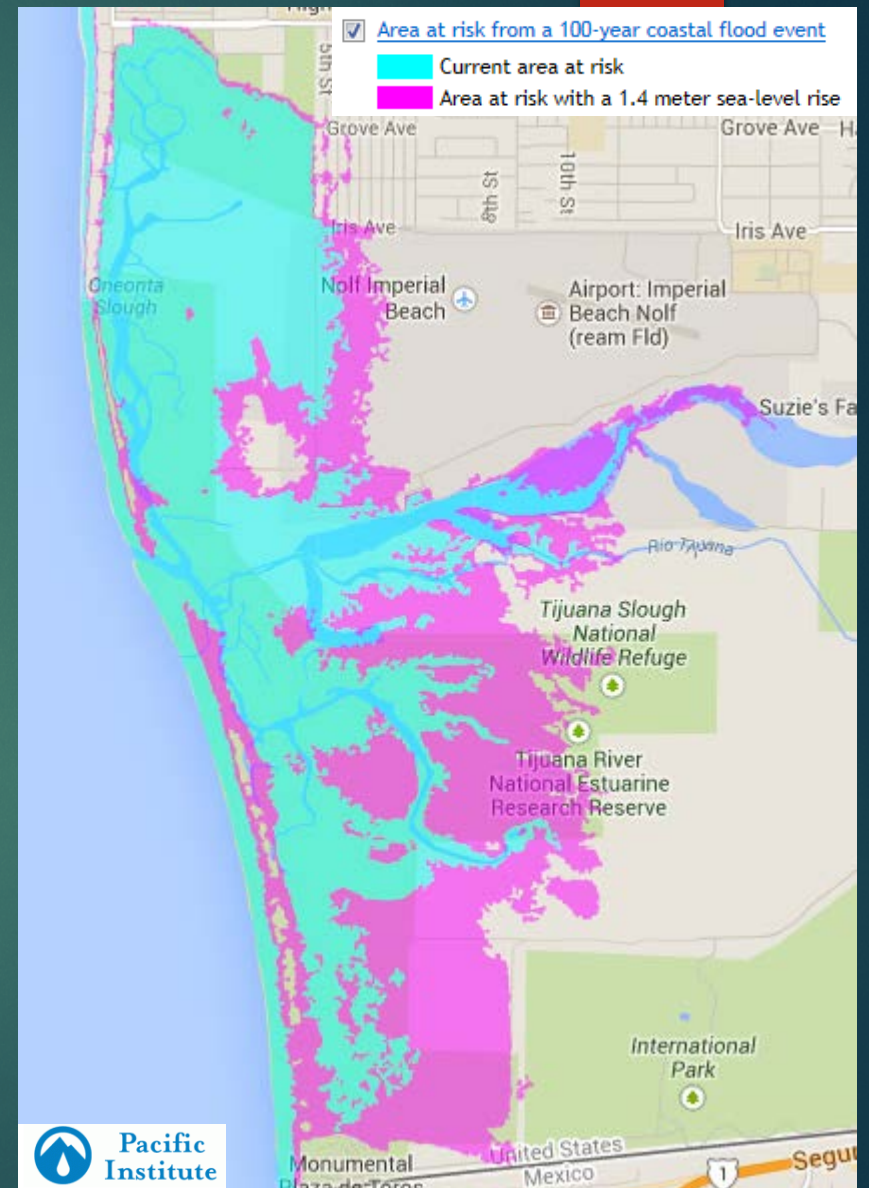


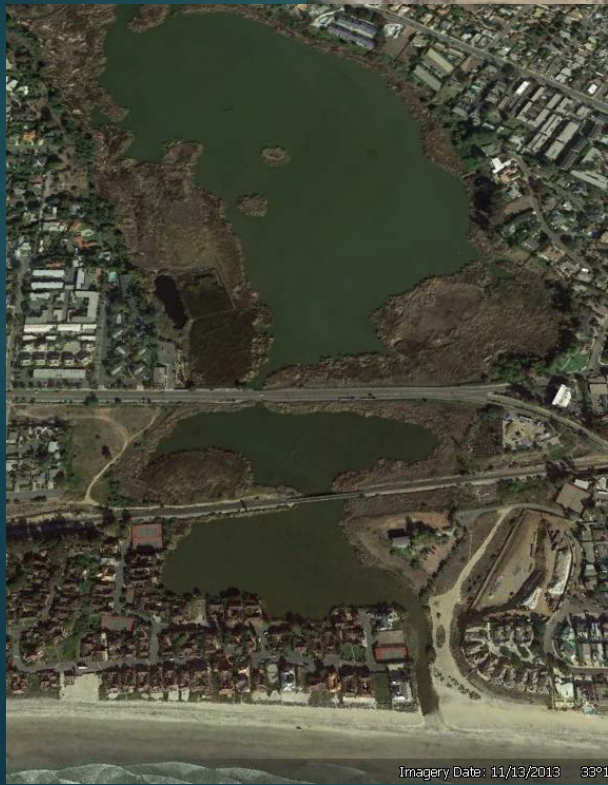
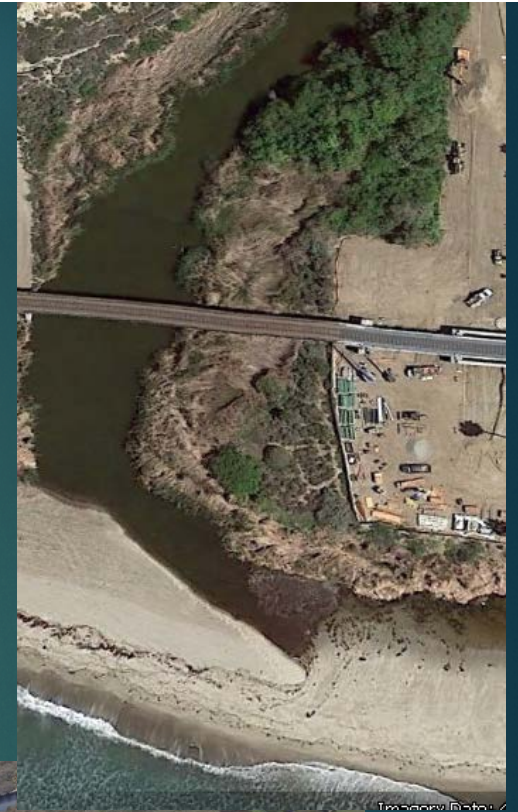
Consideration of Anticipated Sea Level Rise on Restoration Strategies for Southern California Coastal Wetlands



Project Motivation

- ▶ Many areas of the southern California coast are at risk due to sea level rise (SLR)
- ▶ Different wetlands will be more or less sensitive to sea level rise effects
- ▶ Managers lack tools to assess relative vulnerability of coastal wetlands to SLR
- ▶ Tools are needed to inform restoration & management strategies and approaches





