This project is funded by the California Bay-Delta Authority Science Program

Introduction to IRWM Part 1: Overview and Conceptual Model

S. W. Siegel[1], P.A.M. Bachand[1], J. Lowe[2], N.M. Kelly[3], D. Stralberg[4], V.T. Parker[5], J. Callaway[6], M. Vasey[5], N. Nur[4], G. Page[4], J.N. Collins[7], M. May[7], S. Bollens[9,5], C. Simenstad[8], E. Carpenter[5], R. Dugdale[5], F. Wilkerson[5]

[1]Wetlands and Water Resources, [2]Philip Williams and Associates, [3]University of California, Berkeley, [4]Point Reyes Bird Observatory, [5]San Francisco State University, [6]University of San Francisco, [7]San Francisco Estuary Institute, [8]University of Washington, [9]Washington State University, Vancouver

INTRODUCTION

This poster introduces the IRWM project. It states the CALFED questions that IRWM aims to address, IRWM project goals, the IRWM approach and teams, a road map for all the posters in this Special Poster Session, and the overall conceptual model used to develop a general experimental design and select field study sites.

CALFED QUESTIONS

1.How are tidal marsh ecosystem restoration efforts throughout the region affecting ecological processes at different scales?

At the heart of this question is the need to evaluate whether the investments made to date have yielded the benefits intended to the ecosystem at large. Not only do we want to understand if we've made progress in restoring a variety of desirable ecosystem functions, we also would like to know how effective various approaches are.

2.How best can we carry out cost-effective, informative monitoring of tidal marsh ecosystem restoration efforts to provide longer-term answers to the first question?

This question's premise is that we need to understand how to apply our finite monitoring resources most effectively to gain the greatest insight into the fruits of our collective efforts.

IRWM PROJECT GOALS

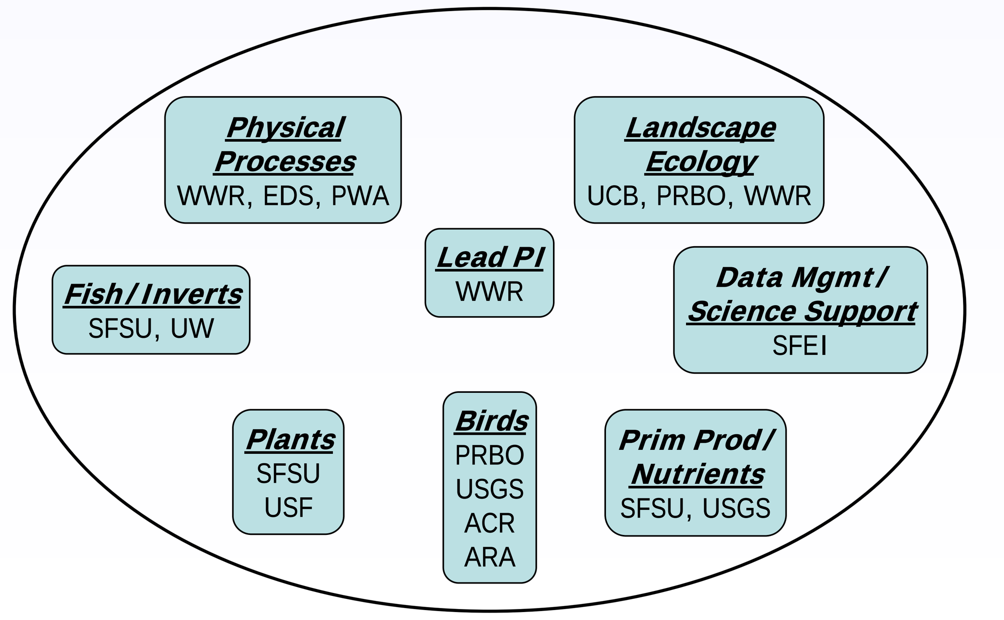
1. **To provide initial answers to the first question above**
2. **To determine methodological approaches at the site and regional scale for gathering and evaluating monitoring data**
3. **To complete baseline conditions monitoring at selected field sites to form the basis of longer-term monitoring**

