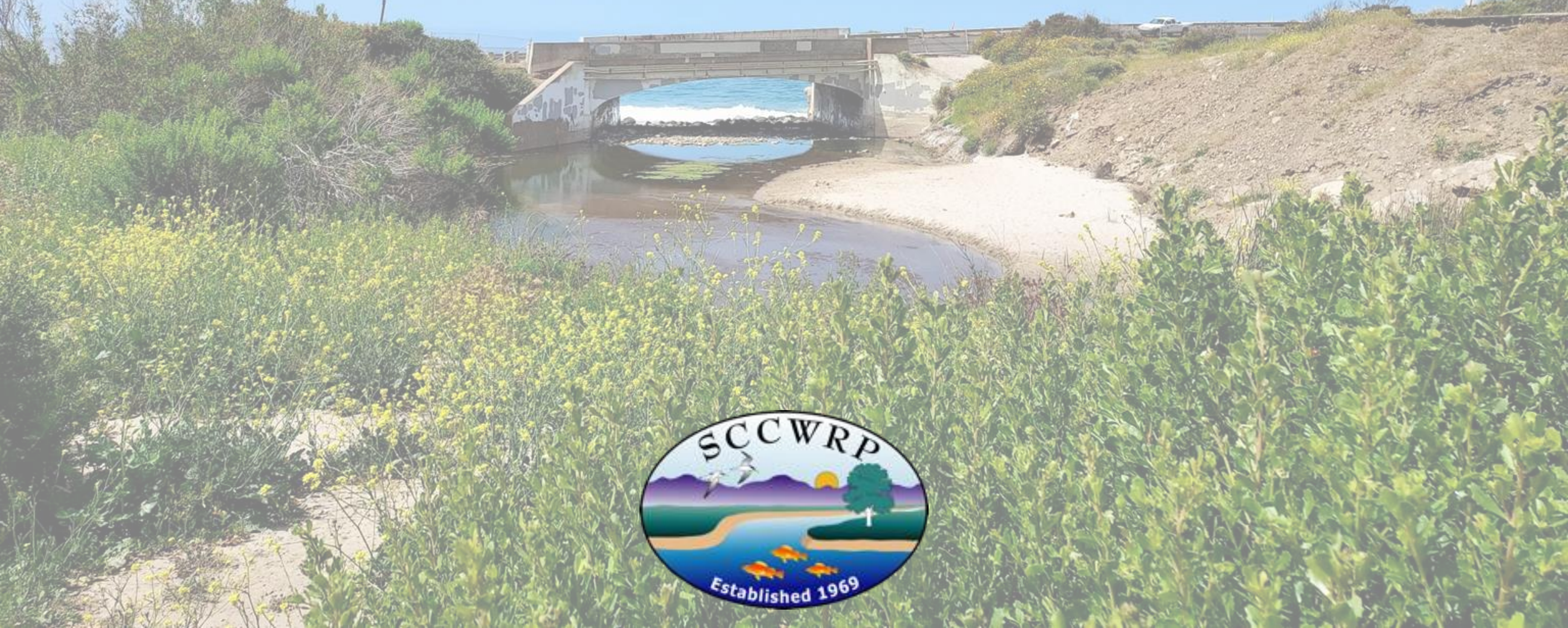
Restoration Monitoring Approaches: Lessons From California

Eric D. Stein – Southern California Coastal Water Research Project



Can Monitoring Help Us Judge Success?

- What is success?
- How does our concept of success change over time?
- What tools and approaches are most effective?

Source: EcoAtlas

Success: An Unclear, Subjective Descriptor of Restoration Outcomes

Joy B. Zedler

Ecological Restoration 2007

The pathway of restoration is often slow and not necessarily smooth. In addition, people involved will evaluate a project as a success or failure depending on their interests as well as specific measurements used to evaluate.

Assessments of success depend on perspective, goals, and time

Lessons Learned in California

- *Success is in the eye of the beholder*
- *Collaboration is key to gauging success*
- *Evaluation of success requires context*
- *Meaningful conclusions about success take time*
- *None of it matters if you can access and interpret the data*

Success is in the Eye of the Beholder

The definition of success depends on the functions prioritized for the restoration project; therefore, a function-based monitoring program is essential

Success is Based on the Functions Prioritized by Each Restoration Project

Nekton Habitat	Primary Production
Protected Species Support	Secondary Production
Nutrient Cycling	Sea level rise amelioration and resilience
Bird habitat	Shellfish support
Nursery habitat	Support of vascular plant communities
Wildlife support	

Estuarine Marine Protected Area Monitoring Program (eMPA)

OCEAN PROTECTION COUNCIL

The California Estuarine Marine Protected Area (EMPA) Monitoring Program is an ongoing effort to assess the quality and condition of estuaries statewide.

The program goals are to monitor California estuaries with a standard, comprehensive function-based assessment framework to determine the health of California's estuaries and the efficacy of MPA designation.

Multiple Indicators Can be Used to Assess a Given Ecological Function

Prioritize indicators for inclusion based on functions of interest:

1. Key ecological functions

2. Designated goals

Estuary		Indicators		
		Water quality	Water nutrient concentration	General community composition (eDNA)
Functions	Nekton Habitat			
	Primary Production			
	Secondary Production			
	Protected Species Support			

Green squares represent the indicators that can be used to evaluate function

Estuaries		Indicators												
		Water quality	**Water nutrient concentration**	**General community composition (eDNA)**	**Sediment characteristics**	**Benthic infauna abundance/diversity**	**SAV/macroalgae distribution**	**Fish abundance/ diversity**	**Crab abundance/ diversity**	**Marsh vegetation distribution/ diversity/ invasives**	**Marshplain elevation**	**Sediment accretion rates**	**Mouth dynamics**	**General habitat condition**
Ecosystem Functions	Nekton Habitat													
	Primary Production													
	Secondary Production													
	Protected Species Support													
	Nutrient Cycling													
	SLR Amelioration													
	Bird Habitat													
	Shellfish Support													
	Nursery Habitat													
	Support Vascular Plants													
	Wildlife Support													

Estuaries		Indicators												
		Water quality	Water nutrient concentration	General community composition (eDNA)	Sediment characteristics	Benthic infauna abundance/diversity	SAV/macroalgae distribution	Fish abundance/ diversity	Crab abundance/ diversity	Marsh vegetation distribution/ diversity/ invasives	Marshplain elevation	Sediment accretion rates	Mouth dynamics	General habitat condition
Ecosystem Functions	Nekton Habitat	■	■				■	■	■					
	Primary Production			■	■		■			■	■	■		■
	Secondary Production					■	■			■				
	Protected Species Support	■		■			■	■	■	■	■		■	■
	Nutrient Cycling		■		■	■	■			■		■	■	
	SLR Amelioration						■			■	■	■		■
	Bird Habitat					■	■	■	■	■	■		■	■
	Shellfish Support	■	■	■	■	■	■							
	Nursery Habitat					■	■	■	■				■	
	Support Vascular Plants	■			■		■			■	■	■		■
	Wildlife Support	■	■	■			■			■	■			■

Collaboration is the Key to Gauging Success

Development and application of consistent methods allows for leveraging of efforts

Buy-in among all agencies and partners is important to developing consensus about success

Standard Monitoring Protocols

- **Abiotic Factors:**
  - In-situ water parameters
  - Basic water chemistry and nutrients
  - Sediment cores
- **Biotic Factors:**
  - Fish surveys, BRUV
  - Crab surveys
  - Benthic invertebrates
- **Estuary Habitat Surveys:**
  - Estuary Habitat Condition (CRAM)
  - Marsh Plain Vegetation and Topo Surveys
  - SAV Surveys
  - Community Composition Assessments (eDNA):
  - SLR Vulnerability and Marsh Plain Accretion Rate Estimates
- **Watershed Processes and Stressors:**
  - Trash/microplastics
  - Landscape Stressors
  - Historical Habitat Change Analysis

Management Advisory Council

NATIONAL PARK SERVICE

Coastal Conservancy

CALIFORNIA STATE PARKS SINCE 1864

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION NOAA U.S. DEPARTMENT OF COMMERCE

NOAA FISHERIES

NATIONAL ESTUARINE RESEARCH RESERVE SYSTEM

NATIONAL ESTUARY PROGRAM

SFEI SAN FRANCISCO ESTUARY INSTITUTE

The Nature Conservancy

U.S. FISH & WILDLIFE SERVICE DEPARTMENT OF THE INTERIOR

OREGON Fish & Wildlife

OCEAN PROTECTION COUNCIL

UC SANTA CRUZ

SAN FRANCISCO STATE UNIVERSITY

Management Questions Developed by the MAC

- Assessing baseline conditions and subsequent trends of key metrics in EMPAs and non-EMPA estuaries:
  - ✓ Abundance, distribution, and conditions of habitats
  - ✓ Populations of native, culturally important, and special-status species
  - ✓ Populations of invasive species
- Assessing the impacts of the following:
  - ✓ Conservation status
  - ✓ Recreation
  - ✓ Climate change, including sea level rise, ocean acidification, and flow/sediment delivery
  - ✓ Upstream water diversions, pollution, and watershed management
- Developing information to support planning for:
  - ✓ Mouth/inlet management
  - ✓ Restoration, enhancement, and adaptive management
  - ✓ Inland migration of habitats
  - ✓ Infrastructure re-alignment

