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Redwinged Blackbird. Central Pennsylvania, 2011. Photo Credit: C.A. Cole

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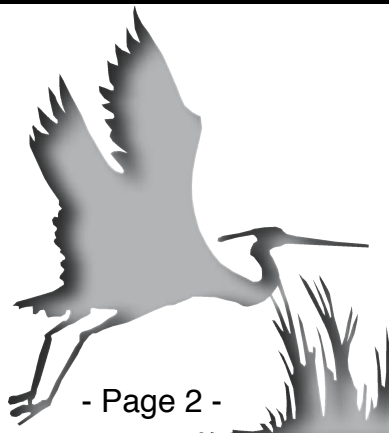
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Aim and Scope of Wetland Science and Practice

The *WSP* is the formal voice of the Society of Wetland Scientists. It is a quarterly publication focusing on news of the *SWS*, at international, national and chapter levels, as well as important and relevant announcements for members. In addition, manuscripts are published on topics that are descriptive in nature, that focus on particular case studies, or analyze policies. All manuscripts should follow guidelines for authors as listed for *Wetlands* as closely as possible. All papers published in *WSP* will be reviewed by the editor for suitability. Letters to the editor are also encouraged but must be relevant to broad wetland-related topics. All material should be sent electronically to the current editor of *WSP*. Complaints about *SWS* policy or personnel should be sent directly to the elected officers of *SWS* and will not be considered for publication in *WSP*.

Wetland Science and Practice

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WSP

PRESIDENT'S MESSAGE

The Role of the SWS in the 21st Century

Over the last several months the executive board and AMP have been focused on the 2012 SWS membership drive and I began to think about the role and value of scientific societies like the SWS in the 21st Century. Like many other scientific societies SWS membership has been decreasing and two of my goals during my tenure as President have been focused on rebuilding our membership and bringing value to members. These last few months have allowed me to reflect on a number of fundamental questions, which I'm sure potential members inevitably ponder. That is, "Why should I join the SWS" and "What's in it for me".

Scientific societies have existed for about 400 years and the dissemination of knowledge through printed media and society meetings was their primary role. Although present-day societies are much more focused with respect to the area of specialization than they were four centuries ago, promulgating science and educating the public still remain two of the central tenets of the SWS and other modern societies. Nevertheless, at a more fundamental level the reasons for being a member change with time and these reasons are largely governed by societal values and norms and personal beliefs. Today, perhaps more so than ever we've reached an important crossroad because of workplace diversity. This is probably one of the few times, perhaps the first, where people from four generations (Traditionalists, Baby Boomers, Generation-X, and Generation-Y) can be found in the workplace. Each generation is shaped by events and these shared experiences shape thinking, values, and behaviors. The generational differences are enormous. Think about how you might respond if your first job was with working with someone from your grandparents or great-grandparents generation or your new boss was the same age as your grand-children or great grand-children. Imagine how seriously they might consider your contributions or even understand what you are talking about. The workplace is further complicated because we are now working under a technological umbrella.

The point here is that each generation has an opinion on what a scientific society should represent and the direction that needs to be followed to remain a viable entity. While it may appear that the opinions among generations are not well aligned, the SWS has and continues to have a rich history of diversity in its membership (academic, government, and industry) and we are well poised to embrace the benefits that each group brings to the table. So then, what is the role of the SWS moving forward and what benefits can be conferred to its members?

In my opinion, increased communication (regardless of whether it is with handwritten note, e-mail, or social media) by all members and having more participation in Society business by the younger generation is crucial not only for the survival of the society, but for its growth. The younger generation is the future of the Society. The Strategic Plan maps the society's short- and to some extent, its long-term goals and objectives, and this roadmap that provides guidance for the



Executive Board. But, if our members don't weigh in or participate in the process of developing a Strategic Plan not all points of view will be represented and the society's goals and objectives will be biased towards a narrow sector of the society. As such, the membership is at odds with the activities or direction of the society. The good news is that if you participate, the problem can be easily fixed.

Social interaction is a learned behavior and we've done a terrible job at passing those skills on to the younger generation. Although we live during a time where we can instantly communicate with almost anyone in the world or find information on the WEB with a few clicks of the mouse, we've effectively created a vacuum by substituting e-mail, social media, and the internet with face time. This may not necessarily be a huge impact to some of the Traditionalists, Baby Boomers, and older Gen-X'ers, but the impact on our younger scientists may be significant. I don't want to marginalize these individuals because they are smart and have a lot to offer, but they've not been taught how to "work the room" at a scientific meeting that is assuming that they've attended a meeting. Personal relationships and the ability to interact and effectively communicate with one's peers and the public at large is an important part of being a scientist. These skills are learned and can be honed by attending meetings and putting in some face time. I can't stress the importance of face-to-face meetings. I'm sure we can all remember discussions that we've had with peers and mentors over dinner or a pint.

More importantly, ideas can be nurtured through discussions with colleagues. We've all had manuscripts that were trashed, but talking to colleagues and working through the issues is a huge benefit of being connected or mentored by a more senior member of a society. Although new concepts and patterns can be discovered by re-processing previously published data, science moves forward with testing new ideas. Sadly, many of our newly minted graduates have not been challenged in the right manner. Again, don't get me wrong, they are very good at what they were required to learn, but independent thinking and multi-tasking are not part of the skill set. I'm sure that my senior colleagues thought the same when I graduated, but at one point in my career I belonged to at least 8 societies and took every opportunity to attend meetings, discuss ideas, and seek mentorship.

So rather than continue on this philosophical trip down memory lane I am returning to the purpose of this message. What is the purpose of the SWS? Some may consider our journal Wetlands is the only reason to be a member, while others think it's all about re-connecting with friends and colleagues at the annual meeting. The professional opportunities that the SWS membership provides includes student and research grants, networking opportunities at chapter and annual meetings, and opportunities to vet new and innovative ideas. The monetary investment is small and the payback is what you make of it. Think about your SWS membership as an investment into the future. Becoming involved will certainly enhance your membership experience, but it may also help advance your career professionally. Each

PRESIDENT'S MESSAGE

member might have their own opinion, but I think it's much more than that and the answer is embodied in the Mission, Vision, Goals, Objectives, and Actions in the SWS Strategic Plan (<http://www.sws.org/about/strategic.mgi>). However, success can only be achieved when all sectors of our diverse membership are represented and participate in the process. Imagine how effective the SWS could be at the international level if the Mission, Vision, Goals, Objectives, and Actions embodied our diversity and represented the entirety of the membership.

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December, 2011
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Editor's Note:

Well, here it is - the first issue of Wetland Science and Practice with a fully refereed article (thanks to Christopher Solek and his co-authors for being our guinea pigs, as it were). My thanks to our editorial board for helping with the reviews. All errors that you might find are the fault of Ben LePage (no, not really – mea culpa in advance). I hope to see many more such articles submitted – we are low for the next issue, but we are talking with folks from the PNW Chapter to publish proceedings from their annual meeting this coming fall. That's an exciting development and may serve as a good model for the types of articles we can publish in WSP. So, again, please think about the types of materials you can publish here and let's get some things in the queue.

Andy Cole
WSP Editor

Determining the Health of California's Coastal Salt Marshes Using Rapid Assessment

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Abstract

The integration of rapid assessment methods with probability-based regional survey designs provides a cost-effective means for making unbiased assessments of wetland condition over a relatively large area within a short period time. We demonstrated this synergy through a statewide probability-based survey of the condition of perennially tidal saline estuarine wetlands (salt marshes) in California using the California Rapid Assessment Method (CRAM). An estimated 85% of the State's salt marshes scored within the top 50% of possible CRAM index scores. Among the four CRAM attributes for salt marshes, Buffer and Landscape Context had the highest scores. Physical Structure was the attribute for which California's salt marshes scored the lowest. CRAM index and attribute scores showed a general decrease from northern to southern California. The presence of dikes, levees, and other water control structures that restrict tidal exchange was a severe stressor that is responsible for low physical structure scores. Urbanization of surrounding land uses was significantly correlated to poor wetland health statewide. Information on landscape and local stressors gathered via the CRAM assessment suggest possible management actions that could be used to improve wetland health. This study demonstrates how incorporation of a rapid assessment method into a regional, probability-based survey can be used as context for evaluating the condition of wetland restoration projects.

Keywords

wetland monitoring, ambient condition, CRAM, restoration effectiveness, probabilistic survey

Introduction

Considerable resources have been invested in wetland restoration and management in the United States, mostly to offset historical losses and mitigate current threats. Since 1990, it is estimated that public and private organizations have spent approximately \$15 billion on over 30,000 river and wetland restoration projects (Malakoff 2004, Bernhardt et al. 2005). The National Coastal Wetlands Conservation Grant Program awards between 13 and 17 million dollars annually to acquire, restore, manage or enhance coastal wetlands (USFWS 2010). The need to account for the effectiveness of these investments and to track wetland status and trends has led to the proliferation of wetland monitoring and assessment programs across the country, such as the United States Environmental Protection Agency (USEPA) National Wetland Condition Assessment (<http://water.epa.gov/type/wetlands/assessment/survey/index.cfm>).



An important design element of many large-scale wetland monitoring programs is the use of probabilistic survey methods that allow scientists to assess the ambient (overall) condition of large areas based on data collected from a representative sample of locations (Stevens and Olsen 2004). Because probability-based surveys provide the ability to make unbiased assessments of wetland condition over a relatively large area, they have become the key basis for design of many state and regional monitoring programs (NAS 2001, USEPA 2010).