IRWM APPROACH & TEAM

IRWM has taken a methodical, sequential approach to its development and implementation. This approach consists of (1) identifying a clear set of questions important to the CALFED program – these questions are listed above – (2) create a multi-disciplinary team necessary to address those questions, (3) creating a set of conceptual models identifying at multiple scales our understanding of tidal marsh ecosystems, their evolutionary trajectories after restoration, and their ecological processes, (4) developing numerous hypotheses from these conceptual models, (5) defining regional and site-specific experimental designs that would yield data from which we can evaluate the hypotheses and conceptual models, (6) identifying the universe of potential field sites and applying criteria to select sites that fulfill our experimental design, (7) obtaining permission and permits to use selected field sites, and finally (8) implementing field data collection and analysis. IRWM received its project funding in fall 2003 and today we are in the final stage of this approach.

IRWM consists of seven discrete "teams" organized thematically and with Principal Investigators, Co-Principal Investigators, Collaborators, and project staff from twelve academic, non-profit, and for-profit organizations (see Figure 1). In addition to these teams, the project includes a Lead Principal Investigator tasked with keeping the entire project moving forward and promoting collaboration amongst all the component parts. Figure 1 illustrates this structure. Two teams – physical processes and landscape ecology – provide the regional perspective expressed through general conceptual models and the remaining biological resource teams provide more detailed ecological process perspectives as expressed through several focused conceptual models.

Figure 1. IRWM Team Configuration and Organization Comprising PIs, Co-PIs, Collaborators, and Staff



ROAD MAP FOR THE IRWM-BREACH COMBINED POSTER SESSION

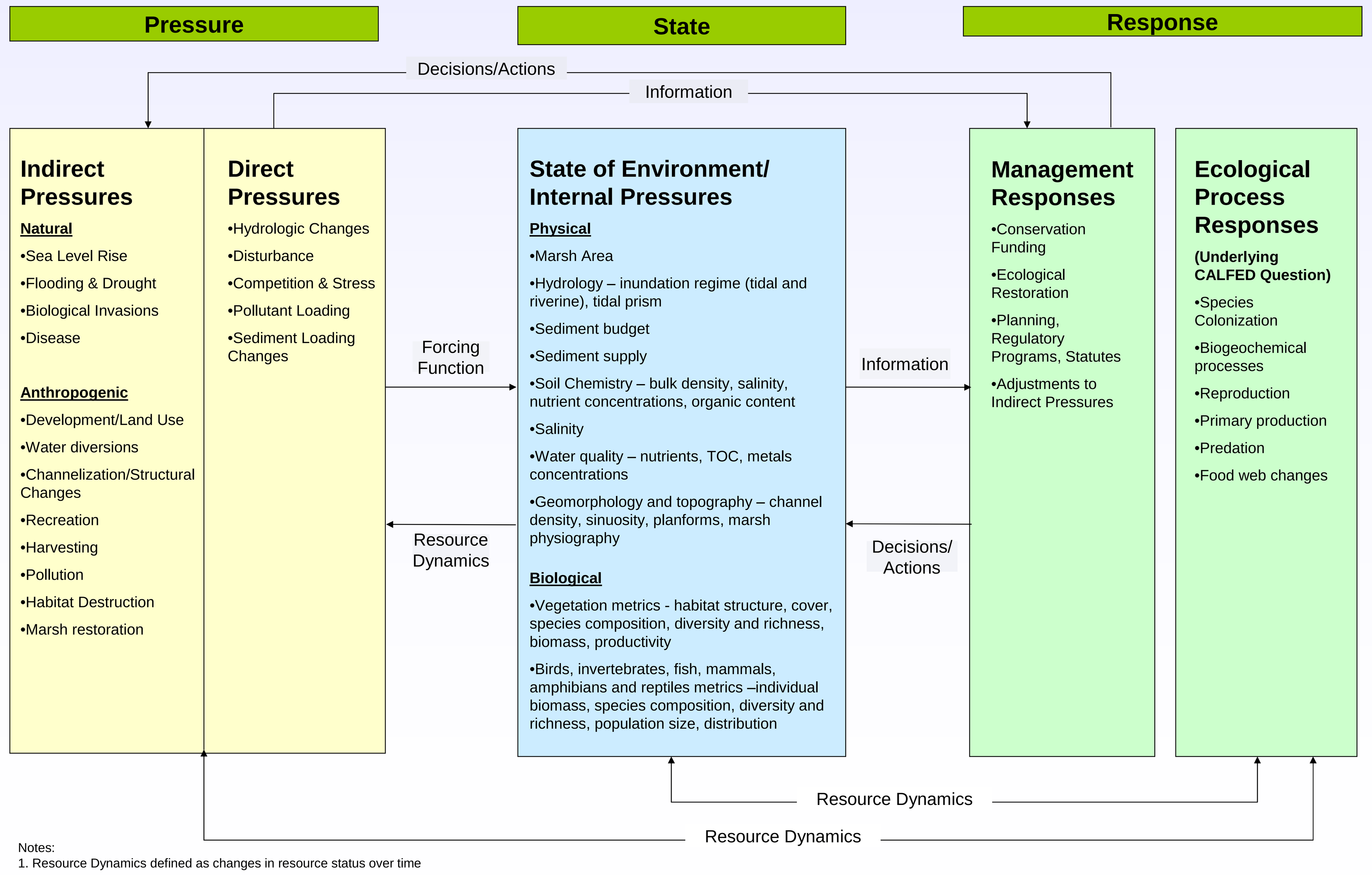
This poster session presents a total of 16 posters, 11 of which represent early IRWM results and 5 of which represent results from BREACH I and II. The CALFED Science Program previously funded the two-phased BREACH project which examined the evolutionary trajectories of numerous tidal marsh restoration projects from San Pablo Bay in the West to the central Delta in the East. Many PIs and organizations participate in both projects hence the combined poster session at this conference. Figure 2 lists the posters in this poster session.

