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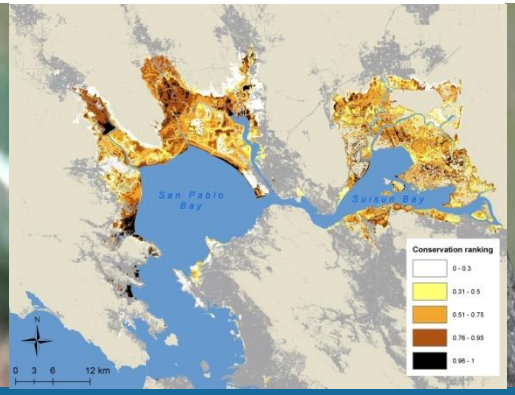


Prioritizing tidal marsh conservation and restoration efforts given high uncertainty due to future environmental change

Sam Veloz, Leo Salas, Nadav Nur, Julian Wood, Diana Stralberg ,Dennis Jongsomjit, Len Liu

Grant Ballard PRBO Conservation Science;

Lisa Schile UCB; John Callaway USF; Tom Parker SFSU, Steve Crooks PWA

PRBO Conservation Science

Applied Bird and Ecosystem Science to Advance Conservation for Wildlife and People

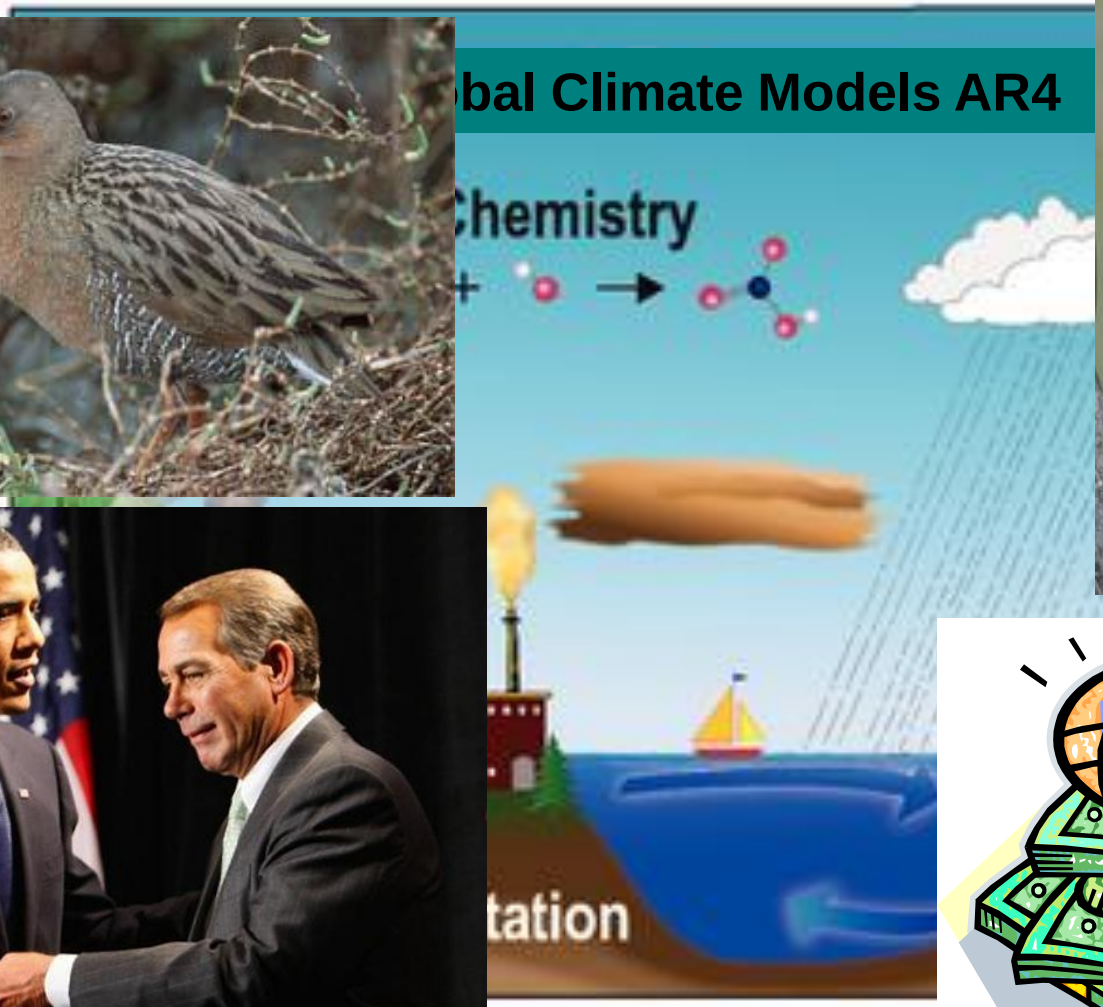
- Founded in 1965
- 140+ staff and seasonal biologists
- 2012 Budget: ~$9m

Using birds and other species as indicators of change

PRBO Conservation Science

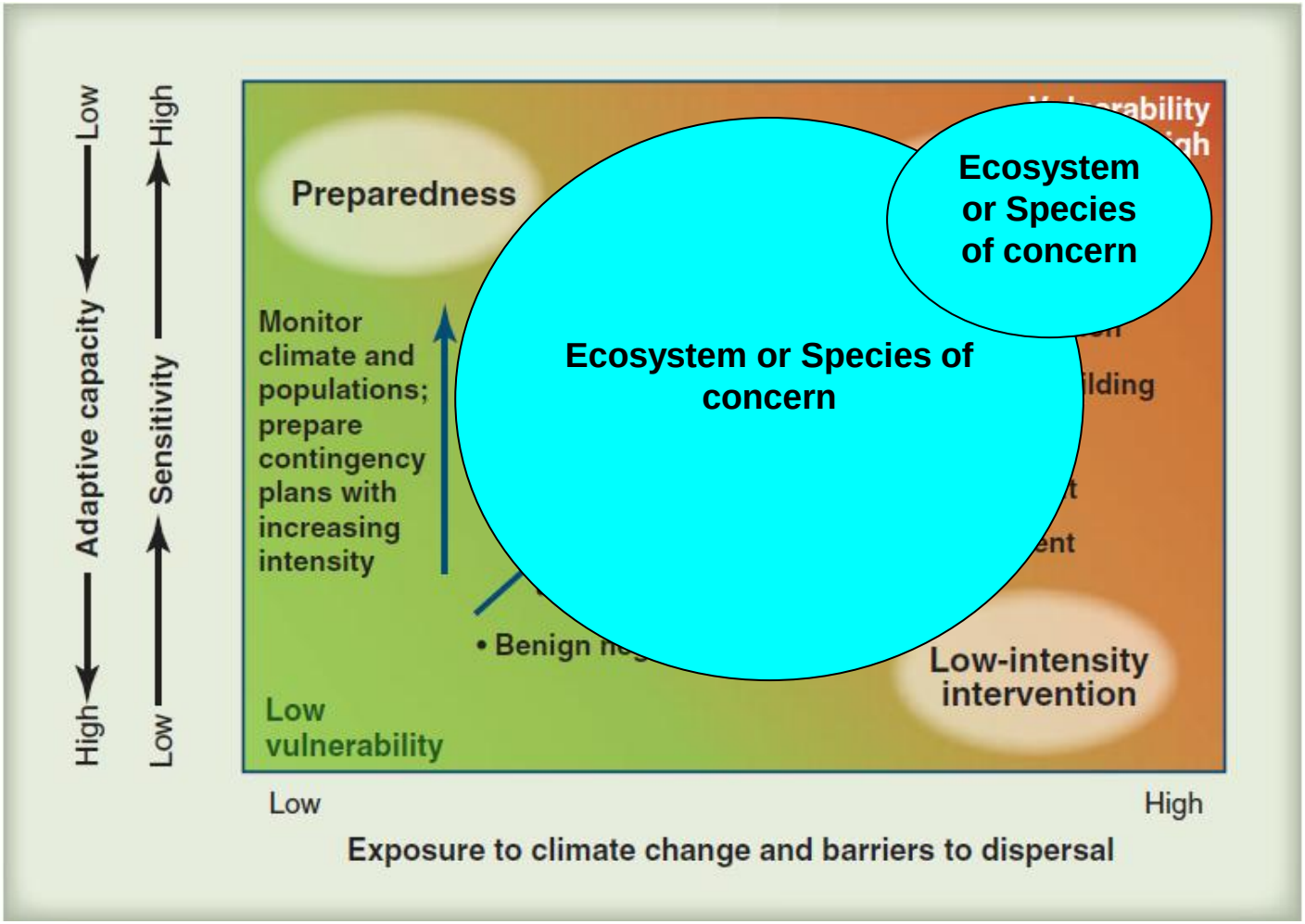
PRIORITY: Reduce Impacts of Environmental Change on Ecosystems & Enhance Capacity to Adapt

Future forecasts will always involve uncertainty



IPCC AF

Traditional approaches for uncertainty: Refine models to produce accurate and precise results