Implementing large regional wetland monitoring programs often requires that an accurate assessment of overall condition be made using standard tools and protocols during a single site visit within a relatively brief period of time. This has made the use of conventional, time-intensive assessment methods less tractable for these types of applications. As an alternative, rapid assessment methods (RAMs) are gaining popularity for use in a range of monitoring programs (Stapanian et al. 2004, Cohen et al. 2005, Fennessy et al. 2007, Scozzafava et al. 2011). RAMs are structured diagnostic tools that combine scientific understanding of process and function with best professional judgment in a consistent, systematic, and repeatable manner (Sutula et al. 2006). The basic assumptions of most RAMs is that ecological conditions vary predictably along stress gradients and that conditions can be evaluated based on a fixed set of observable field metrics. These metrics represent measures of a specific biological or physical attribute which reflects some element of ecological condition and can be related to key ecosystem functions (Stein et al. 2009a). RAMs can be used to extend the geographic application and understanding derived from expensive and geographically restrictive special studies and intensive assessments. In this way, RAMs can be the cornerstone of a comprehensive monitoring program and make basic assessment of wetland projects affordable (Sutula et al. 2006).

The application of RAMs as a tool for wetland condition assessment is not novel to the science of wetland monitoring. Over the past ten years, the USEPA has supported the development and implementation of RAMs to support national wetland assessment goals (USEPA 1998, 2006). RAMs have also been developed and applied in various state and regional wetland condition assessments (Fennessy et al. 2007), but rarely used as the foundation for a statewide assessment program. Skepticism of RAM results has limited their use in monitoring and regulatory programs. As a result, despite the stated preference of many wetland programs to consider overall function or condition in decision making processes, few do so in a rigorous manner (Stein et al. 2009b).

In this paper, we describe an application of the California Rapid Assessment Method for Wetlands (CRAM; Collins et al. 2007) in the context of the first statewide assessment of estuarine wetlands (salt marshes) in California. CRAM was developed as a diagnostic tool for the assessment of general wetland health and produces condition scores that are comparable and repeatable for all wetland types (using different “modules” for different wetland types) across regions in California (Collins et al.

2007). The objectives of this survey were to: 1) generate probability-based estimates of the condition and anthropogenic stressors affecting salt marshes within four coastal regions of California, and 2) use CRAM to assess the condition of a subset of estuarine restoration or mitigation projects located in salt marsh habitats throughout coastal California. By applying CRAM at the statewide, regional, and project scales, we demonstrate how probability-based surveys can provide context for interpretation of site-specific assessments.

Methods

Study Area and Assessment Target Population

This survey focused on the assessment of intertidal emergent wetlands (salt marshes) in those California estuaries that have a perennial surface water connection to the ocean (i.e., perennially tidal). In order to determine how salt marsh conditions vary regionally, four coastal regions were identified for the purposes of this study: North Coast; Central Coast; San Francisco Estuary, and South Coast (Figure 1). These regional delineations were based on a combination of the ecoregional boundaries developed by Hickman (1993) and California Regional Water Quality Control Board jurisdictions. The San Francisco Estuary and its attending watersheds were treated as a separate study region for this study because they contain 75% of the State's salt marsh acreage.

Estuarine Habitat Inventory

The sample frame for the ambient survey was created by overlaying the current National Wetland Inventory (NWI; USFWS 2011) onto National Agricultural Imagery Program (NAIP) imagery (NAIP 2005). From among the wetland categories, the sample frame was established to include areas identified as intertidal emergent wetlands. Whenever possible, regional maps were revised based on local knowledge.

Study Design

A stratified generalized random tessellation (GRTS) design (Stevens and Olsen 1999, 2004; Stevens and Jensen 2007) was used to probabilistically select 150 assessment sites (Figure 1) from the revised estuarine habitat maps, with 30 sites allocated to Central Coast, San Francisco Estuary, North Coast, and South Coast, respectively. Additional funding permitted the allocation of 30 additional sites in the South Coast, for a total of 60 sites in this region. South Coast sites were evenly divided between large (>500 acres) and small (<500 acres) estuaries. Probability-based estimators were area-weighted (based on percent of salt marsh acreage) to account the number of sites selected by the GRTS design within a given salt marsh and the total salt marsh area represented by each site. Sutula et al. (2008a) provide a detailed explanation of the GRTS design as it was applied in this study.





Figure 1: California coastline showing approximate boundaries of the four coastal regions and the location of the 150 probabilistic sites included in the statewide assessment of estuarine wetland condition.

Field Survey of Ambient Condition

From August through November 2007, field assessments were conducted at the 150 probabilistically selected sites using the CRAM perennial estuarine module. CRAM assesses four overarching attributes of wetland condition: Buffer and Landscape Context, Hydrologic Regime, Physical Structure, and Biotic Structure (Collins et al. 2007). Each attribute is related to several attribute-specific metrics and submetrics that are evaluated in the field for a prescribed assessment area (Table 1). Assessment Area (AA) sizes and delineation adhered to the guidelines in Collins et al. 2007. Wetlands less than 0.1 ha were excluded from the sample frame for this study.

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

Table 1: Relationship between CRAM attributes, metrics (m), and submetrics (s).

Each CRAM metric or submetric is evaluated using a standardized set of narrative descriptions, schematic diagrams, or simple quantitative measures. Choosing the alternative that best describes each metric in an attribute generates a score for that attribute. The attribute scores are averaged to produce an overall index score. Attribute and index scores are expressed as percent possible; scores range from 25 (lowest possible) to a maximum of 100. In the context of CRAM, wetland condition is evaluated based on observations made at the time of the assessment. Higher scores represent better condition and infer a higher potential to provide the functions and services expected for the wetland site being assessed (Collins et al. 2007). The estuarine module of CRAM has been validated against independent, more intensive measures of condition including benthic invertebrates, riparian birds, and estuarine



plant richness and diversity (Stein et al. 2009). This has resulted in refinement of the metrics for this wetland type and provides an increased level of confidence that higher CRAM condition scores equate to a higher level of function.

Extensive inter-team calibration exercises were conducted prior to this research, with field personnel from all four regions jointly applying the methodology at field sites within each of the four regions. The intercalibration training documented an average error rate among field teams of ± 6 points for attribute scores and ± 9 points for index scores (Sutula et al. 2008a,b). The variability in condition as measured by the standard error of the mean for index and attribute scores was generally much less (approximately 3%). Thus, differences in CRAM index and attribute scores of 10 points or more among regions were considered to be significant.

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

Assessment of Projects Using CRAM

Ten estuarine restoration projects were selected in the San Francisco Bay, Central Coast, and South Coast regions of the State, respectively (n= 30), and assessed using CRAM. The North Coast region was not included in this phase of the survey. The lack of comprehensive project inventories for all regions except the Central Coast prevented the use of a probabilistic approach for selecting the projects, thus the projects included in this survey were not considered representative of the population of projects as a whole and were considered as case studies to demonstrate how project and ambient assessment can be used in concert. Furthermore, because the survey included sites of special interest to regional coastal zone managers, sites were not standardized by size, type, and age since restoration. Projects larger than two CRAM assessment areas (larger than 2.0 ha) required multiple assessments, based on the guidance for project assessment (Collins et al. 2007). In these cases, attribute scores were averaged to generate an overall project index score.

Data Analysis

Area-weighted estimates of condition were analyzed using cumulative frequency distribution (CFDs) plotted from distributions of statewide and regional CRAM index and attribute scores. The CFD plots allow one to estimate what percent of the wetland area of that wetland type is less than or equal to a particular score, 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 separated into four equal score quartiles: (1) Quartile 1 (> 82); (2) Quartile 2 (64-82); (3) Quartile 3 (44-63); and (4) Quartile 4 (< 44). These four ranges of CRAM scores represent a theoretical continuum of condition along various stressor gradients, with 100 and 25 representing the highest and lowest possible scores possible, respectively, on each gradient (Sutula et al. 2006). These bins were then overlaid onto the CFDs to estimate the percentage of wetland area within a particular range of scores for each region and statewide. The mean scores, as well as the percent of area within each of the quartiles, represent statistical estimates derived from a probability-based selection of sites. Measures of confidence or standard errors used a local variance estimator that utilizes distances between sites to increase precision (Stevens and Olsen 2004).

Non-parametric Spearman's rank correlation coefficients were calculated to explore relationships between CRAM index scores and sources of stress. The Stressor Severity Index for a site was calculated as the percent maximum possible score for all stressors combined. Kruskal-Wallis one-way analysis of variance (ANOVA) by ranks was used to test differences in median CRAM Index scores between regions and for the major individual stressors identified statewide and regionally. 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 severe categories.

Results

Summary of Extent and Geographic Distribution of California Salt Marshes

A total of 154,128 ha of perennially-tidal subtidal and intertidal estuarine habitat were identified in California based on the NWI database. Salt marsh comprises 12% of this area (17,990 ha), distributed among the four coastal regions depicted in Figure 2. The San Francisco Estuary is the largest estuary in the state, and contains three-quarters of the estuarine habitat, including most of the salt marsh acreage. Outside of this region, the acreage of estuarine habitat is fairly equally distributed among the North Coast, Central Coast and South Coast. However, the estuaries of the Central Coast and South Coast each have approximately three times as much area of salt marsh than the North Coast estuaries (Figure 2).