Management Needs

Assessing baseline conditions and subsequent trends of key indicators:	Habitat abundance and distribution	
	Habitat condition	
	Abundance and distribution of native, culturally important, and special-status species	
	Abundance and distribution of invasive species	
Assessing factors that affect conditions:	EMPA designation	
	Recreation and consumptive human uses	
	Climate change impacts	Aquatic temperatures
		Sea level rise
		Ocean acidification
		Watershed freshwater and sediment inputs
	Upstream water diversions	
	Watershed urbanization and agriculture	
Developing information to support:	Nature-based climate change adaptation	
	Mouth/inlet management	
	Habitat restoration, enhancement, and adaptive management	
	Inland/upslope migration of habitats	
	Infrastructure realignment	
Identifying appropriate reference locations for estuaries		
Assessing how EMPAs support offshore ecological communities		

Partnering with Permitting Agencies

- Incorporate standard protocols to:
  - ✓assess condition
  - ✓evaluate alternatives
  - ✓Identify potential mitigation areas

- Use indicators and protocols in mitigation monitoring requirements and performance standards

- Support and take advantage of the sentinel site/reference site monitoring

- Incorporate data into estuary portal

California Water Quality Monitoring Council & California Estuary Monitoring Workgroup (CEMW)

- California Water Quality Monitoring Council
  - ✓ Established by Ca. Legislature in 2006 (SB 1070)
  - ✓ Co-chaired by Natural Resources Agency and CalEPA

- Two Major Goals:
  - ✓ Improve coordination of water quality monitoring programs in California
  - ✓ Make information more accessible to agencies and the public (web portals)

- California Estuary Monitoring Workgroup
  - ✓ improve data sharing and access to help leverage resources
  - ✓ share tools and approaches and increase standardization
  - ✓ Current priority initiatives
    - Website/catalogue of existing monitoring programs in California
    - Develop statewide guiding questions and conceptual models

WATER QUALITY
MONITORING
COUNCIL

Evaluation of Success Requires Context

There needs to be a common set of sentinel sites to help contextualize site-specific monitoring results

There should be coherence between regional and site-based monitoring

Successful Relative to “What”: Setting Expectations

- Sentinel site
  - ✓Reference sites
- Ambient condition
- Regional/watershed goals

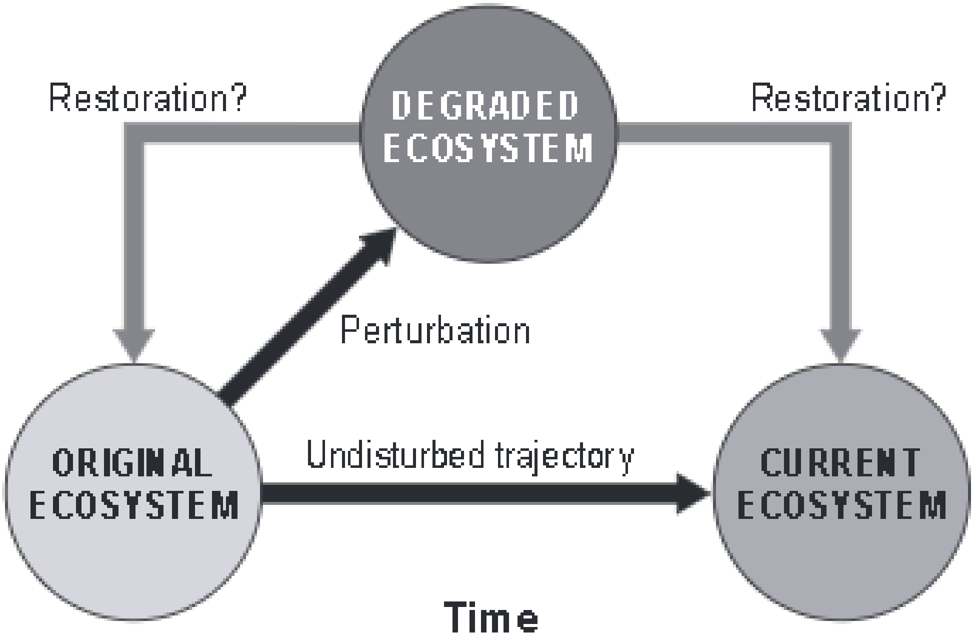


Fig. 1.5 Time changes an undisturbed ecosystem, making targets from the past hard to determine.

Harris and Van Diggelen 2006

Building a Sentinel Site Network

Sentinel site: Wetlands that are designated for long-term monitoring to track ecological condition through time, evaluate the effect of regional trends in external conditions/stressors, and as a basis of comparison (context) for restoration or mitigation sites

Three categories:

1. **Reference** - sites that reflect the least altered wetlands in the landscape, and often the sites used to compare reference conditions for project-specific monitoring (*not all sites will be reference for all functions*).
2. **Restoration** – sites that have been or are presently being restored. These sites have undergone large-scale restoration and are sites that can be tracked over time to understand their long-term ecological progression.
3. **Impacted/Degraded** – sites that are identified to be impacted by or at risk of impact from factors such as a major development project. These sites could also be heavily degraded.

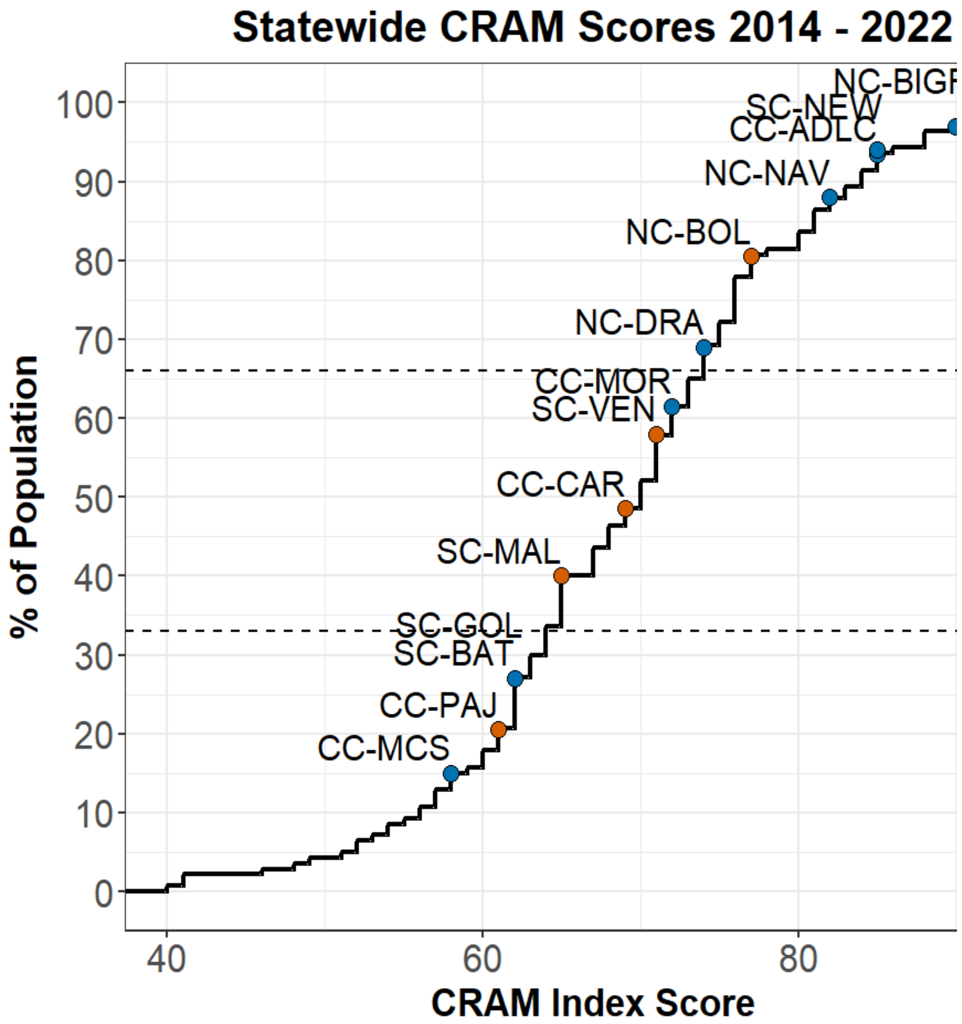
Defining Reference

Reference: Sites that reflect the least altered wetlands in the landscape, and often the sites used to compare to for project-specific monitoring.