Figure 2. IRWM and BREACH Posters

Poster Topic	***IRWM Posters***	***BREACH Posters***
Project Purpose	IRWM Purpose and Conceptual Models	
Physical Processes	Physical Processes Monitoring in Tidal Marshes	
Marsh Habitat		Sediments, Vegetation and Location Controls on Marsh Development
Nutrient	Nutrients/Primary Productivity in Wetlands	
Inverts		Invertebrate Assemblages
Inverts/Fish		Fish and Macroinvertebrate Interactions
Fish	Fish of Tidal Wetlands of SF Estuary	Native and Non-Indigenous Fish
Birds	Birds in Tidal Wetlands	Avian Response to Tidal Marsh Restoration
Vegetation	Channel Density and Vegetation Patterns	
Vegetation	Vegetation Mapping	
Vegetation	Napa Marshes Vegetation	
Landscape Ecology	Landscape Metrics	

Figure 3. Generalized Pressure-State-Response Model Evaluating Ecosystem Response of Marsh Restoration

Various indirect and direct natural and anthropogenic pressures affect the state of the marsh. Physical and biological state indicators can be used to describe the state of the marsh and serve as internal pressures via feedback mechanisms. State indicators provide information to develop appropriate management and design responses and to define resource dynamics that drive ecosystem responses. The model shown here provides examples for the San Francisco Estuary and the Delta.



Notes:
1. Resource Dynamics defined as changes in resource status over time

FORMULATION OF THE IRWM INTEGRATED CONCEPTUAL MODELS

The IRWM conceptual models derive from the underlying CALFED question stated above – *"How do tidal marsh restoration efforts affect ecosystem processes at different scales?"*. To formulate its conceptual models, the IRWM team drew upon principals from Pressure-State-Response models as a framework for identifying and characterizing model elements and used a tiered approach to integrate models across all project teams. The resulting conceptual models then served to inform our experimental designs at the regional scale (sites selected for the project) and at the site scale (placement of sampling stations within each site).

