent imagery and local expertise.

Generate authoritative maps that are readily accessible to the public

For wetland and riparian maps to benefit local land use planning and decisions, they must be adopted by federal and state agencies that oversee environmental planning and management, and they must be readily accessible to local agencies and the public. The NWI Wetlands Online Mapper (http://wetlandsfws.er.usgs.gov/wtlnds/launch.html) provides public access to finalized NWI maps. It provides access to the State inventory maps completed by NWI, which is considering ways to accept maps done by FGDC standards (FGDC 2008). It does not currently serve draft riparian maps or other additional attributions important to California stakeholders.

The NWI mapper provides public access to NWI maps across the nation. It does not, however, provide maps of wetland projects or information about the wetlands that are mapped. To meet these needs, the USEPA and the State are supporting development of the Wetland Tracker information system (www.wetlandtracker.com, Section 5). It is designed to access and share data and information about wetlands and riparian areas through user-defined queries operating on interactive versions of the State wetland inventory. The Wetland Tracker is being piloted in California coastal regions, where it is beginning to be used by local agencies and wetland interest groups to communicate about wetlands. The Wetland Tracker does not currently allow for downloading of wetland and riparian maps, but interactive downloading of data is part of funded future updates of the Tracker.

Be affordable and doable by many work centers

The State wetland inventory, as produced through NWI, involves techniques for aerial photo interpretation and digitization in a GIS, plus data clean-up and field-based quality control procedures that are commonly employed in current landscape mapping and analysis. It does not utilize some common visualization tools, such as Google Earth and Virtual Earth that are widely available.

The NWI methods that have been employed to create the State inventory can be implemented by many work centers. NWI has been able to partner with many states and regional work centers across the nation to help meet its mission. As part of its effort to inventory wetlands on behalf of California, NWI has partnered with the San Francisco Estuary Institute (SFEI), Southern California Coastal Water Research Project (SCCWRP), and California State University at Monterey Bay, who in turn have partnered with the California State Universities at Northridge and Chico, plus the Prison Industries Authority. These partnerships are the source of the inventory data quality goals being discussed here.

Revised State Wetland Classification and Mapping Methods

The partnerships that have formed around wetland and riparian mapping in California are giving rise to new methods and a proposed classification system that are designed to better meet the inventory data quality goals discussed above. The new approaches are part of a State wetland and assessment plan that is being developed to support the emerging State Wetland and Riparian Protection Policy. The plan will proffer a standard wetland definition, classification system, delineation method, and mapping method based on the following tenets:

- *Definition* distinguishes wetlands from other landscape features
- *Classification* distinguishes one type of wetland from another
- *Delineation* determines the boundary of a wetland in the field
- *Mapping Methods* control the accuracy and precision of wetland maps based on remote sensing in terms of wetland size, shape, location, distribution, and abundance

There is an important difference between delineation and mapping. Delineation involves expert use of field indicators to estimate the boundaries between wetlands and adjoining terrestrial and/or aquatic environments. It is the most spatially resolute approach to determining wetland boundaries. Delineation methods vary among agencies within California, but the federal standard is provided by the USACE (1987). The accuracy of delineation depends on the method being used and the expertise of the delineators. Although delineation is a form of mapping, the term “wetland mapping” is conventionally reserved for demarcating wetland boundaries based on remote sensing, usually aerial image interpretation. The accuracy of the maps depends on the quality of the supporting imagery, the exactness of the methodology, and the expertise of the cartographers. Since delineation and mapping rely on different indicators, they seldom result in the same wetland boundaries. Given that conditions are never as clear in an aerial image than they are in the field, delineations are usually more accurate than maps. Delineations are typically required to resolve issues of jurisdiction and wetland project design. Maps are used to track changes in wetland distribution and abundance across landscapes and larger areas, for which delineations would be prohibitively expensive and time consuming, and to assess large-scale ecological conditions and processes.

The State wetland monitoring plan is especially concerned with meeting the State's needs for information to assess wetland policies and programs. This requires comparing projects to each other and to ambient conditions, which requires that project wetlands and ambient wetlands are defined, classified, delineated, mapped, and assessed in strictly comparable ways.

The effort to build State capacity to assess wetlands has focused on CRAM (Collins *et al.* 2007) as a cost-effective way to assess projects relative to ambient condition, plus managing assessment results and other wetlands information (i.e., Wetland Tracker). State-federal steering committees and regional science teams have emphasized the need for CRAM to be uniformly applicable across as many wetland types as possible, given that significant costs for CRAM development and implementation accompany each type. The basic wetland systems of NWI proved to be untenable as a CRAM typology because the broad variability in wetland form and structure within some systems decreased the ability of CRAM to detect change. The subsystems were also untenable because they pertain in part to aquatic (i.e. non-wetland) habitats and otherwise subdivide wetland system more than necessary for CRAM. Another concern was that neither NWI nor any other existing classification system called out certain wetland types, such as vernal pools, wet meadows, and seasonal estuaries that are the specific subjects of some State policies and programs. Over the course of its development, CRAM has been revised and adjusted to assess seven wetland types. The CRAM typology is a mixture of NWI classification (Cowardin *et al.* 1979), HGM Classification (Brinson 1993), and operative State wetland nomenclature.

Once the CRAM typology was developed, methods were needed to create sample frames for CRAM-based assessments. The methods focus on mapping wetlands as CRAM assessment areas and classifying them according to the CRAM typology, while meeting the data quality goals for the State wetland inventory as discussed above. The methods comply with all the draft FGDC standards except with regard to classification. The CRAM typology can be translated into the NWI habitat classification system required by the draft standards, but the translation is not ideal. The CRAM types correspond to NWI types at various levels in the NWI classification system. As a consequence, most wetlands that are classified according to the CRAM typology will have to be re-classified according to the NWI system in order to update NWI. Using both classification systems is possible but not necessary for the State inventory to meet its data quality goals. Although the two systems can be translated from one to the other, albeit imperfectly, the CRAM typology is easier and less expensive to use, and it is the only classification system that supports ambient assessment using CRAM.

Mapping wetlands correctly is more important than how they are classified. If the wetland maps meet the inventory data quality goals, then the mapped wetlands can be classified using any system deemed necessary. It would be possible, for example, to provide NWI with authoritative State maps that me*et al*l the FGDC standards except regarding classification, and let NWI classify the maps based on its system. This could yield maps that meet the State's needs, while also helping to update NWI maps at significant cost savings for NWI.

The inventory data quality goals are being translated into new mapping procedures based on the pilot projects in southern California and SF Bay area. They specify imagery and other source materials that are widely available and likely to be regularly updated through existing state and federal programs. They can serve as CRAM sample frames because they employ the CRAM typology and the minimum mapping units are at least as small as the recommended CRAM assessment areas. There is a comprehensive QAQC process for accuracy and precision that is matched to local agency needs. Draft maps are reviewed by local agencies to assure their usefulness in local land use planning and decisions. Re-mapping using these protocols can therefore help track local net changes in wetland kind, extent, size, shape, etc. In the Bay Area, each wetland is mapped in three components: open water, vegetated area, and non-vegetated area. Since the relative abundance of these components varies with rainfall, sea level, and wetland age, re-mapping them might track climate change and the maturation of restoration and mitigation projects.

The following procedure has been developed for multiple work centers to produce comparable maps of wetlands and riparian areas. The procedure requires expert wetland detection on 1-m pixel resolution natural color imagery of dry season conditions during the last 5 years viewed at a scale of 1:5,000 or 1:2,500 depending on the type of wetland being mapped. Wetland boundaries can be mapped at a larger scale. The details of this procedure are contained in the mapping protocols.

1. Map the entire drainage network, including all surface water storage features open to the atmosphere, and all natural and artificial channels including ditches and first-order channels.
2. Perform QAQC to estimate the accuracy and precision of the drainage network map.
3. Repeat steps 1 and 2 until QAQC standards are met.
4. Determine flow direction and Strahler stream order for each channel. The product from this step is used by the USGS to update the National Hydrographic Dataset (NHD).
5. Buffer each channel to create riverine wetland polygons.
6. Map other wetland based on aerial imagery and collateral data, according to the specifications of the protocol.
7. Perform QAQC to estimate the accuracy and precision of the wetland maps.
8. Repeat steps 5 and 6 until wetland mapping QAQC standards are met. The product from this step can be used by the USFWS to update the National Wetlands Inventory (NWI).
9. Run the riparian model on the combined drainage network map and the wetland map.
10. Perform final “heads-up” digitizing to catch obvious riparian areas omitted by the riparian model.
11. Perform QAQC to estimate the accuracy and precision of the riparian maps.
12. Repeat steps 10 and 11 until riparian QAQC standards are met.

The preferred method of mapping riparian areas is based on the riparian definition provided by the National Research Council (NRC 2002). According to this definition, riparian areas are not necessarily distinct landscape features, but zones or areas of material and energy transformation and exchange between wet and dry environments. All aquatic and wetland features adjoining terrestrial environments have some amount of associated riparian area. The existence of a riparian area does not depend on vegetation, and there is no kind or species of vegetation that cannot be riparian.

Mapping this definition of riparian therefore requires an assessment or estimate of the extent of the definitive riparian processes. Given that the area is bounded on one side by the wetland or aquatic system, then the challenge becomes mapping its width, or how far it extends toward or into the adjacent terrestrial environment. The model being piloted in southern California and the Bay Area estimates the width of riparian areas adjoining riverine wetlands and other types of wetlands according to published relationships between width and plant community architecture, topography, and riparian function (Collins *et al.* 2007). The model relies on vegetation maps and digital elevation maps available throughout California. The model is greatly improved when it runs on vegetation maps produced by the California Vegetation Mapping Project because of its accuracy and high resolution. In the absence of CVMP maps, the model runs on the much less accurate and coarser vegetation maps produced by the USFWS (CalVeg, Parker and Matyas 1981). The generalized steps in the model are as follows:

1. Identify the vegetation type adjoining the wetland and the slope of the land perpendicular the wetland boundary.
2. Buffer the wetland based on vegetation, slope and wetland type to show the probable extent of riparian area for that wetland.
3. Extend the estimated riparian area an additional 1m for every 1 degree increase in adjacent land slope greater than 20 degrees (e.g., 3-m increase for 23 degree slope).
4. Perform additional heads-up digitizing to map obvious riparian vegetation omitted by the model.

Use of State Wetland Inventory Data to Assess Trends in Habitat Extent and Distribution

One of the key management questions common to state agencies is understand the trend in wetland extent and distribution over time. There is a well acknowledged difficulty in using the existing State Wetland Inventory data for this purpose, for two reasons: 1) accuracy of mapping at the scale typically conducted and 2) the cost of comprehensively mapping a region or state with sufficient frequency to provide an up-to-date analysis of trends (e.g., on the order of every 5 to 10 years). This assessment was based on existing maps of estuarine wetlands included in the National Wetland Inventory, and these data are known to have both of the above constraints.

Acknowledging these difficulties, the USFWS NWI has gone to a probability-based survey approach to assess trends in wetland acreage on a national level (Dahl 2005). The approach involves random selection of 4,682 randomly selected sample plots; each plot is 4 square miles (2,560 acres) in area. Wetlands within these plots are mapped with remote sensing data in combination with a greater degree of ground-truthing to determine wetland change (a.k.a. "status and trends plots"). Because of the lower error rate in mapping with this approach, trends in wetland change can be detected earlier than with conventional NWI mapping methods (Dahl 2005).

California faces similar problems with respect to the costs of comprehensive mapping and the accuracy of existing maps of estuarine habitat. For this reason, a statistical approach is recommended to improve the tracking of trends in habitat acreage. These data would also facilitate the tracking the impacts of climate change on estuarine wetlands. Notably, California wetlands have been under-represented in the NWI National Status and Trends assessments (T. Dahl, pers. Comm.). With the National Wetland Assessment that will be conducted, additional plots will be added to the State, with approximately 290 statewide. The State of California should consider intensifying this status and trends assessment and assuring that the data acquired are classified in a manner consistent with emerging HGM typologies for CRAM and Project Tracking (see detailed recommendation in Sutula *et al*. 2008).

Recommendations

- Continue to develop wetland and riparian mapping methods that are specifically designed to meet the needs of the State to assess net change in the amount of wetlands and riparian areas and to assess the performance of all state, regional, and local wetland and riparian protection policies, programs, and projects.

- For the purposes of the State, adopt a wetland and riparian classification system that supports the assessment of wetland and riparian conditions and functions.

- Focus on producing the best possible maps of wetland and riparian areas that can be classified according to multiple classifications systems.

- Consider augmenting the State wetland inventory by further classifying wetlands according to the HGM and LLWW classification systems.

- Link riparian and wetland mapping to the State's Vegetation Mapping Project.

- Consider implementing a status and trends approach to future updates of the Statewide Wetlands Inventory. Assure that collaboration with the USFWS NWI on this effort addresses California's data quality goals and adopted classification. Intensify the number of status and trends plots beyond the 290 for California.

4. CRAM DEVELOPMENT AND IMPLEMENTATION

Wetland rapid assessment methods have been gaining popularity for use in a range of wetland regulatory, ambient assessment, and management applications (Fennessy *et al*. 2004, Stapanian *et al*. 2004, Breaux *et al*. 2005, Cohen *et al*. 2005, Fennessy *et al*. 2007, Wardrop *et al*. 2007). The need for increased assessment and for program accountability has resulted in an expansion of ambient monitoring programs, more rigorous performance monitoring for mitigation and restoration projects, and an increased focus on landscape scale and cumulative impact assessment processes (USEPA 2002a). In recognition that an intensive assessment is not always practical or desirable, the USEPA has proposed a three-tiered approach to monitoring and assessment, termed Level 1-2-3. Under this approach Level 1 consists of habitat inventories and landscape-scale assessment, Level 2 consists of rapid assessment, and Level 3 consists of intensive assessment (Kentula 2007, USEPA 2002b). Because it is less time-consuming and relatively inexpensive Level 2, or rapid assessment, is emerging as a key element of many monitoring programs.

Over the past six years an interregional team of scientists from academia, non-profit research institutes and agencies, funded through several USEPA Region 9 Section 104(b) Wetland Development Grants, developed the CRAM for wetlands. The overall goal of CRAM is to provide a rapid, scientifically defensible, and repeatable assessment method that can be used routinely for wetland monitoring and assessment.

The purpose of this section is to describe the status of CRAM development and its implementation within agency programs, and the utility of CRAM for addressing agency management concerns, under the working assumption that CRAM will be among the state-sanctioned rapid methods used to track the performance of permitted projects, restoration or enhancement projects, and ambient condition.

Background on CRAM Assessment Framework

The CRAM assessment framework consists of four overarching “attributes” of wetlands: Buffer/Landscape Context, Hydrology, Physical Structure, and Biotic Structure. Within each of these attributes are a number of “metrics” that address more specific aspects of wetland condition (Table 4-1). To conduct a CRAM assessment each of the metrics is evaluated in the field to yield a numeric score for an assessed wetland based either on narrative or schematic descriptions of condition or on thresholds across continuous values. Metric descriptions are based on characteristics of wetlands observed across a gradient of reference conditions for each wetland type evaluated (Smith *et al*. 1995). Choosing the best-fit description for each metric generates a score for each attribute. Metric scores under each attribute are aggregated in CRAM to yield scores at the level of attributes, and attribute scores are aggregated to yield a single overall “index” score, via simple arithmetic relationships. Attribute and index scores are expressed as percent possible, ranging from 25 (lowest possible) to a maximum of 100. Metric and attribute scoring in CRAM was developed such that the incremental increase in condition associated with moving from one category to the next higher category is the same across metrics and attributes; that is, an increase from category “D” to category “C” is proportionally the same as an increase from category “B” to category “A.”

Table 4-1. Schematic of CRAM attributes and metrics. The four attributes sum to an overall CRAM index score.

Attribute	Metric
Buffer and Landscape Context	Landscape Connectivity
	Buffer
	Percent of AA with Buffer
	Average Buffer Width
	Buffer Condition
Hydrology	Water Source
	Hydroperiod
	Hydrologic Connectivity
Physical Structure	Structural Patch Richness
	Topographic Complexity
Biological Structure	Plant Community
	Number of Plant Layers Presents
	Number of Co-dominants
	Percent Invasion
	Horizontal Interspersion and Zonation
	Vertical Biotic Structure

CRAM also provides a stressor check list to help explain the assessments and to identify possible management actions to improve condition. Stressors are represented as categorical scores ranging from "0", indicating no stressor was present; "1", indicating that the stressor is present but unlikely to cause significant impact; and "2", indicating that the stressor is present and likely to cause a significant impact. The Stressor Severity Index for a site is the percent maximum possible score for all stressors combined.

CRAM is currently developed for six types of wetlands throughout California: estuarine wetlands, riverine wetlands and their associated in-stream and riparian habitats, depressional wetlands, vernal pools, lacustrine wetlands, playas, and slope wetlands/seeps. The general CRAM approach, attributes, and metric categories are consistent across wetland types that roughly correspond to HGM classes, but the specific narratives used to score each metric are customized, as needed, for the characteristics of the wetland type being assessed. A detailed description of the method is provided in the CRAM manual (Collins *et al*. 2007).

The underlying assumption of CRAM is that a "living-resource support" function is a common management endpoint, is easily discernable, and integrates the contributions of HGM, physicochemical, and biotic interactions within a wetland. Relationships among "habitat" and physical and biological processes have been demonstrated for a variety of taxa [including fish, amphibians, and invertebrates (Talmage *et al*. 2002, Baber *et al*. 2004)] and form the basis for numerous other condition-assessment methods (Ladson *et al*. 1999, Ode *et al*. 2005, Davies and Jackson 2006). Stevenson and Hauer (2002) reported a strong relationship between results based on indices of biotic integrity (IBIs) and HGM functional assessments.

CRAM metrics and attributes reflect an underlying assumption that such relationships exist for factors known to be important for wetland-dependent ecosystem elements. CRAM metrics are accordingly scaled such that wetlands that provide the greatest degree of "living-resource support" receive higher scores, and as the degree of support declines the metric scores decrease accordingly. This assumption underlying CRAM has been validated for estuarine and riverine wetland classes using Level 3 data that reflect capacity to provide the living-resource support function.

It is important to note that CRAM measures condition and not function. Ecosystem functions are processes that occur over time, which are difficult to quantify through static measurements. CRAM assessments measure ecological condition, which in turn can be used to imply level of function. However, additional functional analysis tools are necessary to directly measure functions. Under currently used function-assessment methods, such analyses will involve more intensive, Level 3 tools that directly relate the assessed function at a site of interest to relative function at reference site(s).

Utility of CRAM to Address Agency Management Needs

This report includes substantial discussion about how CRAM and the related products developed by this project may be applied to a variety of local, state, and federal agency wetland program needs. The intent in developing CRAM was to provide a rapid and flexible, yet scientifically rigorous, methodology that can be used in conjunction with an agency's other tools in managing wetlands. The CRAM methodology provides a defensible approach that assesses wetland conditions based on the attributes of buffer and landscape context, hydrology, physical structure, and biological structure.

CRAM results may be used in a variety of management contexts, including, but not limited to: 1) pre-project surveys to identify the general management context of a site before a management action or project is undertaken, 2) surveys following a proposed action to document post-project conditions as part of an impact assessment, 3) periodic surveys at mitigation sites to document the changes that occur on the site through time, 4) periodic surveys at enhancement sites to document the changes in conditions through time, and 5) periodic surveys of wetlands in managed areas to monitor trends in the managed wetlands. In most cases, CRAM will be used in conjunction with other tools to support management decisions (rather than as a single, independent tool). At the present time an interagency workgroup is developing implementation guidance for applying CRAM in contexts such as those described above.

Application of CRAM for project assessment can be illustrated by the following example using the two wetlands illustrated in Figure 4-1. These two sites have substantially different CRAM attribute scores that immediately convey understanding about conditions in the wetlands.

The two wetland sites have similar CRAM index scores, which indicate that both sites fall into a category of sites below the "best" in the North Coast region. However, the causes of impairment for the two sites differ substantially, and these management-relevant factors can be elucidated by considering the attribute scores.

The first site is surrounded by uplands with a variety of commercial, industrial, and residential land uses, and the hydrology supporting the wetland (both tidal and freshwater) is largely channeled through ditches. The first site accordingly earned low attribute scores on both the Landscape and Hydrology attributes. The Physical Structure attribute for the first site earned a moderate score, higher than might have been expected, owing to the retention of substantial structural patch richness and moderate topographic complexity. The Biotic Structure attribute for the first site earned a high score because the site retains substantial dominance by a variety of native species, low dominance by invasive species, and the site includes a variety of vegetation layers and patch types.

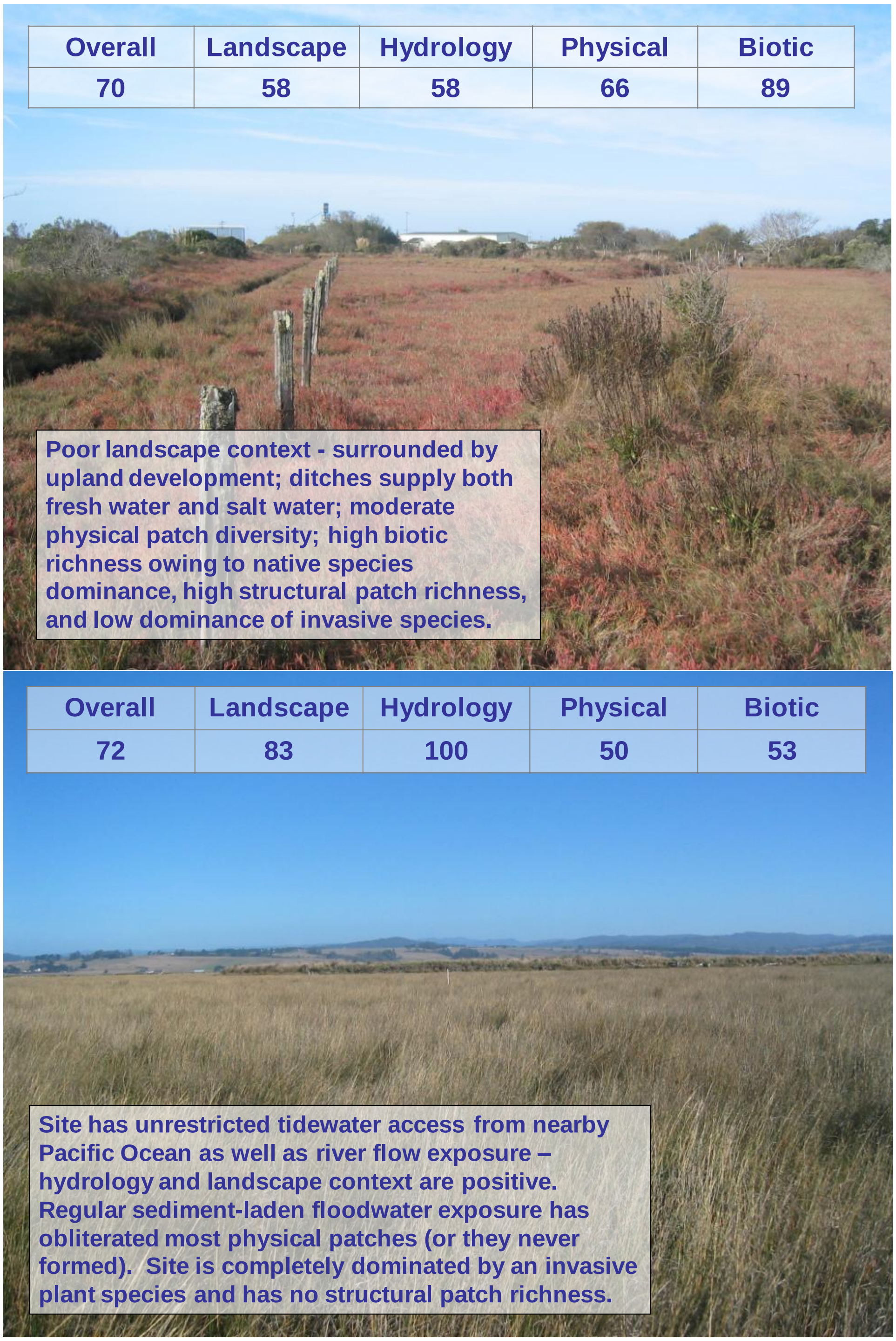


Figure 4-1. CRAM scores for two estuarine wetland assessment areas (AAs) illustrating how attribute scores inform wetland management discussions.

The second assessment site earned high scores for the Landscape Context and Hydrology attributes because the site is located adjacent to the estuarine waters of a large river, not far from the Pacific Ocean, with essentially no hydrological restrictions. The second site was found to present very low structural patch richness and topographic complexity, which was interpreted to be a consequence of excessive flood-borne sedimentation. The site also earned a very low attribute score for Biotic Structure, a consequence of the site's complete dominance by an invasive plant species, resulting in a marsh with little variation in biotic conditions.

Based on the pictures presented by the attribute scores and the underlying metric scores, the appropriate management concerns for these two sites might be identified. Appropriate management for the marsh at the first site might include management to enhance the site's hydrology while increasing efforts to protect water quality in its vicinity and to prevent sedimentation from adjacent upland 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 second site probably would not include substantial efforts to protect the site from additional sedimentation, and no effort to enhance the site's hydrology. Management goals might include efforts to increase structural complexity, such as through creating tidal channels in the marsh. Management actions might well include efforts to remove some or all of the dominant invasive species in combination with efforts to establish native saltmarsh species on and near the site.

Status of CRAM Development and Implementation

Several technical and administrative objectives must be accomplished in order to realize full implementation of CRAM into agency programs as a tool for monitoring and assessment. Once completed, these items provide the support necessary for agency staff to facilitate the seamless integration of CRAM into existing programs.

Technical

- Validation of CRAM for each wetland class
- Reference networks for various CRAM classes
- Peer review of CRAM
- Pilot projects that demonstrate how CRAM can be applied in various circumstances
- Full implementation of eCRAM and management of a statewide database

Administrative

- Guidelines that outline how CRAM should be used for projects
- Ongoing CRAM training program
- Quality assurance program, including audit teams

The status of each objective is summarized below.

Status of Technical Needs for Implementation

Validation of CRAM for Each Wetland Class

Development of CRAM metrics involves the application of ecological concepts and best professional judgments translated into a set of standardized diagnostic questions that are used to assess condition. Because of their integrative nature and reliance on translating ecological relationships into field indicators that reflect wetland condition, it is important that CRAM be calibrated and validated against independent measures of wetland condition in order to establish its scientific defensibility (Sutula *et al*. 2006). The goal of this process is not to maximize correlation between CRAM metrics and any single measure of condition; instead, the goal is to optimize CRAM results against multiple independent measures of condition.

CRAM has been *calibrated* for all wetland classes as an element of the iterative development process. This process included making adjustments in the metrics based on testing CRAM at sites where relative condition was "known" based on prior assessments and agency evaluations.

CRAM has been *validated* for the estuarine and riverine wetland categories. Validation tested CRAM's responsiveness to "good" vs. "poor" wetland condition, its ability to represent a range of conditions, internal redundancy among its component metrics, use of alternative models to integrate the metrics into overall scores, and reproducibility of results among independent assessment teams. Validation was completed using existing assessment data based on avian diversity, benthic macroinvertebrate indices, and plant community composition. Results for riverine and estuarine wetlands indicated that CRAM is an effective tool for assessing general wetland condition, based on its correspondence with multiple independent assessments of condition. Most CRAM attributes appropriately captured a range of wetland conditions. The one exception, Buffer and Landscape Context, was modified on the basis of the calibration analysis to improve its representativeness. Several metric combination models were tested for each CRAM attribute, and in most cases the "neutral" model (i.e., a linear combination of metrics) was comparable to alternative models that were based on more complex computations.

Addressing potential variability of CRAM assessments among users is another key component of validation. Inter-observer variability has been generally minimized by structuring CRAM metrics with non-overlapping categories of condition. Assuming that practitioners are adequately trained before applying CRAM, the structure of each metric is designed to produce consistent observer responses and thus consistent metric scores. In addition, the CRAM development team has assembled, and posted online, reference documents that illustrate the variability in metric conditions that may be observed for several wetland classes; similar reference manuals are planned for other wetland classes, including illustrations of regional variations. Reproducibility analysis during the validation revealed several problematic metrics where ambiguous language or metric construction led to high inter-team error rates. Clarification of metric construction and inclusion of additional guidance rectified these problems and improved the overall average error among independent assessment teams to ±5%. Results of the validation process have been documented in a manuscript that has been accepted for publication in the peer-reviewed journal *Wetlands*.

As was demonstrated for the ambient survey of perennially saline wetlands along the length of California's coast, training and "intercalibration" among field teams is important to assure that CRAM metrics are interpreted consistently among individuals and among regions. Details of the proposed CRAM training program are provided below.

Validation has been completed only for the estuarine and riverine classes. Validation of additional wetland classes, particularly the depressional class, is a priority for future work.

Reference Network for Various CRAM Classes

A crucial component of a comprehensive statewide wetland assessment program is the development of a network of wetland reference sites. Reference conditions provide an accepted means for defining appropriate regional expectations for observable metric conditions and accounting for natural variability. Reference sites can be used to: 1) assure that CRAM practitioners and agency staff are using the same internal frame of reference for scoring CRAM for all wetland types across all regions of the state, 2) establish an upper bound for performance criteria for wetland projects, 3) document the accuracy of CRAM in capturing the gradient of disturbance across the state, 3) train CRAM practitioners with regional examples of high-, medium- and low-scoring wetlands, 4) document the variability in wetland conditions within and among regions over time, and 5) identify the conditions associated with recovery trajectories for wetland types assessed with CRAM.

The inter-regional variability in perennially saline estuarine wetlands identified in the ambient survey resulted in the identification of a need for regionalized networks of CRAM reference sites. The ambient survey confirmed that conditions attainable in saline estuarine wetlands along California's 860-mile shoreline are not all the same (see Section 6). In effect, each region of the state will require a set of estuarine reference sites that appropriately illustrate the range of conditions that can be observed by CRAM practitioners within the region; it would be misleading for agencies and practitioners to unknowingly apply a reference standard to wetlands in a region based on conditions that can't be observed in the region. The CRAM development team expects that similar regionalized reference wetland sets will be necessary for wetlands in other categories; this possibility will be evaluated critically in the phase of CRAM development beginning in 2009. The development of regional reference wetland sets may best be considered in conjunction with other QA/QC tasks to be addressed by regional audit teams.

In early 2009 the first phase of identification and selection of reference sites will begin. This first phase will establish the framework for selecting reference sites; will identify a full network of reference sites for the perennially tidal estuarine type, and a minimum of 3 sites each for riverine, vernal pool, and depressional wetlands in 7 of the 10 California bioregions. The conceptual framework for this effort will build on the existing approach that has been proposed for rivers and stream by the SWAMP Bioassessment committee (Ode and Schiff 2008).

Peer Review of CRAM

CRAM has undergone extensive peer review for all wetland types. Over 100 scientists and managers representing State and Federal agencies, universities, consulting firms, and local governments participated in CRAM development. The framework for method development has been published in the peer-reviewed *Journal of the American Water Resources Association* (Sutula *et al*. 2006).