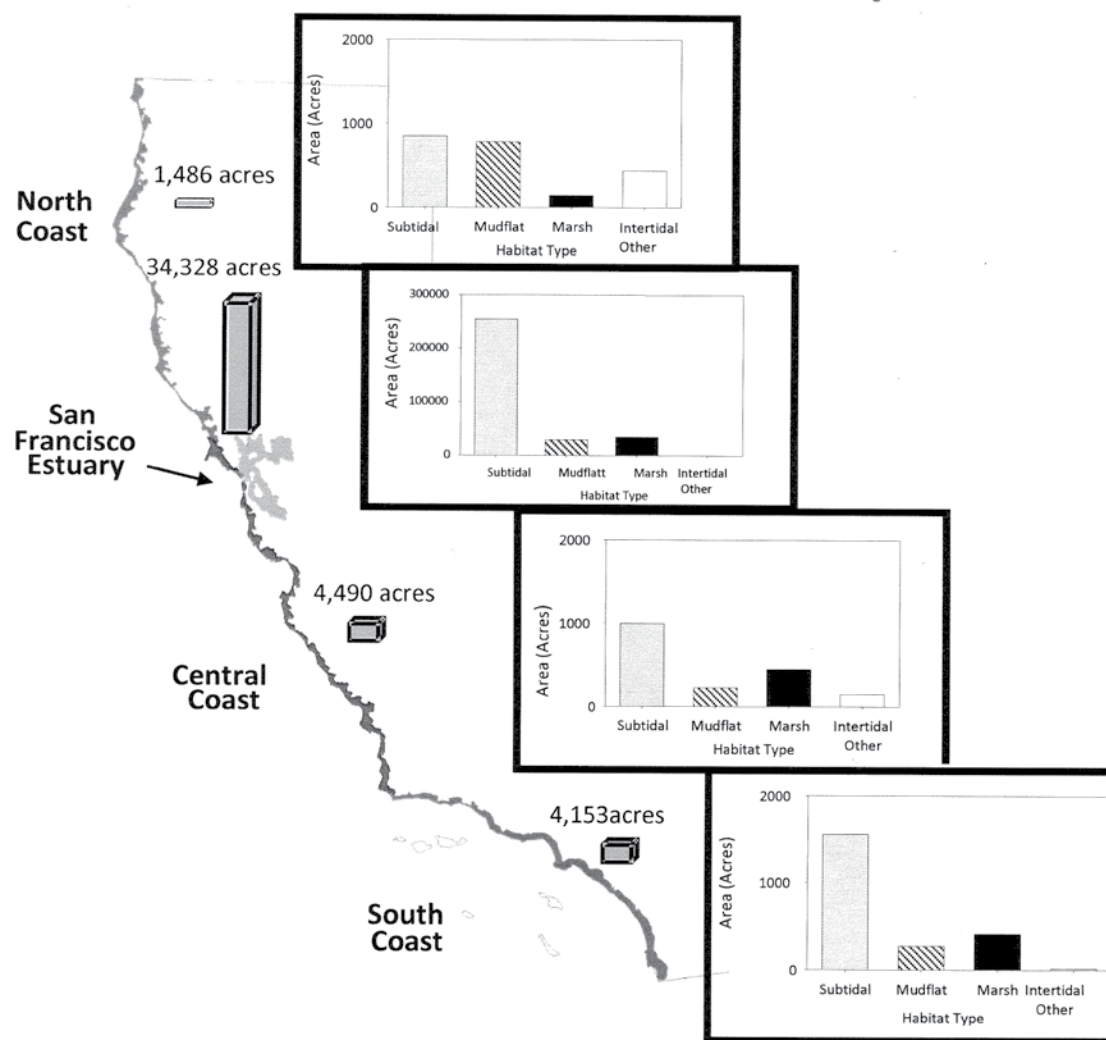


Figure 2: California coastline showing boundaries of the four coastal regions of the statewide assessment of salt marsh condition and the relative distribution of salt marsh habitat within each region. Inset graphs show relative importance of salt marsh versus other habitat types in the perennially tidal estuaries of each region.

Statewide Estimates of Salt Marsh Condition

Approximately 16% of California salt marshes received CRAM index scores in the top quartile (score > 82; Table 2). The majority of salt marsh acreage (69%) scored in the second quartile of CRAM index scores (63-82) statewide. Less than 1% of the state's estuarine marsh acreage scored in the lowest quartile (<44). Among the four CRAM attributes, salt marshes achieved their highest scores for Buffer and Landscape Context, with an estimated 64% of the total acreage scoring in the top quartile, and 96% in the top two quartiles. The Hydrologic Regime attribute and Biotic Structure attribute scores included 80% and 75%, respectively, within the top 50% of scores. The Physical Structure attribute produced the lowest scores, with 62% of the salt marsh acreage scoring in the bottom 50% of possible scores.

Score Type	Mean Score	Percent of Salt Marsh Area in Four Score Bins			
		Quartile 1 (>82)	Quartile 2 (63-82)	Quartile 3 (44-63)	Quartile 4 (<44)
CRAM Index	76 (1)	16	69	14	1
Landscape Context	88 (2)	64	32	4	0
Hydrologic Regime	80 (2)	36	44	18	2
Physical Structure	59 (2)	10	28	31	31
Biotic Structure	76 (2)	35	40	23	2

Table 2: Summary of Statewide CRAM index and attribute scores. The first column contains the mean and standard error (in parentheses) of CRAM index and attribute scores statewide. The last four columns present the estimated percentage of salt marsh area to score within each quartile of CRAM scores. Higher scores equate to higher condition.

Regional Estimates of Salt Marsh Condition

Regional differences in CRAM index scores were highly significant (p -value < 0.0001). A comparison of regional distribution of CRAM index scores (Figure 3) indicates that the condition of salt marshes generally decreases from the North Coast to the South Coast in California. North Coast wetlands had the highest mean index scores (82 ± 1), followed by the San Francisco Bay region (78 ± 1), and Central Coast (71 ± 2). The mean index scores for the South Coast were 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 San Francisco Estuary was 5% lower. The attribute scores generally followed the same trends as the index scores.

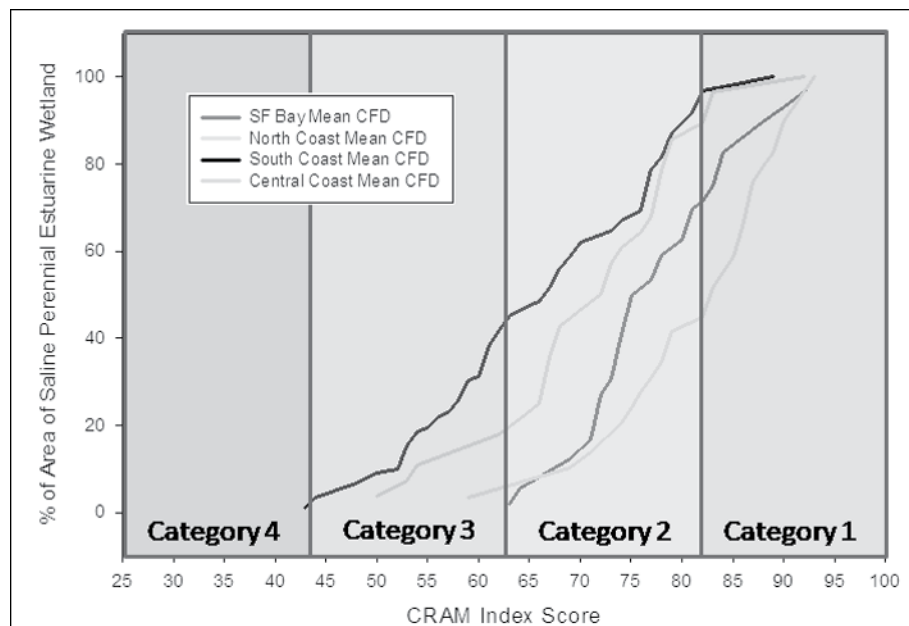


Figure 3: Cumulative frequency distribution (CFD) of CRAM Index scores as a function of percent of area of perennially tidal estuarine marsh by region.



There were regional differences at the CRAM attribute level as well. All regions scored high (81-90) for Buffer and Landscape Context. Physical Structure; however, this attribute was the lowest-scoring among all regions except the North Coast. The North Coast received the highest scores for the Hydrologic Regime and Physical Structure attributes, while the San Francisco Estuary achieved the highest scores for Buffer and Landscape Context and Biotic Structure attributes. Differences among regions were most significant with respect to the Hydrologic Regime and Physical Structure attributes, with the North Coast estuaries scoring from 21-28 points higher for these attributes in comparison with the other regions (Table 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)	87 (1)
Landscape Context	83 (1)	90 (2)	81 (2)	82 (2)
Hydrologic Regime	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)	87 (2)

Table 3: Mean and standard error (SE) CRAM index and attribute scores statewide and by region. Scores range from 25 to 100 with the standard error given in parenthesis. Differences of ± 10 points or more between regions are considered to represent substantial distinctions.

Along the southern California coast, approximately 75% of salt marsh area (3,070 acres) is located in large estuaries (>500 acres). Wetlands in large estuaries had significantly higher CRAM index scores, primarily due to higher attribute scores for Hydrologic Regime and Biotic Structure, than small estuaries (p-value >0.05; Figure 4). This difference was greatest for Biotic Structure, which was 13 % higher.