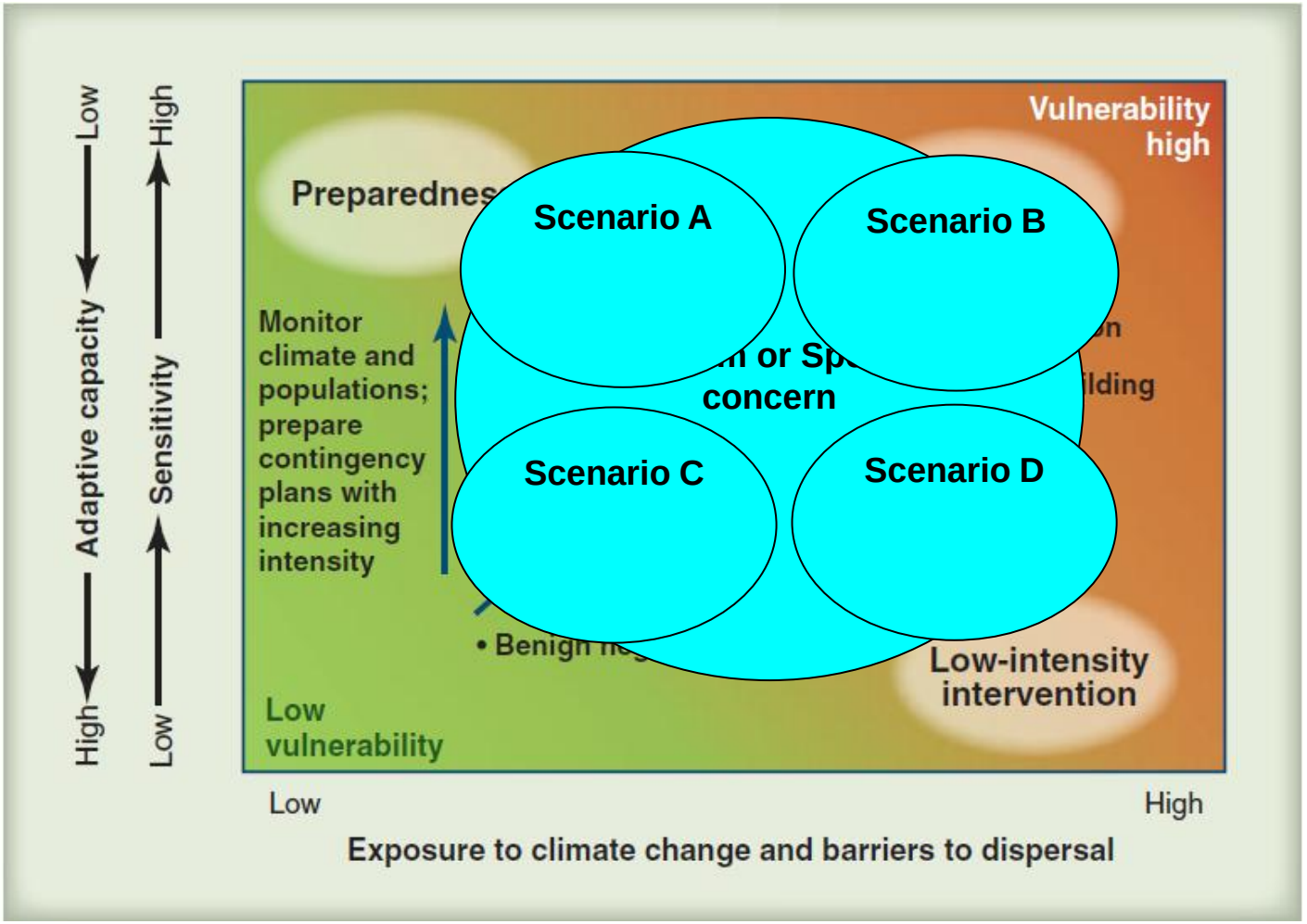
Dawson et al., 2011, Science

Scenario analysis

- Scenarios are:
  - Plausible alternative future conditions
  - Ideally based on data or expert knowledge
  - Bracket the range of possible future conditions

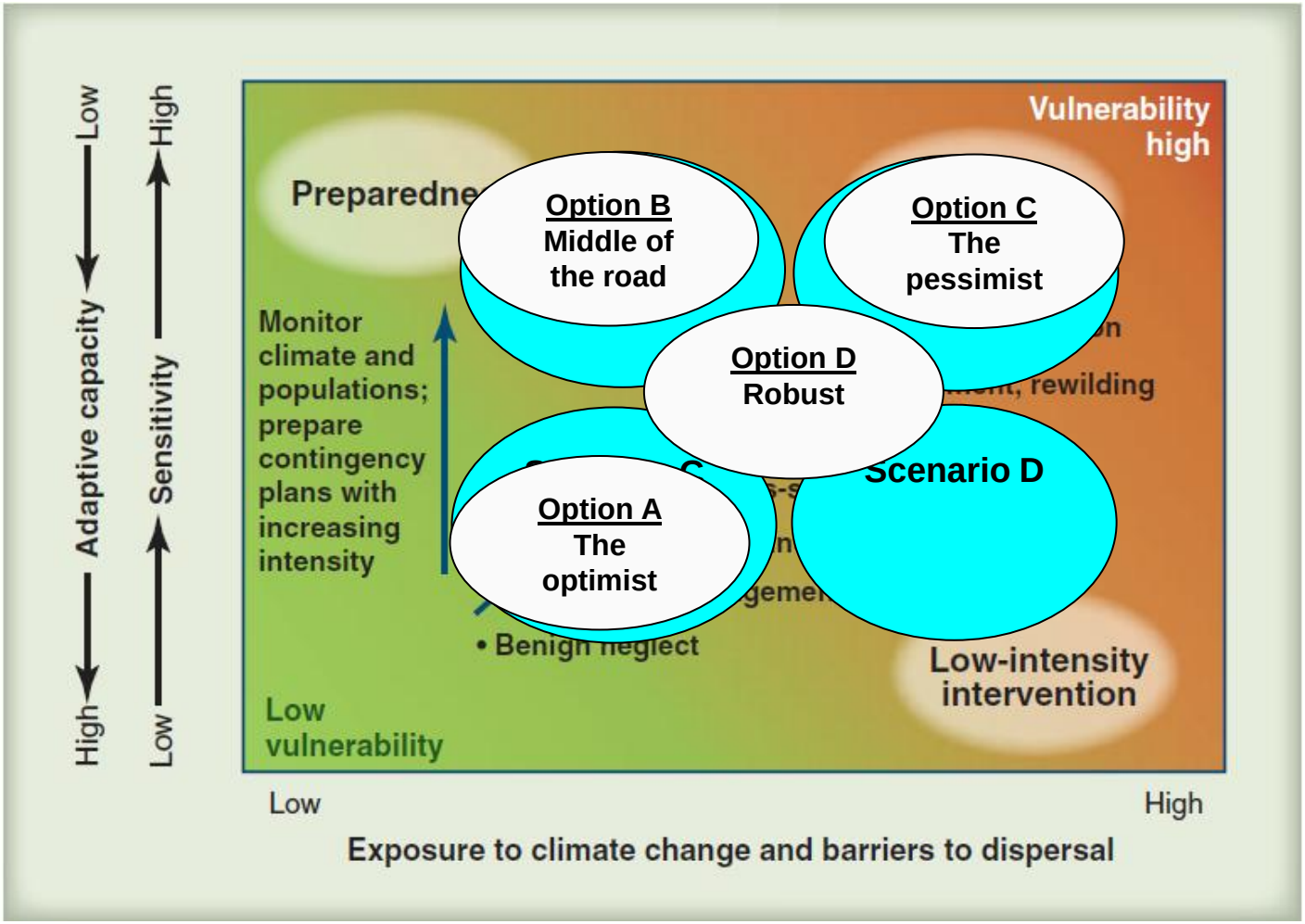
- Scenarios are **not**:
  - Predictions
  - Used to identify the most likely future

