

Overview of Linkages Between the Land and Shallow Receiving Waters

Peter Goodwin
UMCES

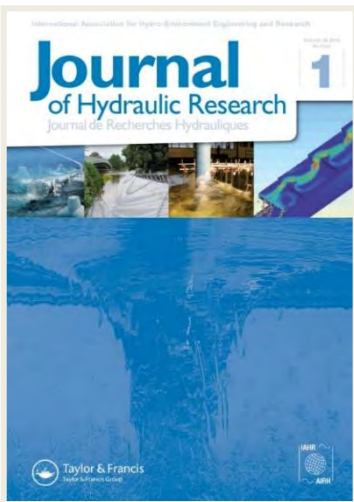
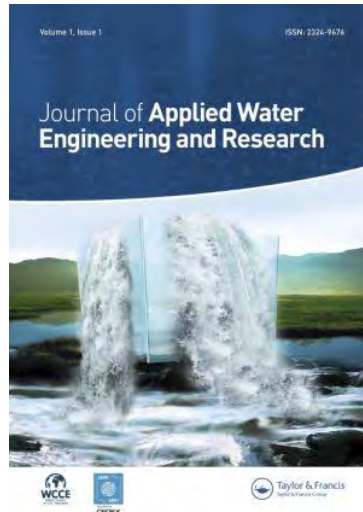
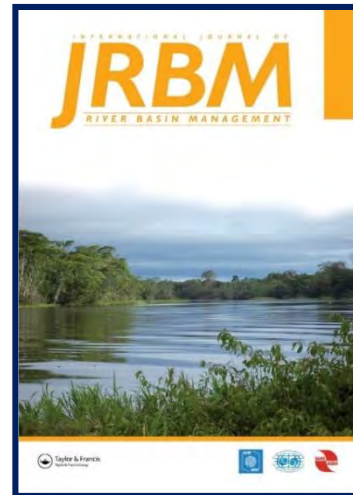
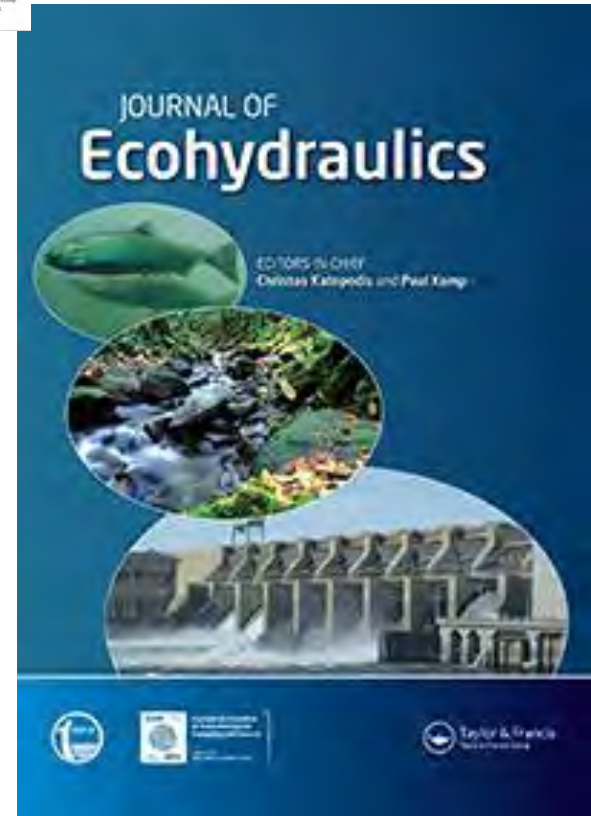
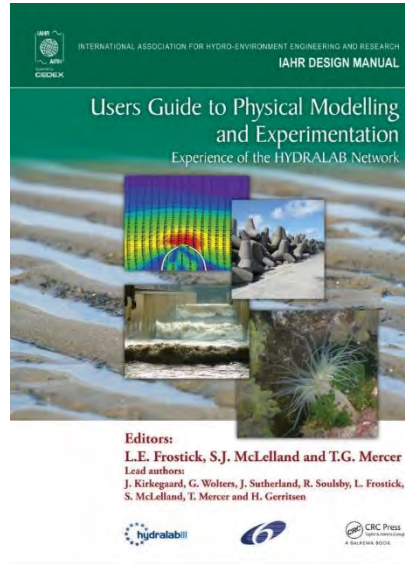
Outline

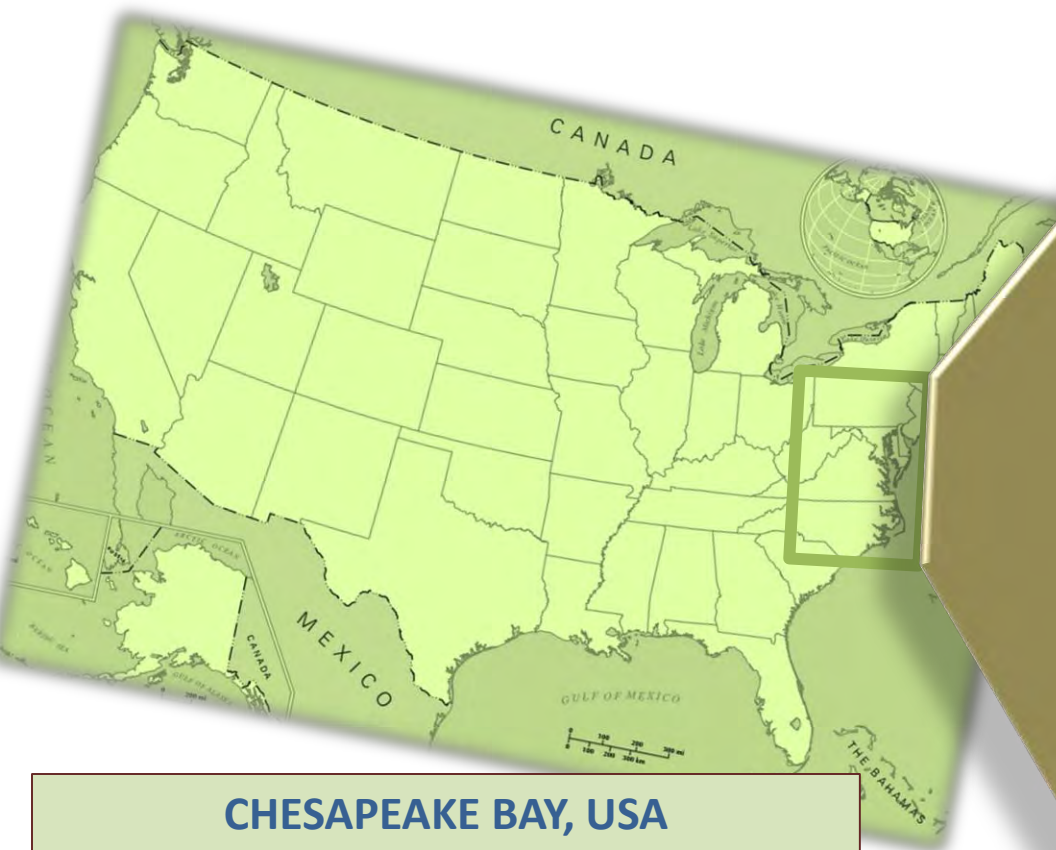
- Why the concept is exciting
- Fluvial physical processes
- Estuarine physical processes
- Discussion of elements of a conceptual model



International Association for Hydro-Environment Engineering and Research

Supported by
Spain Water and IWHR, China





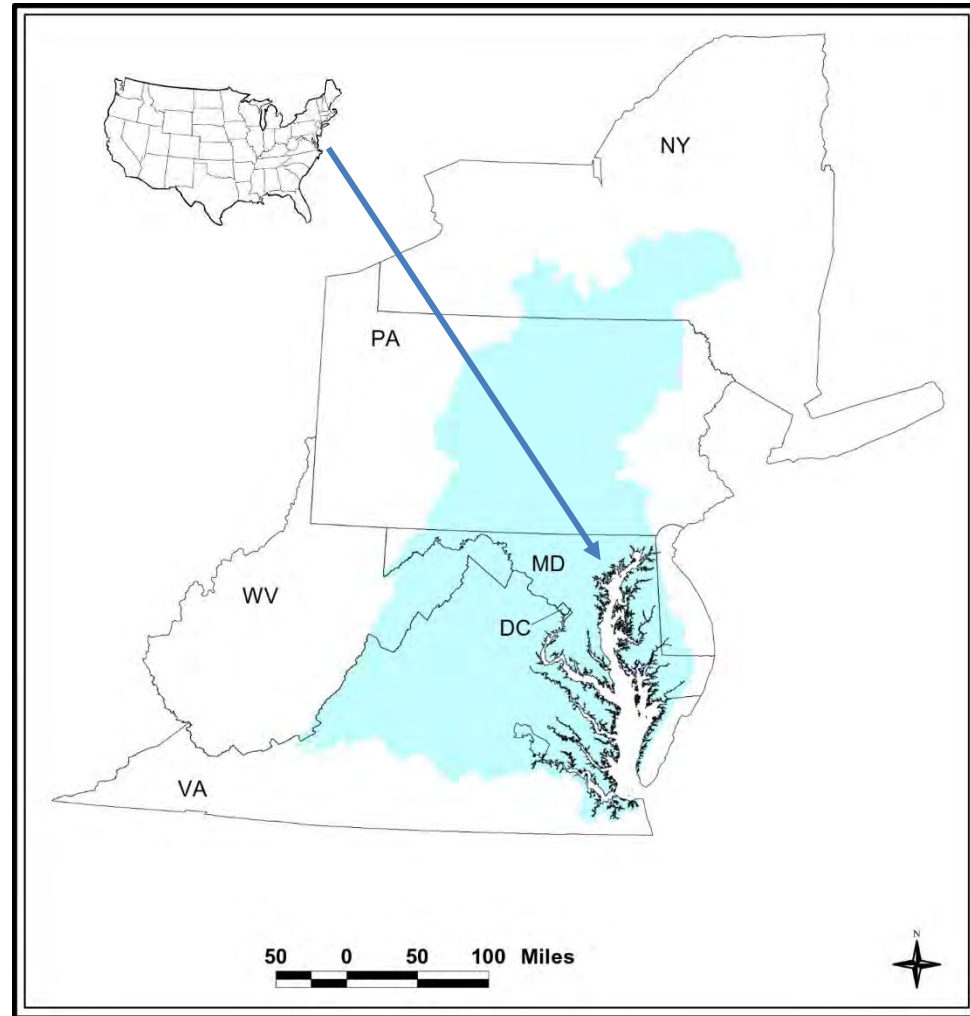
CHESAPEAKE BAY, USA

- 64,000 square miles (165,800 km²)
- Parts of 6 states plus Washington D.C.
- Largest Estuary in North America

Images courtesy of:
Ann Swanson
Executive Director
Chesapeake Bay Commission

CHESAPEAKE BAY STATISTICS

- 18 million people
- 10,000 miles (16,093 km) of shoreline
- 21 feet (6.4 m) average depth
- 150 Rivers: 180,000 miles (290,000 km) creeks, rivers and streams
- 3,200 species of plants and animals
- **Triblets are likely a significant percentage of the landscape and under-studied**





The Value of Knowledge Exchange:

In California we need to consider "novel ecosystems" that function almost completely differently than the ecosystems in which the plants and animals evolved.

Resilient or sustainable ecosystems are not necessarily desirable ecosystems

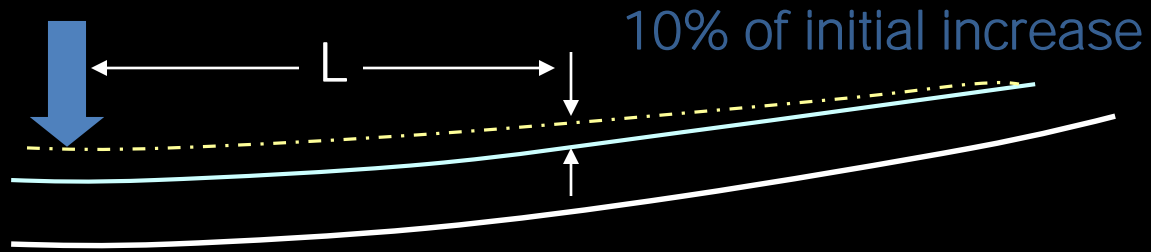
Peter B. Moyle, 2014

Why the concept is exciting.

- Prioritizing management actions when resources are limited
- Adaptive learning – drawing together practitioners and research scientists
- There are some very interesting scientific processes to explore – how much control do we have?
- Under-studied part of the landscape ecology
- Opportunities for networking in the US and globally.