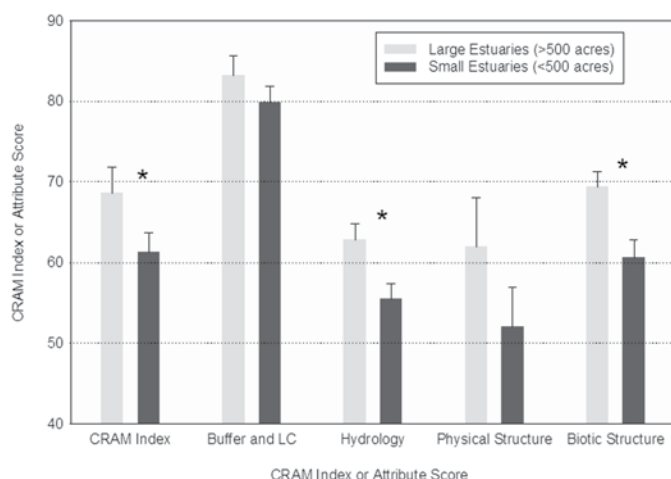


Figure 4: Plots of mean and upper 95% confidence interval for CRAM index and attribute scores for large and small estuaries in the South Coast. The size threshold of 500 acres includes both subtidal and intertidal acreage. An asterisk (*) indicates significant difference between large and small estuaries (p-value<0.05). LC = Landscape Context.

Analysis of Common Stressors

CRAM index scores were significantly negatively correlated with the total number of stressors found at each site (non-parametric spearman's rank correlation $r = -0.44$; $p\text{-value} < 0.0001$). Dikes/levees were the most common stressor on wetlands statewide, impacting 43% of the sites visited (Table 4). The degree of impoundment due to dikes and levees was judged to be severe at 34% of the sites visited. The lack of treatment of invasive plants, nonpoint source (NPS) discharges, and contaminant pollution due to bacteria, pathogens, and heavy metals were among the other most frequently cited severe stressors statewide. Dikes/levees, excessive sedimentation (from watershed), and flow obstructions, such as culverts, were highly significant statewide (Table 5).

Stressor Name	State (n=150)	NC (n=30)	SF (n=30)	CC (n=30)	SC (n=60)
Dike/levees (h)	43	30	50	23	70
Non-point Source (NPS) discharge (h)	38	47	7	57	43
Lack of treatment of invasive plants adjacent to AA/ buffer (b)	34	80	7	17	33
Heavy metal impaired (p)	28	7	33	23	48
Bacteria and pathogens impaired (p)	25	13	17	27	43
Pesticides or trace organics impaired (p)	25	17	30	27	28
Nutrient impaired (p)	20	3	0	30	45
Predation & habitat destruction by non-native vertebrates (b)	20	0	53	3	23
Trash or refuse (p)	18	17	3	30	22
Excessive sediment or organic debris from watershed (p)	20	67	7	3	3
Ditches (borrow, agricultural drainage, mosquito control) (h)	16	23	33	0	7
Excessive runoff from watershed (p)	11	7	10	7	20
Grading/ compaction (p)	7	7	0	0	22
Flow obstructions (culverts, paved stream crossings) (h)	8	3	0	13	13
Excessive human visitation (b)	8	7	3	13	10
Flow diversions or unnatural inflows (h)	5	0	0	3	18
Pesticide application or vector control (b)	6	0	10	3	12
Mowing, grazing, excessive herbivory (b)	6	7	3	13	0



Stressor Name	State (n=150)	NC (n=30)	SF (n=30)	CC (n=30)	SC (n=60)
Engineered channel (riprap, armored channel bank, bed) (h)	3	0	3	3	7
Dredged inlet/channel (h)	3	7	0	0	7
Lack of vegetation management to conserve natural resources (b)	4	0	0	10	5
Actively managed hydrologic regime (h)	3	3	0	7	3
Weir/drop structure, tide gates (h)	3	0	0	10	3
Filling or dumping of sediment/soils (p)	2	3	0	0	5
Point Source discharges (h)	2	3	0	0	5
Plowing/disking (p)	3	0	10	0	2
Dams (reservoirs, detention basins, recharge basins) (h)	3	0	0	10	2
Vegetation management (p)	3	0	3	7	0
Median Number of Stressors Per Site	10	6	9	9	15
n = number of sampling sites/region; h= hydrological stressor, p= physical stressor, b=biological stressor					

Table 4: 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 (n). CC = Central Coast, NC = North Coast, SC = South Coast, SF = SF Estuary.

Although sites with a high number of stressors had significantly lower CRAM scores statewide, the predominance of individual stressors varied by region (Table 4). In the North Coast, the lack of treatment of invasive plant species (the dominant invasive species was identified as *Spartina densiflora*, a non-native cordgrass) was the most frequently occurring stressor (88% of sites) and the most severe stressor (70% of sites) at all sites. North Coast CRAM index scores were significantly lower for sites where this stressor was severe ($p = 0.046$; Table 5). For the San Francisco Estuary salt marshes, dikes and levees were among the most frequently stressors (50% of sites) and the most severe stressors (37% of sites) to occur. In the Central Coast, non-point source pollution was identified as the most frequently occurring stressor (56% of sites) and the most severe stressor (23% of sites). In the South Coast, dikes and levees were the most frequent stressor (70% of sites) and the most prevalent severe stressor (63% of sites). Non-parametric ANOVA tests showed that the number of stressors and number of severe stressors did not significantly differ between large and small estuaries in the South Coast (p -value = 0.98 and 0.78, respectively).

Stressor Type	Kruskal-Wallis Test (p-value)				
	Statewide	North Coast	SF Bay	Central Coast	South Coast
Dikes/Levees	0.0001 (n=76,14,59)	0.14 (n=30,3,6)	0.19 (n=17,4,11)	0.21 (n=31,3,4)	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)	NA	0.11 (n=23,0,5)	0.0012 (n=52,2,6)

Table 5: Summary of results of non-parametric ANOVAs examining the relationship of median CRAM index scores relative to the five major stressor types observed statewide and by region. The values in parentheses are the numbers of sites in which the stressor was absent, present but not severe, and severe, respectively. Note that flow obstructions were not an observed stressor type in the SF Bay.

Assessment of Projects with CRAM

For the restoration projects evaluated, overall CRAM index scores were lower than the median ambient condition scores in every region of the State; however, specific results varied by attribute (Table 6). The upper range of attribute scores for Landscape Context and Hydrologic Regime for projects were 15 - 18% lower than the statewide ambient scores for these attributes (Table 6). Project sites had higher scores than ambient sites for Physical Structure in the San Francisco 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.

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
Hydrologic Regime	82	65	82	67	61	55
Physical Structure	59	68	57	66	59	56
Biotic Structure	78	65	63	57	67	59

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



Discussion

Condition assessments are an important aspect of wetland monitoring as they provide a means to measure the relative ability of a wetland to support and maintain its complexity and capacity for self-organization with respect to species composition, physico-chemical characteristics and functional processes as compared to wetlands of a similar type without human alterations (USEPA 2004). Methods best suited to assess condition reflect this by providing a quantitative measure describing where a wetland lies on the continuum ranging from least impacted condition to highly impaired. Because a primary goal of monitoring and assessment programs is to report on the ambient (overall) condition of the wetland resource, methods that evaluate condition directly can effectively serve programmatic needs. The information derived from condition assessments can also be used to develop and support aquatic life use designations for the implementation of wetland water quality standards (USEPA 2003).

Use of rapid assessment methods, which provide a more holistic assessment of wetland condition, in conjunction with probabilistic survey designs allows for a broader perspective on wetland condition. Probability-based surveys are becoming a commonly used monitoring tool within state and federal ambient monitoring programs (Fennessy et al. 2007, Kentula 2007, Scozzafava et al. 2011). A key advantage of the probability-based ambient survey is that it produces an unbiased, statistically representative estimate of condition at the state or regional scales, thus helping to inform program evaluation and restoration funding decisions at a broader scale. Although there are numerous examples of coastal wetland or estuarine monitoring programs in the United States that have utilized probability-based sampling designs, these applications have been primarily focused on contaminant-related management issues (Lamberson and Nelson 2002), or have sampled specific indicators (Fetscher et al. 2010). Assessments that focus only on individual measures of wetland quality or function (e.g. water quality, endangered species) provide a limited view of the condition of the resource as a whole. More inclusive assessment of ecological health that factor in multiple aspects of the system's ecology, hydrologic regime, and physical structure allow for a better representation of all ecological links e.g. water/sediment interactions and provide the ability to make more informed management decisions (Fairweather 1999).

Condition of California's Salt Marshes and Relationship to Major Stressors

This study generated important baseline information on condition of California's salt marshes throughout the state. Buffer and Landscape Context, Hydrologic Regime and Biotic Structure were the attributes for which the State's salt marshes scored the highest. This result was driven by two factors. There is a strong correlation between both Landscape Context and Biotic Structures scores with size, reflecting decreases in percent developed lands adjacent to wetlands as well as a well-established relationship

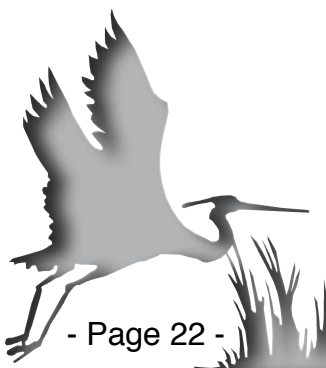
between habitat area and plant species richness (Rosenzweig 1995). Second, a statistical design that reports on area percentages will most likely select sites from larger wetlands, even if that design is spatially balanced (Stevens and Olsen 1999). Central and South Coast regions have small lagoons and river mouth estuaries that are more fragmented (by roads, railroads, levees, and developed areas). These sites tend to have muted tidal hydrologic regimes which typically results in lower species richness (Noss and Csuti 1994). This is reflected in the lower Buffer and Landscape Context, Hydrologic Regime, and Biotic Structure scores for Central Coast and South Coast compared to the San Francisco Bay and North Coast regions.