Use scenarios to characterize the future



Dawson et al., 2011, Science

Examine how management might vary given different scenarios



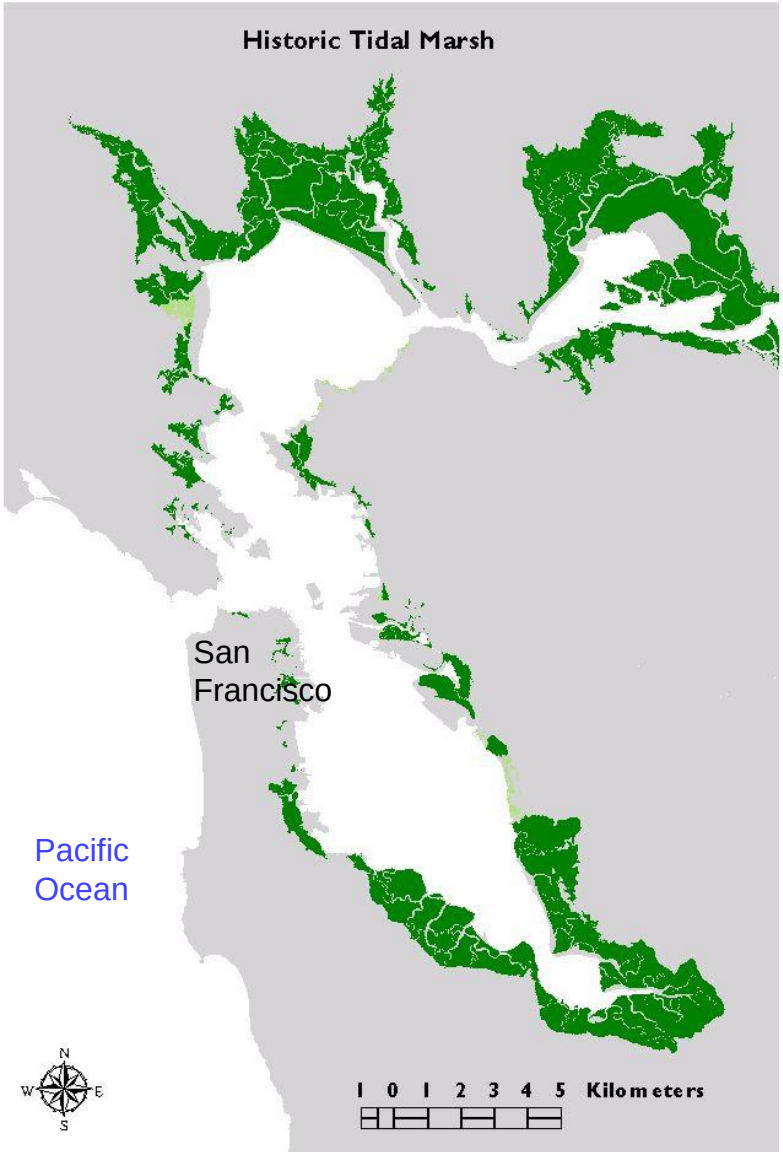
Dawson et al., 2011, Science

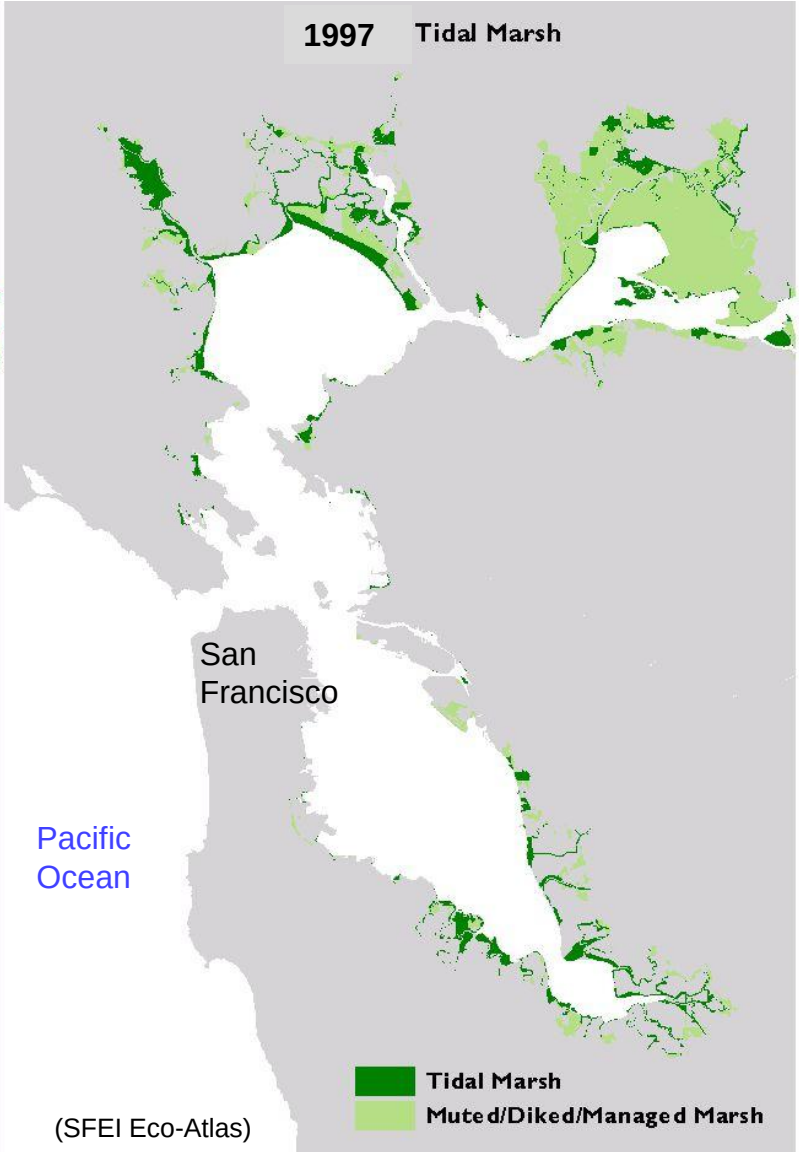
Robust decision making

- Find management strategies which are robust to a range of future climate conditions
- These strategies perform well but may not necessarily be optimal for future conditions

Prioritizing restoration in the San Francisco Estuary given high uncertainty in future conditions

Background- 90% Loss of Tidal Marsh in SF Bay

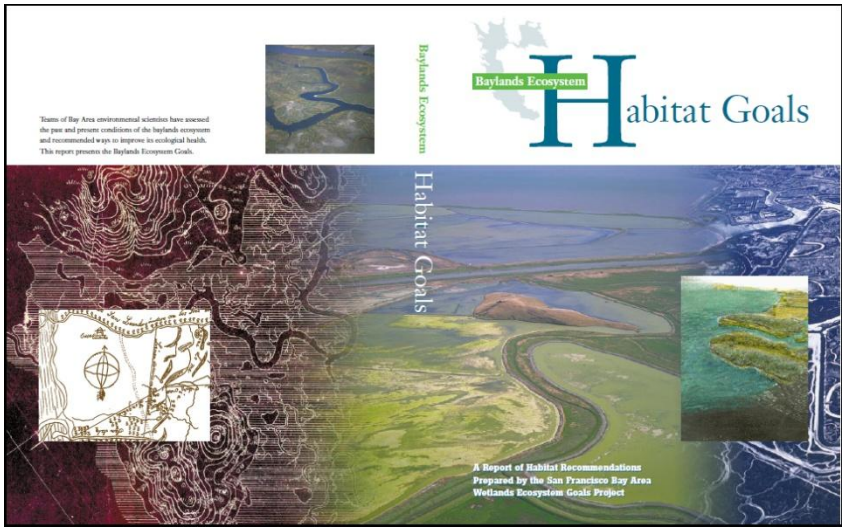




(SFEI Eco-Atlas)

Background- Changing Landscape

- **Habitat lost to: agriculture, salt ponds, urban development**
- **1999 Bayland Habitat Goals: Restoring 55,000-65,000 acres of tidal marsh habitat**

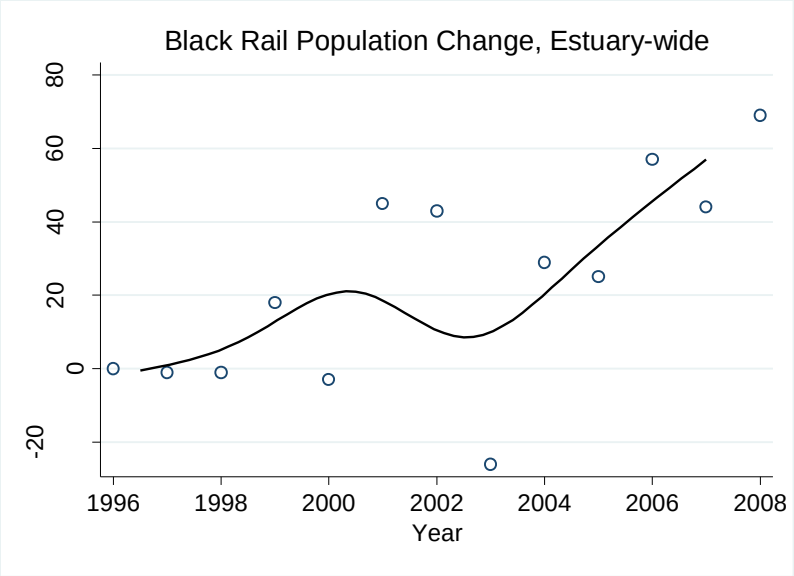


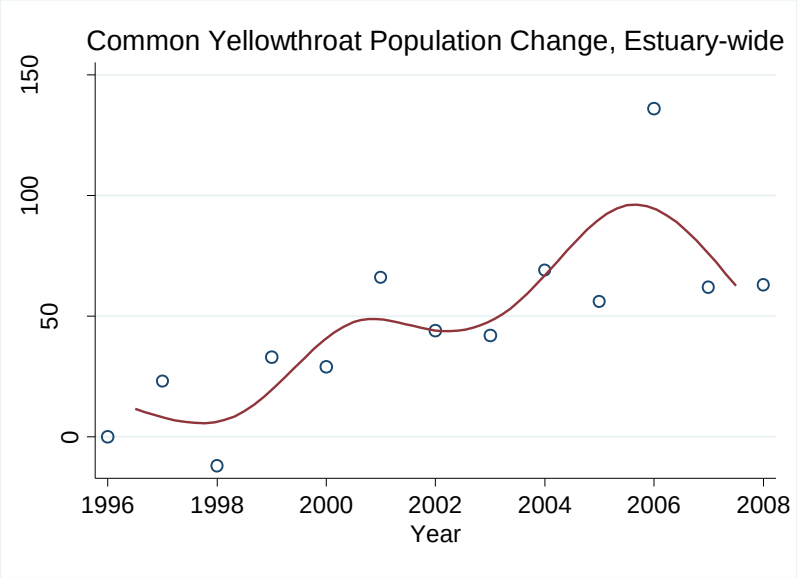
Diked Baylands

Restored marsh

Tidal marsh bird population: indications of restoration success?

Nur and Wood, unpublished

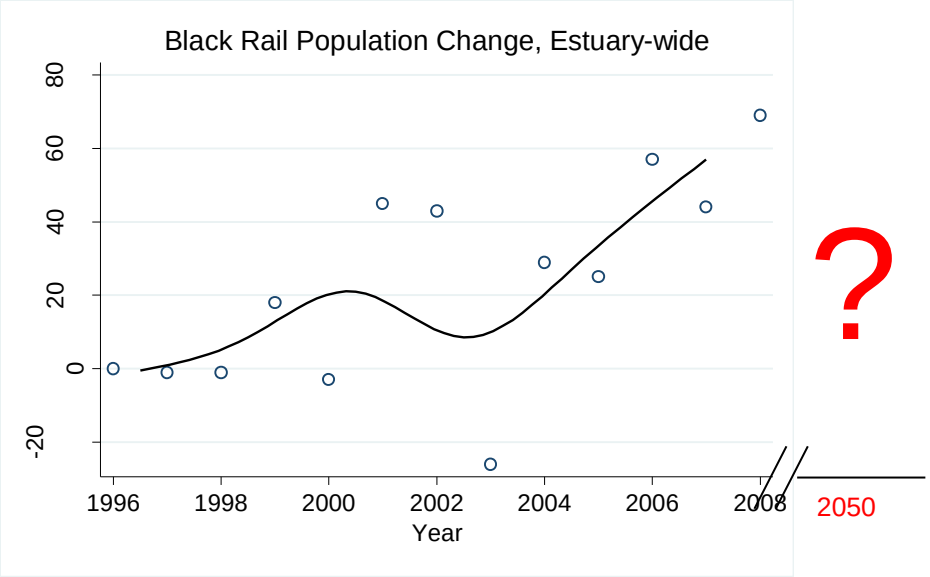


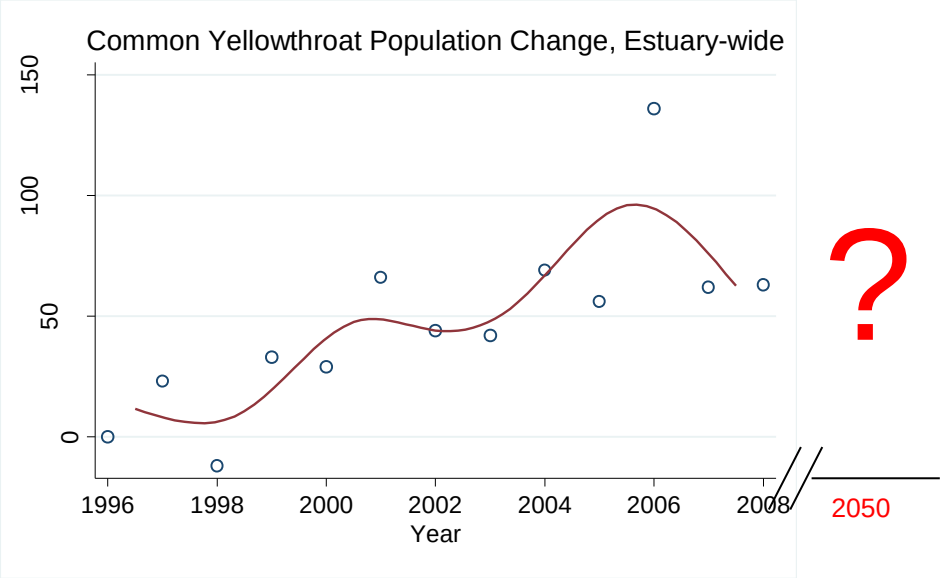


Will habitat be there in the future?

How will changing climate affect tidal marsh birds?