Fluvial Processes





h = bankfull depth

$$L \sim \frac{h}{2S_0}$$

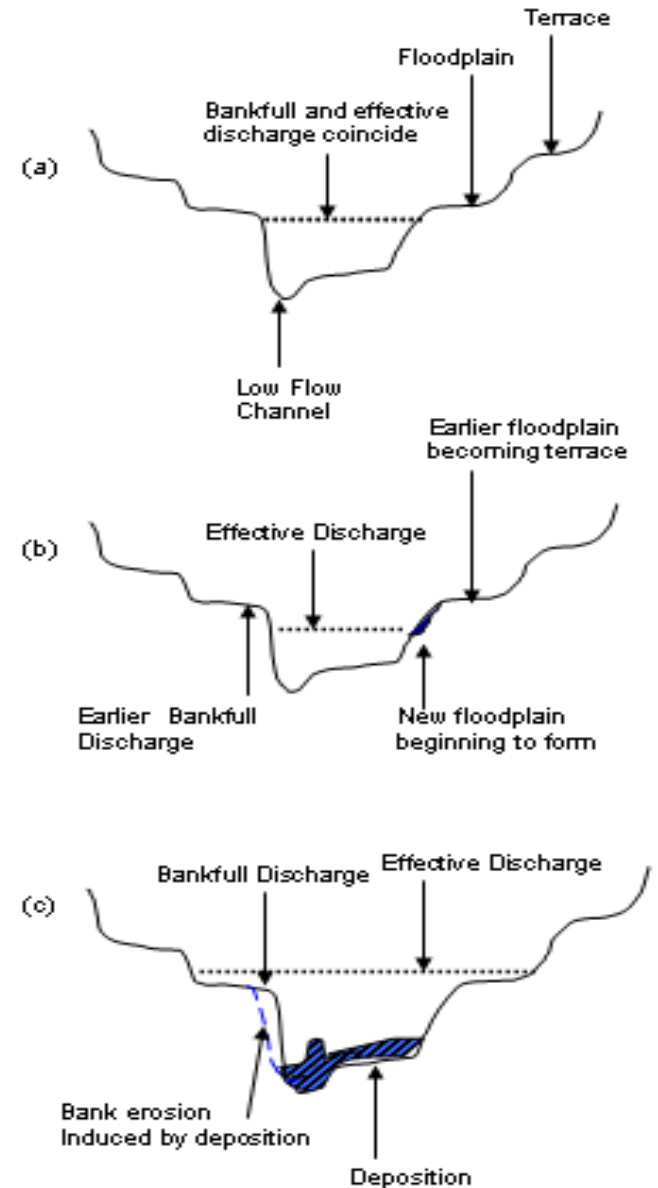
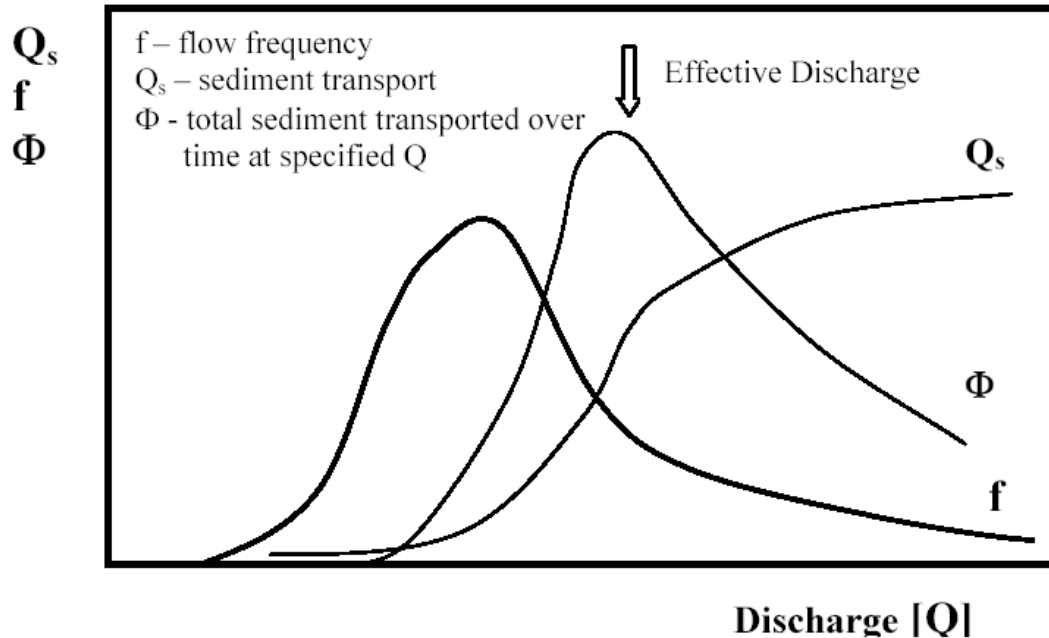


Reference:

P.G. Samuels, 1989. (December)

Procs of ICE. Research and Theory pp. 571-582

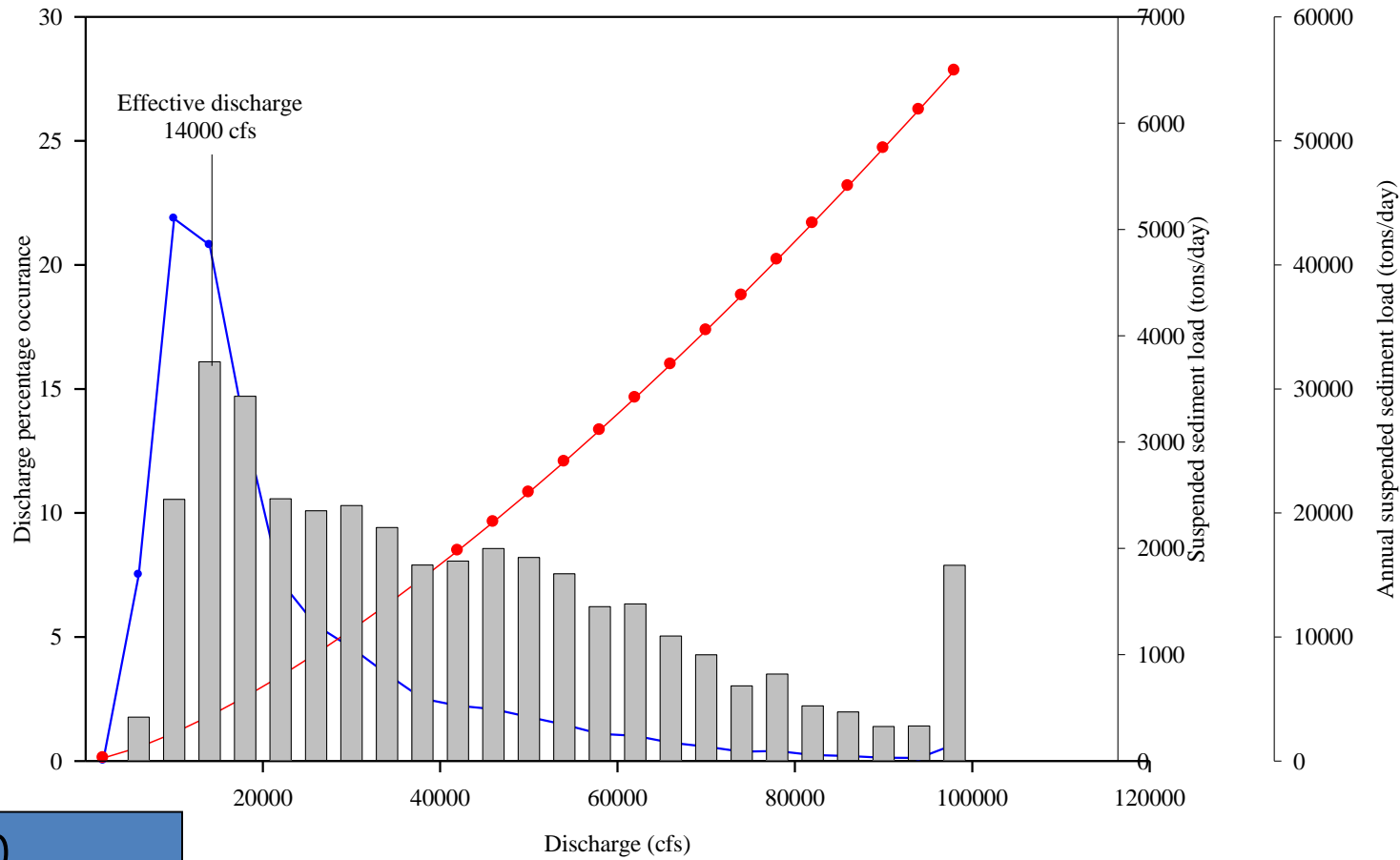
Why is Effective Discharge a Robust Indicator?



$$\Phi_e = \alpha Q_e^\beta \times f(Q_e)$$

$$\alpha Q_e^\beta \times f(Q_e) = \alpha Q_R^\beta \times f(Q_R)$$

$$\frac{\log\left(\frac{f(Q_e)}{f(Q_L)}\right)}{\log\left(1 - \frac{\Delta Q}{Q_e}\right)} \leq \beta \leq \frac{\log\left(\frac{f(Q_e)}{f(Q_R)}\right)}{\log\left(1 + \frac{\Delta Q}{Q_e}\right)}$$



$\Delta Q = 10 \text{ cfs}$, b is 3.0

$Q_s = aQ^b$

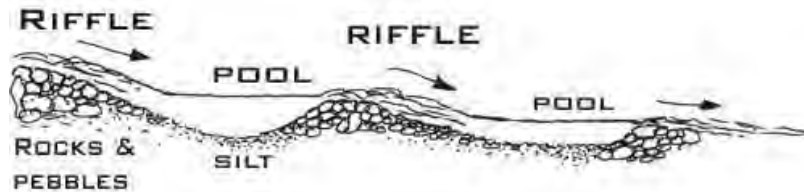
b can vary from 2.27 to 3.42 before estimate of Q_e changes

U.S. Bureau of Reclamation Columbia-Snake Salmon Recovery Office:

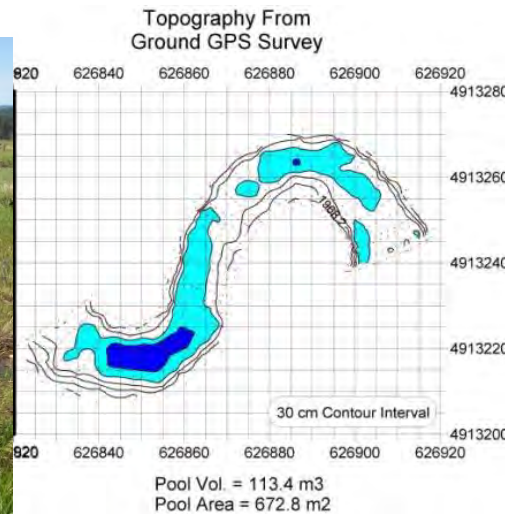


Need for design guidelines as well as a means for determining design success metrics

Pool-riffle morphology provides:



- ❑ Physical habitat diversity for other aquatic biota
- ❑ Critical spawning habitat
- ❑ Thermal refugia in summer and winter
- ❑ Habitat for different salmonid life stages



Fundamental Question

Why do the pools in some systems persist despite major perturbations, while in other rivers a relatively small change in watershed characteristics result in the permanent loss of pool-riffle habitat?

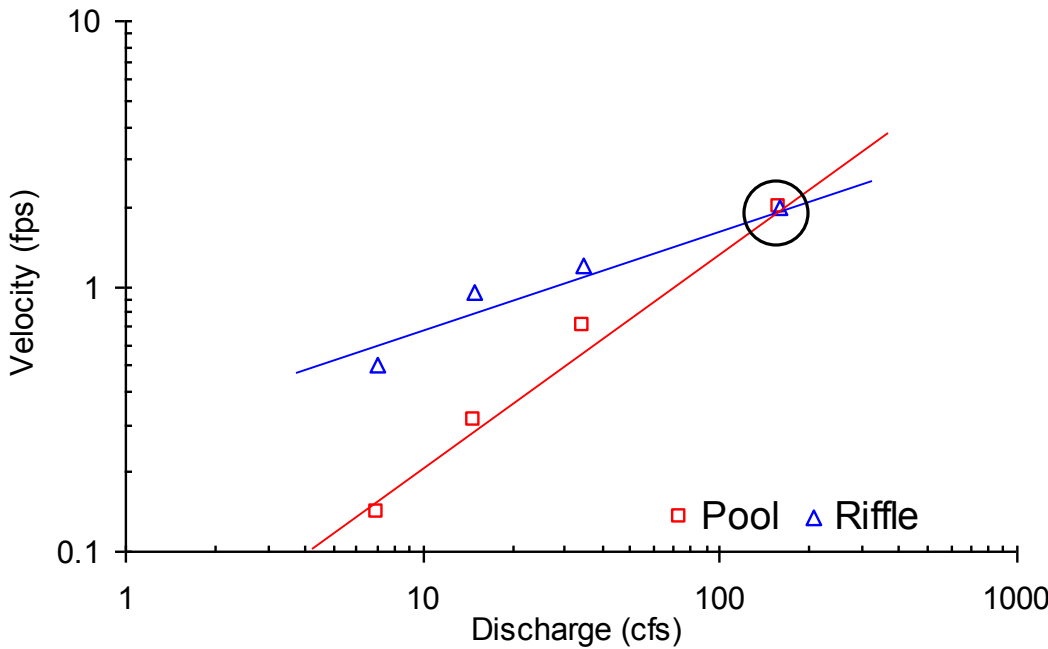


A Possible Mechanism for Pool Sustainability

- Keller (1971) proposed the velocity reversal hypothesis as the mechanism responsible for pool-riffle sustainability
- Caamaño et al (2009) used analytical methods to build on the velocity reversal hypothesis:
 - Developed simple 1-dimensional criteria to predict the occurrence of velocity reversal
 - Illustrated the phenomenon using output from a 3-dimensional numerical model