Relationships between RAM scores and stressor data can suggest possible management actions to increase the overall condition of wetlands. Physical Structure was the attribute for which the State's estuarine marshes scored the lowest. A wetland's physical structure can be affected by anthropogenic modifications to the tidal and freshwater hydrologic regime, sediment transport, and geomorphology of the marsh, which results in reduced integrity of marsh physical structure (Day et al. 1989). Not surprisingly, dikes/levees were the most frequent and most severe stressor identified 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 (Zedler and Callaway 2000, Fell et al. 1991, Fetscher et al. 2010). Sites bounded by levees or other water control structures that reduce the wetland tidal action can be expected to have a lower rating for almost all metrics relative to other sites. For example, South Coast sites where levees were present had, on average, 15 point lower CRAM index scores than sites where this stressor was absent.

Results from rapid assessments can help to prioritize restoration activity and help identify pristine areas for conservation. CRAM index and attribute scores showed a general decrease from north to south. This pattern is partially explained by an overall north-south gradient in condition relating to urbanization along the coastline. This relationship was supported by the strong negative correlation between CRAM Index scores and percent of adjacent developed land and the presence of infrastructure, such as dikes and levees (the stressor types most directly linked to urbanization). Previous studies have also found that indices of urbanization of surrounding land uses are correlated with indicators of wetland condition (e.g., Brown and Vivas 2005, Mack 2006, Fennessy et al. 2007, Wardrop et al. 2007, Sutula et al. 2008a,b, Johnston et al. 2009).

Utility of Probability-Based Surveys in Providing Context for Project Assessments

Evaluation of the overall ecological benefit associated with restoration activities requires application of standard approaches and tools that allow compilation and synthesis of findings across many wetlands and broad geographic areas. The use of



rapid assessment in both probability-based surveys and as an element of individual restoration project monitoring provides a cost-effective mechanism to report on restoration effectiveness at a regional or statewide level. In California, CRAM Index scores of estuarine projects were lower than ambient scores for their respective region, with the gap most pronounced for the South Coast. In addition, the scores for the Buffer and Landscape Context and Hydrologic Regime attributes for projects were 15-18% lower than ambient scores in all regions. Differences can be attributed to a number of factors: size of project versus ambient wetland patches, landscape context, and project age/ maturation. For example, the fact that restoration projects tended to be smaller and more completely embedded in urbanized landscapes than ambient sites, could have lowered the Buffer and Landscape Context scores for projects. True differences are difficult to tease out without control of these confounding factors and well as a pre- and post-restoration baseline assessment. However, this study demonstrates the concept of how the use of low-cost rapid assessments, when incorporated into both regional and project assessments, becomes a mechanism to evaluate restoration program effectiveness. Future incorporation of rapid assessment into pre and post project monitoring at both impact and restoration sites, along with monitoring over time through the restoration trajectory will provide greater insight into the net effect of restoration actions relative to permitted wetland losses.

Importance of Reference in Probability-Based Surveys

Patterns in estuarine wetland condition based on ambient surveys and rapid assessment data must be interpreted with care, because gradients in latitude, geomorphology, hydrologic regime, and ecology among estuaries will control, to some extent, the best attainable (or reference) condition. Each CRAM module incorporates an internal standard for wetlands assessed with the module, based on established relationships among wetland conditions and related ecological processes (Stein et al. 2009a), and all assessed wetlands are evaluated against this internal model of the “best” wetlands in the class (Collins et al. 2007). Differences among regions must nonetheless be interpreted with an awareness of the existing natural variability among wetlands in those regions. In order to address 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 Rheinhardt 1996).

Although the ambient survey provides opportunities for identifying and selecting sites to comprise regional reference networks of estuarine wetlands, the internal CRAM standard for salt marshes should continue to be evaluated in the light of this first-time statewide ambient survey. Evaluation of internal standards will 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. As reference sites are identified statewide, CRAM metrics can be adjusted to account for natural variability (e.g. latitudinal gradients) and regional differences in any wetland

type. Further, identification of reference sites would assist in the development of performance thresholds for CRAM scores to differentiate between impaired from non-impaired conditions. While these thresholds may be subjective, a priori selected reference sites will ultimately verify the appropriateness of the threshold for the various CRAM metrics (Barbour et al. 1999).

Utility of RAMs in Probability-Based Surveys

The data obtained from our study indicate that a rapid method like CRAM was able to capture a variety of important regional differences in the condition of salt marshes in California. An assessment of salt marsh vegetation community structure in southern California and the San Francisco Bay estuaries found similar regional patterns in the condition of salt marsh vegetation in California (Fetscher et al. 2010). Regional differences in condition can have implications from a management perspective. For example, while the general negative correlation between estuarine wetland condition and intensity of adjacent land use is clear from this study, the management actions needed to address the issue at the regional scale will vary with the particulars of local land use history and practice.

Thus our study provides an example of how rapid assessment can provide similar insight into the general patterns of overall wetland condition comparable to the data collected through more intensive methods. Although rapid methods like CRAM provide a cost-effective means for basic assessment of overall ecosystem health, they are just one element of a comprehensive regional monitoring program. In most cases, RAMs will need to be used in conjunction with more intensive methods, rather than as stand-alone tools, to support management decisions. Intensive methods are essential to answer more precise management questions about particular plant and animal species, water quality parameters, or other condition aspects that are not individually assessed using RAMs. However, addition of rapid assessment to more intensive protocols has an advantage in that the CRAM data is available at the completion each assessment. . Although the addition of rapid assessment typically add 1-2 hours to the length of time the field crew is on site, the time required to process and obtain the assessment results is relatively minimal compared to methods that require the analysis of laboratory samples. In addition, RAM results can be used to help focus and prioritize the need and location for more intensive assessments. Thus, the low cost of RAM makes them ideal for addition for all state-sponsored assessments and becomes the mechanism through which state wetland management and restoration program effectiveness can be evaluated (Kentula 2007).

Although the inherent limitations of RAMs must be recognized, their integration with probabilistic survey designs provide a means to make unbiased estimates of wetland condition and can substantially reduce the amount of field time and kinds of data needed to monitor wetlands across large areas. Because estuaries throughout the world are recognized as important transitional habitats in larger wetland matrices,



with few global examples of holistic survey approaches for determining their condition, RAM applications provide vital information to inform the management of these unique wetland resources.

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Literature Cited

- Barbour, M.T., J. Gerritsen, B.D. Snyder, and J.B. Stribling. 1999. Rapid bioassessment protocols for use in streams and wadeable rivers: Periphyton, benthic macroinvertebrates and fish, Second Edition. EPA 841-B-99-002. U.S. Environmental Protection Agency; Office of Water; Washington, D.C.
- Bernhardt, E.S. 2005. Synthesizing U.S. river restoration efforts. *Science* 308: 636-637.
- Brinson, M.M., and R. Rheinhardt. 1996. The role of reference wetlands in functional assessment and mitigation. *Ecological Applications* 6: 69-76.
- Brockmeyer R., J. Rey, J. Virnstein, K. Gilmore, and L. Earnest. 1997. Rehabilitation of impounded estuarine wetlands by hydrologic reconnection to the Indian River Lagoon, Florida (USA). *Wetlands Ecology and Management* 4:93-109.
- Brown, M.T., and M.B. Vivas. 2005. Landscape development intensity index. *Environmental Monitoring and Assessment* 101:289-309.
- Cohen, M.J., C.R. Lane, K.C. Reiss, J.A. Surdick, E. Bardi, and M.T. Brown. 2005. Vegetation based classification trees for rapid assessment of isolated wetland condition. *Ecological Indicators* 5:189-206.
- Collins, J.N., E.D. Stein, M. Sutula, R. Clark, A.E. Fetscher, L. Grenier, C. Grosso, and A. Wiskind. 2007. California Rapid Assessment Method (CRAM) for Wetlands, v. 5.0.2. Available at: www.cramwetlands.org.
- Day, J.W., C.A.S. Hall, W.M. Kemp, and A. Yáñez-Arancibia. 1989. Estuarine ecology. Wiley-Interscience. New York, NY.

