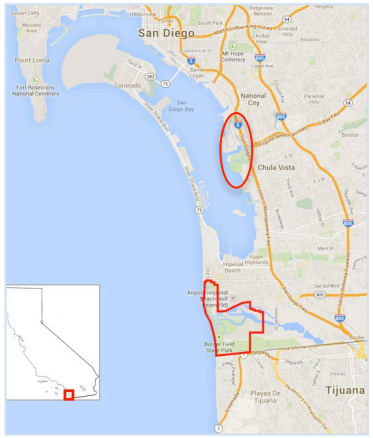
# Adaptive approaches to wetland restoration in southern California

Adaptive Management → Adaptive Restoration

(San Diego Bay) (Tijuana Estuary)




Joy Zedler, UW-Madison
Formerly PERL at SDSU

# Adaptive management

- Plan → implement
- Assess → find problem
- Mid-course correction

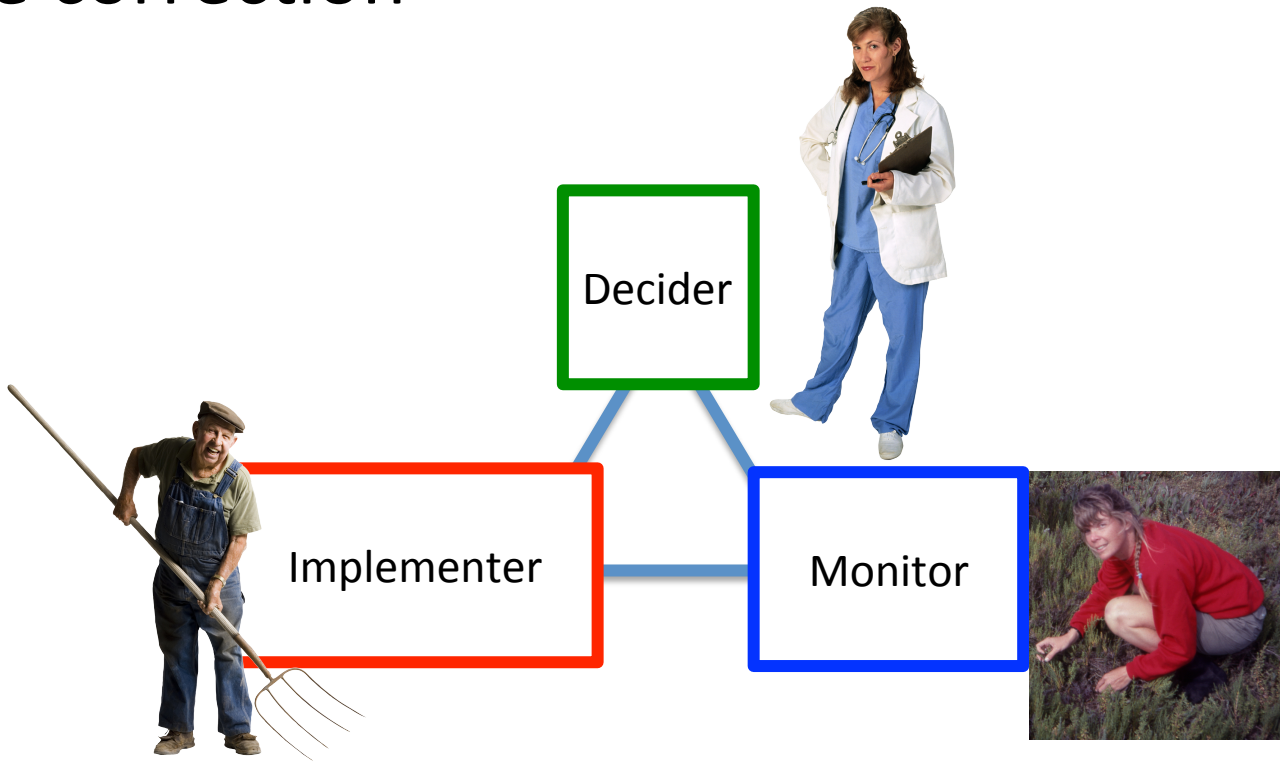
We all do it…..informally

Setting the day's agenda

Cooking dinner

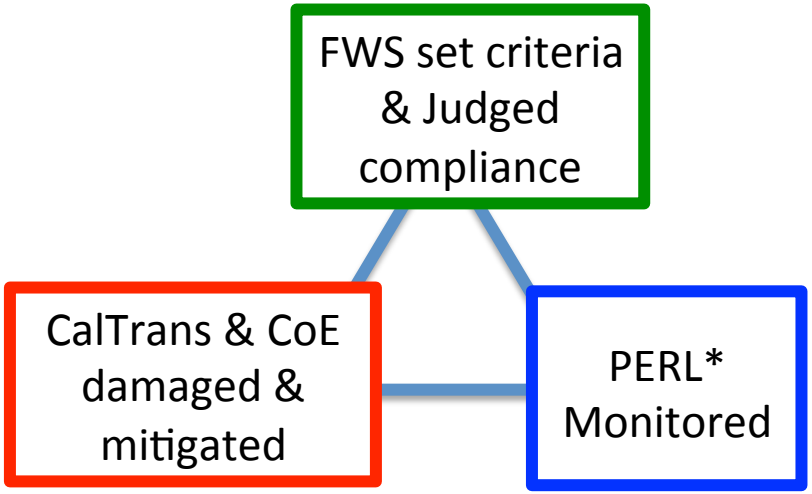
# Adaptive management team

- Plan → implement
- Assess → find problem
- Mid-course correction



# Adaptive management team: San Diego Bay

- Plan → implement
- Assess → find problem
- Mid-course correction

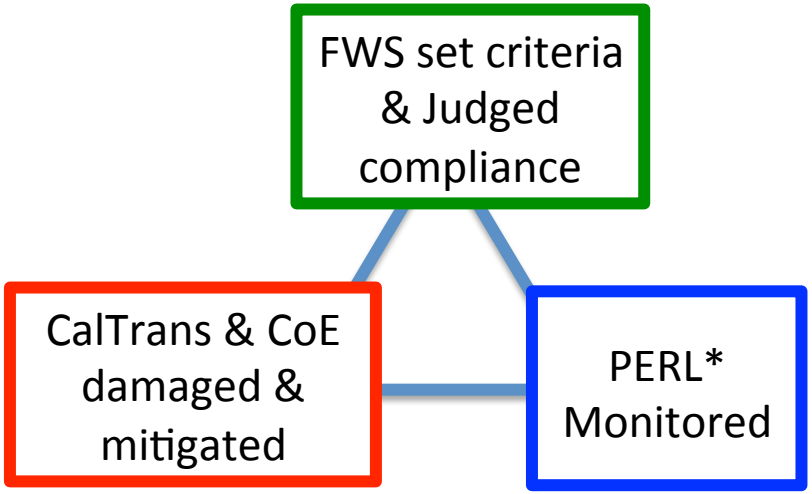



*Pacific Estuarine Research Lab

+ overly optimistic predictions

# Adaptive management team: San Diego Bay

- Plan → implement
- Assess → find problem
- Mid-course correction




*Pacific Estuarine Research Lab

OOPs

+ overly optimistic predictions

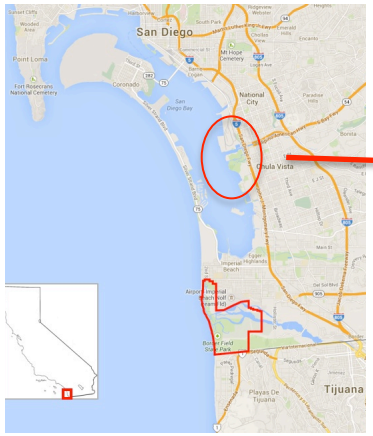
# Sweetwater Marsh mitigation efforts

Freeway widening led FWS to mandate habitat restoration for 3 species protected by the Endangered Species Act:

Salt marsh bird's beak