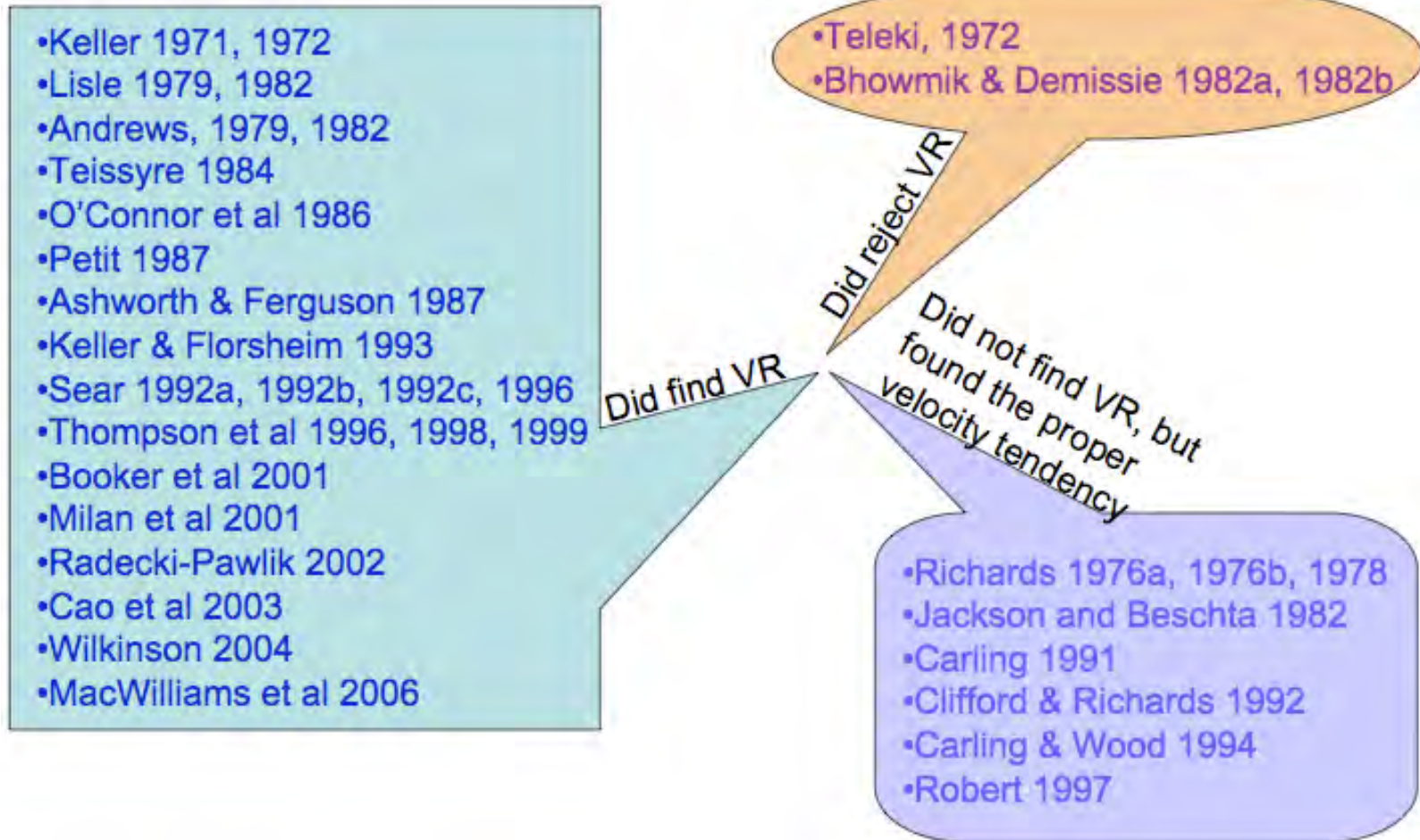
A Possible Mechanism for Pool Sustainability

Velocity Reversal Hypothesis for Pool-Riffle Sequences
[Keller; Keller and Florsheim]



Data from Keller (1971)

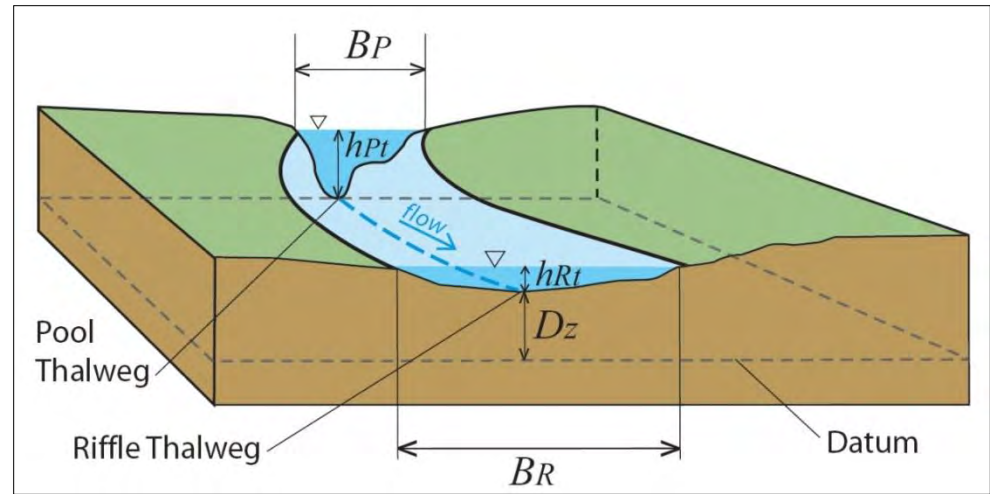
Velocity Reversal Hypothesis for Pool-Rifle Sequences



Findings differ:

Background

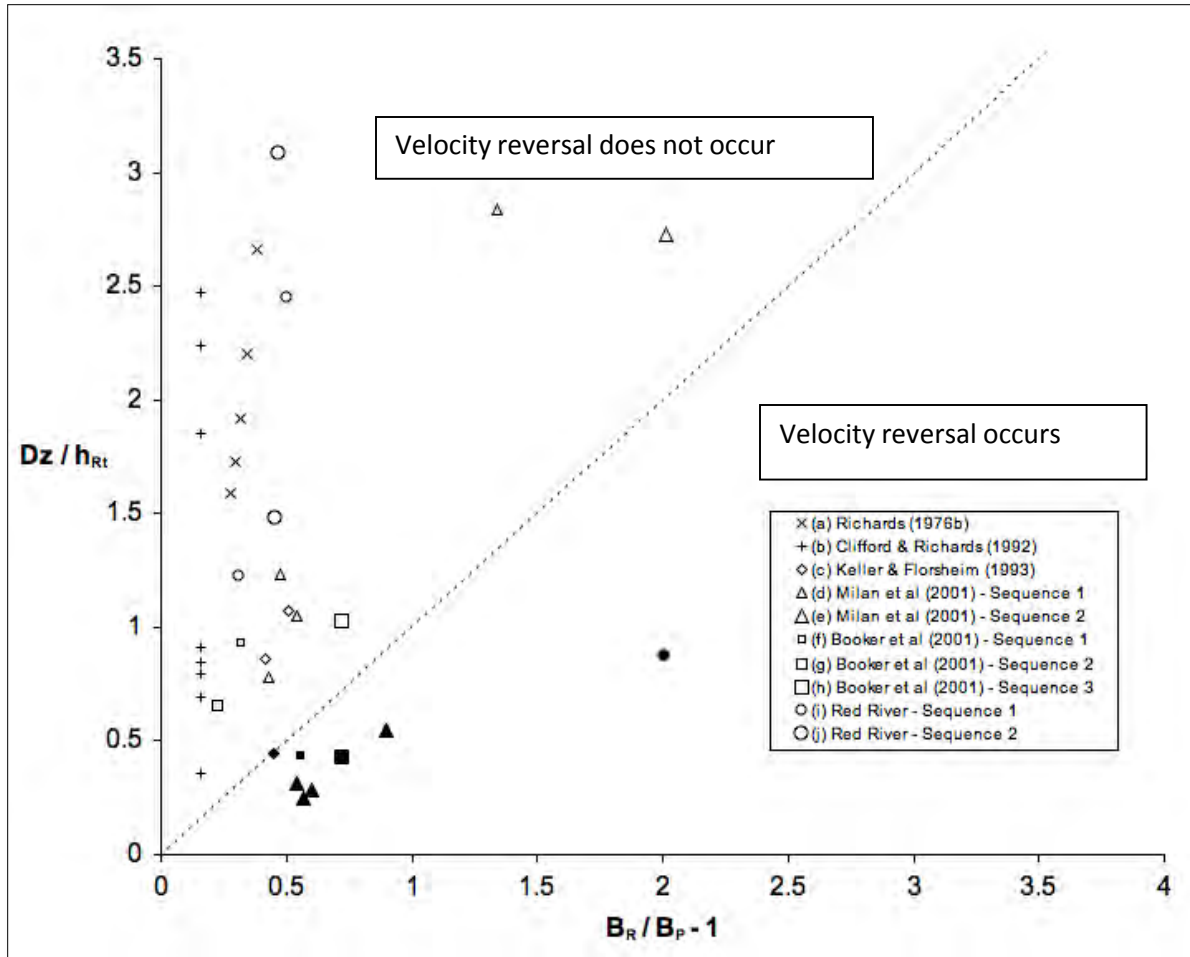
$$\frac{B_R}{B_P} - 1 = \frac{D_z}{h_{Rt}}$$



Where:

z_{Pt} , z_{Rt}	=	pool and riffle thalweg elevations
h_{Pt} , h_{Rt}	=	pool and riffle thalweg water depths
B_P , B_R	=	pool and riffle water surface widths
D_z	=	residual pool depth defined as the difference between the pool and riffle thalweg elevations
$(z_{Rt} - z_{Pt})$		

Velocity Reversal Condition



Velocity Reversal Occurs:

$$\frac{B_R}{B_P} - 1 > \frac{Dz}{h_{Rt}}$$

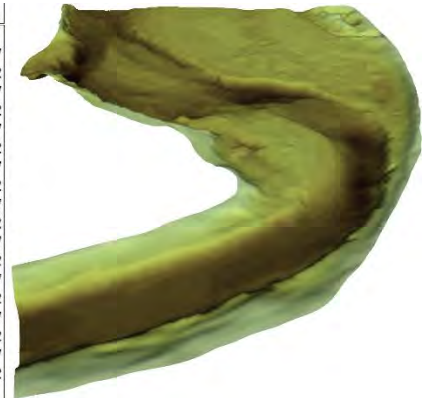
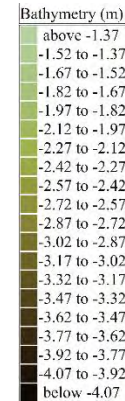
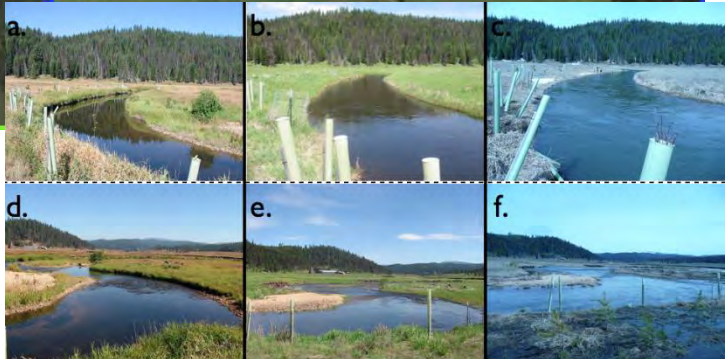
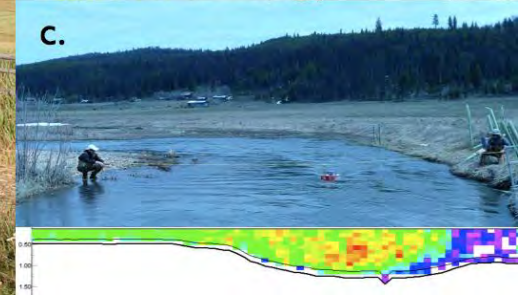
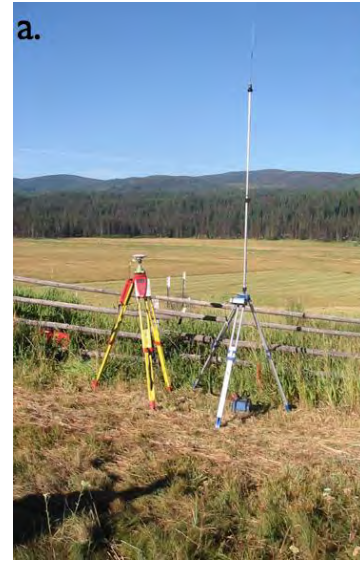
Velocity Reversal Does NOT Occur:

$$\frac{B_R}{B_P} - 1 < \frac{Dz}{h_{Rt}}$$

If velocity reversal is associated with bed shear stress reversal and sediment flux reversal then:

- Pools will disappear if criteria is not met
- Example of questions that can be answered: why does removal of livestock from stream channel increase the sustainability of pools?
- The effect of significant deposition before conditions of VR are achieved. Moderate level of pool sedimentation results in VR occurring at lower discharges. Critical point is reached where VR will not occur

Pool-Riffle Flow Structure Conceptual Model – Field Information



What is the dynamic equilibrium condition for current climatic regime?

If the river-floodplain is constrained by urban development – what is the expected channel response?