In January 2008 the US Army Engineer Research and Development Center (ERDC) provided the results of their independent peer review of CRAM. The review concluded that:

> *"CRAM is a reasonable and well-supported approach to wetland assessment. Overall, CRAM development and support programs have been well thought out and the result is*

a scientifically defensible product that can be used for most of the applications for which it is intended".

The ERDC review recommended that 1) future development should include clear guidance on how the method can be used in typical monitoring, planning, and regulatory scenarios; and 2) tools should be developed to predict the rate and extent of change over time in response to restoration actions. The implementation guidelines have subsequently been completed (see Section 4) and several proposals have been submitted requesting funding to develop the recommended restoration trajectories.

In September 2008 the SWRCB initiated an external peer review of CRAM through the University of California, Davis. This process has been used by the State Waterboard for the past ten years for review of technical products that are being considered for use or inclusion in regulatory programs or to support policy decisions. The State Waterboard's peer review questions were reviewed and coordinated through the California Department of Fish Game to address their concerns and support the Department's ongoing internal review process.

Pilot Projects that Demonstrate How CRAM can be Applied in Various Circumstances

Pilot projects are an important element of the initial implementation of any new method or program. They allow small scale application, which limits the risk associated with an unproven tool. They also allow experimentation to provide a "proof of concept" that a new approach is viable and achieves the desired results. Finally, pilot projects provide templates to guide future broader-scale implementation.

CRAM has been demonstrated for ambient monitoring, watershed assessment, program evaluation, and project evaluation. CRAM was used to assess the health of the State's estuarine wetlands (Section 6) and was the basis for the State's first 305(b) report on these important habitats (Sutula *et al*. 2008). Three watershed demonstration projects have been completed in California (Section 7). In each of these three instances, the Napa River, Morro Bay, and San Gabriel River watersheds, CRAM was used in conjunction with other Level 1, 2, and 3 tools to provide an evaluation of overall watershed condition and to provide context for project evaluations. These demonstrations not only illustrate the use of CRAM for watershed planning, but how CRAM can be used to support analysis at Level 1 or 3.

CRAM was used as central component of the study by Ambrose *et al*. (2006) which assessed the performance of the State Water Resource Control Board's Section 401 permit program. Program performance was based on success of compensatory mitigation at replacing the area and condition of wetlands lost to impacts permitted under Section 401. Of the 143 permit files evaluated using CRAM, the majority did not result in compensatory mitigation projects that are similar to natural wetlands, despite meeting the written conditions in the permits.

CRAM is currently being included in a portion of the sites sampled on the SWRCB Perennial Stream Assessment program. Under this ambient assessment program, sites are sampled probabilistically for benthic macroinvertebrates and the results are used to provide a measure of overall condition of wadeable streams. The pilot addition of CRAM to the list of indicators sampled will demonstrate use of CRAM for ambient monitoring and will allow further exploration of the relationships among assessments based on CRAM and those based on benthic macroinvertebrate data.

In 2006 CRAM was used in a study of the habitat value of urban wetlands, including treatment wetlands conducted in depressional wetlands in southern California (Sutula *et al*. 2008). This study demonstrated that urban wetlands that are created, restored or enhanced for habitat objectives versus water quality or multiple objectives have some basic differences that may constrain the type or condition of habitat that can be provided. Multi-objective and treatment wetlands had significantly lower CRAM physical structure scores than habitat wetlands, which were characterized by oval configurations shorelines, steep slopes and lack of macro- and micro-topography.

eCRAM and the CRAM Statewide Database

Data management is one of the 10 elements of a wetland monitoring program identified by the USEPA. Integrated reporting on wetland health has been hampered in the past by lack of standardized methods and electronic data transfer formats that ensure widespread availability of wetland data. eCRAM, a field-to-PC CRAM data management application, addresses these concerns by providing a user-friendly electronic data entry interface, automatic calculation of CRAM scores, and an option to upload the CRAM results to a statewide database.

Significant updates have been made to eCRAM to take advantage of portable computer technology to bring detailed aerial imagery and automated assessment forms into the field. Future work required to ease the implementation of CRAM into agency programs includes the following:

- Mechanism for CRAM users to download CRAM results into an excel spreadsheet
- Mechanism to automatically format CRAM scores for a project into a standardized report
- Development of modules for other wetland classes (currently, only data for riverine, estuarine, and seasonal depressional classes can be uploaded)
- Ability to edit assessment area polygons
- Implement version control for data submittals. After a user uploads an assessment, it will be locked, such that the data can no longer be changed without permission. Subsequent changes could be coded as "revisions"

Status of Administrative Needs for Implementation

Guidelines that Outline How CRAM should be Used for Projects

The ERDC peer review noted that the implementation of CRAM in agency programs requires a set of guidelines or procedures that outline how CRAM should and should not be used to assess projects, requirements for a “complete” CRAM assessment, and QAQC measures. An interagency implementation workgroup has been meeting since February 2007 with the goal of identifying feasible ways to implement CRAM in a coordinated manner among partner agencies.

The workgroup has cooperatively produced a draft set of "CRAM Implementation Guidelines." The guidelines are intended to provide a common technical foundation upon which all agencies can develop agency-specific policies and procedures for using CRAM for *project assessment.* The guidelines outline how CRAM may be used at several points of the permit/project evaluation process, including:

1. Assessment of pre-project conditions at proposed project site
2. Assessment of existing condition at proposed restoration/mitigation site
3. Evaluation of alternative project designs
4. At the time of PERMIT ISSUANCE
5. Assessment of post-project conditions
6. Assessment of conditions immediately following restoration/mitigation
7. Ongoing performance monitoring of restoration/mitigation sites

The final draft review guidelines are currently being reviewed by the agencies and the SWMW. It is anticipated that individual agencies will develop policies and procedures for using CRAM based on these guidelines.

Ongoing CRAM Training Program

Applying and interpreting CRAM should be straightforward to scientists and managers who are familiar with basic wetland ecology, assessment, or delineation. However, training is required for the application of CRAM in a consistent and appropriate manner that will result in reproducible scores.

It is anticipated that two types of training courses will be offered that target the various end-users of CRAM: 1) a general-audience one-day introduction to CRAM for agency and other staff who do not intend to conduct field assessments; and 2) a three-day "practitioner-level" course designed for wetland scientists who intend to perform CRAM field assessments.

The introductory course has three main objectives: 1) build capacity within the State agencies regarding CRAM by providing an overview of the method; 2) provide information to State agency staff on applications of CRAM in 401 certification, DFG 1600, ambient monitoring, SWAMP, and wetland and stream protection practices; and 3) provide a modest level of hands-on experience working with CRAM in the field. To date eight one-day training courses have been offered in California, three of which were administered through the California State Water Board Training Academy. Over 150 agency staff have attended these workshops over the past year, and class sizes have averaged 20 participants.

The three-day practitioner-level course is designed for wetland scientists who intend to perform CRAM field assessments. These courses will include an overview of CRAM and its applications, intensive hands-on field training in one or more wetland types, and training in the use of eCRAM and attendant quality assurance issues. Practitioner courses will also build capacity for the use of CRAM by providing a solid technical grounding in the method so that more agency staff and consultants can reliably perform CRAM on both project-level and ambient assessments for use in regulatory and planning applications, with a focus on project-based assessments. To date three three-day practitioner workshops have been conducted.

A training program to qualify instructors to teach the Introductory and Practitioner training courses is also in development. This training program will increase the pool of qualified CRAM trainers in multiple wetland types and ensure that instructors fully understand the field methodology, eCRAM, and data quality issues. These workshops will provide an opportunity for future CRAM instructors to work closely with the CRAM PI Team on teaching skills, applications of CRAM, and improving technical understanding of CRAM. In addition these workshops will provide opportunities to refine the content and use of teaching tools (PowerPoint presentations, field books, photo-dictionaries, etc.) in both classroom and field settings.

Quality Assurance Program

The interagency CRAM guidelines outline basic QAQC procedures designed to ensure the validity of CRAM assessments and maximize the reproducibility of assessment results. These QAQC procedures outline the components that must be documented with any CRAM assessment to allow reviewers to evaluate the results, including assuring that the most recent version of CRAM is used; that all required data fields are completed; that appropriate explanations, photographs, and supporting materials are provided and the stressor checklist is completed; that acceptable map(s) showing the location of all CRAM Assessment Areas is provided; and that the CRAM practitioner has completed a training course (within the past five years) for the wetland class being assessed.

It is anticipated that regional audit teams will also be established to assist with QA/QC, training, and as evaluators on particularly difficult wetland assessments. The audit teams will consist of trained CRAM instructors, development team members, and staff of responsible agencies. The development team recommends that the regional audit teams independently review approximately 10 - 15% of all submitted CRAM assessments annually for each region. Furthermore, high-value, high-profile, or controversial sites may be reviewed by experienced practitioners at the request of an implementing agency. Assessments failing to meet the basic quality standards may be rejected, additional information may be requested, and/or a reassessment may be requested. Establishment of reference sites will allow practitioners to refresh their perceptions of the on-the-ground conditions underlying the metrics and will facilitate ongoing training and QA of CRAM assessments. Funding for initial establishment of the CRAM audit teams has been tentatively awarded and work on this effort should begin in early 2009.

Recommendations

Much progress has been made toward CRAM implementation. Continued success will depend on achieving several priority next steps:

- Validate additional wetland classes, beginning with depressional wetlands
- Establish full reference network for all wetland classes, statewide
- Develop recovery trajectories based on CRAM for several priority wetland classes
- Complete development of the CRAM training, QA, and audit programs
- Refine eCRAM to enhance data download and automated reporting features

5. STATUS OF PROJECT TRACKING DEVELOPMENT AND IMPLEMENTATION VIA THE WETLAND TRACKER

California has invested billions of dollars in the conservation, restoration and management of its wetlands. To date, the impact of this effort cannot be evaluated because the extent and condition of wetlands are not consistently monitored. More recently, the National Wetland Mitigation Action Plan and a SWRCB evaluation of the effectiveness of CWA Section 401 water quality certification recommends improvements in wetland monitoring, project tracking, and follow-through in evaluating compensatory mitigation in order to better track net change in wetland and riparian acreage and condition (Ambrose *et al*. 2006).

One essential element of this wetland monitoring program is the tracking of the effects of all projects (e.g., development projects which fill or degrade wetlands as well as restoration, enhancement, and compensatory mitigation projects) on wetland extent and condition. The need for project tracking is further supported by a the National Research Council's report on "Compensating for Wetland Losses under the Clean Water Act" (NRC 2002), which noted the need to: 1) create tools to better inform the regulatory and management processes to make them more adaptive and performance-based; 2) provide mechanisms to engage all regulatory programs via consistent approaches and tools; 3) conduct assessments to provide a regional context for decision-making, including evaluation of cumulative impacts; 4) develop a consistent approach to assessment project performance; and 5) provide a common framework and platform for data management and dissemination. Project tracking is essential in order to evaluate the California's "no net loss" wetlands policy. In October 2006, the SF Bay RWQCB and SFEI began to pilot the tracking of all projects, although the concept was in development several years prior to this. The foundation of this effort is a publicly available, web-based information management system called the Wetland Tracker (www.wetlandtracker.org).

The WDP project sought to expand state capacity to track projects by: 1) standardizing among coastal regions the definition of project and the core data elements required to track projects, 2) upgrading the functionality of the Wetland Tracker, and 3) launching Wetland Trackers within the Central Coast and South Coast regions. The purpose of this section is to summarize the progress of the WDP to increase capacity for project tracking and to provide an understanding of how the functionality of the Wetland Tracker may be expanded to meet the needs of a Wetlands Data Portal for California.

What is Project Tracking?

"Project tracking" is documentation of a "project's" net impact on wetland acreage and condition. "Project" is defined as follows:

> *"A project is any on-the-ground activity which results in a change in the acreage or condition of a wetland."*

In addition to this definition of project, wetland acquisition projects will be included among projects in the South Coast Wetland Tracker. Data key to Project Tracking include the following:

- A map of the project boundary
- A map and tabulation of the extent of wetland habitat types pre-project and "as built"

- Condition of wetland habitat impacted by a project; both pre-project and "as built" condition would be assessed, at a minimum, using CRAM

Agencies with regulatory authority over wetlands have a responsibility to document how the permittee has complied with the conditions of the permit. Likewise, agencies which provide grant funding for projects are frequently required to document the efficacy of grant funding. This is also known as "project tracking." Although the data collected through agency project tracking are not central to assessing the net impact on wetland habitat and condition, regulatory agencies are central to the strategy for implementing wetland project tracking; therefore, development of wetlands project tracking within the State of California requires incorporation of data elements which aid regulatory and non-regulatory agencies in tracking projects. These additional data elements aid the analysis of the effectiveness of the compensatory mitigation programs, including compliance with permit conditions (Ambrose *et al*. 2006).

Strategy to Track Projects

The SWRCB's 401 water certification program captures a large percentage of the permitted wetland projects, including USACE 404 and the State Waste Discharge Requirement (WDR) programs. Figure 5-1 illustrates the proposed primary flow of information into Wetland Tracker from the 401 certification program. After a 401 certification is issued for a project, completed Project Tracking forms and maps are submitted by the proponent to Regional Board and Wetland Tracker staff. Forms and maps are reviewed and applicants are contacted with any issues (e.g., missing information, incomplete maps, etc.). Information and maps are uploaded into the Wetland Tracker database and made available on the website. Updates to project information are submitted to Regional Board and Wetland Tracker staff via email. Changes are incorporated into the database and documented for future reference. As the definition of projects is expanded beyond those requiring 401 certification, this flow of information will need to be modified. While the submittal of updated maps with project monitoring reports is a goal, this has not been fully implemented yet.

The RWQCB Region 2 Water conducted a pilot effort of this strategy to track projects and require habitat maps of projects to be submitted as a condition of a 401 Certification or Waste Discharge Requirement (WDR). In the South Coast, the Southern California Wetland Recovery Project's (WRP, www.scwrp.org) interagency subcommittee on Integrated Wetland Regional Program (IWRAP) implementation is developing guidance for Project Tracking. This guidance will aid the expansion, at minimum regionally, of Project Tracking into other Regional Boards, as well as the programs of other agencies such as the California Coastal Conservancy, California Department of Fish and Game, Wildlife Conservation Board, etc. Early results from the RWQCB Region 2 pilot experience indicate that Project Tracking and its implementation through the Wetland Tracker is useful. However, improved consistency of the submitted habitat maps is clearly required. An online mapping tool is the proposed way to achieve the consistency needed in order to track net change in wetland and riparian acreage and condition.

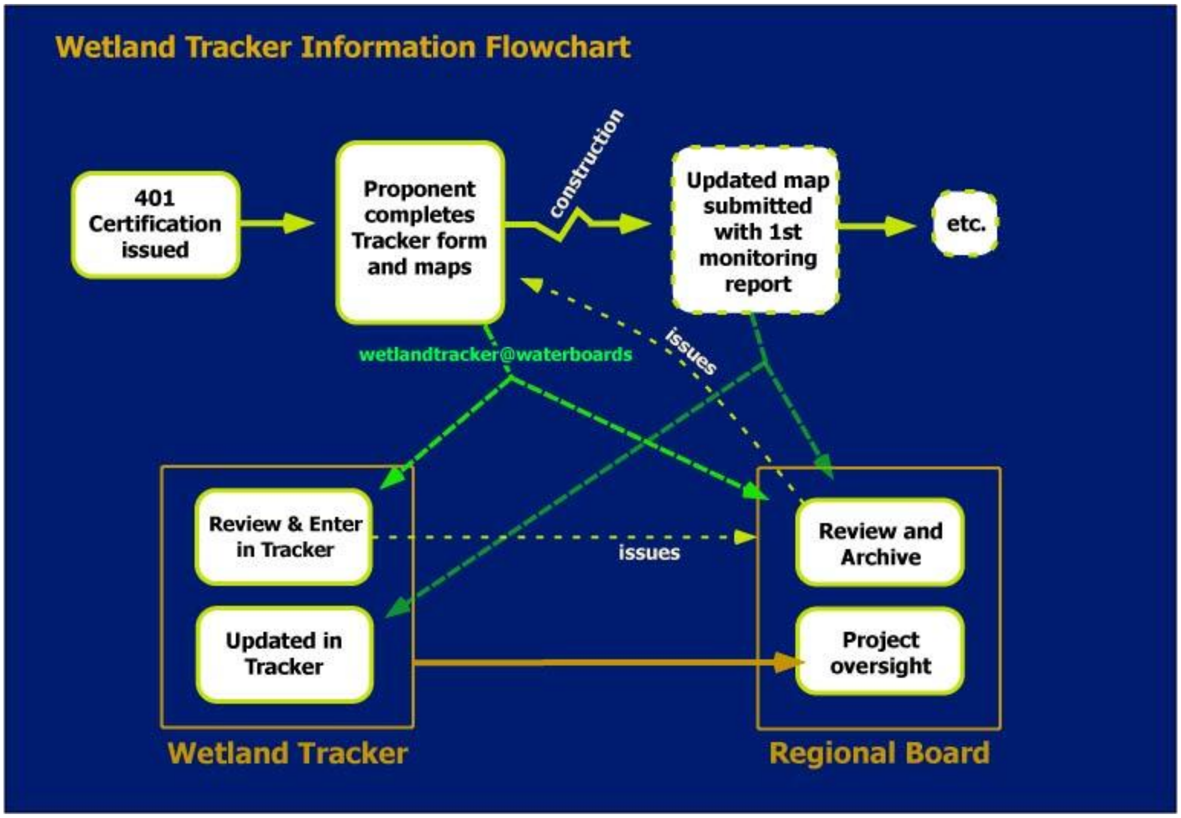


Figure 5-1. Proposed flow of information on projects from permittee or grantee to Regional Board.

Standardized Project Tracking Data Form

Project Tracking in California originated with the SF Bay RWQCB. One objective of the WDP project was to expand the capacity for project tracking into the Central Coast and South Coast regions. This required the standardization, to the extent possible, of data fields that a project proponent would be required to fill out when submitting a project to be uploaded to the Wetland Tracker.

WDP project staff facilitated a process wherein the WRP interagency committee on IWRAP implementation worked in collaboration with SF Bay RWQCB staff to standardize the data fields of the Project Tracking data form. Because WRP partner agencies represent the 17 major state and federal agencies involved in wetland protection, conservation, restoration, and regulation, the assumption was the review by agency staff, albeit from one region, would address a good portion of the input that agency staff would likely provide from all the regions. Clearly, if Project Tracking is going to be expanded statewide, greater review and consensus is required on this form on behalf of agency staff in all regions of the State.

Establishment of Regional Wetland Trackers in Central and South Coast

Among WDP milestones include the establishment of project tracking databases in the Central Coast and South Coast. Currently, the California Wetland Tracker includes 315 restoration and mitigation projects in three regions: 265 projects in the Bay Area, 36 South Coast projects, and 14 Central Coast projects. An additional 23 estuarine and riverine Central Coast projects that were assessed as part of the WDP project are in the process of being uploaded to Wetland Tracker.

During the WDP project, the SF Bay RWQCB began requiring project permittees to submit project data to the Wetland Tracker. Currently, there are several new projects submitted each month to the Bay Area Wetland Tracker from new 401/WDR permittees. The RWQCB Region 2 and SFEI have collaborated closely on the development of the Wetland Tracker, which therefore addresses some of the special needs from the Regional 2 Water Board, such as summary reports and customized project views for 401 projects.

In the South Coast, the Wetland Recovery Project has endorsed the use of the Wetland Tracker to store WRP project data. Towards this end, all completed and planned WRP projects have been documented, assessed with CRAM, and loaded into the Wetland Tracker database. A pilot program to implement Project Tracking in the WRP member agencies' programs is pending development of guidance by the interagency IWRAP subcommittee.

In the Central Coast, a three-year restoration success grant (2006-2009), which was partially funded by Proposition 50, is examining the success of approximately 100 riverine, estuarine, and depressional restoration projects. Criteria for project selection included State-funded projects that were less than 10 years old and publicly accessible. Projects are being assessed with CRAM and project information is being collected for uploading into the Wetland Tracker. In addition, discussions have started with RWQCB Regional 3 staff for implementing the Project Tracking data form into their permitting requirements.

Expanding the Functionality of Wetland Tracker

The Wetland Tracker was conceived as a way to track wetland projects in the SF Bay region. Over the course of the WDP project, the vision for the Wetland Tracker has expanded, with the broader goal of providing a publicly accessible source of authoritative information about the distribution and health of wetlands and related habitats in California. Towards this end, the Wetland Tracker is under consideration as the State's Wetlands Data Portal by the WQMC.

The Wetland Tracker features a web-based, user-friendly Google Earth interface that allows users to view standardized sets of data and maps and to share data among agencies and the public on wetland and riparian habitats and related projects. The Wetland Tracker includes present day and historical maps (where they exist) of wetlands and riparian areas (e.g., EcoAtlas current and historical baylands in the Bay area). . The sources of regional maps are from regional updates of the State Wetland Inventory of the California Resources Agency and the NHD of the United States Geological Survey (USGS). CRAM data are not currently included within the Wetland Tracker database; however, CRAM assessment polygons and overall scores can be viewed within the Wetland Tracker and the CRAM attribute scores can be accessed from the statewide CRAM database (www.cramwetlands.org). A near-term action item is to seamlessly integrate both ambient and project CRAM scores into the Wetland Tracker database.

Each region's Wetland Tracker has a similar format in order to consistently present information across the State. The Wetland Tracker contains a project list, interactive map, project information pages, file upload capability, and list of project files and web links, if available. Screen shots are shown below for each of these main pages, along with a brief description.

From the home page, a user can access data for a particular region. The North Coast Wetland Tracker is pending development.

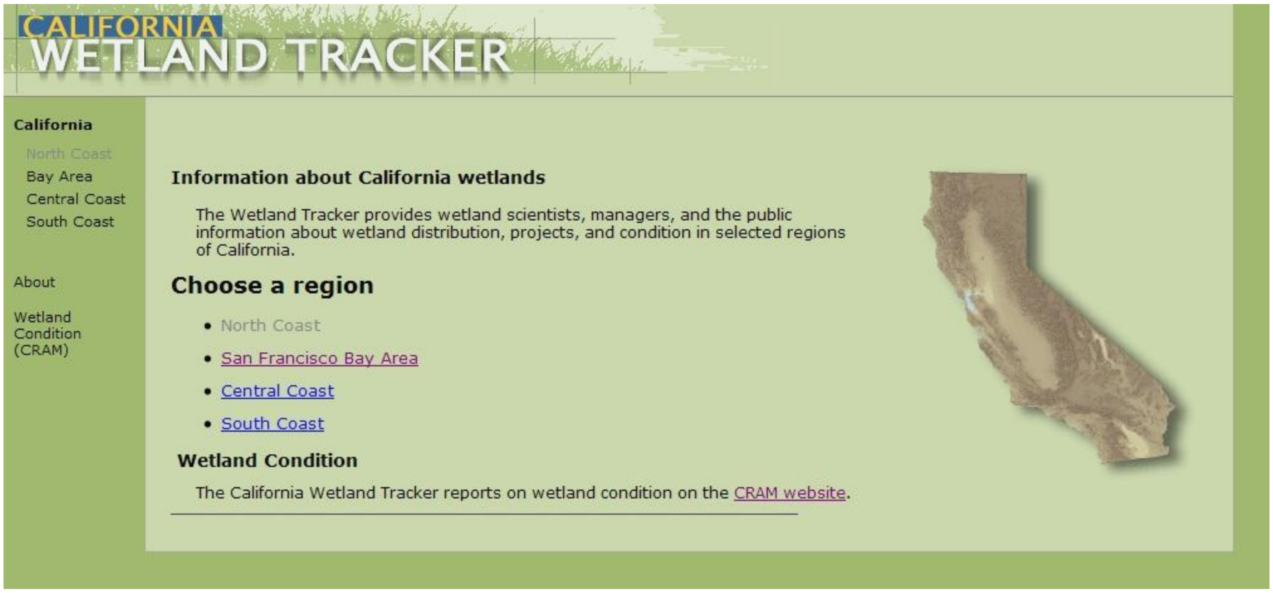


Figure 5-2. Screen shot of the California Wetland Tracker home page.

Project data can be accessed through a project list (Figure 5-3) or from an interactive map (Figure 5-4). Icons are used to indicate if certain types of information are available for a project, including plan/permit information, performance criteria, monitoring reports, prepared maps, photos, and if the project can be viewed on the interactive map.

Figure 5-3. Screen shot of the project list page in the South Coast Wetland Tracker.

An interactive map allows a user to select layers for viewing, including present day habitats, historical habitats, wetland projects, and CRAM assessments (Figure 5-4). Transparency sliders allow users to control the opacity of each layer. Users can also select the background map from a basic shoreline outline, USGS topographic maps, Google satellite, or Google terrain imagery. The default background is Google satellite imagery.

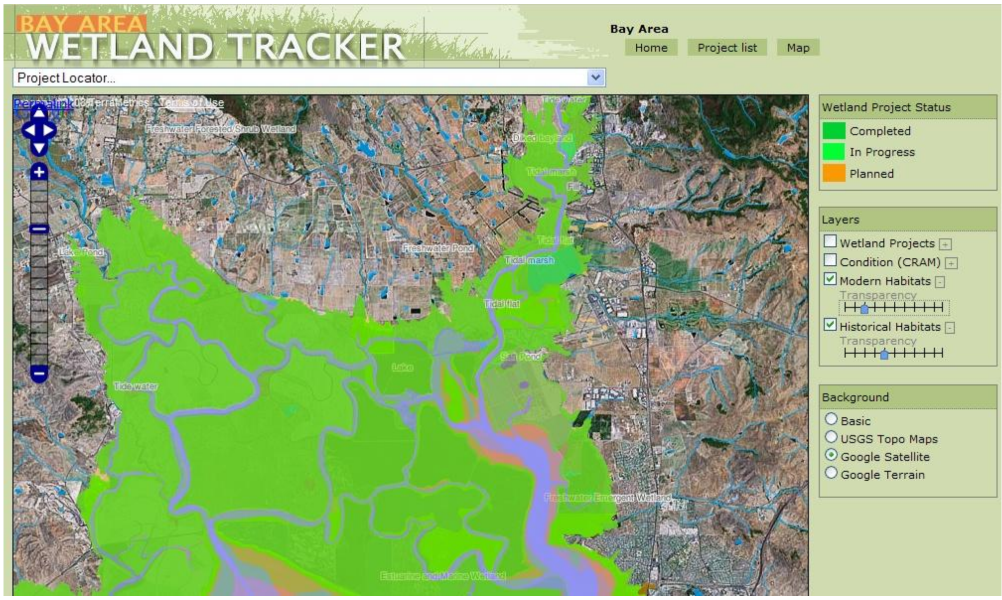


Figure 5-4. Screen shot of the interactive map allowing users to select layers for viewing and to locate projects.

Selecting the CRAM layer displays the locations and overall CRAM scores for ambient and project site assessments in red, and CRAM Assessment Area (AA) boundaries are shown as red polygons (Figures 5-5 and 5-6).

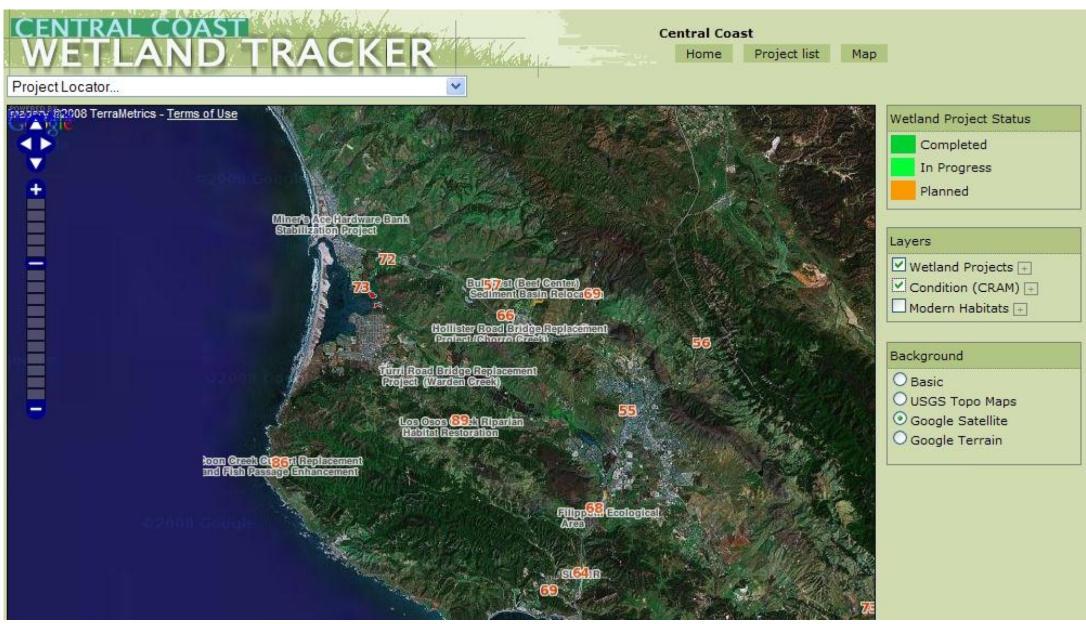


Figure 5-5 Screen shot of the CRAM layer displays the locations and overall CRAM scores for ambient and project site assessments, shown in red text.

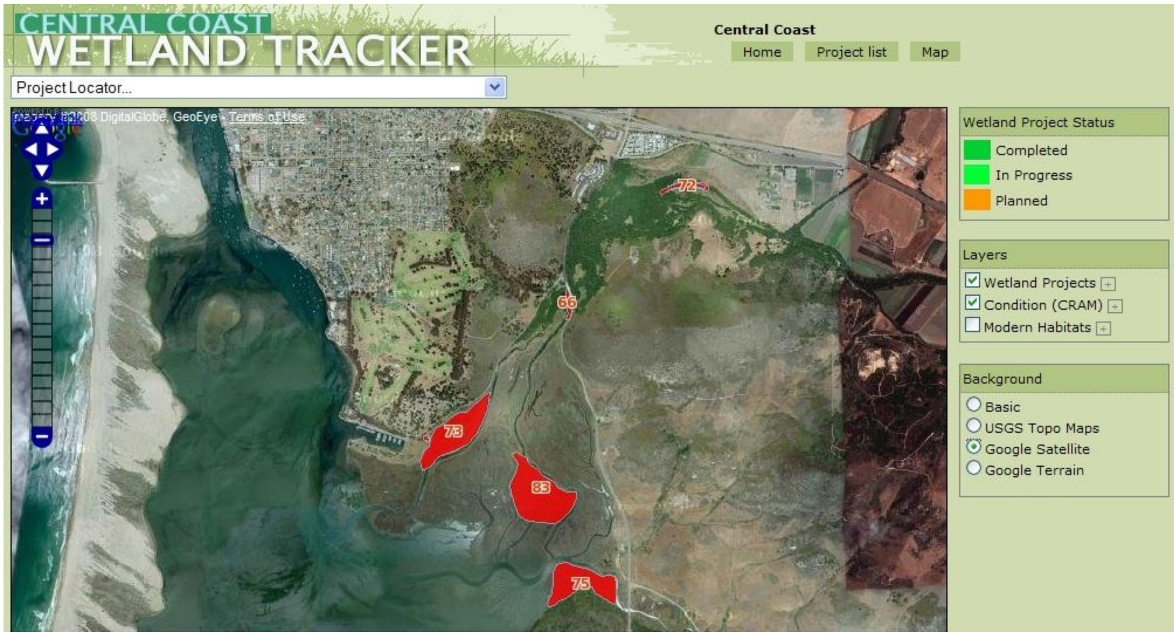


Figure 5-6. A screen shot displaying the CRAM Assessment Area boundaries, shown as red polygons.