Light-footed clapper rail

California least tern




# FWS: This federally-endangered plant must be reintroduced, form 5 patches, & increase for 3 yrs

Salt marsh bird's beak
*(Cordyanthus maritimus* ssp. *maritimus),*

~15 cm tall; flowers ~1 cm

Hemi-parasite (needs hosts to obtain water & nutrients to produce seeds in summer)

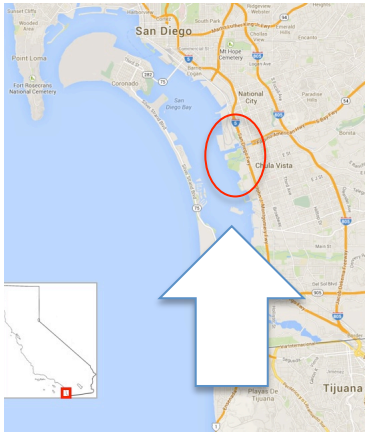
Annual plant:
must get pollinated,
**must produce seeds**

# Salt marshes (1990s):

remnant

&

constructed




1. Seeds sown on a new island

**OOPs**…Few seeds were produced.

2. Our research showed that pollinators didn't nest on islands.

Burrowing bees only nest above the tide line.

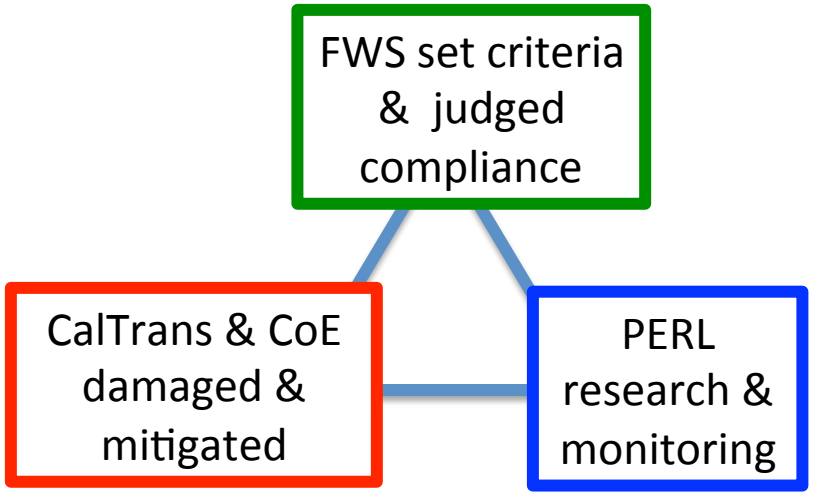
04.08.2004

3. Mid-course correction:
   Sow seeds on mainland

4. Monitor outcome:

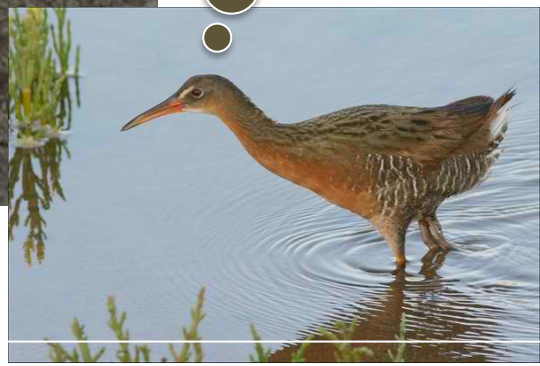
   (14,000 plants in 1995).

5. Criteria achieved*




*OOPs: <100 plants in 2014

# FWS: Create seven 2-acre home ranges with nesting sites for the light-footed clapper rail (now = Ridgway's rail)

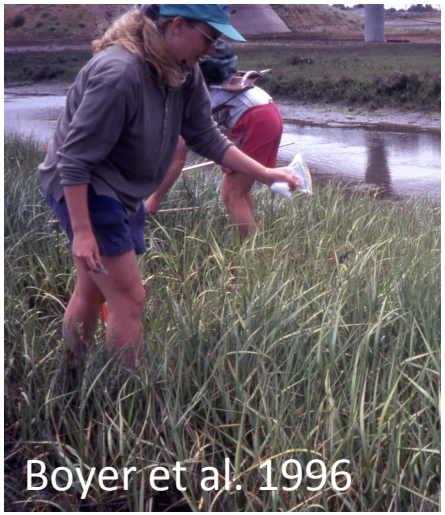



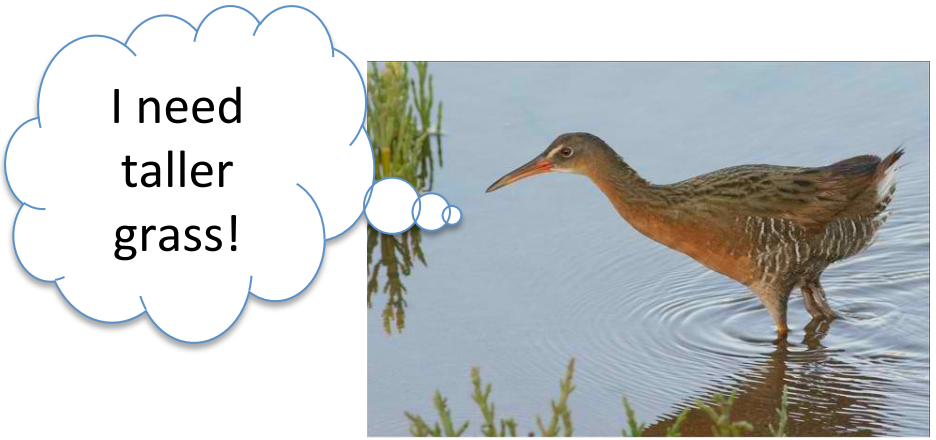
1. Construct & plant marshes
2. Assess cordgrass height; test stressors