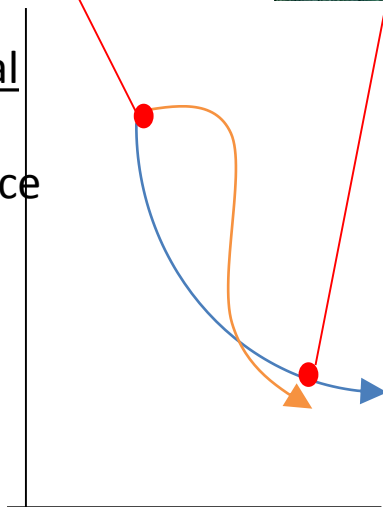


Andy Tranmer
andyt@uidaho.edu

Center for Ecohydraulics Research
University of Idaho



Available Fluvial Energy
Alluvial Resistance

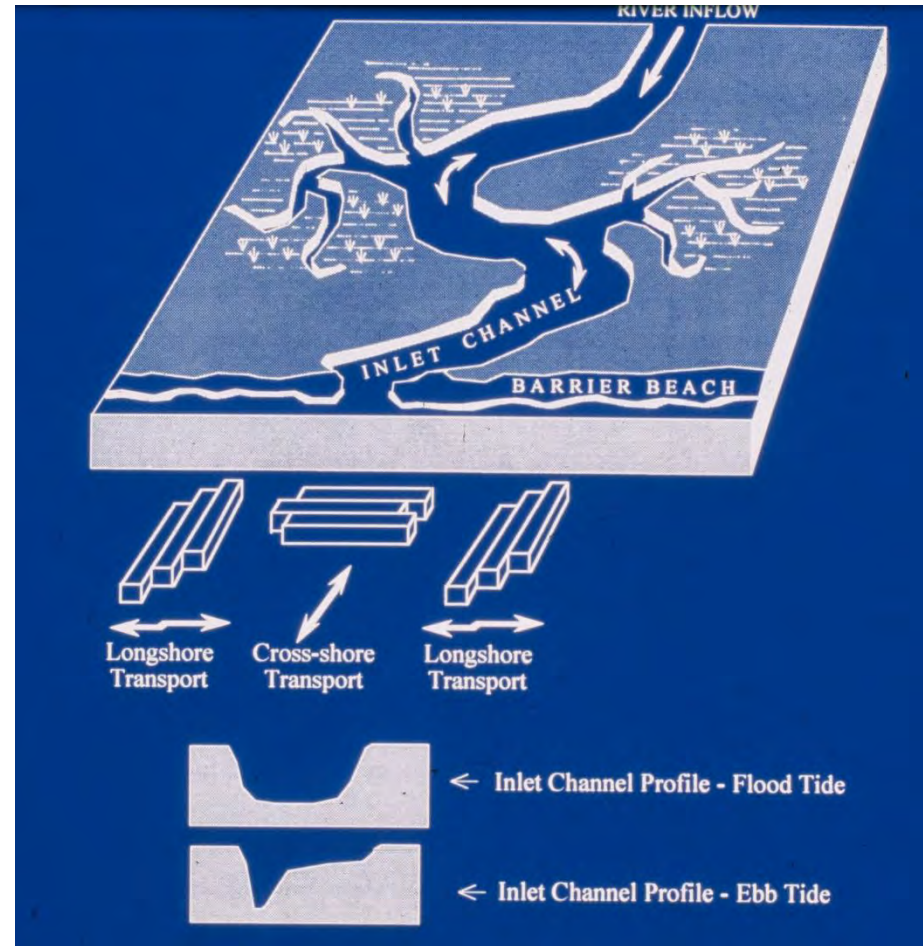


Alluvial Form

	Investigators	Extremal Hypotheses
Energy	Leopold and Langbein (1962)	Maximum entropy + Uniform energy expenditure
	Langbein and Leopold (1964)	Minimum rate of work + Uniform energy expenditure
	Brebner and Wilson (1967)	Minimum energy degradation rate
	Yang (1976)	Minimum unit stream power
	Chang (1979, 1980)	Minimum stream power
	Yang et al. (1981)	Minimum rate of energy dissipation
	Huang (1983, 1988)	Maximum rate of energy dissipation
	Grant (1997)	Critical energy dissipation
	Deng and Zhang (1994)	Maximum entropy production
	Cao and Knight (1995)	Minimum stream power + Equal probability
	Cheema et al. (1997)	Minimum rate of change of unit stream power
	Molnar and Ramirez (1998, 2002)	Minimum specific stream power
	Yalin and Da Silva (1999, 2000)	Minimum Froude number
	Singh et al. (2003)	Maximum entropy production + Minimum energy dissipation rate
Conveyance/Efficiency	Chang (2008)	Uniform power expenditure + Uniform sediment load
	Da Silva (2009)	Maximum entropy + Minimum Froude number
	Jefferson (1902)	Maximum sediment transport per available energy slope
	Inglis (1947)	Minimum energy expenditure per imposed sediment load
	Rubey (1952)	Maximum hydraulic radius
	Pickup (1976)	Maximum bedload transport
	Kirkby (1977)	Maximum sediment efficiency
	Ramette (1980)	Maximum bedload discharge
	White et al. (1982)	Maximum sediment transport capacity
	Jia (1990)	Minimum Froude number + Maximum stability
Resistance	Huang and Nanson (2000, 2002)	Maximum flow efficiency
	Nanson and Huang (2008)	Least action principle
	Tou (1965)	Minimum channel mobility
	Davies and Sutherland (1980, 1983)	Maximum friction factor
	Davies (1987)	Maximum shear stress
	Abrahams et al. (1995)	Maximum flow resistance
Tinkler (1997)	Critical flow resistance	
Eaton et al. (2004)	Maximum total friction factor	

The Physical Processes of Wetlands and Estuaries

- Tides
- River discharges
- Tidal inlet dynamics
- Wave action
- Sediment transport
- Salinity and WQ
- Relative Sea Level Rise
- Vegetation
- Bio-compaction/
bioturbation
- Geomorphic Evolution



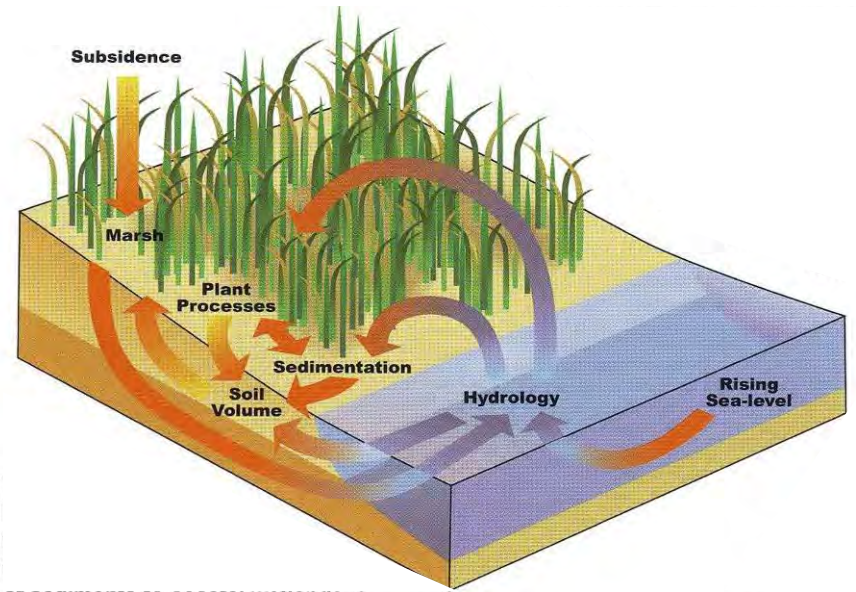
Hydraulic Geometry in Tidal Channels

$$A = c.P^f$$

Where A = cross-sectional area of channel

P = potential tidal prism

c, f are empirical parameters established by observation





The 3rd National Conference on Coastal and Estuarine Habitat
Restoration

Forging The National Imperative

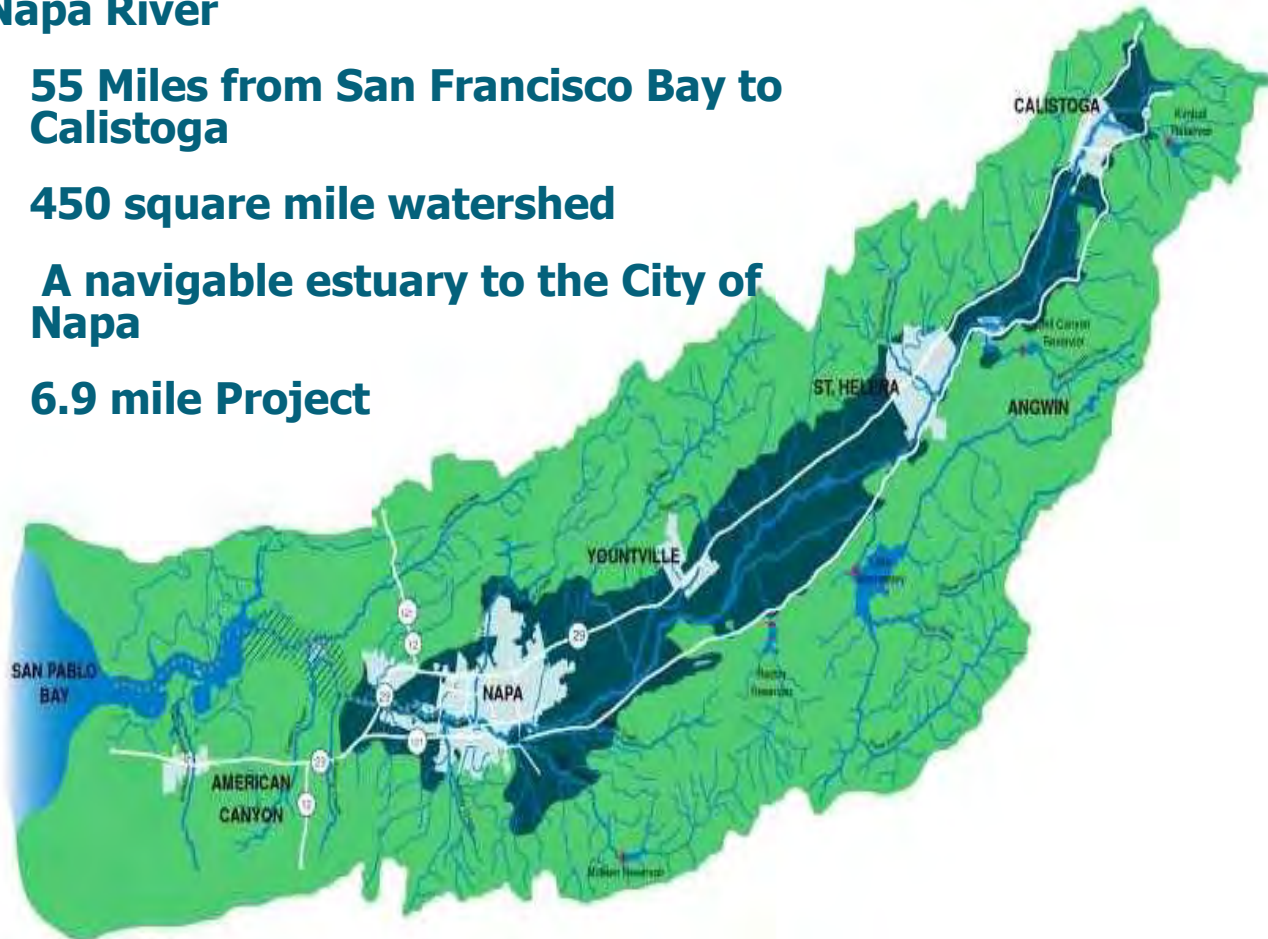
Circulation patterns: Persistent freshwater lenses in Tijuana Estuary



What happens in the transition zone

Napa River

- **55 Miles from San Francisco Bay to Calistoga**
- **450 square mile watershed**
- **A navigable estuary to the City of Napa**
- **6.9 mile Project**

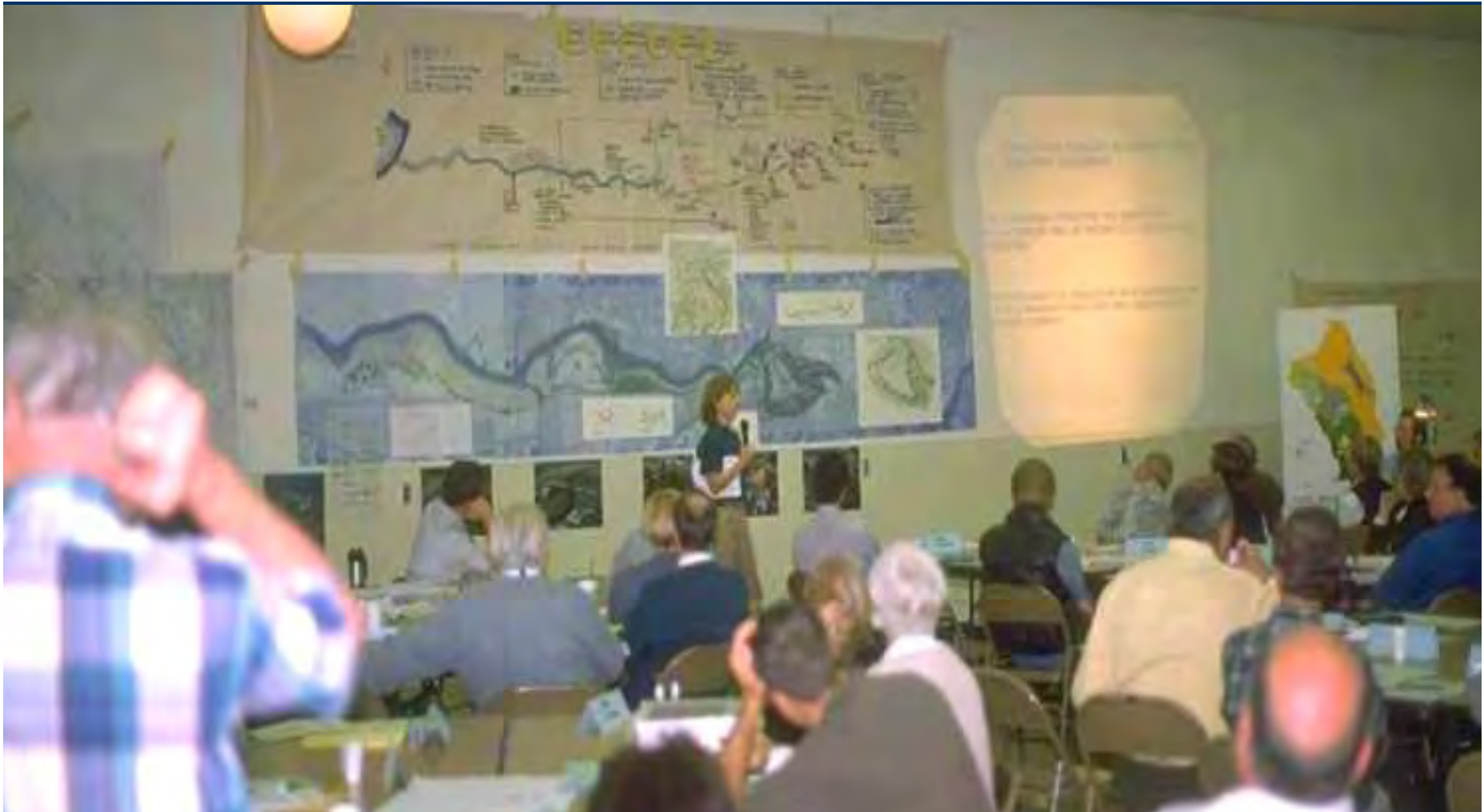


27 major floods in past 120 years
County Courthouse, Napa - 1896



COMMUNITY COALITION FORMED

27 local stakeholder groups and 24 agencies



COMMUNITY COALITION FORMED

27 local stakeholder groups and 24 agencies

The Living River Strategy for the
Napa Watershed



Napa to tame river by letting it run free

3-5-98 West Times

■ Voters approve a historic tax measure that aims to reduce flooding through natural methods

