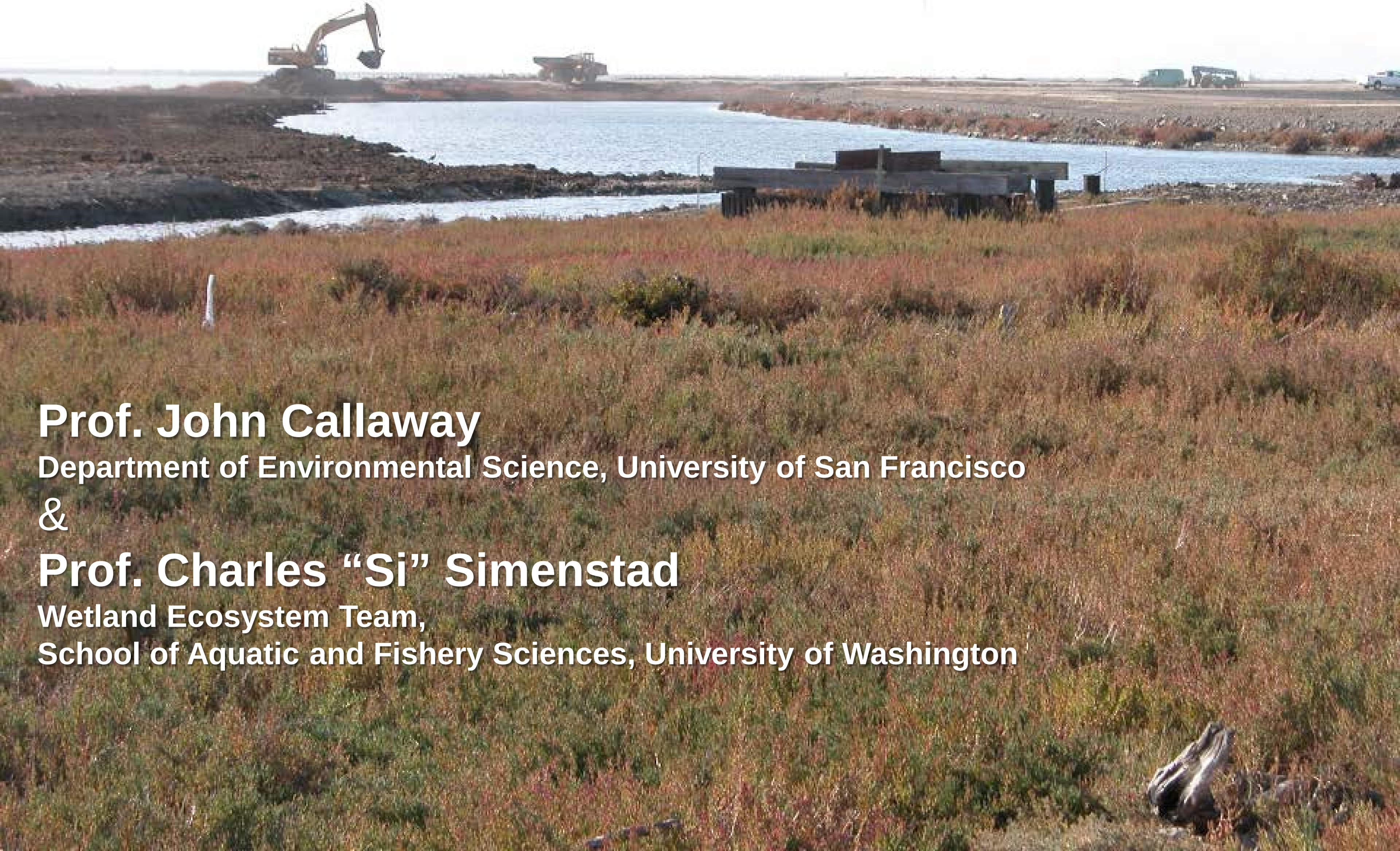
Association of State Wetland Managers

Improving Wetland Restoration Success

March 17, 2015: Pacific Coast Wetland Restoration



Prof. John Callaway

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&

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Wetland Ecosystem Team,

School of Aquatic and Fishery Sciences, University of Washington

- Plant and soil ecology
- Restoration experimentation
- Climate change impacts
- California tidal wetlands

- Estuarine and coastal tidal wetlands
- Research focus on Pacific Northwest estuaries, particularly recovery of juvenile Pacific salmon habitat
- Broad spectrum of investigative scales
- Strategic restoration planning

- Research on tidal wetland restoration since 1980’s
- Planning and reviewing/advising comprehensive restoration program at local to regional scale
- National input vis a vis USAEC-EA

wetland ECOSYSTEM TEAM
UNIVERSITY OF WASHINGTON AQUATIC & FISHERY SCIENCES

http://depts.washington.edu/wet/
http://fish.washington.edu/people/simenstd/

Presentation Topics:

1. Introduction and background
2. Perspectives
3. Pacific coast wetlands
4. Restoration management measures
5. Persistent issues and uncertainties
6. Lessons learned
7. Resources

Naturally restoring tule marsh; Liberty Island, northern Sacramento River delta, California; photo by C. Simenstad

Mutual Perspectives

- Comprehensive view of estuarine/coastal wetlands, from head of tide to ocean forcing
- Need for consideration <u>and application</u> of landscape-watershed setting
- Apply landscape ecology concepts to highly connected estuarine wetlands
- Extricate mitigation mindset from non-regulatory restoration, particularly “fast-forwarding”
- Replace “command and control” approach with natural process-based restoration
- Move from opportunistic restoration to strategic restoration planning, to achieve sustainability and resilience of restored wetlands

Estuarine Wetland Definition and Scope

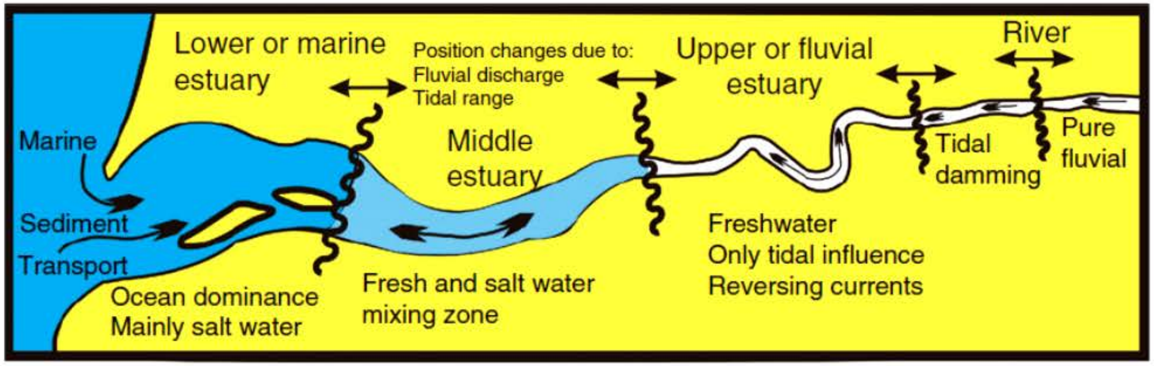


Figure 8 Schematic structure of an estuary. Boundaries between reaches may change in position depending on river discharge and tidal range.Modified from Perillo, G.M.E., 1995b. Definition and geomorphologic classifications of estuaries. In: Perillo, G.M.E. (Ed.), Geomorphology and Sedimentology of Estuaries. Elsevier, Amsterdam, pp. 17-47 and Syvitski, J.M.P., Harvey, N., Wolanski, E., Burnett, W.C., Perillo, G.M.E., Gornitz, V., Bokuniewicz, H., Huettel, M., Moore, W.S., Saito, Y., Taniguchi, M., Hesp, P.,Yim, W.W.-S., Salisbury, J., Campbell, J., Snoussi, M., Haida, S., Arthurton, R., Gao, S., 2005a. Dynamics of the coastal zone. In: Crossland, C. J., Kremer, H.H., Lindeboom, H.J., Crossland, J. I. M., Le Tissier, M.D.A. (Eds.), Coastal Fluxes in the Anthropocene. Springer, Berlín, pp. 39–94.

From: Perillo and Piccolo. 2011. In Global Variability in Estuaries and Coastal Settings. 1.01.3.2 In Simenstad and Yanago (eds.) Introduction to Classification of Estuarine and Nearshore Coastal Ecosystems. Treatise on Estuarine and Coastal Science. Elsevier

Adopt more comprehensive view of tidal wetlands (vs. Cowardin et al. 1979) that is more commensurate with current science and literature of estuarine ecology: *Wetlands that are periodically influenced by tidal flooding, inclusive of tidal freshwater (upper or fluvial estuary) reaches; including floating and submerged aquatic, herbaceous, scrub-shrub, and forested wetland ecosystems.*

[we won’t address floating and submerged aquatic wetlands; scrub-shrub and forested wetlands aren’t often targeted toward restoration, but are often implied/expected)

Restoration Principles: need to approach restoration at multiple scales

Overarching

- Restoring physicochemical processes promotes ecosystem resilience
- Conserving connectivity to intact ecosystems is the most effective method to maintain functioning
- Large-scale restoration planning needed to apply an ecosystem approach at landscape level

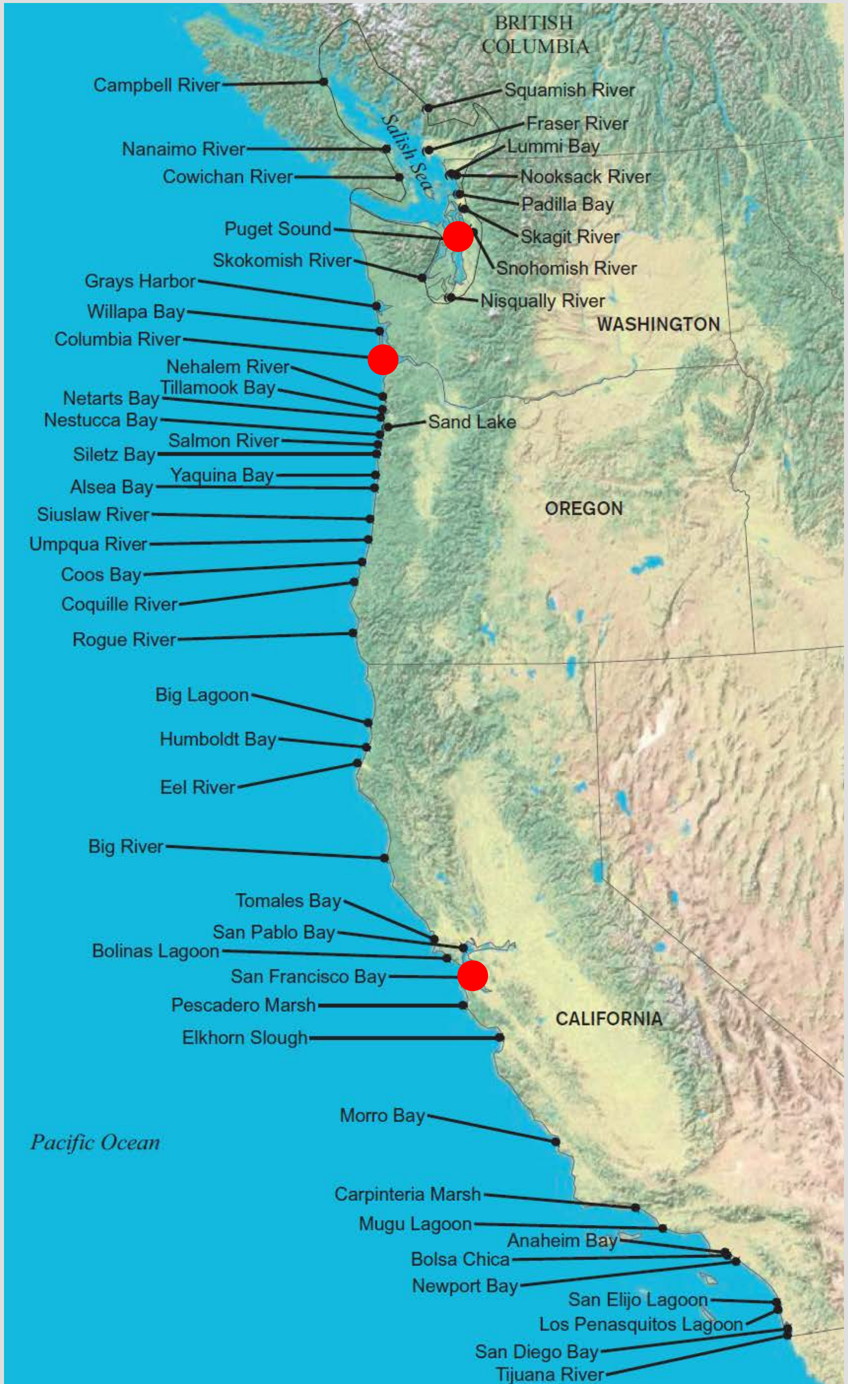
Landscape

- Natural composition and configuration of ecosystems should be restored to promote landscape resiliency
- Restoring heterogeneity on multiple scales supports more resilient landscapes
- Surrounding area has significant influence on the success of restoration efforts
- Landscape connectivity should be restored to reduce fragmentation and facilitate the flow of energy, material and biota among ecosystems

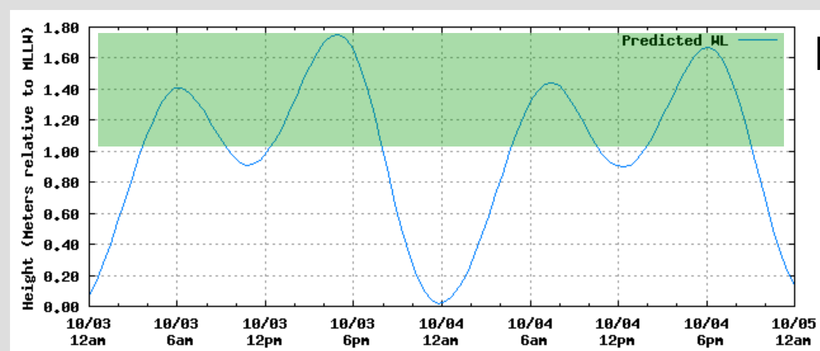
Local-Site

- Larger patches generally encompass more ecological components than smaller patches
- Rare or vulnerable ecosystems and species should receive high priority to preserve a region’s biodiversity
- Ecological components that exert disproportionally greater influence on the integrity of an ecosystem should receive special attention
- Cumulative impacts must be considered to accurately assess ecosystem degradation and restoration success

Source: Greiner, C.A. 2010. Principles for strategic conservation and restoration. Puget Sound Nearshore Ecosystem Restoration Project, Rept. 2010-01. Wash. Dept. Fish Wildl., Olympia, WA, and U.S Army Corps Engineers, Seattle, WA.
http://www.pugetsoundnearshore.org/technical_papers/conservation_and_restoration_principles.pdf



- Few large estuarine systems
  - Puget Sound
  - Columbia River
  - San Francisco Bay
- Many small, isolated systems, with small, local watersheds
- Mixed, semi-diurnal tides



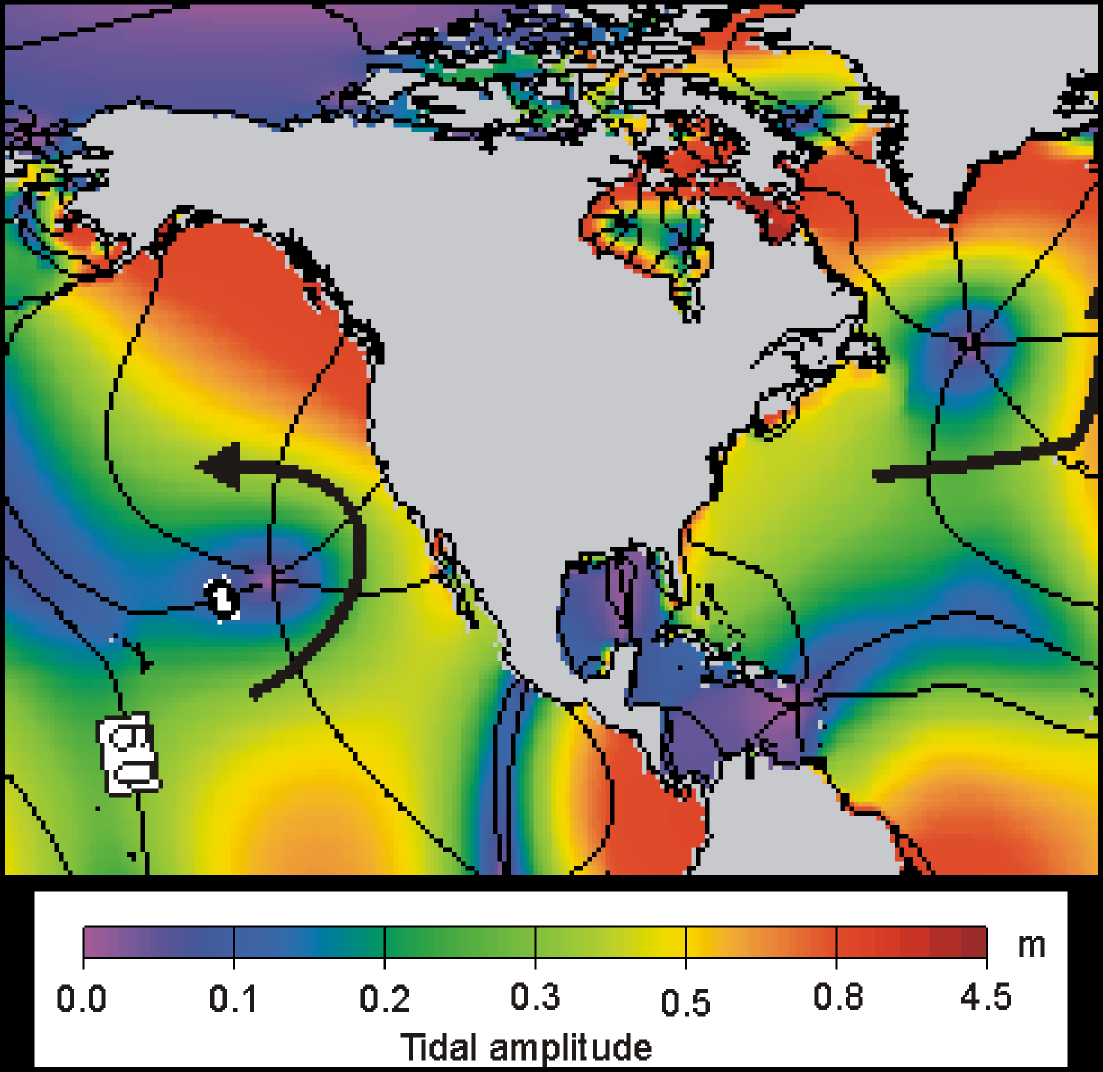
MHHW

MSL

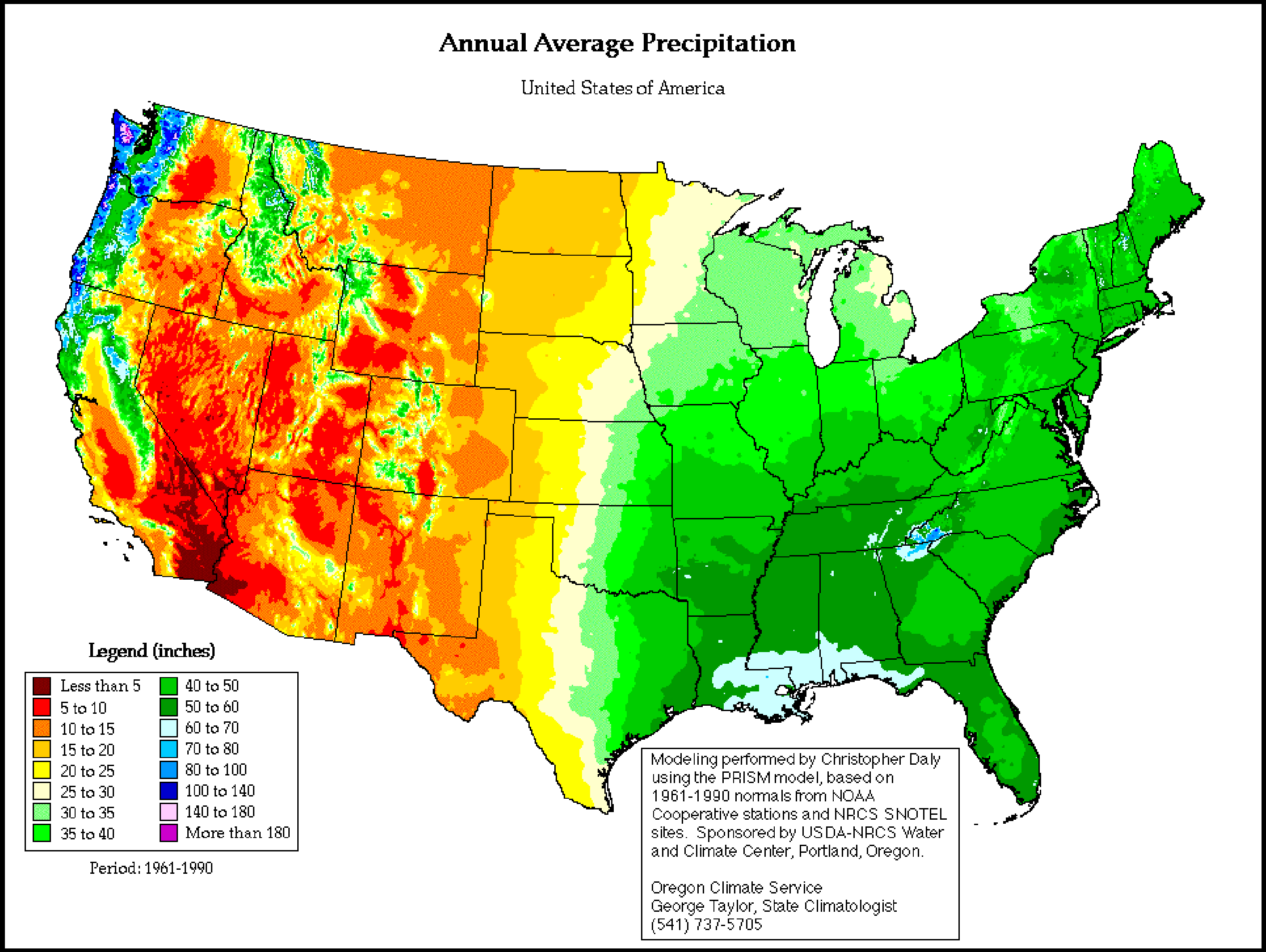
MLLW

Callaway et al. (2012)

Strong North-South Gradient in Tidal Amplitude ...

