Tidal Marshes

Contribution to Climate Change Mitigation and Adaptation

Stephen Crooks Ph.D.

Conservation International
and
Environmental Science Associates

UNFCCC Workshop on technical and scientific aspects of ecosystems with high-carbon reservoirs not covered by other agenda items under the Convention

Oct 26[nd] 2013, Bonn, Germany.

Wetlands Feed Fish

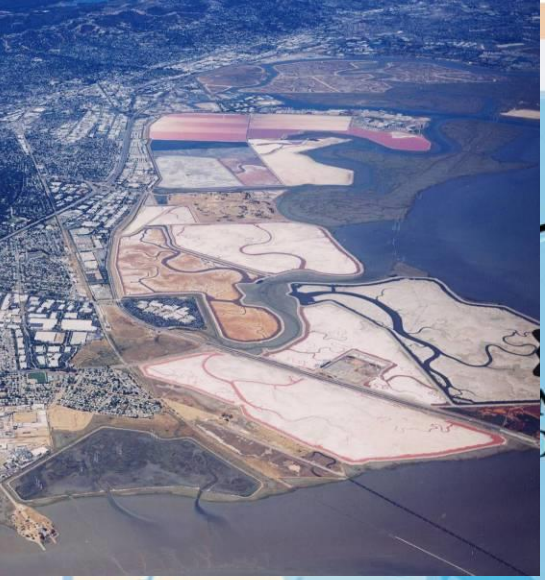
(*floodplain fatties*)