- Fairweather, P.G. 1999. Determining the 'health' of estuaries: Priorities for ecological research. *Australian Journal of Ecology* 24:441-451.
- Fell P., K. Murphy, M. Peck, and M. Recchia. 1991. Reestablishment of *Melampus bidentatus* and other macroinvertebrates on a restored impounded tidal marsh—comparison of populations above and below the impoundment dikes. *Journal of Experimental Marine Biology and Ecology* 152:33-48.
- Fennessy, M.S., A.D. Jacobs, and M.E. Kentula. 2004. Review of rapid methods for assessing wetland condition. EPA/620/R-04/009. U.S. Environmental Protection Agency, Washington, D.C. 75 p.
- Fennessy, M.S, A.D. Jacobs, and M.E. Kentula. 2007. An evaluation of rapid methods for assessing the ecological condition of wetlands. *Wetlands* 27:543-560.
- Fetscher, A.E., M. A. Sutula, J.C. Callaway V.T. Parker, M. C. Vasey, J.N. Collins, and W.G. Nelson. 2010. Patterns in Estuarine Vegetation Communities in Two Regions of California: Insights from a Probabilistic Survey. *Wetlands* 30:833–846. DOI 10.1007/s13157-010-0096-9
- Hickman, C. 1993. *The Jepson manual of high plants of California*. University of California Press. Berkley, CA.
- Johnston C.A., J.B. Zedler, M.G. Tulbure, C.B. Frieswyk, B.L. Bedford, and L. Vaccaro. 2009. A unifying approach for evaluating the condition of wetland plant communities and identifying related stressors. *Ecological Applications* 19:1739–1757.
- Kentula, M.E. 2007. Monitoring wetlands at the watershed scale. *Wetlands* 27:412-415.
- Lamberson J., and W. Nelson. 2002. Environmental Monitoring and Assessment Program, National Coastal Assessment Field Operations, West Coast Field Sampling Methods-Intertidal 2002. U.S. Environmental Protection Agency, Newport, RI.
- Mack, J. 2006. Landscape as a predictor of wetland condition: An evaluation of the Landscape Development Index (LDI) with a large reference wetland dataset from Ohio. *Environmental Monitoring and Assessment* 120:221-241
- Malakoff, D. 2004. Profile: Dave Rosgen: The river doctor. *Science* 305:937-939.
- National Academy of Sciences (NAS). 2001. *Compensating for wetland losses under the Clean Water Act*. National Academy Press. Washington, DC.



National Agriculture Imagery Program (NAIP). 2005. United States Department of Agriculture Farm Service Agency. Aerial Photography Field Office, Salt Lake City, Utah.

Noss, R.F. and B. Csuti. 1994. Habitat fragmentation. pp. 237-264 In G.K. Meffe and C.R. Carroll (eds.), Principles of conservation biology. Sinauer Associates. Sunderland, MA.

Rosenzweig, M. L. 1995. Species diversity in space and time. Cambridge University Press. New York, NY.

Scozzafava, M., M.E. Kentula, E. Riley, T.K. Magee, G. Serenbetz, R. Sumner, C. Faulkner, and M. Pryce. 2011. The national wetland condition assessment: National data on wetland quality to inform and improve wetlands protection. National Wetlands Newsletter 33:1-13.

Stapanian, M. A., T. A. Waite, G. Krzys, J. J. Mack, and M. Micacchion. 2004. Rapid assessment indicator of wetland integrity as an unintended predictor of avian diversity. Hydrobiologia 520:119–126.

Stein E.D., A.E. Fetscher, R.P. Clark, A. Wiskind, J.L. Grenier, M. Sutula, J.N. Collins, C. Grosso. 2009a . Validation of a wetland rapid assessment method: Use of EPA's level 1-2-3 framework for method testing and refinement. Wetlands 29:648-665.

Stein E.D., M. Sutula, A.E. Fetscher, R.P. Clark, J.N. Collins, J.L. Grenier, C. Grosso. 2009b . Diagnosing wetland health with rapid assessment methods. Society of Wetland Scientists Research Brief No. 2009-0010. 5 pp.

Stevens, D.L., Jr., and S.F. Jensen. 2007. Sampling design, implementation, and analysis for wetland assessment. Wetlands 27:515–523

Stevens, D.L., Jr., and A.R. Olsen. 1999, Spatially-restricted random sampling designs for design-based and model-based estimation. pp. 609-616 In Accuracy 2000: Proceedings of the 4th International Symposium on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences. Delft University Press. The Netherlands.

Stevens, D.L., Jr., and A.R. Olsen. 2004. Spatially-balanced sampling of natural resources. Journal of the American Statistical Association 99:262-277.

RESEARCH
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Sutula, M.A. , J.N. Collins, R. Clark, R.C. Roberts, E.D. Stein, C.S. Grosso, A. Wiskind, C. Solek, M. May, K. O'Connor, A.E. Fetscher, J.L. Grenier, S. Pearce, A. Robinson, C. Clark, K. Rey, S. Morrisette, A. Eicher, R. Pasquinelli, K. Ritter. 2008a. Status of perennial estuarine wetlands in the State of California. SCCWRP Technical Report 571. 48 pp.

Sutula, M.A. J.N. Collins, R. Clark, R.C. Roberts, E.D. Stein, C.S. Grosso, A. Wiskind, C. Solek, M. May, K. O'Connor, A.E. Fetscher, J.L. Grenier, S. Pearce, A. Robinson, C. Clark, K. Rey, S. Morrisette, A. Eicher, R. Pasquinelli, K. Ritter. 2008b. Assessment of the status of the State's estuarine wetlands in: Chapter 6 California's wetland demonstration program pilot. A final project report to the California Resources Agency, SCCWRP Technical Report 572. 111 pp.

Sutula, M.A., E.D. Stein, J.N. Collins, A.E. Fetscher and R. Clark. 2006. A practical guide for the development of a wetland assessment method: The California experience. *Journal of the American Water Resources Association* 42:157-175.

U.S. Environmental Protection Agency (USEPA). 1998. Condition of the mid-Atlantic estuaries. U.S. Environmental Protection Agency, Office of Research and Development. Washington D.C., USA. EPA/600/R-98/147.

U.S. Environmental Protection Agency (USEPA). 2003. Elements of a State Water Monitoring and Assessment Program. EPA 841-B-03-003. Washington D.C. 14 pp. (<http://www.epa.gov/owow/monitoring/repguid.html>)

U.S. Environmental Protection Agency (USEPA). 2006. Application of Elements of a State Water Monitoring and Assessment Program for Wetlands. 12 pp. www.epa.gov/OWOW/wetlands/monitor/#elements

United States Fish and Wildlife Service (USFWS). 2010. National Coastal Wetlands Conservation Grant Program. <http://www.fws.gov/coastal/coastalgrants/faq.html>

United States Fish and Wildlife Service (USFWS). 2011. National Wetlands Inventory. Branch of Resource and Mapping Support. <http://www.fws.gov/wetlands/index.html>.

Wardrop, D. H., M. E. Kentula, D. L. Stevens, Jr., S. F. Jensen, and R. P. Brooks. 2007. Assessment of wetland condition: an example from the Upper Juniata watershed in Pennsylvania, USA. *Wetlands* 27:416-30.

Zedler, J.B., and J.C. Callaway. 2000. Evaluating the progress of engineered tidal wetlands. *Ecological Engineering* 15:211-225.



ESTIMATING THE EXTENT OF NON-JURISDICTIONAL WETLANDS: What Methods Are Being Used To Determine This?

Colleen Charles

Issue: As identified in the 2008 report, Status and Trends of Wetlands in the Coastal Watersheds of the United States 1998-2004, wetlands in coastal watersheds were disappearing when trends for the same time period suggested that the country as a whole was gaining wetlands. This fact points to the need for more research on the natural and human forces behind these trends in coastal areas. The 2008 report presents the latest status information on coastal wetland resources and provides estimates of losses or gains (prior to Hurricanes Katrina and Rita) that occurred in coastal watersheds between 1998 and 2004. Much of the wetlands lost can be attributed to development along the coasts. Both regulated and non-regulated wetlands are being lost - but how do we determine the amount of non-jurisdictional wetlands that are lost to human forces? Are there methodologies that are presently being used that can be transferred across the landscape?

In response to concerns of the rate of wetlands loss in coastal regions the Interagency Coastal Wetlands Working Group (ICWWG) came together to help identify the causes of these losses as well as identify strategies being used to address them. Remote sensing and GIS methodologies would be of particular interest. The ICWWG is a federal workgroup led by the U.S. Environmental Protection Agency (EPA) with participation from other federal agencies, including National Oceans and Atmospheric Administration (NOAA), U.S. Fish and Wildlife Service (FWS), U.S. Geological Survey (USGS), and the U.S. Army Corps of Engineers (Corps). This group is developing pilot studies to identify the most significant underlying causes of coastal wetlands loss in select geographic areas. The ICWWG is requesting input from the community of wetland practitioners on a component of the study design: identifying estimates or ways to estimate what percentage of coastal wetlands are potentially not under the jurisdiction of the federal Clean Water Act (CWA), i.e., not considered "waters of the United States." (U.S. Supreme Court decisions in *Solid Waste Agency of Northern Cook County v. U.S. Army Corps of Engineers* and *Rapanos v. United States*, have restricted the ability of EPA and the Corps to regulate certain wetlands and other waters under the CWA and have caused confusion over which waters are clearly protected by the Act.) The ICWWG is seeking this input for analytical purposes only. The Corps and EPA will continue to determine CWA jurisdiction on a case-by-case basis for regulatory purposes. If you have any methodologies, techniques, suggestions, or citations that would be helpful to these pilot studies please send them to Colleen Charles at colleen_charles@usgs.gov.

Background:

To help identify the causes of coastal wetland losses, as well as strategies being used to address them, the ICWWG held seven regional workshops involving local, state and federal stakeholders. Based on findings of the workshops the ICWWG provided input to the National Ocean Policy Implementation Plan to address regional ecosystem protection and restoration. The input was accepted as an Action Item in the draft Strategic Action Plan for Regional Ecosystem Protection and Restoration.

Action 2: Reduce coastal wetland loss and improve understanding of coastal wetland status and trends.