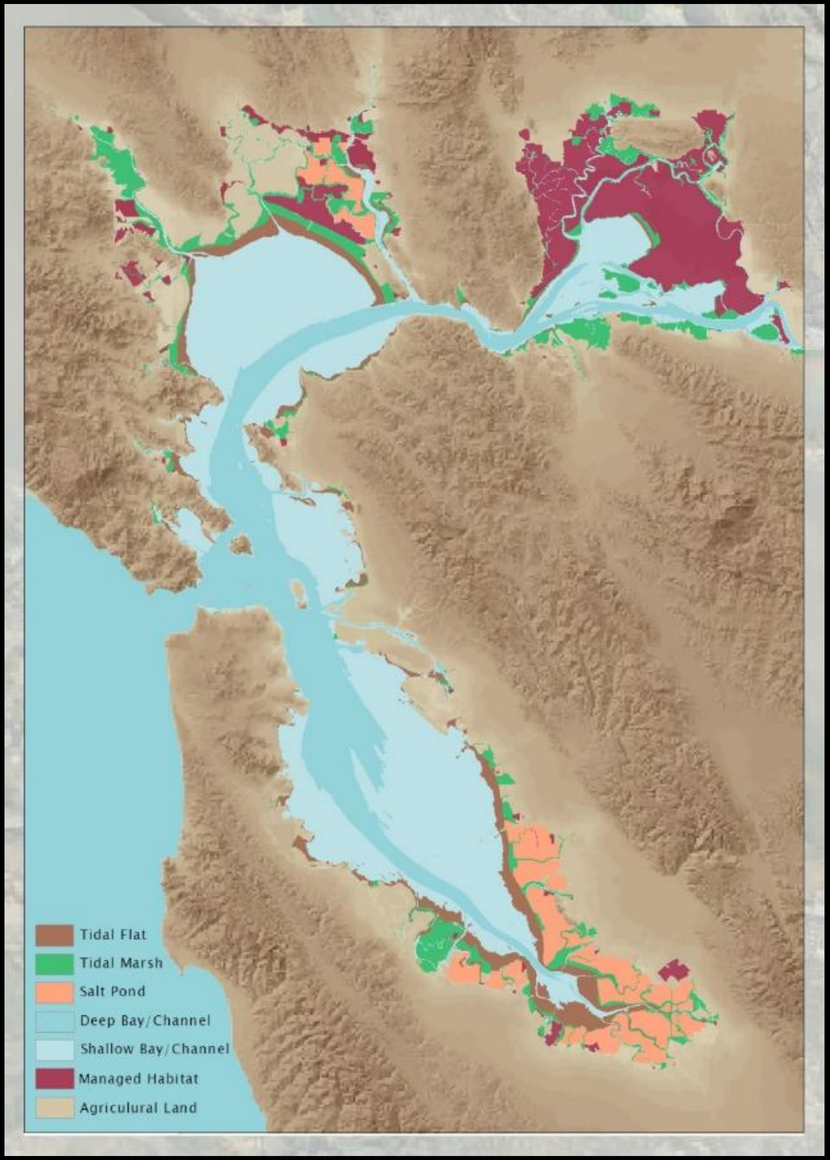


... and in Precipitation



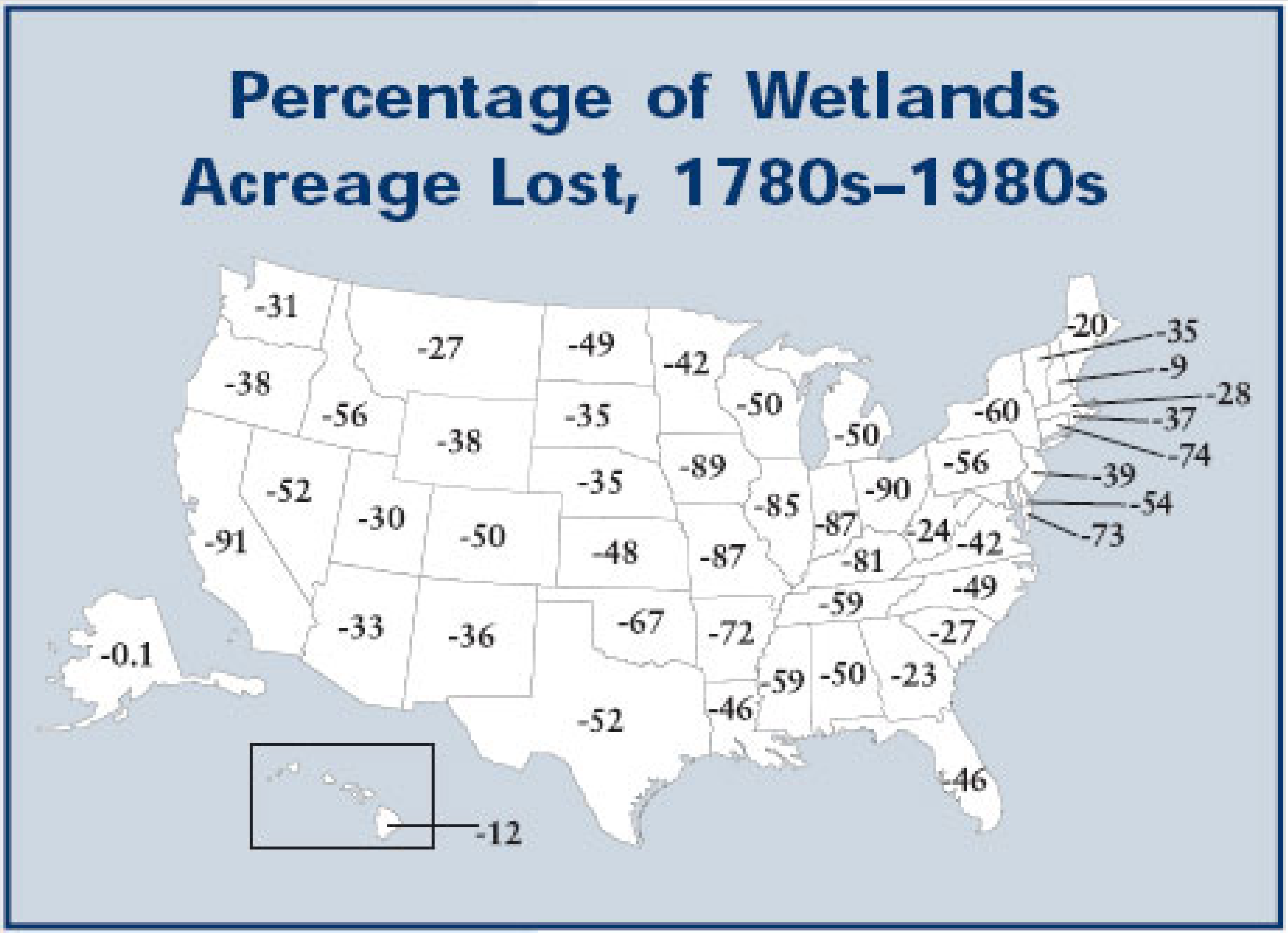
http://www.ocs.oregonstate.edu/

Past and Present Distribution of SF Bay Wetlands



(from San Francisco Estuary Institute)

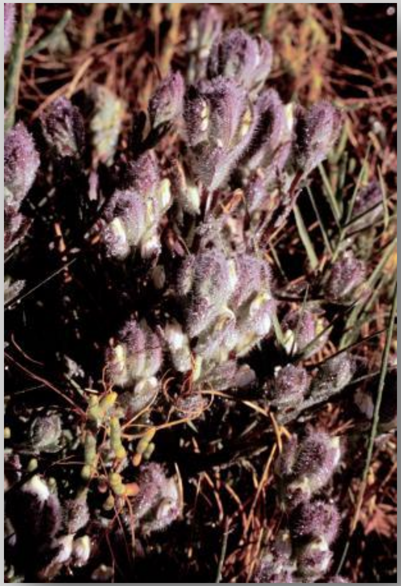
Wetland Loss by State

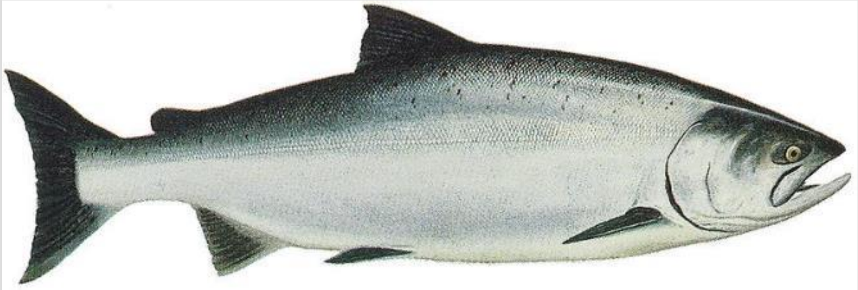


modified from Dahl (1990); http://www.northassoc.org/

Pacific Coast Wetlands are Intensely Urbanized

Endangered Species in Pacific Coast Wetlands





Long History of Mitigation Monitoring and Research ...

FUNCTIONAL EQUIVALENCY TRAJECTORIES OF THE RESTORED GOG-LE-HI-TE ESTUARINE WETLAND[1,2]

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WETLAND MITIGATION ALONG THE PACIFIC COAST OF THE UNITED STATES

Michael Josselyn
Romberg Tiburon Center for Environmental Studies
San Francisco State University

Joy Zedler and Theodore Griswold
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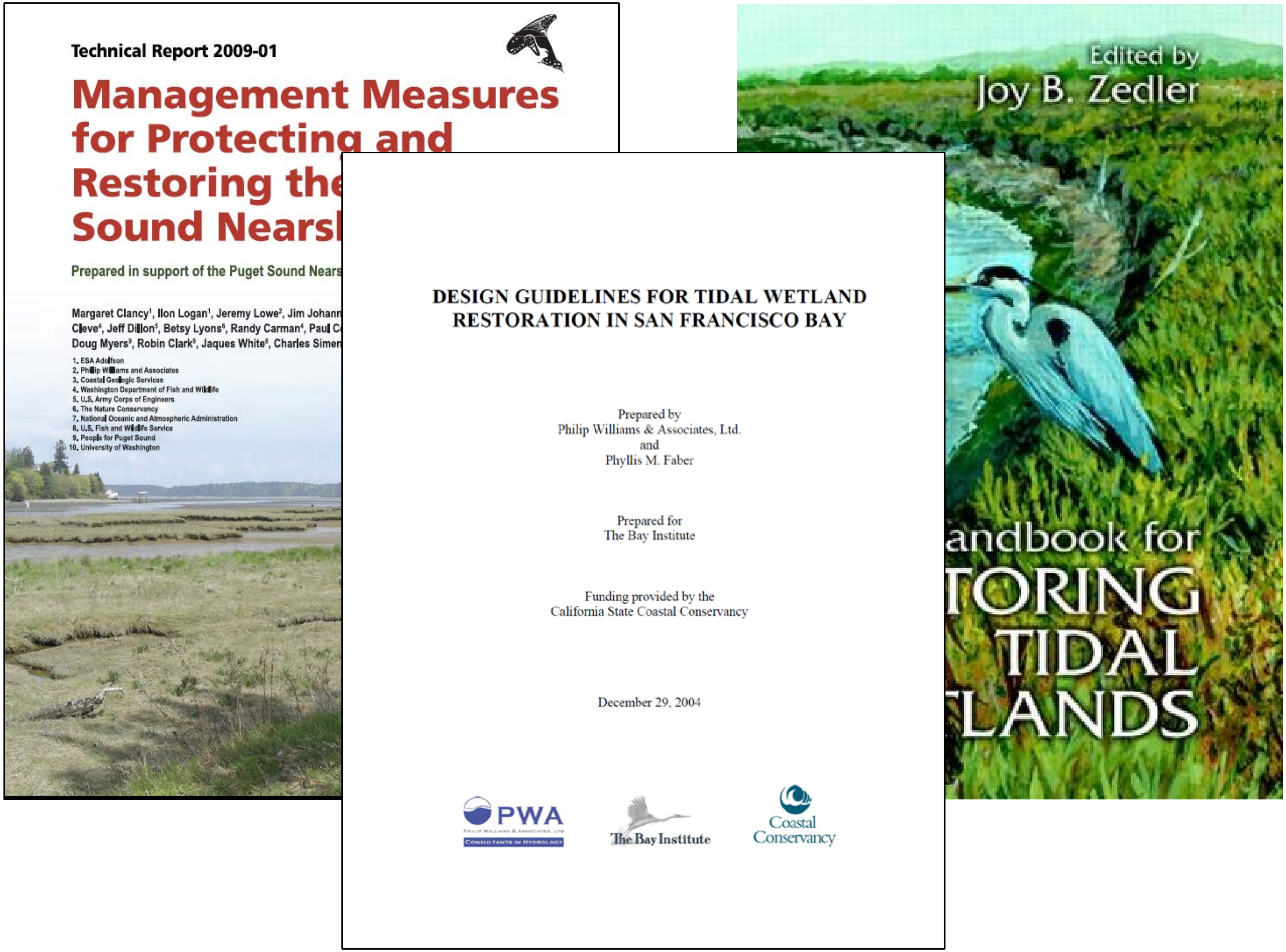
San Diego State University

COASTAL MITIGATION IN SOUTHERN CALIFORNIA: THE NEED FOR A REGIONAL RESTORATION STRATEGY[1,2]

JOY B. ZEDLER
Pacific Estuarine Research Laboratory, San Diego State University, San Diego, California, 92182-4625 USA

… and a Number of Restoration "Guidebooks"



Southern California Coastal Wetlands

Spartina foliosa
Sarcocornia pacifica

see Grewell et al. (2007) for plant info

Southern California Coastal Wetlands

from Stein et al. (2014)

Mediterranean climate; highly saline wetlands

Many coastal wetlands are <u>intermittently</u> connected to the tides & little restoration knowledge for these systems

San Francisco Bay Tidal Marshes

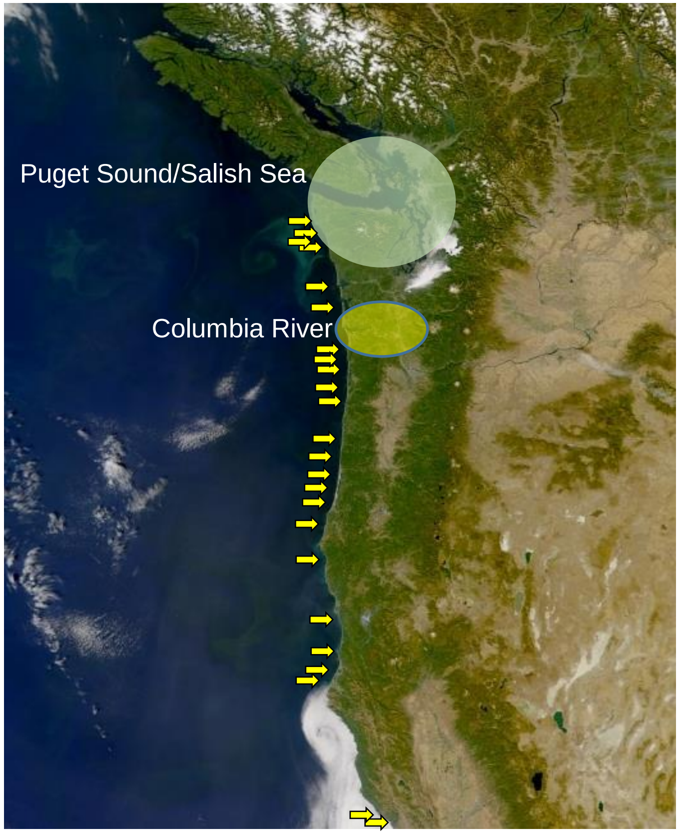
Spartina foliosa
Sarcocornia pacifica

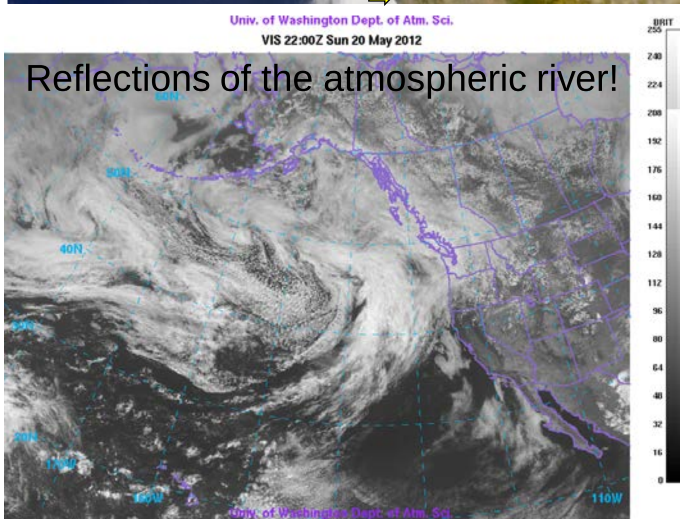
AND many brackish marsh species

Sacramento-San Joaquin Delta

Schoenoplectus acutus
S. californicus
Typha spp.