Imagery Date: 11/13/2013 3391

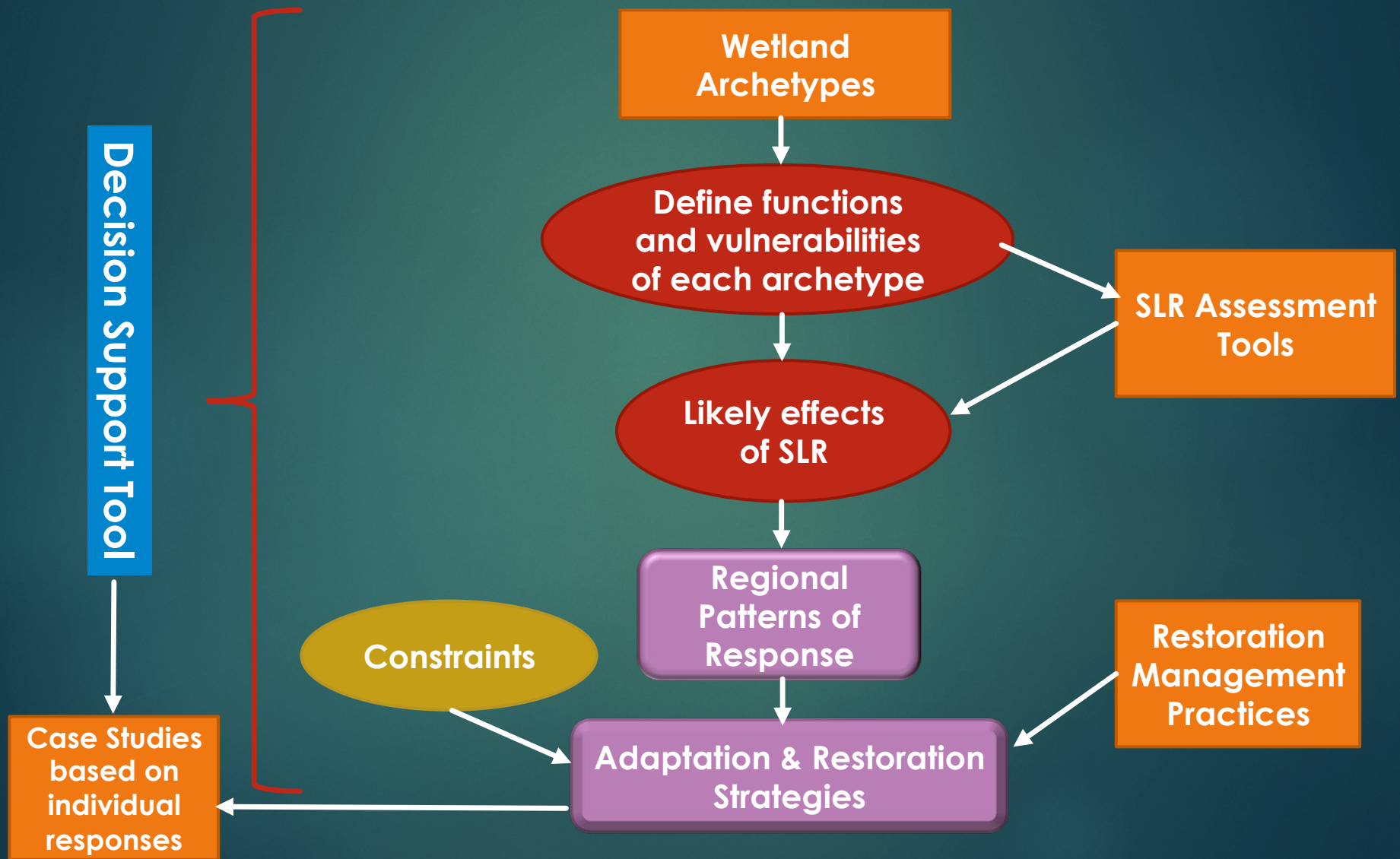
Overall Goals

Develop a method for managers to assess climate change-associated vulnerabilities at specific wetland locations by using the most appropriate tools to develop restoration and management priorities

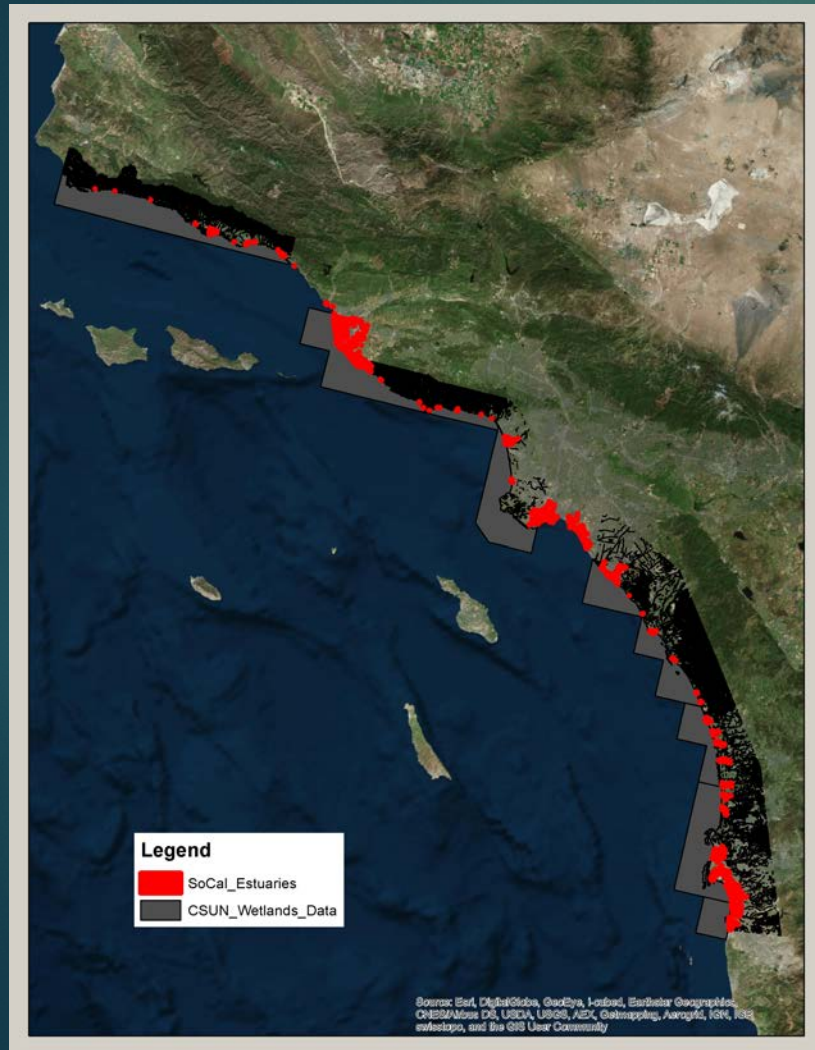
▶ **Leverage off past and current efforts**

- ❑ The Nature Conservancy/Pacific Institute Sea Level Rise Vulnerability
- ❑ NOAA Ecosystem Based Management Tools Network
- ❑ Coastal Storm Modeling System (UC Berkeley)
- ❑ Tijuana NERR Climate Understanding and Resilience Program
- ❑ UCLA Restoration Best Management Practices Assessment
- ❑ S. CA. Wetland Recovery Project Regional Wetland Strategy
- ❑ USGS/LCC Sea level rise modeling across salt marsh gradient
- ❑ California Wetland Protection Program Strategy