1. We are evaluating reference at the **landscape level**, not per indicator. A reference site is not indicator specific, rather a site is chosen more based on *minimal* stressors.
2. We want sites with the highest functional performance possible across all archetypes.
3. We want **resilient** reference sites, where structure and function remain high regardless of stress.
4. The criteria for reference may be region specific.

Context for Gauging Success

Ambient conditions



Reference conditions

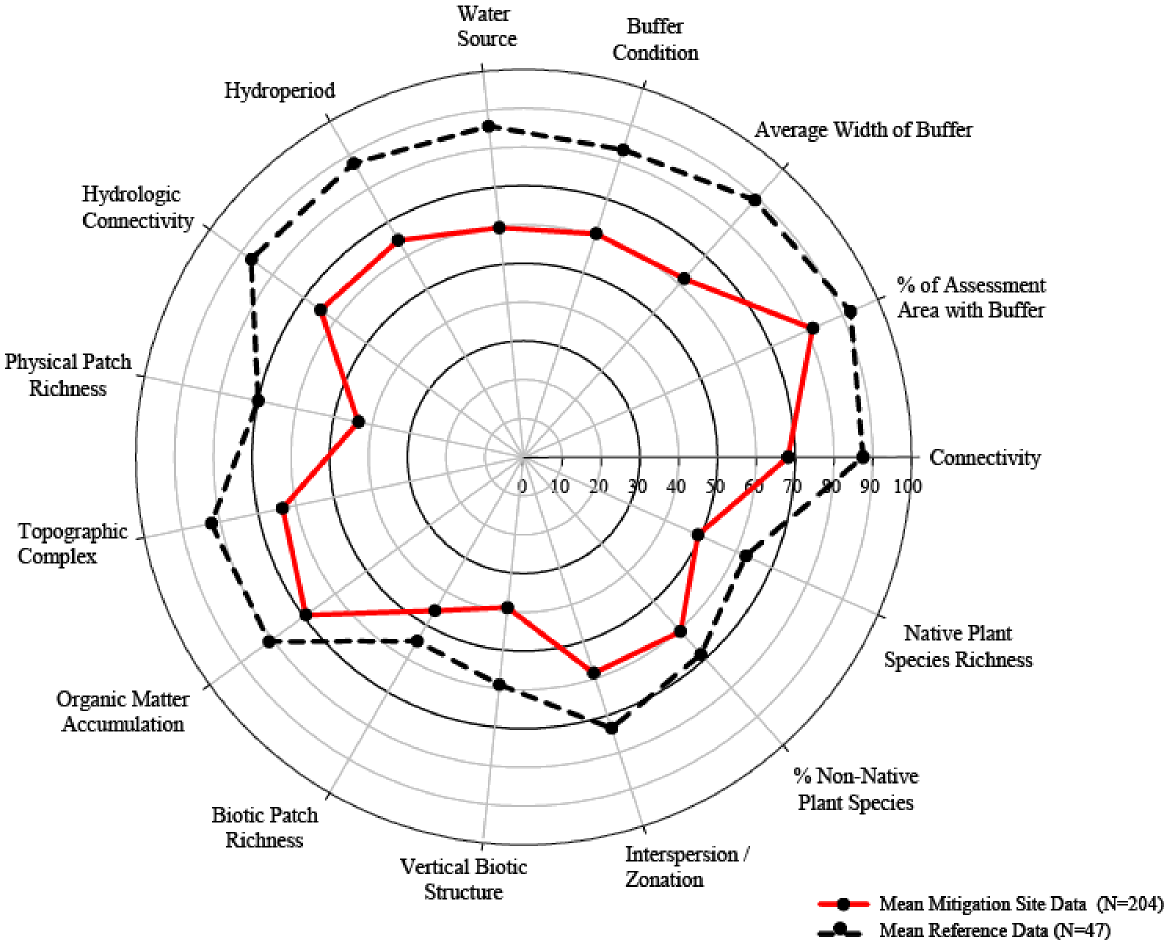
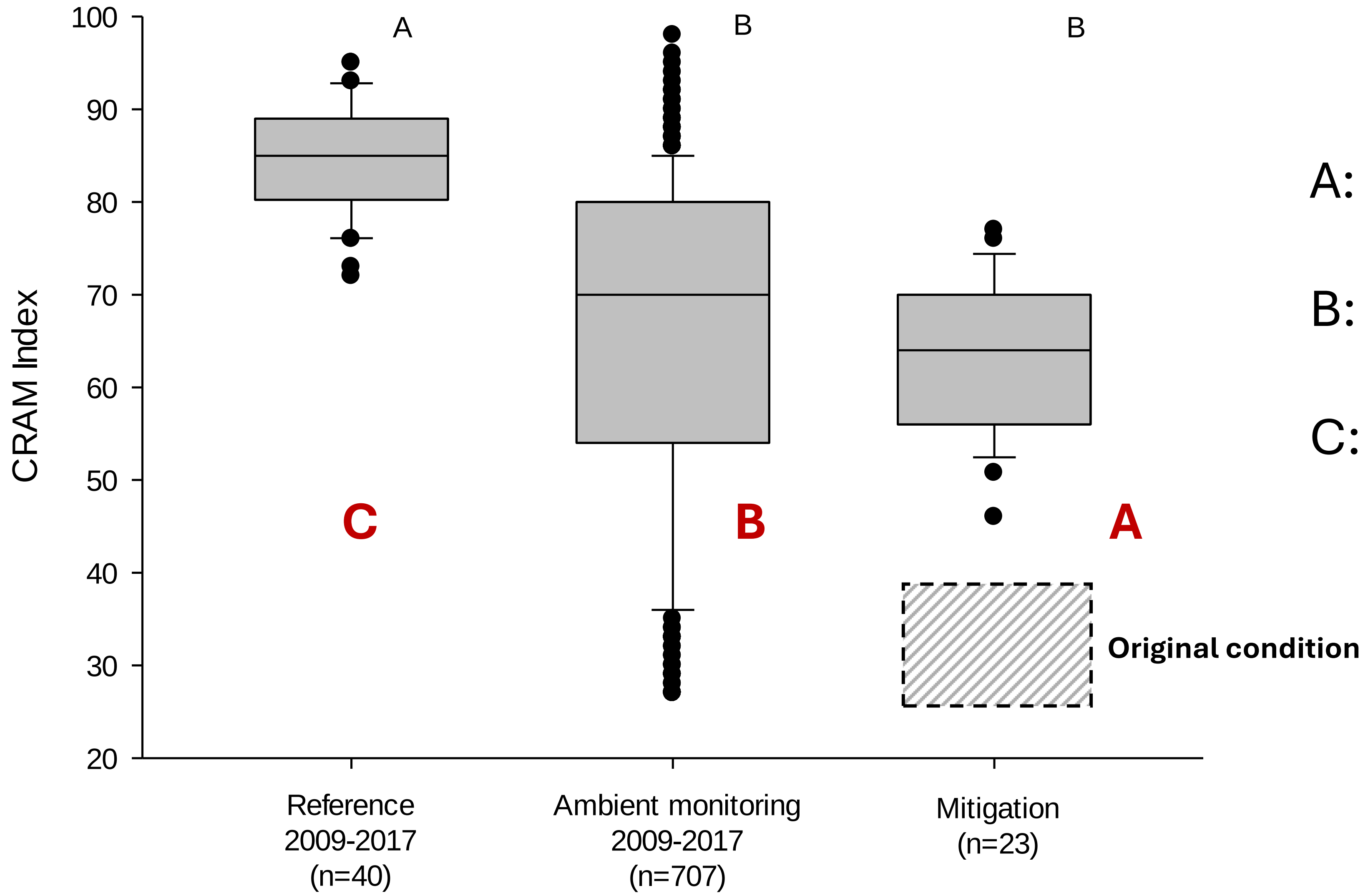


Figure 46. Mean percentage scores for each CRAM metric for mitigation sites (N=204) and reference sites (N=47).