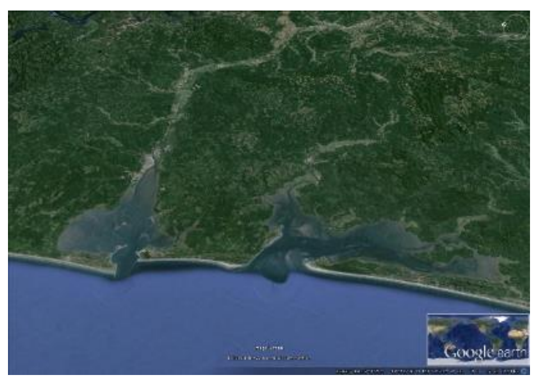
And LOTS more: grading into riparian systems






Tomales Bay


Coos River

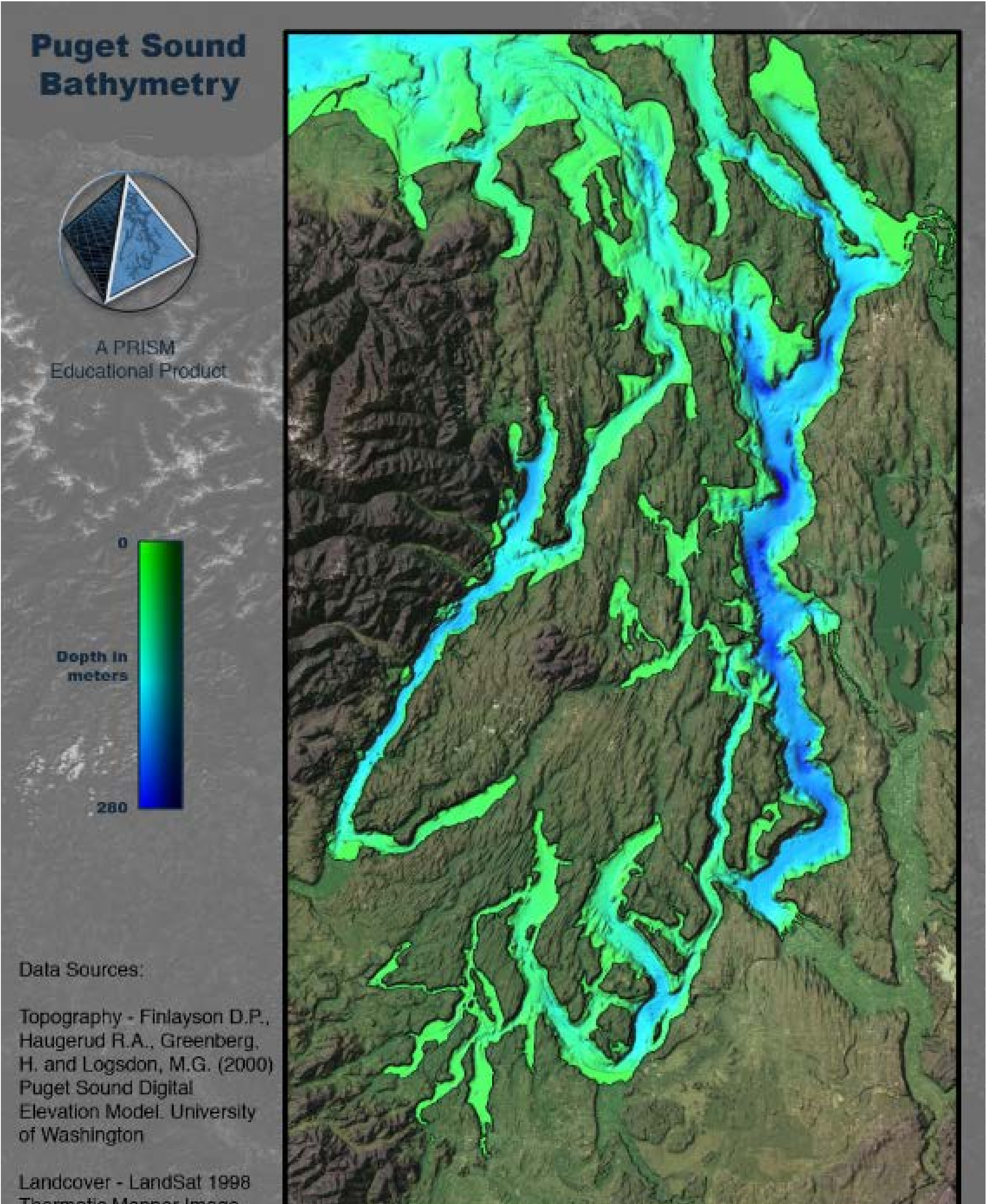

Grays Harbor & Willapa Bay


Russian River


Salmon River


Queets River

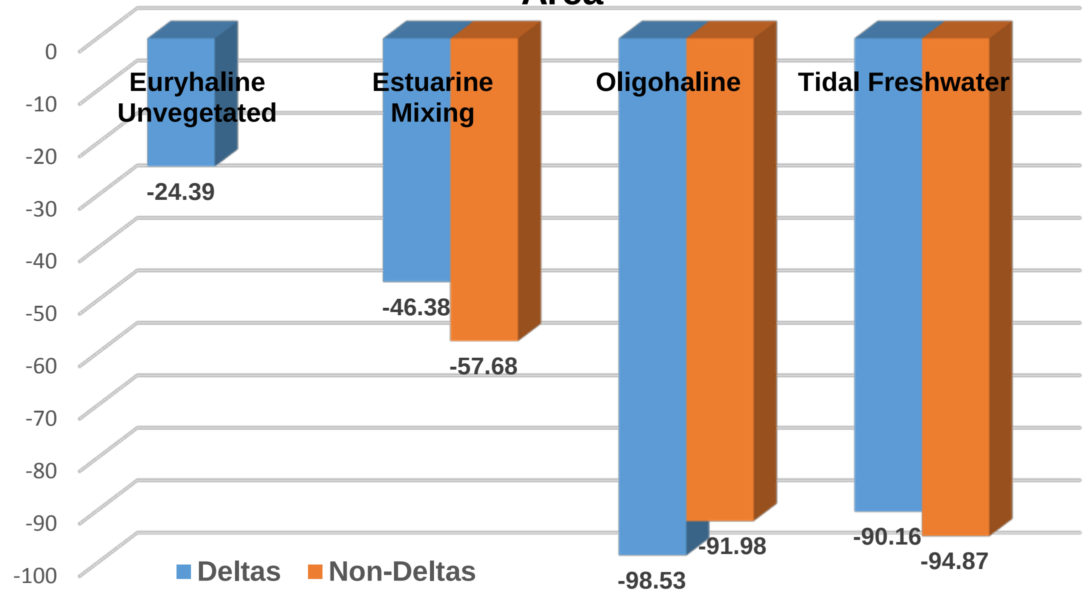

Columbia River estuary; Rkm 45-55 of 233km



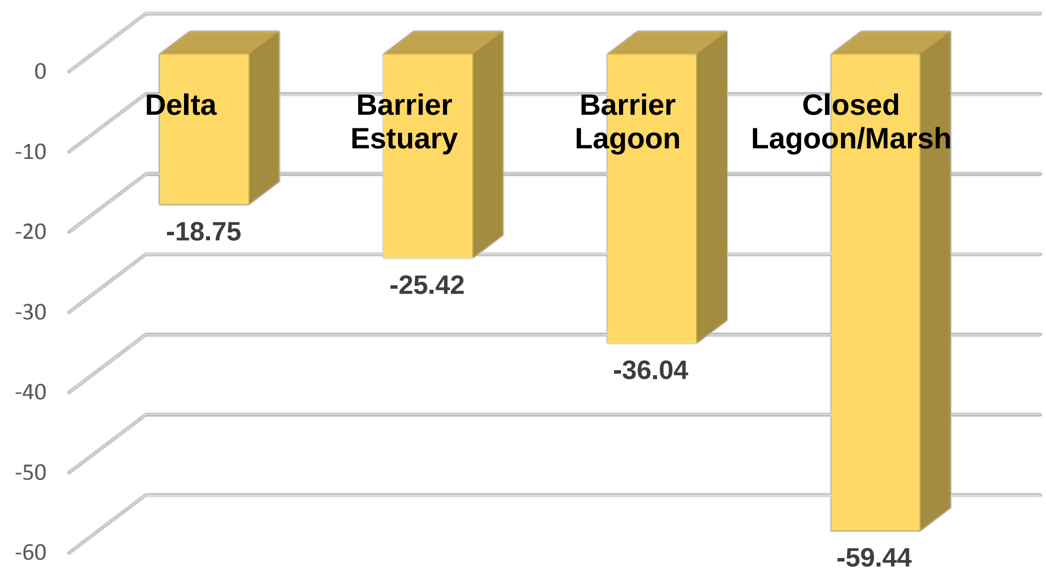
Source: http://www.prism.washington.edu/file/show/1716

- Large estuary (inland sea) complex with a number of large river deltas
- Steep, glacially carved shoreline with narrow nearshore zone
- Mixed sand/gravel beaches
- Large longitudinal heterogeneity, complex shoreline linking different types of estuaries in fjord matrix
- Strong regional gradients: tides, exposure, salinity and geology
- Estuarine and coastal ecology largely linked to shoreline geomorphological processes

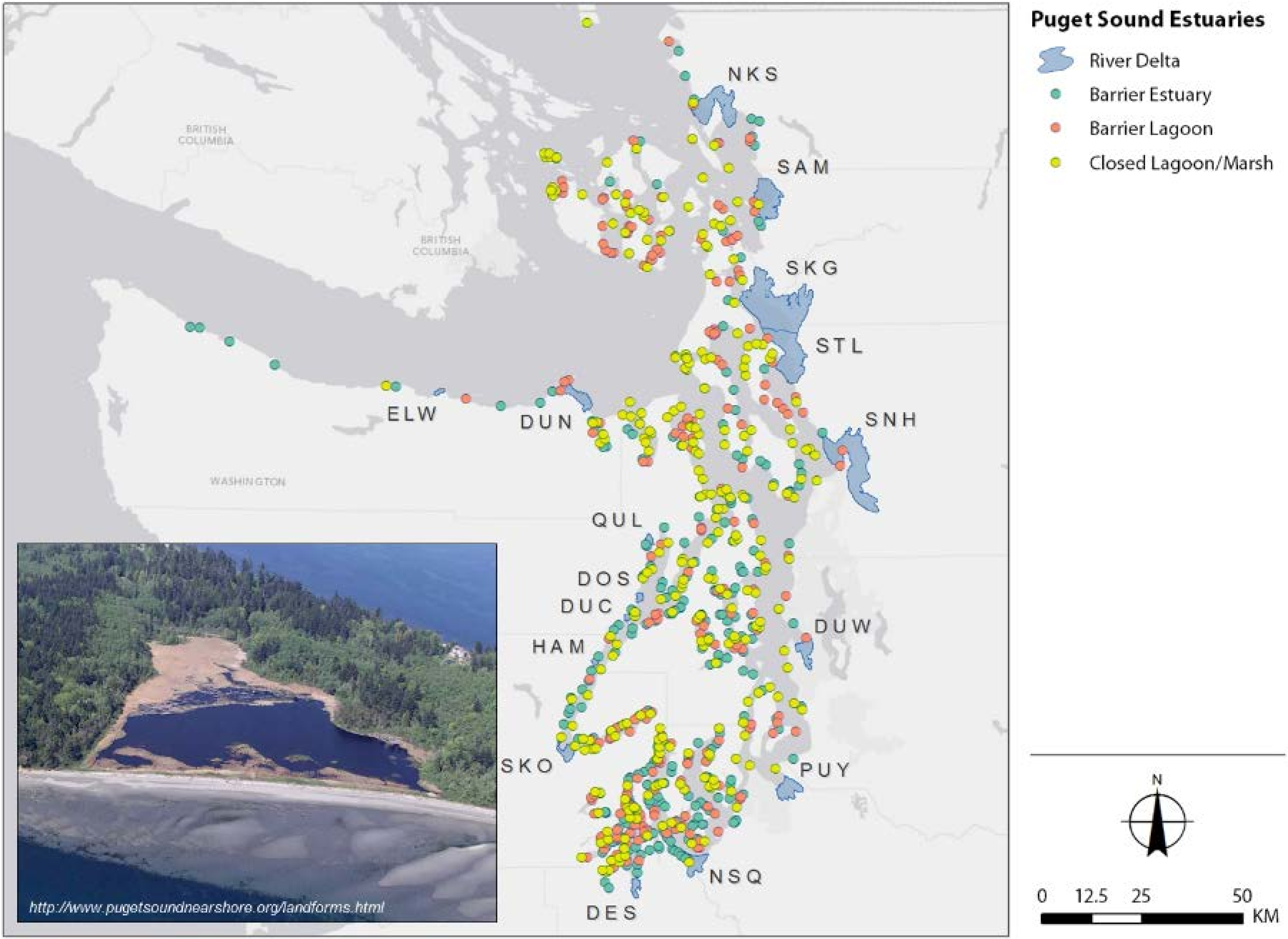
Historic Change in Puget Sound Tidal Wetland Area

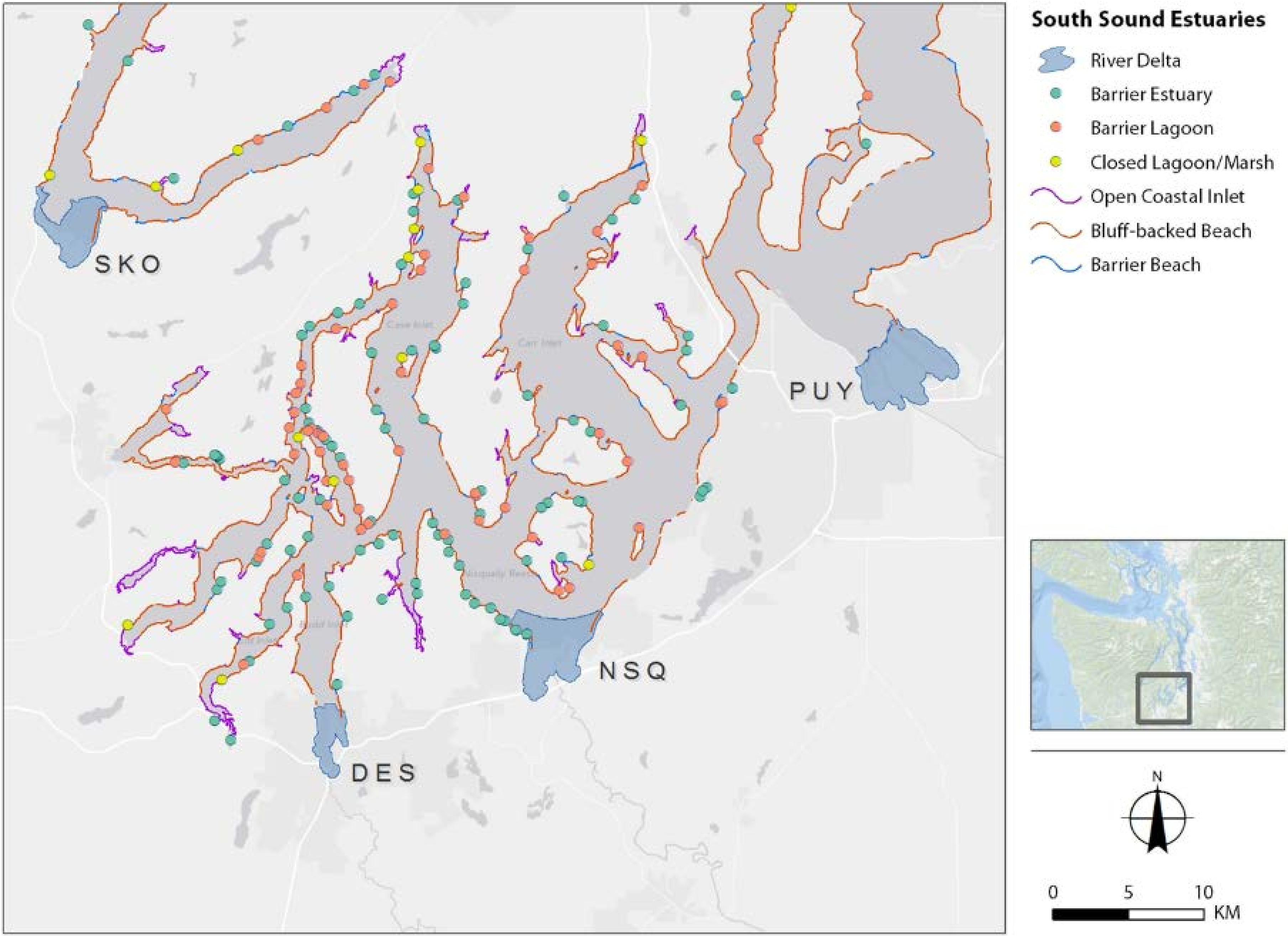


Historic Change in Number of Puget Sound Estuarine Landforms



Source: Simenstad *et al.* (2011; PSNERP Change Analysis)


Puget Sound Estuaries
River Delta
Barrier Estuary
Barrier Lagoon
Closed Lagoon/Marsh
BRITISH COLUMBIA
BRITISH COLUMBIA
WASHINGTON
NKS
SAM
SKG
STL
SNH
ELW
DUN
QUL
DOS
DUC
HAM
DUW
SKO
PUY
NSQ
DES
http://www.pugetsoundnearshore.org/landforms.html
N
0
12.5
25
50
KM


South Sound Estuaries
River Delta
Barrier Estuary
Barrier Lagoon
Closed Lagoon/Marsh
Open Coastal Inlet
Bluff-backed Beach
Barrier Beach
SKO
PUY
NSQ
DES
N
0
5
10
KM

PNW Estuarine Wetlands and Relative Loss

Polyhaline herbaceous ("salt marsh")


Low salt marsh, arrowgrass-jaumea, Coquille estuary, OR. 6/21/2005; Laura Brophy

- *Salicornia virginica (S. pacifica)*—pickleweed
- *Cuscuta salina*—saltmarsh dodder
- *Atriplex patula*—saltweed/fat hen
- *Jaumea carnosa*—fleshy jaumea
- *Troglochin maritimum*—seaside arrowgrass
- *Distichlis spicata*—seashore saltgrass

PNW Estuarine Wetlands and Relative Loss

Estuarine-brackish herbaceous

<u>Low marsh</u>

- *Carex lyngbyei*—Lyngby sedge

<u>High marsh</u>

- *Deschampsia caespitosa*—tufted hairgrass
- *Potentilla pacifica*—Pacific silverweed
- *Agostris alba*—redtop
- Horteum brachyantherum—meadow barley
- *Spergularia marina*—saltmarsh sandspurry

PNW Estuarine Wetlands and Relative Loss

Tidal-fresh herbaceous

<u>Low marsh</u>

- *Lilaeopsis* occidentalis—western lilaeopsis
- *Carex lyngbyei*—Lyngby sedge

<u>High marsh</u>

- *Typha latifolia*—cattail
- *Agostris alba*—creeping bentgrass/redtop
- *Schoenoplectus acutus*—hardstem bullrush
- *Sagittaria latifolia*—wapato

PNW Estuarine Wetlands and Relative Loss

Scrub-shrub

- *Salix* spp.—willow
- *Alnus rubra*—red alder
- *Cornus stolonifera*—red-osier dogwood
- *Physocarpus capitatus*—Pacific ninebark
- *Carex obnupta*—slough sedge
- *Lysichitum americanum*—skunk cabbage
- *Lonicera involucrata*--twinberry

PNW Estuarine Wetlands and Relative Loss

Forested "tidal swamp"

Tidal freshwater zone, Drift Creek, Alsea River estuary, OR. 8/1/2005; Laura Brophy

- *Picea sitchensis*—Sitka spruce
- *Thuja plicata*—red cedar
- *Populus balsamifera*—black cottonwood
- *Fraxinus latifolia*-Oregon ash
- *Salix* spp.—willow
- *Carex obnupta*-slough sedge
- *Lysichiton americanum*—skunk cabbage
- *Pteridium aquilinum*—Pacific water parsley
- *Phalaris arundinacea*—reed canary grass