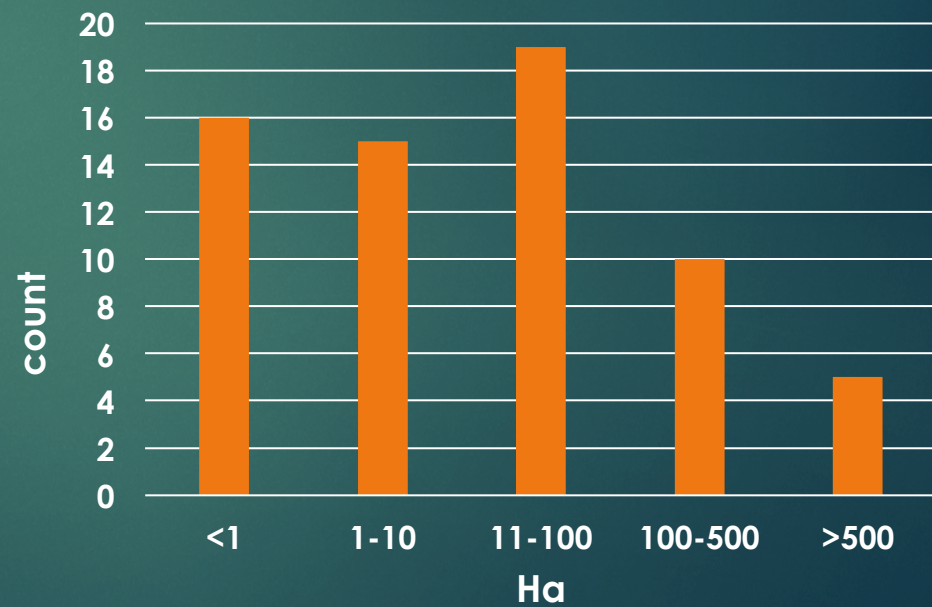
Conceptual Approach



Archetype Analysis

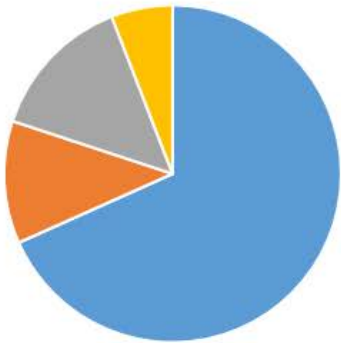


- ▶ 62 “systems”
- ▶ 13,400 ha

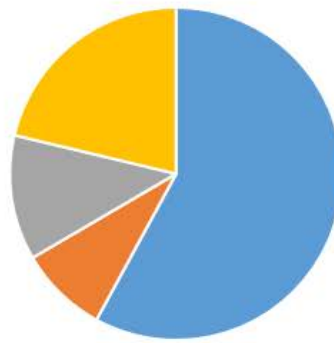


Archetype Analysis

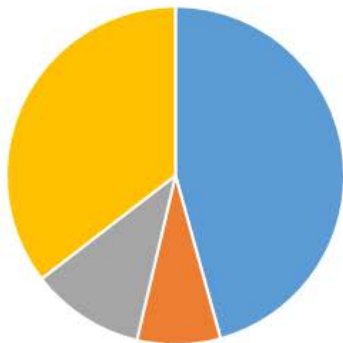
< 1 ha



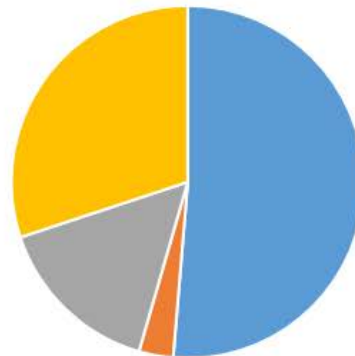
11- 100 ha



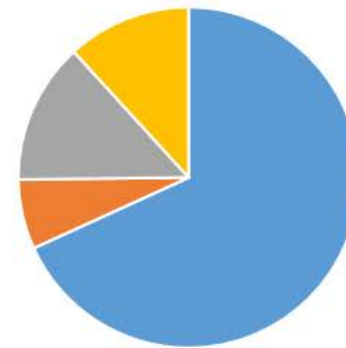
1-10 ha



101 - 500 ha



> 500 ha



- Watershed discharge
- Watershed area/slope
- Watershed slope
- Land use composition
- Adjacent land use types
- Tidal prism
- Mouth armoring

Review Existing Models

	Sea Level Rise and Coastal Flooding Impacts Viewer	Surging Seas	Pacific Institute - The Impacts of Sea Level Rise on California's Coast	Cal-Adapt - Exploring California's Climate	Coastal Resilience Ventura	Our Coast, Our Future	
General	Geographic Scope	National	National	California	California	Ventura County	North-central CA Coast (Bodega Head to Half Moon Bay) and San Francisco Bay
	Organization/Sponsor	NOAA Coastal Services Center	Climate Central	Pacific Institute; California Energy Commission	California Energy Commission; UC-Berkeley Geospatial Innovation Facility	The Nature Conservancy	Point Blue Conservation Science; USGS; Gulf of the Farallones National Marine Sanctuary; Corvair LCC
	Link	http://www.csc.noaa.gov/slr	http://sealevel.climatecentral.org/	http://pacinst.org/publication/the-impacts-of-sea-level-rise-on-the-california-coast-sea-level-rise-maps/	http://cal-adapt.org/sealevel/	www.maps.coastalresilience.org/ventura	http://pointblue.org/cocf
	Description	A visualization tool for coastal communities showing potential impacts from sea level rise and coastal flooding as well as a planning level tool.	Searchable toolkit including 1) detailed maps; 2) individual community analyses; 3) area comparisons; and 4) local sea level and flood risk projections. Over 100 demographic, economic and infrastructure variables analyzed for 1000s of communities from zip code to statewide levels.	Provides access to sea-level rise scenarios generated by the Pacific Institute and the U.S. Geological Survey as part of the CA Energy Commission's Public Interest Energy Research Program (PIER). The tool shows the threat of inundation due to flooding over three depths based on a 100 year flood scenario.	Cal-Adapt hosts a subset of the Pacific Institute 2009 sea-level rise scenarios. The tool shows the threat of inundation due to flooding over three depths based on a 100 year flood scenario.	A visualization tool for local and state decision makers showing potential impacts from sea level rise and coastal hazards designed to help communities develop and implement solutions that incorporate ecosystem-based adaptation approaches	A collaborative, user-driven project focused on providing San Francisco Bay Area coastal resource and land use managers and planners locally relevant, online maps and tools to help understand, visualize, and anticipate vulnerabilities to sea level rise and storms.
	Target Audience	Decision makers, planners, coastal managers, floodplain managers, emergency managers, coastal scientists and engineers, general public	Decision makers, planners, coastal managers, emergency managers, federal and state agencies, journalists and the general public	Public, community planners, businesses	Public, community planners, businesses	Decision makers, planners, coastal managers, emergency managers, coastal scientists and engineers	Including but not limited to: Land Use Planners, Coastal Resource Managers, Restoration Managers, Hazard Mitigation Planners, Floodplain Managers, Emergency Managers, Stormwater Managers, Municipal Engineers, Municipal Leaders, Zoning and Permitting Officials, Public Works Officials, and Conservation Organizations
	Skill Level	Low	Low	Low	Low	Low-Medium	Low
	Main Tool Outputs	Maps, photo simulations, flood frequency graphs	Maps, community analyses, wide area analysis comparisons, projections	Maps	Maps, reports of inundation threat by county	Maps (on-screen and pdf), Summary reports (on-screen), Bookmark links, Downloadable spatial data	Maps (on screen); summary reports (on screen and pdf); downloadable data; SLR projection comparison by both amount and year
	Year Released	2012 (West Coast of US)	Rolling: Fall 2013 - Summer 2014	2009	2011	2013 (Ventura)	2013 Half Moon Bay to Bodega Head, 2014 SF Bay
	Base Sea Level Elevation	MHHW	MHHW	MHHW	MHHW	MHW or MHHW?	MHHW
	Flood/Inundation Controls	Slider bar with inundation delineated in 1 foot increments from 0 - 6 feet	Slider bar with inundation delineated in 1 foot increments from 1 - 10 feet	None	None	Choice of Current, 2030, 2060, & 2100 projections with choice of Low, Medium & High Sea Level Rise Projection Scenarios for each time horizon	Total of 40 combinations of sea level rise and storm scenarios that include 0-2 m SLR in 25 cm increments plus a 5 m extreme, and 4 storm scenarios: no storm, annual, 20 year, and 100 year
Flood Layers Represented	Blue - inundation; Green - low-lying areas	Blue - inundation; Hatched - low-lying but isolated	Current water levels, 19", 39" and 55" inundation	Current water levels, 19", 39" and 55" inundation	Tidal inundation, wave impact, flood inundation, river flood inundation	Blue gradient - inundation/depth; Green - low-lying areas; Yellow - uncertainty	
Uncertainty Represented	Yes	No for elevation, yes for projections	No	No	In future version, analysis completed; layers currently under development	Yes	
Way Uncertainty Represented	Confidence is noted as High vs. Low, so the areas not highlighted as high or low indicate a high confidence of not being inundated. "...the blue areas denote locations that may be correctly mapped as "inundated" more than 8 out of 10 times. Areas with low confidence represent location that may be mapped correctly (either as inundated or dry) less than 8 out of 10 times."	Map does not represent uncertainty in elevation values. However, projection tool presents different sea level rise models and scenarios, and reflects uncertainty information as available for these.	NA	NA	see above	The "Uncertainty" topic displays layers for the minimum inundation and maximum inundation expected for a particular scenario. These layers represent the +/- 50 cm variations in predicted flooding incurred from the modeling and the DEM base data set.	
SLR and Flood Scenarios	Projects local sea level rise	No	Yes	No	No	Yes	Yes
	Projects future flood elevations	No	Yes	Yes	No	Yes	Yes
	Projects future flood risk at fixed elevations	No	Yes	Yes	No	Yes	Yes
	Projection time periods assessed	No	each decade 2020-2100	2100	2100	Current, 2030, 2060, 2100	Tool provided to compare SLR timing/depth estimates from the most commonly cited reports (NRC, COCA, Vermeer & Rahmstorf, IPCC)
	Flood projections factor in changing frequency or intensity of storms	No	No	No	No	Yes	Flood projections combine SLR and storm intensity (annual, 20-year, 100-year storm)
	Allows choice of projection scenarios/models	No	Yes	No	No	Yes	No - single global climate scenario used
	Shows levees	Yes - Links to USACE NLD	Yes	No	No	No?	Yes for San Francisco Bay
	Factors in levees	Yes if they are captured in LIDAR based elevation data	Yes	NA	NA	Yes	Yes for San Francisco Bay
	Inundation Model Used	Modified bathtub approach, modeling hydraulic connectivity and locally adjusted Mean Higher High Water levels.	Modified bathtub approach, modeling hydrologic connectivity and locally adjusted Mean Higher High Water levels.	Bathtub approach	Bathtub approach	HEC-GeoRAS tool in ArcGIS outputs projected against topographic surface composite	USGS Coastal Storm Modeling System (CoMoS)
	Tabulates exposure within designated areas	no just overlay visualization of social and economic data	Yes	Yes, determines acres and percentage at risk with 1.4 meters SL R by county	Yes, determines acres and percentage at risk with 1.4 meters SL R by county	No	Yes - report gives exposure and flood depth for user defined area
Exposure types tabulated	No	>100 demographic, economic, environmental and infrastructure variables	Results of FEMA's Hazus model are available for download	NA	N/A	No	
Designated areas for tabulation	No	zip codes, cities, counties, states, local through federal legislative districts, planning districts, state agency districts	County	County		User drawn polygons or uploaded polygon	