The Pressure-State-Response Model Framework

The Pressure-State-Response (PSR) model provides a widely used, robust and useful framework for analyzing the interactions between environmental pressures, states and responses.

Human activities exert pressures (such as pollution emissions or land use changes) on the environment, which can ***induce changes in the state of the environment*** (for example, changes in ambient pollutant levels, habitat diversity, water flows, etc.). ***Society then responds*** to changes in pressures or state with environmental and economic policies and programs intended to prevent, reduce or mitigate pressures and/or environmental damage.

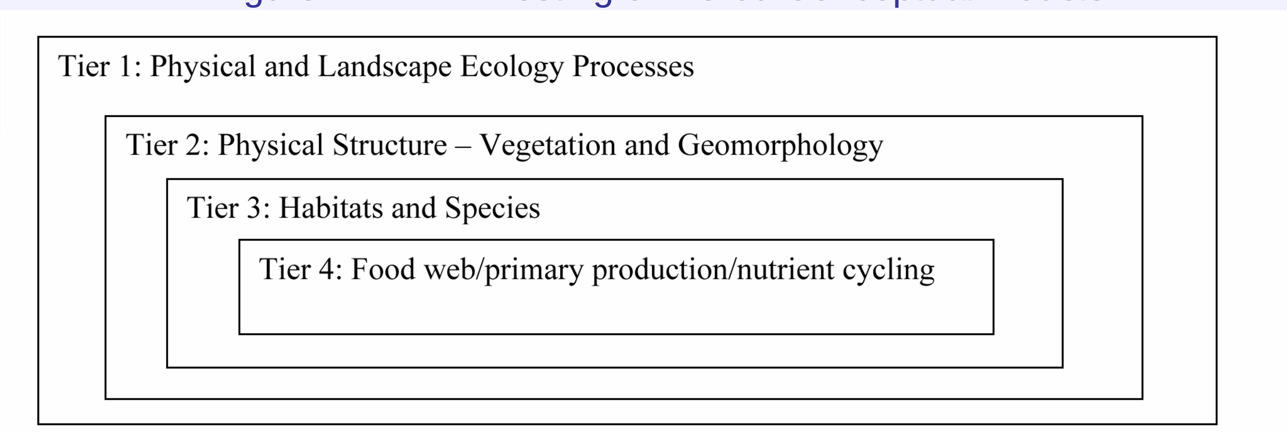
For IRWM, we have added ***environmental responses*** to changes in pressures or states in many ways, such as altered species composition, variable productivity levels, etc. Figure 3 represents this framework.

The "state" represents the conditions that exist and are monitored through measurement of biotic and abiotic indicators (e.g., inundation regime, sediment budget, soil chemistry, water chemistry, geomorphology and topography, vegetation composition, avian nesting, etc.). In the PSR model, measurements of state indicators provide the information to make management responses. Feedback mechanisms in the marsh also create a set of natural responses that reflect outcomes of ecological processes. Marsh restoration, as a management response, addresses pressures and changes the state of a system, resulting in changes in the ecosystem processes, a natural response.

The Four Tiers of the IRWM Integrated Conceptual Models

The IRWM team organized its conceptual models in a tiered fashion reflecting increasing levels of specificity – i.e., working from large spatial and temporal processes to focused ecological processes. The first tier within our integrated conceptual models, commencing at a larger scale and more generality, includes the physical and landscape ecology processes that drive the biology. The second tier, having a greater level of specificity, consists of vegetation and geomorphology – two structural elements that provide habitats for a wide variety of species and their effects on physical, biological, and chemical processes. The third tier consists of even greater specificity about relationships between habitats and the species that utilize the marsh in any manner. The final and most specific tier is the food web support functions of the tidal marsh (e.g., production and nutrient cycling) both within the marshes and between the marshes and the surrounding estuary. Figure 4 illustrates this organizational structure.