Background of PNW Restoration and Related Research

- Emerged from 404 mitigation
- Extensively focused on nekton (juvenile salmon) habitat restoration
- Considerable opportunities where tidal inundation can be reintroduced to leveed wetlands
- Primarily herbaceous marsh restoration; very little attention paid to greatest wetland loss, e.g., scrub-shrub and forested wetland

Restoration Management Measures

Management Measures Grouped by their Potential Restorative Effect on Physical Nearshore Processes

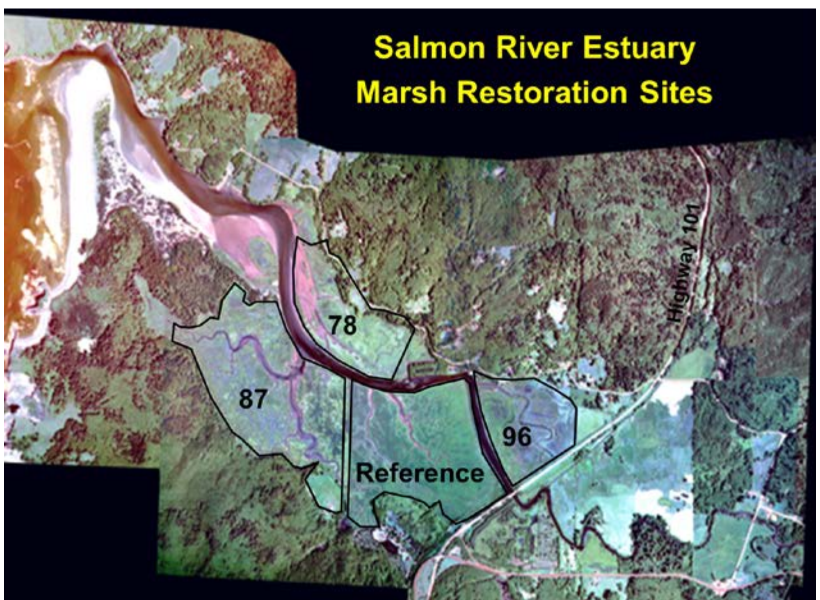
Category	Restorative	Enhancement	Prerequisite	Protective
Role	Exert long-lasting effects on ecosystem processes	Create/promote structural elements (habitats) and/or mimic natural processes	Remove or prevent physical and chemical disturbances	Protect existing resources, limit future impairment, influence human behaviors
Management Measures	Armor Removal or Modification Berm or Dike Removal or Modification Groin Removal or Modification Hydraulic Modification Overwater Structure Removal or Modification Topography Restoration	Beach Nourishment Invasive Species Control Large Wood Placement Species Habitat Enhancement Reintroduction of Native Animals Substrate Modification	Contaminant Removal and Remediation Debris Removal Physical Exclusion Pollution Control	Habitat Protection Policy or Regulations Public Education and Involvement
	Revegetation (spans Restorative and Enhancement)		Property Acquisition and Conservation (spans Prerequisite and Protective)	
	Channel Rehabilitation or Creation (spans Restorative and Enhancement)			

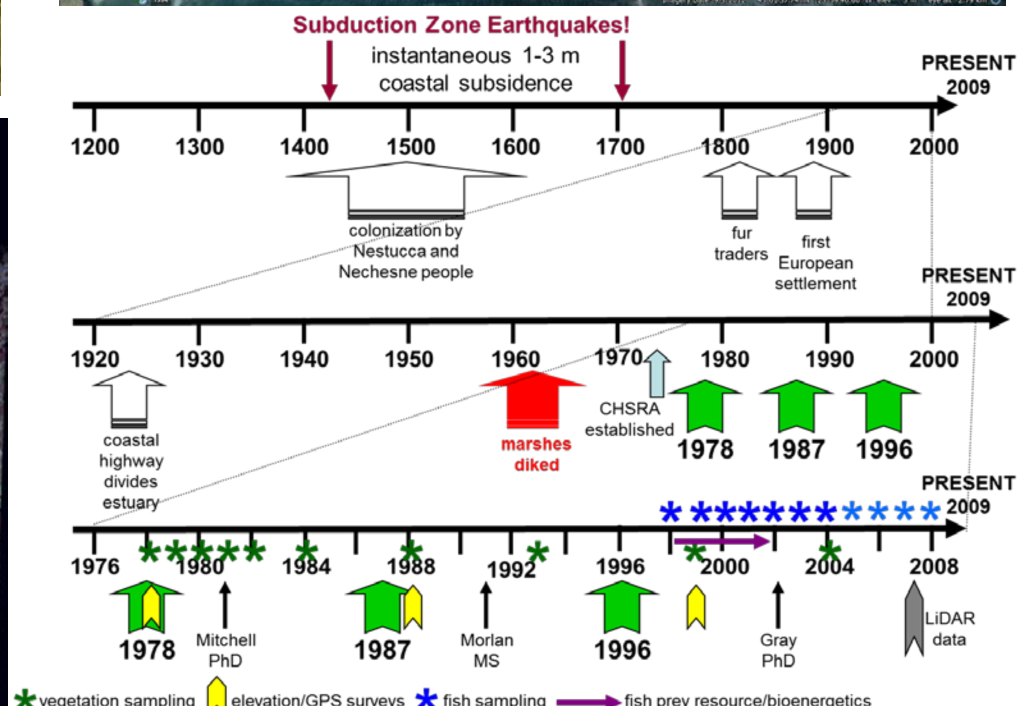
Source: Clancy, M., I. Logan, J. Lowe, J. Johannessen, A. MacLennan, F.B. Van Cleve, J. Dillon, B. Lyons, R. Carman, P. Cereghino, B. Barnard, C. Tanner, D. Myers, R. Clark, J. White, C. A. Simenstad, M. Gilmer, and N. Chin. 2009. Management Measures for Protecting the Puget Sound Nearshore. Puget Sound Nearshore Ecosystem Restoration Project Report No. 2009-01. Published by Washington Department of Fish and Wildlife, Olympia, Washington.

Persistent Issues and Uncertainties

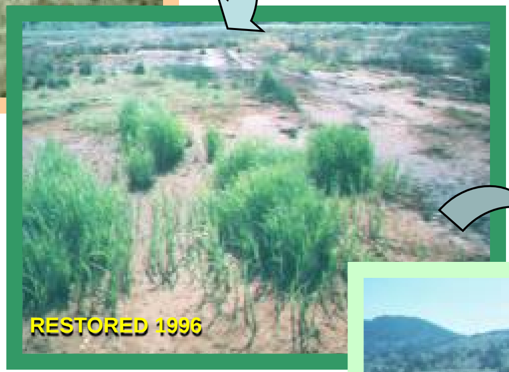
- Breach or remove levees?
- Excavate tidal channels?
- Jump start late seral stages?
  - To plant or not to plant?
  - Fill subsided platforms
- Compromise tidal hydrology (tide gates)?
- Invasives

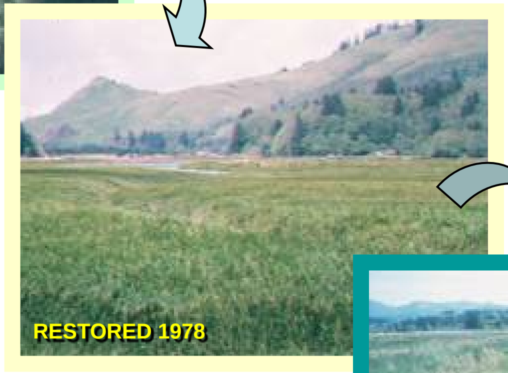
Levee/berm Removal

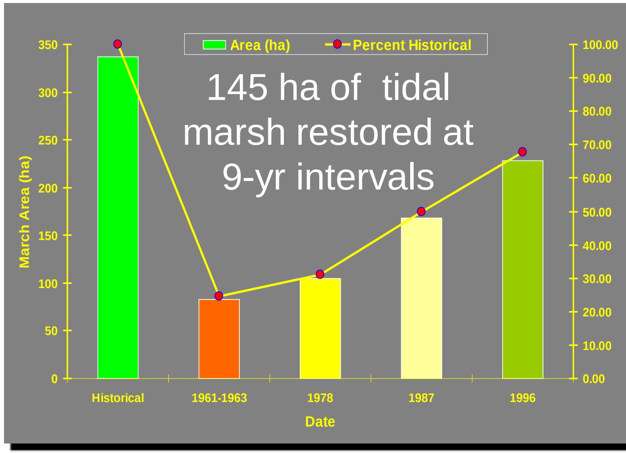




Changes in Salmon River Tidal Marshes with Sequential Restoration 1978-1996: Space-for-Time Substitution?

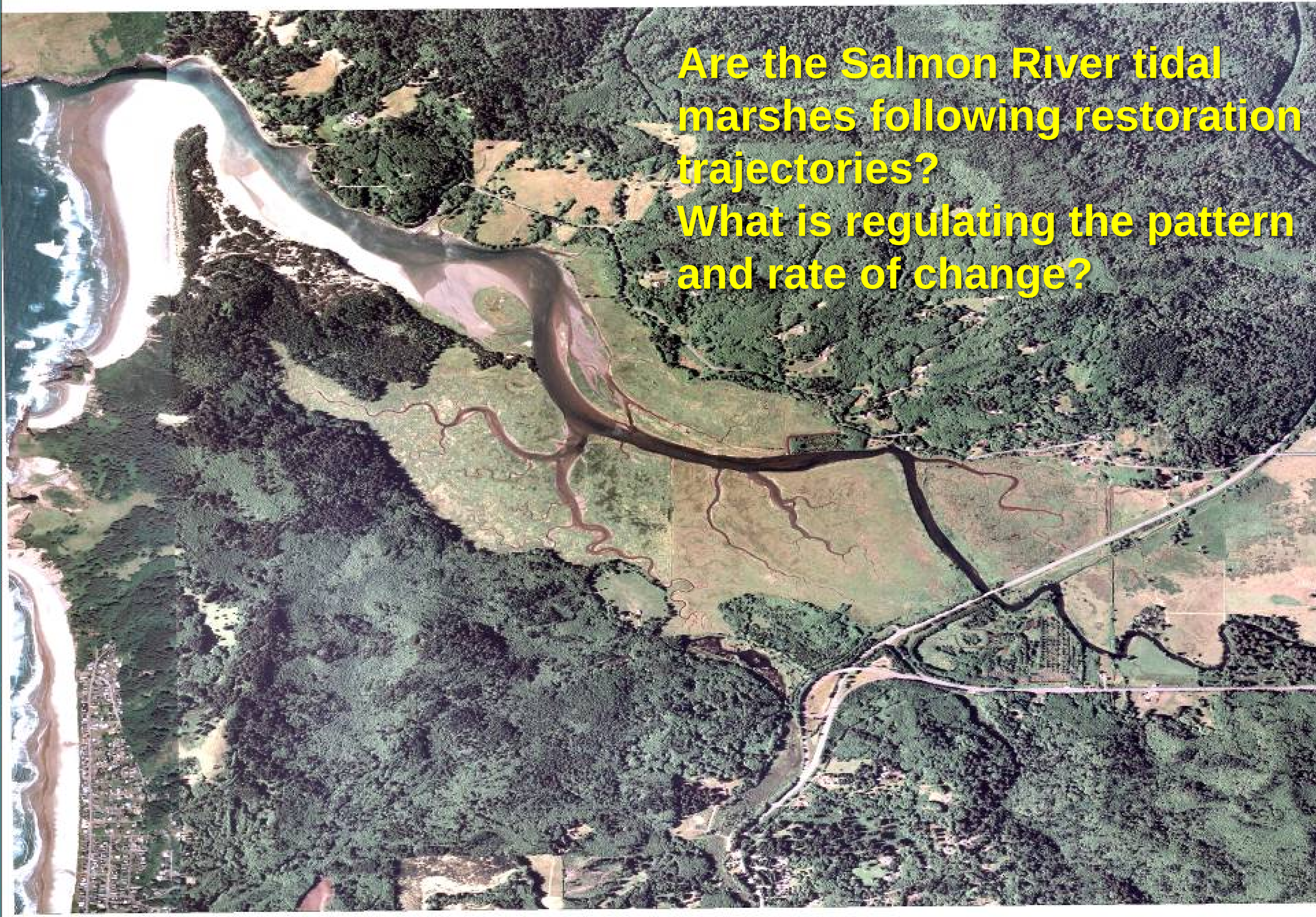


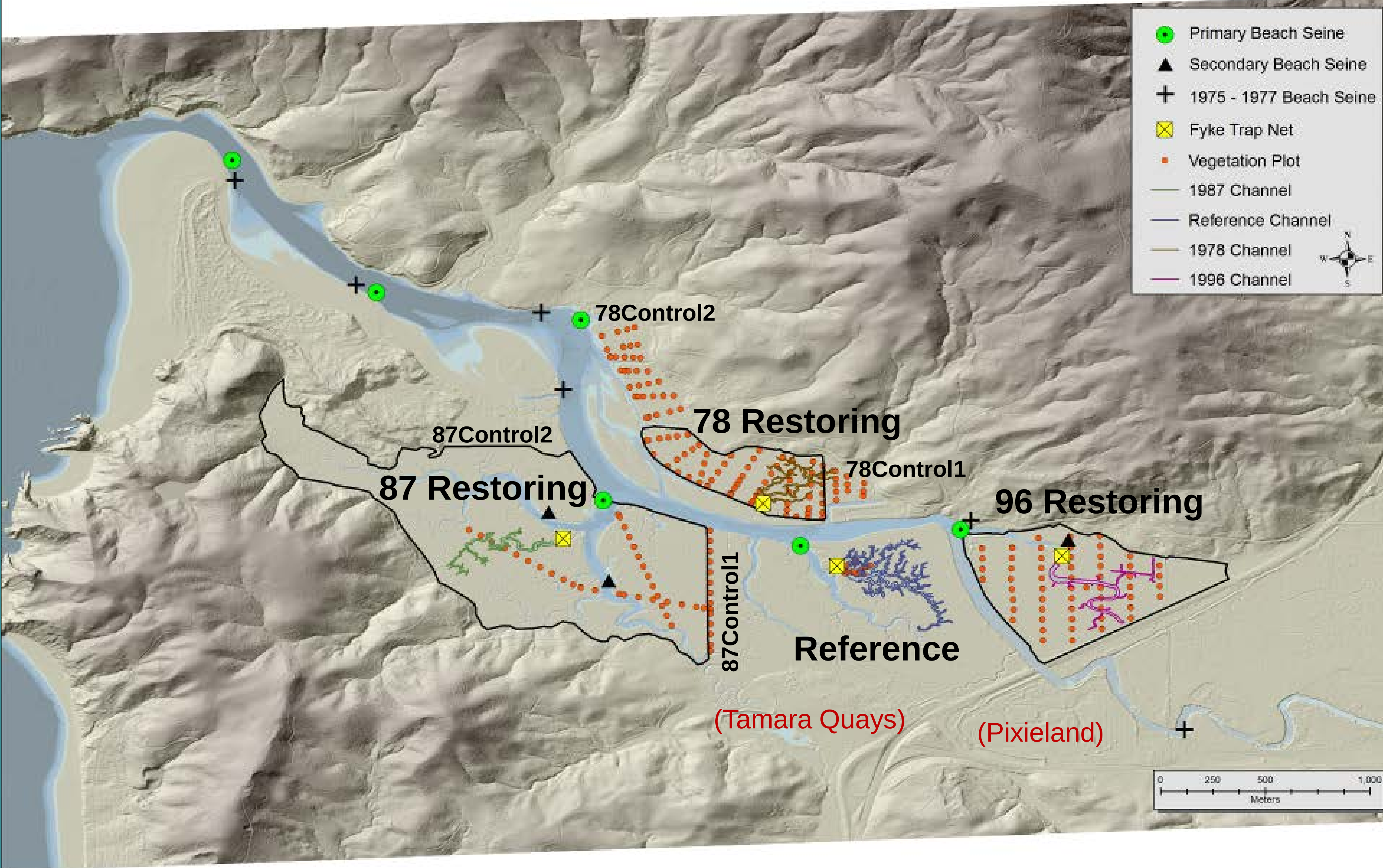




Three estuarine marsh restoration sites (1978, 1987, 1996) in Salmon River estuary, coastal Oregon, allow *space-for-time substitution* assessment of change in fish utilization coincident with marsh community redevelopment.

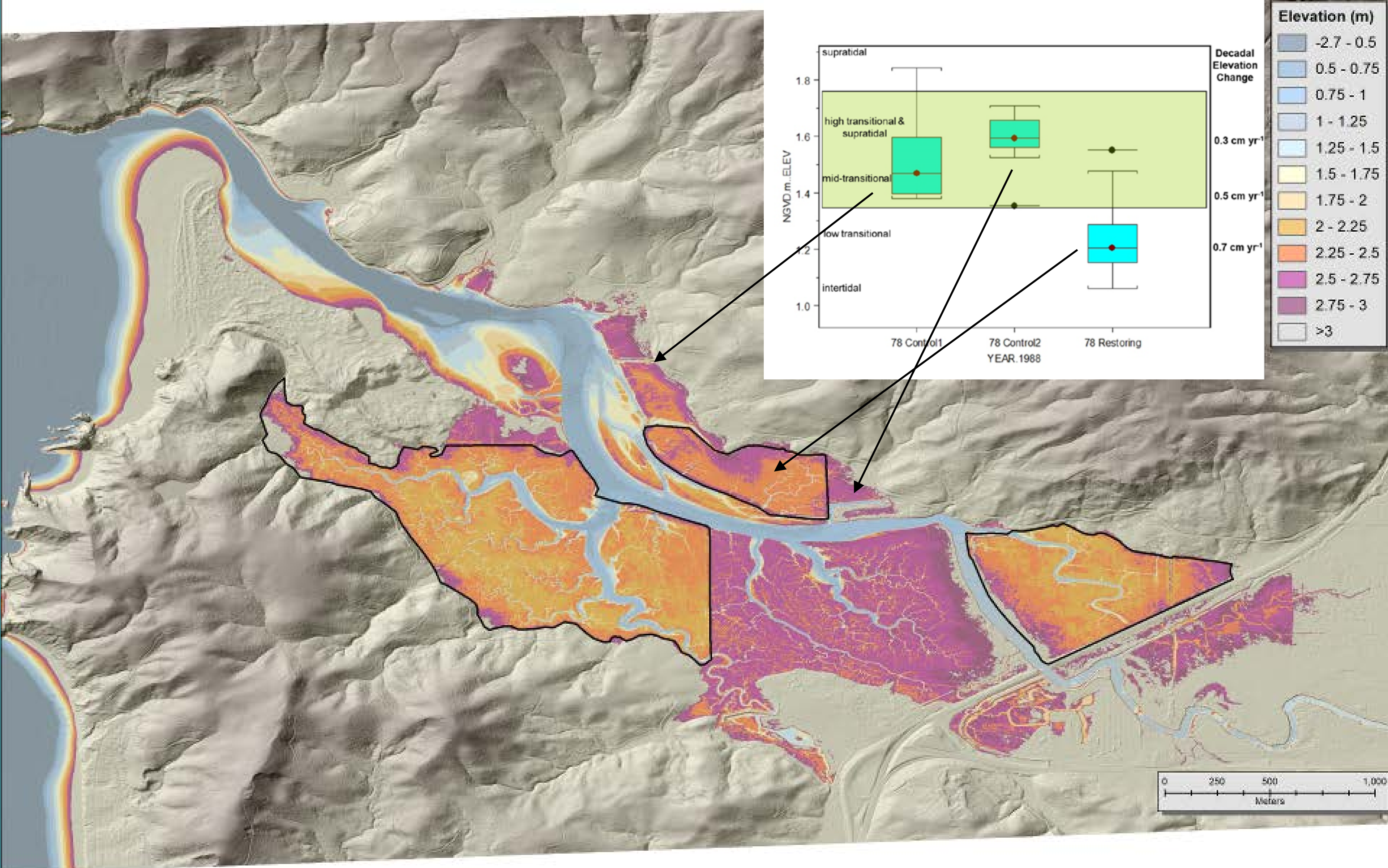
Salmon River Estuary, Oregon: 2005 Aerial Color courtesy of USFS