For each project, a map of the project's boundary (Figure 5-7), if available, and a project information page are provided (Figure 5-8). Projects are color-coded in the interactive map to indicate status.

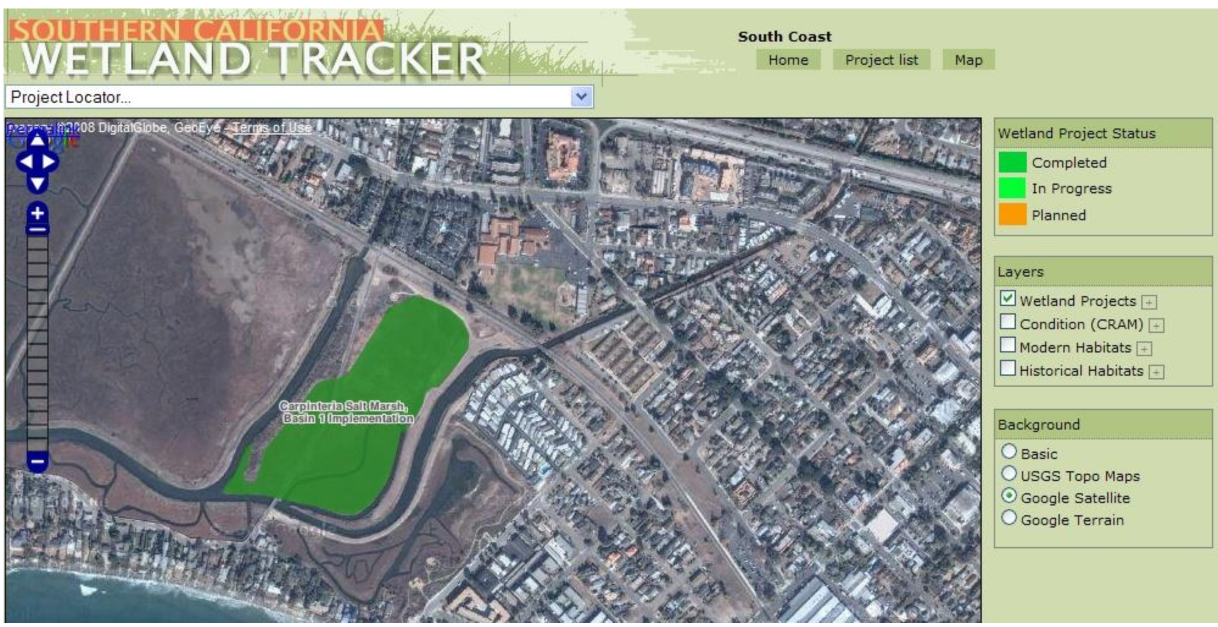


Figure 5-7. A screen shot showing the CRAM project boundary, color coded to indicate status.

The project information page contains important information about the project, such as acreage affected, habitat breakdowns, project management contacts, key project-related events, performance criteria, related CRAM assessments, and associated permit IDs. It also provides a link to the project's map (Figure 5-8).

The file upload feature allows users to upload files in any format, or post a link to a file located on another website (Figure 5-9). All uploads are reviewed before being made available on the website. The project files and web links page provides links to files and a brief description, including the type of file and if the document contains performance criteria or a map. A user can sort the list by *title*, *file type*, *submit date*, and *submitted by* (Figure 5-10).

Under the WDP, a new version of Wetland Tracker (v.2.0.0) was released in June 2008. Upgrades were made to: 1) bring the standardize data transfer formats into line with the new Project Tracking data form; 2) establish regional Wetland Trackers in the Central and South Coast; 3) incorporate backend improvements to the databases and open source coding; and 4) enhance the user experience of the Wetland Tracker interface. Enhancements to the interface included implementing transparency sliders for the map layers, adding a conditional mapping feature, expanding the layout of the project information page, improving the functionality for uploading project files and web links, and augmenting the online documentation about Wetland Tracker, including examples of acceptable habitat maps.

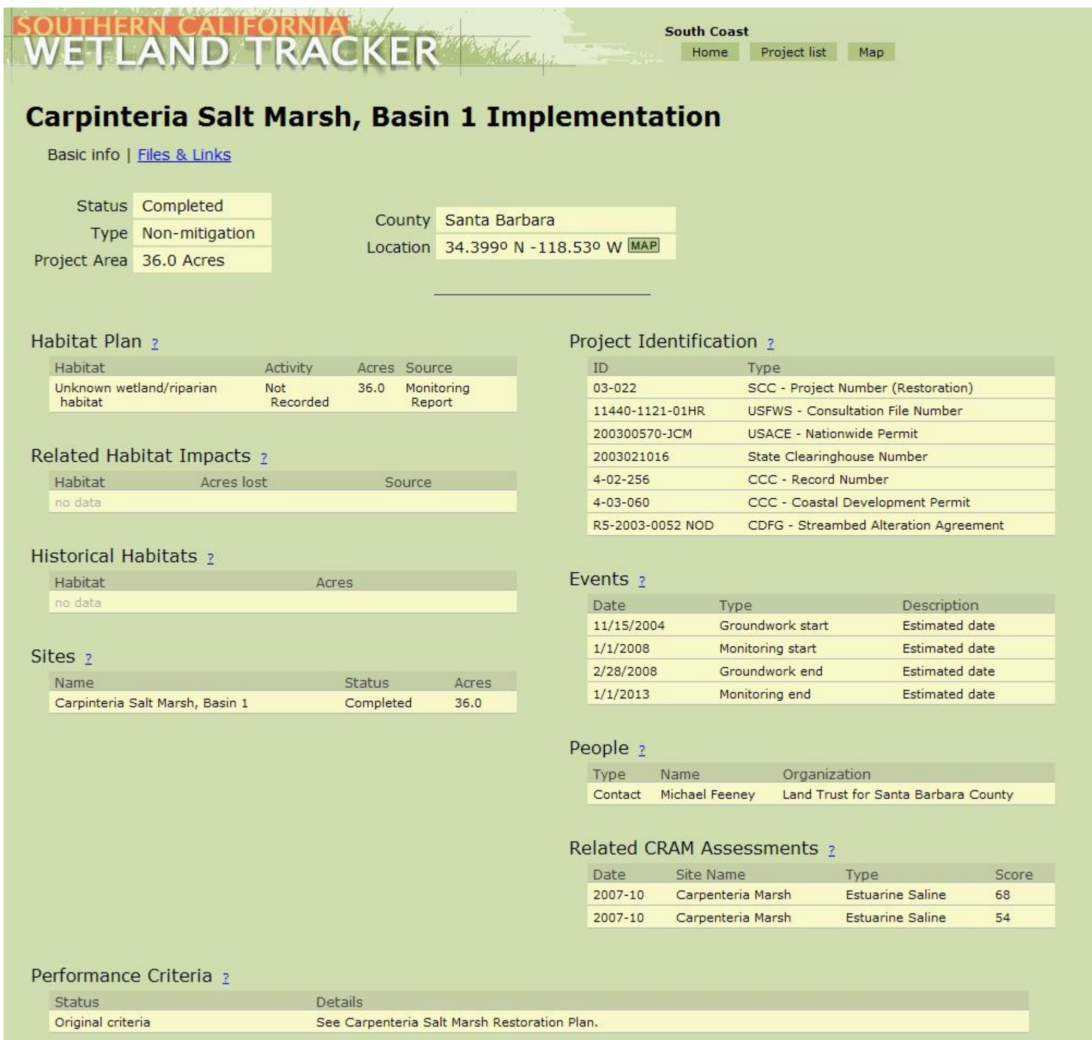
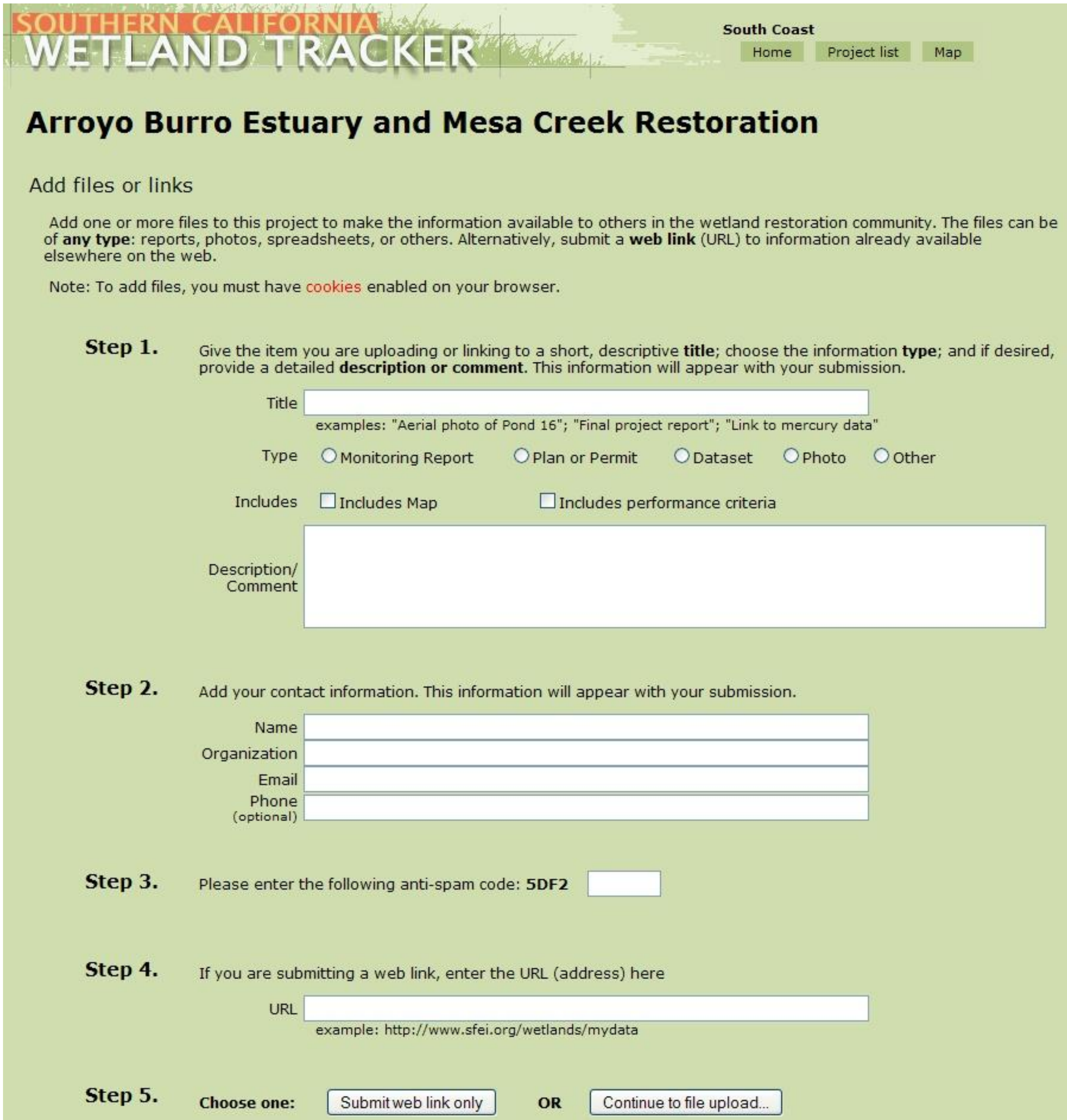


Figure 5-8. Screen shot of a project information page showing important information about the Carpinteria Salt Marsh, Basin 1 restoration project.



SOUTHERN CALIFORNIA
WETLAND TRACKER

South Coast

Home | Project list | Map

Arroyo Burro Estuary and Mesa Creek Restoration

Add files or links

Add one or more files to this project to make the information available to others in the wetland restoration community. The files can be of **any type**: reports, photos, spreadsheets, or others. Alternatively, submit a **web link** (URL) to information already available elsewhere on the web.

Note: To add files, you must have cookies enabled on your browser.

Step 1. Give the item you are uploading or linking to a short, descriptive **title**; choose the information **type**; and if desired, provide a detailed **description or comment**. This information will appear with your submission.

Title

examples: "Aerial photo of Pond 16"; "Final project report"; "Link to mercury data"

Type ○ Monitoring Report ○ Plan or Permit ○ Dataset ○ Photo ○ Other

Includes ☐ Includes Map ☐ Includes performance criteria

Description/ Comment

Step 2. Add your contact information. This information will appear with your submission.

Name

Organization

Email

Phone (optional)

Step 3. Please enter the following anti-spam code: **5DF2**

Step 4. If you are submitting a web link, enter the URL (address) here

URL

example: http://www.sfei.org/wetlands/mydata

Step 5. **Choose one:** Submit web link only **OR** Continue to file upload...

Figure 5-9. Screen shot of file upload feature, demonstrated for the Arroyo Burro Estuary and Mesa Creek Restoration project.

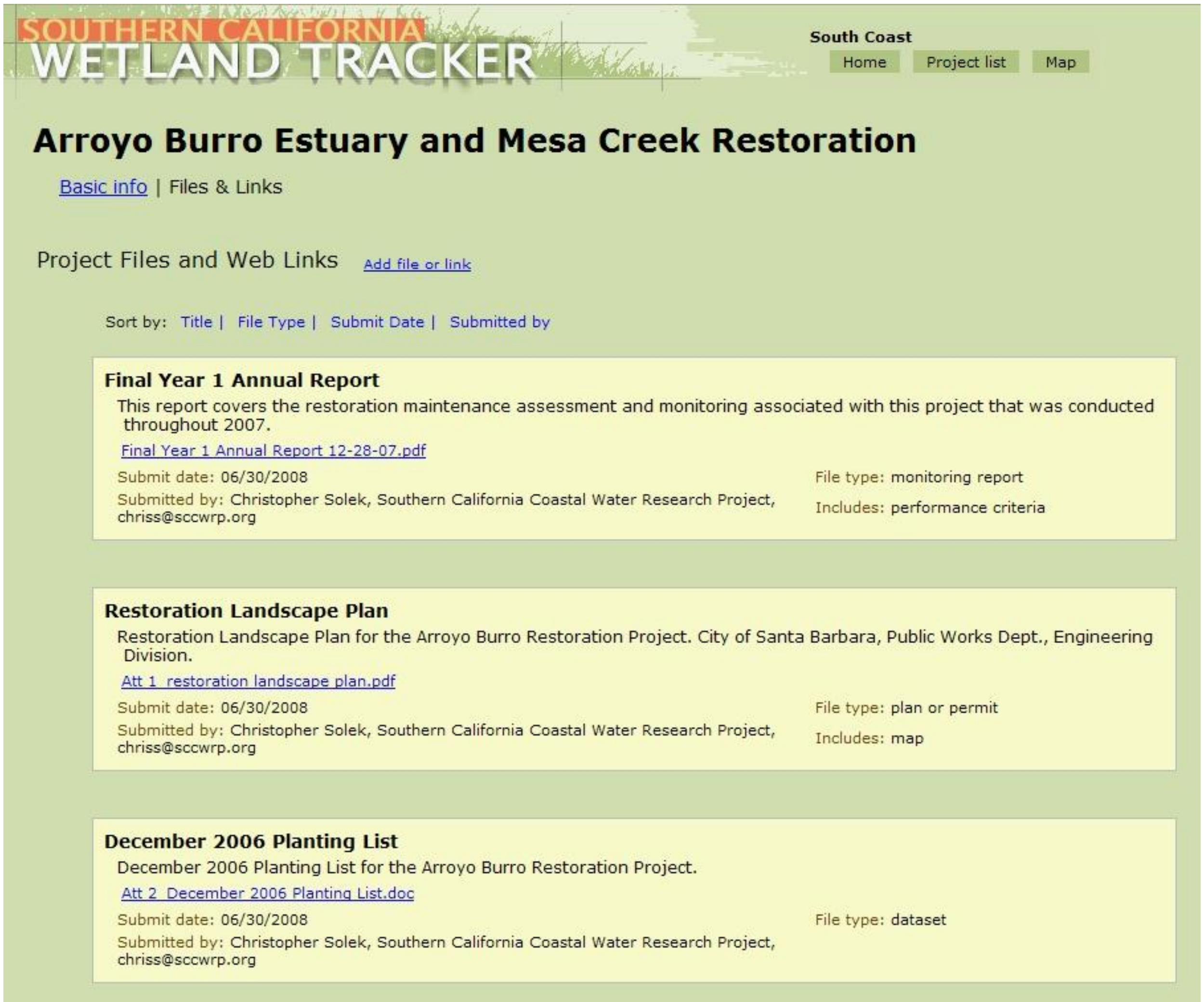


Figure 5-10. Screen shot illustrating the list of document types available for a project. The user can sort the list by *title*, *file type*, *submit date*, and *submitted by*.

Consistency and Coordination with Other Project Tracking Databases

Many agencies already have databases they use for project tracking. Ultimately, a process should be developed to allow sharing data between existing agency databases and the Wetland Tracker. This sharing should lessen the need to enter data in more than one place, while still allowing agencies to maintain their own databases. Data sharing would also allow for information collected in Wetland Tracker to be routinely provided to State or Federal databases for reporting purposes.

One example of an opportunity for data sharing is with the USACE OMBIL Regulatory Module (ORM). ORM is the USACE's tool for project tracking. Agency staff is interested in establishing data exchange capability with ORM in order to allow each system to take advantage of unique information found in the other and to reduce the burden of double reporting required from each applicant. WDP project staff is continuing to explore this option with the Los Angeles District of the USACE to determine how this can be accomplished. Funding is needed to establish this data exchange capacity.

Although the goals of ORM and Wetland Tracker are not entirely the same, there is much commonality between the objectives of the two systems, and therefore opportunity for coordination. Coordinating ORM and Wetland Tracker would provide efficiencies and improve coordination, data sharing, and ultimately enhance the ability of all partner agencies to achieve their wetland protection goals. From the State perspective, connection with ORM would provide some level of permit-tracking functionality that the State desires. From the Federal perspective, connection with Wetland Tracker would provide access to data sets on wetland locations and condition that would be useful for permitting decisions. Additional opportunities for coordination of ORM and Wetland Tracker include:

- Sharing project information
- Requiring GIS files by Water Board
- Adding/coordinating permit tracking numbers for all agencies (short-term-coordination between USACE and Regional Board numbers; long-term standardized numbering system via CEWIQS)
- Accessing status of permit review/processing for all agencies
- Accessing jurisdictional information and reason for no jurisdictional delineation (JD) (There will be a JD associated with every permit, but not a permit associated with every JD.)
- Sharing wetland typology
- Developing and sharing a standard set of special conditions
- Developing and sharing monitoring requirements/standard performance criteria
- Sharing/referencing ORM's rolodex of contacts among multiple agencies
- Coordinating impact information for permits/certifications/mitigations
- Exchanging ambient data from Wetland Tracker to ORM (ORM does not address ambient watershed data)

Funded Next Steps and Recommendations

Funding is in place to enable Wetland Tracker to serve as the common data management system for the State's primary wetland protection policies and programs, including the 401 Certification and WDR Programs, the proposed Wetland and Riparian Protection Policy, and the State's "no net loss" policy. The main product of the current funding will be a new version of Wetland Tracker that streamlines 401 Certification, provides access to historical 401 cases, and enables standardized reports on the status and trends of 401 projects and ambient conditions for watersheds, regions, and Statewide.

Funding has also been approved for Wetland Tracker upgrades including completion of the conversion to open source code, development of online mapping to better standardize habitat maps and project maps, and development of web-based project data entry and update forms. Work to improve data flow, transfer of technology to all regions, and automation of the Wetland Tracker maintenance tasks is also pending, as is agency support for project administration (e.g., implement an email notification system to send assigned agency staff email when important project deliverables are due). Funding is pending a fully integrated CRAM data into Wetland

Tracker. Over the next year, the CRAM and Wetland Tracker databases will be integrated into one database, such that data on wetland condition and related projects (based on CRAM scores) can be accessed through the Wetland Tracker web site. At this time, the accessibility of CRAM data would be enhanced to provide standardized CRAM assessment reports and user-defined data downloads.

Given this funding, it is critical that Project Tracking begin to be implemented in other Regional Boards outside of the SF Bay RWQCB. Currently, the Los Angeles and Santa Ana RWQCBs are initiating a pilot to test out Project Tracking on a limited number of projects. In order for the State to reach its potential in reporting on net change in wetland acreage and condition, it is important that similar efforts be expanded to other coastal regions (Central and North Coast) and inland.

A statewide Wetlands Portal has been proposed using Wetland Tracker as the starting point. This is one of several SWAMP data portals under consideration. The Wetlands Portal would provide public access to wetlands data throughout the state. It is envisioned as a way to integrate the regional Wetland Trackers to provide a statewide picture of wetland condition and related project activity. The Wetlands Portal would be designed to enhance data accessibility and make data exchange easier for managers and researchers. As part of the Wetlands Portal project scope, the definition of projects would be expanded to include agricultural projects, and the information flow of the California Environmental Quality Act (CEQA) and the 401 application process would be used to provide information on planned projects.

As use of Wetland Tracker expands, it will be important to ensure it is maintained properly, and that increasing requests for support and enhancements are fulfilled appropriately. Oversight of Wetland Tracker development and prioritization of tasks, ORM coordination, regional data flow and maintenance, and the integration of Wetland Tracker into SWAMP and CEDEN are unfunded at this time. Stable funding sources for Wetland Tracker should be identified to ensure its continued success and improvement.

Much progress has been made toward developing and expanding the functionality of Wetland Tracker. Continued success will depend on achieving several priority next steps:

- Begin piloting of Project Tracking in remaining coastal and inland Regional Boards
- Integrate CRAM and Tracker databases to assist in providing data on wetland condition and habitat extent
- Develop online Tracker form and project mapping tool
- Provide agency support such as email reminders, standardized Level 2 (CRAM) assessment reports, and user-defined data queries
- Improve the automation of maintenance tasks and the transfer of technology to facilitate efficiently managing and uploading data from the regions
- Establish Tracker oversight group and process for making decisions and prioritizing tasks
- Identify stable funding sources for tool maintenance and development
- Expand the definition of projects to include agricultural projects and coordinate information flow with California Environmental Quality Act (CEQA) and the 401 application process to access information on planned projects

6. ASSESSMENT OF THE STATUS OF THE STATE'S ESTUARINE WETLANDS

Introduction

Estuaries are partially enclosed bodies of water along the coast where freshwater runoff meets and mixes with salt water from the ocean. They are among the most productive natural environments on earth, and support unique and diverse communities of plants and animals (Day *et al*. 1989). The human population is concentrated around estuaries because they provide abundant natural resources and access to the ocean.

One of the first steps in managing estuarine resources is to determine their current condition by answering the key question, "What is the status of California's estuaries?" Often-raised questions relating to the condition of estuaries include: "Are the waters safe to swim?" "Are the fish safe to eat?" and "Is aquatic life healthy?" This document is focuses on reporting on the last question "Is aquatic life healthy?" in estuarine wetlands, an important component of California estuaries.

Estuarine wetlands are the areas of an estuary exposed at low tide that are covered with rooted vegetation (Figure 6-1). They are commonly called salt marshes, although they can also be fresh or brackish depending on their location. They form along the quiet margins of estuaries, away from waves and where sediment deposited by floods and high tides tends to accumulate. The vegetation is uniquely adapted to variable soil salinity and the cycles of wetting and drying caused by the flood and ebb of tidal water. There are approximately four million acres of estuarine wetland in the coterminous United States, which is a small fraction of its historical extent (Dahl 2005). Estuarine wetlands are an integral component of the State's coastal ecosystems.

Estuarine wetlands are highly valued for many reasons (Day *et al*. 1989, Mitsch and Gosselink 2000). They serve as nurseries for commercial fisheries, including salmon, crab, and shellfish. They shelter and feed millions of migratory shorebirds and waterfowl. They serve as critical habitat for most of the coastal threatened and endangered species. Estuarine wetlands filter contaminants from surface water, absorb flood waters, dissipate storm surges, and stabilize shorelines, and trap carbon (Chmura *et al*. 2003). They provide opportunities for boating, fishing, swimming, and other recreational activities that are central to local and regional economies. Estuarine wetlands are a major component of coastal open space and the intrinsic coastal aesthetic. Estuarine wetlands provide so many services that their overall value to society is very difficult to estimate (King 1998). In the SF Estuary alone, the public has invested hundreds of millions of dollars to restore estuarine wetlands in the last decade.

The question of health of estuarine wetlands is restated by local wetland managers in this way: What is the condition of my wetland? Is my project working, how is it doing compared to other projects or to wetlands overall? Legislators and other policy makers ask the same question this way: Are the wetland protection policies and programs working? What is the public getting in return for its investment in wetlands? These questions are largely the same because they can be answered with the same basic information, comprehensive maps of wetlands and related projects, and standardized assessments of their overall condition.

Figure 6-1. Examples of estuarine wetlands from the South Coast, Central Coast, San Francisco Estuary, and North Coast of California.

The purpose of this section is to present the findings of the state's initial effort to answer these questions with regard to estuarine wetlands. The statewide assessment of estuarine wetlands employed the state's "wetland monitoring and assessment toolkit" (Sutula *et al*. 2008). The toolkit is being developed by a consortium of wetland scientists and managers based on recent guidance provided by the USEPA (2006). The guidance recognizes three levels of assessment: inventories and landscape profiles (Level 1), rapid assessment of overall condition or functional capacity (Level 2), and assessment of wetland functions or specific aspects of condition (Level 3). In addition, the guidance calls for public access to assessment results and other information about wetlands. This estuarine assessment employed the Level 1 and Level 2 tools plus web-based information management capabilities currently available in the toolkit. Assessments based on Level 1 and Level 2 tools can be easily incorporated with Level 3 intensive indicators targeting specific management questions to provide a more complete assessment of estuarine wetland health. Likewise, estimates of estuarine wetland health can be incorporate with other assessment of estuarine habitat condition (e.g., sediment and water quality) to provide an integrated picture of health of estuarine aquatic life use.

This report provides broad statistical estimates of the condition of estuarine wetlands statewide and within four coastal regions. The assessment includes an analysis of the distribution and abundance of estuarine wetlands and related habitats based on the existing State Wetland Inventory, plus a field survey of the overall condition of estuarine wetlands according to CRAM

(Collins *et al*. 2007). CRAM is a field-based tool for rapidly assessing the over condition and indentifying the major stressors of wetlands in California, based on visible indicators of landscape and buffer condition, hydrology, and physical and biological structure. CRAM has been peer reviewed (e.g., Ambrose *et al*. 2006) and validated for use in estuarine marsh (Stein *et al*. In press).

Assessment Goals and Management Questions

The California Resources Agency received a Wetland Demonstration Pilot (WDP) grant through USEPA Region IX under Section 104b(3) of CWA in 2005 for the express purpose of demonstrating the State's capacity to evaluate the condition of wetlands. Under agreement with the USEPA, the California Resources Agency chose to demonstrate application of the toolkit on estuarine wetlands statewide, and on wadeable streams and associated riparian areas (i.e., riverine wetlands) within three demonstration watersheds (Sutula *et al*., 2008). To define condition in practical terms, a set of fundamental management questions was assembled for the survey to answer:

- Where *are* the estuarine wetlands and how abundant are they?
- What is the ambient condition of estuarine wetlands statewide and how does their condition vary by region?
- What are the major stressors and how do they vary among coastal regions?
- What is the condition of permitted restoration projects relative to ambient condition? This question was included to show how these assessment data could be used to evaluate policies and programs affecting the distribution, abundance, and condition of estuarine wetlands.

These questions cut across the whole community of wetland managers, regulators, scientists, advocacy groups, affected private sector interests, and the concerned public at large. Clients for the assessment include: the California Resources Agency and its daughter agencies (e.g., California Coastal Conservancy, Coastal Commission, California Department of Fish and Game, etc), the SWRCB and the RWQCB, including the SWAMP, US Fish and Wildlife Service (USFWS), National Marine Fisheries Service, USEPA, and USACE, and various regional and local coastal zone managers such as the Southern California Wetland Recovery Project (www.scwrp.org), the San Francisco Bay Wetlands Regional Monitoring Program (www.wrmp.org), the Humboldt Bay Harbor Recreation and Conservation District (http://www.humboldtbay.org) among others.

Methods

General Approach

The statewide ambient assessment of estuarine wetlands consists of three major components:

- Landscape profile of the extent and geographic distribution of estuarine wetlands and related habitats
- Probability-based survey of the ambient condition of saline perennial estuarine wetlands using CRAM
- Assessment of completed estuarine wetland restoration projects, relative to the statewide ambient condition of estuarine wetlands

The "landscape profile" of estuarine wetlands and related habitat was based on the existing USFWS NWI updated by the regional teams. The landscape profile describes the distribution and abundance of estuarine wetlands relative to other estuarine habitats (Gwin *et al*. 1999) and explores some of the underlying causes for the observed patterns. This landscape profile and the wetland inventory data help to establish a baseline from which future assessments of net change in acreage can be assessed.

The probability-based survey of ambient condition and a targeted assessment of a population of restoration projects utilized CRAM for wetlands (Version 5.0.2; Collins *et al*. 2007), developed through a series of Wetland Program Development grants funded by USEPA Region IX under CWA Section 104b(3). CRAM is a field-based method to assess overall wetland condition or functional capacity based on visible indicators of landscape and buffer condition, hydrological characteristics, and physical and biological structure (Sutula *et al*. 2006, Stein *et al*. in press). The ambient survey results were used as a regional frame of reference against which results of the project assessments were compared.

Assessment Target Population

As indicated by the brief definition given in the introduction, all estuaries are primarily characterized by a longitudinal gradient in water salinity between marine and riverine environments. However, the gradient can range from saline or hypersaline to non-saline, and it is much steeper for some estuaries than others. The freshwater zone can be very narrow for small estuaries in arid areas, and very broad for large estuaries in areas with abundant rainfall. Sources of non-saline water include rivers, streams, overflow from depressional wetlands, lakes, groundwater, point discharges (e.g., effluent from sewage treatment facilities), and storm drains. Some are much smaller than others. There are estuaries associated with large and small coastal embayments, coastal lagoons, major rivers, and small streams. California has a great diversity of estuaries due to its large range in coastal climate, physiography, and land use.

Due to time and funding constraints, it was not possible to comparably survey the conditions of wetlands in all kinds of California estuaries. To select a target population, the estuarine wetlands were first grouped according to their dominant salinity and hydrological regime, given the scientific consensus that these factors affect condition more than any others, then a subset of these groups was selected as the target assessment population based on their prevalence and importance to coastal zone managers. The following groups of estuarine wetlands were considered.