Evaluate effects on archetypes based on existing SLR models

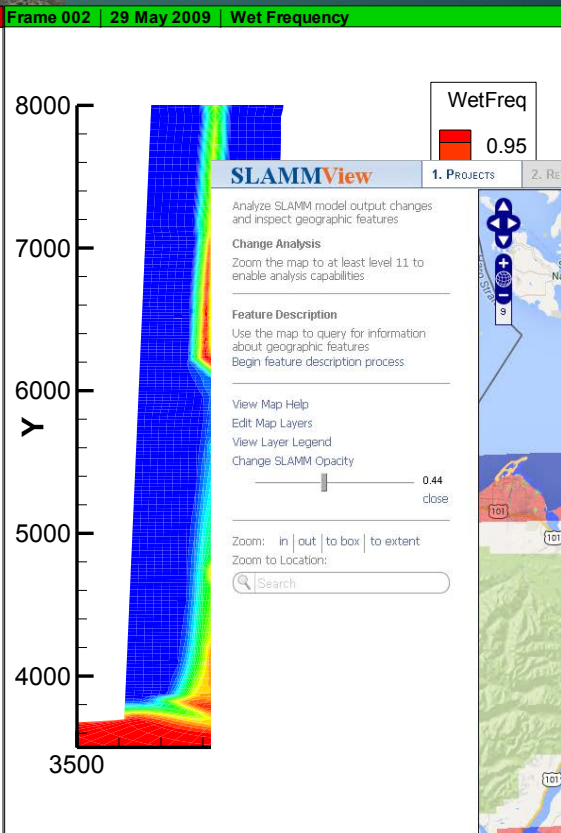
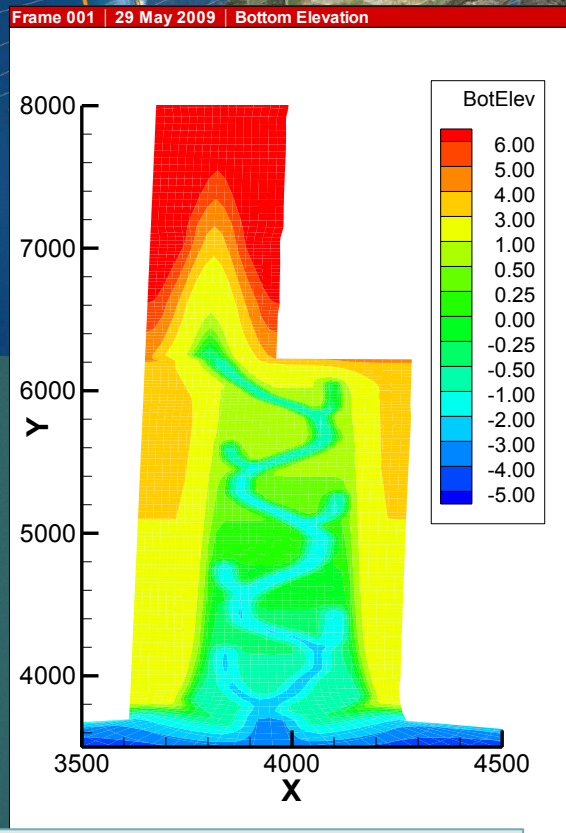
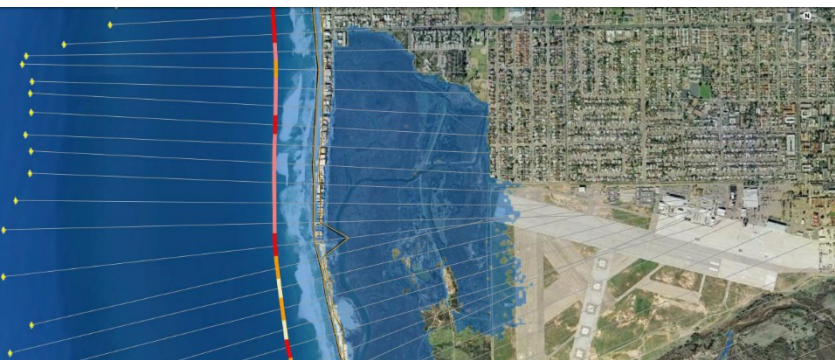
Legend

- MCP Profile
- MHHW start
- MHHW end
- MHW start
- MHW end
- Flood Hazard
- Wave Damage Potential
 - Low
 - Moderate
 - Severe
- Santa Barbara Cliff Failure Potential
 - Minor
 - Major
- Maximum Significant Wave Height (m)
 - < 3
 - > 3

Shoreline Change (m)

- > 40
- 31 - 40
- 21 - 30
- 11 - 20
- 0 - 10
- 1 - 12

USGS
United States Geological Survey



SLAMMView

1. PROJECTS | 2. REGIONS | 3. SCENARIOS | 4. YEARS | 5. COMPARISONS

Analyze SLAMM model output changes and inspect geographic features

Change Analysis
Zoom the map to at least level 11 to enable analysis capabilities