Nur and Wood, unpublished

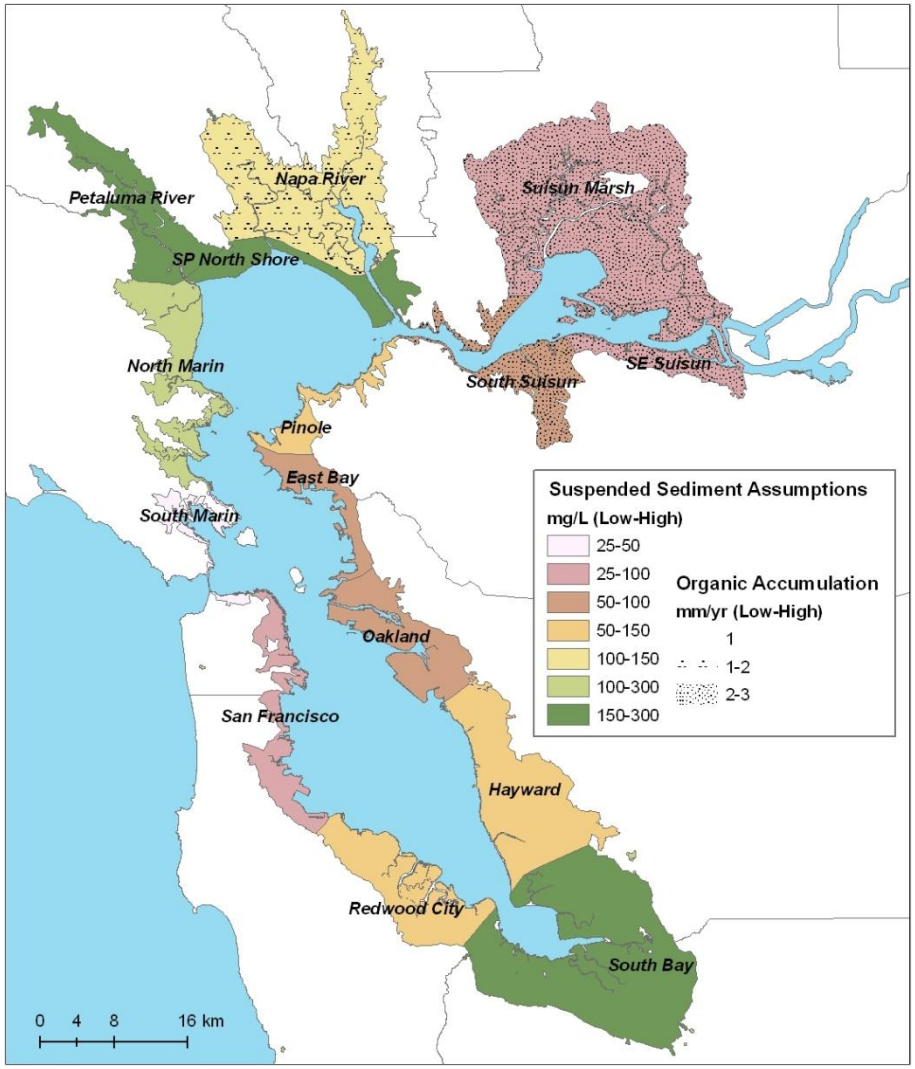




Will tidal marsh habitat sink or swim?

Scenario development: Can marsh accretion keep pace with sea level rise?

- **Sub-regional scenarios**
  - **Suspended sediment**
  - **Organic accumulation**



Global Sea Level Projections (by 2100)

5 m

0.18 to 0.59 m Intergovernmental Panel on Climate Change (*IPCC*, 2007)

- does not include ice sheet contributions

0.5 to 1.9 m Rahmstorf (*Science*, 2007)/ Vermeer and Rahmstorf (*PNAS*, 2009)

- relates sea level rise to mean surface temperature

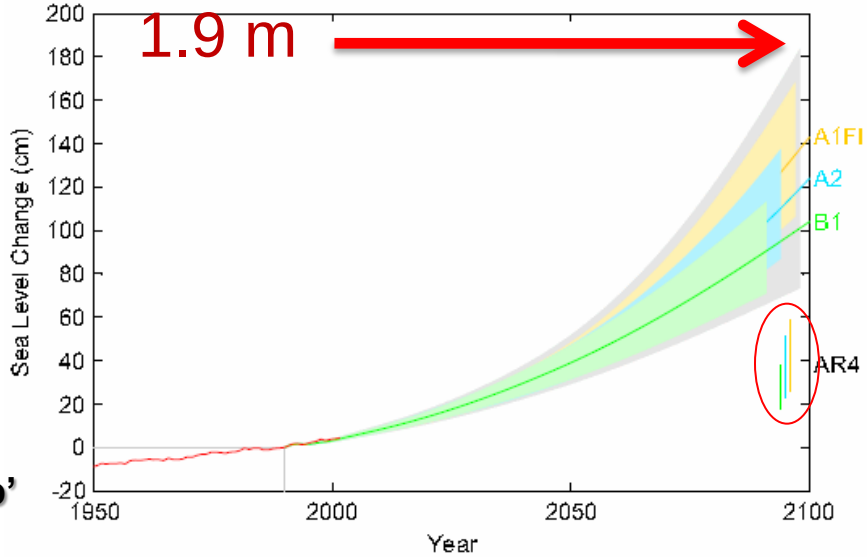
0.8 to 2 m Pfeffer et al. (*Science*, 2008)

- constrained by observations of ice sheet dynamics

5 m Hansen (*Environ. Res. Lett.*, 2007)

- non-linearity, amplifying polar feedbacks- 'albedo flip'
- sea level was 75 m higher at ~50 Ma
- at 5 Ma, sea level was ~25 m higher , but only 2-3°C warmer (A2 emissions scenario is 4.5 °C warmer)

Vermeer and Rahmstorf, PNAS 2009

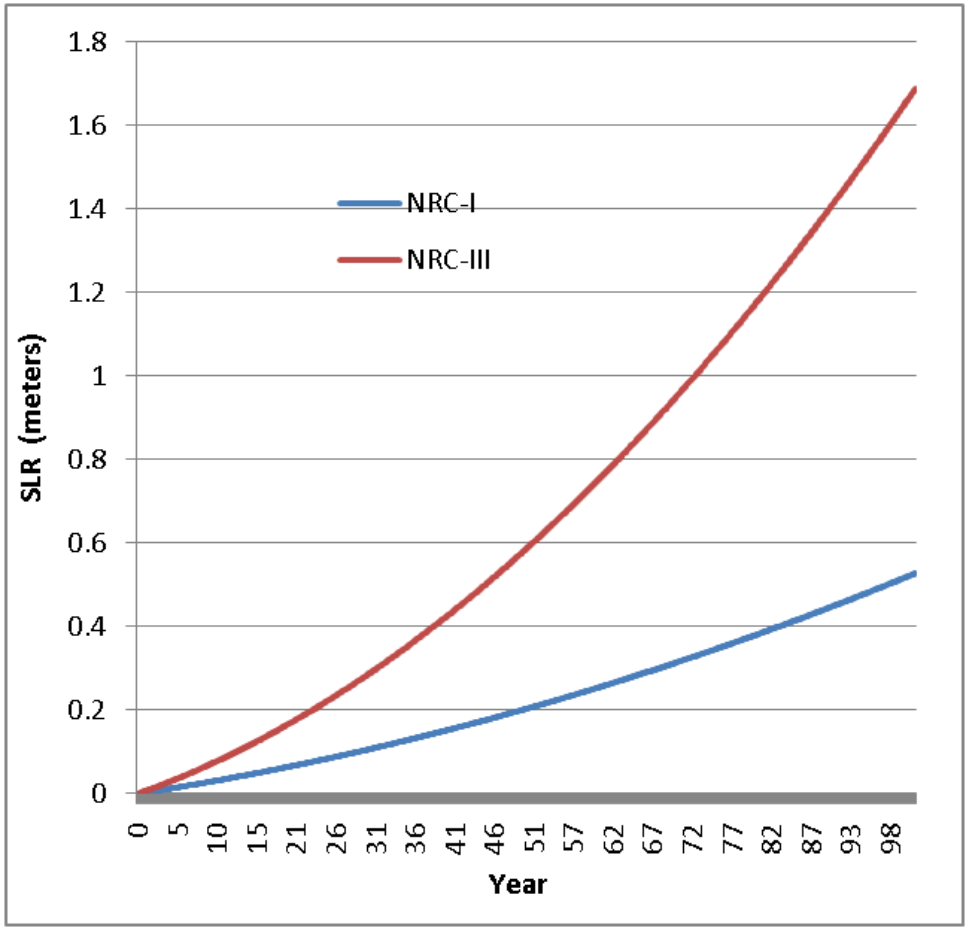


Patrick Barnard, USGS

Scenario development: Can marsh accretion keep pace with sea level rise?

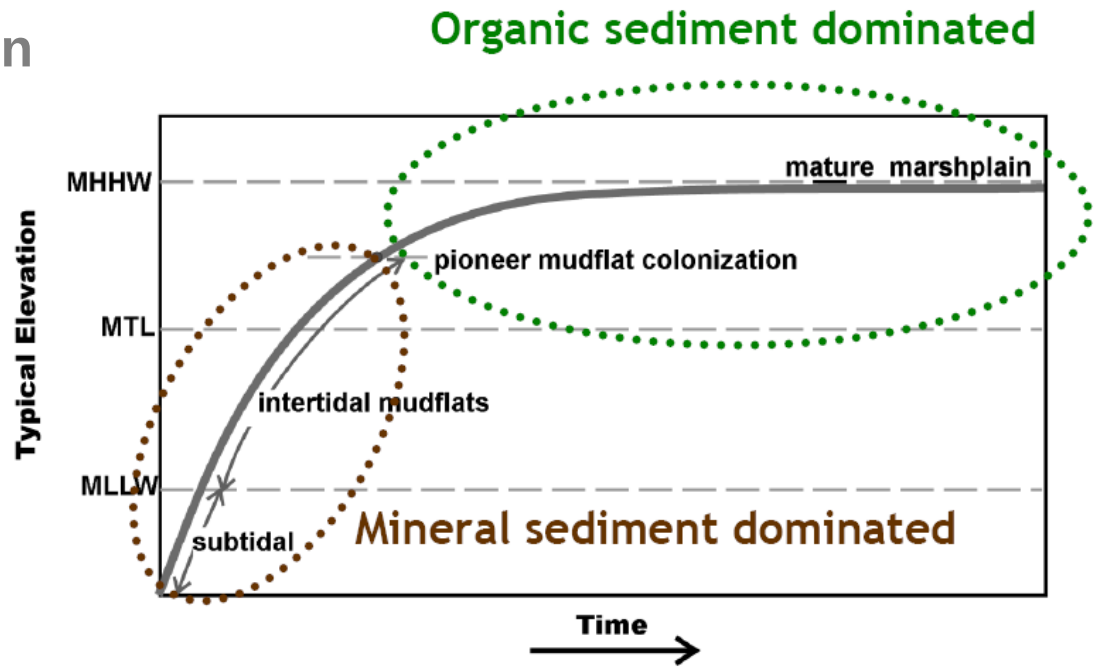
- Sub-regional scenarios
  - Suspended sediment
  - Organic accumulation
- **Sea-level rise by 2110**
  - Low = 0.5 m
  - High = 1.65 m

From National Research Council, adopted by ACOE



Scenario development: Can marsh accretion keep pace with sea level rise?