> ***Saline vs. Non-saline.*** *A saline estuarine wetland is distinguished from a non-saline estuarine wetland by having a dominance of salt-tolerant vascular vegetation along the shoreline, including the banks of larger tidal creeks and sloughs. Non-saline estuarine wetlands are not dominated by salt-tolerant vegetation along their shorelines. In the brackish area of an estuary, the estuarine wetlands can shift annually from saline to non-saline conditions due to changes in freshwater inputs. Very large estuarine wetlands with multiple drainage networks can be saline in some areas and non-saline in other areas. The classification of an estuarine wetland as saline or non-saline can therefore require local knowledge or field reconnaissance.*
>
> ***Perennial vs. Seasonal.*** *An estuarine wetland is perennial if its estuary is perennial, and it is seasonal if its estuary is seasonal. A perennial estuary is distinguished from a seasonal estuary by having a tidal inlet that is continuously open for more than eleven months during most years. A seasonal estuary has a tidal inlet that is closed for at least*

one month during most years. In either case, the inlet can be natural or artificial, and its closure or opening can be natural or managed. While the inlet is open, the estuary is subject to daily fluctuations in water height due to oceanic tides, although the fluctuations within the estuary may be muted relative to the fluctuations in the adjoining ocean environment.

A preliminary reconnaissance indicated that almost all estuarine wetlands in California are perennial, that saline conditions dominate most perennial estuaries, and that most restoration projects are saline. Therefore, given their prevalence statewide, and the desire to assess projects relative to ambient condition, the decision was made to focus on saline wetlands of perennial estuaries.

Many coastal zone managers are also interested in knowing how estuarine wetland condition varies among regions. To address this interest, the statewide assessment was subdivided into four regions (Figure 6-2) based on the eco-regional boundaries developed by Hickman (1993). The regions are listed below.

- North Coast (extending north-south from the northern limits of the Russian River Watershed to the Oregon state border)
- Central Coast (extending south from the northern limits of the Russian River Watershed to Point Conception)
- SF Estuary (extending inland from the Golden Gate to the historical limits of the tides before European contact in the region)
- South Coast (extending south from Point Conception to the Mexico international border)

The SF Estuary and its attending watersheds were treated as a separate region because they have much more estuarine wetland than the other regions combined.

Figure 6-2. California coastline showing boundaries of the four coastal regions of the statewide assessment of estuarine wetland condition.

Landscape Assessment. Wetland maps were used to produce a landscape profile. A wetland landscape profile describes the geographic distribution and abundance of wetlands within and among watersheds, regions, or larger areas (Kentula *et al*. 1992). The perennial estuarine landscape profile for California describes the distribution and abundance of estuarine wetlands relative to all other estuarine habitats and explores some of the underlying causes for the observed patterns. It was also designed to support future assessments of net change in estuarine habitat acreage and to help explain the field-based assessment of estuarine wetland condition.

The landscape profile is based on the most recent USFWS National Wetland Inventory (NWI). For the purposes of this assessment, the inventory was updated and revised by the regional teams. All estuarine subtidal and estuarine intertidal polygons were selected from the NWI dataset for California. These polygons were overlaid onto the National Agricultural Imagery Program (NAIP) imagery from 2005, and also converted to KDL files and overlaid onto the aerial imagery in Google Earth. Each regional team examined these files to identify any needed updates in polygon boundaries or classifications. Any required updates were then made based on the 2005 NAIP imagery, which was also used to assign the habitat polygons to their estuaries. Each estuary, and all of its component habitats, was then classified as either seasonal or perennial, based on estuarine morphology and the local knowledge of the regional teams. Time and budget constraints prevented comprehensive field-based verification of the revised inventory. However, the regional teams in charge of the revisions included experts familiar with local field conditions.

The updated inventory was used to assess the relative abundance of all perennial estuarine habitats. It was also used to calculate the size and shape of estuarine wetlands as basic parameters of their distribution and abundance. To determine how wetland size and shape varies among regions, standard methods for mapping individual wetlands should be applied statewide, a set of rules were created to distinguish one wetland from another or from non-wetland areas based on professional judgment about landcover types and landforms that inhibit the movements of estuarine wetland wildlife, especially species of non-migratory small mammals and birds that reside in estuarine wetlands. In short, an area of estuarine wetland is a unique area unto itself if:

- It is completely separated from any other estuarine wetland by one or more of the following barriers or a combination of them: developed or non-developed upland of any width (including levees and dikes), or subtidal or non-vegetated intertidal habitat at least 50 m wide; or
- It is hydrologically connected to another area of estuarine wetland by drains or pipes, no matter how short, but is otherwise completely disconnected from that estuarine wetland and any other estuarine wetland by the barriers listed above.

The shape of each estuarine wetland thus defined was quantified using the shoreline development index, which evaluates the regularity of a shoreline (Hutchinson 1957). For a wetland that is a perfect circle, the index value is 1.0. Elongate wetlands tend to have values between 2 and 4. Values greater than 4 represent complex branching forms. The following formula was used to calculate the shoreline development index for each estuarine wetland:

$$SLD = SL \div 2 \cdot \mathrm{sqrt}(\pi \cdot A)$$

where SL is the length of shoreline and A is wetland area.

The initial landscape profiles suggested that the distribution and abundance of estuarine wetlands might be related to watershed size and land use history. To explore these relationships, each perennial estuary was assigned to its respective watershed. This was generally straightforward because most estuaries have one watershed to which all of their wetlands can be assigned. In the case of complex estuaries, such as the SF Estuary, wetlands were assigned to local watersheds based on proximity and available data on sediment sources. For example, the contiguous wetlands joining the mouths of the Napa River and the Sonoma Creek in the SF Estuary were assigned to an amalgamated Napa-Sonoma Watershed since both component watersheds provide essential sediment to these wetlands. Most of the wetlands of the Suisun subregion of the SF Estuary, as well as the nearby delta wetlands, were assigned to the amalgamated Sacramento-San Joaquin Watershed because it provides most the sediment upon which these wetlands rely. The watershed boundaries were derived from the map of “planning watersheds” of CalWater 2.2.1. Some of these watersheds had to be combined to contain large estuaries. The watersheds of some very small estuaries had to be mapped directly from the NAIP imagery. The land use associated with each estuarine wetland was quantified using the 2001 National Land Cover Dataset (NLDC) provided by the USGS. For SF Estuary, the NLCD maps of developed lands were combined with the regional maps of reclaimed but non-developed historical estuarine habitats to provide a comprehensive map of lands bound by levees.

Field Survey of Ambient Condition. The field survey of ambient estuarine wetland condition was based on the inventory of saline wetlands of perennial estuaries developed by the regional teams. The survey was designed and site selection was conducted in consultation with USEPA Environmental Monitoring and Assessment Program (EMAP; Anthony Olsen, USEPA, Western Ecology Division, Corvallis). The design features an unequal probability-based allocation of sites by percent of estuarine wetland acreage, with 30 sites allocated to Central Coast, SF Estuary, and North Coast. South Coast was allocated 60 sites evenly divided between wetlands of large and small perennial estuaries, where small estuaries have less than 500 total acres of subtidal and intertidal habitats.

A generalized random tessellation stratified (GRTS) design (Stevens and Olsen 1999, 2004) was used to select the 150 assessment sites from the inventory. The GRTS design results in a spatially balanced sample with the points ordered so that the sequential use of the points as study sites maintains spatial balance. This design is intended to provide good spatial coverage across the entire inventory while allowing for increased sampling or intensification in regions or for subsets of the inventory, such as wetland in small estuaries. In this way, a better allocation of resources is achieved to ensure robust assessments of condition within each region while maintaining an unbiased estimate of condition statewide.

The regional teams were deployed from August through November 2007 to conduct the field-based assessments using the estuarine wetland module of CRAM, version 5.0.2 (Collins *et al*. 2007). CRAM can be used to assess the overall condition of estuarine wetlands and to identify stressors likely to affect their condition. The method separates condition into four attributes with multiple metrics (Table 6-1). Each metric has a standardized set of mutually exclusive descriptions representing a full range of possible condition. Each description has a numerical value representing its potential along a condition gradient. Choosing the best-fit description for each metric generates a score for each attribute. The attribute scores can be averaged as an overall index score. Attribute and index scores are expressed as percent possible, ranging from 25 (lowest possible) to a maximum of 100.

Table 6-1. Schematic of CRAM attributes and metrics.

Attribute	Metric
Buffer and Landscape Contex	Landscape Connectivity
	Buffer
	Percent of AA with Buffer
	Average Buffer Width
	Buffer Condition
Hydrology	Water Source
	Hydroperiod
	Hydrologic Connectivity
Physical Structure	Structural Patch Richness
	Topopgraphic Complexity
Biological Structure	Plant Community
	Number of Plant Layers Presents
	Number of Co-dominants
	Percent Invasion
	Horizontal Interspersion and Zonation
	Vertical Biotic Structure

CRAM also provides a stressor check list to help explain the assessments and to identify possible management actions to improve condition. Stressors are represented as categorical scores ranging from “0”, indicating no stressor was present; “1”, indicating that the stressor is present but unlikely to cause significant impact; and “2”, indicating that the stressor is present and likely to cause a significant impact. The Stressor Severity Index for a site is the percent maximum possible score for all stressors combined.

To maintain the integrity of the spatially balanced survey design, each CRAM score must represent the same amount of wetland area. To meet this requirement, each assessment is restricted to a 1-ha circle of estuarine wetland. If the wetland is smaller than 1 ha but larger than 0.1 ha, the entire wetland is assessed. For the purposes of this survey, wetlands smaller than 0.1 ha were excluded from the sample frame.

The precision of an assessment is an important aspect of its QAQC. CRAM precision was assessed as the difference in attribute and index scores among the regional teams for the same assessment areas. Four one-day field exercises were conducted in each of the four regions, with two to three sites assessed per region by each team. The precision target was ±10% for attribute scores and index scores. Detailed procedures guiding the QAQC procedures governing field assessments and data management were prepared in the QAPP (Sutula *et al*. 2008).

Project Assessment

The goal of restoration project assessments in this survey is to demonstrate how to assess the ambient condition of a project using CRAM and how to use ambient probability-based survey data to provide context for these scores.

The restoration projects selected were drawn from an initial list of projects assembled for three regions (North Coast was not included in this phase of the project). A comprehensive inventory of projects existed for the SF Estuary, but not for the other regions although a process to inventory projects coast-wide is now being implemented.

The lack of comprehensive project inventories prevented the use of a randomized approach for selecting projects to assess. Instead, each regional team chose ten projects (the most sites that every regions could assess) representing a large range in project size and including sites of special interest to regional coastal zone managers. The selected projects are not considered representative of the whole population of projects in any region except Central Coast, where no more than ten candidate projects total were found. Projects larger than two assessment areas (larger than 2.0 ha) required multiple assessments, based on the guidance document for project assessment (Collins *et al*. 2007). In these cases, the attribute scores were averaged to generate an overall project index score.

Data Analysis

Analysis of the CRAM survey data relied on a probability-based statistical approach to produce unbiased estimates estuarine condition regionally and statewide. Using information provided by the sample design, these probability-based estimators take into account the number of sites selected by the design within a given area, as well as the total area represented by each site; together these are called also called “area weights”. Area-weighted estimates of estuarine condition included cumulative distribution functions (CDFs), which give the percent area of the resource below a particular attribute value as a function of that value, as well as means, standard errors, and 95% confidence intervals. CDFs were calculated for CRAM Index and the four attribute scores, as their scores approximate continuous data. Measures of confidence or standard errors used a local variance estimator (Stevens and Olsen 2004) that utilizes distances between sites to increase precision. Prior to any statistical computation, area weights were adjusted to account for missing data, either due to inability to access sites or failure to meet quality controls, as well as minor inaccuracies in the initial sample frame. For a complete description of the statistical tools used in this analysis, as well as a free download of scripts for probability-based estimation, go to http://www.epa.gov/nheerl/arm.

Non-parametric Spearman's rank correlation coefficients were calculated to explore relationships between CRAM index scores and stressor indices. Kruskal-Wallis one-way analysis of variance (ANOVA) by ranks was used to test differences in median CRAM Index scores for the major individual stressors identified statewide and by region. Where CRAM Index scores could be transformed to address unequal variance, parametric ANOVAs were used to generate Tukey's pairwise comparisons for the absent, present and present/severe categories.

Results

Summary of Extent and Geographic Distribution

380,860 acres of subtidal and intertidal estuarine habitat exist in California. Perennially tidal estuarine wetlands comprise 12% of this habitat, or 44,456 acres. Figure 6-3 illustrates how the total acreage of estuarine habitats and the acreage of estuarine wetlands are distributed among the four coastal regions. The SF Estuary is the largest in the state. It has three-quarters of the perennial estuarine habitat, including most of the estuarine wetland. Outside of this region, the acreage of estuarine habitats is fairly equally distributed among the North Coast, Central Coast and South Coast. However, the Central Coast and South Coast have roughly three times more area of estuarine wetland than the North Coast.

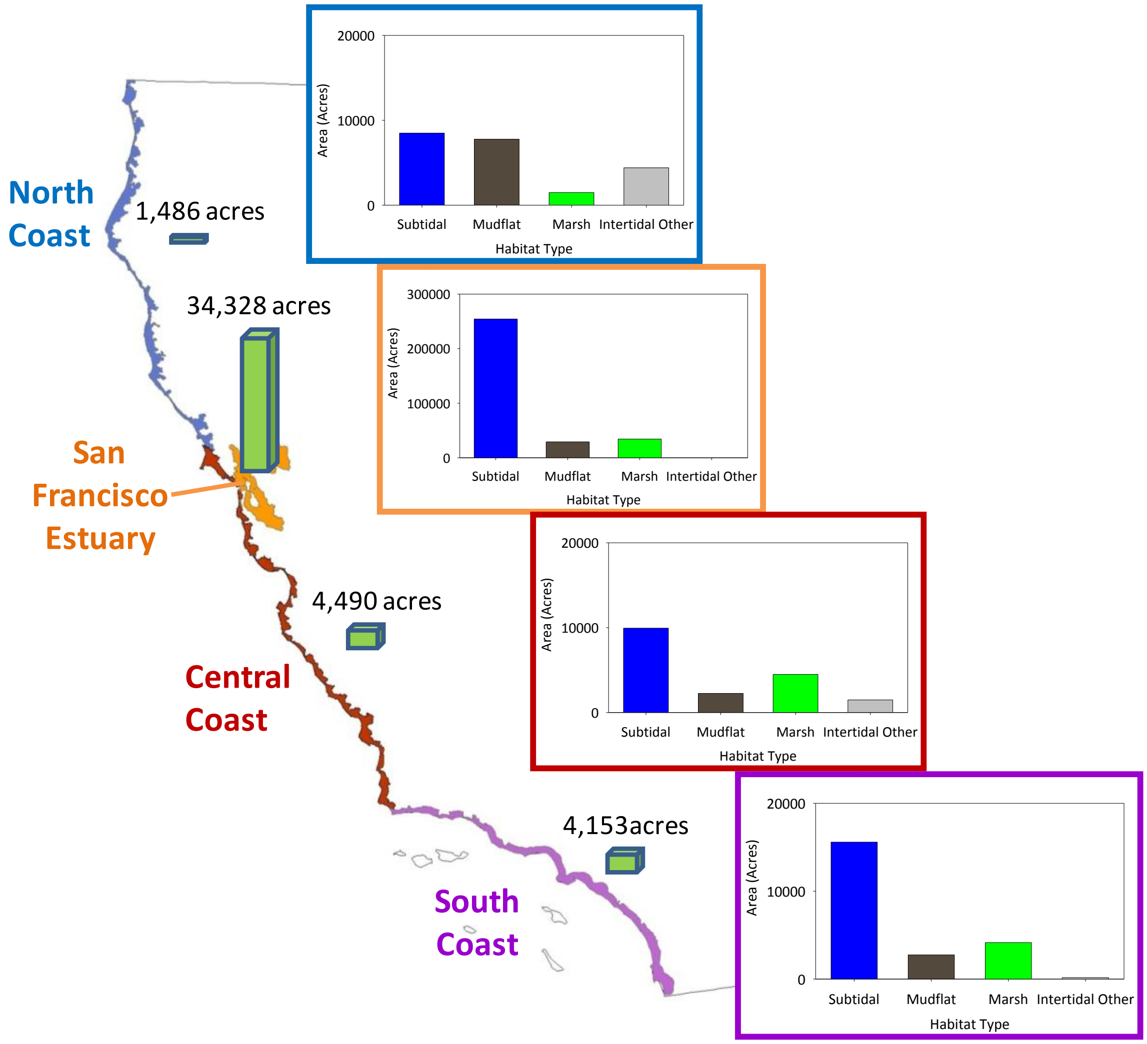


Figure 6-3. Graphic depicting the relative abundance of estuarine wetland habitat among the four coastal regions (dark green bars along the coastline) and its abundance relative to the other estuarine habitat types within each region (inset graphs). Mudflats and wetlands are intertidal habitats. "Intertidal other" represents reefs, aquatic beds, and rocky shorelines. Note unique y-axis scale for SF Estuary.

The inset graphs of Figure 6-3 show the distribution of each of the major estuarine habitat types within each region. In all regions, estuaries are dominated by subtidal habitat, though to a much greater extent in SF Estuary. In the North Coast region, the area of mudflat is about six times that of estuarine marsh; in combination with other intertidal habitats (e.g., intertidal aquatic beds), estuarine marsh is only approximately 10% of the total intertidal estuarine habitat. In both South Coast and Central Coast, estuarine marsh represents 54% of total intertidal habitat.

Historical Estuarine Landscape Change: Evidence for San Francisco Estuary

Historical extent of estuarine wetlands has not been well documented for California. However, historical analysis of the SF Estuary provides evidence of how land use can affect the size and shape of wetlands as well as their distribution and overall amount. The evidence stems from intensive analyses of the historical (Pre-European contact) and current distribution and abundance of wetlands (Figures 6-4 and 6-5). Although changes in all estuarine habitat types have been studied, (Goals Project 1999, Collins *et al*. 2007), only the changes in estuarine wetlands are presented here. Historical change in wetland habitats is better documented for the SF Estuary than for any other region in California. An estimated 15% of the nearly 190,000 acres of historical saline wetland remain (Goals Project 1999).

In the SF Estuary, wetlands were historically distributed fairly evenly among the geometric size classes shown in Figure 6-6. Following almost two centuries of land development in this region, there are only a few wetlands smaller than 0.5 acres, and these are not the same as the wetlands of similar size that existed historically. Those wetlands no longer exist; however, there has been a great increase in the number of wetlands between 0.5 and 200 acres in size. About 25% of these wetlands are restoration or mitigation projects. The rest have either evolved along levees, or they are remnants of historically larger wetlands that have been encroached upon and subdivided by development. The number of wetlands between 200 and 2,000 acres in size has been decreased by about 20%, despite a few completed restoration projects involving hundreds of acres large. The number of wetlands between 2,000 and 4,000 acres has also decreased by about 20%. No existing wetlands are as large as any of the 14 historical wetlands that were larger than 4,000 acres. The largest remnant is the nearly 3,000 acre Petaluma Marsh in Sonoma County, the largest estuarine wetland in California.

A stronger correlation existed between watershed size and wetland area for the historical landscape that the present day, more urbanized landscape in SF Bay (Figure 6-6A). Among present day habitats statewide, the strength of these correlations ranged from high in SF Bay and North Coast (R^2 from 0.83 - 0.80) and decrease southward, with a low R^2 of 0.12 in South Coast (Figure 6-6B through 6-6D)). These data suggest that the regional variation in strength in the correlation between watershed size and wetland area among estuarine wetlands statewide is likely associated with wetland loss stemming from urbanization.

Figure 6-4. Historical and present distribution of wetlands in the SF Estuary downstream of its inland Delta (top panel), with a close up of the Suisun sub-region of SF Estuary (bottom panel).

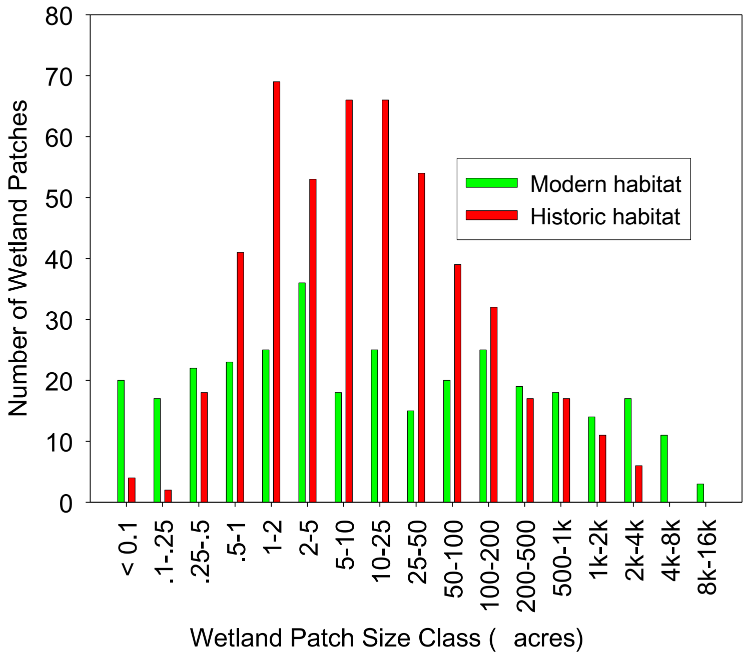


Figure 6-5. Distribution of wetlands among size classes for historical and present day landscapes of the SF Estuary.

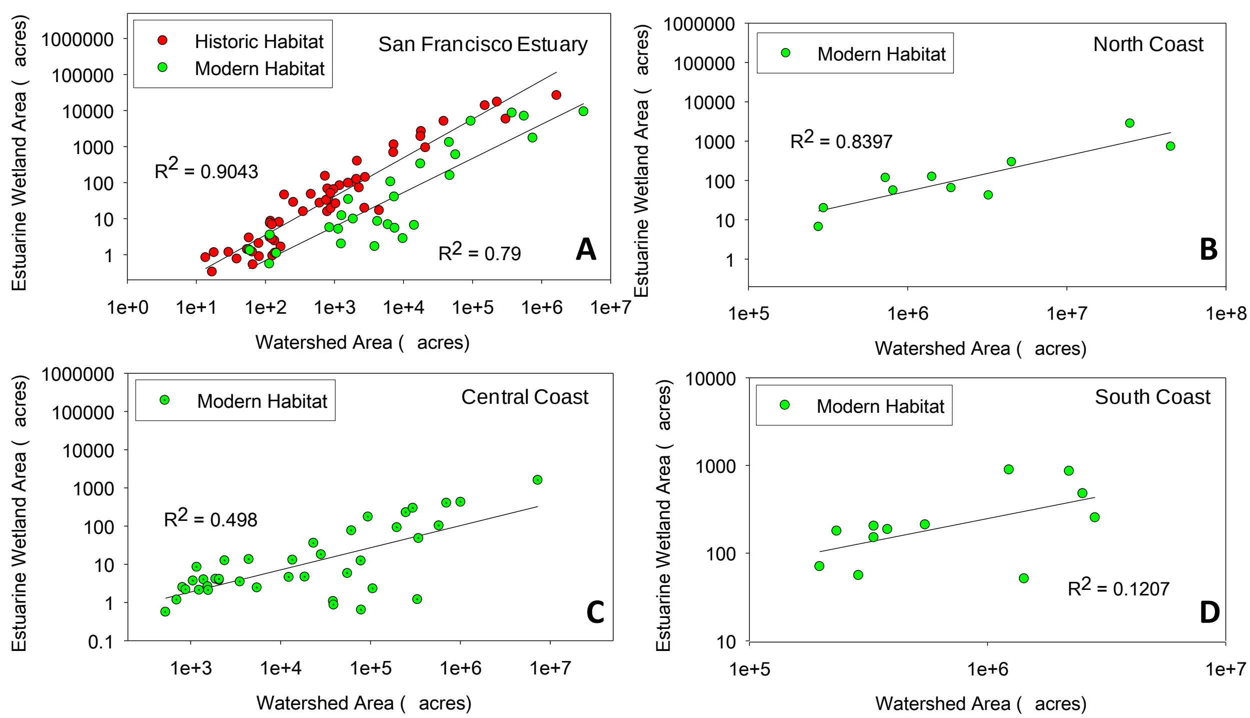


Figure 6-6. Correlation between estuarine wetland area and watershed area for historical and present day SF Estuary (A) and correlation between the total wetland area within estuaries and the size of their watersheds for other regions (B-D).

Urbanization has clear impacts on the shape and edge of estuarine wetlands. Figure 6-7 shows the distribution of the shape index among historical versus present day habitats in SF Estuary. The shape index denotes wetlands that are generally round (x-axis values = 1), much longer than wide (values between 1 and 2), complexly branching (values between 2 and 4), or very complex (values greater than 4). SF Estuary wetlands naturally vary in shape but tend to be round, as indicated by the greater proportion of historical wetlands having very low shape index values and the lack of any historical wetlands having very large values (Figure 6-7A). Some wetlands remain round while getting smaller due to encroaching development all around them. Others get carved into elongate and complexly branching shapes. Both scenarios are clearly evident in Figure 6-7A. However, even the most complexly shaped wetlands appear to eventually become one or more round remnants with repeated encroachment and subdivision.

Patterns in the shape of SF Estuary wetlands can help interpret those of wetlands statewide. Figure 6-7B shows the relative abundance of different shape wetlands in all estuaries statewide. The distributions are generally similar among the regions. Most wetlands in each region are roundish and few have very complex shapes. However, estuarine wetlands tend to be rounder in North Coast and Central Coast than in South Coast or SF Estuary. Only in SF Estuary and South Coast do wetlands have very complex shapes.

The repeated encroachment of urban land uses on SF Estuary wetlands is evident in the percentage of wetland edge developed (Figure 6-8). Every wetland in SF Estuary is bounded by development to some extent. Most wetlands have at least 60% of their margins adjoining developed lands. This includes developed fill, salt ponds, developed uplands, and agricultural lands separated from the wetlands by levees, dikes, or other tidal control structures. The effect of agricultural development is evident in the SF Estuary's Suisun sub-region, where historical reclamation eliminated many large wetland areas and reduced others to small, isolated remnants. (Figure 6-4, bottom panel). The long, narrow wetlands have since developed along the outboard margins of the reclamation levees. Many of the remaining wetlands have complex shapes.

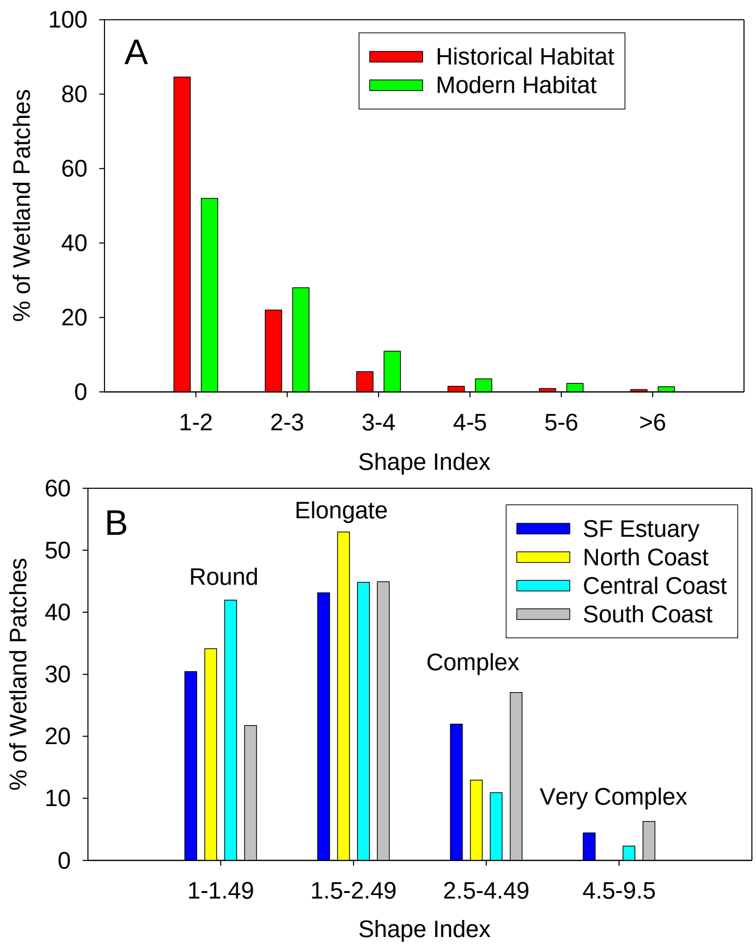


Figure 6-7. Relative abundance of wetland shapes in SF Estuary (A); Distribution of current wetland patches relative to the index of wetland shape statewide (B).

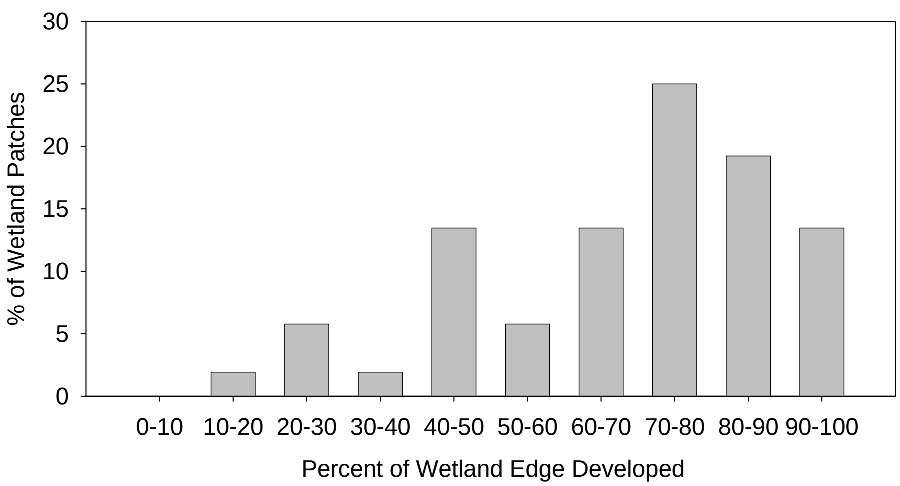


Figure 6-8. Amount of development adjoining SF Estuary wetlands.

Ambient Survey Results

Precision and Guidance for Interpreting Scores. Interpretation of the CRAM probability-based survey results requires an understanding of the statistical uncertainty of the CRAM scores. This uncertainty has two components: the precision of the method (i.e., the rate at which scores for the same condition vary among users) and variability in condition. Inter-team calibration exercises documented an average error rate among users of ±6 points for attribute scores and ±9 points for index scores. The variability in condition as measured by the standard error of the mean for index and attribute scores was generally much less (approximately 3%; Figure 6-9). Thus, differences in index scores of 10 percentage points or more among regions are meaningful, and differences of 10 points in inter-regional attribute scores are likely to be very significant. Beyond this, interpretation of differences in CRAM scores among regions should consider the natural variability in the attributes of estuarine marshes among regions. These considerations are explored in the Discussion section of this report.