Feature Description
Use the map to query for information about geographic features
Begin feature description process

View Map Help
Edit Map Layers
View Layer Legend
Change SLAMM Opacity

0.44 close

Zoom: in | out | to box | to extent
Zoom to Location:

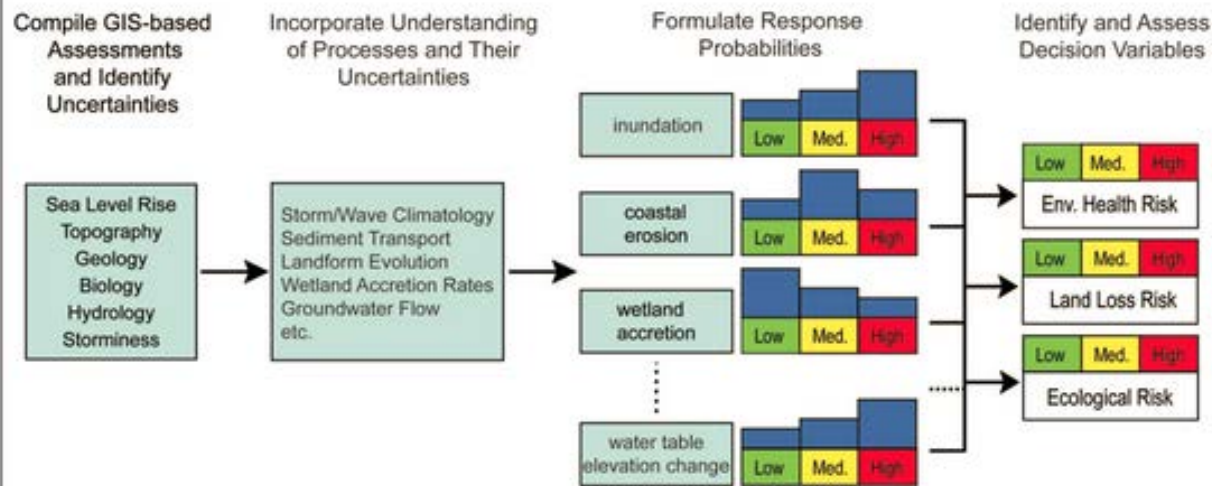
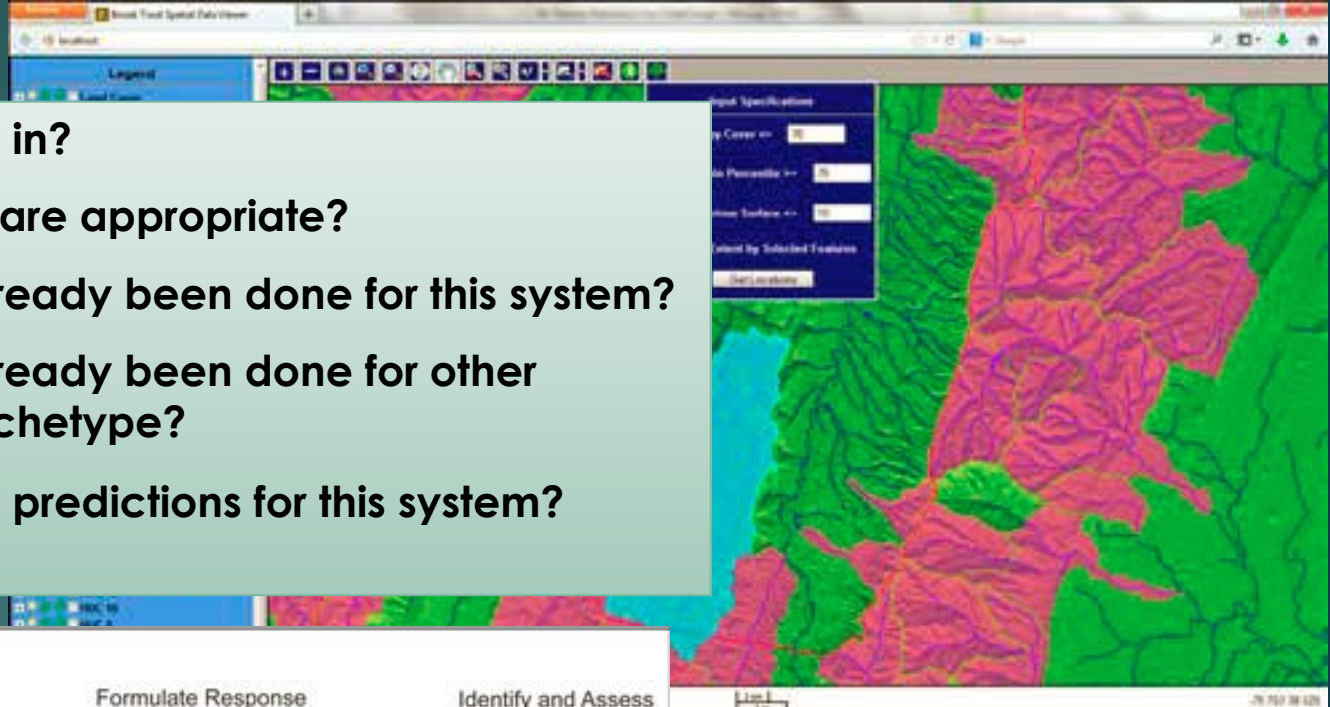
Search

Extrapolate expected “archetype evolution” based on existing marsh evolution models



Decision Support Tools

- ▶ What archetype am I in?
- ▶ What modeling tools are appropriate?
- ▶ Has any modeling already been done for this system?
- ▶ Has any modeling already been done for other systems within this archetype?
- ▶ What are the general predictions for this system?



Future Scenarios Ma x Coastal Resilience | \ x
maps.coastalresilience.org/ventura/

COASTAL RESILIENCE VENTURA COUNTY, CALIFORNIA GET STA

Map Layers
Flood & Sea Level Rise
NEW APPS
Switch Map
Split View
Save & Share
Export Page

Flood & Sea Level Rise

1. Select the hazard to view:

- Tidal Inundation (monthly in feet)
- Wave Impact (large storm)
- River Flood Inundation (large storm)
- Erosion Risk

2. Select the time and amount of sea level rise:

Year: Current, 2050, 2060, 2100

Sea Level Rise Scenario: Low, Medium, High

Large Storm Wave Event (for Erosion Risk): Existing Wave Climate, Doubling of El Niño Frequency, Addition of ARkStorm

Layer Properties: Opaque, Transparent

Methods

Restoration Strategies

- Hard engineering
- Managed retreat
- Acceptable type conversion
- Planned accommodation
✓ elevation, sediment supply
- Abandonment

Expected Products

- ▶ Revised coastal wetland archetypes
- ▶ Assessment of regional vulnerability
- ▶ Matrix of available restoration management practices
- ▶ Decision support tool for application of restoration strategies in light of sea level rise effects

Will support WRP regional restoration strategy

Expected completion: July 2017

An aerial photograph of a river delta system. The river flows from the top right towards the bottom left, where it branches into several smaller channels. The surrounding landscape is a mix of green fields and dense forests. In the background, a large body of water, likely the ocean, is visible under a clear blue sky.

THANK YOU!