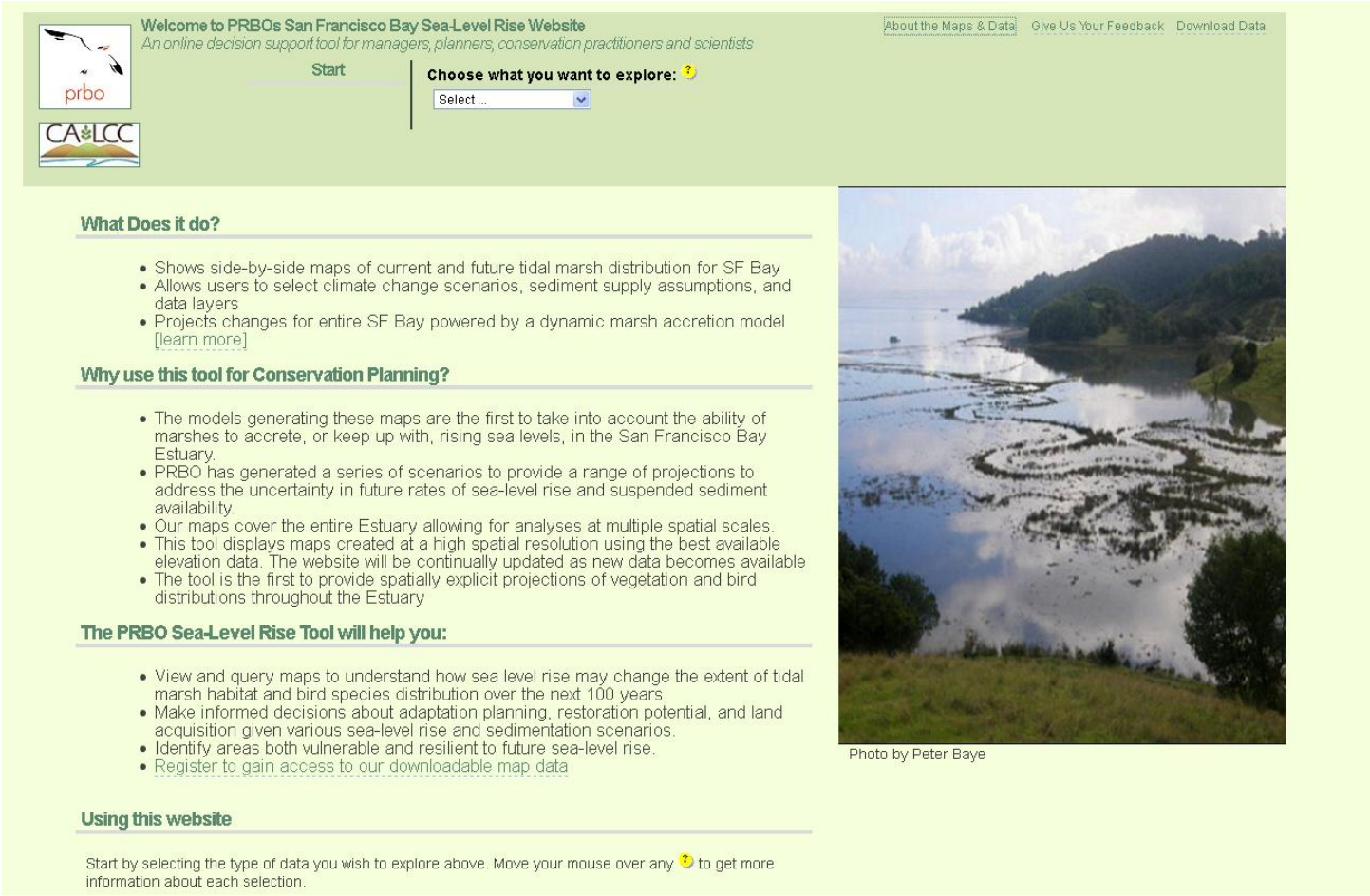
- Sub-regional scenarios
  - Suspended sediment
  - Organic accumulation
- Sea-level rise
- **Marsh 98 Accretion Model**



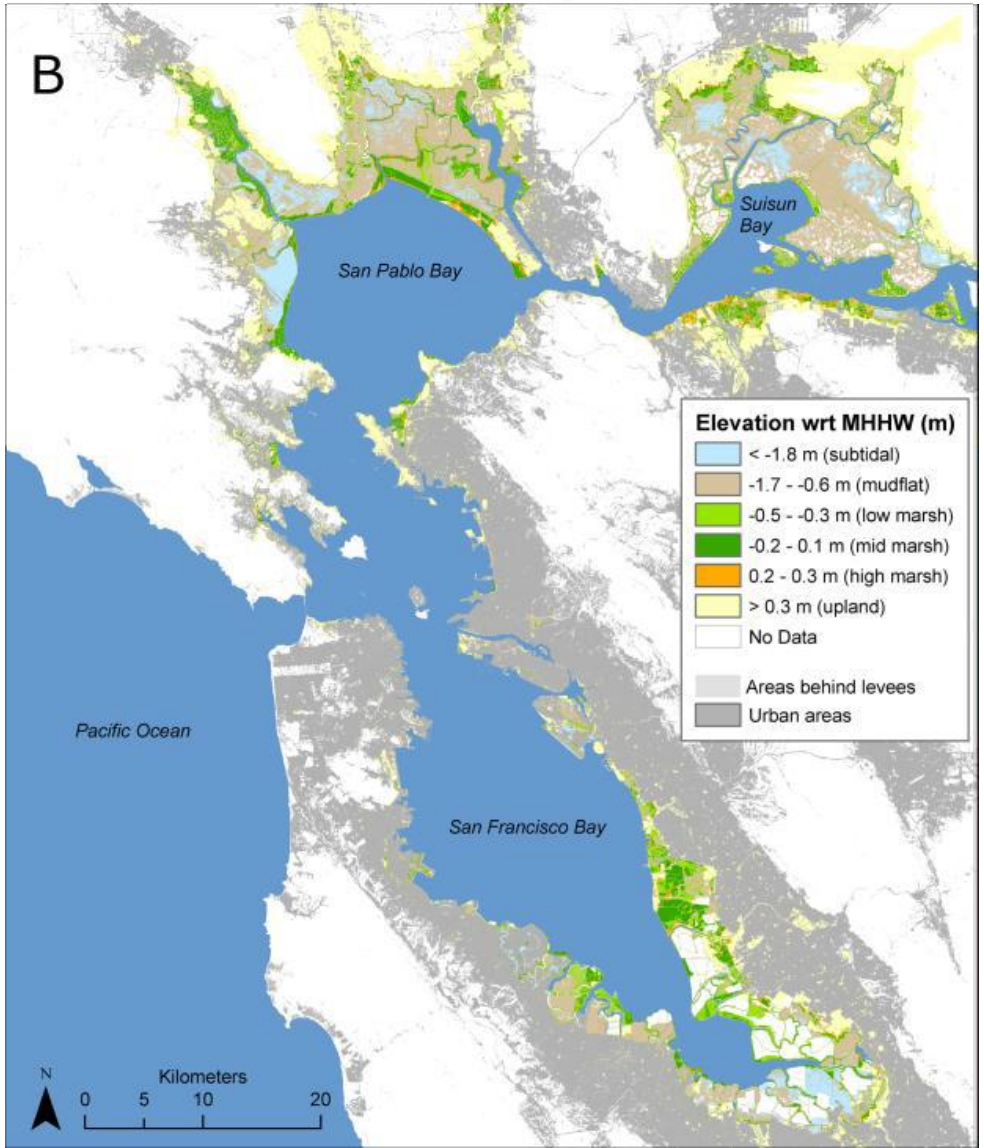
S. Crooks, ESA PWA

Online SF Bay Tidal Marsh Sea-Level Rise Tool

www.prbo.org/sfbayslr



Current tidal marsh habitat and potential habitat with restoration (levee removal)



Marsh sustainability is extremely sensitive to sediment availability and SLR scenario