Figure 4: IRWM Nesting of Tiered Conceptual Models

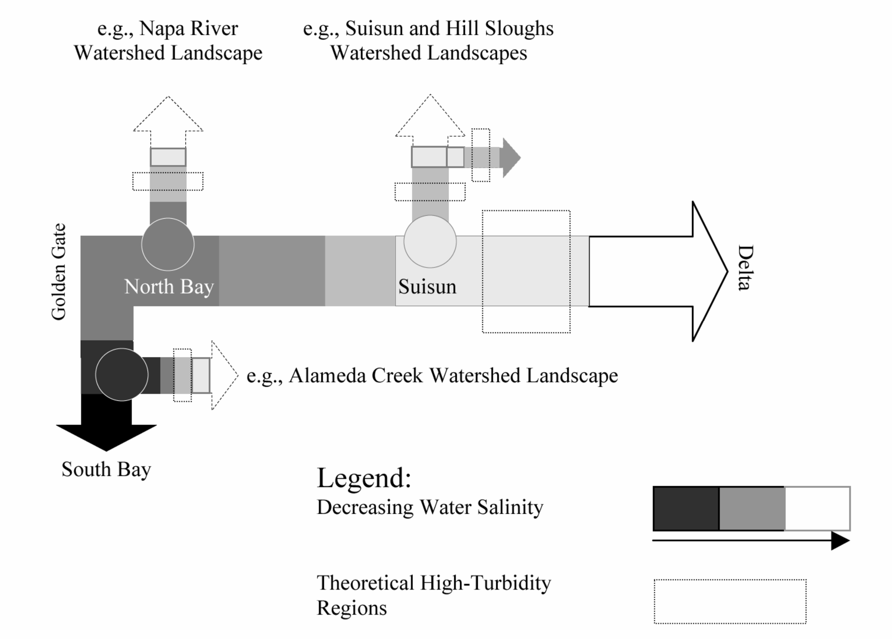


Tier 1 – Physical processes, landscape ecology, and biology exert controls on marsh presence and restoration evolution

As an introduction, we present the Tier 1 model within this poster. Models of Tiers 2-4 may be found in associated posters in this session. Tidal marshes exist where the twice-daily tides inundate intertidal landforms; elevation and landform-mediated water flow patterns most directly affect inundation regime. The vegetation that comprises the marsh plain derives from the inundation and salinity regimes interacting with plant species' physiological tolerances and interspecific competition and from the colonization mechanisms that bring plants into a restoration site. The proximity of a restoration site to other tidal marshes along with its landscape position relative to tides, rivers and streams, salinity regime, sediment supply, and adjacent land uses affects how and what flora and fauna colonize and establish and how landforms evolve. Accretion to restore intertidal marsh elevations and maintain them with sea level rise and internal settling stems from external sediment supply and internal peat accumulation. Foraging birds and fish, benthic invertebrates, algal growth, decomposition, and sunlight and wind exposure modify substrate continually.

Position along the estuarine salinity and tidal range gradients and proximity to sediment sources exert a strong control over the interacting biological and physical processes that affect tidal marsh restoration evolution and the resultant effects on ecological processes that support target biological resources. Figure 5 illustrates the estuarine salinity gradient element of this conceptual model.