Different Ways to Gauge Performance

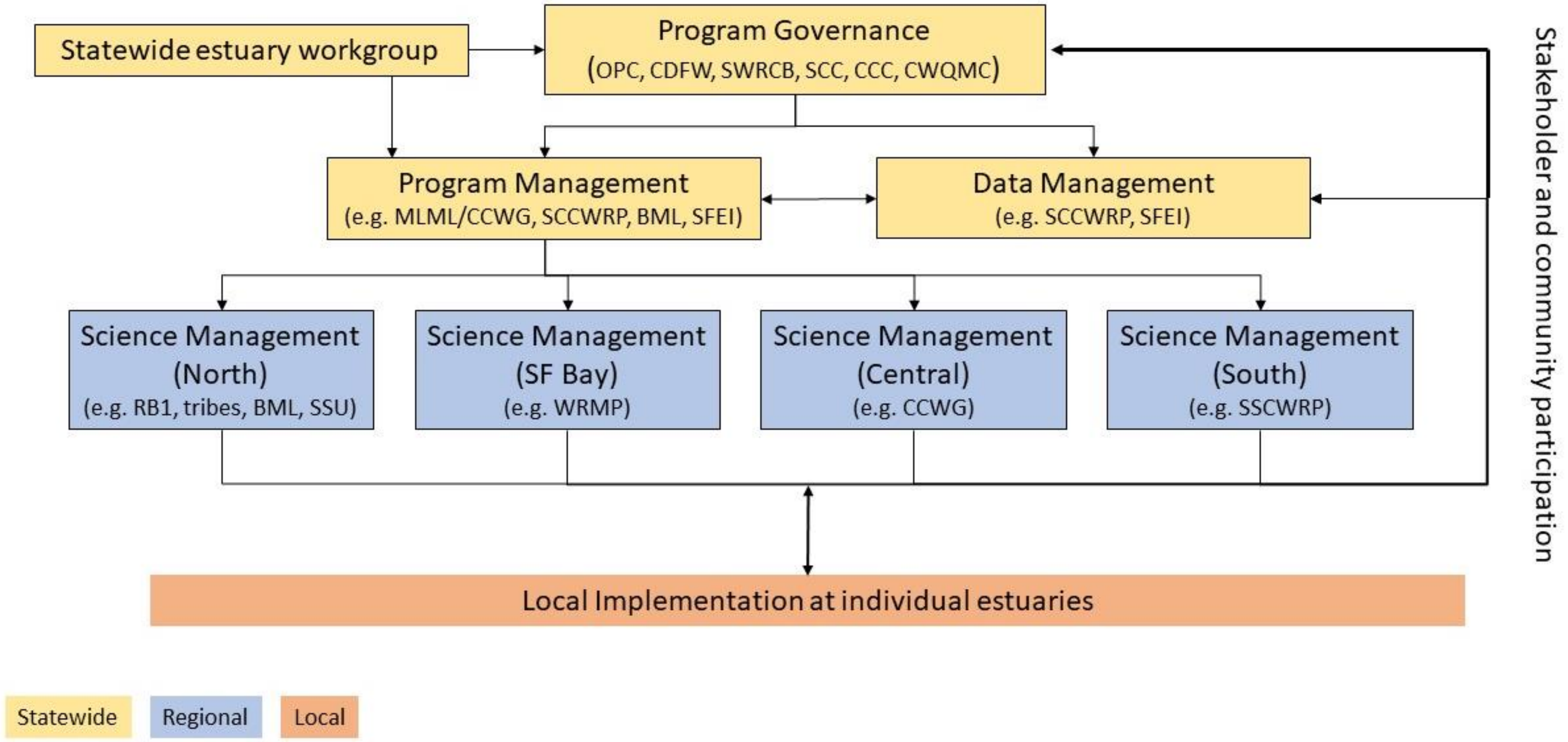


A: Improvement from baseline

B: Comparison to ambient

C: Comparison to reference

Coherence Across Different Levels of Monitoring

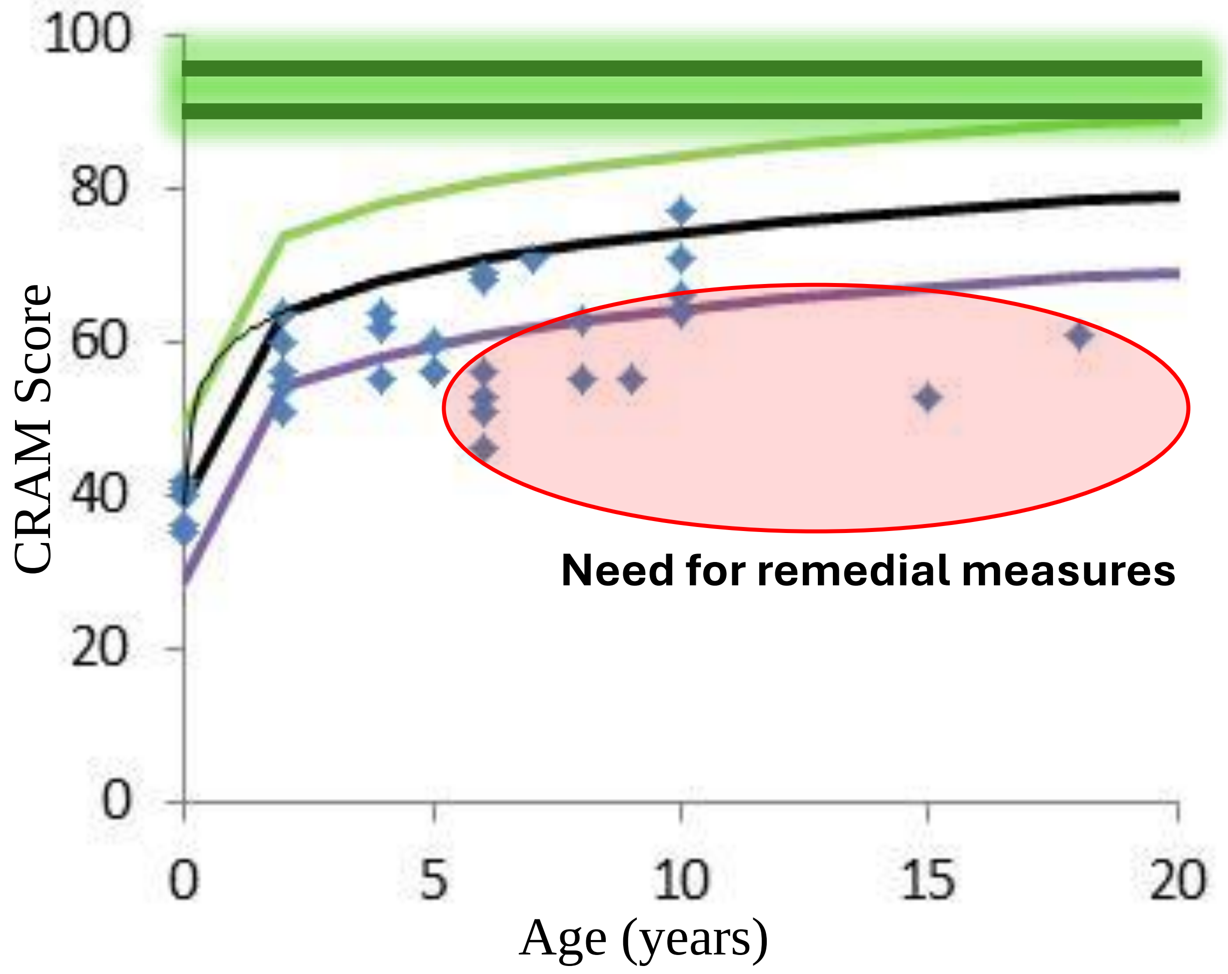


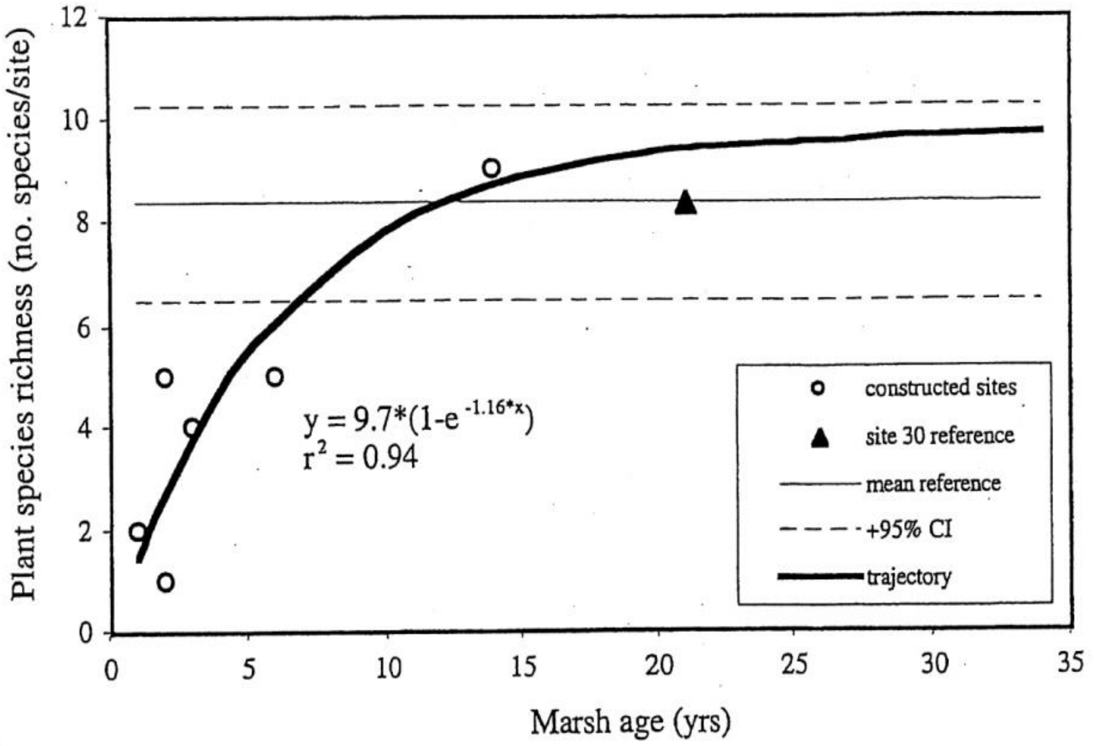
Meaningful Conclusions About Success Take Time