*Rallus obsoletus longirostris*

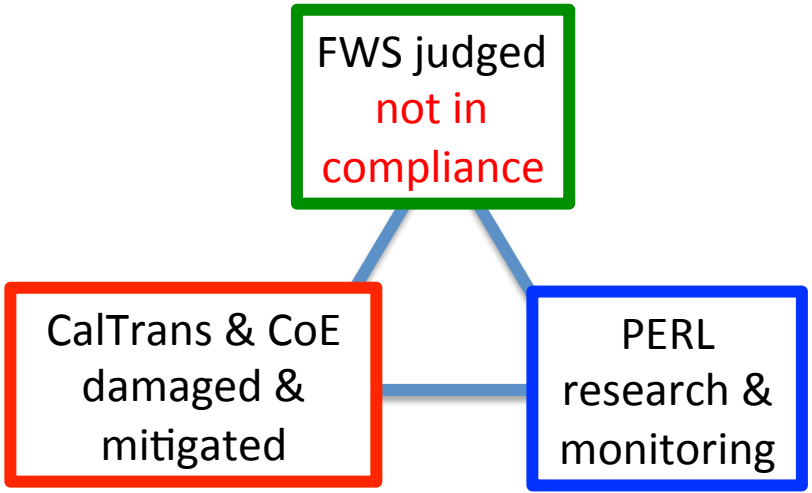
**OOPs**. Field experiments showed that sandy dredge spoil could not provide tall cordgrass for this bird's nests. `

Experiments found limitation by nitrogen.




3. Mid-course correction: Add nitrogen for 5 years
4. Monitor: Cordgrass still short
5. Decision: Criteria unachievable



FWS: Create tidal channels with adequate fish for endangered California least terns (*Sternula antillarum browni*)

1. Tidal channels excavated
2. Research found ≥75% of the native fish species and ≥75% of density of natural channels for 2 years

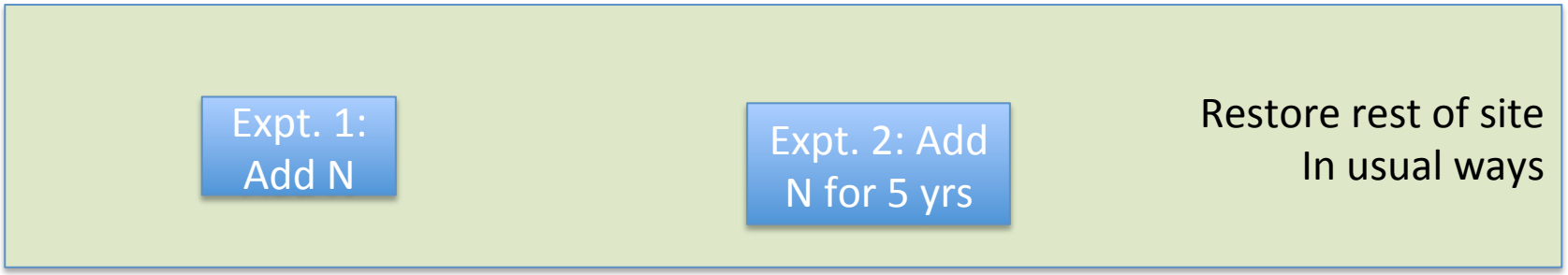
3. Criteria achieved

FWS judged compliance

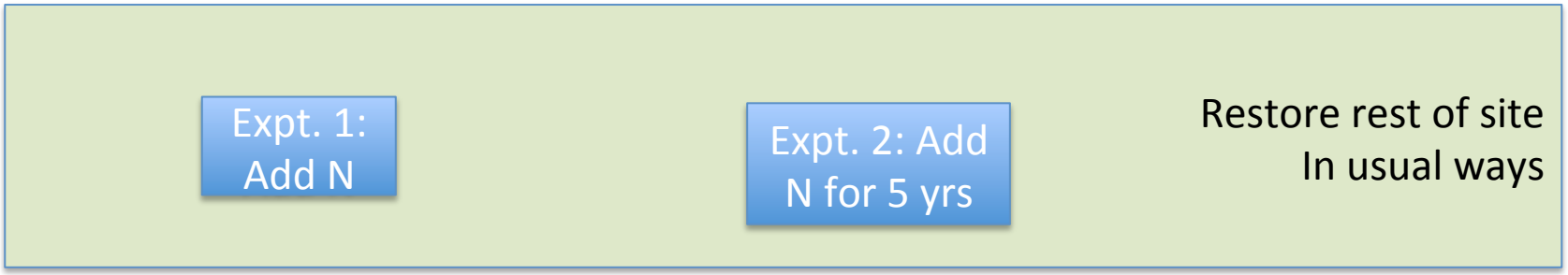
CalTrans & CoE damaged & mitigated

PERL monitored

**Adaptive management** uses science to improve restoration; imbed experiments in sites to test factors that constrain restoration, e.g.:



**Adaptive management** uses science to improve restoration; imbed experiments in sites to test factors that constrain restoration, e.g.:




**Adaptive restoration** is a special case, with phased restoration, restoring sites as large experiments, learning while restoring, e.g.:

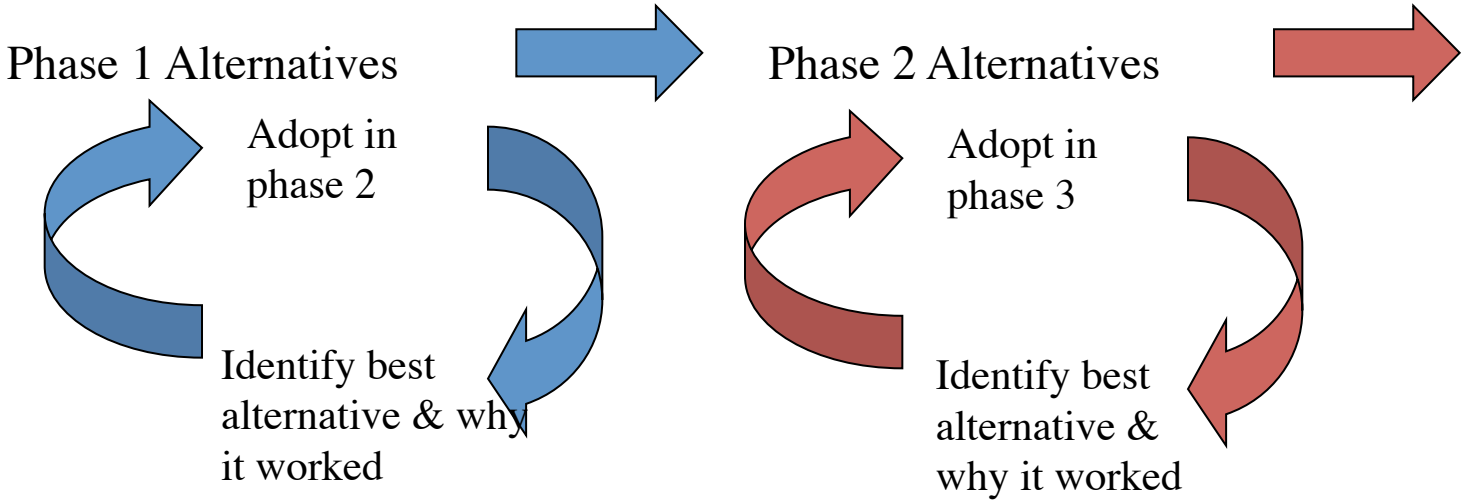

See Leaflet #4 at https://arboretum.wisc.edu/science/research/leaflets

# Adaptive Restoration: Tijuana Estuary:

downstream from a 4530-km$^2$ watershed, mostly in Mexico

# Adaptive restoration: Learning while restoring

- Identify unknowns that need to be known
- Restore in phases
- Test alternative approaches in large field experiments
- Evaluate outcomes
- Apply new knowledge to improve restoration in later phases

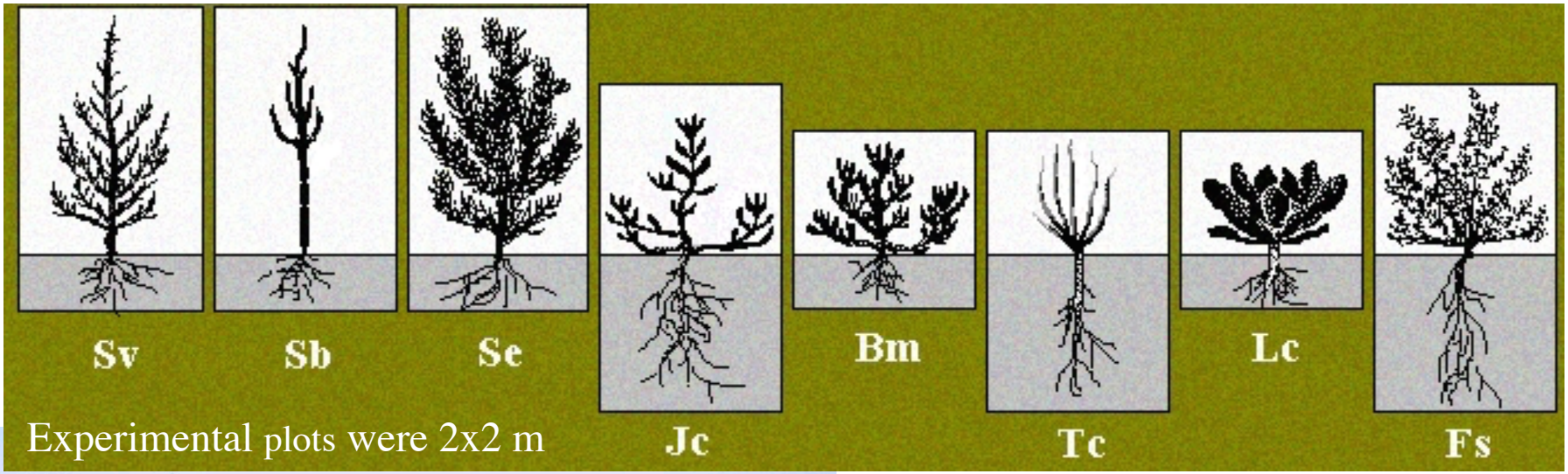


# Tijuana Estuary (Phase 1 restoration): We tested ways to achieve diverse, self-sustaining vegetation

1997

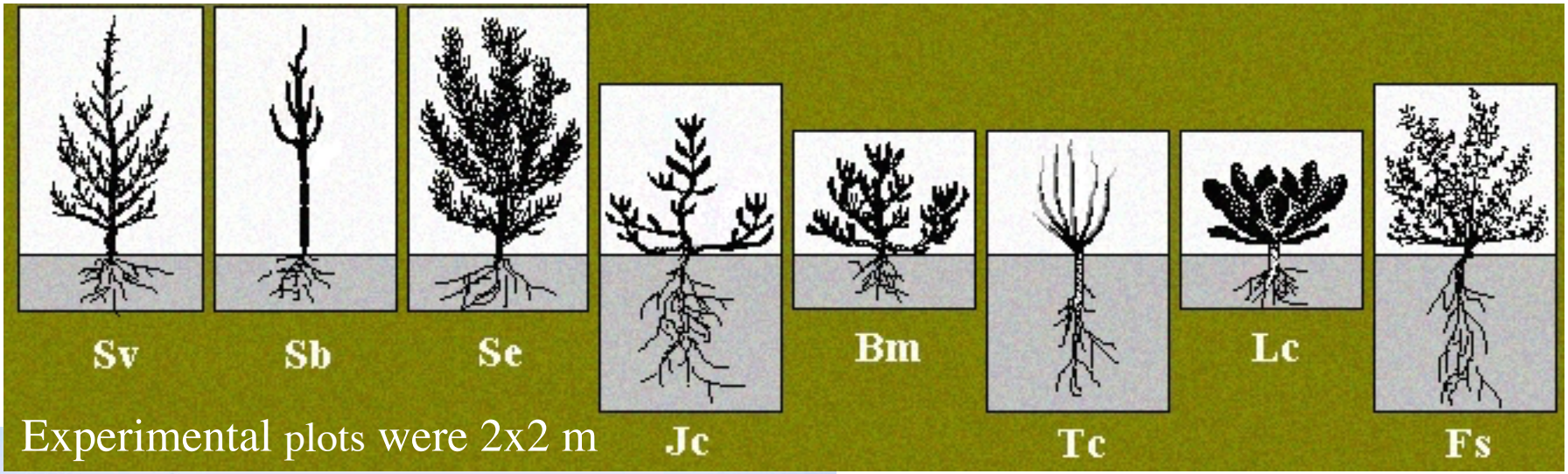
Callaway et al. 2003 and Doherty et al. 2011