By Denis Cuff and John Simerman

TIMES STAFF WRITERS

NAPA — Flood fighters in the West tamed their creeks and small rivers by deepening and narrowing

them with dredgers and concrete. Voters in this historic wine county bucked that tide Tuesday when they approved a precedent-setting flood project to make the unruly Napa River wider and more natural with room to meander without sloshing into bedrooms and stores.

Planners and politicians predict Napa County will lead California on a new path to minimize flooding by letting rivers run a little freer and making people do more to stay out of the way.

"The concrete the river to come ferent th and keep Rippey, a pervisor ing in w as the g

Private called the the bigg its kind ronmen Inste ing the County marshes About nesses

Se



Mika Nasimund rode his fishing boat up Social Road in Napa, which has suffered repeated inundations.



Freeing Napa From Floods

Unique river plan goes before voters

By Glen Martin
Chronicle Staff Writer

Napa County residents who have had it up to here with perennial flooding are preparing to vote tomorrow on a revolutionary plan that could end their woes once and for all — and rescue the nearby Napa River in the process.

If approved by a two-thirds majority vote tomorrow, Measure A, also known as the Napa County Flood Protection and Watershed Management Plan, could make the Napa Valley virtually impervious to catastrophic floods.

It would also restore wetlands, forests and fish and wildlife in the river, which has suffered greatly from decades of urban growth and intensive viticulture.

The measure will raise \$6 million annually for the next 20 years through a sales tax amounting to one-half cent on every dollar.

What makes the plan unique, its advocates say, is the emphasis on river restoration, not destruction. Traditional flood control projects involve channeling rivers and creeks, confining them in strait-jackets of concrete.

By contrast, the Napa River plan would achieve its primary ends by restoring marshlands and riparian forest. The use of



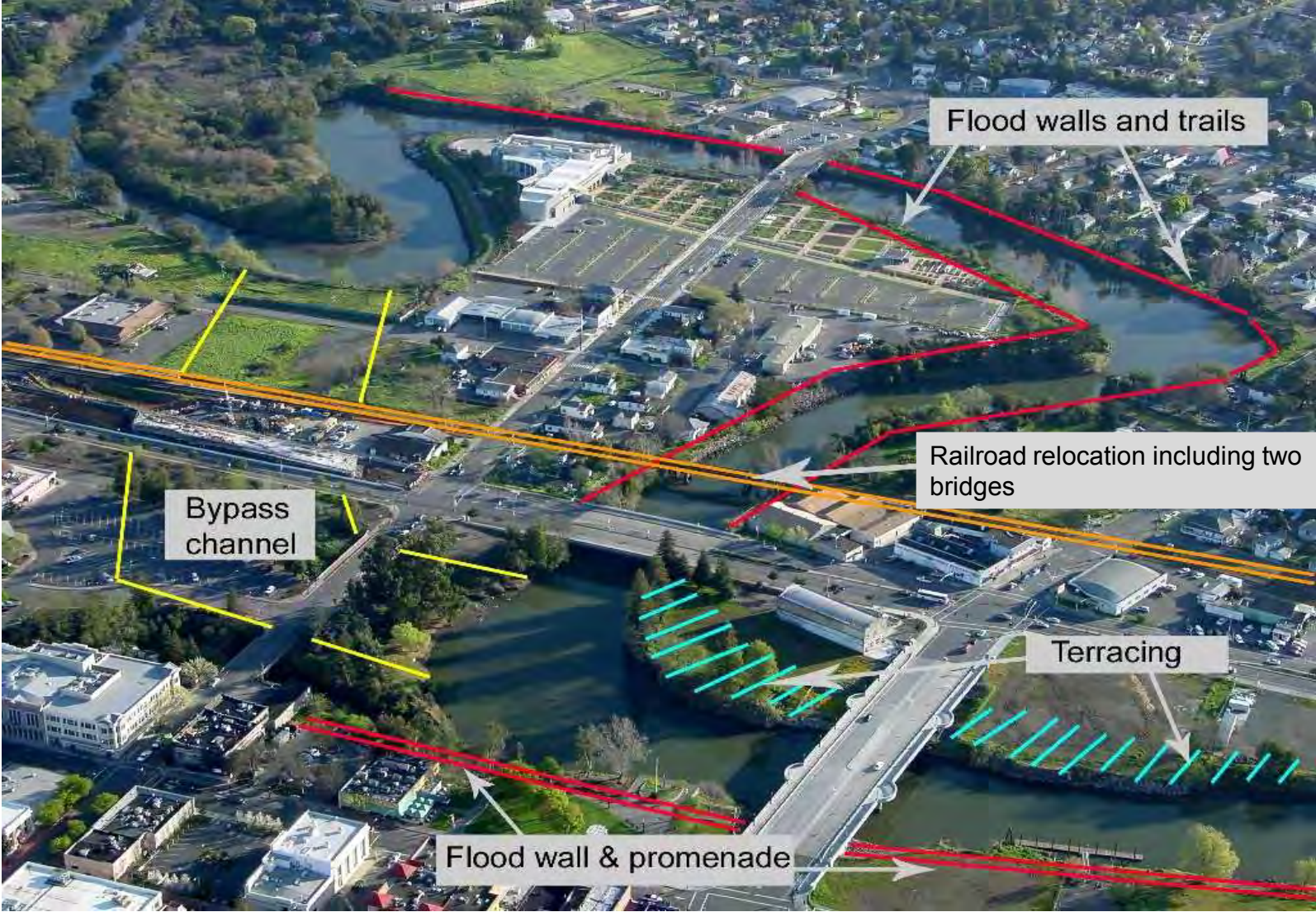
Bridge raised, maintained historic and aesthetic quality



Creation of 659 acres of wetland,
mudflat and open water



NAPA RIVER BYPASS





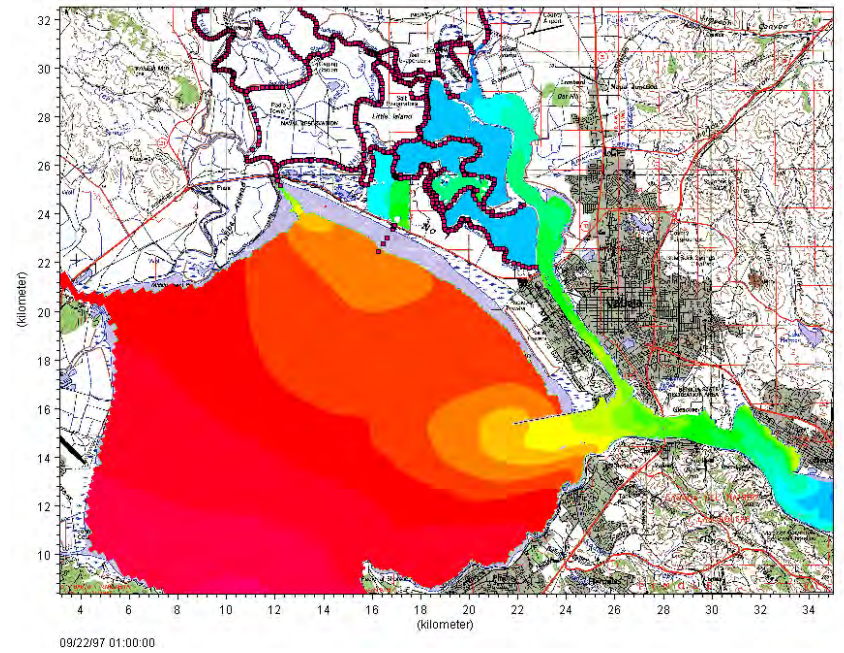
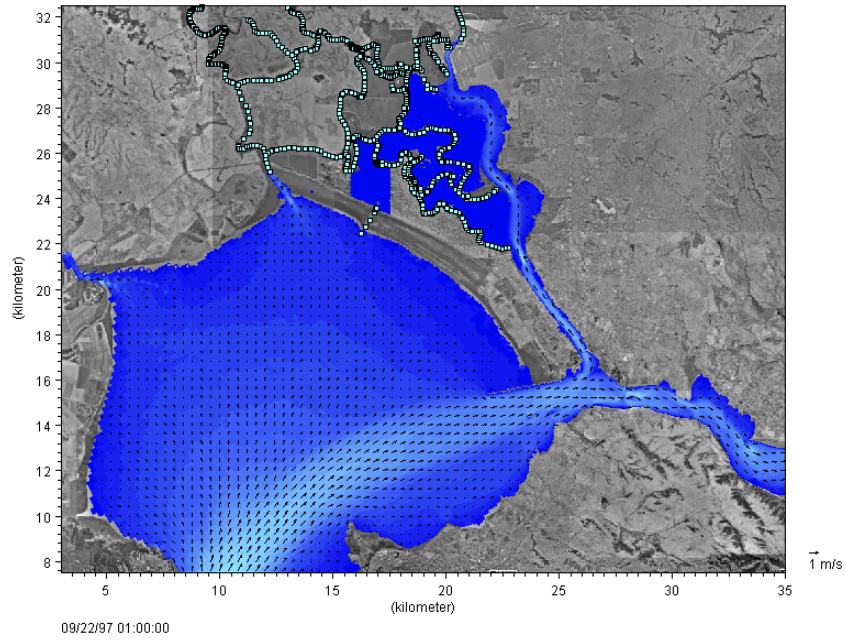
Project of the Year award from the American Public Works Association (APWA)-Northern California Chapter.

Napa Floodplain Restored



9/27/12

10:38am, 5.2' water elevation





NAPA RIVER BANK BEFORE PROJECT



NAPA RIVER BANK AFTER



NAPA CREEK BEFORE



Napa Creek 2015



NAPA CREEK AFTER



California Drought 2012-16

2017 Wettest Winter in Recorded History

Very Dry summer



Fundamental Question:
will the ecosystem recover or was the fire a tipping point?