Long-term monitoring needs to be institutionalized through sustained regional monitoring programs

Monitoring should include measures of resiliency

Success Takes Time



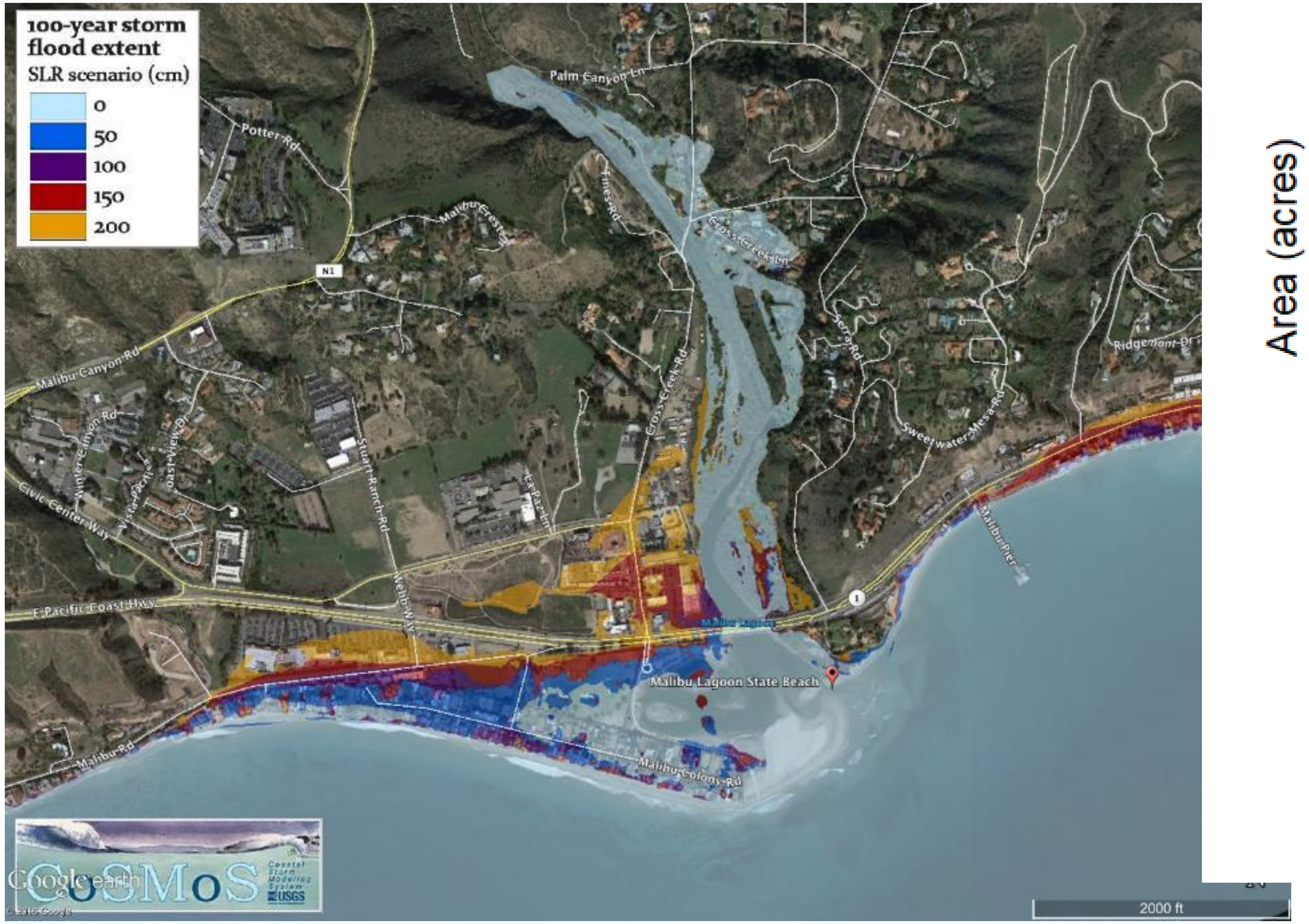


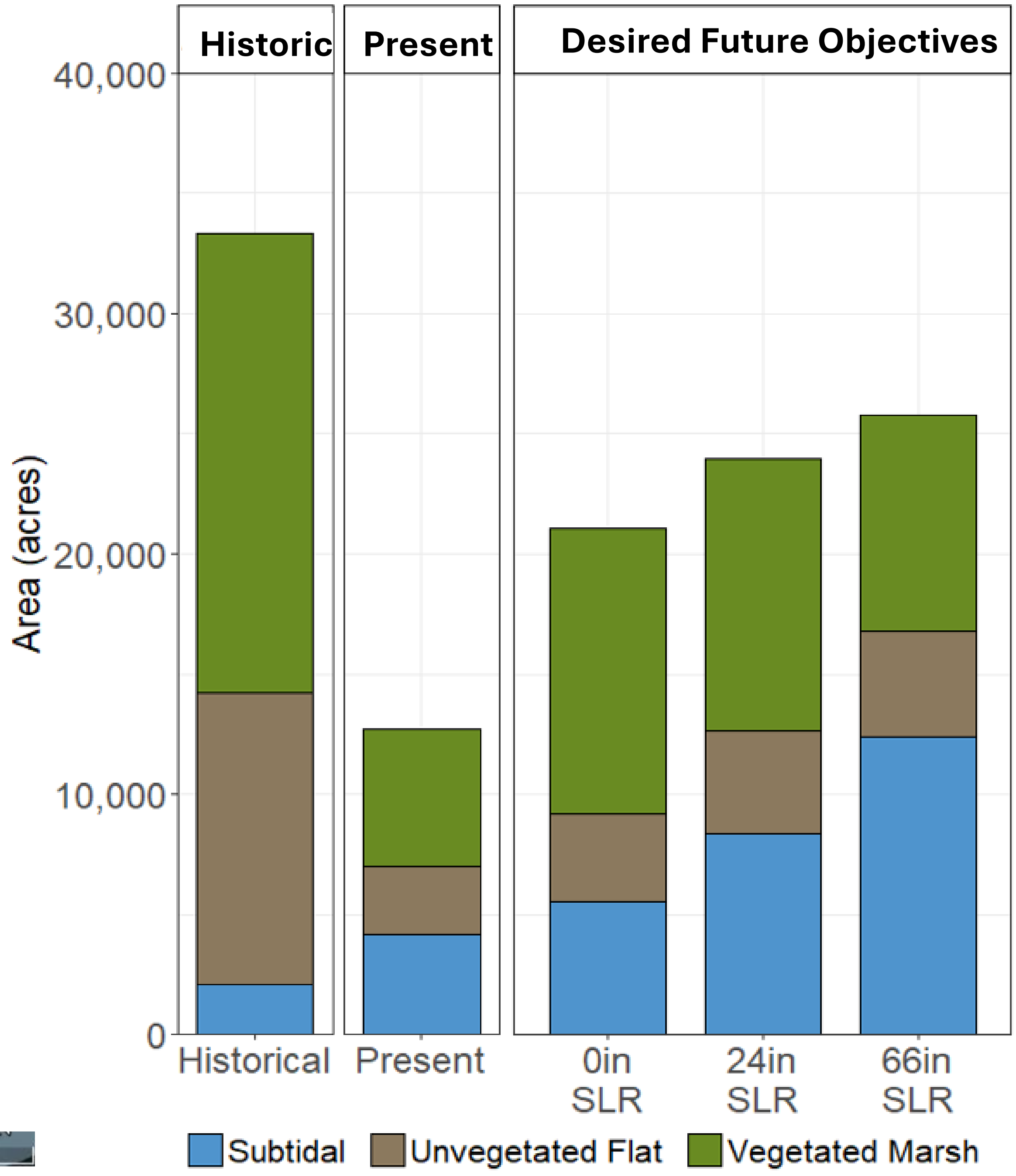
Morgan and Short 2002

Leverage Regional Monitoring Programs

- Estuarine Marine Protected Area Program
  - ✓ **Statewide**
- San Francisco Bay
  - ✓ Wetlands Regional Monitoring Program
  - ✓ Interagency Ecological Program
- Southern California
  - ✓ Bight Regional Monitoring Program
  - ✓ Wetlands Recovery Project Monitoring Program
- USEPA National Estuary Program ★
  - ✓ San Francisco Bay, Morro Bay, Santa Monica Bay
- NOAA National Estuary Research Reserves ☆
  - ✓ San Francisco Bay, Elkhorn Slough, Tijuana Estuary
- San Onofre Nuclear Generating Station Mitigation ★ Program
  - ✓ San Dieguito, Tijuana, Mugu Lagoon, Carpinteria Salt Marsh