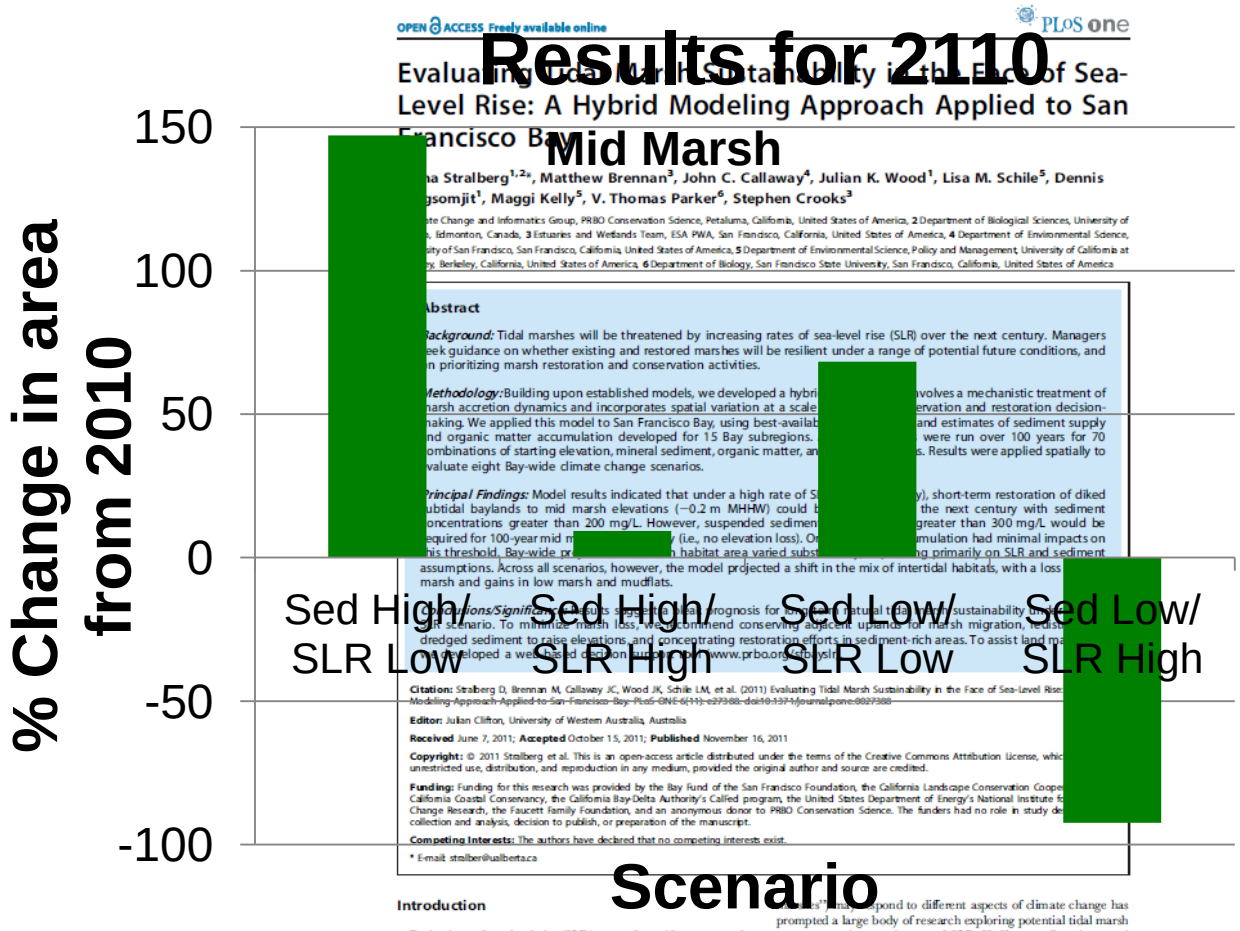
Projections for 2110

Low sediment/ high SLR

Habitat Type

	Above +0.3m (Upland)
	0.2m to +0.3m (High Marsh)
	-0.2m to +0.1m (Mid Marsh)
	-0.5m to -0.3m (Low Marsh)
	-1.8m to -0.6m (Mudflat)
	-2.4 m to -1.8m (Subtidal)
	Bay water level
	No Data

Accretion model results: Tidal marsh habitat is very sensitive to the SLR scenario and sediment availability



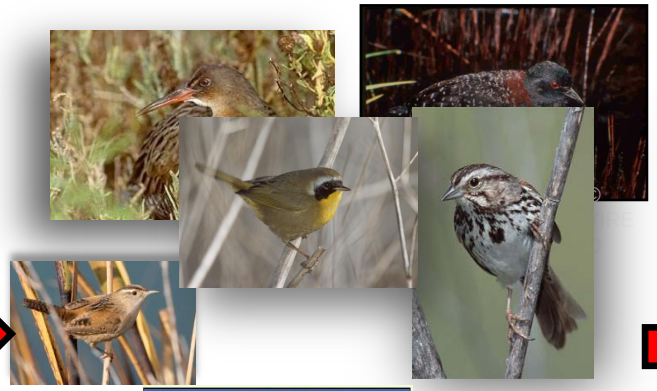
http://www.plosone.org/article/info%3Adoi%2F10.1371%2Fjournal.pone.0027388

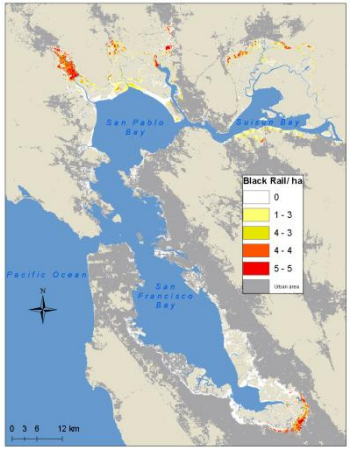
Results – summary of key findings

- **Models are sensitive to sediment and sea level rise scenarios but not organic accumulation**
- **We project increases in tidal marsh habitat in all scenarios except for low sediment/ high sea level rise (93% of mid and high marsh lost)**
- **Up to 7,500 ha (current) and ~32,500 ha (future sed high/slr low) of diked baylands have restoration potential.**
- **Up to 3,300 ha of uplands could become marsh by 2100.**
- **Sediment-rich areas have better prospects for long-term sustainability.**

How will tidal marsh birds respond to future scenarios?

We used our bird observations with marsh accretion results to model tidal marsh bird response to sea level rise, including changes in salinity





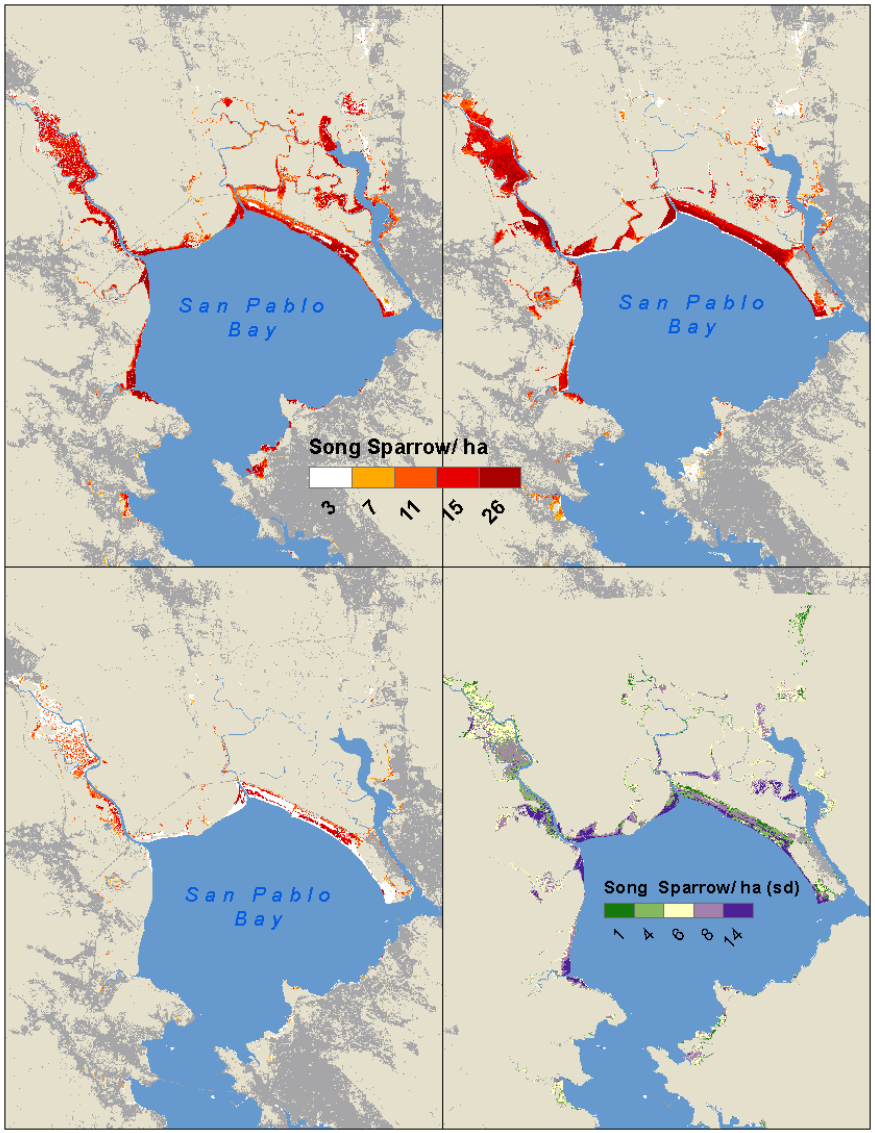
Variation in response in space and by scenario

2010

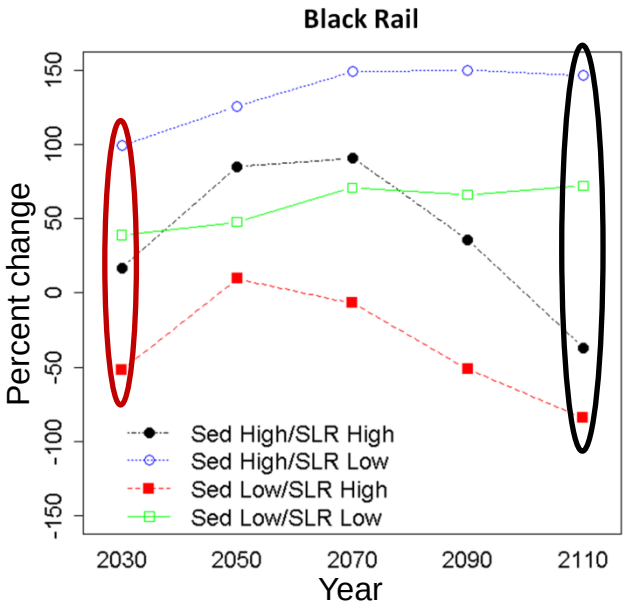
2110: High sediment/ High SLR

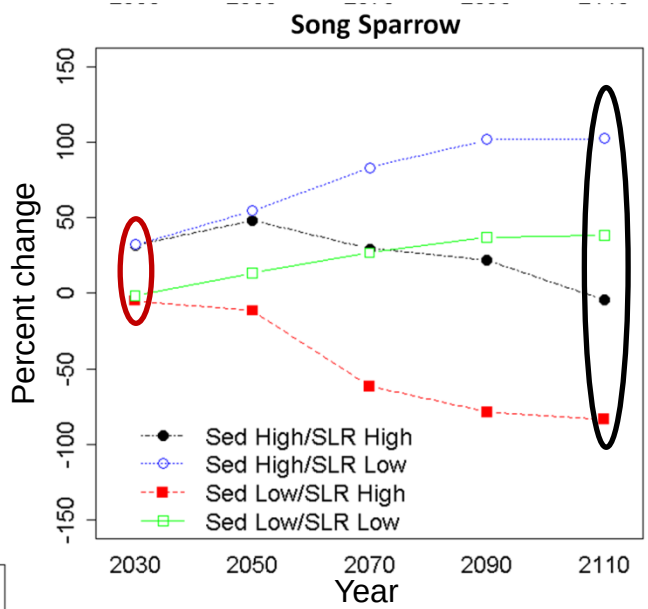
2110: Low sediment/ High SLR

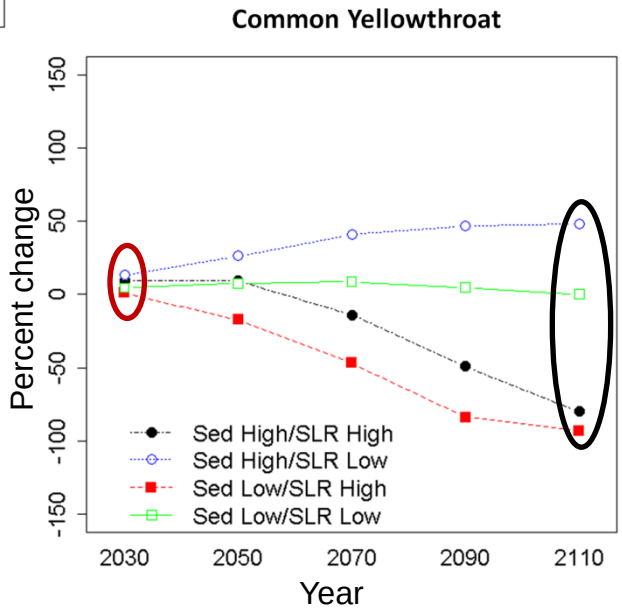
2110: Variation across scenarios



Tidal marsh birds are also sensitive to scenarios







Is the robust solution the best solution given high uncertainty?