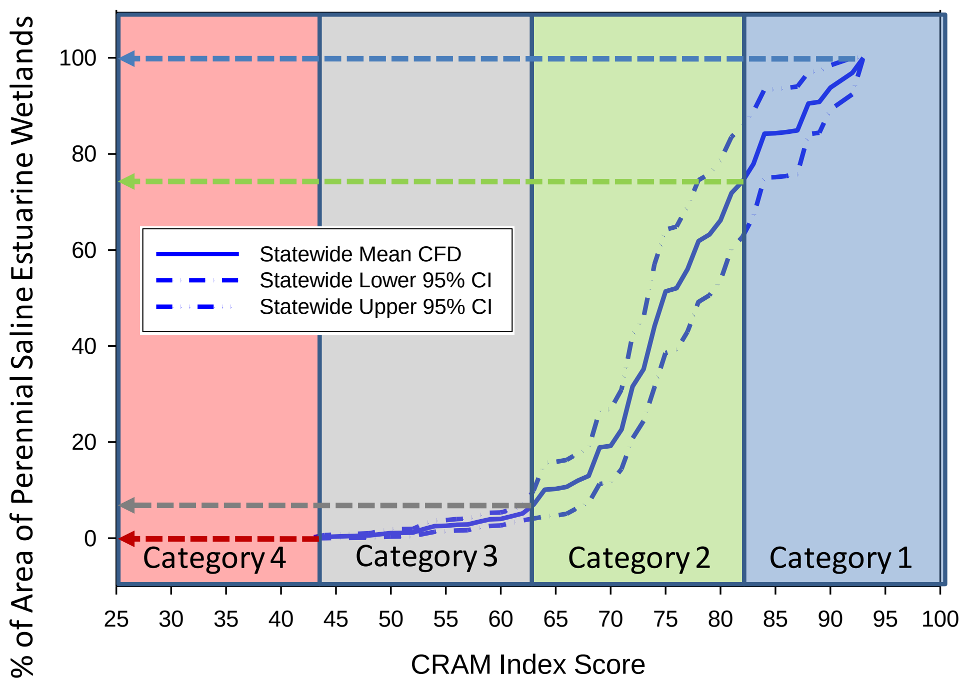


Figure 6-9. Cumulative Frequency Distribution (CFD) of CRAM index scores as a function of percent of area of saline perennial estuarine wetlands statewide. The solid curve represents the mean CFD. Dashed curve represents the 95% confidence intervals. Colored categories within each graphic represent the total range in possible index scores (25 - 100), separated into four equal categories. These categories correspond to an internal reference network for CRAM, based upon "best attainable condition." The horizontal lines drawn back to the Y-axis shows how the percent of area within each of these categories (e.g., 100 - 84 = 16% of area found within Category 1) might be calculated.

The results of the field survey of estuarine wetland ambient condition are presented in two basic ways. First, the average index and attribute scores were computed for each region and statewide. Next, the Cumulative Frequency Distributions (CFDs) were plotted from cumulative distribution functions of CRAM index and attribute scores for each region and statewide. The CFDs are based on the number of sites per score expressed as a percentage of the total number of sites. The total range in possible index scores (25 - 100) was then separated into four equal categories. Scores greater than 82 were assigned to Category 1; scores between 63 and 82 were assigned to Category 2; scores between 44 and 63 were assigned to Category 3; and scores less than 44 were assigned to Category 4. Based on CRAM, higher scores represent better condition and higher potential to provide the functions and services expected for the kind of wetland being assessed. These categories of scores were then overlaid onto the CFDs to estimate the percentage of wetland area in each category of condition for each region and statewide. The mean scores, as well as the percent of area within each of the categories, represent statistical estimates derived from a probability-based selection of sites.

Statewide Estimates of Estuarine Wetland Condition. An estimated 16% of the State's 44,456 acres of saline, perennial estuarine wetlands received CRAM index scores were assigned to Category 1 (Figure 6-10; Table 6-2). The majority of acreage (69%) was in Category 2. Less than 1% of the acreage of the state's estuarine marsh was assigned to Category 4.

Among the four CRAM attributes, landscape context was the attribute for which estuarine wetlands had the highest scores statewide. An estimated 64% of the total acreage was assigned to Category 1. Physical structure was the attribute for which the State's wetlands scored the lowest. 62% of the total estuarine acreage statewide had scores within the range of Categories 3 and 4.

For Category 1, the distribution of Hydrology and Biotic Structure scores for statewide acreage of perennially tidal estuarine wetlands (35 and 36%, respectively) were similar to those for estuarine marsh acreage. One-fifth to one-quarter of total acreage statewide was assigned to Categories 3 and 4, respectively, based on these two attributes.

Table 6-2. Summary of Statewide CRAM index and attribute scores. The first column presents the mean and standard error (in parentheses) of CRAM index and attribute scores statewide. The last four columns present the estimated percentage of estuarine wetland area to score within each category.

Statewide	**Mean Score**	**Percent of Estuarine Wetland Area in Four Score Bins**			
		Category 1 >82	Category 2 63 - 82	Category 3 44 - 63	Category 4 < 44
CRAM Index	76 (1)	16	**69**	14	1
Landscape Context	88 (2)	**64**	32	4	0
Hydrology	80 (2)	36	**44**	18	2
Physical Structure	59 (2)	10	28	**31**	**31**
Biotic Structure	76 (2)	35	**40**	23	2

Analysis of Common Stressors. CRAM index scores were significantly correlated with the number of stressors and severe stressors found at each site (non-parametric spearman's rank correlation r = -0.44 and -0.44, respectively; p-value <0.0001). Dike/levees, lack of treatment of invasive plants, bacteria and pathogens impaired, nonpoint source discharges, and heavy metal impaired were among the five most frequently cited severe stressors noted statewide (Table 6-3). Dikes/levees were the number one stressor on wetlands statewide, affecting 43% of the sites visited. The degree of impoundment due to dikes and levees was judged to be severe at 34% of the sites visited (Table 6-4). In South Coast, the number of stressors and the number of severe stressors did not significantly differ between large and small estuaries (<500 acres in size).

Table 6-3. Statewide and regional prioritization of stressors based on their frequency of occurrence among sites, regardless of severity. Statewide frequencies are based on regional means to account for regional differences in sample size. CC = Central Coast, NC = North Coast, SC = South Coast, SF = SF Estuary.

Stressor Name	State (n=150)	NC (n=30)	SF (n=30)	CC (n=30)	SC (n=60)
Dike/levees	43	30	50	23	70
Non-point Source (NPS) discharges	38	47	7	57	43
Lack of treatment of invasives adjacent to AA/ buffer	34	80	7	17	33
Heavy metal impaired	28	7	33	23	48
Bacteria and pathogens impaired	25	13	17	27	43
Pesticides or trace organics impaired	25	17	30	27	28
Nutrient impaired	20	3	0	30	45
Predation & habitat destruction by non-native vertebrates	20	0	53	3	23
Trash or refuse	18	17	3	30	22
Excessive sediment or organic debris from watershed	20	67	7	3	3
Ditches (borrow, agricultural drainage, mosquito control)	16	23	33	0	7
Excessive runoff from watershed	11	7	10	7	20
Grading/ compaction (N/A for restoration areas)	7	7	0	0	22
Flow obstructions (culverts, paved stream crossings)	8	3	0	13	13
Excessive human visitation	8	7	3	13	10
Flow diversions or unnatural inflows	5	0	0	3	18
Pesticide application or vector control	6	0	10	3	12
Mowing, grazing, excessive herbivory (within AA)	6	7	3	13	0
Engineered channel (riprap, armored channel bank, bed)	3	0	3	3	7
Dredged inlet/channel	3	7	0	0	7
Lack of vegetation management to conserve natural resources	4	0	0	10	5
Actively managed hydrology	3	3	0	7	3
Weir/drop structure, tide gates	3	0	0	10	3
Filling or dumping of sediment/soils (N/A - restoration areas)	2	3	0	0	5
Point Source (PS) discharges	2	3	0	0	5
Plowing/Discing (N/A for restoration areas)	3	0	10	0	2
Dams (reservoirs, detention basins, recharge basins)	3	0	0	10	2
Vegetation management	3	0	3	7	0
Median Number of Stressors Per Site	10	6	9	9	15

Table 6-4. Statewide and regional prioritization of severe stressors based on their frequency of occurrence among sites. Statewide frequencies are based on regional means to account for regional differences in sample size. CC = Central Coast, NC = North Coast, SC = South Coast, SF = SF Estuary.

Stressor Name	**State (n=150)**	**NC (n=30)**	**SF (n=30)**	**CC (n=30)**	**SF (n=30)**
Dike/levees	34	20	37	17	37
Lack of treatment of invasive plants adjacent to AA or buffer	24	70	0	10	0
Bacteria and pathogens impaired (PS or Non-PS pollution)	15	7	0	17	0
Non-point Source (NPS) discharges	16	13	0	23	0
Heavy metal impaired	13	0	0	17	0
Nutrient impaired	13	0	0	20	0
Pesticides or trace organics impaired	12	3	0	23	0
Excessive runoff from watershed	7	0	3	3	3
Flow obstructions (culverts, paved stream crossings)	7	3	0	13	0
Trash or refuse	7	0	0	17	0
Flow diversions or unnatural inflows	5	0	0	3	0
Ditches (borrow, ag drainage, mosquito control, etc.)	7	13	10	0	10
Grading/compaction (N/A for restoration areas)	4	0	0	0	0
Excessive sediment or organic debris from watershed	6	20	0	0	0
Excessive human visitation	3	0	0	7	0
Engineered channel (riprap, armored channel bank, bed)	3	0	0	3	0
Predation and habitat destruction by non-native vertebrates	3	0	7	0	7
Weir/drop structure, tide gates	3	0	0	10	0
Mowing, grazing, excessive herbivory (within AA)	4	7	0	9	0
Filling or dumping of sediment/soils (N/A- restoration areas)	1	0	0	0	0
Point Source (PS) discharges	1	0	0	0	0
Dredged inlet/channel	1	0	0	0	0
Actively managed hydrology	2	0	0	3	0
Pesticide application or vector control	2	0	0	3	0
Lack of vegetation management to conserve natural resources	2	0	0	3	0
Median Number of Severe Stressors Per SIte	4	3	9	2	9

Non-parametric ANOVAs were conducted to test differences in CRAM index score with respect to major individual stressor variables. Dikes/levees, excessive sedimentation (from watershed), and flow obstructions, such as culverts, were highly significant statewide (Table 6-5). Within regions, the significance of individual stressors varied.

Table 6-5. Summary of results of non-parametric ANOVAs to examine effect of stressor severity on CRAM index score. Numbers in parentheses are the numbers of sites in which the stressor was absent, present but not severe, and severe, respectively. CC = Central Coast, NC = North Coast, SC = South Coast, SF = SF Estuary.

Stressor Variable	Kruskal-Wallis Test (Pr >Chi-Square)				
	Statewide	NC	SFB	CC	SC
Dikes/Levees	0.0001 (n=76,14,59)	0.14 (n=20,3,6)	0.19 (n=17,4,11)	0.21 (n=21,3,4)	0.006 (n=18,4,38)
Lack of Treatment of Invasive Plants in Buffer	0.39 (n=100,33,16)	0.046 (n=5,3,21)	0.78 (n=30,2,0)	0.046 (n=25,1,2)	0.015 (n=40,10,10)
Excessive sediment from watershed	0.0001 (n=124,17,8)	0.35 (n=9,14,6)	0.019 (n=30,2,0)	0. 49 (n=27,1,0)	0.43 (n=58,0,2)
Ditches	0.26	0.19	0.45	0.11	0.11
Flow obstructions	0.0005 (n=135,2,12)	0.18 (n=28,0,2)	--	0.11 (n=23,0,5)	0.0012 (n=52,2,6)

Regional Estimates of Condition and Stress. A comparison of regional CFDs of CRAM index scores (Table 6-6; Figure 6-10) indicates that estuarine wetland condition generally decreases from north to south. North Coast wetlands had the highest mean ambient scores (82 ±1), followed by the SF Bay region, and Central Coast. The mean ambient scores for South Coast was the lowest of the four regions (67 ±1). Mean scores for Central and South Coast were 11 - 15 % lower than North Coast, while that of SF Estuary was 5% lower. The attribute scores generally followed the same trends as the index scores.

All regions scored best for landscape context (81 - 90; Category 1). Biotic Structure was the lowest scoring attribute in the North Coast (72 ±2; Category 2); all other attributes for North Coast scored within Category 1. Physical Structure was the lowest scoring attribute among the other regions. Differences among regions were most significant with respect to Physical Structure and Hydrology. The mean score for Physical Structure was 25 - 27 points higher for North Coast than for the other regions. Hydrology scores in were 21 - 28 points lower than the other three regions.

The CFD data can be also be used to describe the statistical distribution of CRAM scores statewide. 25% of the area of estuarine wetland is likely to have an index score greater than 82. 75% of the area is likely to have a score above 71. Only 14% of the North Coast estuarine wetlands area, compared to 68% of the South Coast area, is likely to score in the lower 25% of index scores (Table 6-7).

Table 6-6. Mean and standard error (SE) CRAM index and attribute scores statewide and by region. Numbers represent percent of possible points, with scores ranging from 25 to 100% and standard error given in parenthesis. Differences of ±10 percentage points or more can be considered meaningful between regions. Blue shaded cells represent Category 1; Green cells represent Category 2; and Gray cells represent Category 3.

CRAM Index or Attribute	North Coast Mean	SF Estuary Mean	Central Coast Mean	South Coast Mean
Index Score	82 (1)	78 (1)	71 (2)	67 (1)
Landscape Context	83 (1)	90 (2)	81 (2)	82 (2)
Hydrology	89 (2)	82 (2)	82 (2)	61 (1)
Physical Structure	84 (2)	59 (3)	57 (3)	59 (3)
Biotic Structure	72 (2)	78 (2)	63 (2)	67 (2)

Table 6-7. Percentage of estuarine marsh area within each region that fell into the top and bottom quartiles (top 25% and bottom 25%) of Statewide CRAM index scores.

Region	Estuarine Marsh Area (Acres)	% Estuarine Marsh Area in Top 25%	% Estuarine Marsh Area in Bottom 25%
North Coast	1,486	45%	14%
SF Bay	34,328	29%	27%
Central Coast	4,490	11%	48%
South Coast	4,193	3%	63%

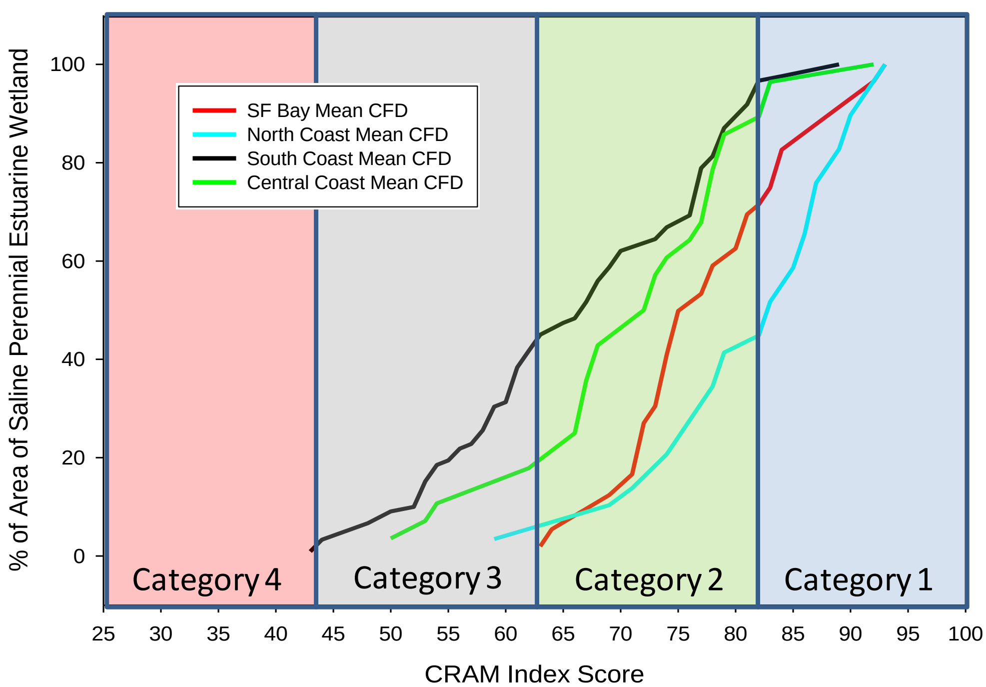


Figure 6-10. Cumulative frequency distribut*ion (CFD) o*f CRAM Index scores as a function of percent of area of perennially tidal estuarine marsh as a function of CRAM Index score by region.

North Coast. Within North Coast, 55% of the 1485 acres of perennially tidal estuarine marsh received index scores in Category 1 (Table 6-7; Figure 6-10) and 45% was in Category 2; a statistically insignificant acreage received scores below the 50th percentile (Categories 3 and 4 combined).

Among the four CRAM attributes, Hydrology was the attribute for which the North Coast estuarine marsh scored the highest; 71% of the total acreage is expected to score in Category 1. North Coast estuarine wetlands also scored well for Landscape Context and Physical Structure; 51% and 45% of the total acreage is expected to score in Category 1 for these two attributes. For both the Landscape and Hydrology attributes, more than 90% of the perennially tidal estuarine wetland area would be expected to score in Categories 1 or 2.

Table 6-8. Distribution of North Coast intertidal wetland acreage among categories of condition. The first column present the mean and standard error (in parentheses) of CRAM index and attribute scores statewide. The last four columns present the estimated percentage of estuarine wetland area to score within each category.

North Coast	Mean	Percent of Estuarine Wetland Area in Four Score Bins			
		Category 1 >82	Category 2 63-82	Category 3 44-63	Category 4 <44
CRAM Index	82 (1)	**55**	45	0	0
Landscape Context	83 (1)	**51**	46	3	0
Hydrology	89 (2)	**71**	29	0	0
Physical Structure	84 (2)	**45**	38	17	0
Biotic Structure	72 (2)	30	**56**	24	0

The Biotic Structure attribute (composed of metrics measuring of the emergent wetland plant species diversity, dominance by non-native species, and plant vertical structure and horizontal interspersion) was the component for which the North Coast estuarine wetland scored the lowest. About 30% of the North Coast estuarine wetland area is likely to score in Category 1 for this attribute. About 24% of the total estuarine wetland area in North Coast is likely to score in Categories 3 or 4 for this attribute Analysis of data at the metric level indicates that the majority of the North Coast sites scored relatively low for dominance by non-native species, vertical structure metrics, and horizontal interspersion.

The results regarding the significance of non-native species are corroborated by stressor data. Lack of treatment of invasive plant species was the most frequently occurring stressor at North Coast sites (88% of sites; Table 6-3) and the most severe stressor (70% of sites, Table 6-4). North Coast CRAM index scores were significantly lower for sites where this stressor was severe ($p = 0.046$, Table 6-5). The dominant invasive species was identified as *Spartina densiflora*. Excessive sediment from local watersheds (20% of sites), dikes and levees (20%), NPS pollution (13%), and mosquito ditching (13%) were the top five severe stressors occurring in North Coast.

San Francisco Estuary. Within the SF Estuary, 31% of the more than 34,000 acres of perennially tidal estuarine wetland is likely to scores in Category 1 for overall condition (Table 6-9; Figure 6- 10). The majority of the acreage (69%) is likely to score in Category

2, with a statistically insignificant percentage of acreage below the 50th percentile (Categories 3 and 4).

Among the four CRAM attributes, Landscape Context was the attribute for which the SF Estuary wetlands scored the highest (mean of 90%). Approximately 71% of the total acreage is likely to score in Category 1 for this attribute. SF estuarine wetlands also scored well for Hydrology; 43% of the total acreage within this region is expected to score within Category 1 for the Hydrology attribute. For Landscape Context, Hydrology, and Biotic Structure, more than 83% of the wetland area of the SF Estuary is likely to score in Categories 1 or 2. Physical Structure is the attribute for which the SF estuarine wetlands scored the lowest (mean of 59; Table 6-9). Analysis of metric level data showed that wetlands in this region has many sites in Category 3 (42%) for the number of physical patch types (pannes, pools, channels, etc.) and Category 2 (52%) for topographic complexity (52%).

Table 6-9. Distribution of SF Estuary intertidal wetland acreage among categories of condition. The first column presents the mean and standard error (in parentheses) of CRAM index and attribute scores statewide. The last four columns present the estimated percentage of estuarine wetland area to score within each category.

SF Estuary	Mean	Percent of Estuarine Wetland Area in Four Score Bins			
		Category 1 >82	Category 2 63-82	Category 3 44-63	Category 4 <44
CRAM Index	78 (1)	**31**	69	0	0
Landscape Context	90 (2)	**71**	26	3	0
Hydrology	82 (2)	**43**	**43**	14	0
Physical Structure	59 (3)	5	31	**33**	31
Biotic Structure	78 (2)	41	**49**	10	0

Dikes and levees were among the most frequently occurring stressors (50% of sites; Table 6-3) and the most severe stressor for the SF Estuary wetlands (37% of sites, Table 6-4). Sites with levees present had a mean CRAM index score seven points lower than sites lacking this stressor, though this difference was not significant (Table 6-5). Mosquito ditching (10% of sites) and predation by non-native vertebrates (7% of sites) were among the most severe stressors, while heavy metal and pesticide/organic contamination were among the most frequently occurring stressors.

Central Coast. Within the Central Coast region, 11% of the 4,500 acres of perennially tidal estuarine marsh is expected to score in Category 1 for overall condition (Table 6-10; Figure 6-10). The majority of the acreage (17%) would probably score in Category 2, with 17% of the wetlands area below the 50th percentile.

Among the four CRAM attributes, Hydrology was the attribute for which Central Coast perennially tidal estuarine marsh scored the highest. Approximately 53% of the total acreage is expected score in Category 1 for the Hydrology attribute. Central Coast estuarine wetlands also scored well for Landscape Context; 36% of the total acreage within this region would probably score in Category 1 for Landscape Context. For Landscape Context and Hydrology, more than 81% of the acreage of perennially tidal estuarine marsh in Central Coast is likely to score in Categories 1 or 2.

Physical structure was the attribute for which the Central Coast estuarine wetland scored the lowest. Only 5% of estuarine wetland in this region scored is likely to score in Category 1. Approximately 64% of the total estuarine wetland acreage in Central Coast would have scores below the 50th percentile for the whole state, with 31% likely to score in Category 4. Analysis of metric level data indicated that 50% of the acreage of Central Coast estuarine wetlands would tend to score in Categories 3 or 4 for both structural patch richness and topographic complexity.

The Central Coast estuarine wetlands also scored somewhat low for Biotic Structure. Only 11% of the wetland acreage in this region would tend to score in Category 1. A total of 57% of the Central Coast wetland acreage would probably score below the 50th percentile for the state as a whole, with 12% in Category 4. Analysis of metric level data indicates that the majority of Central Coast sites scored lowest in horizontal interspersion (75% of acreage in Category 4) and highest in percent invasion (93% of acreage in Category 1).

Table 6-10. Distribution of Central 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 statewide. The last four columns present the estimated percentage of estuarine wetland area to score within each category.

Central Coast	**Mean**	**Percent of Estuarine Wetland Area in Four Score Bins**			
		Category 1 >82	Category 2 63-82	Category 3 44-63	Category 4 <44
CRAM Index	71 (2)	11	**72**	17	0
Landscape Context	81 (2)	36	**59**	5	0
Hydrology	82 (2)	**53**	28	15	4
Physical Structure	57 (3)	5	31	**33**	31
Biotic Structure	63 (2)	11	32	**45**	12

NPS pollution was identified as the most frequently occurring stressor in Central Coast (56% of sites; Table 6-3) and the most severe stressor (23% of sites; Table 6-4). Dike/levees (17% of sites), nutrient, pesticide, bacteria and heavy metal impairment and trash (17 - 20% of sites) were the most prevalent stressors. Dikes/levees (17% of sites) and trash (13% of sites) were among the most severe stressors in estuarine marshes of this region. Sites with levees present had a mean CRAM index score 10 points lower than that of other sites, though this difference was not significant in a non-parametric ANOVA (Table 6-5)

South Coast. Within the South Coast, 13% of the almost 4,000 acres of perennially tidal estuarine wetland is likely to have CRAM index score in Category 1 (Table 6-11; Figure 6-10). The majority of the acreage would probably score in Categories 2 or 3 (55 and 39%, respectively), with just 3% scoring in Category 4.

Among the four CRAM attributes, Landscape Context was the attribute for which South Coast perennially tidal estuarine wetland scored the highest. Approximately 51% of the total acreage scored in Category 1 for overall condition, and approximately 38% scored in Category 2. South Coast estuarine wetlands also scored moderately well for Biotic

Structure; approximately 76% of the total estuarine wetland acreage within this region would probably score in either Category 1 or 2.

Table 6-11. 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 statewide. The last four columns present the estimated percentage of estuarine wetland area to score within each category.

South Coast	**Mean**	**Percent of Estuarine Wetland Area in Four Score Bins**			
		Category 1 >82	Category 2 62-82	Category 3 44-62	Category 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

Physical structure was the attribute for which the South Coast estuarine marsh scored the lowest. About 71% of the total estuarine acreage within the region had scores below the 50th percentile of possible points for the state as a whole (Categories 3 and 4 combined), with 25% scoring in (Category 4). Results of metric level scores illustrate that the majority of acreage of South Coast estuarine wetland had Category 3 scores for both topographic complexity and structural patch richness.

The South Coast estuarine wetlands also scored somewhat low for Hydrology with only 5% of the acreage likely to score in Category 1 for this attribute. The majority of the acreage (approximately 49%) is likely to score below the 50th percentile based on the statewide data. Estuarine wetland marsh in this highly urbanized region scored lowest for water source (87% of sites in Category 3) and hydrologic connectivity (55% of sites in Categories 3 and 4 combined).

Approximately 75% of the South Coast estuarine wetland (3070 acres) is located in large estuaries, defined for this study as having a total acreage of subtidal and intertidal habitats combined that exceeds 500 acres. Wetlands in large estuaries had significantly higher CRAM index scores, primarily due to higher Hydrology and Biotic Structure attribute scores, than small estuaries (p-value >0.05; Figure 6-11). This difference was greatest for Biotic Structure, which was 13 % higher.

Dikes and levees were the most frequent stressor (70% of sites; Table 6-3) and the most prevalent severe stressor for South Coast sites (63% of sites; Table 6-4). Contaminant pollution (heavy metals, nutrients, bacteria, pesticides/organic compounds), lack of treatment of invasive plants in the buffer, culverts and other flow obstructions, and grading or compaction were also among the most cited severe stressors in this region. 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; Table 6-5). 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; Table 6-5). Non-parametric ANOVA tests showed that the number of stressors and number of severe stressors did not significantly differ between large and small estuaries p-value = 0.98 and 0.78, respectively).

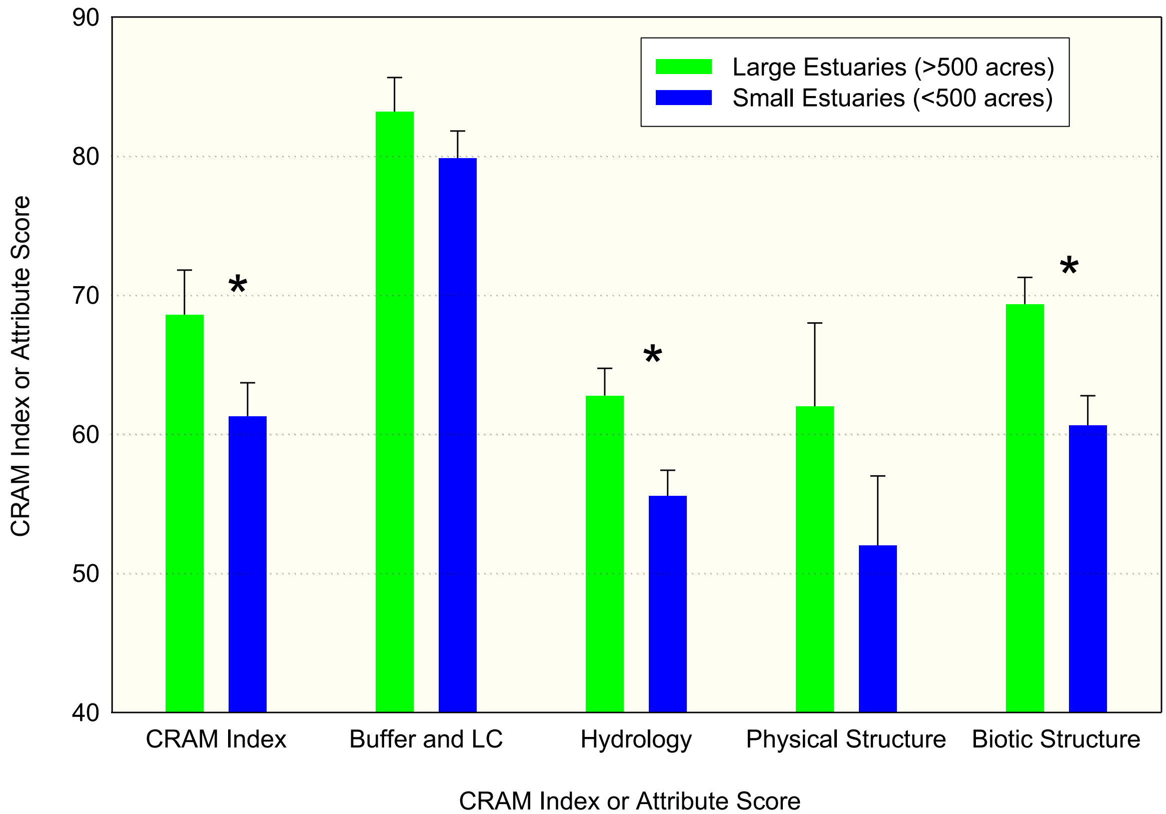


Figure 6-11. Plots of mean and upper 95% confidence interval for CRAM index and attribute scores for large and small estuaries in South Coast. Size threshold of 500 acres includes both subtidal and intertidal acreage. An asterick (*) indicates significant difference between large and small estuaries (p-value < 0.05). LC = Landscape Context.

Assessment of Projects

Table 6-12 summarizes the CRAM assessments of completed restoration projects. Notably, the projects assessed (n = 30, 120 acres) represent less than 1% of the total ambient acreage of the state. The CDFs of CRAM index scores from projects assessed in all regions relative to that of statewide ambient conditions show that projects had on average 10% lower scores (Figure 6-12). The upper range of Landscape Context and Hydrology attribute scores for projects were 15 - 18% lower than the statewide ambient scores for these attributes (Table 6-13). Project related sites had higher scores than ambient sites for Physical Structure in the SF Estuary and Central Coast regions. Physical Structure scores were essentially the same between projects and ambient sites in South Coast. Statewide, the scores for the Biotic Structure attribute were 6 - 13% higher for ambient sites than project related sites.

Table 6-12. Summary of project assessment data. All projects assessed were completed as "as-built" restoration projects.

Region	Number of Projects	Number of Assessment Areas	Total Area Assessed (Acres)
SF Estuary	10	22	41
Central Coast	10	13	31
South Coast	10	20	48
Total	30	54	120

Table 6-13. Comparison of statewide (Ambient) and project related (Project) mean CRAM index and attribute scores for SF Estuary, Central Coast, and South Coast.