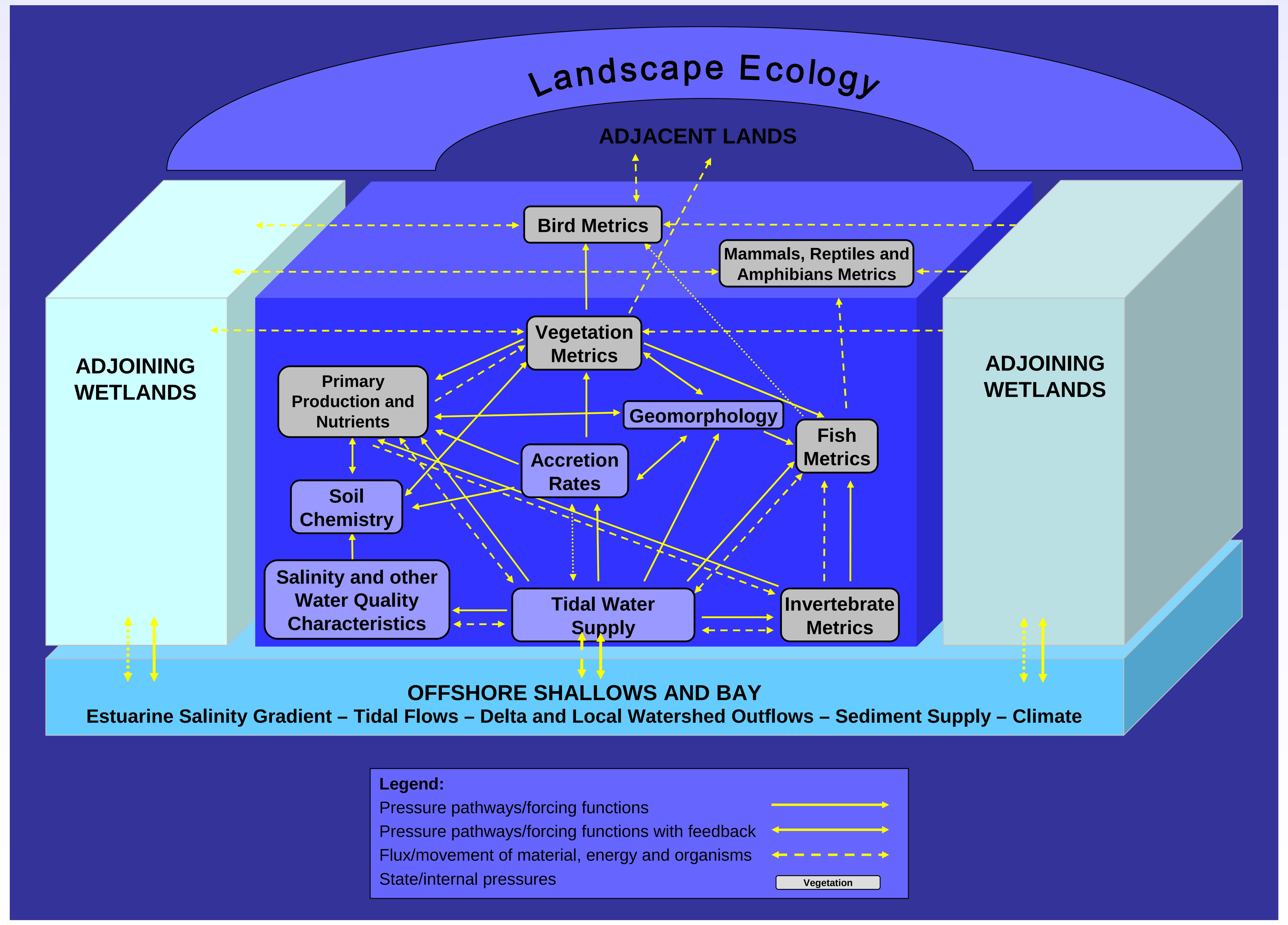
Figure 5. Diagram of Primary (Golden Gate – Delta) and Secondary (Local Watershed) Salinity Gradients



At landscape level, this conceptual model identifies landscapes in San Pablo and Suisun bays and the Delta by their structure (meaning the spatial relationship among distinct wetland patches or their elements), their function (meaning the flow of mineral nutrients, water, energy, or species among component patches or between landscapes), and change (meaning the temporal alterations in the structure and function of landscapes or their components). The processes of interest are varied, and overlap with those of the other teams that prepared this Integrated Regional Wetland Monitoring (IRWM) pilot program proposal to CALFED. Our premise is that the structure, function and change of patches across landscape mosaics affect fundamental ecosystem processes, which determine the trajectories of wetland restoration. At the landscape scale, the spatial configuration of wetland patches—e.g., their size, shape and connectivity—and the composition of surrounding uplands are the key components of structure.

Figure 6 illustrates the landscape-level conceptual model incorporating the underlying physical processes and linkages to the biological resources that utilize tidal marshes. Each of the Tier 2 through 4 conceptual models then provides the details intimated by this overall conceptual model.

Figure 6. Landscape-Level Conceptual Model



For more information visit: **www.irwm.org**