Account for Future Conditions





Include Indicators of Resiliency

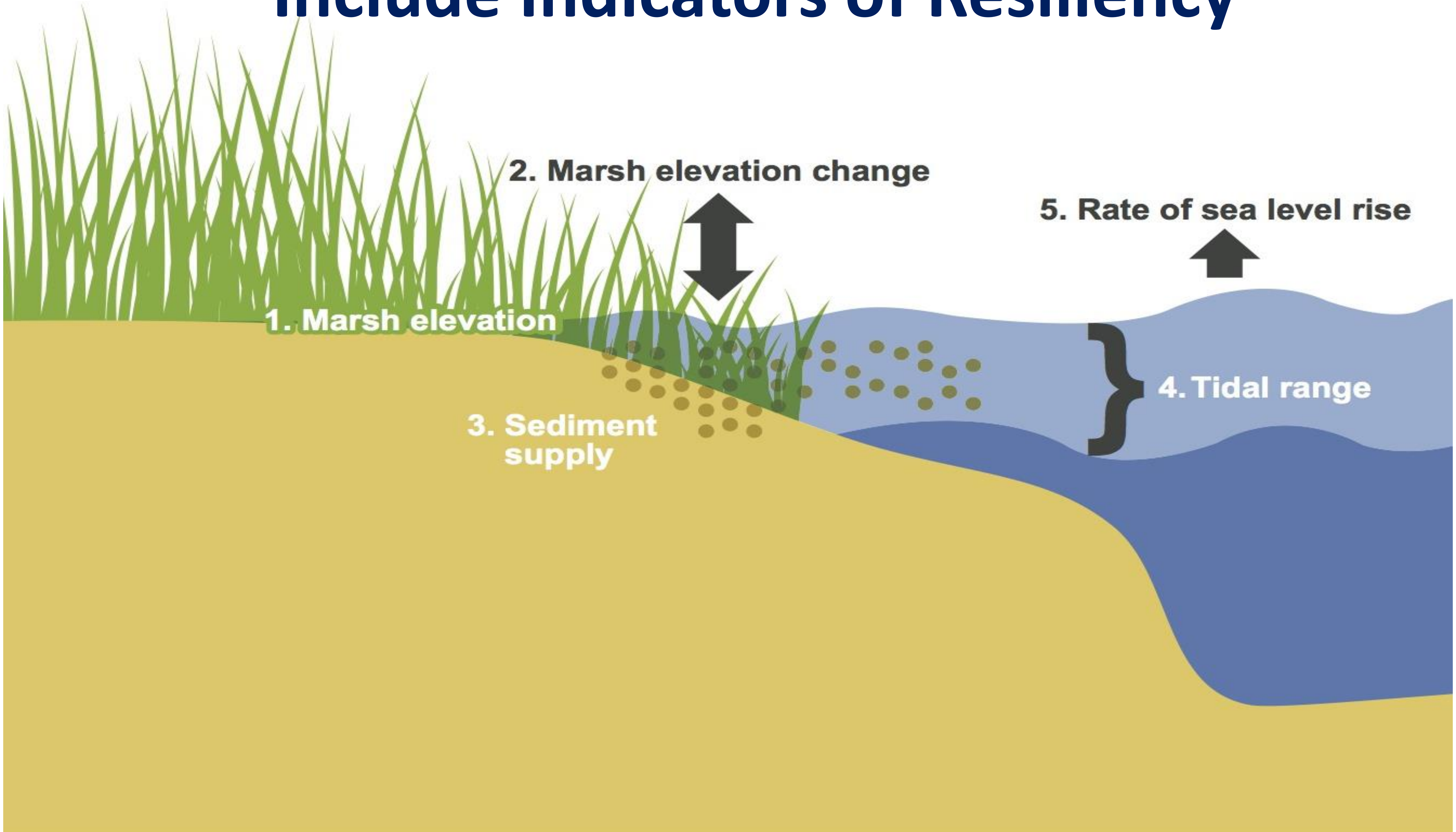


Table 1. Summary of metrics and approaches used for each.

Category	Metric	Data needs
MARS metrics (Raposa *et al* 2016)		
Marsh elevation distributions	Percent of marsh below MHW	Frequency distribution of marsh elevations; estimate of mean high water
	Percent of marsh in lowest third of plant distribution	Frequency distribution of marsh elevations
	Skewness	Frequency distribution of marsh elevations
Marsh elevation change	Elevation change rate (mm yr^{-1})	Time series data from surface elevations tables (SETs)
Sediment/accretion	Short-term accretion rate (mm yr^{-1})	Time-series data from marker horizons
	Long-term accretion rate (mm yr^{-1})	Soil cores for radiometric dating
	Turbidity(NTU)	Mean turbidity from water quality sondes
Tidal range	Tidal range (m)	Mean daily tidal range from water quality sondes
Sea-level rise	Long-term rate of SLR (mm yr^{-1})	Long-term data from NWLON station
	Short-term inter-annual variability in water levels (mm)	Inter-annual variability data from NWLON station
Ganju *et al* (2017) metrics		
	Flood-ebb turbidity differential	Mean suspended sediment concentrations on flood and ebb tides
	UVVR	Relative area of vegetated marsh and unvegetated areas from aerial photographs
Observed change in vegetation		
	Decadal change in UVVR	UVVR (see above) assessed at 2 + points spanning ~10 years
	Percent of marsh plain with vegetation	Area of vegetated marsh divided by total marsh landscape area (vegetated+unvegetated) × 100
	Decadal change in percent vegetated	Change in above, assessed at 2 + points spanning ~10 year

Wasson et al. 2019

None of it Matters if You Can’t Access and Interpret the Data

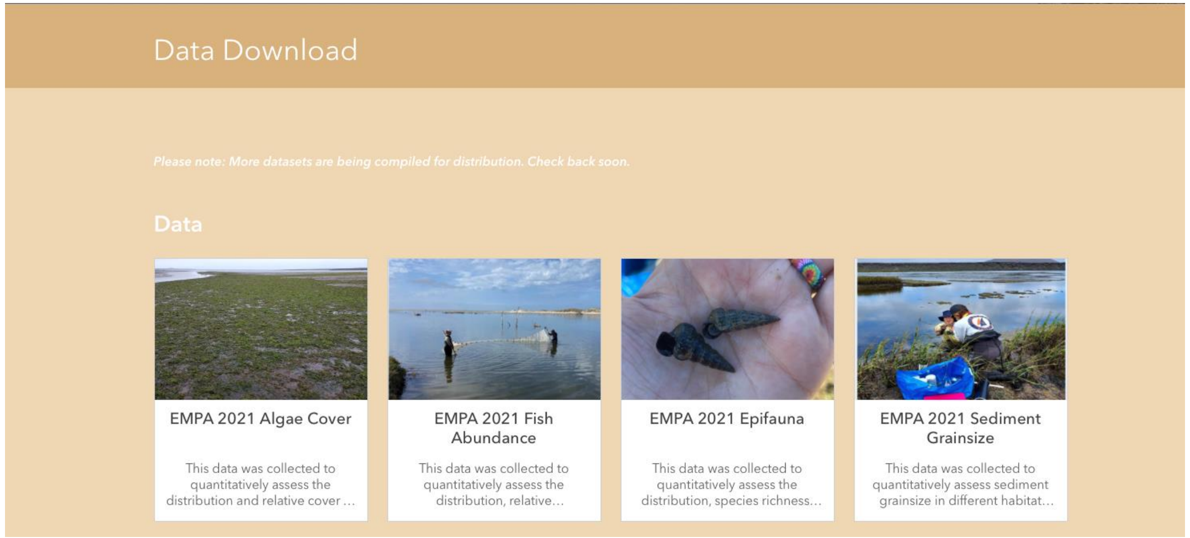
Strive for an integrated, electronic data flow through all steps of the data management process from data collection through publication