Photo: Jeff Opperman. Research by Carson Jeffres

ESA

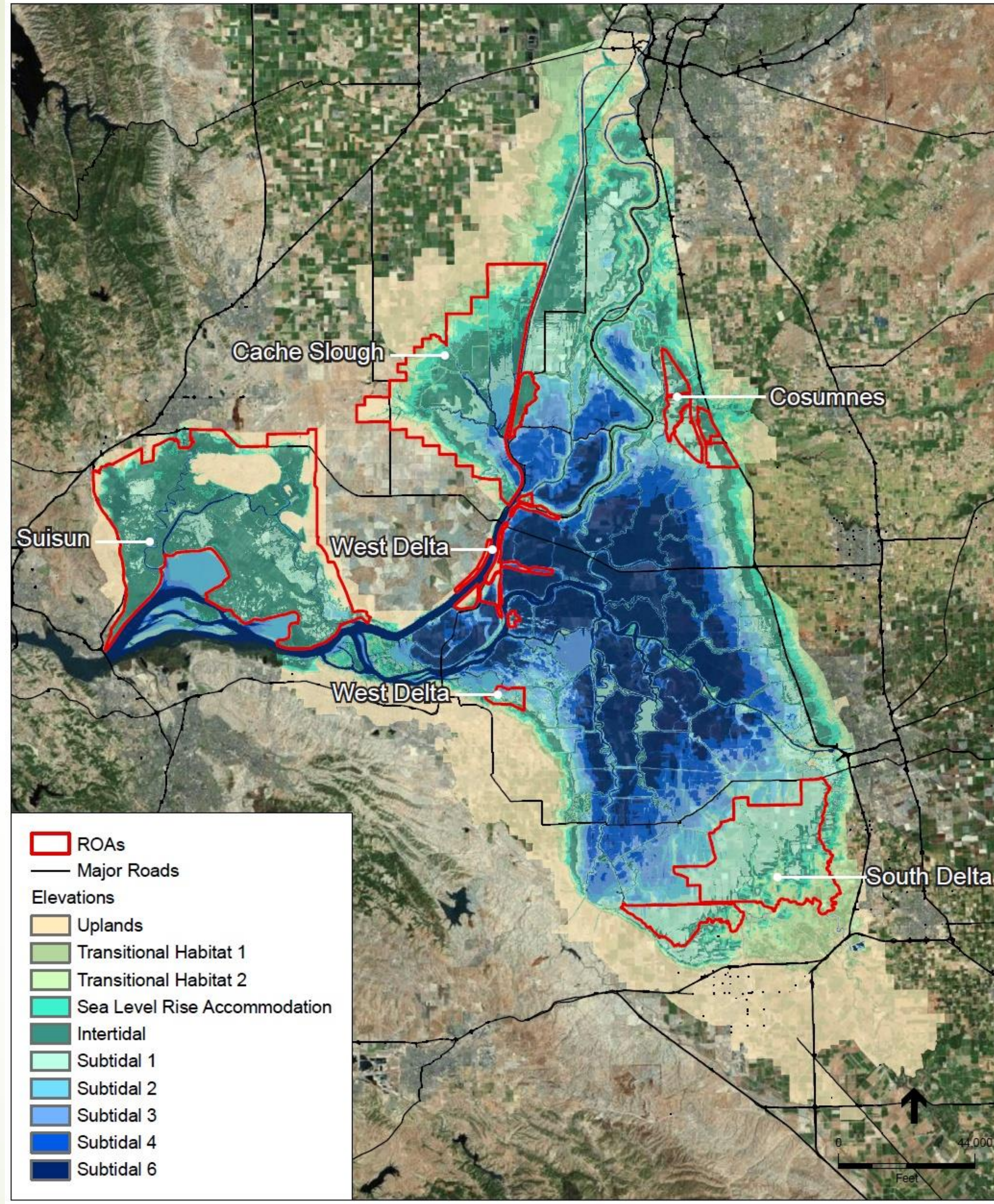
37 years of restoration experience

1400 wetlands projects



South Bay Salt Pond Restoration Project
Hayward
Union City
Fremont
Newark
Milpitas
Alviso
San Jose
Sunnyvale
Mountain View
Palo Alto
East Palo Alto
Redwood City
South San Francisco Bay
WEST BAY PONDS
ALVISO PONDS
MBERG ONDS
Dumbarton Bridge
Alameda Creek
Alameda County Flood Control Channel
Redwood Creek
Newark Slough
Mowry Slough
Coyote Creek
Guadalupe Slough
Alviso Slough
92
880
84
101
237
N
S
E
W

- Restoration planning for 26,000 ha of wetlands
- $3 billion dollars cost estimate
- Plan part of state water management and climate change adaptation
- Modeling of wetland response to sea level rise



SOURCE:

DWR 2007 LiDAR; ESA-PWA 2012

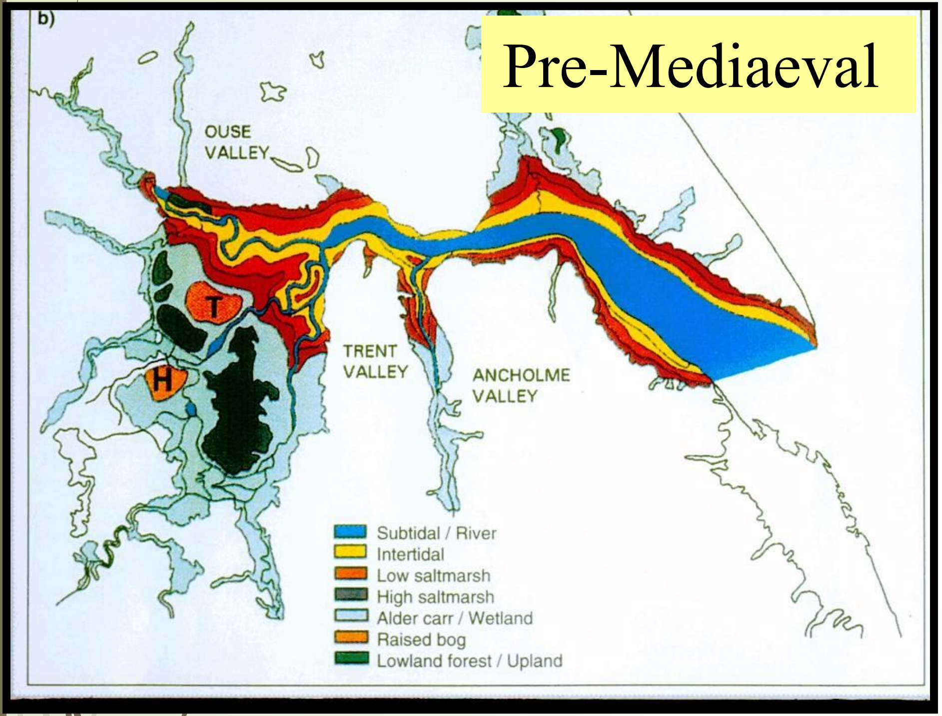
Bay Delta Science Conference.