CONTACTS:

ERIC STEIN

PRINCIPAL SCIENTIST – BIOLOGY

ERIC@SCCWRP.ORG

(714) 755-3233

STEVE STEINBERG

PRINCIPAL SCIENTIST – INFO MGT & ANALYSIS

STEVES@SCCWRP.ORG

(714) 755-3260

EXTRA SLIDES

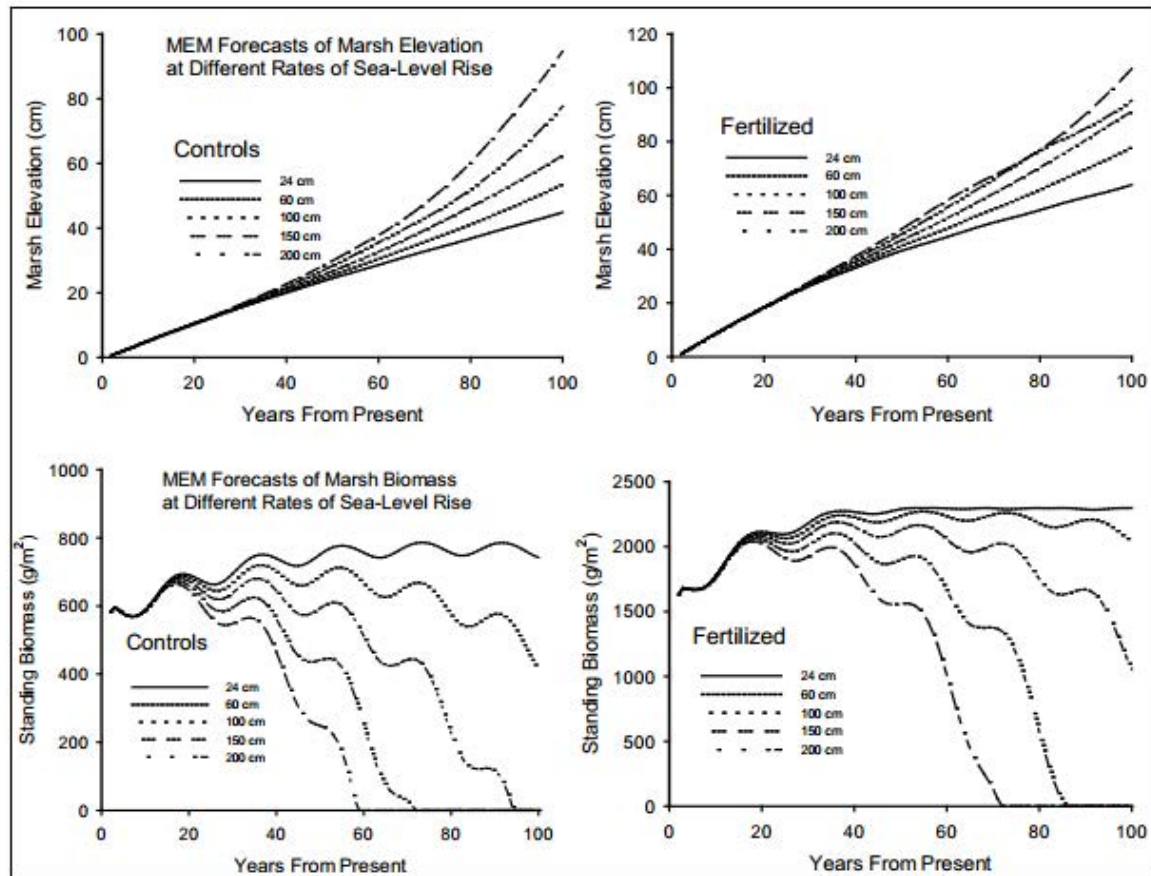
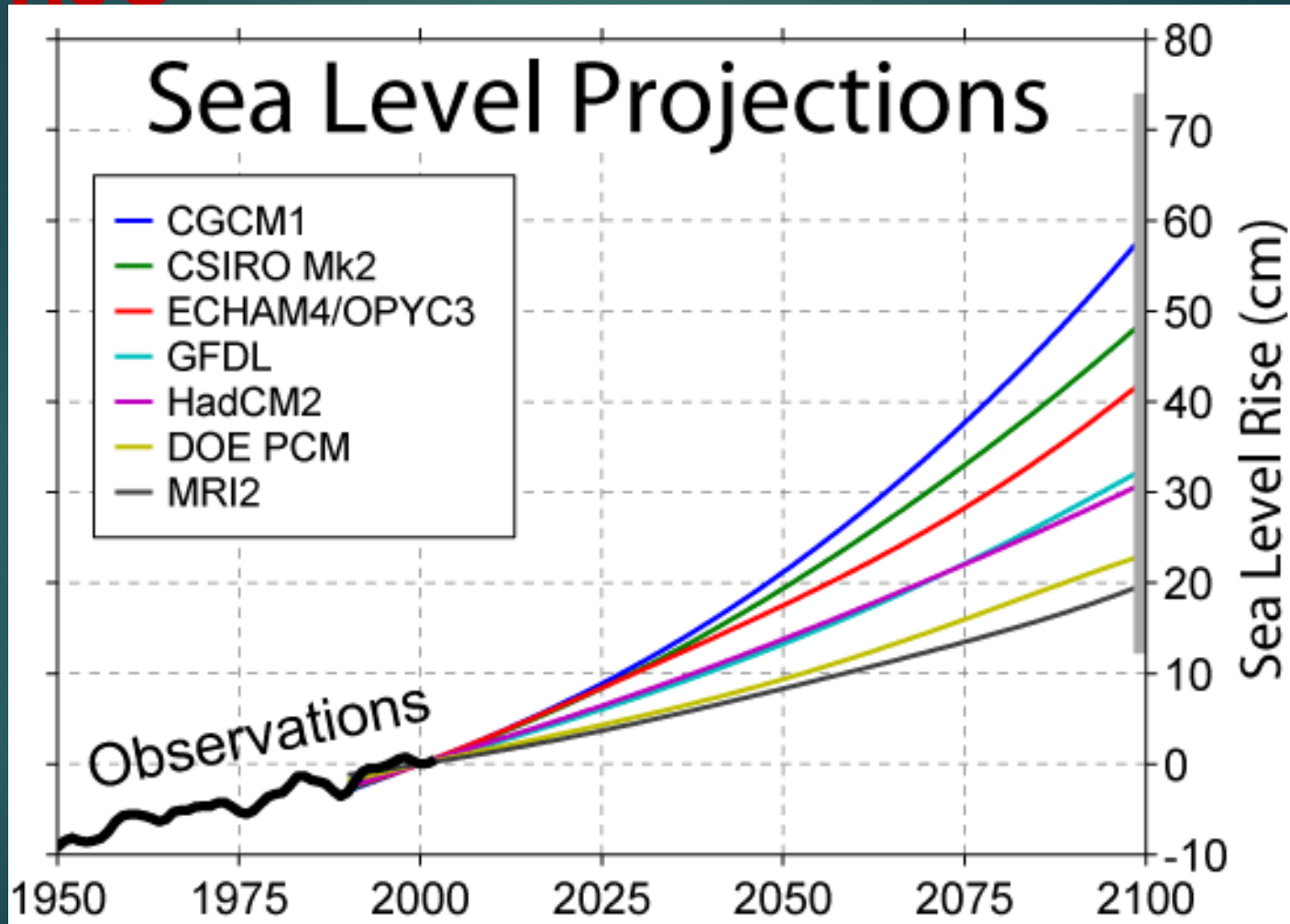
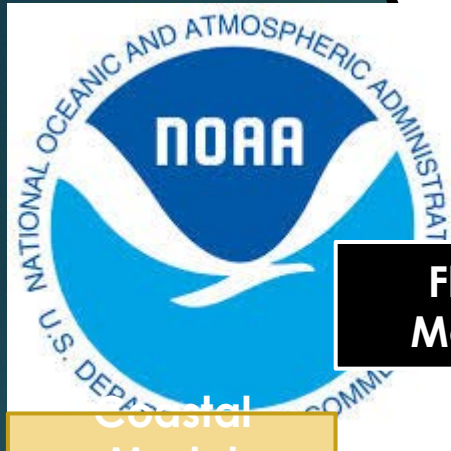
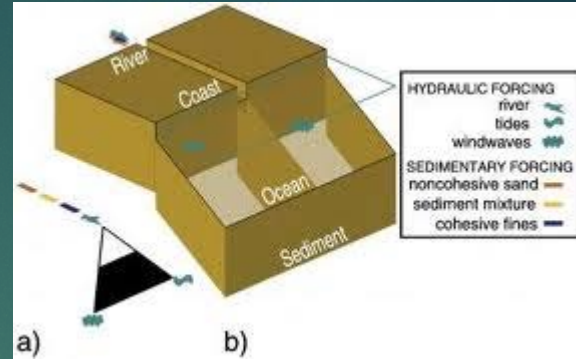
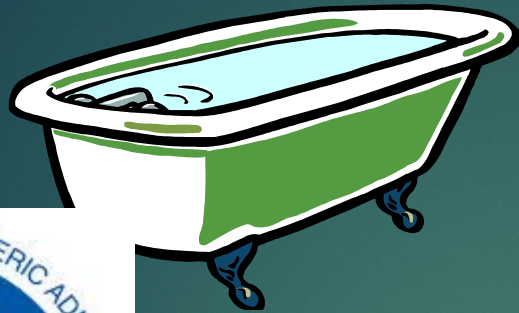