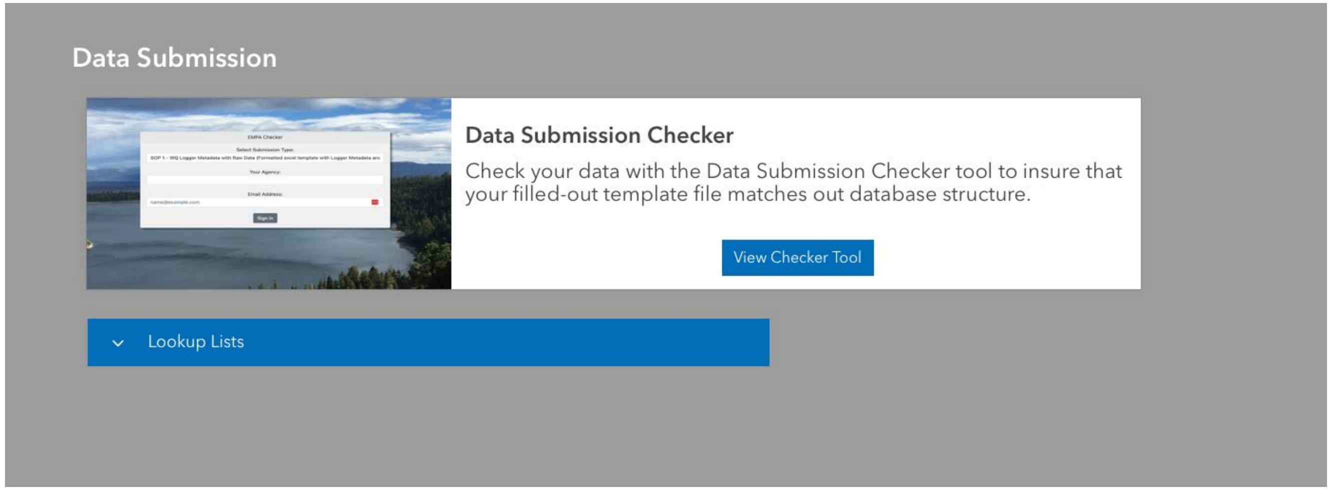
Manage data in a geospatial format to enhance data visualization and interpretation and facilitate data integration across programs

Use an open data format that includes web services and application program interfaces (APIs) to facilitate data

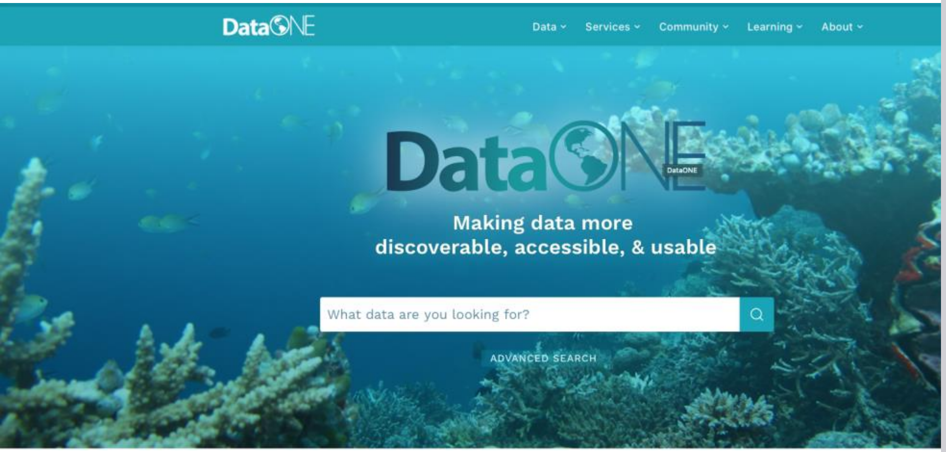
Standard Data Assembly and Infrastructure to Increase Comparability and Encourage Collaboration

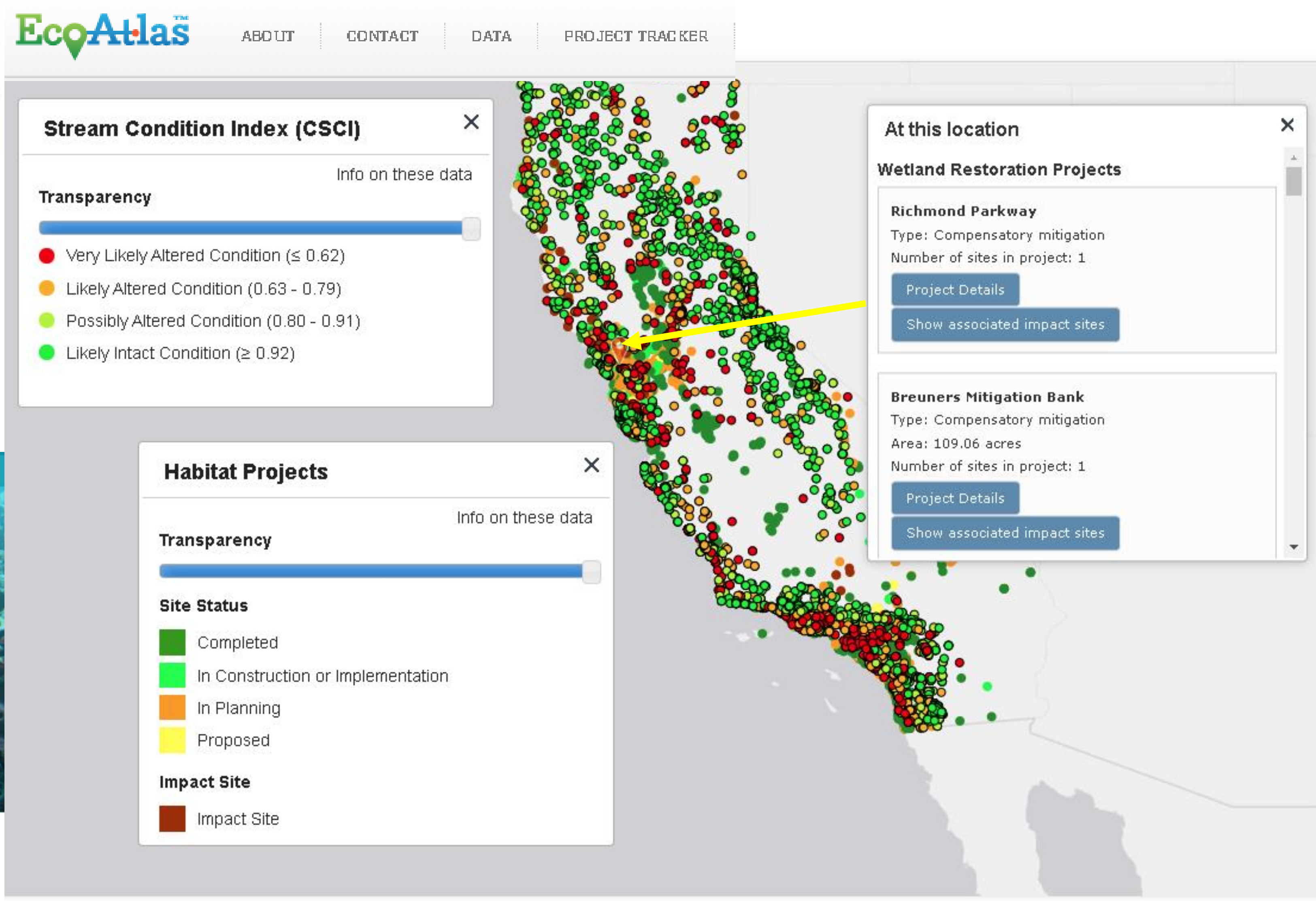
https://empa.sccwrp.org





https://empa.sccwrp.org





Lessons Learned in California

- *Build trust*
- *Find common ground*
- *Identify low-hanging fruit*
- *Generate early success*
- *Demonstrate value*
- *Tell your story*