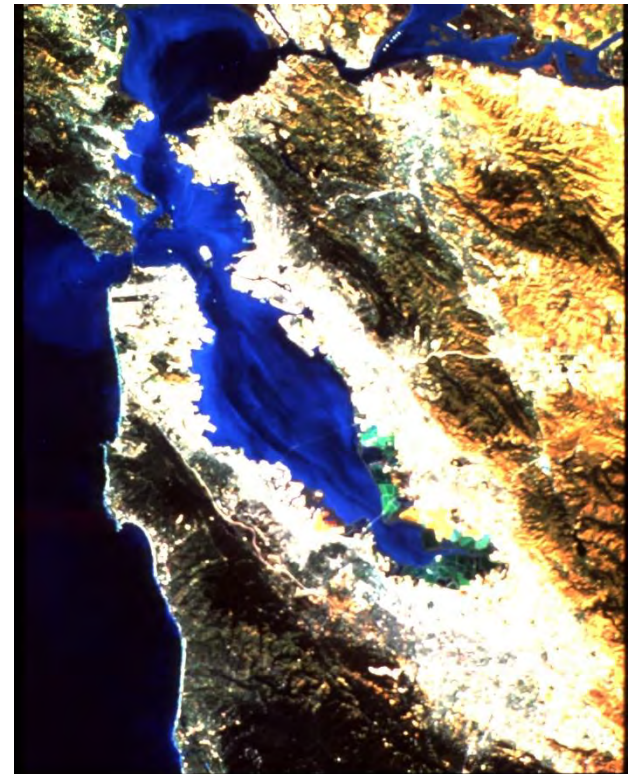
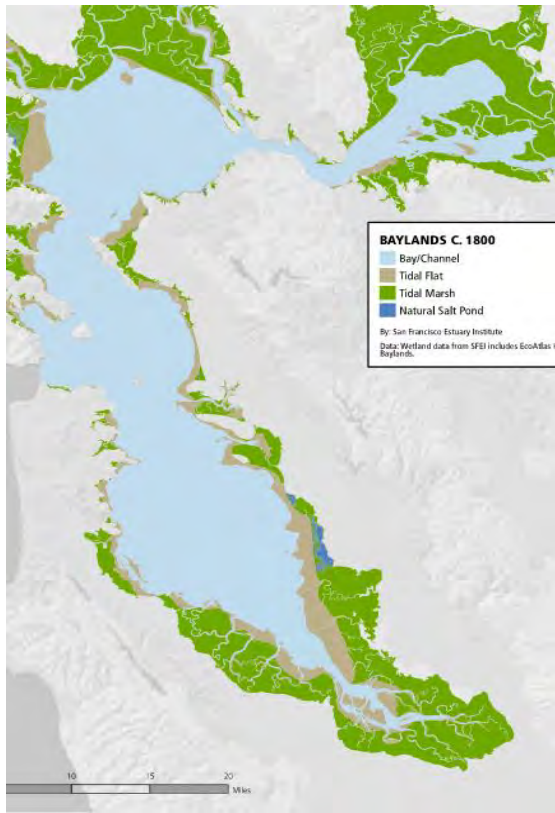
Tidal Wetlands

Loss is significant

[80% in California - 97% in San Francisco Bay]

80% loss in habitat => 50% loss in species [E.O. Wilson]

San Francisco Bay – *most invasive species in an estuary*



Tidal Wetland Restoration

First Generation -1970s

- Restore Tidal Action
- Single discipline



Ancient Marsh – about 2500 old

Historic Marsh
US Coast and Geodetic Survey
c. 1870



Modern Marsh – 1920s



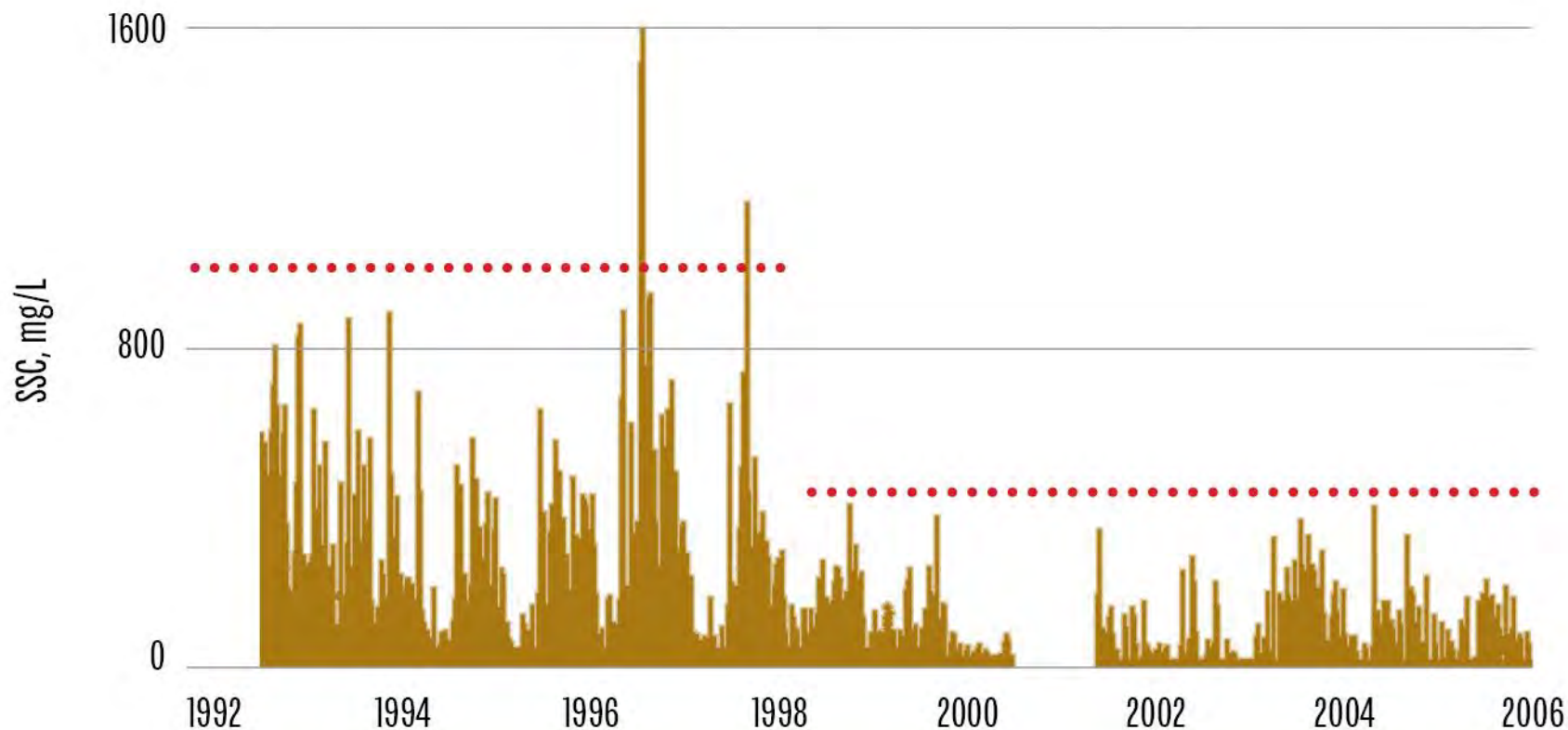
Philip Williams & Associates, Ltd.
Consultants in Hydrology

Warm Springs Marsh Historic Tidal Channels, cir

SEDIMENT SUPPLY

hydraulic mining





Tidal Wetland Restoration

Second Generation -1980s

- Recognition of Role of Physical Processes
- Development of geomorphic templates
- Monitoring of performance [Warm Springs - San Jose]
- Adaptive Learning/Management



Tidal Marsh Profile



Note:
The landward boundary of the high marsh shifts from year to year within the wetland-upland transition zone.

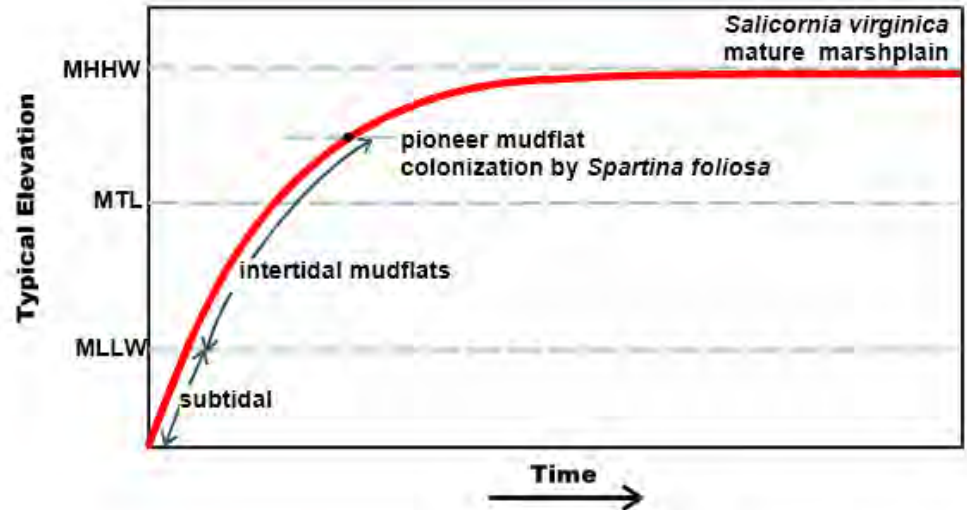
figure 2

Tidal Wetland Restoration Handbook
Vertical Profile of Tidal Marsh

Tidal Marsh Evolution



Muzzi Marsh, 1980



Muzzi Marsh, 1984



Muzzi Marsh, 2003

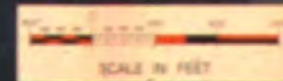
Tidal Wetlands Restoration

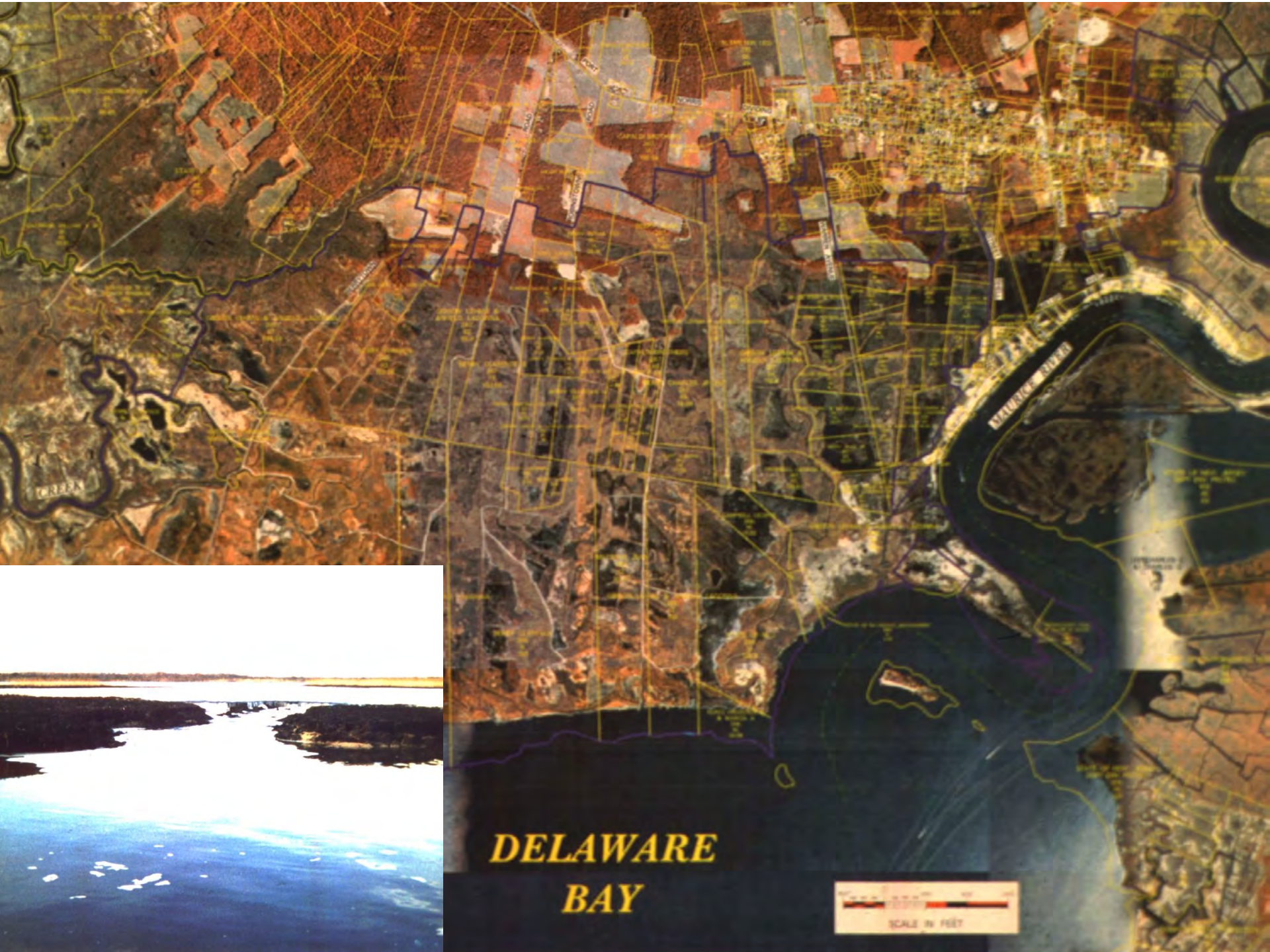
Third Generation -1990s

- Refinement of models, data collection, databases of characteristics, interpretation
- Designs much closer to dynamic equilibrium
- Examples: Delaware Bay, San Dieguito Lagoon, Sonoma Baylands
- Adaptive management