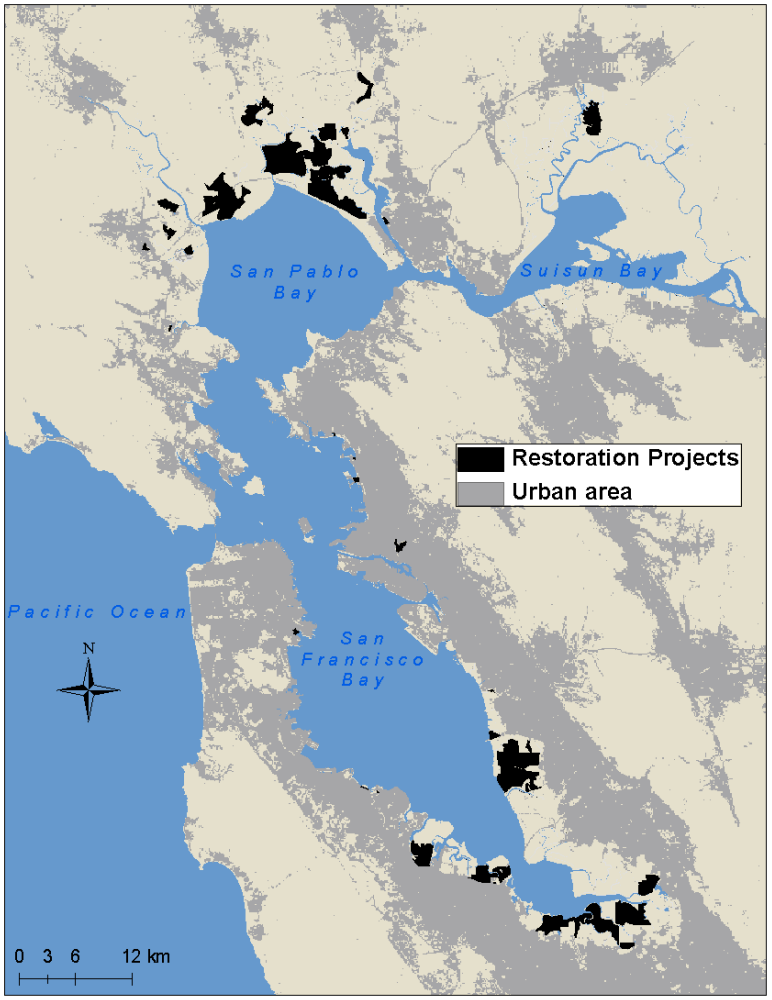
Experimental Design

There are 97 proposed or in progress restoration projects in the SF Estuary.

Select the top 25% of these projects to prioritize for restoration?

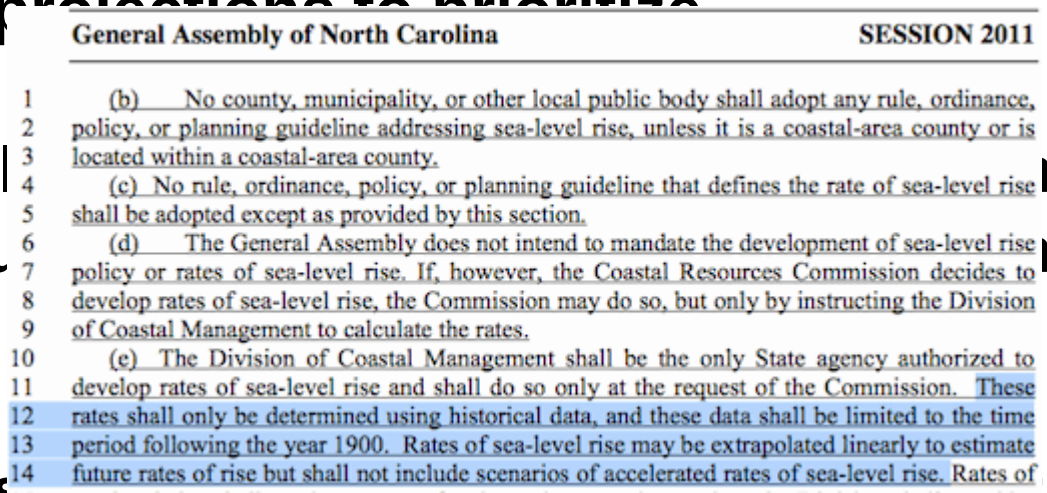
Use each future scenario, and two alternative methods to test restoration prioritization.

Use each future scenario to evaluate the restoration prioritization for that scenario.



Restoration prioritization method

- **Assume future projections are too uncertain, use current p**
- **Iterativel** **narios is the tru** **t/ high and low**
- **Robust st** **oritize, select site** **narios, down-weig** **ross scenarios**



General Assembly of North Carolina SESSION 2011

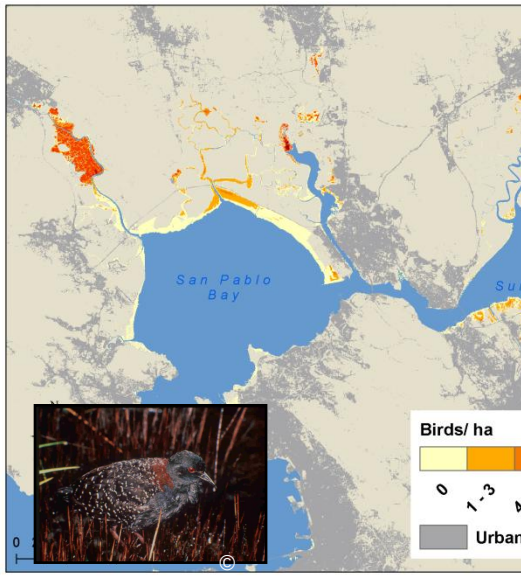
(b) No county, municipality, or other local public body shall adopt any rule, ordinance, policy, or planning guideline addressing sea-level rise, unless it is a coastal-area county or is located within a coastal-area county.

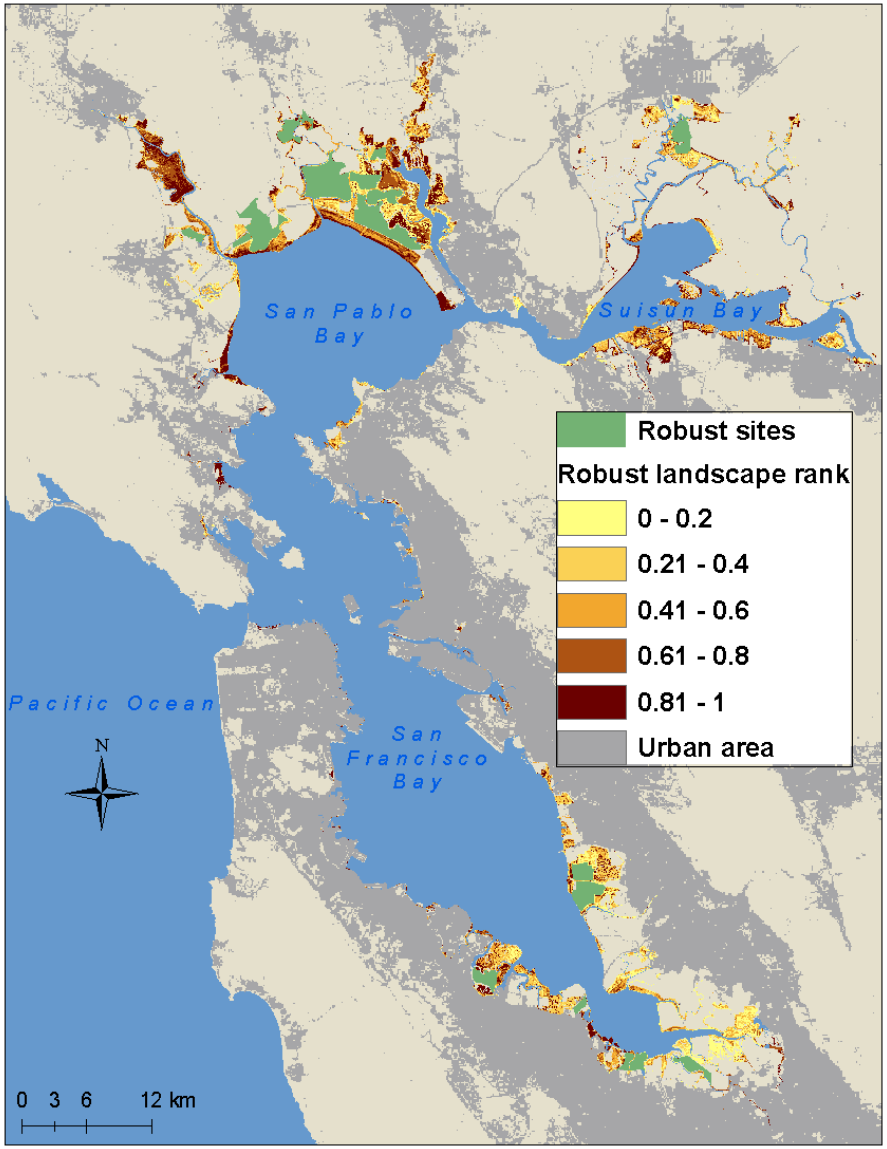
(c) No rule, ordinance, policy, or planning guideline that defines the rate of sea-level rise shall be adopted except as provided by this section.