Salmon River Estuary, Oregon
Comprehensive OSU, NOAA, ODFW, UW study sites, 1978-2008

2007 LiDAR Image courtesy USFS (NGVD vertical datum)

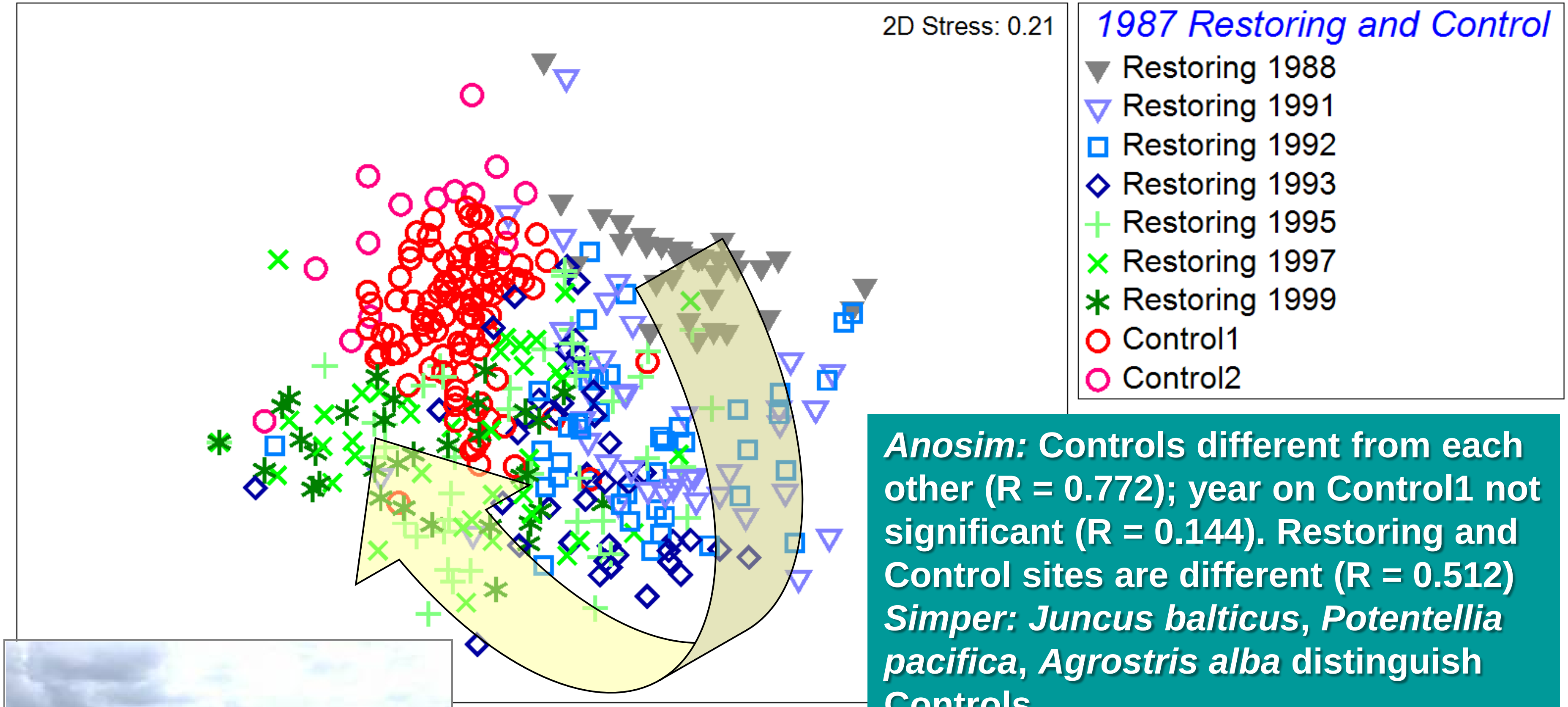


Elevations of Restoring Marshes 2007: 30 years after first marsh restoration Salmon River Estuary, Oregon

2007 LiDAR Image courtesy USFS (NGVD vertical datum)

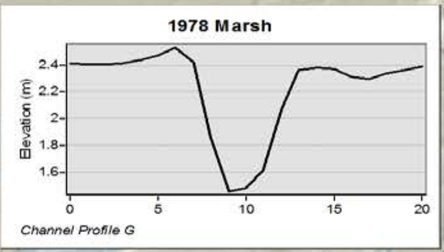
NMDS-87RESTORING

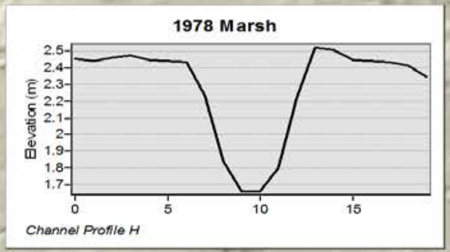
Time Series of 1988-2009 vs. Controls

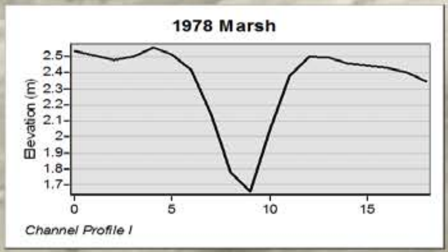


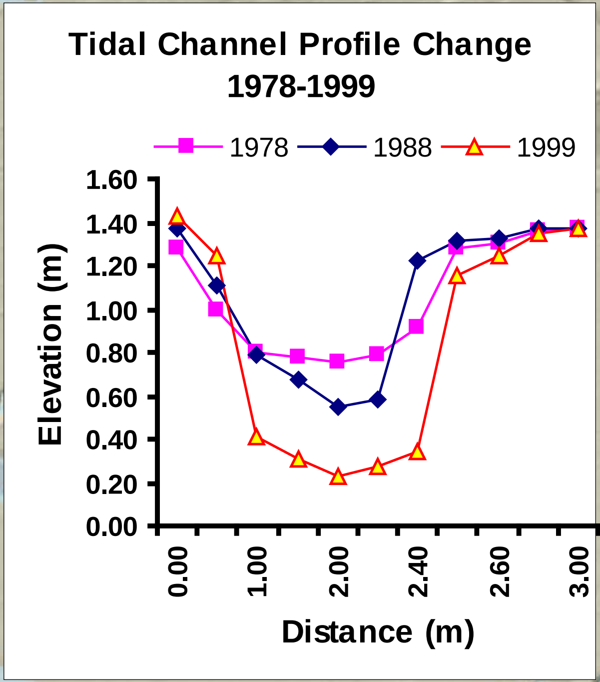
Anosim: **Controls different from each other (R = 0.772); year on Control1 not significant (R = 0.144). Restoring and Control sites are different (R = 0.512)** ***Simper: Juncus balticus*****,** ***Potentellia pacifica*****,** ***Agrostris alba*** **distinguish Controls.**

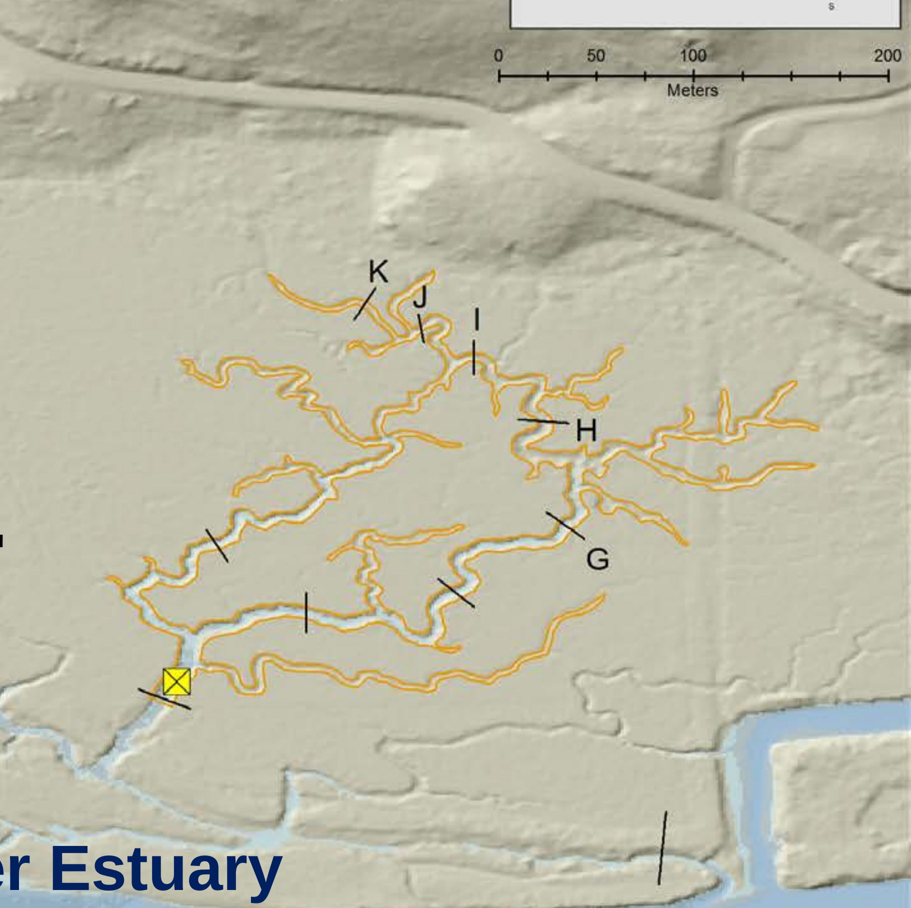
Data source: Frenkel et al. unpubl



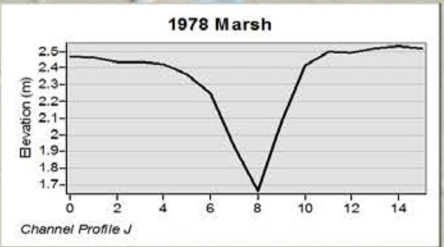


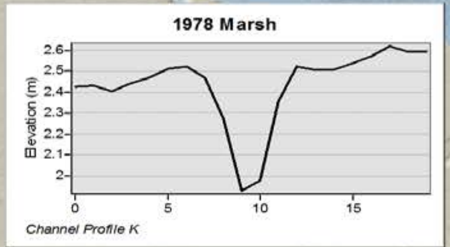






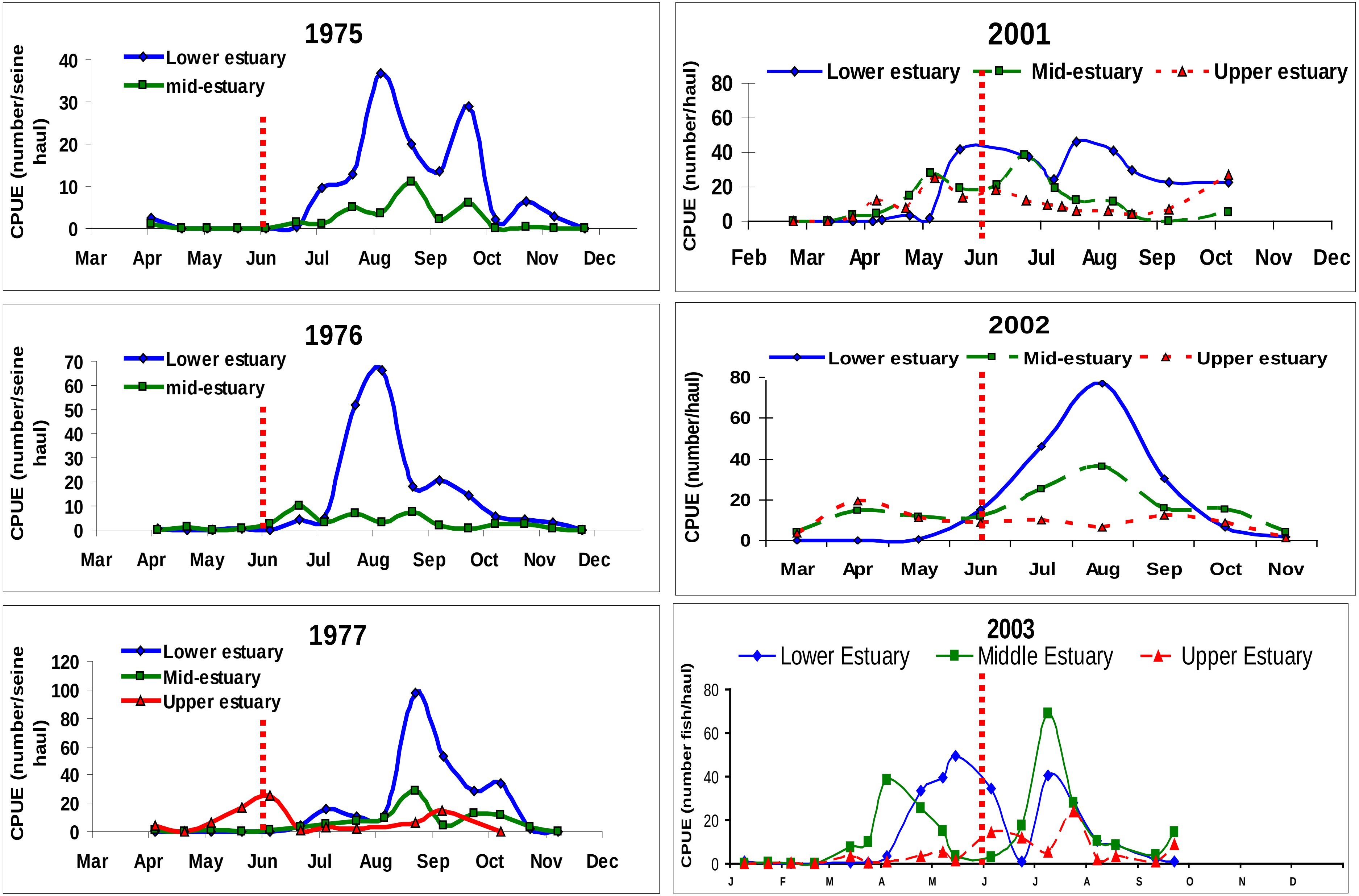
78Restoring Marsh, Salmon River Estuary





2007 LiDAR Image courtesy USFS (NGVD vertical datum)

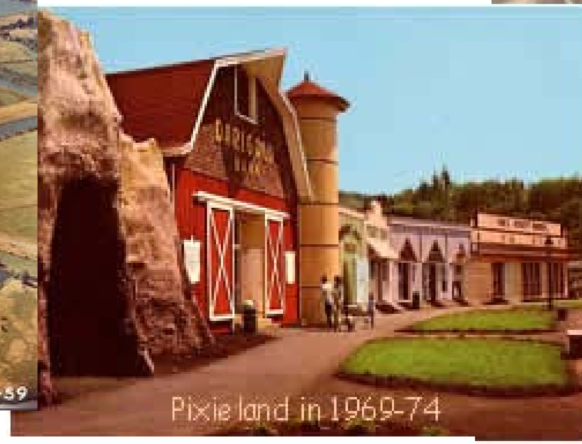
JUVENILE CHINOOK SALMON RESPONSE TO RESTORING MARSHES IN THE SALMON RIVER ESTUARY?

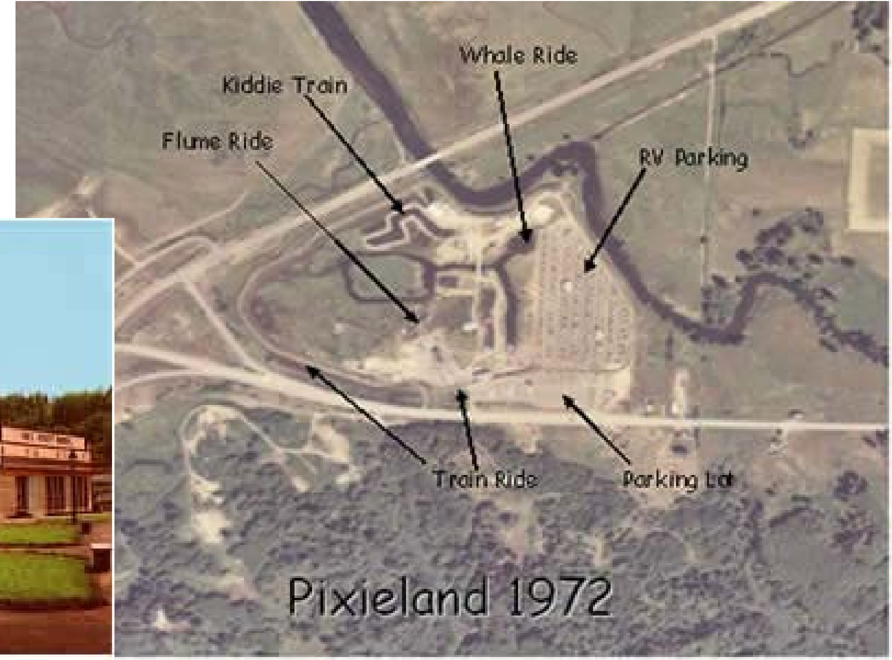


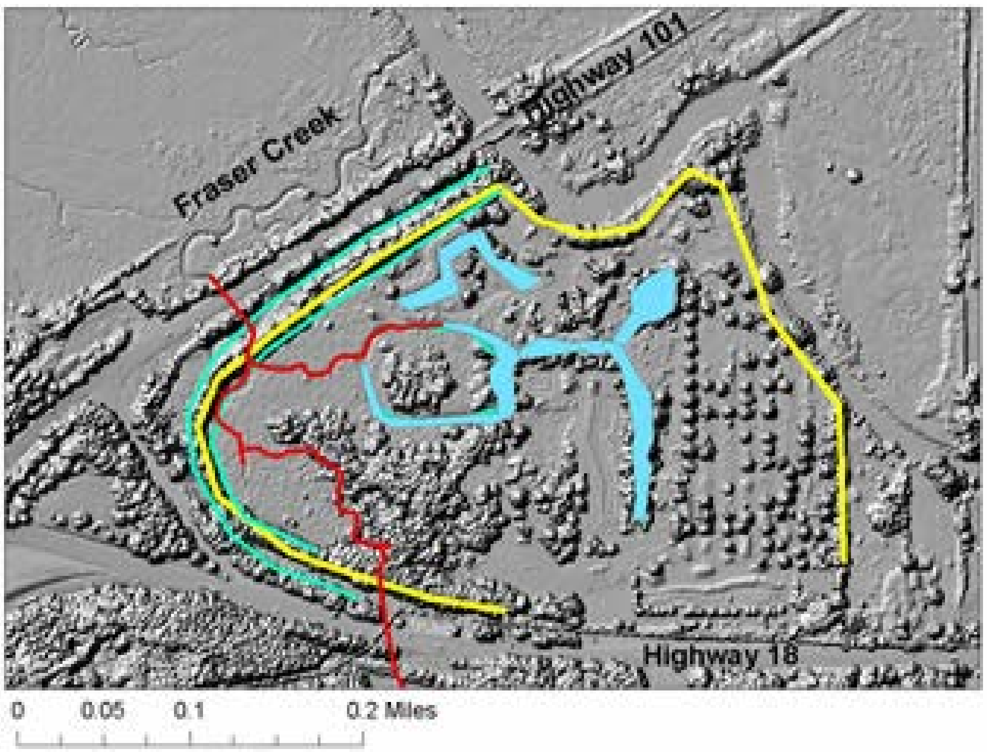
Topography Restoration (Excavation)

- Historic fill for development
- Wood and other waste

The demise of Pixieland!