To reduce, and work toward the goal of reversing, coastal wetland loss, Federal agencies (principally EPA, NOAA, USACE, and FWS) will work together and in cooperation with States and Tribes to identify the underlying causes of loss and opportunities to more effectively protect and restore the important functions and values provided by wetlands in coastal watersheds. Due to a number of factors that include natural process and increasing human impacts in densely populated coastal areas, wetlands in coastal counties are being lost at a rate four to five times higher than inland wetlands. Some of the most well-known coastal wetland losses are near-shore tidal, or estuarine, wetlands, particularly along the coast of Louisiana and the rest of the Gulf of Mexico. The overarching strategy to address wetland loss will be based on the results of pilot studies conducted to identify the most common underlying factors responsible for coastal wetland loss and the most successful tools for addressing this loss. There are numerous on-going efforts to restore wetland ecosystems (e.g., the Gulf Coast Ecosystem Restoration Task Force). The actions discussed here are intended to complement these ecosystem restoration plans.

Outcomes

Conservation of coastal wetlands (including freshwater and saltwater wetlands in coastal watersheds) will improve through recommended strategies and collaborative actions that can be taken by Federal, State, Tribal, and/or local entities to reduce and ultimately reverse the loss of coastal wetlands.

To address one of the milestones of Action 2, the ICWWG is in the process of developing a framework in 2012, in which to compile and assess data and information from pilot coastal watersheds. The focus of the pilot studies is on coastal watersheds defined as 8-digit HUCs that contain head of tide. Although many wetlands in coastal watersheds are tidal and therefore clearly jurisdictional, coastal watersheds also contain freshwater non-tidal wetlands that may or may not be jurisdictional¹. For example, wetlands that are adjacent to non-navigable tributaries that are not relatively permanent are themselves not jurisdictional if they lack a



significant nexus with traditional navigable waters. In addition, intrastate, non-navigable, isolated wetlands, are not jurisdictional where they lack a clear relationship to traditional navigable waters. Such non-tidal wetlands with uncertain jurisdictional CWA protections may account for many waters in particular geographic areas. Wilcox et al. (2012), note that there are at least 400,000 hectares of depressional wetlands in the Texas coastal plain with uncertain protections². The results of the pilot studies will form the overarching strategy to address wetland loss in coastal watersheds by identifying the most common underlying factors responsible for wetland loss and the tools for addressing this loss.

1. The regulatory definition of waters of the United States includes “[a]ll waters which are currently used, or were used in the past, or may be susceptible to use in interstate or foreign commerce, including all waters which are subject to the ebb and flow of the tide” (33 C.F.R. § 328.3(a)(1); 40 C.F.R. § 230.3(s)(1)). Tidal waters are included in these waters, which were not at issue in the Supreme Court’s decisions in SWANCC or Rapanos.

2. Wilcox, B.P., D.D. Dean, J.S. Jacob, and A. Sipocz. 2011. Evidence of Surface Connectivity for Texas Gulf Coast Depressional Wetlands. *Wetlands* 31(3): 451-458. <http://essm.tamu.edu/media/45630/evidence-of-surface-connectivity-for-texas-gulf-coast-depressional-wetlands.pdf>

2012 SWS PNW Chapter Annual Meeting

East or West, Water Defines Us All

Conference dates: September 19-21, 2012

Venue: The Grove Hotel, Boise, Idaho

The next Pacific Northwest Chapter SWS Conference will be held September 19-21, 2012 in Boise, Idaho at the magnificent Grove Hotel.

This is sure to be an exciting event with new material for the concurrent and plenary sessions. The conference will also follow familiar and previously successful formats of poster sessions, exhibitor booths, a silent auction, chapter business meetings, social functions and field trips or workshops. Idaho has numerous unique wetlands and waters systems near the city of Boise for field trip opportunities.

This is a wonderful opportunity for informational exchange and connecting with people so please join us this fall!

For more info, see: <http://depts.washington.edu/uwconf/sws/index.html>



Rocky Mountain Chapter News

The Rocky Mountain Chapter of SWS has seen some big changes in the last year! It has updated its website; appointed a state coordinator in each of its five states including New Mexico, Colorado, Utah, Montana, and Wyoming; and started holding events that bring together both members and non-members.

The new website allows for members to post information on the “Bulletin Board,” interact with others via the web using the “Discussion Board,” and post events and publications. The state coordinators are organizing local events to energize the membership and enhance wetland education in each state. Since 2009, Chapter President, Andy Herb, has been hosting the “Denver Speaker Series” twice a year that provides presentations and a discussion forum for wetland issues and projects that are relevant to those working, studying, or otherwise interested in wetlands. The meetings have been a great success, attracting 40 to 50 people for each event. They are sponsored by local companies so they can be offered free to members. Montana has followed in Colorado’s footsteps by holding their first Speaker Series this past fall in Bozeman, MT and is in the process of organizing their next event to be held in Missoula, MT. Other events are planned in 2012 for Albuquerque, NM; Salt Lake City, UT; and Jackson, WY.

The overall goal of the Denver Speaker Series and the events in the other RM Chapter states is to add value to SWS membership and to attempt to integrate wetland experts from the three main wetland sectors: regulatory/government, research/academia, and applied/consulting. Andy believes that too often these sectors are operating independently and that each sector has something to learn from the other two. He believes that sharing information so that all groups are informed of the latest research, trends, and methods regarding wetlands will translate to a better understanding of wetlands, a more focused approach to wetland management, and higher quality, consistent work in all sectors.

If you are interested in becoming involved or want to learn more about the Rocky Mountain Chapter, check out the website at <http://www.sws.org/regional/rockymountain/index.html>.

The Ecology and Management of Atlantic White Cedar Symposium

June 12-14, 2012

The Hilton Garden Inn on the waterfront in Suffolk, VA

<http://www.ncsu-feop.org/AWC/index.html>

This triennial symposium will address approaches used to characterize and/or monitor Atlantic White-Cedar (AWC) ecosystem hydrology, soils, biogeochemical cycling, nutrient fluxes, plant physiological ecology, biodiversity, genetics, pathology, wildlife biology, threatened and endangered species, fisheries and aquatic resources, silvicultural techniques, paleoecology, bird conservation, taxonomy, culture practices in nurseries and the field, regional issues, and ecological conservation/integrity at the local and landscape scale.

Special themes for the 2012 symposium are cultivation and establishment of Atlantic White-Cedar biodiversity of AWC ecosystems.

The host is the Great Dismal Swamp National Wildlife Refuge.

Virginia Association of Wetland Professionals

The Virginia Association of Wetland Professionals (VAWP) is pleased to announce its 2012 Spring Workshop, to be held on Friday, May 11th, at the Lewis Ginter Botanical Gardens in Richmond, VA. The theme of this year's meeting is "Threats to Aquatic Resources in Virginia." The workshop will present an update and overview of various biological and physical threats to aquatic resources (wetlands, streams) within the state of Virginia. There will also be some discussion of possible solutions to combat these threats. A wide range of speakers will discuss Phragmites (distribution, impacts, control, and eradication), predation within wetland systems by nutria and geese, invasive mussels and their effect on stream systems, biotic response of aquatic systems to development, status of permitted tidal wetland losses in VA, effects of climate change/sea-level rise, and other topics! We have also reached out to universities within the Commonwealth, to have graduate students display their research in poster sessions throughout the day. The meeting will be 8:30 a.m. to 3:30 p.m. Lunch, snacks and beverages provided! Any questions? Please contact Tara Fisher, VAWP Programs Chairperson, at 757-382-6206 or tfisher@cityofchesapeake.net.



Launch of Ramsar's new series: Scientific and Technical Briefing Notes

http://www.ramsar.org/cda/en/ramsar-news-bn-series-launch/main/ramsar/1-26%5E25619_4000_0__

The Secretariat and the Scientific and Technical Review Panel (STRP) are pleased to announce the launch of a new series of Ramsar publications: Briefing Notes, a series of occasional communications on scientific and technical matters relevant to wetlands and to Convention implementation. These are published in English in electronic form (PDF), and when resources permit they will be published also in French and Spanish, the other official languages of the Convention.

The purpose of these Briefing Notes is to provide a means to share relevant and interesting scientific and technical information with diverse audiences within Ramsar and in the wetlands community more generally. While Briefing Notes are scientific in nature, they are generally not as detailed as Ramsar Technical Reports and are written in less formal language in order to make them more broadly accessible. Briefing Notes can cover a range of topics, including tasks within the STRP work programme as well as other emerging or current scientific issues of interest to the Convention.

The first two Briefing Notes in the series are now available and can be downloaded from here. Number 1 provides an overview of the series, while Number 2 addresses the issue of increasing demand for water storage capacity and what this could mean for wetlands in the future. Many of the information papers which have been provided by the STRP to support scientific and technical Draft Resolutions for the 11th Meeting of the Conference of the Parties to the Convention (Ramsar COP11) will also be published in the Briefing Notes series during the time before the COP.

For more information, contact the Secretariat stp@ramsar.org.