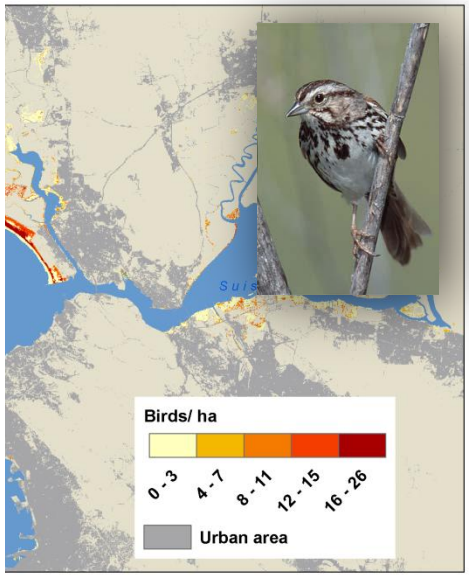
(d) The General Assembly does not intend to mandate the development of sea-level rise policy or rates of sea-level rise. If, however, the Coastal Resources Commission decides to develop rates of sea-level rise, the Commission may do so, but only by instructing the Division of Coastal Management to calculate the rates.

(e) The Division of Coastal Management shall be the only State agency authorized to develop rates of sea-level rise and shall do so only at the request of the Commission. These rates shall only be determined using historical data, and these data shall be limited to the time period following the year 1900. Rates of sea-level rise may be extrapolated linearly to estimate future rates of rise but shall not include scenarios of accelerated rates of sea-level rise. Rates of

Zonation Conservation Planning Software (Moilanen, A. 2007)







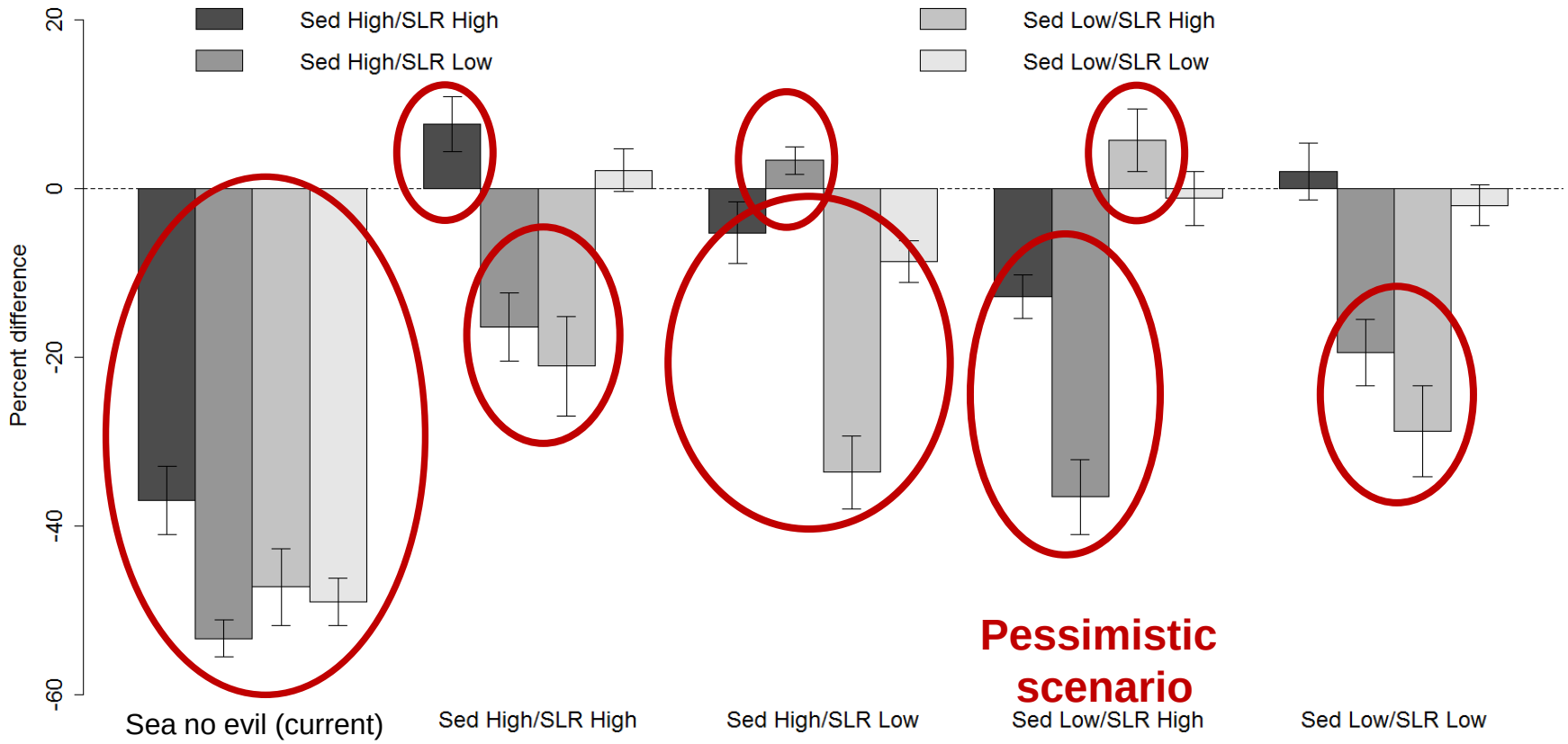
Robust strategy performs consistently well

When the "Sea no evil" strategy performs poorly in every scenario

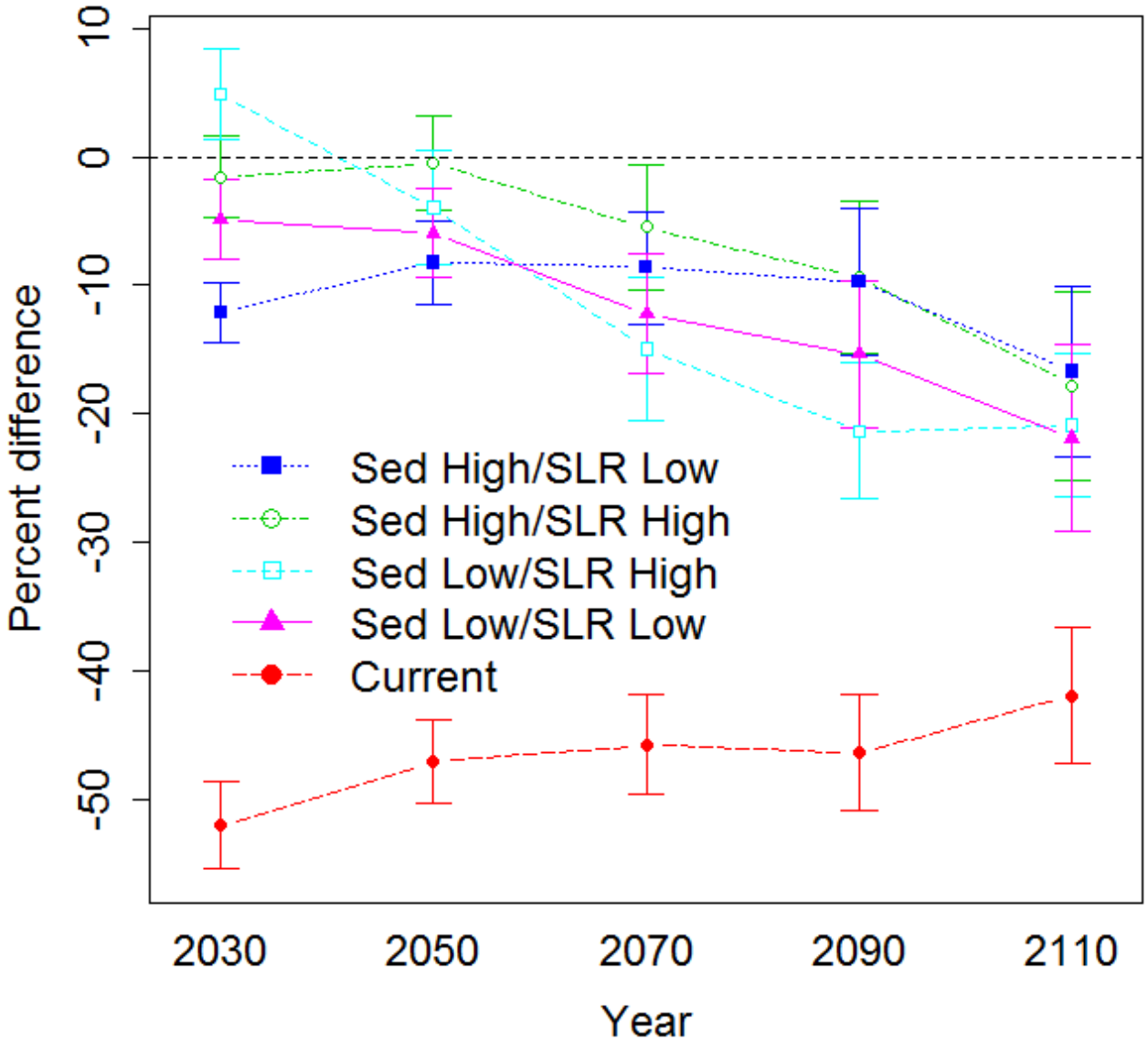
The "Sea no evil" strategy performs poorly in every scenario

When the robust strategy performs poorly in every scenario

the robust strategy does better



Robust strategy performs the best when uncertainty is high



Summary: Robust decision making may lead to more efficient management when uncertainty is high

- In our study, incorporating all scenarios in restoration prioritization provided consistently high performance for choosing the best restoration projects
- High uncertainty should **NOT** be an excuse to ignore the future
- Incorporating future models, even when the wrong future scenario was chosen, tended to produce better results than relying on current conditions
- When uncertainty is high, robust decision making using future scenarios may lead to better adaptation planning than trying to predict the future precisely

Future Work

- Incorporate models for population viability
- Include habitat for shorebirds coupled with mudflat models
- Work with partners to develop new tools to evaluate the effects of floods and storm hazards (http://data.prbo.org/apps/ocof/)
- Engage stakeholders to at local levels to apply our tool in adaptation planning efforts

Acknowledgments

Funding: Coastal Conservancy, CA LCC , Bay Fund of the San Francisco Foundation

Collaborators: John Callaway (SFU); Lisa Schile & Maggi Kelly (UC Berkeley); Tom Parker & Ellen Herbert (SFSU); Lynne Stenzel, Gary Page (PRBO)

Technical Assistance: Doug Moody (PRBO Conservation Science); Justin Vandever (PWA)

Conservation Input: Coastal Conservancy, SF Bay Joint Venture, BCDC, USFWS, Sonoma Land Trust, Sonoma Open Space District

Scientific Input: Dave Schoellhamer (USGS), Neil Ganju (USGS), Stuart Siegel (WWR), Bruce Jaffe (USGS)

Elevation Data: Noah Knowles (USGS), FEMA, Joel Dudas (DWR), Stuart Siegel (WWR), Sonoma County

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