Mean CRAM Index or Attribute Scores	SF Estuary		Central Coast		South Coast	
	Ambient	Project	Ambient	Project	Ambient	Project
Index Score	78	67	71	63	67	59
Landscape Context	90	72	81	64	82	65
Hydrology	82	65	82	67	61	55
Physical Structure	59	68	57	66	59	56
Biotic Structure	78	65	63	57	67	59

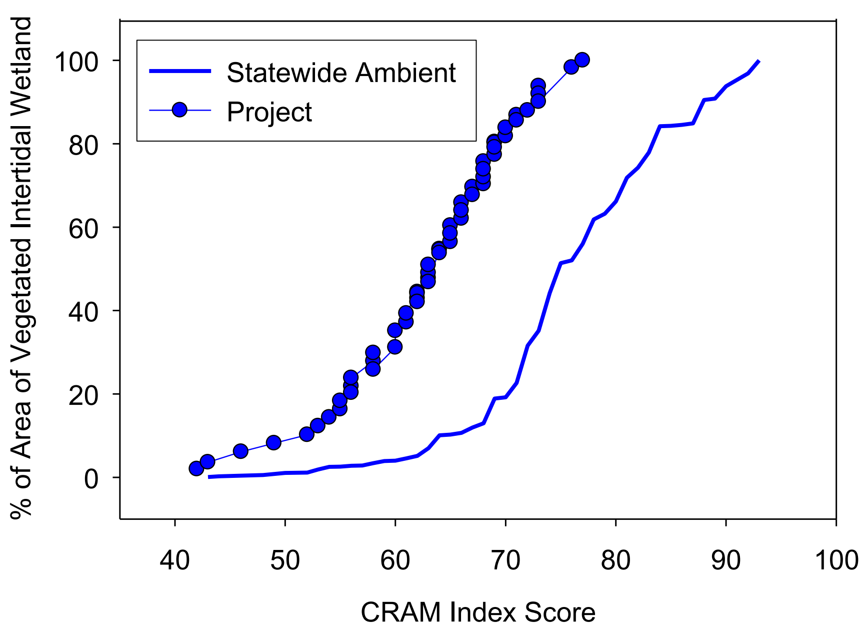


Figure 6-12. CDFs of 30 projects in the SF Estuary, Central Coast, and South Coast relative to statewide CDF of CRAM index scores. Note that the total area of projects assessed is 120 acres, relative to the statewide ambient total of almost 44,500 acres.

Discussion

The Importance of Distributions, Amounts, and Shapes of Estuarine Wetlands

The ecological and social values or services of estuarine wetlands are well celebrated (Day *et al*. 1989). Flood control, pollution filtration, carbon entrapment, and hunting and fishing are some of the local services that are common to many estuaries. Many species of migratory birds and fish depend on estuarine wetlands along their migratory pathways. These kinds of services link one location or region to another all along the California coast. The locations of wetlands, their sizes, and their shapes strongly influence all of their services. In general, as the size of an estuarine 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 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 estuarine wetlands. However, to provide all the services that are appropriate and needed, the ideal estuarine landscape is likely to have abundant, large, round, wetlands.

Effect of Land Use Changes on the Landscape Profile of Estuarine Wetlands

State-wide, California has lost approximately 91% of its wetlands, reducing the total surface area occupied by wetlands from 5% of the land to less than one-half of one percent (Dahl 1990). Utilizing existing maps with base imagery dating from 1980 to 2002, with local updates by regional teams of wetland experts, this survey estimates that California has 44,456 acres of perennial estuarine wetland remaining statewide. 77% of this acreage is in the SF Estuary. Accurate estimates of estuarine wetlands loss are not available for California (California Coastal Commission 1989). However, the historical change in the distribution and abundance of estuarine wetlands and other habitats is better documented for the SF Estuary than for any other region in California.

Since European contact, the amount of wetlands in the SF Estuary has decreased by nearly 99%. Most of its historical wetland was non-saline, and less than 1% of that remains. Only about 15% of its historical saline wetland remains (Goals Project 1999). The rest of the existing area of estuarine wetland in the SF Estuary has evolved since the advent of European land use in the region due land use that has increased sediment supplies and changed the locations where sediment accumulates along the estuary shoreline. The work accomplished to date has documented not only the magnitude of the loss, but also how the changes in spatial distribution, shape, and size of estuarine wetlands have affected the distribution of wildlife and created opportunities for estuarine wetland restoration.

Connectivity refers to the connection between habitat patches that permit the dispersal of plants and movements of wildlife essential to their survival. Habitat patches and their connections vary among species depending on their life histories (Wiens 1976). Anthropogenic activities such as diking, filling and altering the hydrology of wetlands tend to disrupt connectivity (Fell *et al*. 1991, Grossinger 2001). Historic maps of SF Estuary show that alterations in land use have decreased patch size as well as severely altering the shapes. Historical trend analysis of estuarine wetlands from SF Estuary shows that the fewer large patches now exist, while the number of small wetland patches has increased. The historical changes in the size-frequency distribution of estuarine wetlands in SF Estuary undoubtedly represent a decrease in connectivity for some of species, especially species with small home ranges restricted to estuarine wetlands.

Urbanization of estuarine wetlands has also increased their perimeter length relative to their aerial extent, which increases the exposure of even large wetland patches to disturbance factors. In the more urbanized estuaries of the South Coast and the SF Estuary, many wetlands are embedded in intensive land uses and bounded by levees. These conditions diminish the hydrological and ecological connectivity among wetlands and increase their susceptibility to adverse changes in wetland function because of stressors (Grossinger 2001).

Use of the current landscape profile of the State and the historical landscape profile of the SF Estuary provides evidence that estuarine wetlands are tightly linked to their immediate watersheds, and that this linkage can be weakened by land use. The strength of relationship between watershed area and wetland area likely reflects the truism that larger watersheds tend to have larger valleys, which accommodates ongoing estuarine transgression and wetland development, and that larger watersheds tend to have larger sediment supplies that can sustain larger areas of wetlands after they have evolved. A stronger correlation between watershed size and wetland area was found for the historical landscape than for the present day, more urbanized landscape. Among regions, this correlation was weakest for the South Coast, where remaining wetlands have been severely reduced in size by land use. For Central Coast and SF Estuary, the residual errors of the correlations were primarily due to urbanized estuaries. These correlations are stronger when restricted to undeveloped and largely agricultural estuaries because of historical reclamation of estuarine wetlands for agriculture seldom involved all wetland areas and reclamation that was delimited by large tidal channels. The reductions in tidal prism caused by reclamation caused many of these channels to “downsize” as they became places where sediment accumulated and wetlands evolved. A strong correlation exists for the North Coast, which has the largest proportion of estuaries dominated by agriculture. These results support the hypothesis that the inter-regional variability in the correlation between watershed size and wetland area is partially related to regional differences in the amount of urbanization.

Although land use varies in kind and intensity among the estuaries of California, it has affected the distribution, abundance, size, and shape of estuarine wetlands in consistently deleterious ways. It has decreased the amount of estuarine wetland, increased the number of wetlands, decreased their size, and therefore increased the distance between wetlands. It has also increased their perimeter length relative to their aerial extent. In the more urbanized estuaries of the South Coast and the SF Estuary, many wetlands are embedded in intensive land uses and bounded by levees. These conditions diminish the hydrological and ecological connectivity among the wetlands, increase their susceptibility to invasion and local catastrophic events, and reduce their overall capacity to serve society.

The profile of ecological change can help to create a common vision for ecosystem restoration, and inform regional efforts to set quantitative acreage targets (Gwin *et al*. 1999). Data of this kind were essential to a multi-agency process adopted to establish targets for future restoration of SF Estuary wetlands that successfully demonstrated how science-based assessments can guide planning and management actions (Goals Project 1999). Studies of historical landscapes can reveal a broader palette of restoration choices than otherwise recognized by recovering lost knowledge about the full range of habitat types and conditions that naturally characterized a region before it was transformed by present day land use. This has practical value in many ways. For example, the careful analysis of historical conditions can reveal no-longer-visible variations in habitat along large-scale gradients of environmental moisture and temperature that serve as models for predicting the effects of climate change and assessing how it can be exploited to restore ecological services in the future. Studies similar to those conducted in the SF Estuary are needed elsewhere. Comparable studies have been initiated in South Coast (Stein *et al*. 2007), Elkhorn Slough (Van Dyke and Wasson 2004), and within a diverse selection of watersheds draining to the SF Estuary (Robin Grossinger - SFEI, personal communication).

Accuracy of the Inventory of Estuarine Habitats

One of the objectives of this assessment was to establish a baseline against which future assessments can be compared. The landscape profile of perennial estuarine wetland habitat maps generated for this study should be used with caution for this purpose. There are two reasons for this: 1) accuracy of mapping at the scale typically conducted and 2) the cost of comprehensively mapping a region or state with sufficient frequency to provide an up-to-date analysis of trends (e.g., on the order of every 5 to 10 years). This assessment was based on existing maps of estuarine wetlands included in the National Wetland Inventory, and these data are known to have both of the above constraints.

Acknowledging these difficulties, the USFWS NWI has gone to a probability-based survey approach to assess trends in wetland acreage on a national level (Dahl 2005). The approach involves random selection of 4,682 randomly selected sample plots; each plot is four square miles (2,560 acres) in area. Wetlands within these plots are mapped with remote sensing data in combination with a greater degree of ground-truthing to determine wetland change (a.k.a. “status and trends plots”). Because of the lower error rate in mapping with this approach, trends in wetland change can be detected earlier than with conventional NWI mapping methods (Dahl 2005).

California faces similar problems with respect to the costs of comprehensive mapping and the accuracy of existing maps of estuarine habitat. For this reason, a statistical approach is recommended to improve the tracking of trends in habitat acreage. These data would also assist in tracking the impacts of climate change on estuarine wetlands. Notably, California wetlands have been under-represented in the NWI National Status and Trends assessments (T. Dahl, pers. Comm.). With the National Wetland Assessment that will be conducted, additional plots will be added to the State, with approximately 40 to 60 plots in estuarine habitat and roughly 277 statewide. The State of California should consider intensifying this status and trends assessment and assuring that the data acquired are classified in a manner consistent with emerging HGM typologies for CRAM and Project Tracking (see detailed recommendation in Sutula *et al*. (2008).

Statewide and Regional Patterns in Estuarine Wetland Condition and Common Stressors

An estimated 85% of the State's nearly 44,500 acres of saline estuarine wetland scored within the top 50% of possible CRAM index scores. The statewide results were strongly influenced by the SF Estuary, because it has the most saline estuarine wetland. The statewide results must always be interpreted with this influence in mind. Perhaps the most useful aspect of the probabilistic survey design using CRAM is that it provides a basis for calculating the proportions of the total area of saline estuarine wetlands within a region or statewide that are estimated to score within any given category of condition, relative to the best attainable condition. When this is combined with the Landscape Profile and Stressor Checklist, then the likely distribution of condition can be assessed relative to location, based on where the various stressors and other environmental factors are operating.

Landscape Context was the attribute for which the State's estuarine wetlands scored the highest. Approximately 64% of the total acreage of estuarine wetland would tend to have Landscape Context scores within the top category of possible scores. Two factors drive this result. First, Landscape Context scores tend to increase with wetland size and decrease with percent developed lands adjacent to wetlands. Because SF Estuary has the largest remaining estuarine wetlands and most of the wetland acreage, the statewide Landscape Context score reflects conditions in the SF Estuary. Second, 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). This phenomenon is expected to have occurred not only for the SF Estuary, but also in the other regions, including southern California – a region known for fragmentation of its estuarine wetland and highly developed surroundings.

Hydrology is the critical factor affecting the physical structure and vegetation in all wetlands (Mitsch and Gosselink 2000). The CRAM Hydrology attribute is composed of measures relating to freshwater water source, hydrologic connectivity and hydroperiod. The CRAM Biotic Structure attribute is composed of measures of plant community composition, vertical structure and horizontal zonation and interspersion. Statewide, 35 to 36% of estuarine marsh acreage had scores for Hydrology and Biological Structure within the top category of possible CRAM scores, another a reflection of conditions in the SF Estuary. A positive correlation is evident between Biotic Structure scores and estuarine wetland size. This reflects the well-established relationship between habitat area and species richness (Rosenzweig 1995). The SF Estuary, which has the largest estuarine wetlands, also had the highest Biotic Structure scores. Regions that are more fragmented (by roads, railroads, levees, and developed areas) and muted from the tides typically have lower species richness (Noss and Csuti 1994). This helps to explain the lower Biotic Structure scores for Central Coast and South Coast.

Physical Structure was the attribute for which the State's estuarine marshes scored the lowest. About 62% of the acreage tends to be in the bottom 50% of possible scores for this attribute. The Physical Structure attribute is composed of measures of topographic complexity and the number of physical patch types (e.g., pannes, pools, channels etc.). The richness of physical, structural surfaces and features in a wetland reflects the diversity of physical processes, such as energy dissipation, water storage, and sediment transport, which strongly affect the potential ecological complexity of the wetland (Maddock 1999). The expectation is that immature and invaded wetlands tend to have low scores for Physical Structure because they are not fully developed or the invasions are homogenizing conditions by creating more uniform rates of sedimentation. Anthropogenic modifications to the tidal and freshwater hydrology, sediment transport, and geomorphology of the marsh through watershed urbanization, dredging, dikes and levees, mosquito ditching, tide gates, etc. result in reduced integrity of marsh physical structure (Day *et al*. 1989). These reasons help explain the low scores for Physical Structure for all region except North Coast, where the score were high. Given that the North Coast estuarine wetlands are subject to excessive sediment supplies due to logging in their watersheds, and given the extensive invasion of these wetlands by *Spartina densiflora,* the high scores for Physical Structure might seem anomalous. However, *S. densiflora* grows in large clumps that create prominent sediment mounds, and tends not tend to form uniform meadows. Many North Coast estuarine wetlands are subject to riverine flooding and wind-wave action that apparently deposit sediment extensively in channels as well as in the fringing marshes themselves. It appears that a combination of flood-related sedimentation and colonization by *S. densiflora* has affected both the Physical Structure attribute and the Biotic Condition attribute in North Coast estuarine marshes.

Not surprisingly, dikes/levees was the most frequent and most severe stressor identified statewide. 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, etc (Zedler and Callaway 2000, Fell *et al*. 1991, E. Fetscher, unpublished data). Presence of culverts and other flow obstructions compound the negative effect of levees; South Coast sites with this stressor had on average 15 point lower CRAM scores than sites where this stressor was absent. 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. In this case, the results are not area-weighted and thus are not skewed by conditions in the SF Estuary.

CRAM index and attribute scores showed a general decrease from north to south. This difference was most pronounced for Hydrology and Physical Structure attributes (25- to 30-point difference between North and South Coast) and least different for the Landscape Context attribute (less than a 10 point difference). These patterns are suggestive of an overall north-south gradient in condition relating to urbanization along the coastline. Previous studies have found negative correlations between coastal urbanization and various ecological parameters (Brown and Vivas 2005, Mack 2006, Sutula *et al*. 2008). For estuarine wetlands, urbanization is a complex mix of factors and processes that affect wetland shape, size, abundance, and structure. It usually represents the latest and most intensive phase in a complex history of land use development, which typically begins with relatively low intensity indigenous management, transitions through a series of increasingly intensive agricultural uses to suburban development, and culminates in industrial and/or dense residential development, perhaps with the addition of wetland restoration projects. Each phase tends to leave a mark on the estuarine landscape, and most of these marks are levees, dikes and drainage ditches that carve the landscape into remnant patches of historical estuarine habitats. At the same time, natural sedimentary processes develop new intertidal flats and wetlands, usually along the margins of altered or artificial shorelines. While the general negative correlation between estuarine wetland condition and intensity of adjacent land use is clear, the corrective measures will vary with the particulars of local land use history and practice.

Natural Variability and the Need for Regional Reference Networks

The four categories of CRAM scores developed for this survey 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 (Collins *et al*. 2007, Sutula *et al*. 2006). The data obtained in the field studies indicate that CRAM captured a variety of important regional differences among perennial saline estuarine wetlands in California.

These differences must be interpreted carefully however, as gradients in geomorphology, hydrology, and ecology among estuarine embayments, river mouths, and coastal lagoons will control to some extent the “best attainable” condition. Several examples exist that are relevant for the interpretation of CRAM. First, Physical Structure scores could be expected to be somewhat lower in coastal lagoons with restricted tidal inlets relative to SF Estuary, an embayment with a large tidal prism. Second, North Coast estuarine wetlands apparently tend to have fewer co-dominant plant species than estuarine wetlands of other regions (Grewell *et al*. 2008). Because CRAM assumes that greater diversity of co-dominant plants represents greater potential to provide more services or higher levels of service, the less diverse wetlands of North Coast tend to result in lower scores for Biotic Structure (the attribute scores for North Coast wetlands are also reduced by the lower architectural complexity of the native vegetation and the dominance in many locations by an invasive species). This result is an indication that North Coast wetlands achieve lower scores than estuarine wetlands that have higher intrinsic species richness. This is a measured result that demonstrates a regional difference, and it indicates that North Coast estuarine wetlands should be compared with estuarine wetlands in other regions with this difference clearly understood. Similar considerations are relevant for other inter-regional comparisons.

In order to address these questions of natural variability, there is a critical need to establish regional networks of reference sites that illustrate the full range of conditions for each CRAM metric, including the best attainable condition (Brinson and Rheinhart 1996). This regional survey provides important opportunities for selecting sites to comprise the reference networks. The CRAM methodology provides a single internal statewide standard with which to assess all sites, but differences between regions must be interpreted with an awareness of the existing natural variability among regions. The internal CRAM standard should continue to be evaluated in the light of this first-time statewide ambient survey in order to assure that the methodology appropriately identifies the “best attainable condition” for estuarine wetlands in the State of California as a whole, without respect to region.

Comparison of Projects versus Ambient Condition

Project assessment results reported in this survey are intended to demonstrate how the condition of estuarine wetland “projects” can be assessed within the context of regional or statewide ambient survey of wetland condition. For this survey, a project is defined as “any activity that can result a change in the extent or condition of a wetland.” Thus a project will include impact sites from development activities, mitigation sites resulting from compensatory mitigation or non-regulatory wetland creation, restoration or enhancement.

As envisioned, project assessment would occur prior to impact or restoration, then repeated as the project matures and 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. As no pre-project CRAM assessment were available for this study, only completed projects were assessed. For the purpose of this study, a project is completed when all construction plans and designs have been implemented. Projects were not selected based on their size or age. This means that projects varied in size and some were older and more ecologically mature than others. Additional analyses involving careful control on project age, landscape position, and pre- and post-construction condition are required to better assess the differences between projects and ambient sites (Kentula 1992). As explained in the methods section, the projects were not selected probabilistically and thus are not statistically representative of the population of estuarine wetland projects in any region or statewide.

The CRAM Index and Attribute scores of restoration projects tended to be 5 - 20% lower than ambient scores for their region, with the gap most pronounced for South Coast. Landscape Context scores and hydrology scores in projects were 15 - 18% lower than ambient scores in all regions. Projects tended to be smaller and more completely embedded in urbanized landscapes than ambient sites, and thus could be expected to have lower Buffer and Landscape Context scores. The project sites also had more urbanized water sources resulting in most sites scoring in Category 3 for water source, where most ambient sites scored in Category 2 for this metric. Because of the probability-based ambient survey design, ambient sites tended to be in larger wetland patches, and this would also tend to elevate their Landscape Context scores relative to projects.

Biotic Structure scores were 6 - 13% higher for ambient sites than project sites in all regions. These differences probably relate to differences in age; most ambient sites are probably older with more developed plant communities. Projects in the SF Estuary Central Coast had higher Physical Structure scores than ambient sites. In the more completely urbanized South Coast, Physical Structure scores did not differ between projects and ambient sites. Differences can be attributed to a number of factors: size of project versus ambient wetland patches, landscape context, project age and maturation. True differences are difficult to tease out without control on these confounding factors.

Figure 6-13 illustrates how CRAM could be used to document the improvement in acreage and condition that a restoration project provides. 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 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 adjoining piece of remnant wetland comparable to the pre-project conditions of the project site was conducted. Assuming that the Talbert 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.

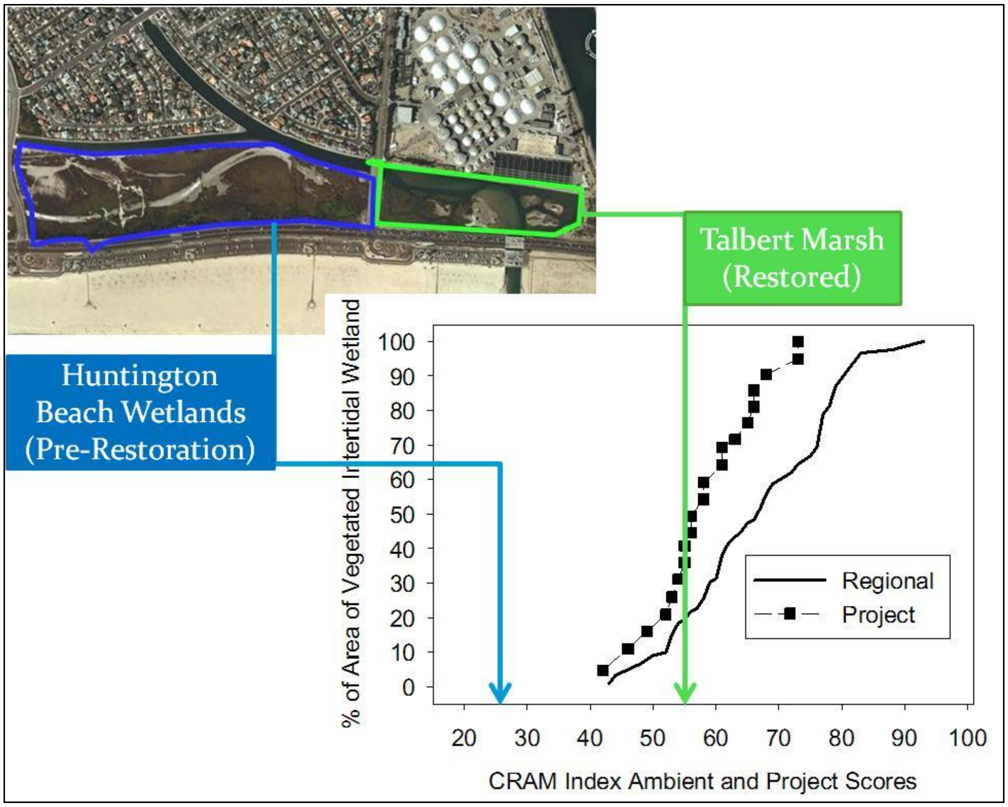


Figure 6-13. Improved condition of an estuarine wetland due to restoration of full tidal action. The pre-project CRAM index score for Talbert Marsh Restoration Project is presented by the score for the Huntington Beach Wetlands because both sites were historically part of the same larger estuarine wetland.

One important purpose of wetland monitoring and assessment is to evaluate the effects of wetland policies, programs, and projects on the ambient condition of wetlands (NAS 2001). 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 and report on the effectiveness of public investment in restoration. In addition, these data would lend themselves to the development of performance curves for restoration sites that would help to scale expectations for restoration or mitigation efforts. The expectations could be calibrated for wetland size and shape, landscape position, surrounding land uses, hydrology, and the age of the project.

Suggested Management Actions

Within each region, CRAM scores and the stressor checklist suggest possible management actions to increase the overall condition of some wetlands. Table 6-14 summarizes the percentage of estuarine wetland acreage within each region that tends to score within the two lowest categories of condition, the severe stressors associated with these areas, and possible management actions to reduce or ameliorate these stressors. The assumption is that the observed stressors cause the observed conditions. Before any management actions are taken, the effects of the possible causes should be more thoroughly investigated. It is important to note that relatively high average scores for a region do not signify that the management issues of its estuarine wetlands do not warrant attention.

Conditions in North Coast estuarine wetlands will be improved by controlling sediment and removing limitations on hydrology, as described below. Improving biotic conditions in the North Coast region requires a specific focus on controlling the invasive cordgrass *S. densiflora*. This species was introduced regionally through shipping operations approximately 150 years ago. Its current dominance clearly indicates that North Coast wetlands are unlikely to attain higher conditions of species richness or biological structure unless the dominance by this exotic species is addressed. This is particularly important in the North Coast owing to a strong regional interest in restoring or enhancing estuarine wetlands for fishery habitat purposes.

While numerous historic and current land use impacts have led to reduced condition of Central and South Coast wetlands, three main management actions have been identified to enhance region-wide estuarine condition. As indicated earlier, historical levees and dikes that have modified tidal circulation have caused a general decline in estuarine wetland condition. They are the one overriding cause of declining condition that is common to all regions. Unfortunately, they are among the most common features in the present day estuarine landscape. They began to appear with the earliest stages of agricultural development following European contact, and have tended to get larger, more numerous, and more intrusive as development has advanced. 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 is required. Many of these crossings will need to be modified to accommodate rising sea levels and increased wave run-up; improved tidal exchange between estuarine wetlands and their estuaries should be a design criterion, balanced with the cost of infrastructure improvements required for such projects.

Numerous stressors affecting the condition of saline estuarine wetlands originate in their watersheds or adjoining uplands. These include 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 altered the salinity regimes of many estuarine wetlands. In some estuaries, erosion control or impoundment of sediment behind dams has significantly reduced the supplies needed to sustain estuarine wetlands. Conversion of floodplains to agriculture and other development has reduced their abilities to filter runoff and buffer estuaries from upstream contaminants. Better management of urban and agriculture runoff through integration of Best Management Practices within and downstream of these land uses is necessary and has been documented to reduce contaminant inputs to these systems, reduce toxicity of water and sediments and to improve flood control. Expansion of restoration efforts within the upstream reaches of estuaries will greatly reduce the stresses on downstream reaches. At the landscape scale, estuaries should be regarded as downstream extension of their watersheds. Improving the overall condition of estuaries and their wetlands will ultimately require changes in watershed management to 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.

Table 6-14. Summary of CRAM attribute results, severe stressors identified, and recommended management action.

Region	% marsh area with CRAM Index or attribute scores within the lower two categories of CRAM scores					Major stressors identified	Recommended Management Actions
	Index	LC	Hydro	PS	BS		
North Coast	0	3	0	17	24	Invasive plants, dikes and levees, excessive sedimentation, ditching	1. Remove invasive plant species from estuarine wetlands regionally, and include measures to control re-invasion in restoration and enhancement projects. Reestablish or reintroduce native species. 2. Use BMPs, where feasible, to reduce sedimentation from upland land uses in wetland watersheds. 3. Assure adequate tidal circulation in estuarine restoration or enhancement projects through levee removal or setback, tidegate removal, and tidal circulation improvement. 4. Develop mosquito management approaches that are consistent with reduced hydrological impacts to wetlands.
SF Estuary	0	3	14	64	10	Levees, predators, ditching heavy metal and organic contaminants	1. Remove invasive plant species from estuarine wetlands regionally, and include measures to control re-invasion in restoration and enhancement projects. Re-establish or reintroduce native species. 2. Increase the size of estuarine wetlands to reduce the effects of terrestrial predators and other stressors. 3. Improve tidal circulation to minimize the need for ditching. 4. Assess the opportunity to integrate estuarine wetland restoration and enhancement to infrastructure repair and replacement 5. Link estuarine wetland restoration to upstream management of sediment and water quality by integrating estuarine wetland management to watershed management
Central Coast	17	5	20	64	57	NPS runoff, contaminants, dikes/levees and trash	1. Restore aquatic transitions (creeks, drainage swales and brackish systems) to increase filtration of water prior to discharge into estuaries. 2. Expand use of agriculture and urban BMPs within watersheds. 3. Remove or redesign flow restrictions to establish more stable marsh plain and/or replicate historical estuarine tidal exchange. 4. Implement enhancement projects through levee removal, setback, tidegate removal/redesign, and tidal circulation management to allow for expansion of marsh plain.
South Coast	42	11	49	71	25	Dikes/levees, NPS runoff, contaminants, trash, excessive sediment	1. Assure adequate tidal circulation in estuarine restoration or enhancement projects through levee removal or setback, tidegate removal, and tidal circulation improvement. 2. Expand use of agriculture and urban BMPs within watersheds 3. Restore aquatic transitions (creeks, drainage swales and brackish systems) to increase filtration of water prior to discharge into estuaries. 4. Remove invasive plants from upland transitions zones and buffer. 5. Incorporate historical ecology to guide restoration planning, particularly with respect to the distribution of subhabitat types.

Summary Findings and Recommendations

CWA Section 305(b) requires each state submit biennial reports describing the health of its surface water, including wetlands, to the USEPA. This document reports on the health of California's perennial, saline estuarine wetlands.

Estuaries are partially enclosed bodies of water along the coast where freshwater runoff meets and mixes with salt water from the ocean. Based on the draft definition of wetlands for California, an estuarine wetland is an area within an estuary that is exposed at low tide and covered with rooted vegetation.

The health of the state's estuarine wetlands is estimated from a statewide survey of the distribution, abundance, and ambient condition of estuarine wetlands. The survey had three components: 1) landscape profile; 2) probability-based assessment of ambient condition; and 3) assessment of selected estuarine wetland restoration and mitigation projects. The results help answer four fundamental management questions: 1) where *are* the State's estuarine wetlands and how abundant are they; 2) what is the ambient condition of estuarine wetlands statewide and how does their condition vary by region; 3) what are the major stressors and how do they vary among coastal regions; and 4) what is the condition of permitted restoration projects relative to ambient condition. This fourth question demonstrates how data could be used to evaluate policies and programs affecting the distribution, abundance, and condition of estuarine wetlands.

The landscape profile described the distribution and abundance of the State's estuarine wetlands relative to other estuarine habitats and explored the underlying causes through a detailed examination of trends in the SF Estuary. A probability-based survey was used to assess the ambient condition of saline, perennial estuarine wetlands. The statewide ambient survey involved 120 sites allocated equally among four regions: North Coast, SF Estuary, Central Coast, and South Coast. An additional 30 sites were allocated to South Coast to test for a difference between large and small estuaries. The field survey was conducted in the Fall of 2007. The statewide ambient survey in turn served as a regional frame of reference for project assessments.

Both the ambient survey and the project assessments utilized CRAM (Version 5.0.2). CRAM is a field-based method to assess wetland condition based on visible indicators of four wetland attributes: Landscape Context, Hydrology, Physical Structure, and Biological Structure. Results were reported as the percent of the total area of estuarine wetland in California likely to fall within four categories equally-spaced categories of possible CRAM index or attribute scores, which range from 25-100: Scores greater than 82 = Category 1; scores between 63 and 82 = Category 2; scores between 44 and 63 = Category 3; and scores less than 44 = Category 4.