Success is in the eye of the beholder

Collaboration is key to gauging success

Evaluation of success requires context

Meaningful conclusions about success take time

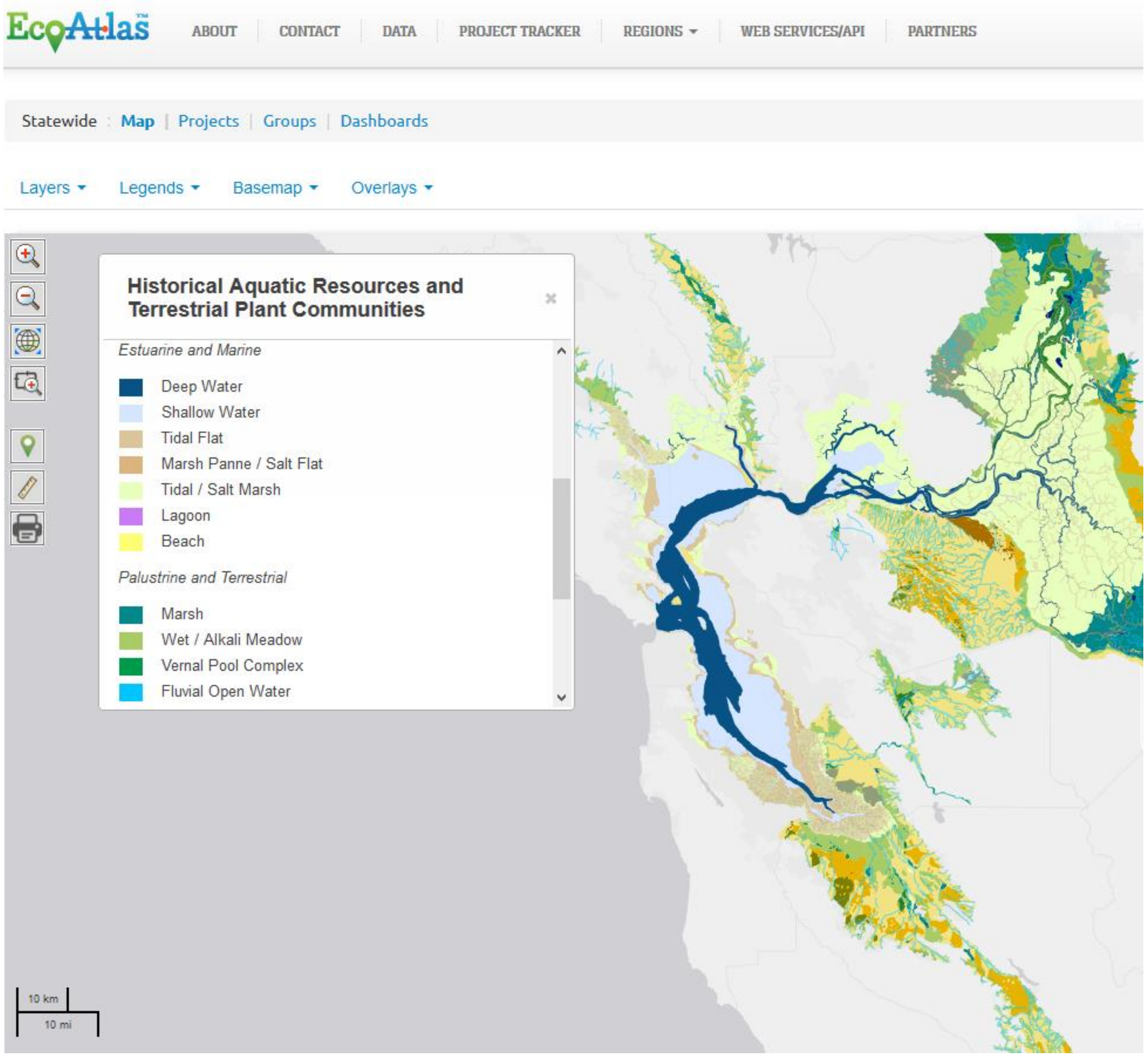
None of it matters if you can access and interpret the data

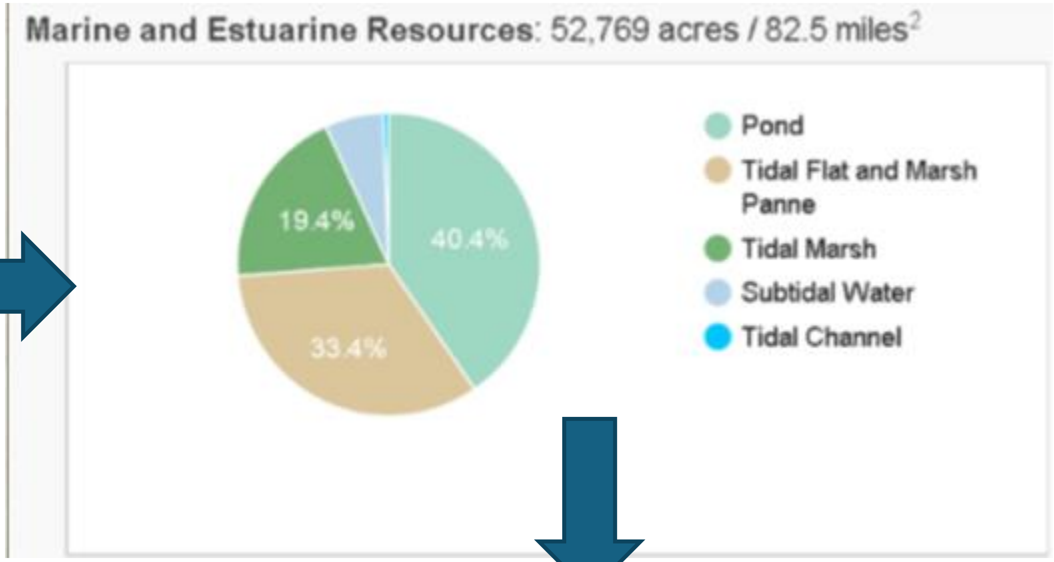
Thank you!

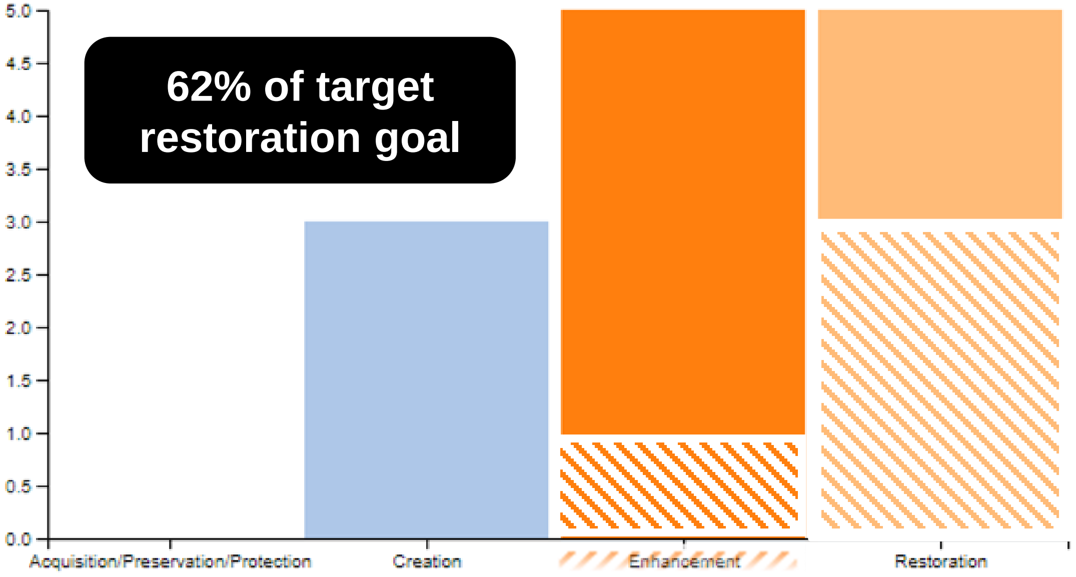
Eric Stein
erics@sccwrp.org
www.sccwrp.org
714-755-3233

EXTRA SLIDES

Targets Based on Landscape Profiles







Keys to success

- *Don't force it – find common ground*

- *Everybody is busy and this is nobody's job*
  - ✓*Need a designated "point person"*
  - ✓*Empower key motivated individuals*
  - ✓*Encourage leaders to emerge*

- *Remove all barriers to information flow*
  - ✓*Informed participants are engaged and supportive participants……that includes the public*

Keys to Success

- *Establish a clear and common vision & stick to it*
  - ✓Things that directly affect the problem are part of the solution -others things lead to other problems.

- *Start modestly, learn as you go*

- *Obtain early successes and relish in them*

- *Stay engaged -- don't be complacent*

- *Think/plan regionally . . . . Act/implement locally*

Protocols Can be Used to Develop Appropriate Performance Standards

- Measures a single aspect of condition or function
- Can be measured objectively in a repeatable manner
- Clear and unambiguous
  - ✓Somebody else will likely have to interpret what you meant
- Defensible
- Readily quantifiable targets with known levels of confidence
- Tied to established goals and objectives
- Can inform adaptive management actions and/or contingency actions

Example Performance Standard

- At the end of year 3, at least 80% of Area A shall have a benthic invertebrate index score within 10% of the median reference population score.
  - ✓If this standard is not met, the site will be re-evaluated within 120 days of the original field assessment
  - ✓If the standard is still not met, metric level analysis and/or causal assessment shall be conducted to identify likely reasons for failure

Indicator	Metric	Questions		
		Stressors	***Condition***	***Resilience***
Habitat	Extent marsh			
	Extent seagrass bed			
	Habitat diversity			
	% buffer, transition zone			
WQ	Temp			
	DO			
	Salinity			
	Chlorophyll a			
	Turbidity			
Vegetation	Extent, diversity, % invasive/native			
	Percent marsh below MHW			
	UVVR – relative area of vegetated marsh and unvegetated (aerial photos)			
	Percent of marsh in lowest third of plant distributions			

Key Elements of Resiliency

Condition

Diversity

Complexity

Consistent Approaches

Vulnerability

Exposure

Sensitivity

Regional Plans

Adaptive Capacity

Transgression

Migration

Accretion

Innovative Tools

Identify opportunities based on conservation needs and societal benefits

UN DECADE ON ECOSYSTEM RESTORATION

TECHNICAL ARTICLE

Adaptive management of large-scale ecosystem restoration: increasing certainty of habitat outcomes in the Columbia River Estuary, U.S.A.

Chanda Littles[1,2], Jason Karnezis[3], Katie Blauvelt[4], Anne Creason[3], Heida Diefenderfer[5], Gary Johnson[6], Lynne Krasnow[7], Phil Trask[4]