Groin Removal/Channel Reconnection

To Plant or Not to Plant?

Depends on:

- project goals
- scale
- species life history
- propagule sources

Natural Recruitment in SF Bay Salt Ponds

April 2008 September 2009 Salt Pond A21

http://steel.ced.berkeley.edu/research/hidden_ecologies/

Photos © Cris Benton

Invasive Species Are an On-going Challenge

Many invasive plants

- *Spartina alterniflora*
- *Lepidium latifolium*
- *Polypogon monspeliensis*
- *Lythrum salicaria*
- *Phalaris arundinacea*

And animals

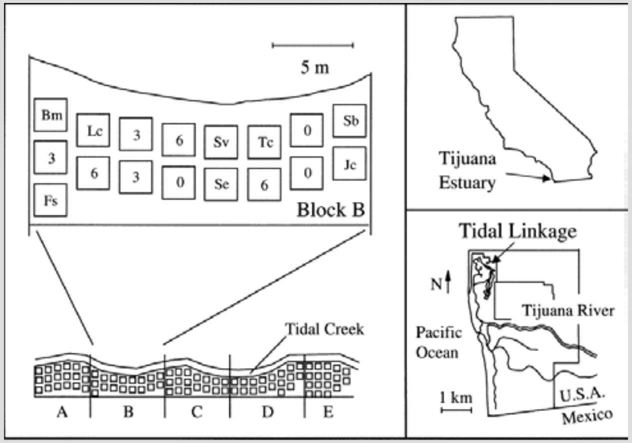
- European green crabs
- Chinese mitten crabs
- Sailfin mollies
- Yellowfin gobies

No silver bullet: identify problematic species; manage to promote natives and minimize impacts

Callaway Recommendations to Improve Success in Wetlands Restoration and Creation

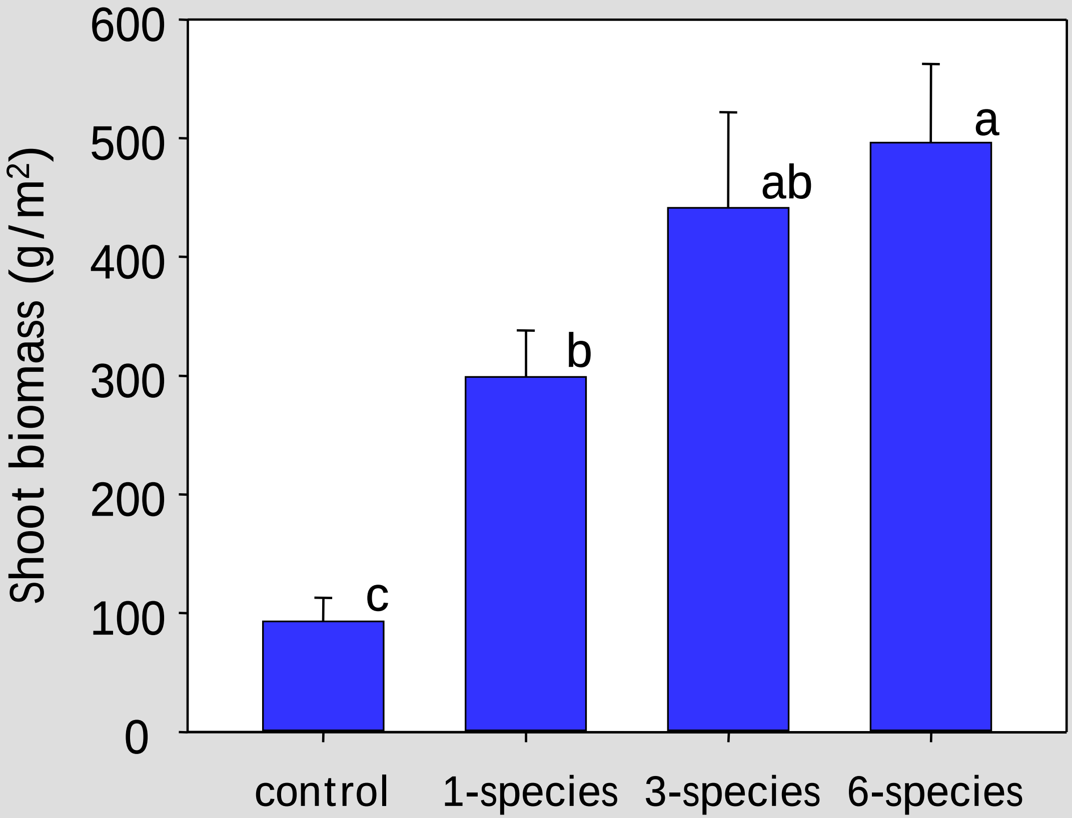
Cause of Failure	Recommendation	Details
1. Sticking with the tried and true approach / lack of experimentation	Include experimentation in restoration design across a range of scales, from mesocosms to large-scale sites	Need to identify critical factors up front and design replicated experiments to evaluate factors that limit restoration development, as well as new techniques for restoration
2. Narrow focus for restoration design and planning	Incorporate landscape and regional planning into restoration design	Follow the lead of the multiple projects on the Pacific Coast that have considered regional issues in restoration prioritization and planning.
3. Too much emphasis on “command and control”	Work with natural processes to promote development of restoration sites	Consider natural plant dispersal and recruitment in planting needs; promote natural sediment accumulation and creek development in restoration sites.
4. Sediment will become a limiting factor for many coastal restoration projects	Manage sediment as a valuable resource rather than disposing of it as “spoils”	Tidal wetlands must keep pace with sea-level rise. However, many systems are experiencing reductions in watershed sediment inputs and this will be compounded by future increases in sea-level rise.
5. Urbanization and climate change will constrain many projects	Evaluate constraints and manage for resiliency	Coastal wetlands are highly sensitive to elevation and future restoration efforts could be severely constrained by urbanization on one side and rising seas on the other. Planning for change and resiliency will be necessary to maintain wetlands into the future.

1: Include More Experimentation



Tijuana River NERR is a model for incorporating experiments & Joy Zedler’s approach of “adaptive restoration”

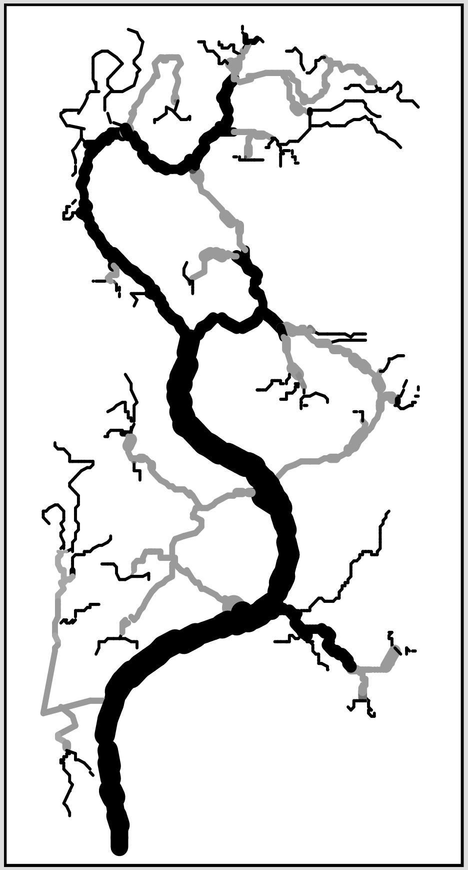
Species Diversity Affects Productivity



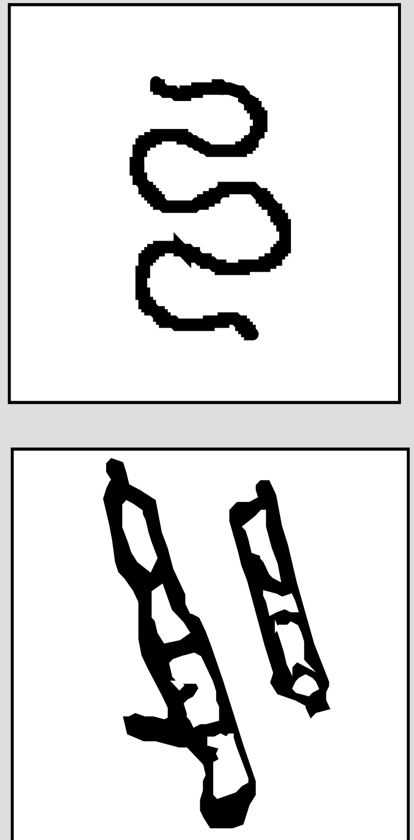
but most restored wetlands have reduced species diversity

Do Tidal Creeks Matter?

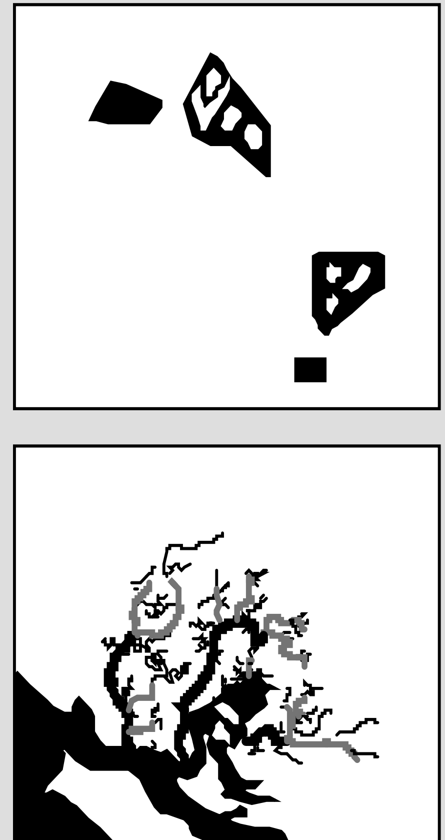
Tijuana Estuary:
Natural



Sweetwater Marsh:
Constructed

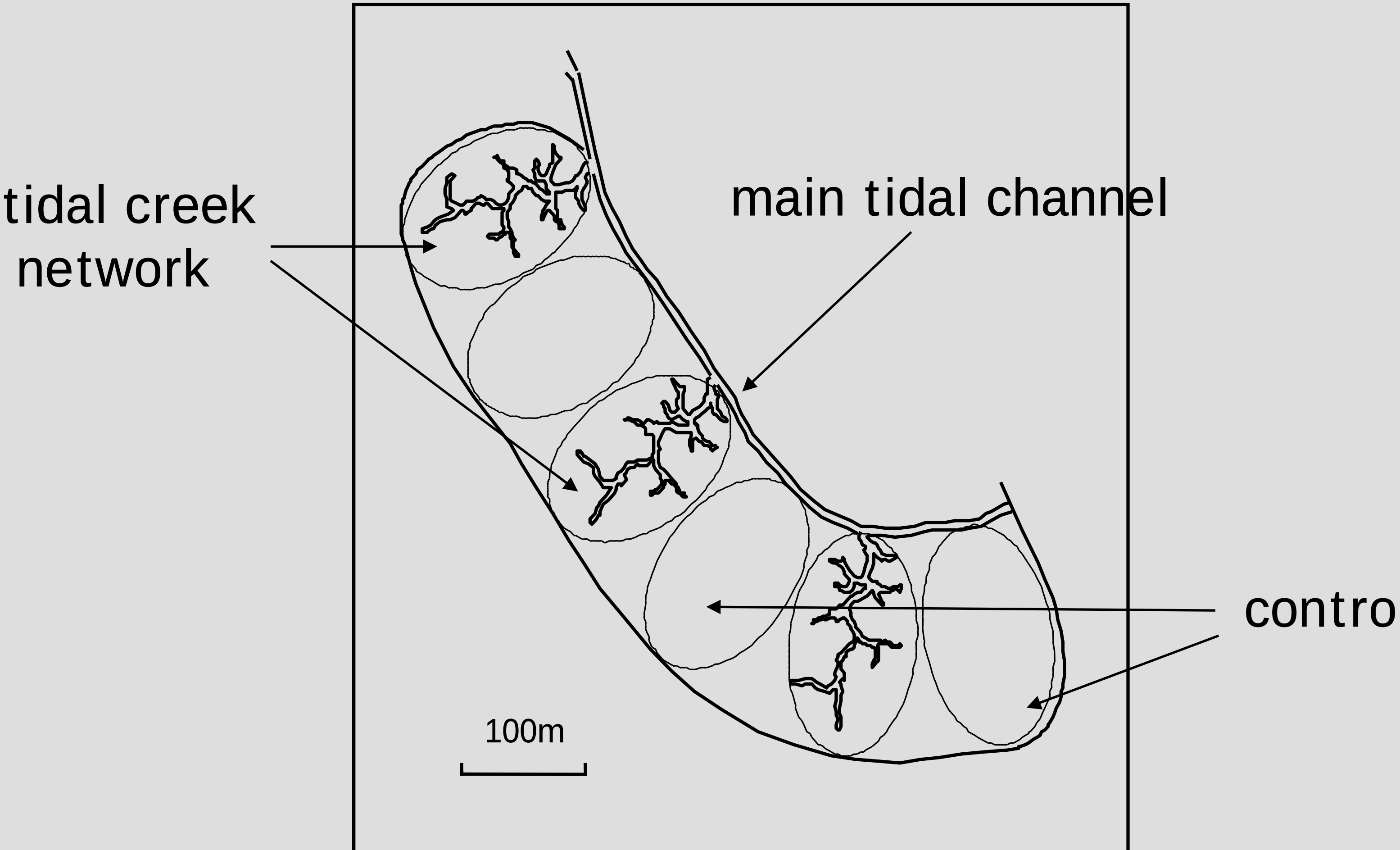


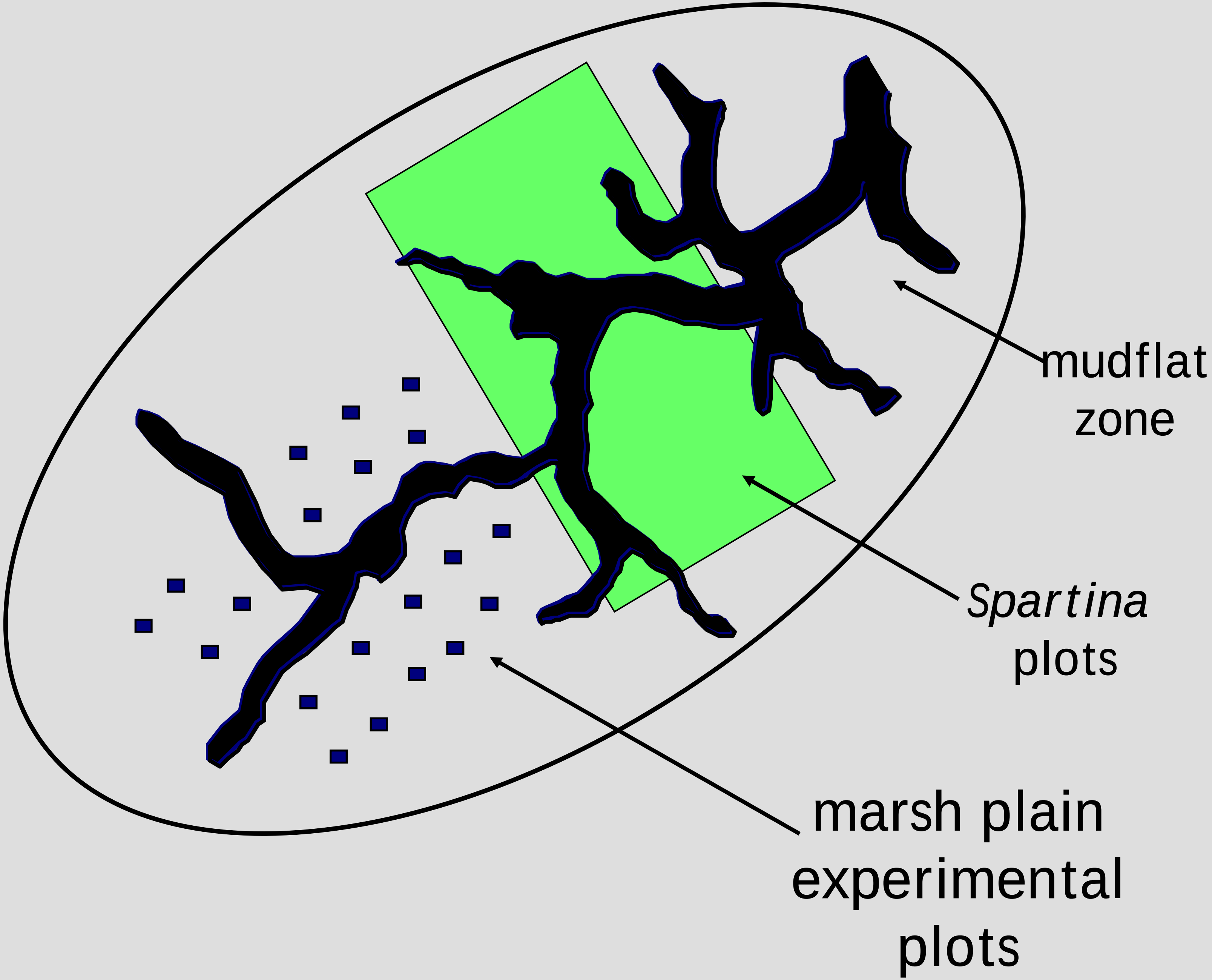
Seal Beach:
Constructed & Natural

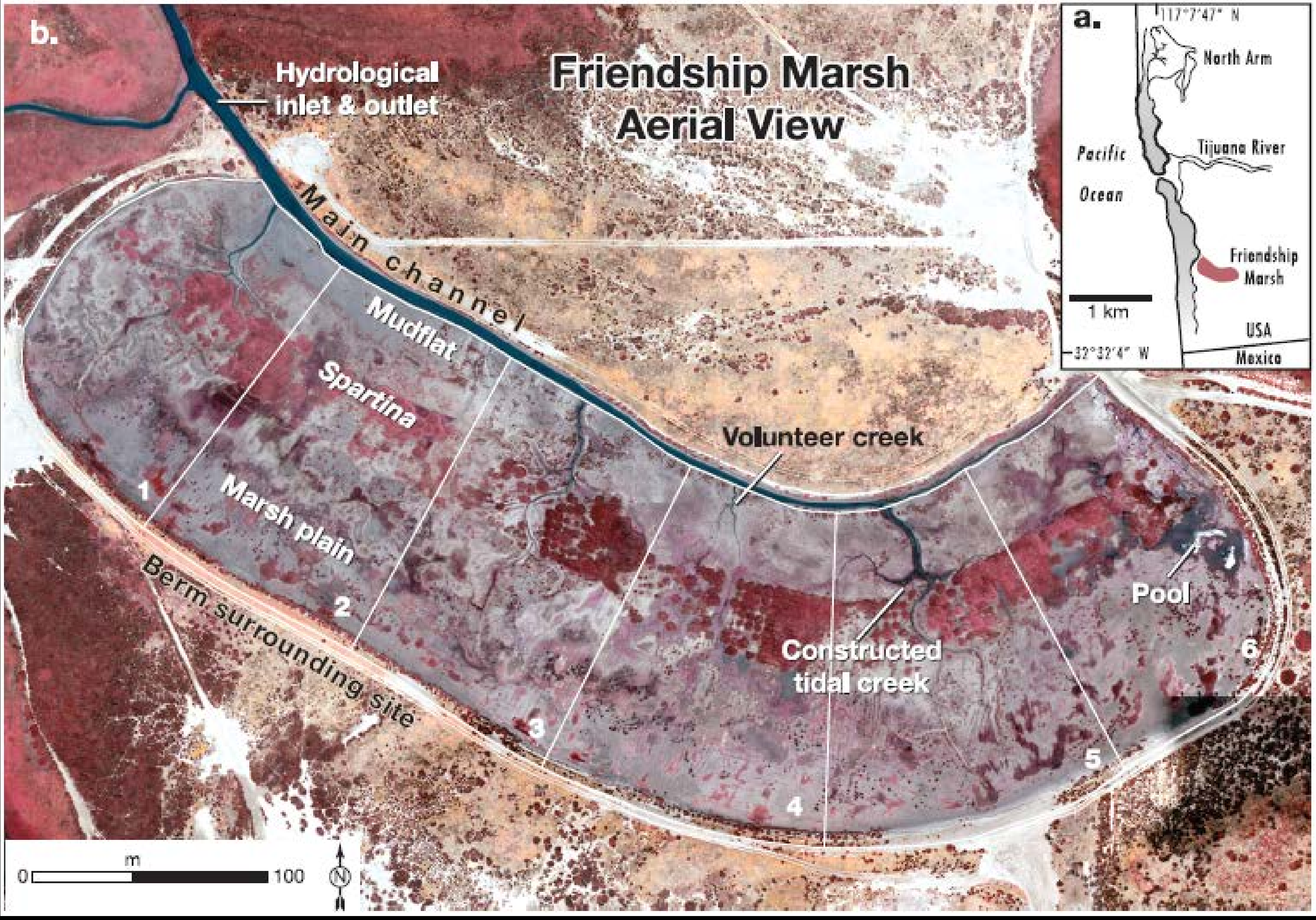


(from Julie Desmond)