Figure 1

Elevations and ROAs of Delta-Suisun Marsh Planning Area

ESA PWA

Continuum of coastal ecosystems – loss over time

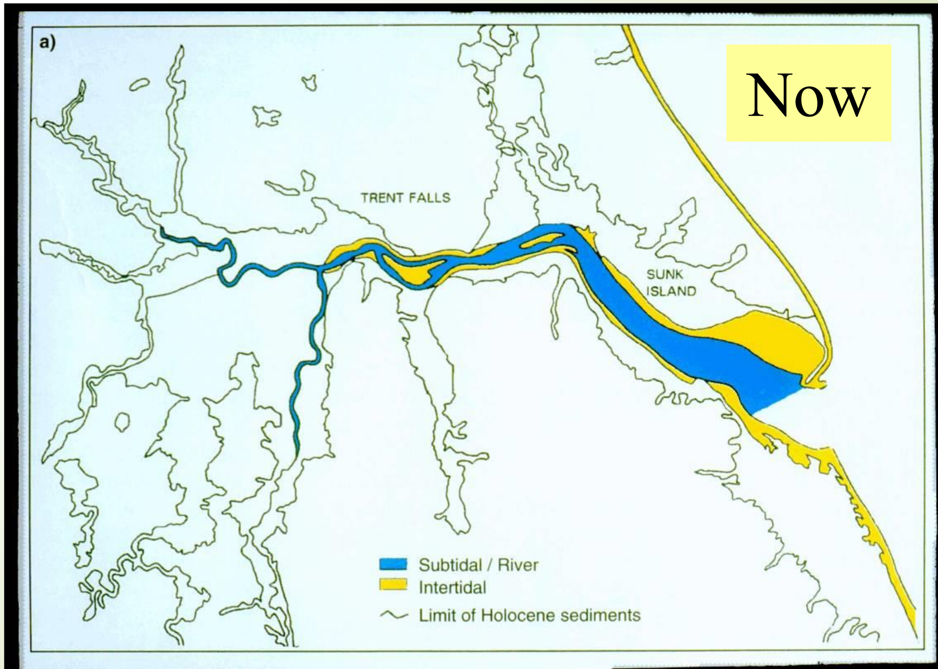


The Humber Estuary

Extensive diked wetlands
Post industrial estuary
Agricultural run-off

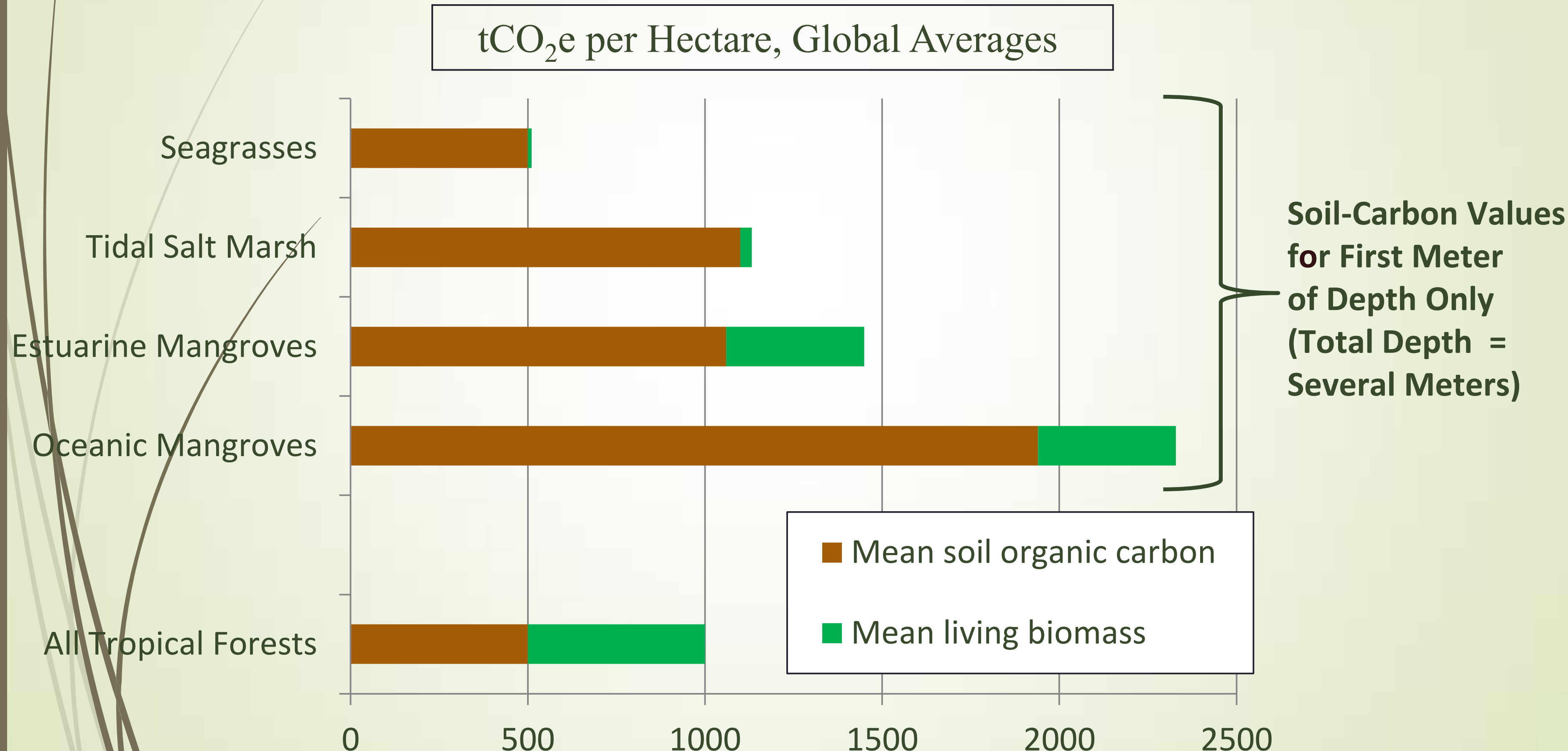
405 km of levees
870 km^2 of drained wetlands

C deposition >99% decrease
Release of historic carbon
Andrews et al., 2000, 2006



Long term carbon sequestration

Distribution of carbon in coastal ecosystems

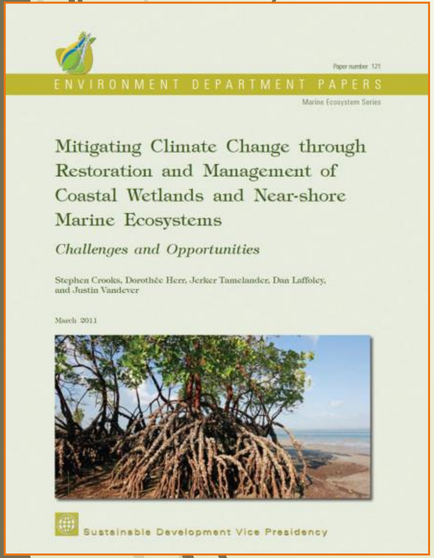


Data summarized in Crooks *et al*., 2011; Murray *et al*., 2011, Donato et al., 2011

Drainage brings carbon loss

Surface from SRTM

Volume calculated between marshplain elevation and present day land surface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Paper number 121

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Challenges and Opportunities