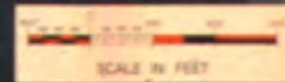


**DELAWARE
BAY**





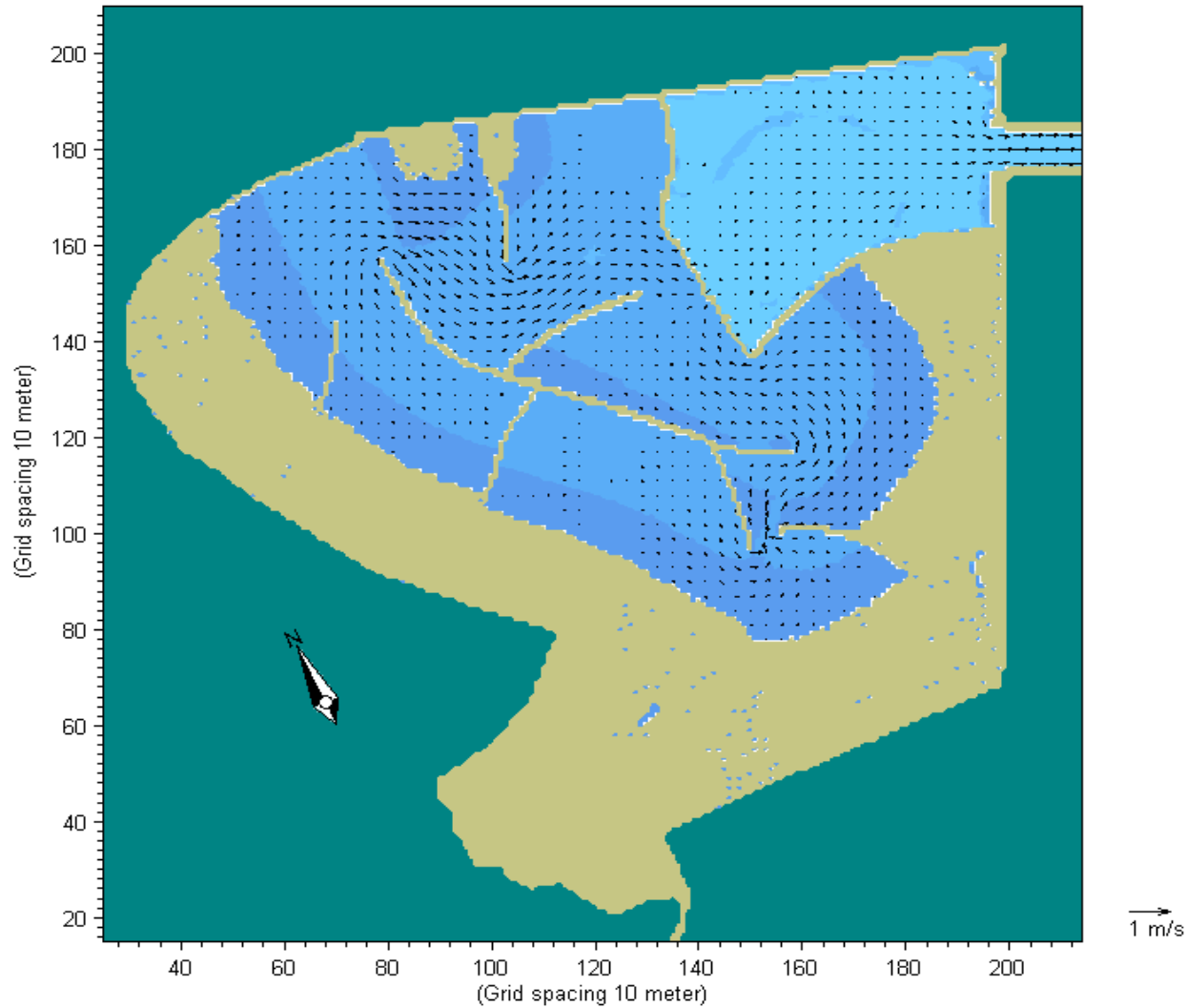
**DELAWARE
BAY**



Hamilton Wetlands Morphological Modeling

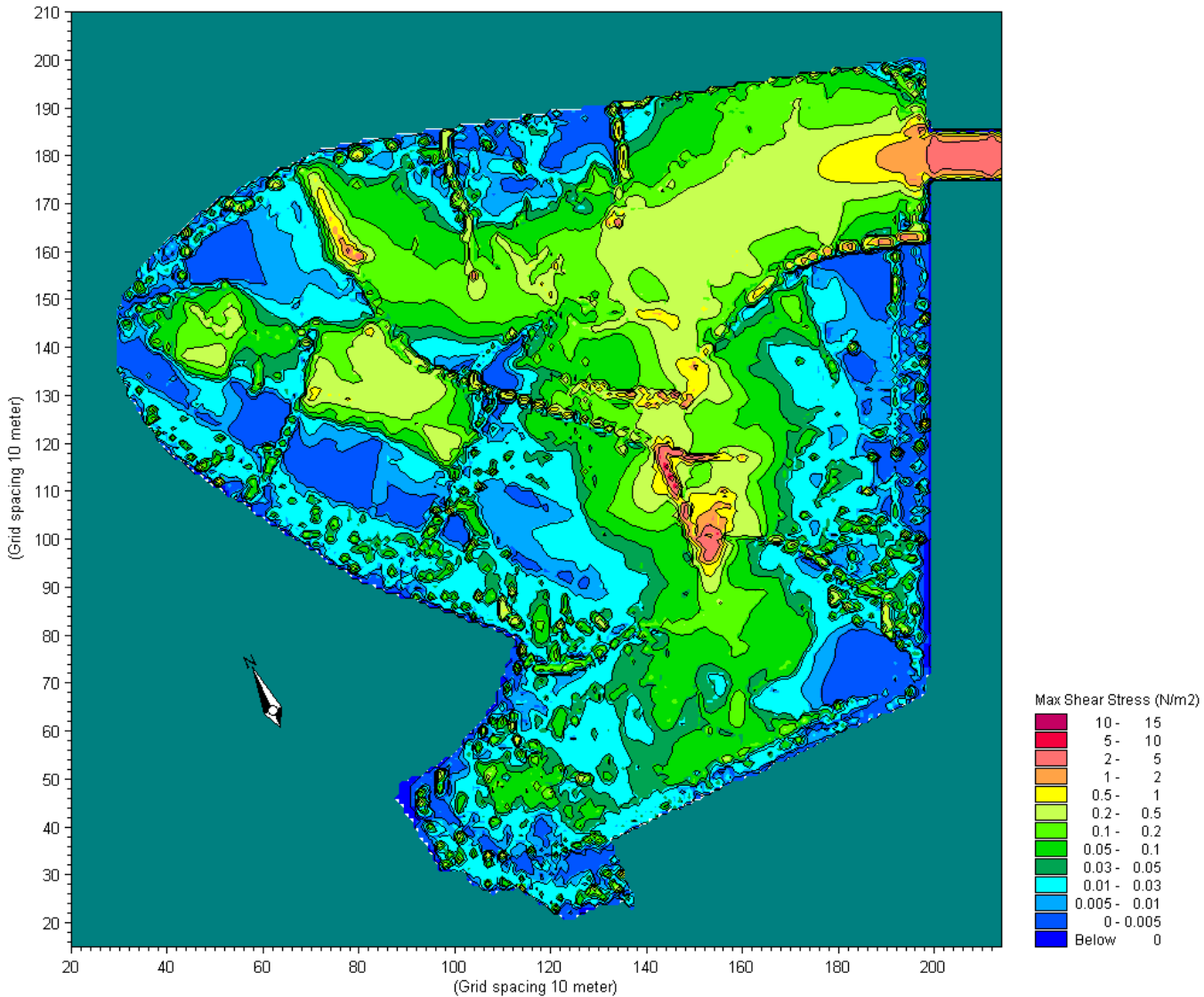


Hamilton Wetlands Morphological Modeling



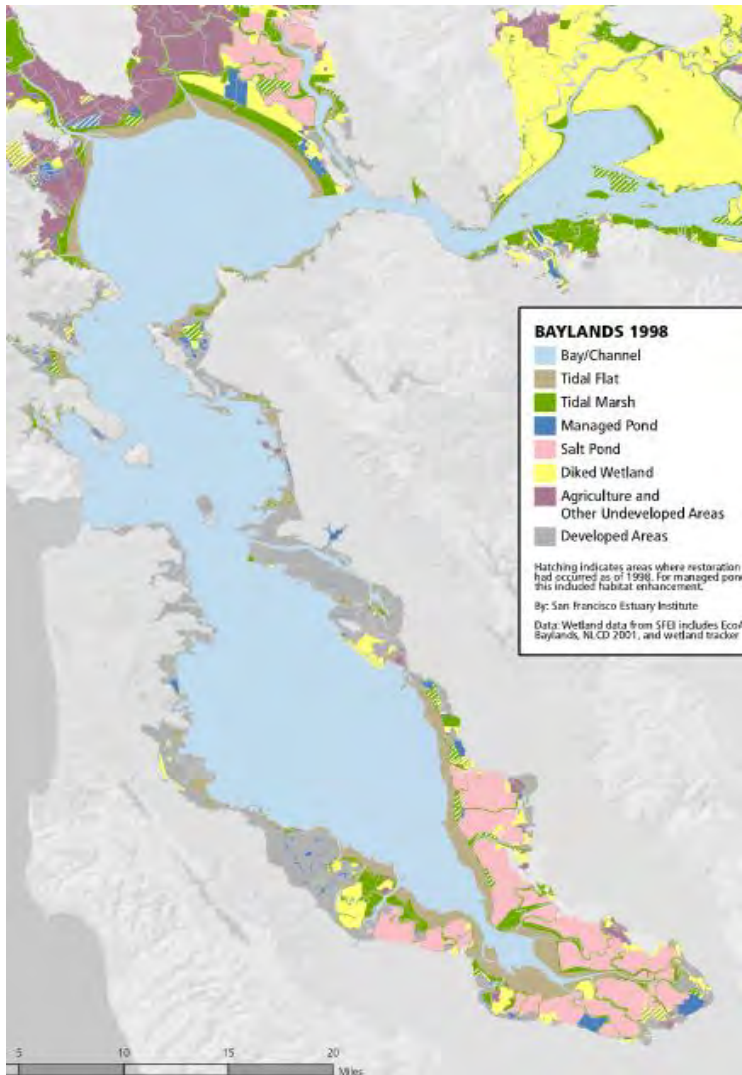
01/04/00 11:06:00

Hamilton Wetlands Morphological Modeling



01/01/00 11:06:00

Tidal Wetlands Restoration: Fourth Generation



- Landscape Ecology
- Historical Ecology
- Not to 'restore' since landscape irreversibly altered
- Understand key process to restore ecosystem function
- Mosaic of habitats
- Scale to restore processes

The Baylands and Climate Change: **WHAT WE CAN DO**

LETITIA GRENIER
SAN FRANCISCO ESTUARY INSTITUTE

SPUR
16 Feb 2016
San Francisco,
CA

SFEI | AQUATIC
SCIENCE
CENTER
SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

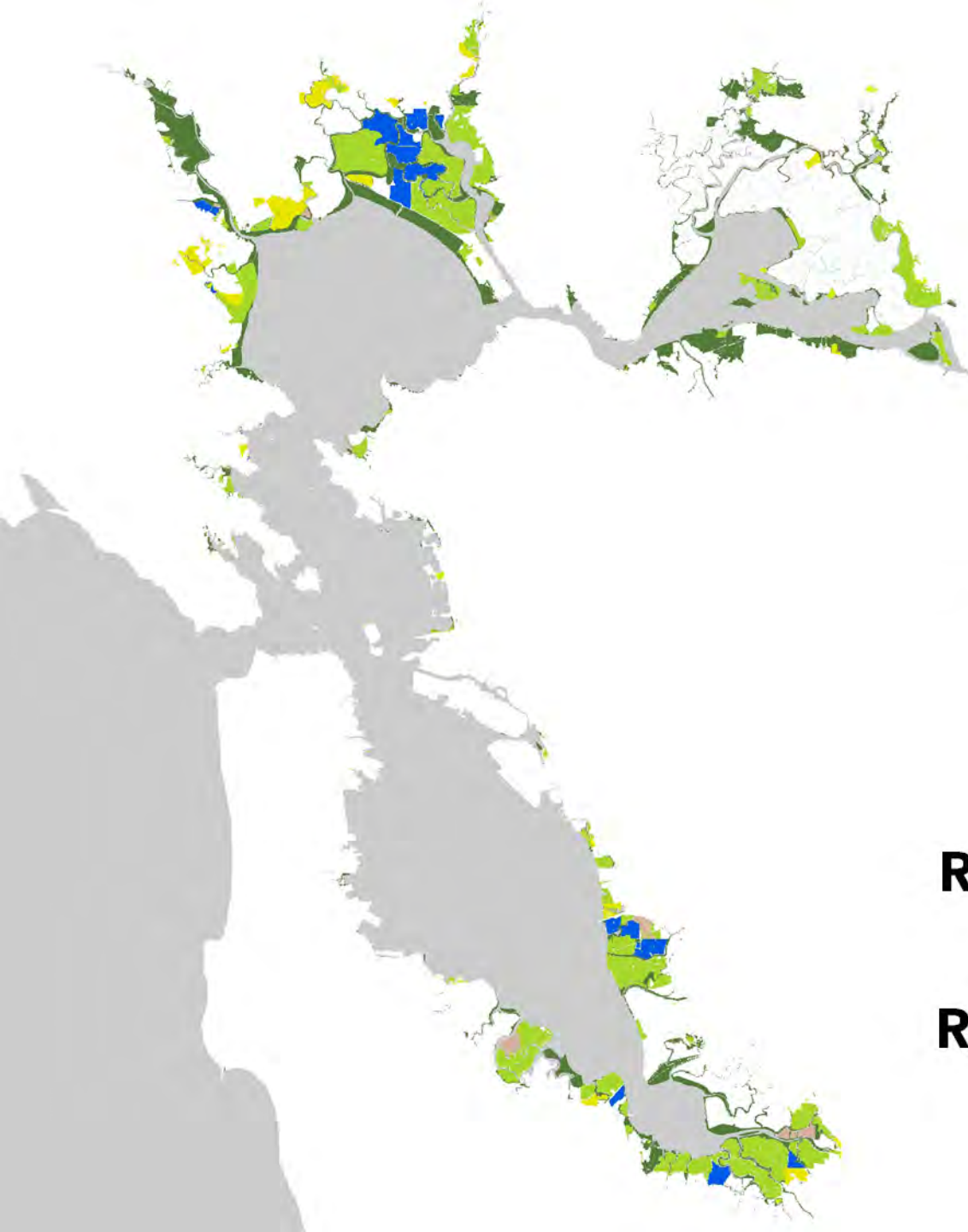
Email: letitia@sfei.org

Tel: +1-510-875-5723

PHOTO: Shira Bezael

A photograph of a white egret in flight, captured against a backdrop of a cloudy sky. The bird is positioned on the right side of the frame, with its wings spread wide, showing the intricate details of its feathers. It appears to be landing on or taking off from a clump of tall, green and brown grasses in the foreground. The lighting is soft, suggesting either early morning or late afternoon.