Figure 2. MEM forecasts of marsh elevation and standing biomass for different sea level rise scenarios.

Forecasts were made for ambient (controls) and fertilized marshes. The sea level rise scenarios ranged from a constant rate equivalent to 24 cm/y to a rapidly accelerating rate that raised mean sea level to 200 cm by the end of a century.

Sea levels are projected to rise





Fluvial and Coastal Models Drive SLAMM

adapt



Coastal Model Outputs

- Projected Erosion Rates

Fluvial Model Outputs

- Projected River Flows
- Water Levels?

SLAMM Inputs

- High-Res LiDAR
- Wetland Maps
- Dike/Levee Locations
- Impervious Surfaces
- Uplift/ Subsidence
- Tidal Datums

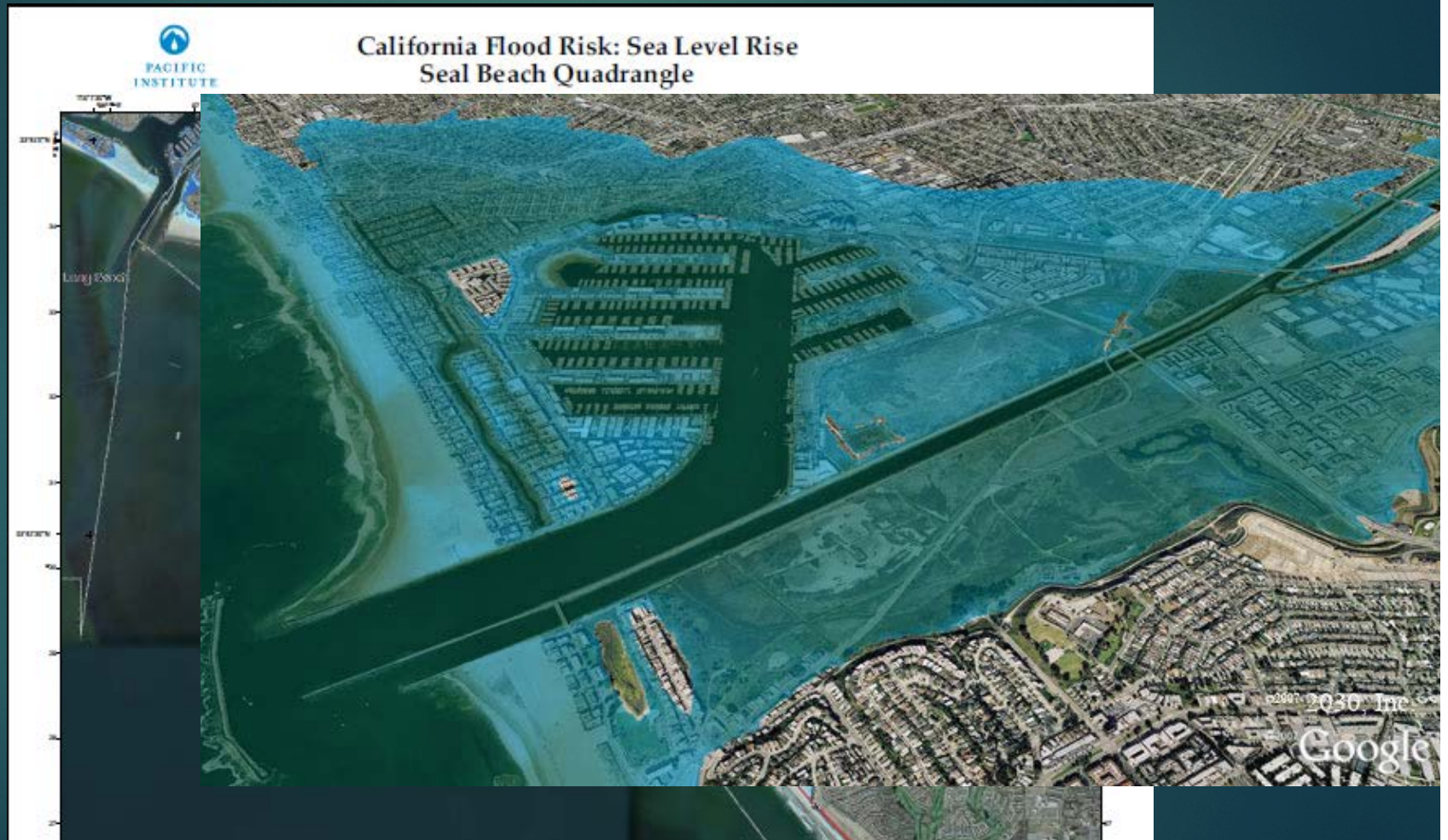
SLAMM Outputs

- Shoreline Change
- Wetland Migration
- Habitat Evolution



Coastlines are threatened

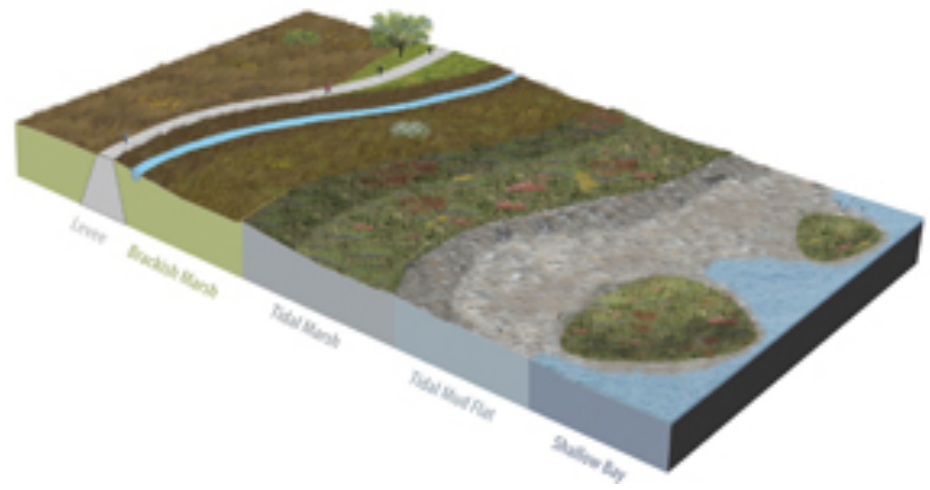
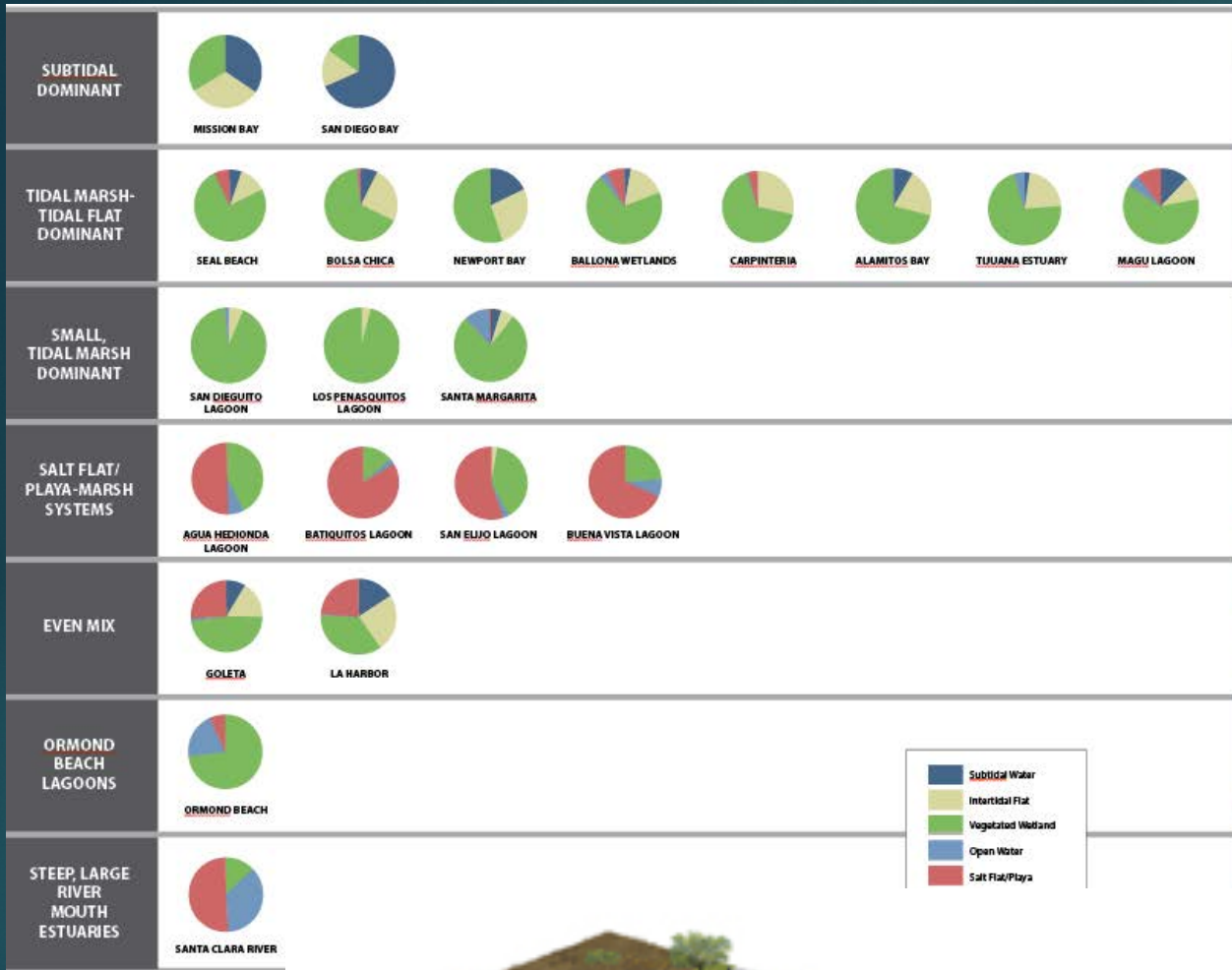
1.4 m rise would flood ~150 mi² of land adjacent to wetlands



http://www.pacinst.org/reports/sea_level_rise/



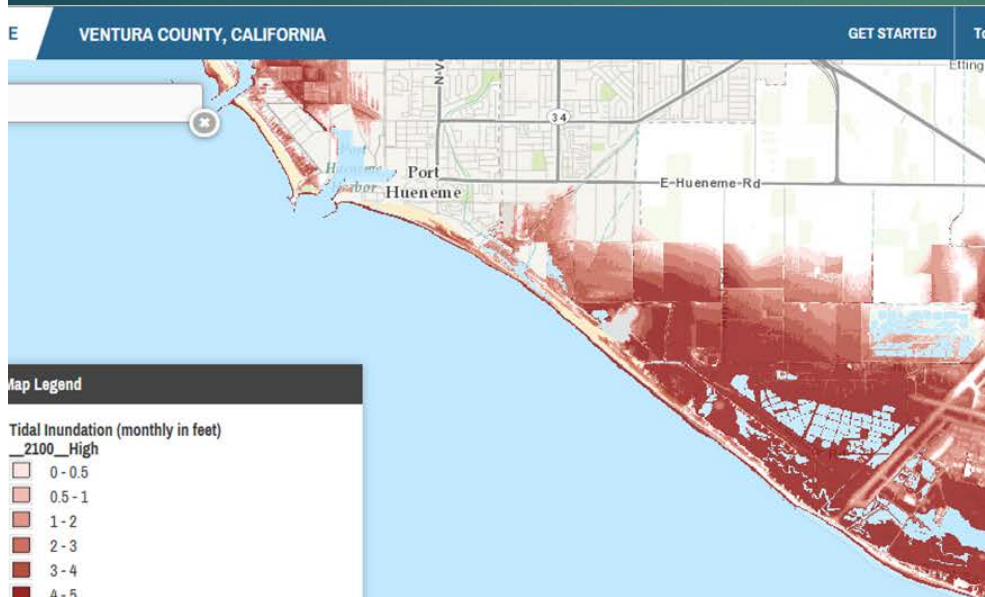




Decision-Support

- ▶ Tools vs. Models
- ▶ Usability
- ▶ Uncertainty, ecological assets and economic information

The screenshot shows a web-based GIS application. At the top, there's a browser window with the URL 'http://data.prbo.org/app'. Below the browser, there's a navigation menu with options like 'HOME', 'GET STARTED', 'FLOOD MAP', 'NEWS', 