International Symposium on Aquatic Plants “Plants in hydrosystems: from functional ecology to weed research”

27-31 August 2012, Poznań, Poland

Symposium organized by:

European Weed Research Society (EWRS)

International Society on Limnology (SIL) - Working Group on Macrophytes

Polish Hydrobiological Society

Poznań University of Life Sciences

Scientific context:

The main theme of the symposium is ‘Plants in hydrosystems: from functional ecology to weed research’. The symposium holds:

- ***13th EWRS International Symposium on Aquatic Plants***
- ***2nd SIL International Workshop of Working Group on Macrophytes***

The following sessions are planned:

- Biology, ecology and distribution of aquatic plants,
- Aquatic plants in biomonitoring
- Nature conservation of aquatic and riparian vegetation
- Invasive species, management and control
- Environmental management in relation to aquatic plant cover
- Aquatic vegetation and environmental relationships
- Hydrobotanical systems in waste water treatment
- Remote sensing of aquatic vegetation
- Multifunctional charophytes: indicative value and environmental importance
- Role of aquatic vegetation in biogeochemical cycling
- Plant-microbe interaction
- Ecological restoration: aquatic vegetation and ecosystems
- Vegetation-hydrology interactions and flood control

Preliminary programme:

27th August (Monday): registration, opening ceremony, plenary lecture, reception

28th August (Tuesday): oral and poster sessions

29th August (Wednesday): oral and poster sessions, symposium dinner

30th August (Thursday): field excursion

31st August (Friday): oral and poster sessions, closing ceremony



Pre-Symposium programme:

25th-26th August (Saturday-Sunday):

Four independent modules are offered, focussing on different topics: identification of *vascular macrophytes* (1), *aquatic bryophytes* (2) and *charophytes* (3) as well as a *field workshop* (4) where training on the ecological status of a river will be offered combined with training on identification of local river and lake macrophytes.

Post- Symposium programme:

From 1st September (Saturday) – the post-symposium tour is offered as either a 3-day tour or a 2-day tour, starting in Poznań.

Registration fees for meeting (mid-conference excursion included):

EWRS/SIL Members: early 270€/late 370€

Others: early 300€/late 400€

Students: early 200€/late 250€

The fees cover participation in all symposium sessions, symposium material, abstract book, lunches and coffee or tea during the breaks as given in the program, the reception and a field excursion including dinner on Thursday evening.

Important dates:

30th April 2012 – deadline for early payment

31st May 2012 – deadline for abstract submission

5th June 2012 – final abstract decision

Symposium venue:

The symposium will be held in the city of Poznań, Poland. The symposium will be hosted by the Poznań University of Life Sciences.

Travel information:

By plane:

Poznań has regular plane connections with e.g. Barcelona-Girona, Copenhagen, Dortmund, Edinburgh, Frankfurt, Liverpool, London, Munich, Oslo, Rome, Warsaw, Zurich and Cracow.

By train:

EuroCity trains, regularly connecting Berlin and Warsaw, go via Poznań. It takes three hours to get from Berlin to Poznań as does the train journey from Warsaw. There are also convenient rail connections with all major towns and cities in Poland.

Accommodation:

Accommodation is plentiful in Poznań with a good choice of hotels and hostels.

Contact information:

<http://www.aquaticplants2012.pl>

aquaticplants@up.poznan.pl

phone: +48 61 8466510

fax: +48 61 8466510

CalWeedMapper

CalWeedMapper is a new website for mapping invasive plant spread and planning regional management strategies (calweedmapper.calflora.org). Users generate a report for their region that synthesizes information into three types of strategic opportunities: surveillance, eradication and containment. Land managers can use these reports to prioritize their invasive plant management, to coordinate at the landscape level (county or larger) and to justify funding requests. For some species, CalWeedMapper also provides maps of suitable range that show where a plant might be able to grow in the future. The system was developed by the California Invasive Plant Council (Cal-IPC) and is designed to stay current by allowing users to edit data.

The Calweedmapper website displays data on all 200 invasive plant species from Cal-IPC's statewide Inventory. These data combine two sources: interviews with invasive plant experts and occurrence information from Calflora and the Consortia of California Herbaria (CCH). The maps show abundance, spread and management status for each species, displayed by USGS quadrangle.

Users can generate reports in pdf format based on a selected region or species. The Regional Management Opportunity Report provides a summary table of information for all plants that present opportunities for management in the selected region. The Regional Species Report provides a map that illustrates the plant's spatial distribution in the region. These reports are designed to help land managers prioritize and fund their work.

This dynamic tool allows users to comment on and update abundance, spread and management information. Also, any new occurrence data submitted to either Calflora or CCH will update the data in CalWeedMapper. As a result, the maps will show current information.

To show where a given plant is most likely to spread, CalWeedMapper also displays suitable range based on climate. Computer models were used to generate suitable range for some plant species based on where they currently grow. The maps show the areas that contain suitable range based on climate conditions in 2010 and 2050. These maps can help land managers with climate adaptation planning and preparing for the movement of new invasive plants into their region.



Central Coast Wetland Group



The Central Coast Wetlands Group at Moss Landing Marine Laboratories is offering a twelve-month Postdoctoral Scholar Award to participate in State efforts to improve wetland and stream monitoring and characterization. Applicant should hold a Doctoral Degree in the fields of Biology, Community Ecology or Coastal Watershed Processes or related fields. Applicants should have received their doctoral degree within the past 3 years. The research will focus on status and trends of seasonal estuaries / coastal confluences and the development of wetland and riparian monitoring programs for the central coast. The recipient of the award will receive a stipend of up to \$50,000 in compensation and benefits for a 12 month appointment. In addition, limited support is available for travel expenses, equipment, supplies and special services. Second year appointment is contingent on additional grant funding.

Application will be reviewed beginning: April 15, 2012.

Areas of Research Focus:

- Evaluation of status and trends of seasonal estuaries / coastal confluences
- Development of regional numeric indicators of creek and river conditions
- Development of wetland and riparian monitoring programs for the central coast
- Wetland/ coastal habitat adaptations to Climate Change
- Grant writing and management

Additional tasks may include:

- Data Analysis and research publication
- Implementation of the California Wetland and Riparian Area Monitoring Program (WRAMP).
- Graduate course instruction at Moss Landing Marine Laboratories

For more information on current projects of the Central Coast Wetlands Group contact [Ross Clark](#) or [Kevin O'Connor](#) and visit www.centralcoastwetlands.org.

INTECOL Proceedings Available on CD

The 2-volume Proceedings of the INTECOL's First International Wetlands Conference, held in New Delhi in 1980 (published 1982 as *Wetland Ecology and Management*) is being reproduced by the organizers of the Conference –the National Institute of Ecology, on a CD. The CD will be priced at US \$ 25 (including air mail postage). For details, please contact Brij Gopal (brij44@gmail.com).

LinkedIn: Living Shoreline Erosion Control Group

Kevin Du Bois, at the City of Norfolk, VA has created a Living Shoreline Erosion Control user group on LinkedIn. The group was formed to encourage the exchange of information and ideas among interested scientists, policy makers, regulatory staff, local park or public land managers, marine contractors, and citizens. If you are interested in joining, use the Group search tool in LinkedIn and sign up today!

Kevin R. Du Bois, PWS, PWD,
Bureau of Environmental Services, 508 City Hall Building, Norfolk VA 23510
Cell: 757-621-2564

Calendars

SWS-SAC Wetland Photo Calendars are for sale at <http://www.cafepress.com/swssac.590838069>. We've received great reviews from those that have already purchased theirs and they are hanging on the wall. Even though we are going into March, they are still many months of beautiful wetland photos left. Also, when folks are done with the calendar, their favorite photos will look good in frames on the wall.



Long Pasture Wildlife Sanctuary Presents: A Hands-On Wetland Creation Workshop for Professionals

Part of the Spadefoot Toad Restoration Project

Dates: May 22-24, 2012

Location: 345 Bone Hill Rd. Barnstable, MA

Hosted by: Mass Audubon In collaboration with:

- Center for Wetlands and Stream Restoration
- Partners in Amphibian and Reptile Conservation
- USDA Natural Resources Conservation Service
- USFWS Partners for Fish and Wildlife Program.

Who Should Attend: Biologists, foresters, hydrologists, engineers, technicians, educators, land trusts, and other non-profit and environmental org professionals.

Cost: \$240 which includes lunches on three days, hand-out materials, signed copy of the book Wetland Restoration and Construction - A Technical Guide by Thomas Biebighauser, and more!

SWS Student Award Winners – Prague

Congratulations to all 140 participants in the Prague 2011 Student Presentation Competition. The Awards Committee would like to acknowledge the time and effort needed to prepare and deliver a professional poster or oral presentation. It is also the pleasure of the Awards Committee to recognize the winners of the competition and those students who received honorable mention.

Dagmara Sirova

OUTSTANDING ORAL PRESENTATION

University of South Bohemia, Czech Republic

Faculty of Science

Elodie Maillard

OUTSTANDING POSTER PRESENTATION

University of Strasbourg, France

Laboratory of Hydrology and Geochemistry

Annette Piepenbrock

HONORABLE MENTION, ORAL PRESENTATION

University of Tuebingen, Germany

Vicky Ortiz-Santiago

HONORABLE MENTION, POSTER PRESENTATION

University of Hawaii at Hilo, United States of America

Cristian Estop Aragonés

HONORABLE MENTION, ORAL PRESENTATION

University of Bayreuth, Germany

We would also like to take this opportunity to thank those attendees who served as judges and offered constructive feedback to future scientists. As the 2012 annual meeting in Orlando approaches, the Awards Committee challenges a new cohort of student researchers to share their findings in the field of wetland science and other attendees to evaluate these presentations.





Wetland Economics 101



WETLAND SCIENCE AND PRACTICE



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