# We tested the need to plant each of the 8 halophytes




After planting in 1997

# We tested the need to plant 3- and 6-species combinations




After planting in 1997 & in 1999

Plots with 6 species initially had more NPP, N crop, & canopy complexity

Callaway et al. 2003, Lindig-Cisneros & Zedler 2002; Keer & Zedler 2002

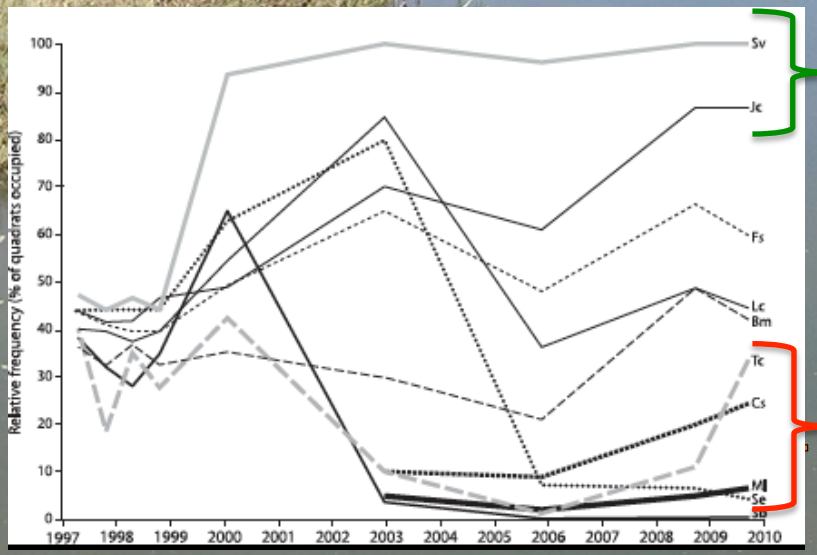
# OOPs:

Algal bloom after old-sewage-lagoon sediments were disturbed. Coots arrived to eat algae; coots trampled seedlings.

Some seedlings needed replanting.

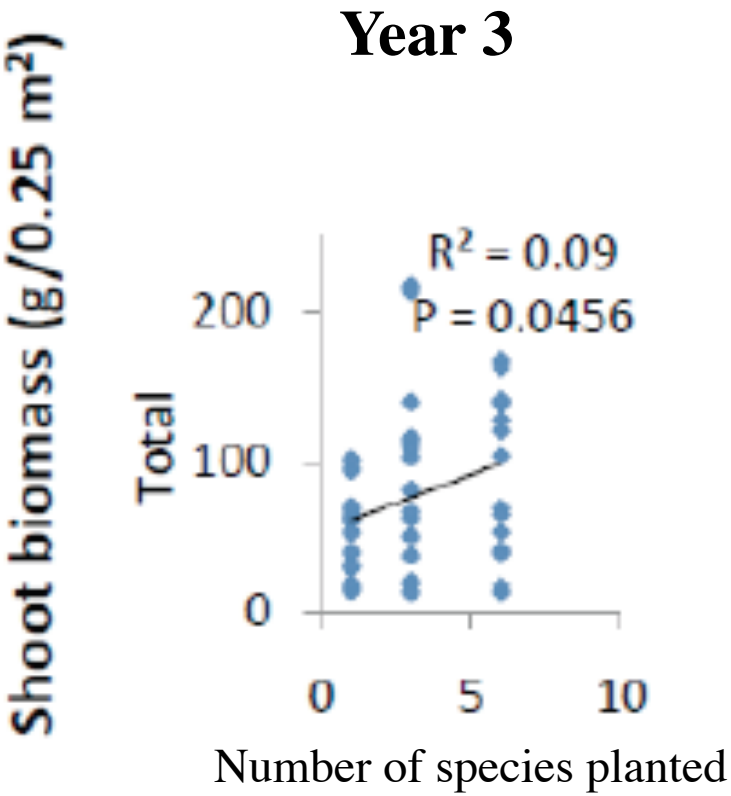
**Year 7: 100% cover**

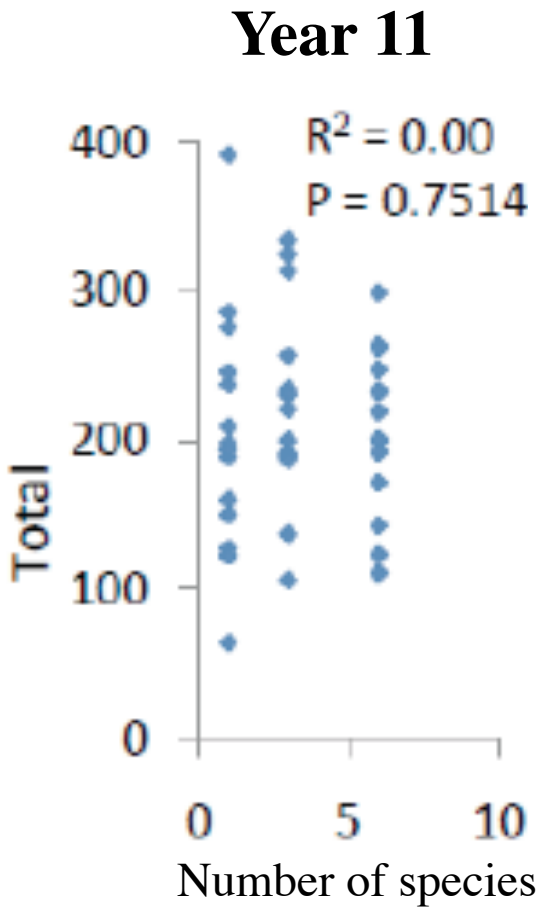
**Year 13:** Pickleweed, Salt marsh Daisy