'EVENTS', and 'ABOUT US'. The main interface features a map of a coastal area with various layers overlaid. On the left, there's a 'frequency' dropdown menu and a 'Choose other layers to view with topic data' section with checkboxes for 'Placenames', 'Land Use', 'Protected Areas', 'Rivers & Streams', 'Cliff and Shoreline Retreat', 'Shorebirds', 'Coastal Armoring', 'Roads and Transportation', 'Trails', 'Buildings', and 'Utilities & Services'. On the right, there's a legend for 'Cliff Intersection - 2010' and 'Cliff Retreat - 2100' through '2050'. Below the map, there's a 'Sea Level Rise' section with a slider set to '5 ft SLR' and a 'Legend' for 'Water Depth'. At the bottom, there's a navigation bar with 'RESOURCES', 'CLIMATE TOOLS', 'DATA ACCESS', and 'COMMUNITY'.



The screenshot shows the 'SEA LEVEL RISE: THREATENED AREAS MAP' for Marin County. The map displays a coastal area with a legend for 'Inundation Area' showing categories: 'Current', '10 in. rise', '30 in. rise', and '65 in. rise'. A message box on the right states: 'No data was found for the region you selected. This is either because you searched for data outside of the state of California, or because there just wasn't a measurement available. Please click another region in the state of California.' The map includes a 'Map Date' of '3/1/2011' and a 'Report a map error' link. At the bottom, there's a 'CLIMATE TOOLS' button.