Landscape Profile

Approximately 91% of the historical amount acreage of California wetlands has been lost due to reclamation and land use. Accurate estimates of estuarine wetland loss in particular are only available for the SF Estuary. In spite of losing approximately 85% of its saline wetlands and almost 92% of its freshwater tidal wetlands, the SF Estuary has almost 44,500 acres of estuarine wetlands at this time, about 77% of all the estuarine wetlands in the state. Although land use varies among the estuaries of California, it has affected the distribution, abundance, size, and shape of estuarine wetlands in consistently deleterious ways. It has decreased the amount of estuarine wetland and increased the number of small wetlands, thus increasing the distance between wetlands. In the more urbanized estuaries of the South Coast, Central Coast, and SF Estuary, many wetlands are embedded in intensive land uses and bounded by levees. These conditions diminish the hydrological and ecological connectivity among the wetlands, increase their susceptibility to invasion and local catastrophic events, and reduce their overall capacity to serve society.

Ambient Survey

An estimated 85% of the State's saline estuarine wetland scored within the top 50% of possible CRAM index scores. The statewide results are strongly influenced by the SF Estuary, which has most of the saline estuarine wetland. Landscape Context was the attribute for which the State's estuarine wetlands scored the highest. The CRAM Landscape Context consists of indicators of aquatic connectivity and natural buffer size and condition. With regard to Landscape Context, an estimated 64% of the total acreage of estuarine wetland was in the top category of CRAM scores. This is a reflection of the relatively large size of SF Estuary wetlands and their more rural context.

With regard to Hydrology and Biological Structure, an estimated 35% of the State's estuarine wetland acreage scored within the top category of CRAM scores. The CRAM Hydrology attribute is about freshwater source, hydrologic connectivity, and hydroperiod, while the Biological Structure attribute is about plant community composition, vertical vegetation structure, and horizontal zonation and interspersion of plant species or assemblages. Urbanized estuaries tend to have smaller wetlands with lower Hydrology and Biotic Structure health scores.

The State's estuarine wetlands scored lowest for the Physical Structure attribute, which is about the topographic complexity of a wetland and its diversity of physical patch types (e.g., pannes, pools, channels etc.). For this attribute, an estimated 62% of the acreage scored in the lower 50% of possible CRAM scores. Non-natural tidal and freshwater hydrology and excessive sediment supplies have reduced the physical complexity of wetlands in South and Central Coasts and SF Estuary The presence of dikes, levees, and other water control structures that restrict tidal exchange is significantly correlated to poor wetland health.

CRAM index and attribute scores showed a general decrease from north to south. This difference was most pronounced for Hydrology and Physical Structure (25-30 point difference from North to South Coast) and least pronounced for Landscape Context (difference < 10 point). This north-south gradient in condition tracks a similar gradient in density or extent of urbanization. While the general negative correlation between wetland condition and adjacent land use is clear, the corrective measures will vary with the particulars of local land use history and practice. Regional differences must be interpreted carefully because of inherent natural variability.

Project Assessments

Project assessments demonstrate how the condition of estuarine wetland projects can be assessed by comparing them to the ambient condition of comparable wetlands. The assessed projects include impact sites from development activities, mitigation sites resulting from compensatory mitigation, and non-regulatory wetland creation, restoration or enhancement sites. The project health scores tended to be 5 - 20% lower than the ambient scores for their regions, with the difference most pronounced for South Coast. The low scores for projects could be attributed to various factors: projects tend to be smaller, younger (less developed), and more closely associated with developed landscapes.

Suggested Management Actions and Other Recommendations

Within each region, CRAM scores and the stressor checklist suggest possible management actions to improve wetland health. The stressors affecting the condition of estuarine wetlands originate in their watersheds or adjoining uplands. In urbanized areas, decreases in water supplies due to upstream withdrawals or increases due to urban runoff have altered estuarine salinity regimes. In some estuaries, erosion control or impoundment of sediment has significantly reduced the amount needed to sustain estuarine wetlands. In others areas, such as the North Coast, timber harvesting activities upstream have led to excessive sedimentation. In all regions, conversion of floodplains to developed land use has reduced their abilities to filter runoff and buffer estuaries from upstream contaminants. Better management of urban and agriculture runoff through integration of Best Management Practices is necessary to reduce contaminant inputs to these systems, reduce toxicity of water and sediments and to improve flood control. Expansion of restoration within the upstream reaches of estuaries will reduce the stresses downstream.

Improving biological conditions in the North Coast region requires controlling the invasive cordgrass *S. densiflora*. Its intermediate dominance in many wetlands increases their structural complexity, but this will probably decrease as the dominance increases. Many North Coast estuarine wetlands are unlikely to attain higher conditions of species richness or biological structure unless this invasion is controlled.

Historical levees and dikes modify tidal circulation and thereby cause a general decline in estuarine wetland condition. 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 is required so that they no longer impede tidal circulation. Many of these crossings will need to be modified to accommodate rising sea levels and increased wave run-up; improved tidal exchange between estuarine wetlands and their estuaries should be linked to infrastructure repair and replacement as a design criterion.

Estuarine wetlands should be regarded as downstream extensions of local watersheds. Improving the overall condition of estuarine wetlands will ultimately require changes in watershed management to 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 rise.

One of the objectives of this assessment was to establish a baseline against which future landscape profiles could be compared. However, a comprehensive base map of one vintage and adequate precision and accuracy to meet local and state needs has proven to be very difficult to develop once, and is likely to be more difficult to replicate. For this reason, it is recommended that the state adopt the sampling approach used by the NWI Status and Trends (ST) assessments. For the national assessment being planned for 2011, 40-60 ST plots have been allocated to California estuarine habitat. This is likely to be an inadequate sample size to re-assess the distribution and abundance of estuarine wetlands within the State of California. The state should consider intensifying the proposed survey with additional ST plots. The existing comprehensive base map of estuarine wetlands produced for this report could be used to calculate the relationship between sample size and accuracy of the profile, as needed to identify the optimal number of ST plots.

Networks of reference sites that illustrate the full range of conditions for each CRAM attribute and metric should be established for each region of the state. Such networks are essential for refining CRAM, establishing quality assurance standards, and training CRAM users.

7. DEMONSTRATION OF THE WETLAND TOOLKIT FOR WATERSHED ASSESSMENT

Introduction

Watersheds are becoming popular as spatial templates for wetland protection (ASWM 2002) and for land use planning in general (Sate of California 2002, 2003). California has created an inter-agency Watershed Program (California Resources Agency 2008b) and has sponsored various efforts to develop scientific approaches to watershed assessment (e.g., Shilling *et al*. 2005). Many local communities and agencies are using watersheds as a framework for organizing environmental information (e.g., Orange County Public Works 2008, MCCDA 2004, Napa WICC 2005), and some local agencies are moving forward with independent watershed assessments (e.g., Contra Costa County Watershed Forum 2008). The federal government has a long-standing interest in watershed planning and assessment, especially for safe water supplies (USEPA 1996). The revised CWA rules governing mitigation for unavoidable aquatic resource losses call for mitigation planning at the watershed scale (USACE 2008).

The assessment of watershed condition is typically covers environmental, economic, and social aspects (California Resources Agency 2008b). Given that wetlands can significantly benefit water supplies and aquatic resources, and that the condition of these resources affects the quantity and quality of all life, surveys of wetland condition are important components of watershed assessments. The Level 1-2-3 assessment framework provides an organizing template for aquatic resource assessment. Wetland assessment, through use of the toolkit, can be seamlessly integrated into the evaluation of all aquatic habitats within and among watersheds.

The purpose of this section is to demonstrate how the wetland toolkit can be applied within a watershed context to develop landscape profiles of wetland condition assess the ambient condition of wetlands at the watershed scale, and to assess the performance of wetland projects relative to ambient condition. The examples provided here focus on riverine wetlands and their associated riparian areas (hereafter referred to riverine-riparian habitats). Detailed reports summarizing the results of the assessment of the State's estuarine wetlands and riverine-riparian habitat in three demonstration watersheds are available separately in Appendix 1 (Sutula *et al*. 2008, Solek *et al*. in press, O'Conner *et al*. in press).

Methods

To demonstrate the toolkit at the watershed scale, three watersheds were chosen representing South Coast, Central Coast, and the SF Bay area (Figure 7-1; the North Coast was not included in this portion of the overall study). Demonstration of the toolkit for assessment of riverine-riparian habitat within these watersheds consisted of, at minimum:

- Inventory of wetlands;
- Assessment of ambient condition of riverine wetlands and associated riparian habitat, using CRAM for wetlands (Collins *et al*. 2007); and
- Assessment of planned or completed restoration projects.

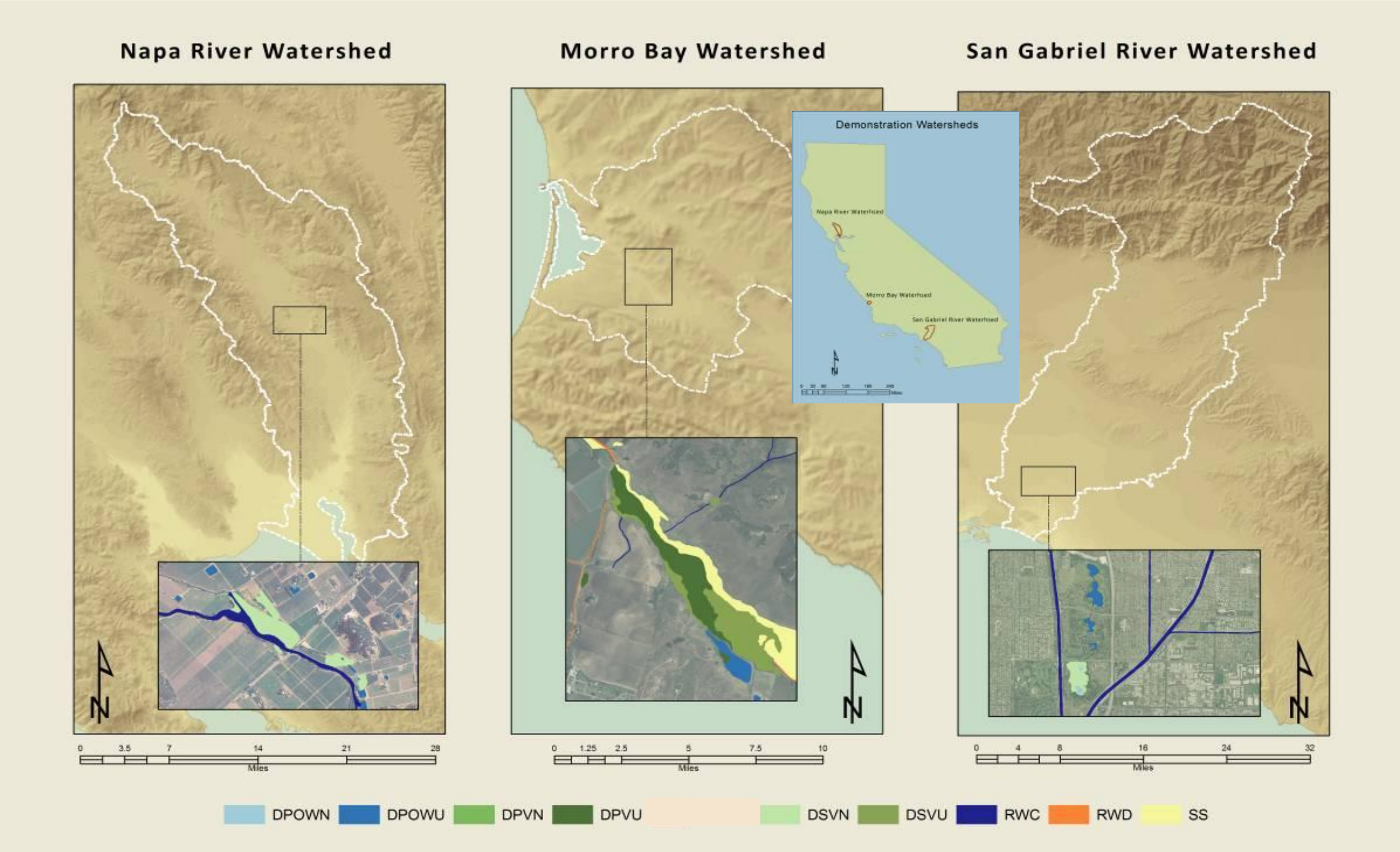


Figure 7-1. Locations of three Demonstration Watersheds showing detail of Level 1 wetland inventory. Legend key: DPOWN/U = Depressional Perennial Open Water Natural or Unnatural; DPVN/U = Depressional Perennial Vegetated Natural or Unnatural; DSVN/U = Depressional Seasonal Vegetated Natural or Unnatural, RWC = Riverine Wetland Channel, RWD – Riverine Wetland Ditch, SS = Seasonal Slope.

A complete reporting of assessment data for each of the three demonstration watersheds is beyond the scope of this section; instead, examples are used to illustrate demonstrate key concepts of toolkit implementation. Each demonstration watershed had a different baseline of existing information upon which to build a picture of ambient wetland condition. The Napa River Watershed had high-resolution NHD, riparian maps (Collins *et al*. 2007) and detailed maps of conditions pre-dating local Euro-American contact (Grossinger *et al*. 2008). Morro Bay Watershed had many completed restoration projects from which to draw representative examples for assessment (O'Conner *et al*. 2008). The San Gabriel Watershed had intensive (Level 3) measures of water quality, toxicity, and benthic macroinvertebrate community structure (Solek *et al*. in press, Stein and Bernstein 2008) in addition to maps of historical conditions (Stein *et al* 2007). By combining the watershed-specific data with the results of the ambient surveys and projects assessments, a more complete demonstration of the wetland assessment toolkit at the watershed scale was synthesized.

The sample frame for the ambient survey consisted of the natural and artificial channels comprising the National Hydrographic Dataset (NHD). NHD varies in detail depending on its resolution (USGS 2000). High-resolution NHD (1:24,000 scale) was available for the Morro Bay Watershed (Central Coast) and San Gabriel River Watershed (South Coast). For the Napa River Watershed (Bay Area), a draft version of the more resolute local NHD was developed as part of the demonstration project (Figure 7-2). The protocol for developing the local NHD is posted in the protocol section at www.wrmp.org. Using the Generalized Random Tessellation Stratified Design (Stevens and Olsen 2000, 2004), thirty sites were probabilistically selected from each watershed sample frame.

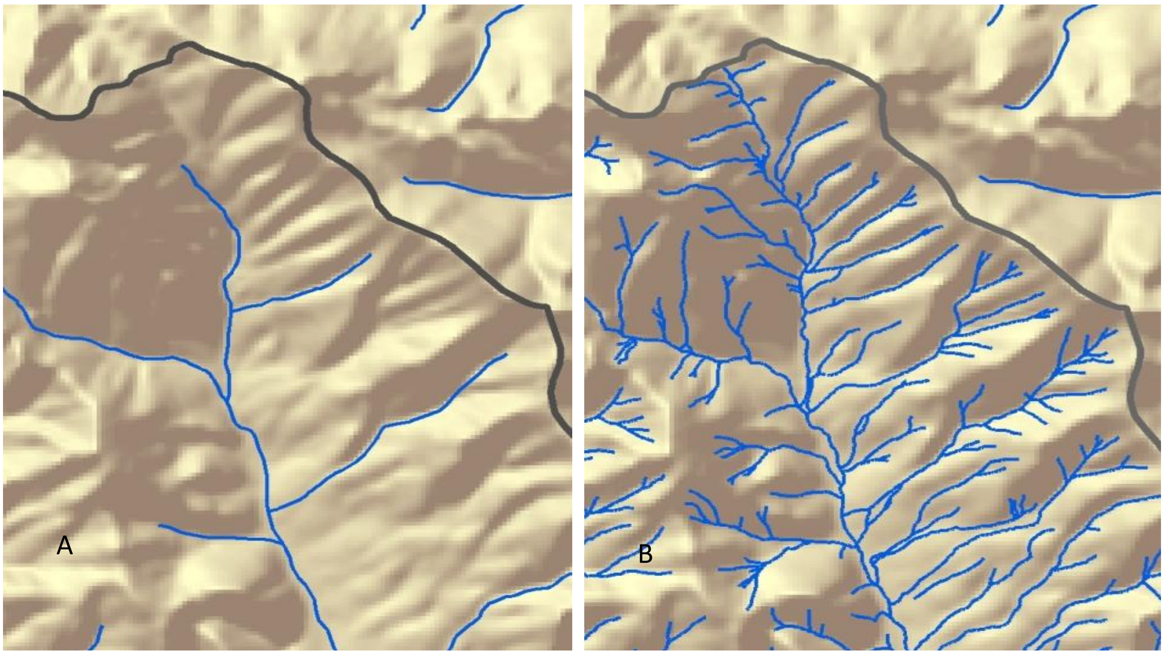


Figure 7-2. Comparison of (A) high-resolution NHD (1:24,000 scale) and (B) local resolution NHD for a small headwater area of the Napa River Watershed.

CRAM was utilized as the principle tool for assessing the ambient condition of riverine-riparian habitats and the status of riverine-riparian projects. CRAM provides an integrated assessment of conditions within a stream and within its adjacent riparian area (Figure 7-3). The method separates condition into four attributes with multiple metrics (Table 7-1). Each metric has a standardized set of mutually exclusive descriptions representing a full range of possible condition for the kind of wetland being assessed. Each description has a numerical value representing its potential along a condition gradient. Choosing the best-fit description for each metric generates a score for each attribute. The attribute scores can be averaged as an overall index score. Attribute and index scores are expressed as percent possible, ranging from 25 (lowest possible) to a maximum of 100. CRAM also provides a stressor check list to help explain the assessments and to identify possible management actions to improve condition. Stressors are represented as categorical scores ranging from “0”, indicating no stressor was present; “1”, indicating that the stressor is present but unlikely to cause significant impact; and “2”, indicating that the stressor is present and likely to cause a significant impact.

Table 7-1. Schematic of CRAM attributes and metrics. The four attributes sum to an overall CRAM index score.

Attribute	Metric
Buffer and Landscape Context	Landscape Connectivity
	Buffer
	Percent of AA with Buffer
	Average Buffer Width
	Buffer Condition
Hydrology	Water Source
	Hydroperiod
	Hydrologic Connectivity
Physical Structure	Structural Patch Richness
	Topographic Complexity
Biological Structure	Plant Community
	Number of Plant Layers Presents
	Number of Co-dominants
	Percent Invasion
	Horizontal Interspersion and Zonation
	Vertical Biotic Structure

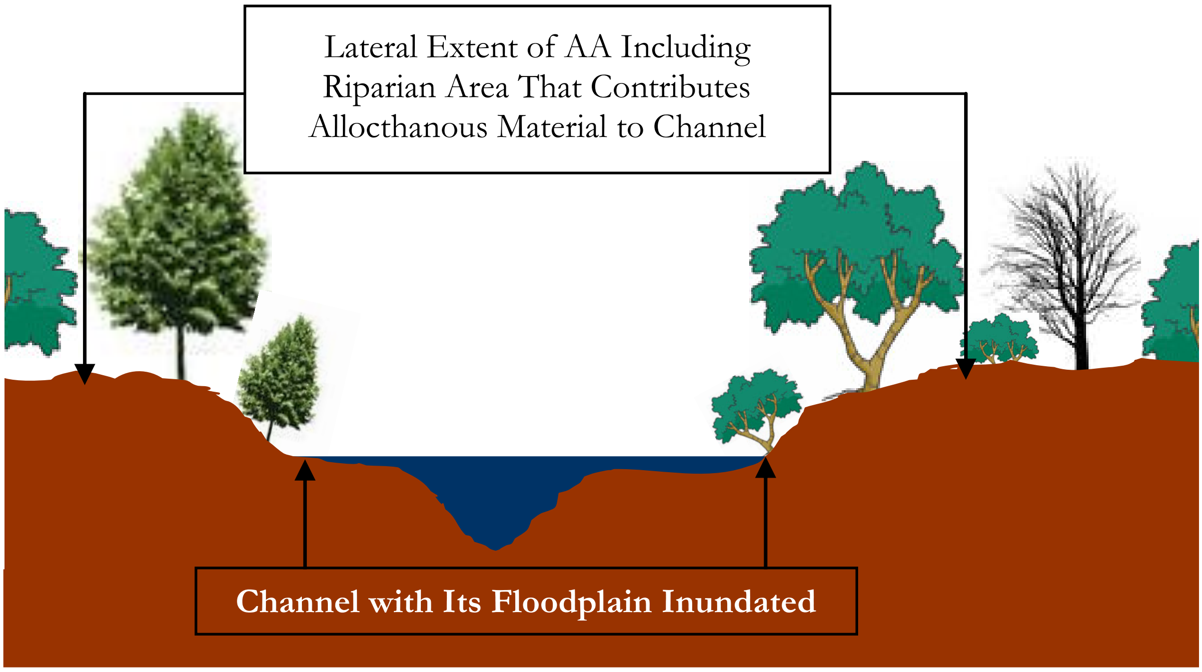


Figure 7-3. Diagram of the lateral extent of a riverine-riparian AA that includes the portion of the riparian area that can help stabilize the channel banks and that can readily provide allochthanous inputs of plant matter, insects, etc. to the active channel.

Analysis of the CRAM survey data relied on a probability-based statistical approach to produce unbiased estimates of condition for each watershed. The approach begins with a map of the drainage network that can serve as the sample frame, which represents all possible assessment sites. The approach takes into account the number of sites selected by the design along a given length of the drainage network, as well as the total length of riverine-riparian habitat that the network represents, to generate length-weighted estimates of condition. These can be translated into cumulative frequency distributions, which allow visualization of the expected percent of each network likely to have any particular CRAM score.

Since CRAM has an internal reference standard, ambient surveys of the same wetland types for different watersheds based on CRAM can be directly compared. However, the ambient surveys of the three demonstration watersheds were also compared to a coincident statewide probabilistic survey of riverine-riparian habitat conducted by the California Department of Fish and Game through the State's SWAMP. This survey typically employs Level 3 indicators such as the benthic macroinvertebrate index of biotic integrity, water chemistry, and toxicity. In a pilot project, CRAM assessments were conducted side-by-side with the typical Level 3 indicators.

The primary goal for assessing projects in the three watersheds was to demonstrate how to compare projects to ambient condition at the watershed scale. At least five riverine-riparian projects were assessed in each of the three demonstration watersheds. Priority was given to projects for which all construction had been completed. However, most of the projects in the Napa River and San Gabriel River watersheds are either in-progress or still being planned. In the case of planned projects, the assessments represent baseline or pre-project conditions. The intent is to re-assess these projects after they have been completed to document net change in acreage and condition, and how project conditions, as assessed using CRAM, changes over time. Data of these kinds can be used to forecast or predict the rate at which projects will evolve to meet their ecological objectives.

The different demonstration watersheds were initiated at different times during the three-year project, beginning with ambient surveys. CRAM methodology evolved over this same period. Therefore, the ambient surveys in the watersheds involved different versions of CRAM. The San Gabriel River watershed demonstration was conducted earliest and the Morro Bay watershed assessment conducted most recently (Table 7-2). The use of different CRAM versions in different watersheds precluded inter-team calibration among the watershed assessment teams. However, the inter-team calibrations that were conducted in 2005, during validation of the riverine-riparian module of CRAM, indicated that inter-team error rates for CRAM index scores and attribute scores equaled ranged from 9-23 CRAM points (Stein *et al*. 2008). While the repeatability of CRAM has been improved since then, no additional measures of inter-team error have been made. All project assessments for al three watersheds were conducted in 2007 with CFRAM version 5.0.2.

Table 7-2. Dates and version numbers used in the ambient assessments.

Watershed	No. of Samples	Date	CRAM version
Morro Bay	31	2007	v.5.0.2
Napa River	30	2006	v.4.2
San Gabriel	30	2005	v.3.0
Statewide	90	2007-2008	v.5.0.2

For each watershed, the ambient survey was conducted during a single field season as prescribed for CRAM assessments (Collins *et al*. 2006). The statewide ambient survey was conducted during the prescribed seasonal window in 2007 and 2008.

All CRAM data were subject to QAQC procedures according to the QAPP prepared for the WDP and on file with USEPA Region 9. The data were managed through the eCRAM database and can be viewed at the CRAM website (www.cramwetlands.org).

Results and Discussion

Analysis of Trends in the Landscape Profile of Riverine Riparian Habitat

A Level 1 map of wetlands was produced for each demonstration watershed. However, historical changes in the distribution and abundance of wetlands were profiled only for the Napa River and San Gabriel River watersheds (Figures 7-4, Stein *et al*. 2007, Solek *et al*. 2008). The Napa River watershed is used herein to demonstrate the utility of these kinds of data. The Napa River Watershed has also been used through the WDP and related projects to compare and contrast alternative methods of mapping riparian areas (Collins *et al*. 2007), based on the riparian definition proffered by the National Research Council (NRC 2002). The preferred approach estimates riparian width in relation to expected riparian function, as affected by channel-side plant community structure and topography. This approach provides insights into spatial and temporal changes in likely riparian function as well as the extent of riparian areas. These data are critical for establishing restoration goals for watersheds (Gwin *et al*. 1999).

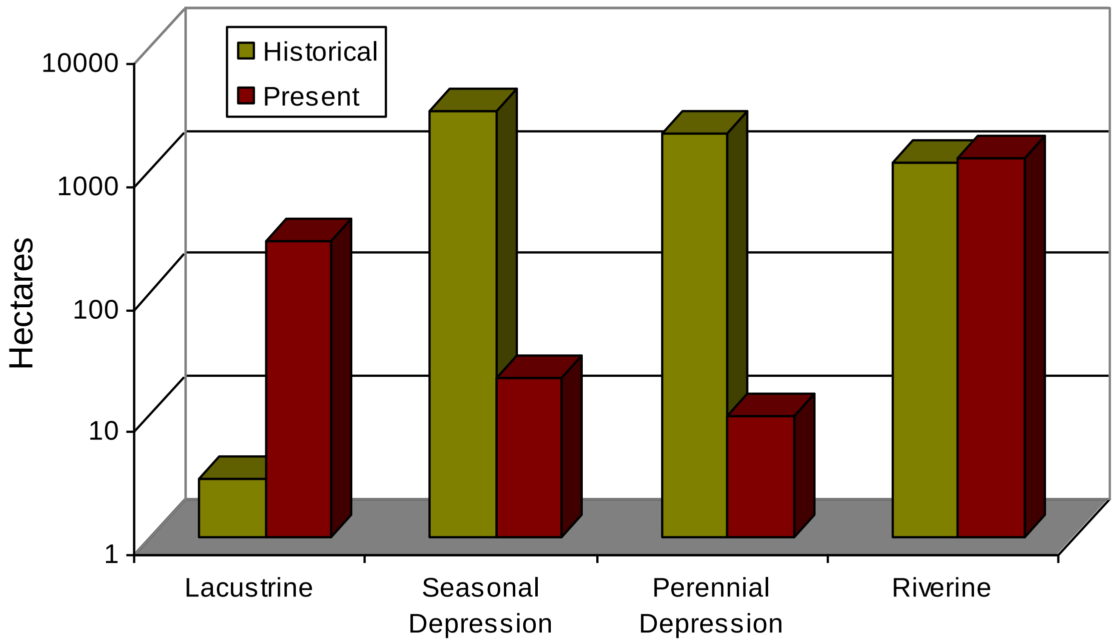


Figure 7-4. Historical and current abundances of selected wetland types in the Napa River watershed, using a local wetland nomenclature.

Historical changes in the abundance of common wetland types within the Napa River watershed reflect two centuries of drainage modification to support agriculture and urbanization. Almost all of the seasonal and perennial depressional wetlands have been drained or filled to make room for urban development, pasture, and vineyards, while the amount of lacustrine wetland has been greatly increased by the construction of large and small reservoirs for flood control, recreation, irrigation, and other consumptive uses (Figure 7-4). More than 2,000 small reservoirs have been built in the Napa River watershed since the mid 19^{th} century to water livestock and irrigate vineyards.

The amount of riverine wetlands has slightly increased in the Napa River watershed due to the addition of irrigation ditches and drainage ditches. This increase in riverine wetlands has been matched by an increase in riparian area (Figure 7-5), as defined by the National Research Council (NRC 2002). However, the amount of riparian area wide enough to support the full complement of riparian functions intrinsic to the Napa River watershed, including terrestrial and riparian wildlife support, has decreased by almost 90%. Some of the wider areas have been narrowed by agriculture and urban encroachment, resulting in an increase in areas of medium width that provide a subset of the full complement of functions. Most of the increase in the total amount of riparian area is due to narrow areas along ditches and around stock ponds that have very limited function.

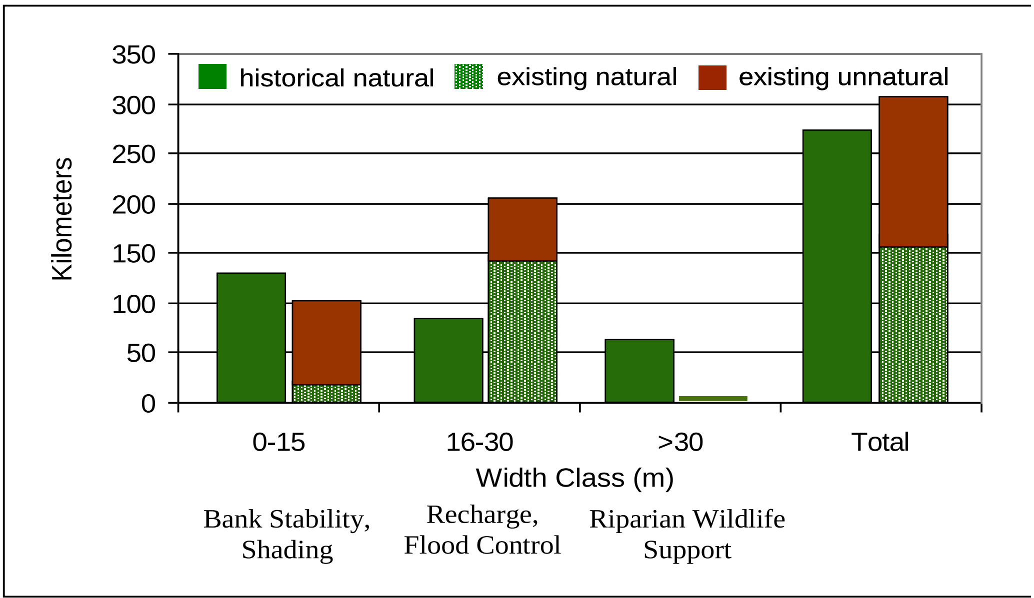


Figure 7-5. Historical change in the abundance of riparian areas of different width classes corresponding to different groups of riparian functions, after Collins *et al*. 2007. The wider riparian areas provide more functions than the narrower areas.

Ambient Condition of Riverine-Riparian Habitats within watersheds and Statewide

The demonstration watersheds can be compared to each other and to the state as a whole based on the ambient surveys of riverine-riparian habitat. The precision of the comparisons is limited because the different surveys used different versions of CRAM. However, most of the differences between the versions pertain to wetland types other than riverine-riparian. Furthermore, the results from these different versions of CRAM are strongly and positively correlated to each other, which suggest that the comparisons based on the different versions are meaningful and not spurious.