OOPs

# **OOPs**. The initial diversity effect was short-lived.



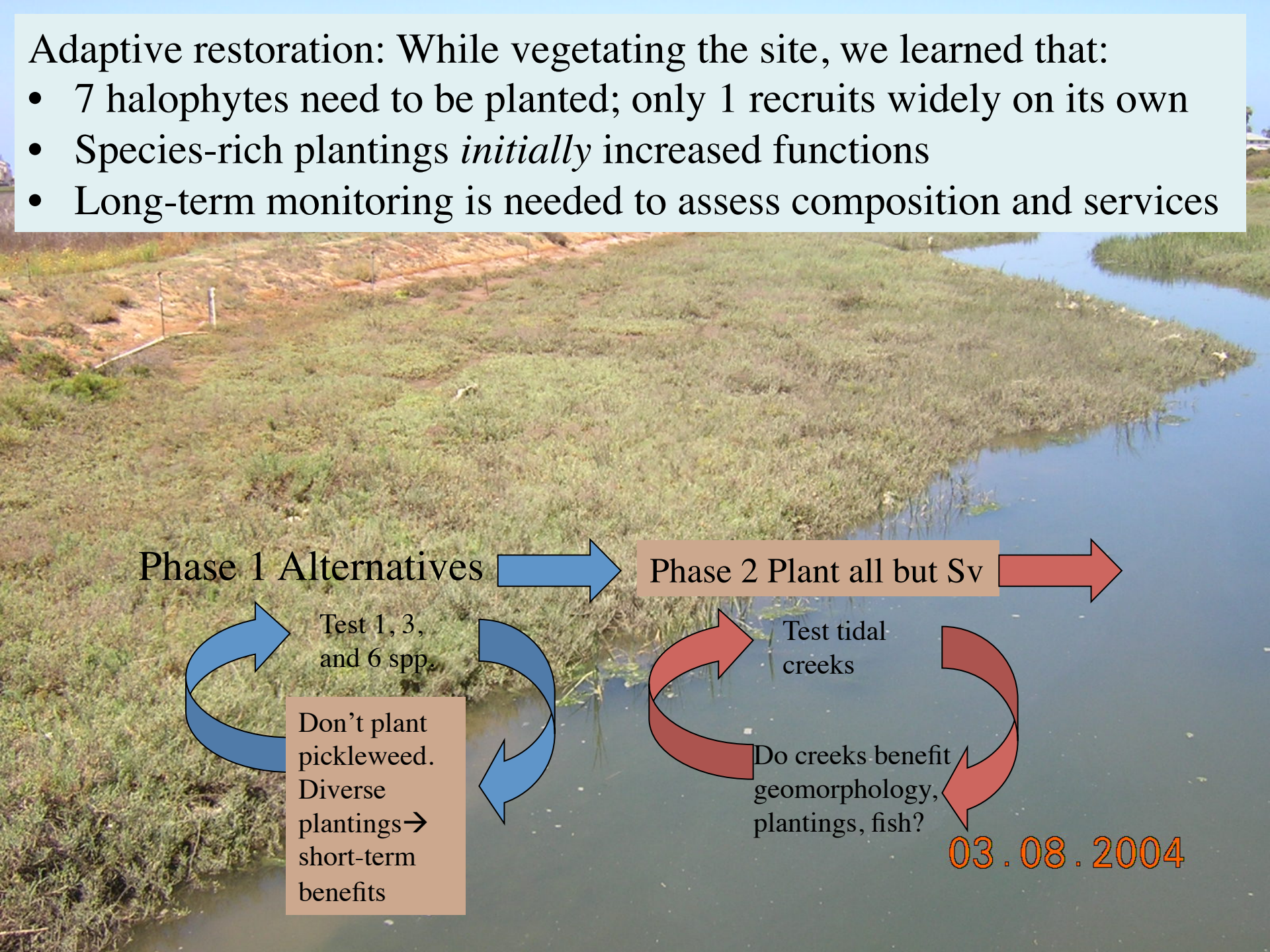




Still, diverse vegetation might be more resilient

Doherty, Callaway & Zedler 2011

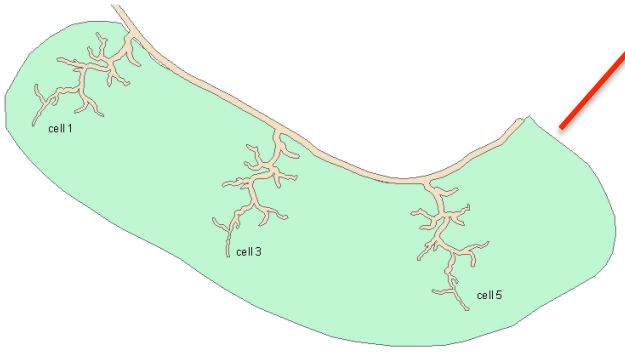
Adaptive restoration: While vegetating the site, we learned that:

- 7 halophytes need to be planted; only 1 recruits widely on its own
- Species-rich plantings *initially* increased functions
- Long-term monitoring is needed to assess composition and services



# Phase 2 restoration of Tijuana Estuary: We tested the need to add topographic heterogeneity (creeks & pools) for fish & plants

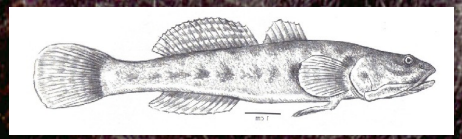
**OOPs:** Last-minute shift in location of 8-ha excavation