Friendship Marsh Experimental Design



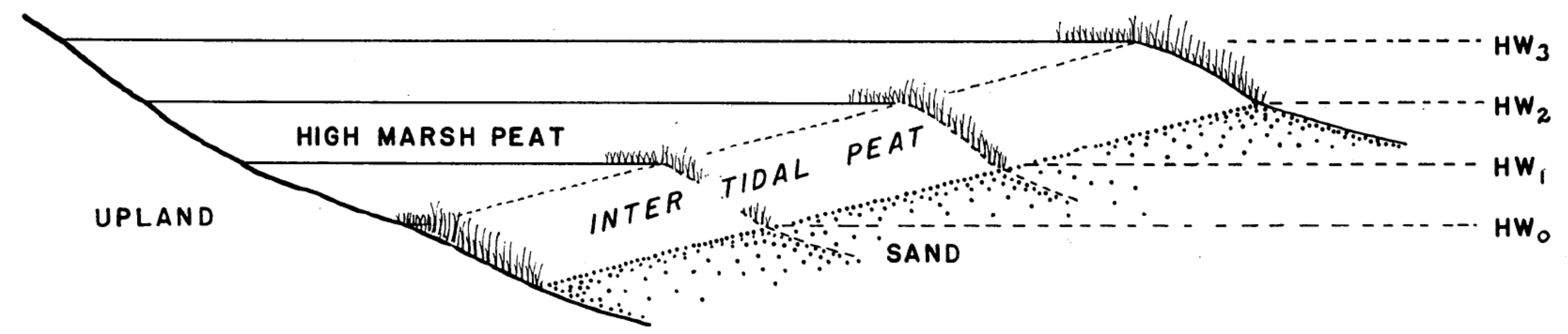

mudflat zone
Spartina plots
marsh plain experimental plots



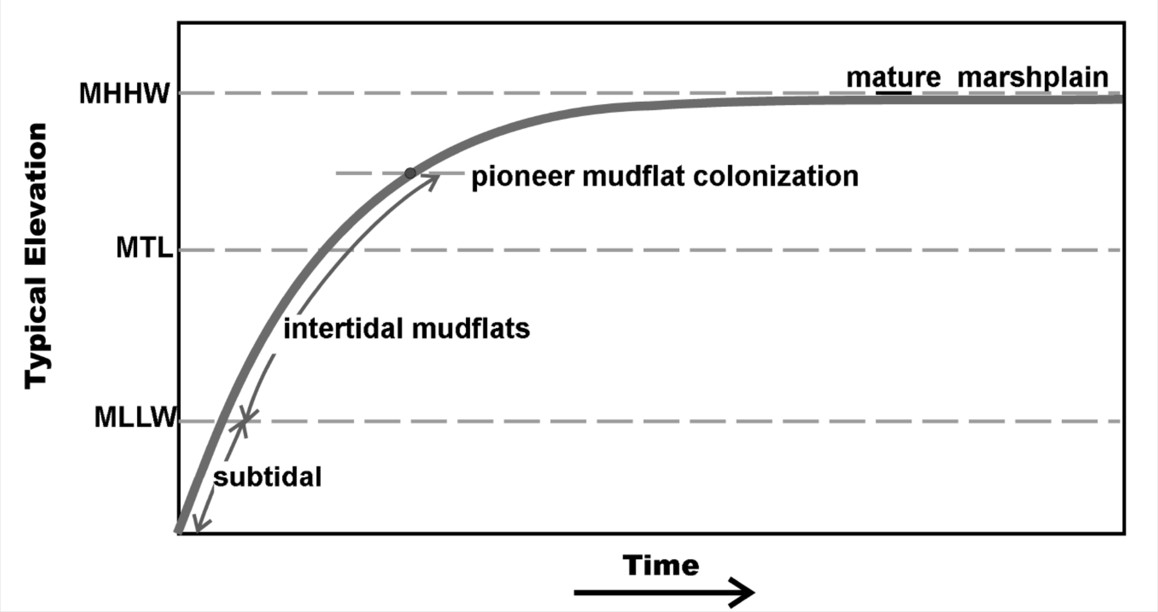
b.
Friendship Marsh
Aerial View
Hydrological inlet & outlet
Main channel
Mudflat
Spartina
Marsh plain
Volunteer creek
Constructed tidal creek
Pool
Berm surrounding site
1
2
3
4
5
6
m
0
100
N
a.
117°7'47" N
North Arm
Pacific Ocean
Tijuana River
Friendship Marsh
1 km
USA
Mexico
32°32'4" W


03.08.2004

3: Work with Natural Marsh Processes



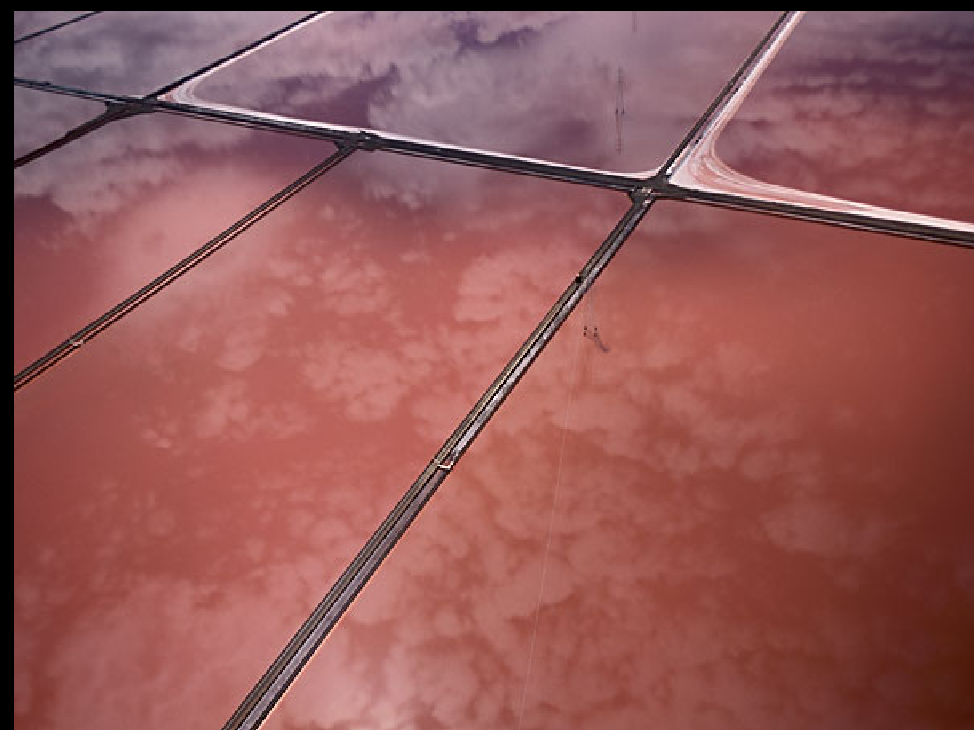
(Redfield 1972)

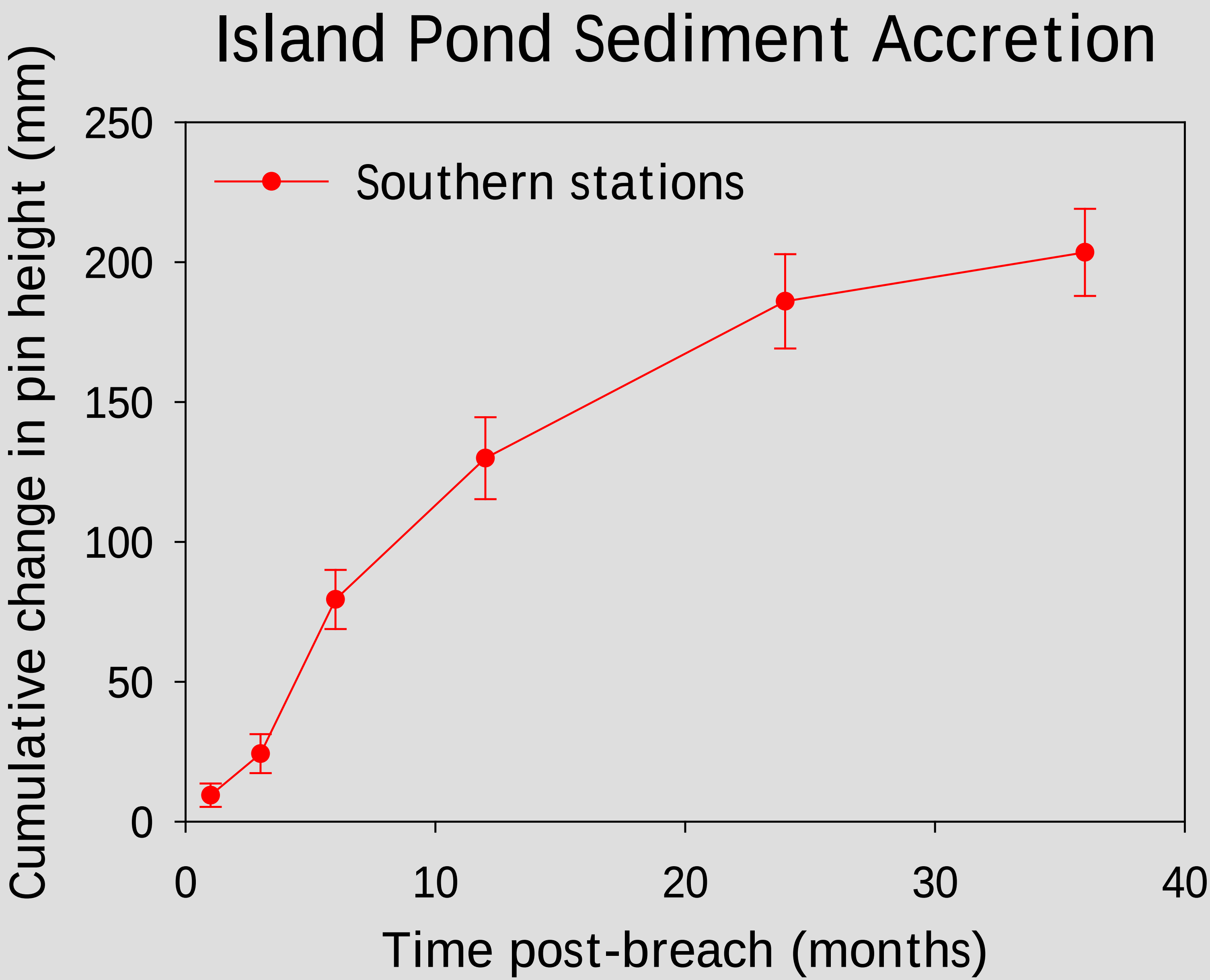


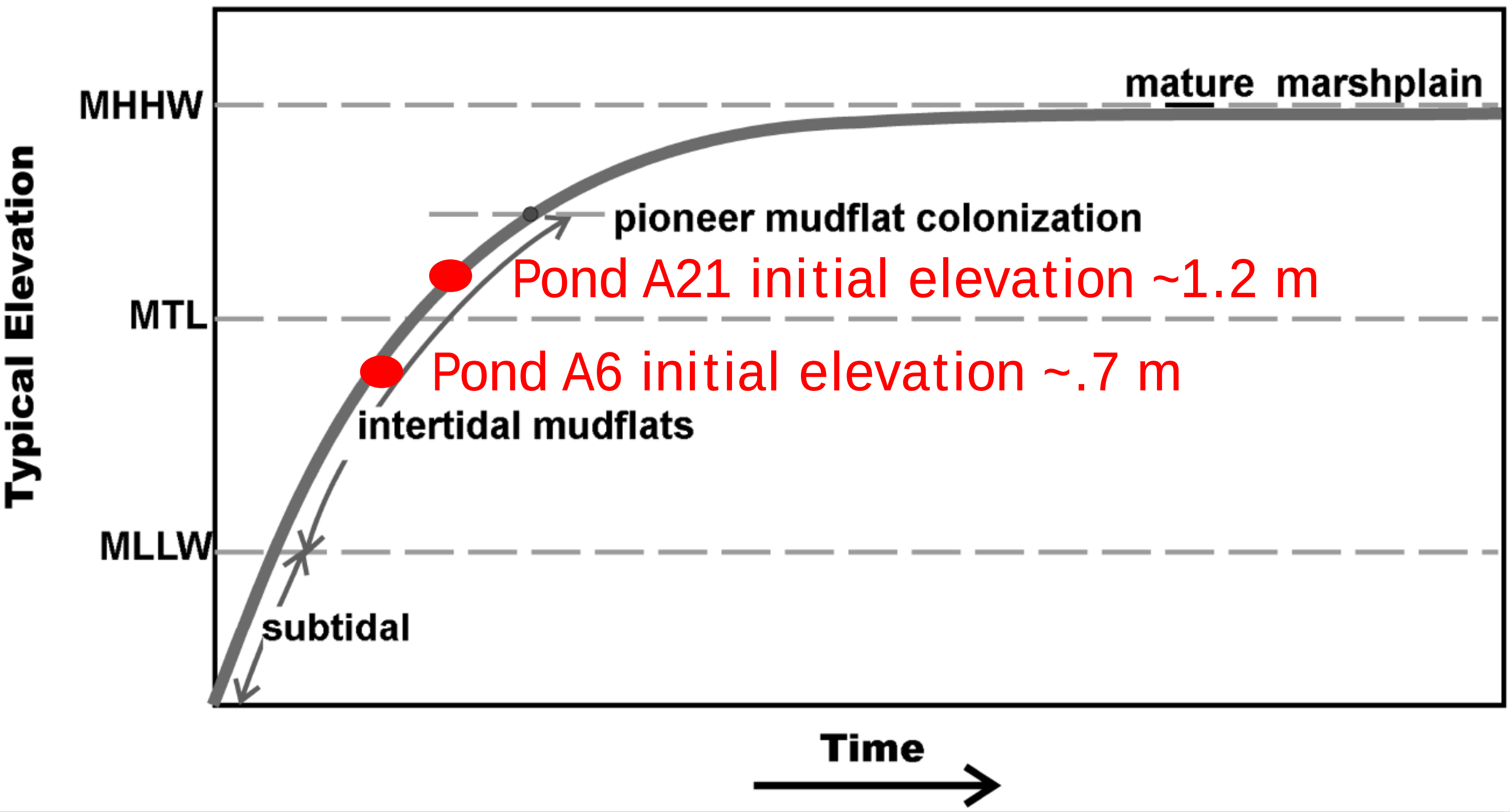
(Williams and Orr 2002)

Major Restoration Uncertainty:

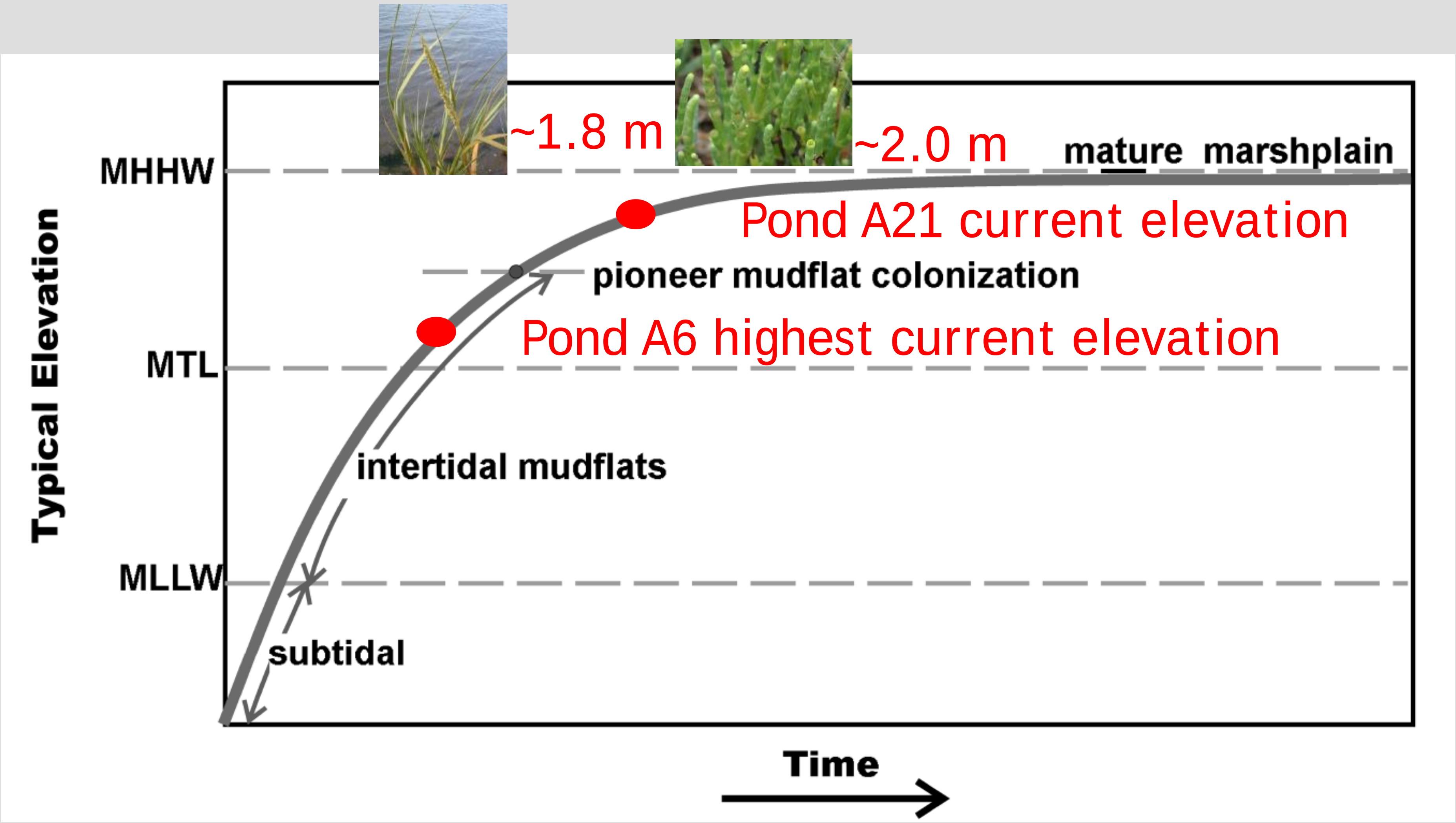
How quickly will salt ponds develop into vegetated tidal wetlands?