The ambient condition of riverine-riparian habitat varied among the three demonstration watersheds. Conditions are generally better in the Morro Bay watershed than they are statewide or in either the San Gabriel River or Napa River watersheds (Figures 7-6 and 7-7). Conditions in the Napa River watershed are generally similar to statewide conditions. Conditions are worst in the San Gabriel River watershed. Average index scores for the Morro Bay and Napa River watersheds fall into the category of medium high scores, whereas the average index score for the San Gabriel River watershed falls into the category of medium low scores (Figure 7-7). No average index scores fall into the category of high scores, although there are a few high scoring sites in each ambient survey. Data of this type illustrate the benefits and cost-effectiveness of utilizing a Level 2 method to capture the gradients in condition within or among watersheds, and place these within the context of statewide ambient condition.

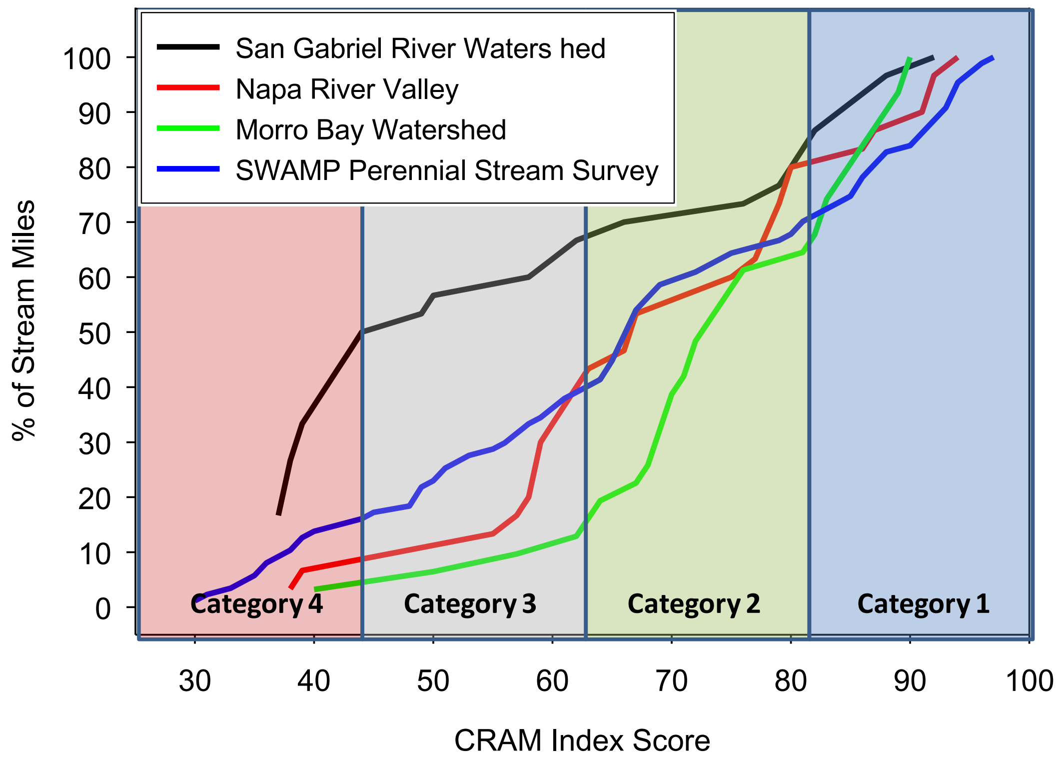


Figure 7-6. Cumulative frequency distribution of riverine-riparian habitat in Morro Bay, Napa River and San Gabriel River watershed relative to statewide condition, based on probabilistic ambient surveys using CRAM. The statewide data were provided through the Perennial Stream Assessment of the State's Surface Water Ambient Monitoring Program (SWAMP).

The CRAM attribute scores suggest plausible causes for the observed differences in ambient condition among the demonstration watersheds. The high index scores for Morro Bay watershed are apparently due to relatively high scores for Buffer and Landscape context, and for Hydrology (Figure 7-7). The Morro Bay watershed scored high for these attributes because it is relatively undeveloped, whereas the Napa River watershed is intensively developed in large part for viticulture, and the San Gabriel River watershed is largely industrial, urban, or suburban. The high scores for Biotic Structure for the Napa River watershed help elevate its index scores over those for the San Gabriel River watershed, but do not compensate for the higher scores for Hydrology and Buffer and landscape Context for the Morro Bay watershed. These relatively high Biotic Structure scores for the Napa River watershed reflect the local history of river and riparian protection through local land use planning that celebrates the Napa River as part of the wine country aesthetic (e.g., USA Today 2007). Index scores for the San Gabriel River watershed are especially depressed by very low scores for Physical Structure and Biotic Structure. This reflects the intensive management of urban streams for flood control and other land use objectives that tend to favor maximum drainage efficiency rather than complex natural conditions.

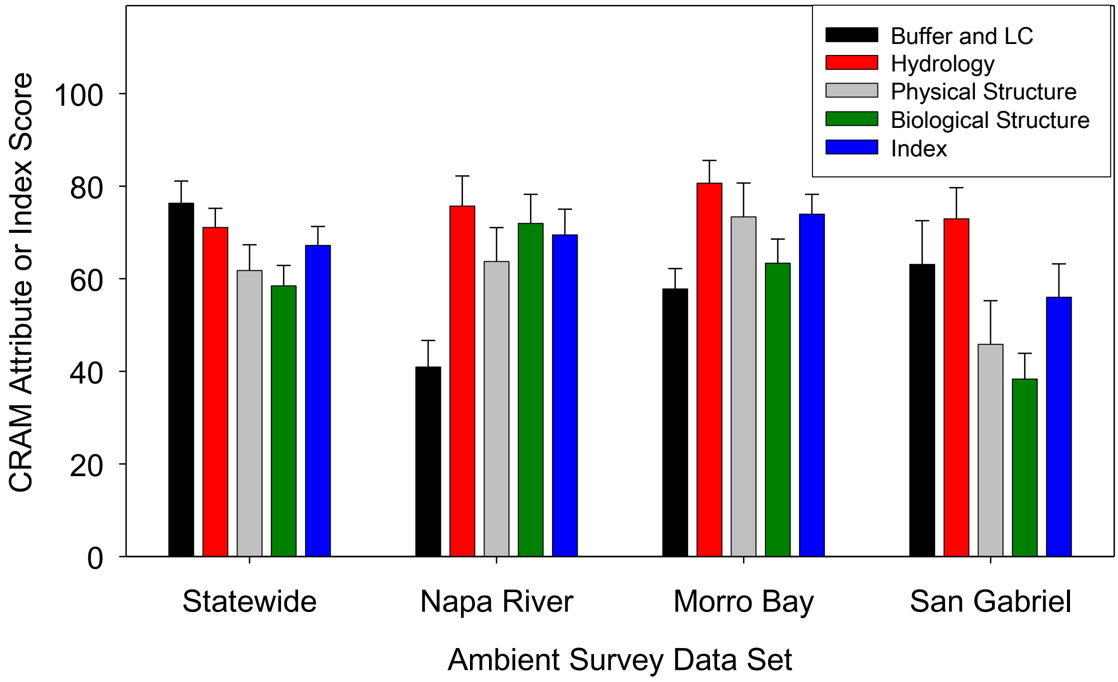


Figure 7-7. CRAM index and attribute scores for the ambient survey of riverine-riparian condition in the three demonstration watersheds. Error bars represent upper 95% confidence intervals.

The Cumulative Frequency Distributions (CFDs) for the Napa Rivera and Morro Bay watersheds cross the statewide CFD near the 65th percentile. Above this percentile, the index scores tend to be higher statewide (Figure 7-6). The average attribute scores do not indicate that any particular attribute accounts for this pattern (Figure 7-7). Case-specific data suggest that, above the 65th percentile for index scorers, the statewide scores for all the attributes tend to be higher than the attribute scores for the demonstration watersheds.

Condition of Watershed Restoration Projects Relative to Ambient Condition

Each watershed demonstration project included the assessment of ten riverine-riparian restoration projects using the same version of CRAM. In Morro Bay watershed, where riverine–riparian restoration has been a serious endeavor for more than a decade, all ten selected projects have been completed, meaning that construction is over and natural processes of habitat development have been re-introduced. Some of the assessed projects in the San Gabriel River and Napa River watersheds are still being constructed. The intent is to re-assess these projects after they are completed to help document their evolution and performance.

Completed projects in the Morro Bay watershed are used here to show how projects can be compared to ambient condition to track restoration progress and to establish project performance curves. By re-assessing projects over time, the rate of project development to meet restoration goals and objectives can be estimated, and these estimates can be used to forecast the rate of develop of future projects. As project data accumulate throughout regions and across the state, they can be used to assess the effect of project design, land use context, and other factors on project performance.

Six of ten projects in the Morro Bay watershed scored above the 50[Th] percentile of the local ambient condition and the statewide ambient condition (Figure 7-8). Two projects scored in category 1, the uppermost 25% of possible index scores. Five projects scored in category 2 (high-medium scores), and three scored in category 3 (low-medium scores). No projects scored in category 4 (the lowermost 25% of possible index scores). The assessed projects undoubtedly differ in their age since completion, although their actual ages are unknown (Figure 7-9). Habitat conditions tend to evolve rapidly after projects are completed. Differences in age among the projects could therefore account for some of their differences in CRAM scores.

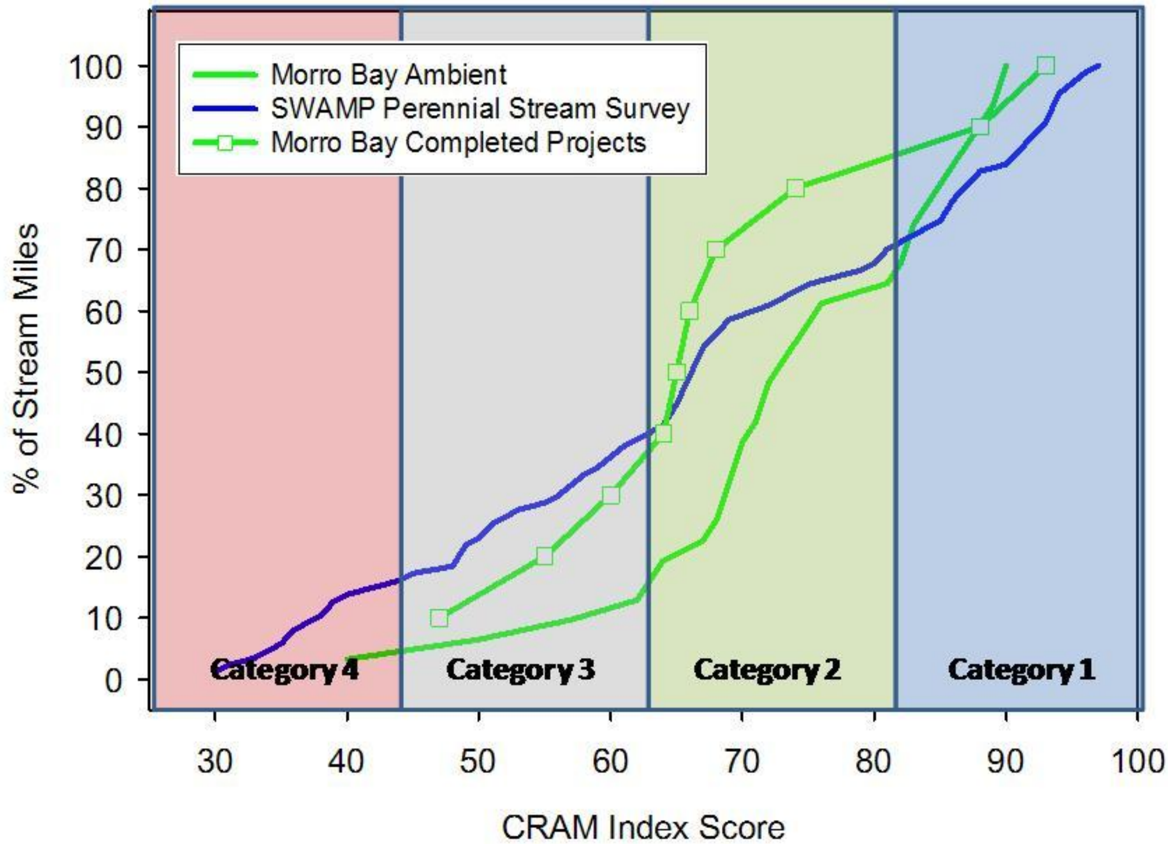


Figure 7-8. Cumulative frequency distribution of CRAM index scores for riverine-riparian projects and ambient riverine-riparian habitat in Morro Bay watershed, relative to statewide ambient condition. The statewide data were provided through the Perennial Stream Assessment of the State's Surface Water Ambient Monitoring Program (SWAMP).

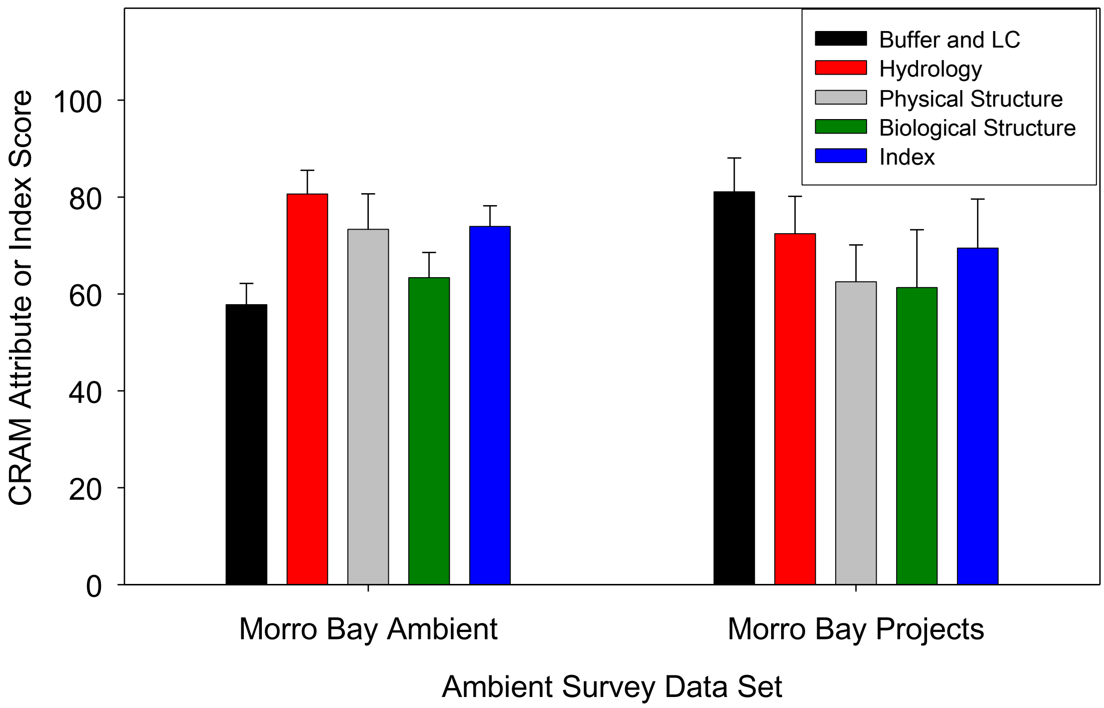


Figure 7-9. Mean CRAM index and attribute scores for Morro Bay Watershed completed restoration projects versus ambient riverine-riparian habitat. Error bars represent upper 95% confidence intervals.

Toward More Comprehensive Watershed Aquatic Resource Assessment Using the 1-2-3 Toolkit

Aquatic resource management depends on a comprehensive understanding of watershed condition. Unfortunately most watershed-based monitoring and assessment is not coordinated and focuses a singular objectives (e.g., regulatory compliance) or specific indicators (e.g., benthic macroinvertebrates). Application of the wetland assessment toolkit and the 1-2-3 Framework at the watershed-scale provides the means to integrate multiple objectives in a coordinated way that leverages funding among a broad range of assessment efforts while concurrently tracking ambient conditions and the performance of wetland projects among disparate programs and policies (Figure 7-10).

Level 1 outputs include base maps and inventories that are fundamental to all assessment efforts, in part because they serve as sample frames for Level 2 and Level 3 assessments, and in part because they serve as base maps for online data portals. Programmatic Level 1 products include updates of state and federal maps and inventories, plus evaluation of no-net-loss policies. Level 1 output, in conjunction with Level 2 and Level 3 results, can provide the information needed for the State to report on the condition of its wetlands pursuant to Section 305b of the Clean Water Act. Monitoring under a variety of state programs, including NPDES, CWA 401 Certification and Waste Discharge Requirements, and the Streambed Alteration (1600) Permits under the State's Fish and Game Code can be coordinated to minimize redundancies, maximize comparability of data, and maximize the geographic coverage of the data. A coordinated approach using standardized tools for data collection and information management can minimize the aggregate costs for multiple programs while improving public access to monitoring and assessment results. Whether Level 2 or Level 3 methods are used to collect data will depend on case-specific circumstances. However, the efficacy of using the less expensive Level 2 methods should be carefully considered before Level 3 methods are employed. In many cases, Level 2 methods can be used augment the Level 3 assessments of specific wetland functions or aspects of condition to provide more robust evaluations of overall functional capacity or health at little additional cost.

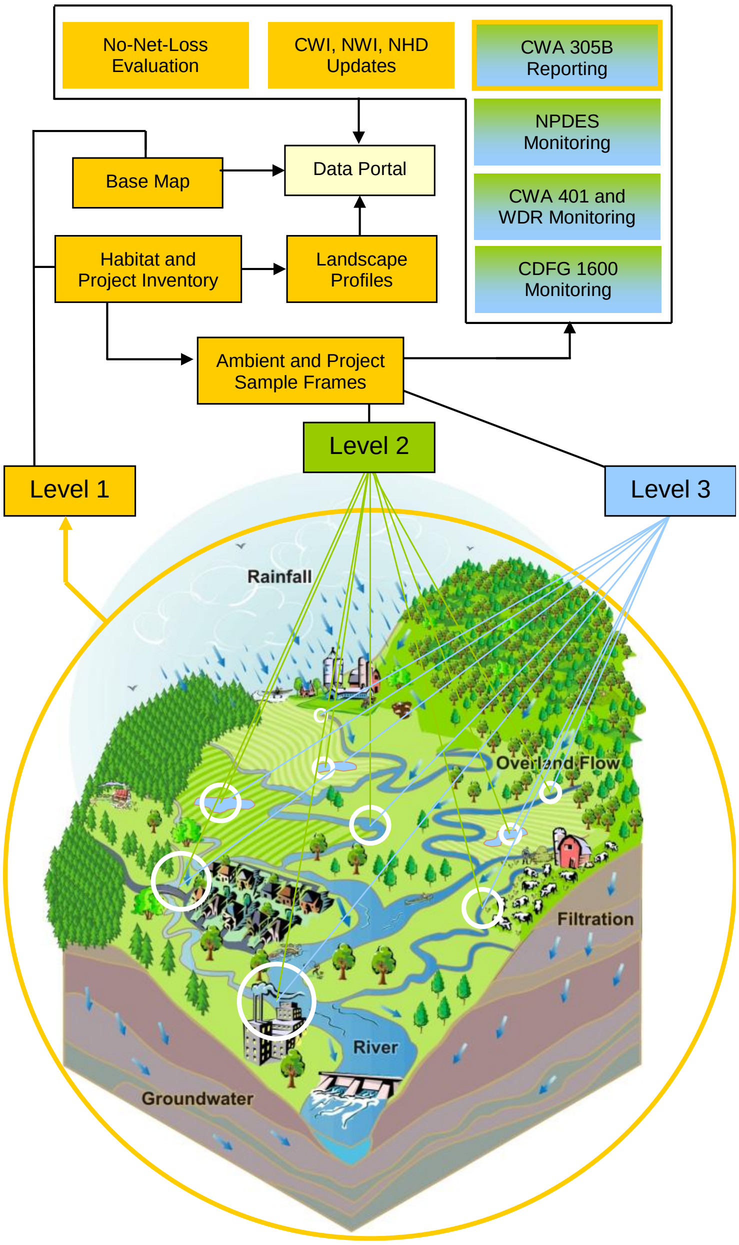


Figure 7-10. Schematic of coordinated approach to comprehensive assessment of wetlands and related projects in the watershed context based on standardized Level 1-2-3 tools and data management protocols. These tools are shared among the various programs and designed to assess different aspects of wetland condition and function under state and federal regulatory and land management policies. Diagram courtesy of the Arkansas Watershed Advisory Group www.awag.org/Education/Watershed_diagram.jpg.

The merits of a three tiered of monitoring approach are best appreciated when illustrated in the form of a simple case study. Because information was available on wetland resource extent and distribution (Level 1), rapid assessment (Level 2), and intensive assessment (Level 3) for the San Gabriel River watershed, it provides a demonstration of how the three levels of monitoring data can be collected, analyzed, and interpreted to provide a robust, integrative assessment of wetland condition at the watershed-scale. Previous sections of this section have focused on how Level 1 maps and Level 2 rapid assessment data can be used to report on the condition of wetland resources within a watershed. This section illustrates an example of how Levels 1, 2, and 3 can be integrated to provide a comprehensive picture of riverine riparian resource condition. A more detailed explanation of the study design and implementation is given in Solek *et al.* (in press) and Stein and Bernstein (2008).

Multiple tiers of monitoring data can be used to make inferences on the causal relationships of wetland condition in a watershed. For example, Level 1 landscape assessment data can occasionally provide insight to corroborate data from Level 2 rapid assessments and Level 2 tools provide the context in which to interpret Level 3 data. In the San Gabriel River watershed, the percent impervious surface was a useful Level 1 landscape-scale indicator of overall riverine wetland condition, showing a negative correlation with wetland condition scores as measured by CRAM (Solek *et al*. in press). Similarly, a Level 2 metric, such as a CRAM index score, can be a good surrogate in the absence of intensive, Level 3 data. A comparison of benthic macroinvertebrate (Level 3) and CRAM indices (Level 2) for the San Gabriel River watershed reveals a positive relationship between benthic macroinvertebrate communities (as measured by IBI) and habitat condition (as measure by CRAM) across streams in this watershed (Figure 7-11). This positive relationship suggests that biotic integrity (as indicated by the benthic macroinvertebrate community) is higher at sites with more intact wetland and riparian communities.

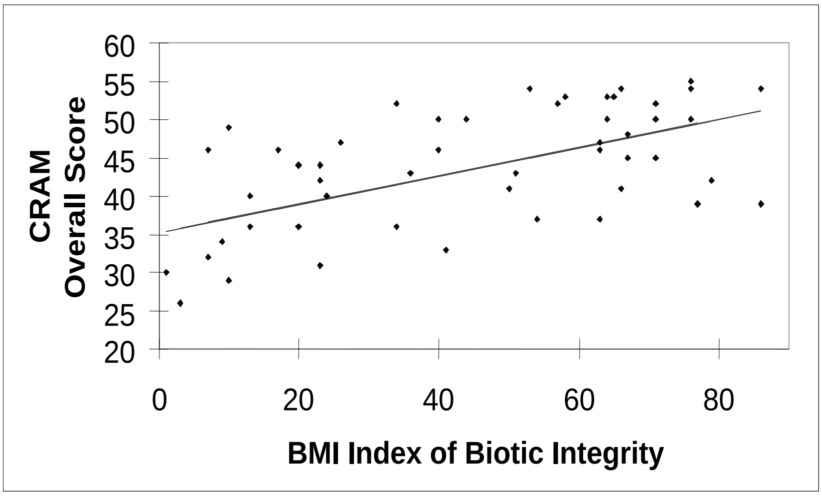


Figure 7-11. Scatter plot and linear regression between overall CRAM scores and IBI scores from the 2005 ambient survey of riverine wetland condition in the San Gabriel River watershed.

Similarly, the combination of CRAM and physical habitat measurements from Level 3 studies suggests that sites with an intermediate disturbance regime tend to have the highest habitat integrity. CRAM scores were highest at sites where the landscape connectivity, buffer and physical habitat structure scores indicate intermediate sedimentation levels. This type of analysis also illustrates how the coarser CRAM assessment and the finer scale physical habitat data complement each other to provide a more refined understanding of factors that affect wetland condition.

Information from Level 1-2-3 studies can also be used to determine how disparities in a watershed potentially influence future regulatory action and helps address management questions that are most relevant to resource managers and the public. For example, a comparison Level 3 data from the San Gabriel River watershed indicates differences in water chemistry, heavy metal concentration, and nutrient loads among three subregions based on watershed position and suggests that metals are highest in the lower watershed that is dominated by storm drain discharge, whereas nutrients are highest in the river's main stem where treated wastewater is the dominant discharge. The information from Level 1 (landscape) and Level 2 (condition) studies corroborate that watershed position is an important determinant of overall water quality in the San Gabriel River. In addition, the positive correlation between CRAM-benthic macroinvertebrate IBI scores and CRAM-SWAMP physical habitat scores provide a weight of evidence to indicate that biotic integrity is strongly dependant on habitat condition. The relationship between CRAM and SWAMP PHAB metrics also suggest redundancies between various tools and potential efficiencies that might be achieved by consolidating measurement approaches. In addition, because trends in aquatic chemistry and IBI scores were detected at targeted sites, this type of Level 3 analysis can be important for identifying targeted sites with anomalous conditions that warrant further examination.

Information on the effectiveness of extensive public investments in wetland and riparian resource conservation is typically not available because efforts are not coordinated and the condition of wetlands and riparian habitat is not monitored systematically. By applying a hybrid sampling design that integrates probability-based surveys, rapid assessment methods (Level 2) and intensive (Level 3) sampling at fixed sites, wetland status and trends assessment can be successfully incorporated into traditional water quality and biological monitoring programs to provide a more robust assessment of the ambient condition of aquatic resources and beneficial uses. For example, prior application of the 1-2-3 framework in the San Gabriel River watershed, most monitoring was permit-mandated and focused primarily around point sources. A watershed-wide probability-based survey that incorporated CRAM and level 3 monitoring protocols provided a cost-effective means of integrating routine water quality, ambient, and disparate, site-specific monitoring data The results of an ambient assessment of this watershed with CRAM indicated that riverine wetlands in the upper, lower, and main stem of the San Gabriel River watershed exhibit a broad range of riverine wetland conditions. This relationship is supported by the water chemistry and bioassessment data (Level 3) collected in the watershed at both the ambient and targeted sampling sites. This information can be used to link assessment of wetland condition with more traditional water-quality monitoring and bioassessment to formulate management actions.

Rapid assessment methods also provide a cost-effective means to collect the Level 2 data that is necessary to provide the context for monitoring activities conducted at the project or site-specific scale. One of the advantages of using a commonly applied rapid assessment tool such as CRAM is the ability to compare scores from a site of interest to other sites or groups of sites. The combination of these can be used to provide assessments of status and trends of wetland and riparian beneficial uses. Level 2 assessments of ambient condition provide the interpretive power and deeper contextual understanding for the Level 3 data collected at specific sites in the watershed. Wetland resource managers commonly want to know how a particular wetland site compares to other sites in the region, what their monitoring data represents, and whether there is a management issue of concern at a specific site. Without an understanding of ambient condition provided through Level 2 assessments, Level 3 data have much less contextual basis on which to base management decisions.

It is important to acknowledge that any conclusions on watershed condition based on an ambient assessment will vary based on the indicator used in the monitoring. Although water chemistry data can indicate "good" water quality based on the standard used, the overall biology of the ecosystem may be in "poor" condition if viewed in the context of physical habitat indicators (such as CRAM scores). For example, resource managers may be interested in determining the percent of stream miles that are "impaired". Using the San Gabriel River as an example, had this assessment relied only on total copper concentrations as an indicator of condition, less than 20 percent of stream miles impaired based on standards for copper (Figure 7-12). If based on toxicity standards, this percentage would be even lower because almost no aquatic toxicity was observed in the watershed. If viewed in the context of biological condition, as indicated by bioassessment data (IBI) or CRAM scores, conclusions about the percent of stream miles impaired would be much higher. This discrepancy indicates that assessments based on water chemistry versus those that measure overall habitat condition provide different types of information. Therefore, conclusions regarding the causes of impairment need to consider the nature of the indicator in order to guide the best management course of action.

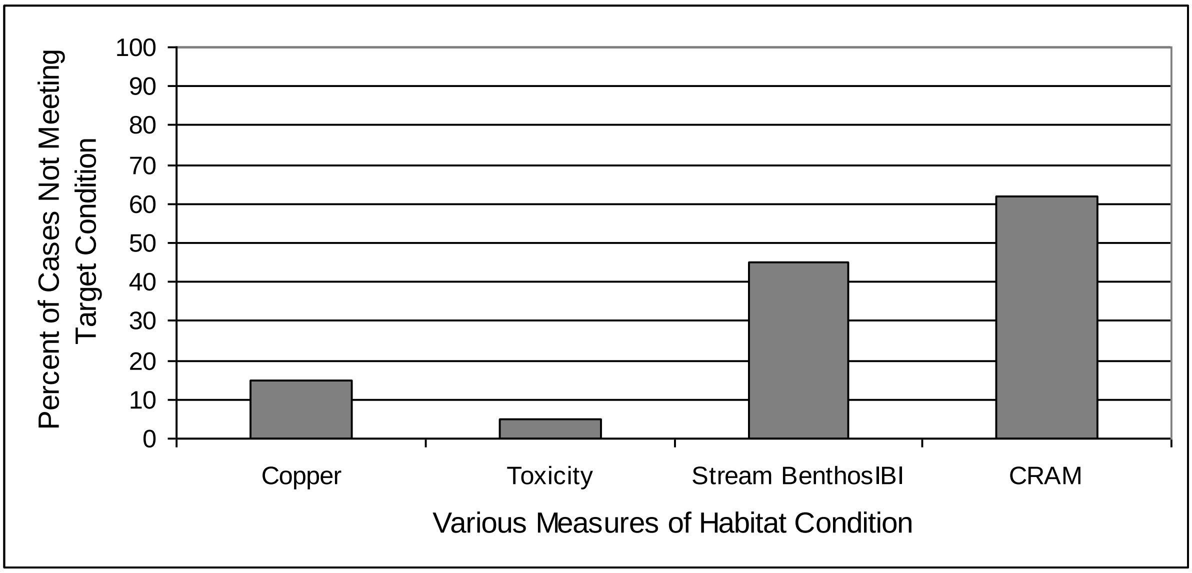


Figure 7-12. Indicators used in the San Gabriel River watershed to assess riverine-riparian condition relative to different environmental policies and programs. For CRAM, the minimum acceptable condition was assumed to be represented by the 25th percentile of index scores based on the statewide ambient survey.

The San Gabriel River watershed provided the template to illustrate the merits of using various levels of data (i.e. wetland resource extent/distribution, ecological condition, and intensive site-specific monitoring) to provide a complete assessment of overall watershed condition. In addition, integrative assessments provide the means to show how information generated from Level 1 landscape scale and Level 2 rapid assessments can be used to interpret and/or supplement more intensive, Level 3 data. A monitoring program based on the Level 1-2-3 assessment framework can be used to guide wetland restoration, provide data on regional wetland condition, and verify the effectiveness of management approaches and/or regulatory actions. Incorporation of this overall framework into agency wetland monitoring programs provides a valuable opportunity to evaluate the effectiveness of public investment in conservation and restoration of these resources.

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APPENDIX 1