**OOPs:** $8-million sediment basins filled in 1st flood

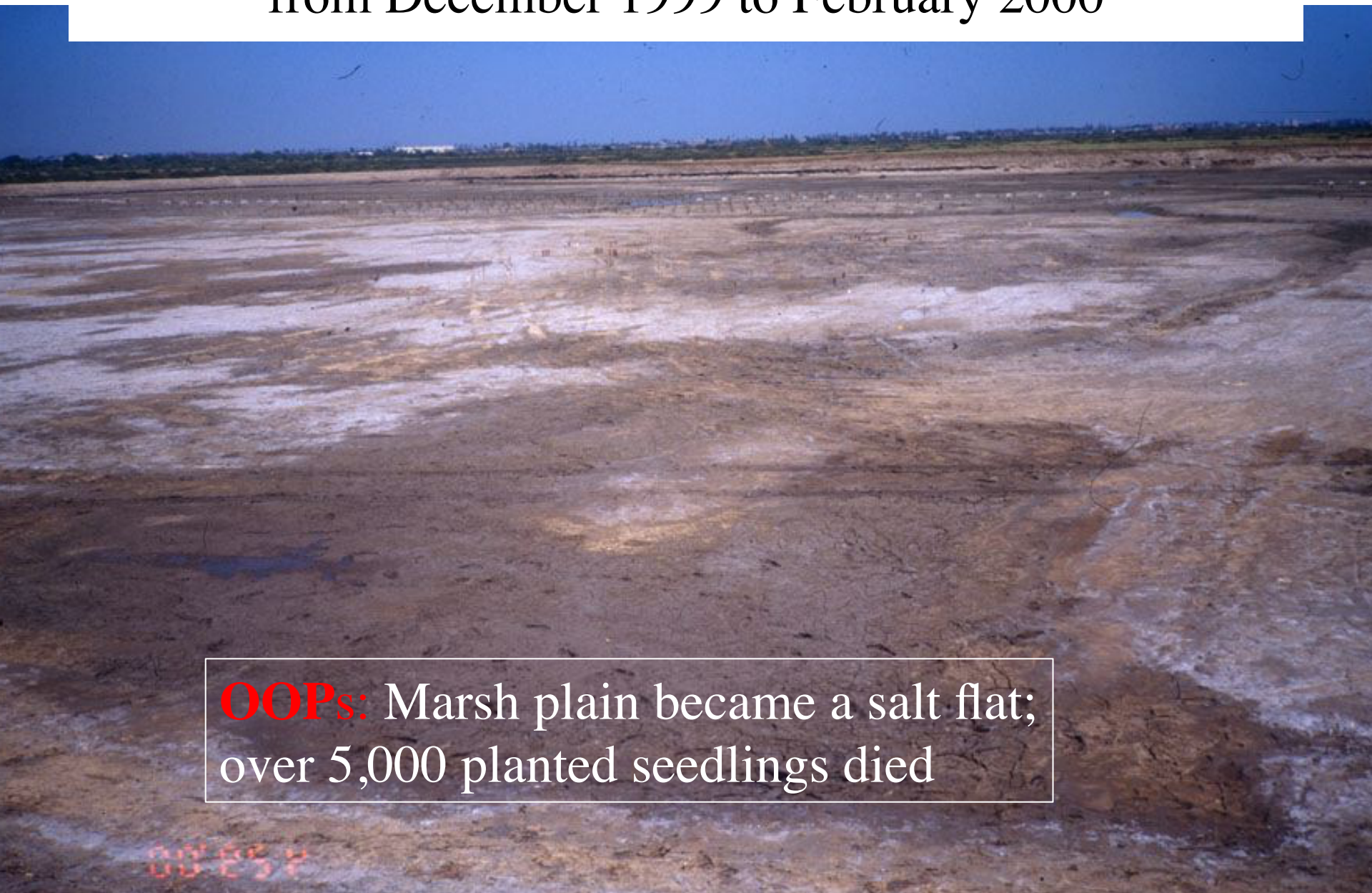
Excavated tidal creek network:

2000 2004→

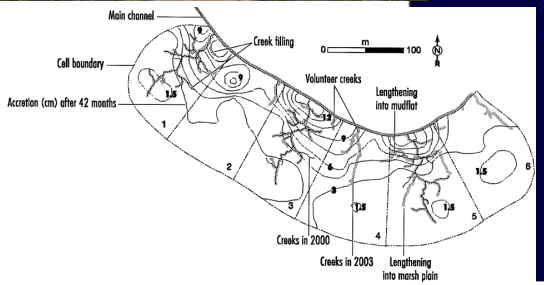



Outcome: Longjaw mudsuckers used creeks to burrow & feed

# OOPs: Tidal connection was delayed from December 1999 to February 2000

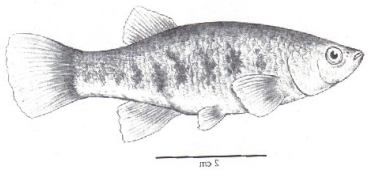


OOPs: Marsh plain became a salt flat; over 5,000 planted seedlings died



**OOPs**--More pools than planned, due to fetch

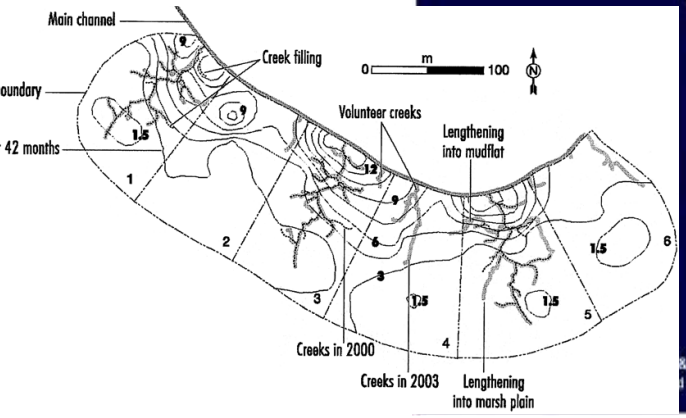


But pools became feeding oases for California killifish that swam up creeks onto the marsh plain

Coastal Environment & Near Earth Observation System, Ltd

**OOPs:** More sediment than expected

But creeks helped convey fine sediment toward mouth

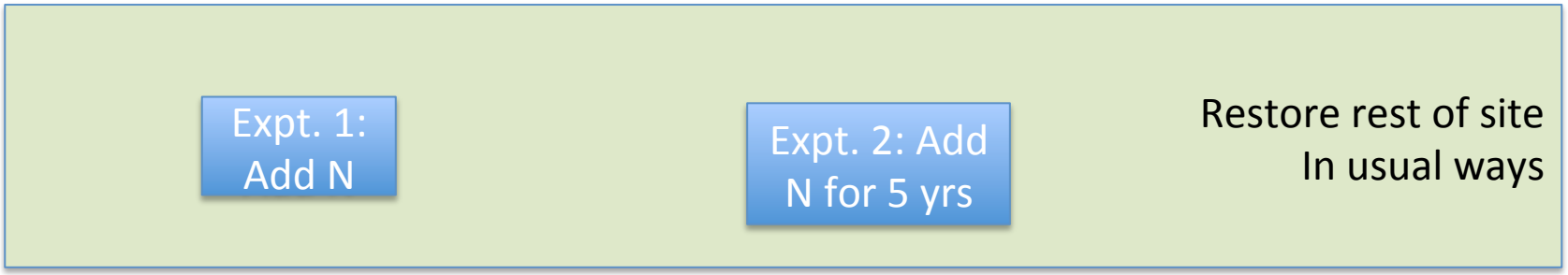



Tidal creeks enhanced

- plant establishment,
- fish use of creeks + marsh plain,
- and sediment export

(Wallace et al. 2005, O'Brien & Zedler 2006, Larkin et al. 2008)