FUTURE



Existing Tidal Marsh



Restored Tidal Marsh



Restored Tidal Flat



Restored Diked Wetland



Restored Managed Pond

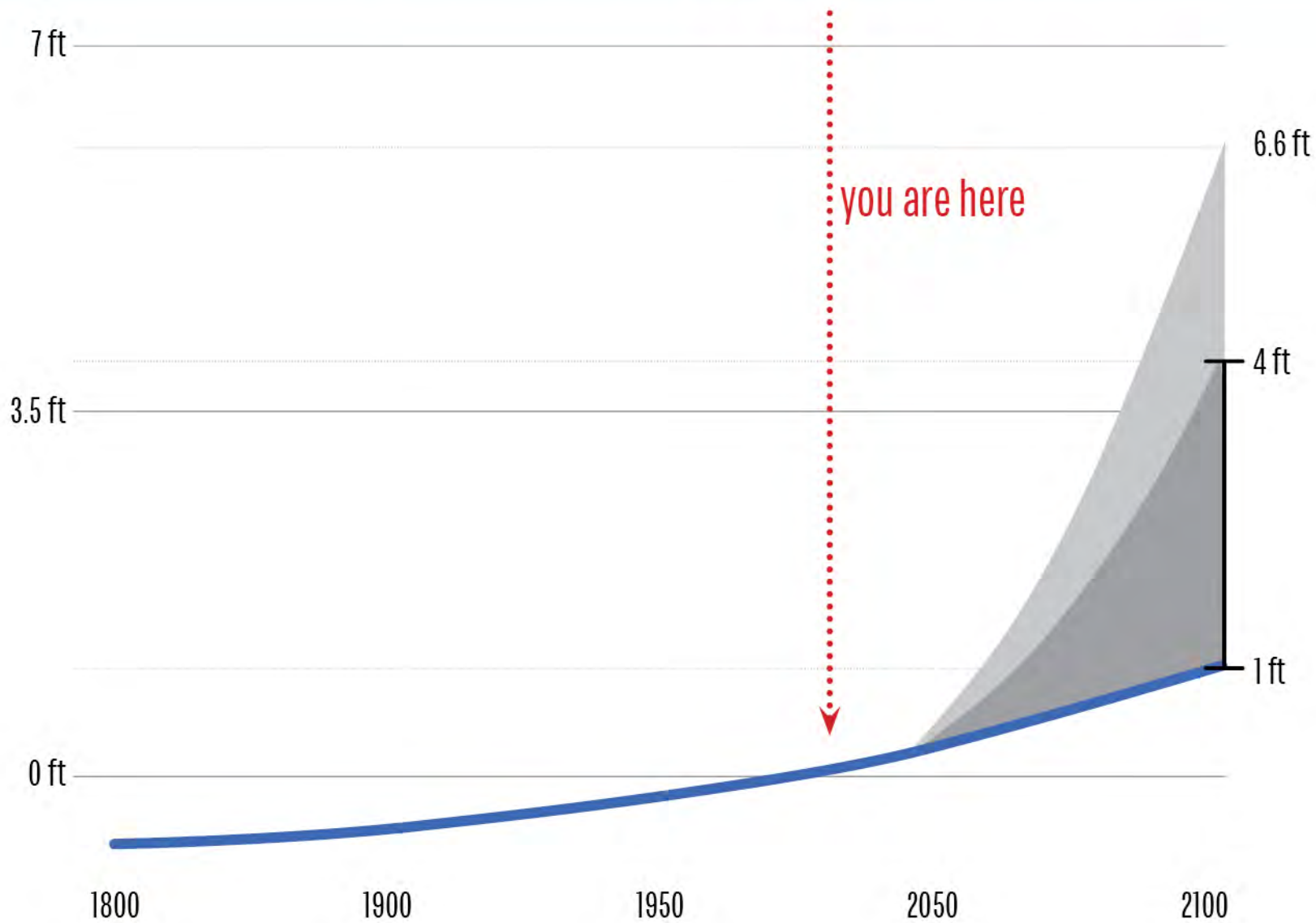


GLOBAL SEA LEVEL

change

SINCE 1800

Courtesy 3rd National
Climate Assessment,
2014



THE
Baylands
AND
Climate Change

WHAT WE CAN DO

BAYLANDS ECOSYSTEM HABITAT GOALS
SCIENCE UPDATE 2015



State of California

Coastal Conservancy



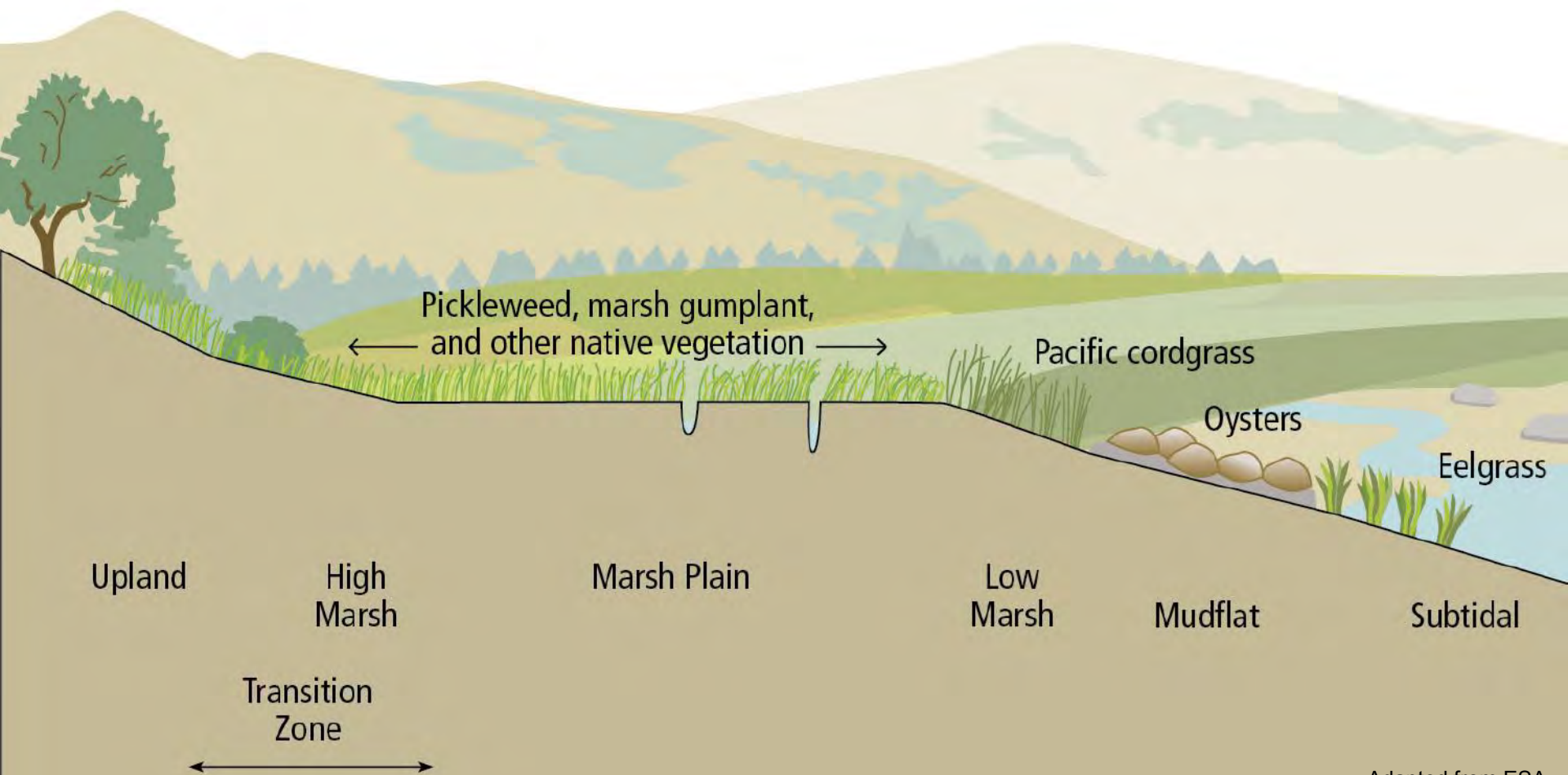


WHAT WE CAN DO

- *Restore complete systems, including processes*
- *Restore soon, in areas marshes are likely to persist*
- *Plan for the Baylands to migrate*

Shira Bezalel

Restore COMPLETE SYSTEMS

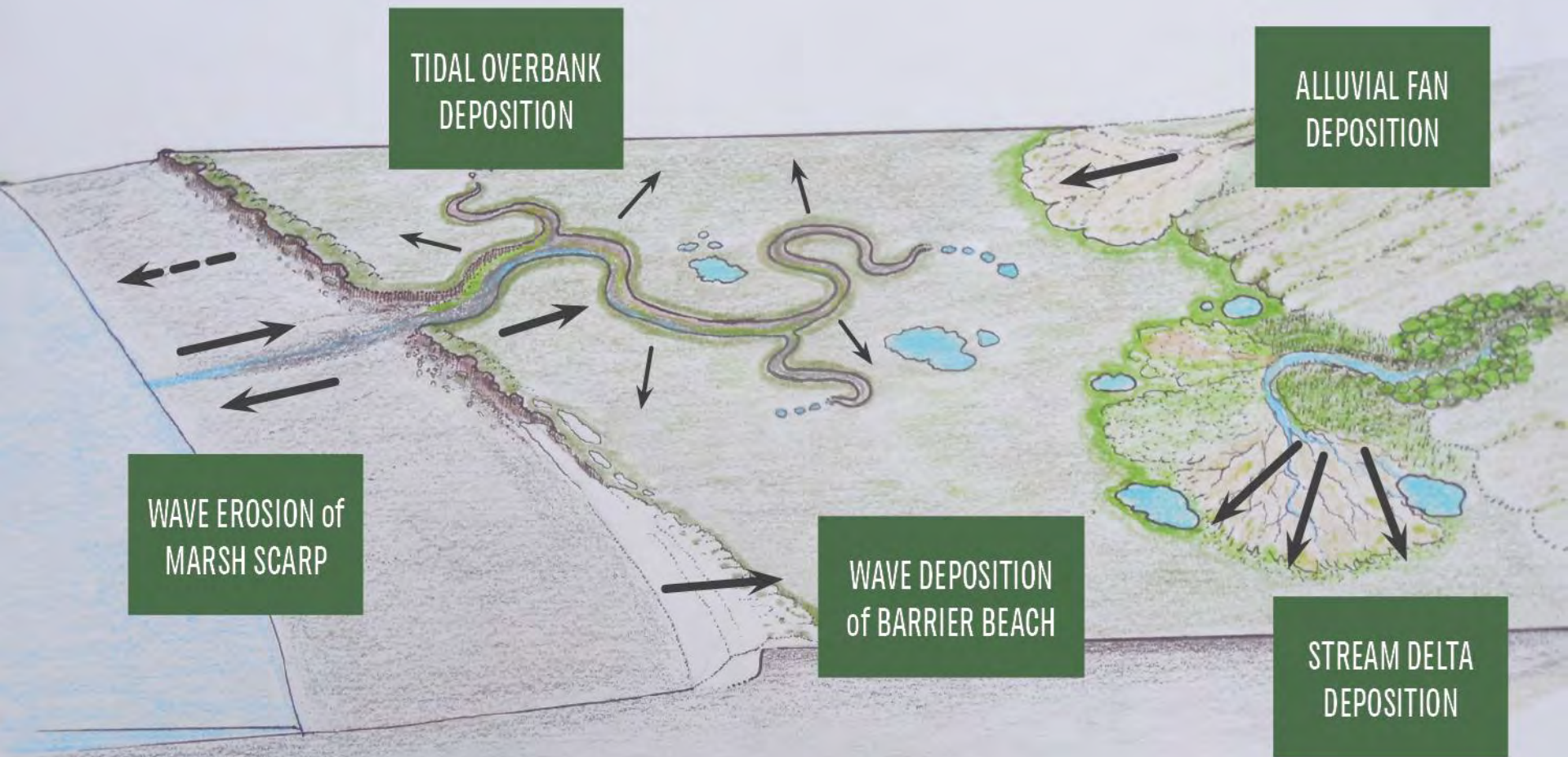


**MEANS
RESTORING**

PROCESSES

**NOT JUST
PLACES**

COURTESY PETER BAYE



restore

MARSHES BY 2030 IN AREAS WHERE THEY'RE LIKELY TO

persist

2006



2014



Build up of sediment and vegetation takes time

Higher starting elevation means marshes survive
sea-level rise for longer

PLAN FOR THE BAYLANDS TO *migrate*



PLAN FOR THE BAYLANDS TO *migrate*



PLAN FOR THE BAYLANDS TO *migrate*



WE HAVE

choices to make



MarineInsight.com

Baylands Goals Science Update



www.BaylandsGoals.org

Nate Kauffman

Carbon Sequestration and Tidal Wetlands

Stephen Crooks PhD

Silvestrum Climate Associates

Principal: Wetland Science & Coastal Management



Building Blue Carbon Experience



Some considerations for a conceptual model

Physical Considerations

- Channel network evolution and stability under normal hydrologic and tidal conditions
- Resilience of network under episodic conditions
- Fluvially dominated, tidally dominated and transition zones
- Flood or ebb dominated (for water and sediment flux)
- Hydroperiod on floodplains and marshplains
- Residence time in system
- Thermal regime
- Circulation characteristics: Tidal pumping, trapping, deadzones. persistence of freshwater lenses
- RSLR

At times of change, the learners will be the ones who will inherit the world, while the knowers will be beautifully prepared for a world that no longer exists.

Alastair Smith

Thank you for your attention.

pgoodwin@uidaho.edu



**International Association
for Hydro-Environment
Engineering and Research**

Supported by
Spain Water and IWHR, China