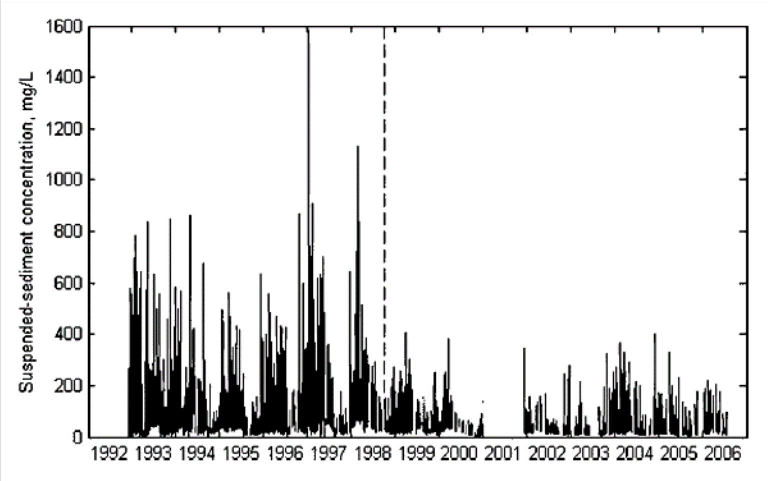

Island Pond Sediment Accretion
Southern stations
Cumulative change in pin height (mm)
250
200
150
100
50
0
0
10
20
30
40
Time post-breach (months)



mature marshplain
MHHW
pioneer mudflat colonization
Pond A21 initial elevation ~1.2 m
MTL
Pond A6 initial elevation ~.7 m
intertidal mudflats
MLLW
subtidal
Typical Elevation
Time


~1.8 m
~2.0 m
mature marshplain
MHHW
Pond A21 current elevation
pioneer mudflat colonization
Pond A6 highest current elevation
MTL
Typical Elevation
intertidal mudflats
MLLW
subtidal
Time

4: Manage Sediment as a Valuable Resource



(from Schoellhamer 2011)

Sediment concentrations are decreasing in many estuaries, just when we need more sediment to counteract increases in sea-level rise

5: Consider Climate Change & Urban Constraints

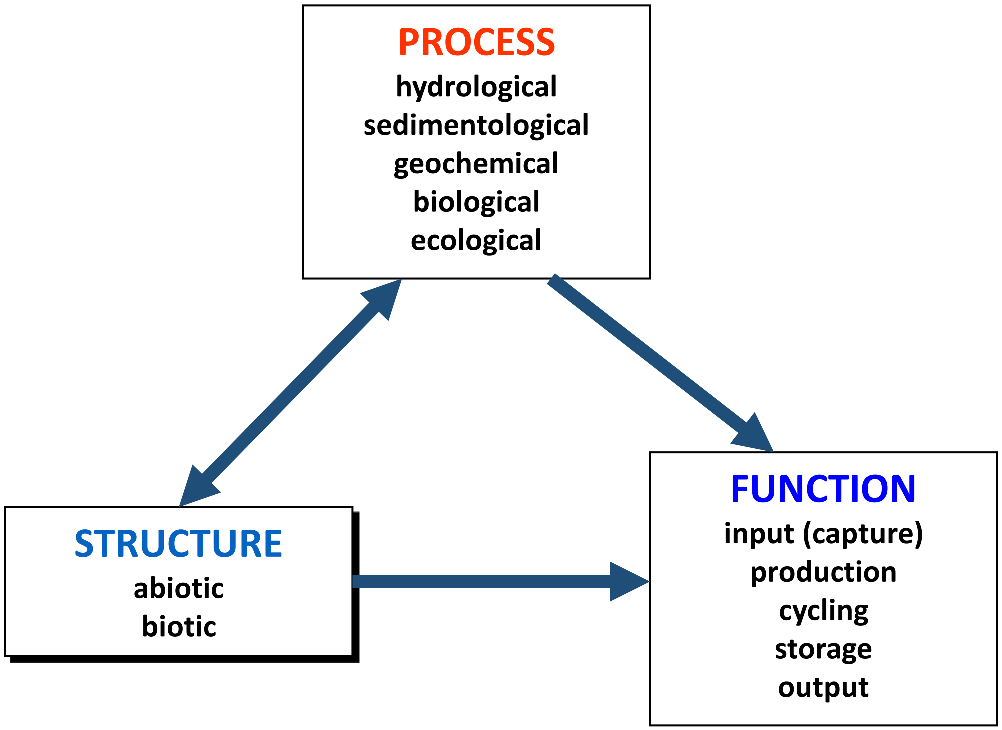
It will be necessary to prioritize resiliency for future restoration and management efforts…

Simenstad Top Five Recommendations to Improve Success in Wetlands Restoration and Creation

Cause of Failure	Recommendation	Details
1. Focus on re-creating wetland structure rather than restoring impaired processes	Concentrate on restoring naturally dynamic processes, particularly uninhibited tidal flooding, sediment and large wood delivery, natural disturbance regimes	Avoid "designing"; mimicking natural processes is seldom effective and often costly; take advantage of uninhibited natural processes to "self-design"; but, take into account altered capacity for dynamic processes and other "novel ecosystem" effects;
2. Inattention to landscape context	Conduct systematic assessment of potential and capacity to restore full connectivity, especially via ecosystem sustaining processes such as sediment accretion, channel migration, etc.; identify constraints at multiple space and time scales	Evaluate and "design" site specific restoration in the context of the landscape/watershed, including a thorough understanding of scaling factors (e.g., channel structure), potential constraints and changes in watershed forcing (e.g., water and sediment delivery), shoreline development, sea level rise, and other factors threatening estuarine wetland sustainability
3. Lack of considering natural disturbance a critical element to wetland structure and function	Set priority on watershed/landscape settings where natural disturbance persists; restore to allow natural disturbance, not suppress it	Select or design restoration that has capacity to absorb and benefit from restoration in a natural disturbance regime; avoid design features that inhibit disturbance, e.g., features that prevdent tidal-fluvial flooding, recruitment and movement of large wood, beavers, etc.
4. Demand for instant gratification	Avoid management measures that are believed to "jump-start" the time required to create a functional or desired ecosystem (e.g., "Fast-Forwarding" of Hilderbrand *et al.* (2005)	Conduct a "cost-function" assessment of restoration actions designed to replicate what tidal and other natural processes accomplish more effectively with time; avoid excavating channels, planting, controlling water flow and other manipulations that may be "counter functional" in the long run
5. Perpetuating the "Cookbook Myth" (Hilderbrand *et al.* 2005)	Must incorporate adaptive management (experiments) to resolve many uncertainties; cookbook approach won't work	Demand monitoring and active adaptive management for highly uncertain management measures; require reporting to managers, practitioners, scientists and stakeholders

1. Focus on re-creating wetland structure rather than restoring impaired processes

- o Natural processes create naturally dynamic and adaptive structure
- o Integrated, process and structure influence function
- o Process-based restoration more likely to be sustainable and promote ecosystem resilience

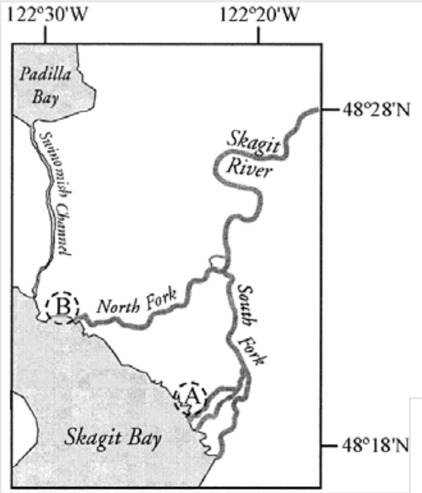


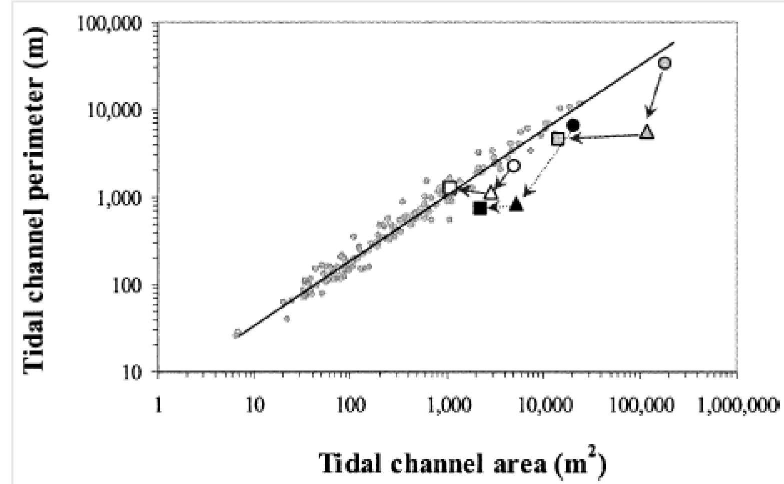
Fundamental question: *How do we restore how tidal wetlands "work", rather than how do we reproduce their "structure"?*

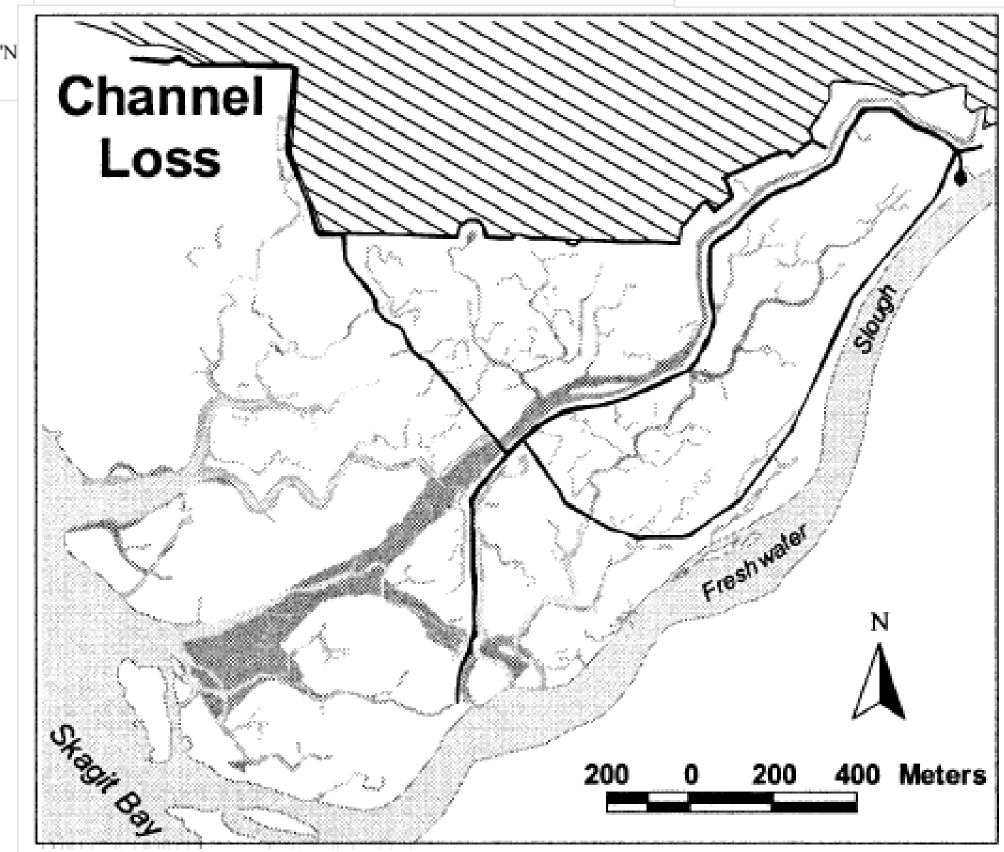

1. Focus on re-creating wetland structure rather than restoring impaired processes
Restoration in a dynamic ecosystem?

2. Inattention to landscape context

2. Inattention to landscape context

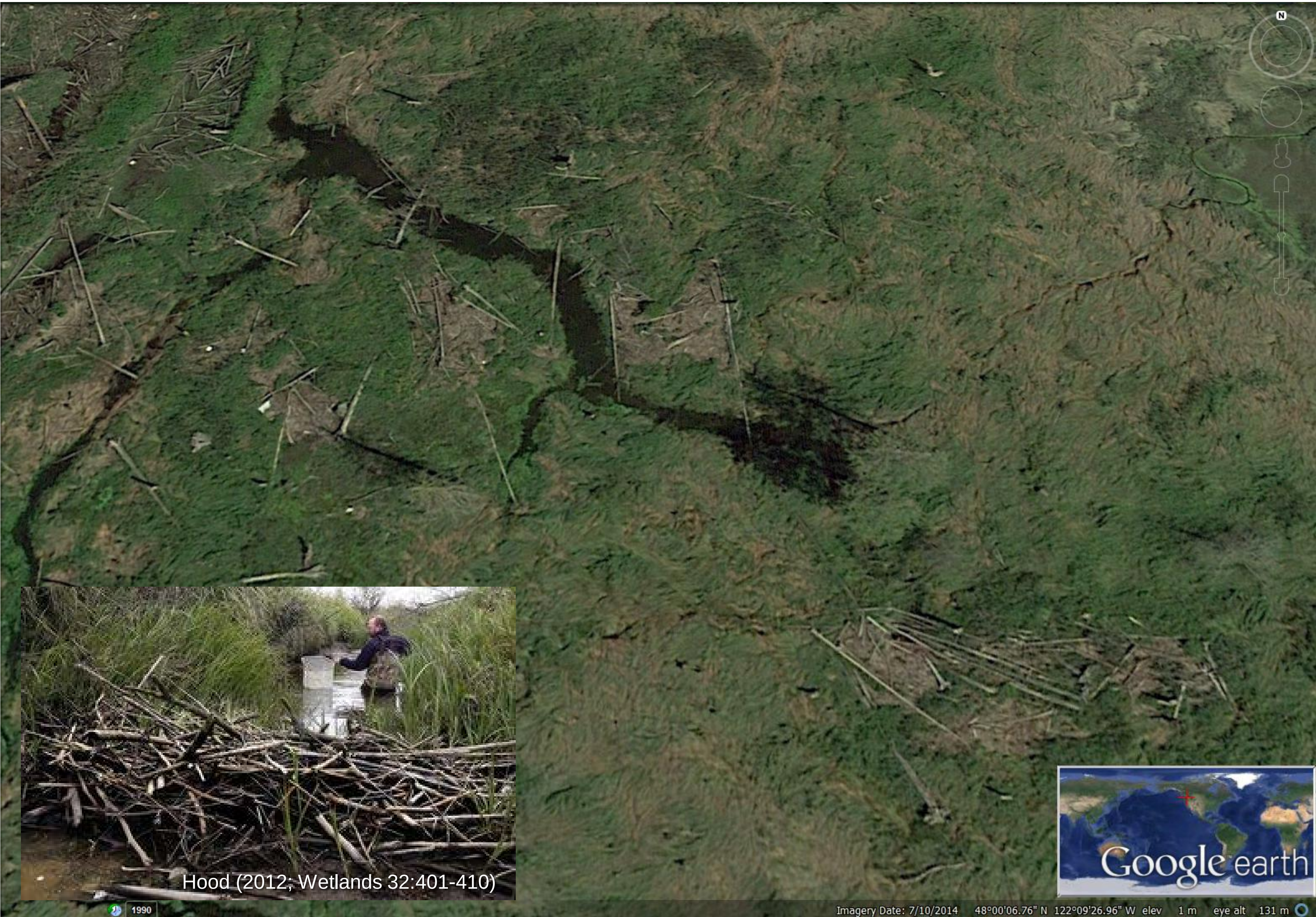






Hood 2004; Estuaries & Coasts 27:273-282.

3. Lack of considering natural disturbance a critical element to wetland structure and function



Hood (2012; Wetlands 32:401-410)

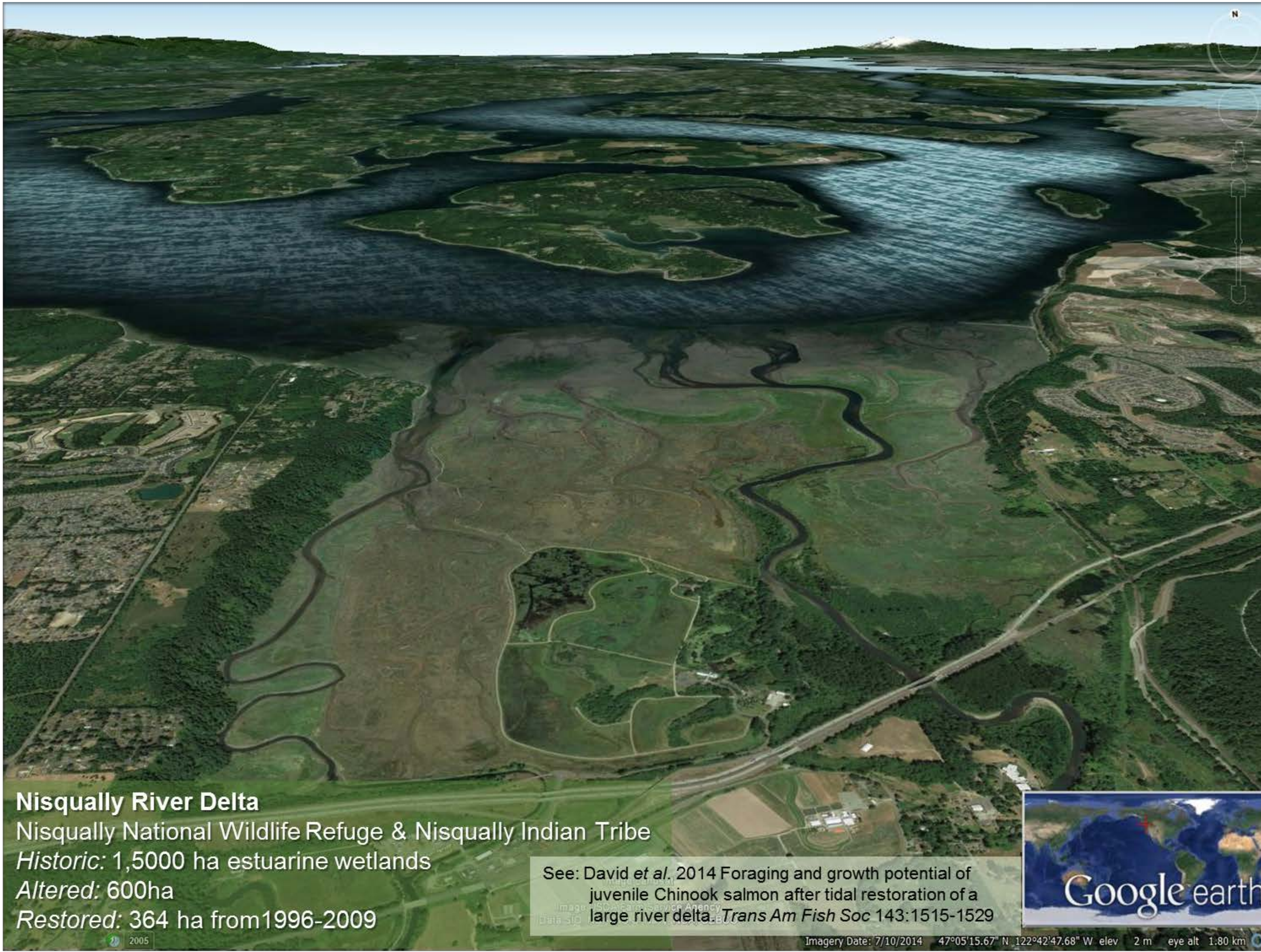
4. Demand for instant gratification

5. Perpetuating the "Cookbook Myth"
(Hilderbrand *et al.* 2005)

Are We Learning Anything?

With abject apologies to Bill Watterson

5. Perpetuating the "Cookbook Myth" (Hilderbrand *et al.* 2005)



Conclusions

- Pacific Coast tidal wetlands are unique and highly diverse, from arid salt marshes of southern California to tidal freshwater wetlands in the Pacific Northwest.
- Landscape-scale considerations are critical
- Moving away from mitigation focus will improve restoration efforts
- Restoration planning should be based on natural processes
- Strategic restoration planning is the only way to achieve sustainability and resilience

Further Resources

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