**Adaptive management** uses science to improve restoration; imbed experiments in sites to test factors that constrain restoration, e.g.:




**Adaptive restoration** is a special case, with phased restoration, restoring sites as large experiments, learning while restoring, e.g.:


Overall advice:

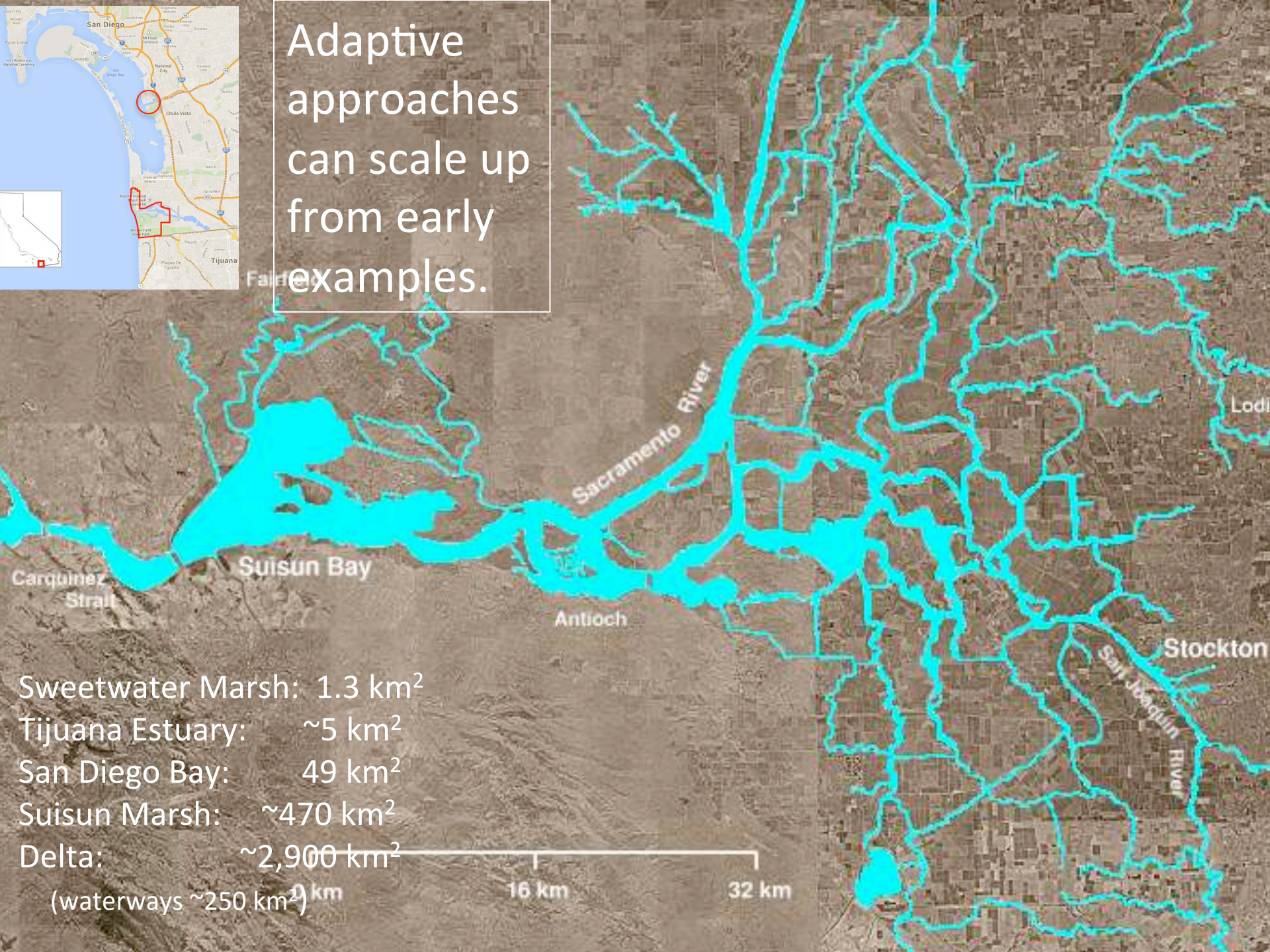
# Set ambitious goals; expect to achieve some

- Restoring *habitat* for rare species is tough
- Restoring their *populations* is tougher
- Weather can help (rain after planting)
  or hinder (drought)
- Sedimentation & erosion
  reconfigure topography
- Provide heterogeneity
  to support biodiversity


**OOPs:** Erosion-control berm failed

Future phases of the next 250-ac restoration can accommodate experiments

The Delta offers opportunities for adaptive restoration to learn while restoring…


Adaptive approaches can scale up from early examples.
San Diego
Chula Vista
Tijuana
Sacramento River
Lodi
Suisun Bay
Carquinez Strait
Antioch
Stockton
San Joaquin River
Sweetwater Marsh: 1.3 km²
Tijuana Estuary: ~5 km²
San Diego Bay: 49 km²
Suisun Marsh: ~470 km²
Delta: ~2,900 km²
(waterways ~250 km²)
16 km
32 km

Anticipate overly optimistic predictions.

In Madison, vegetated swales were designed to trap N & P.

**OOP**s: They were net exporters of N & P (esp. DN & DP)


Why? Swales had 6” of topsoil added (a BMP).

Topsoil was the likely source of excess N & P.

Anticipate overly optimistic predictions.

In Madison, vegetated swales were designed to trap N & P.

**OOPs:** They were net exporters of N & P (esp. DN & DP)


Why? Swales had 6" of topsoil added (a BMP).

Topsoil was the likely source of excess N & P.

**OOPs:** Sown natives did not establish; weeds dominated

**OOPs:** Berms were invaded by an exotic plant, likely imported on equipment, despite rule to wash equipment.

**OOPs:** Water flowed around weirs; all 8 had to be rebuilt.


Given many overly optimistic predictions,
it is wise to invest in research alongside restoration.

## More on wetlands….

*Handbook for Tidal Wetland Restoration* (2001) CRC Press.
*Salt Marsh Secrets: Who Uncovered Them and How?* (2015) trnerr.org/SaltMarshSecrets
*Arboretum Leaflets* https://arboretum.wisc.edu/science/research/leaflets