Stephen Crooks, Dorothée Herr, Jerker Tamelander, Dan Laffoley, and Justin Vandever

March 2011

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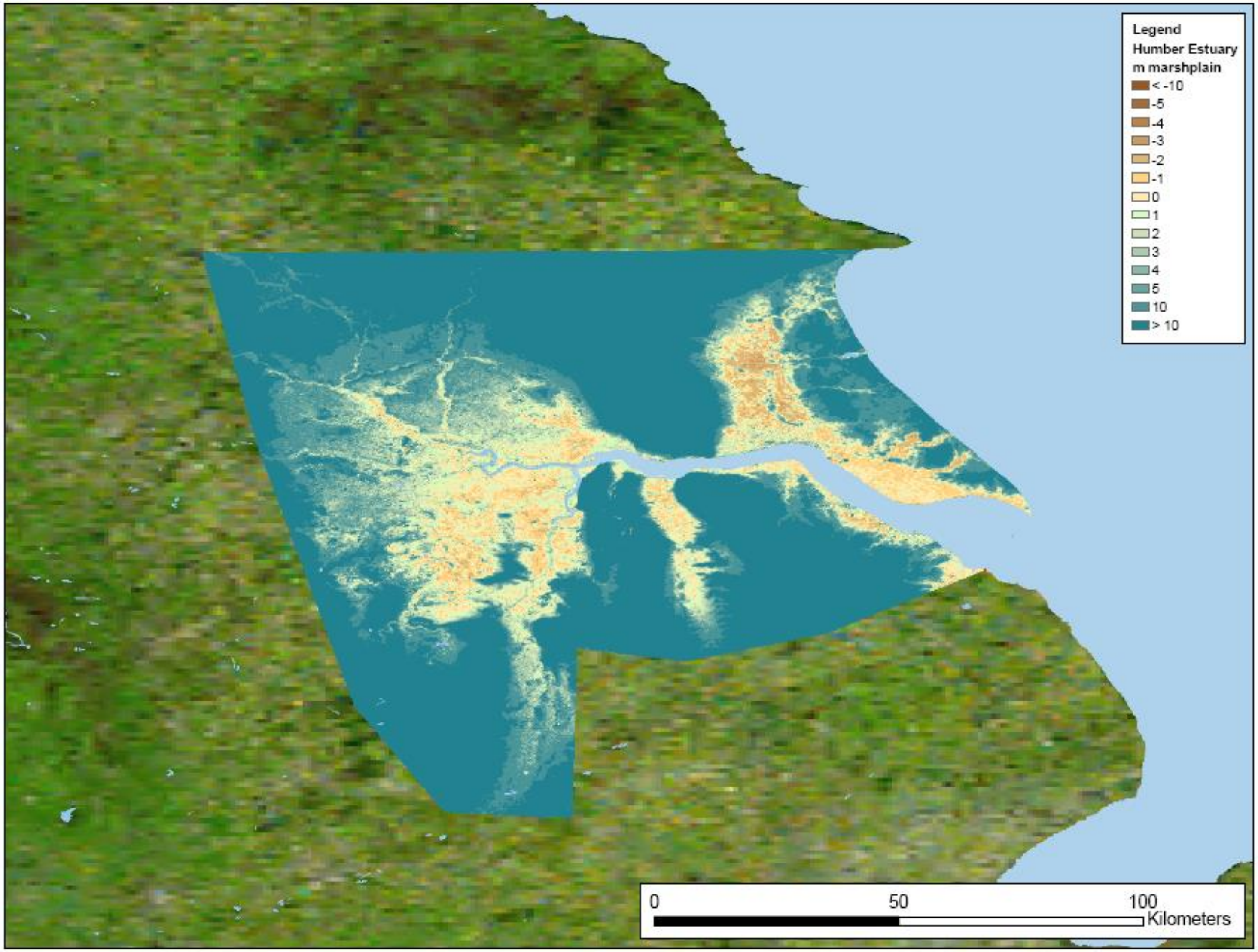
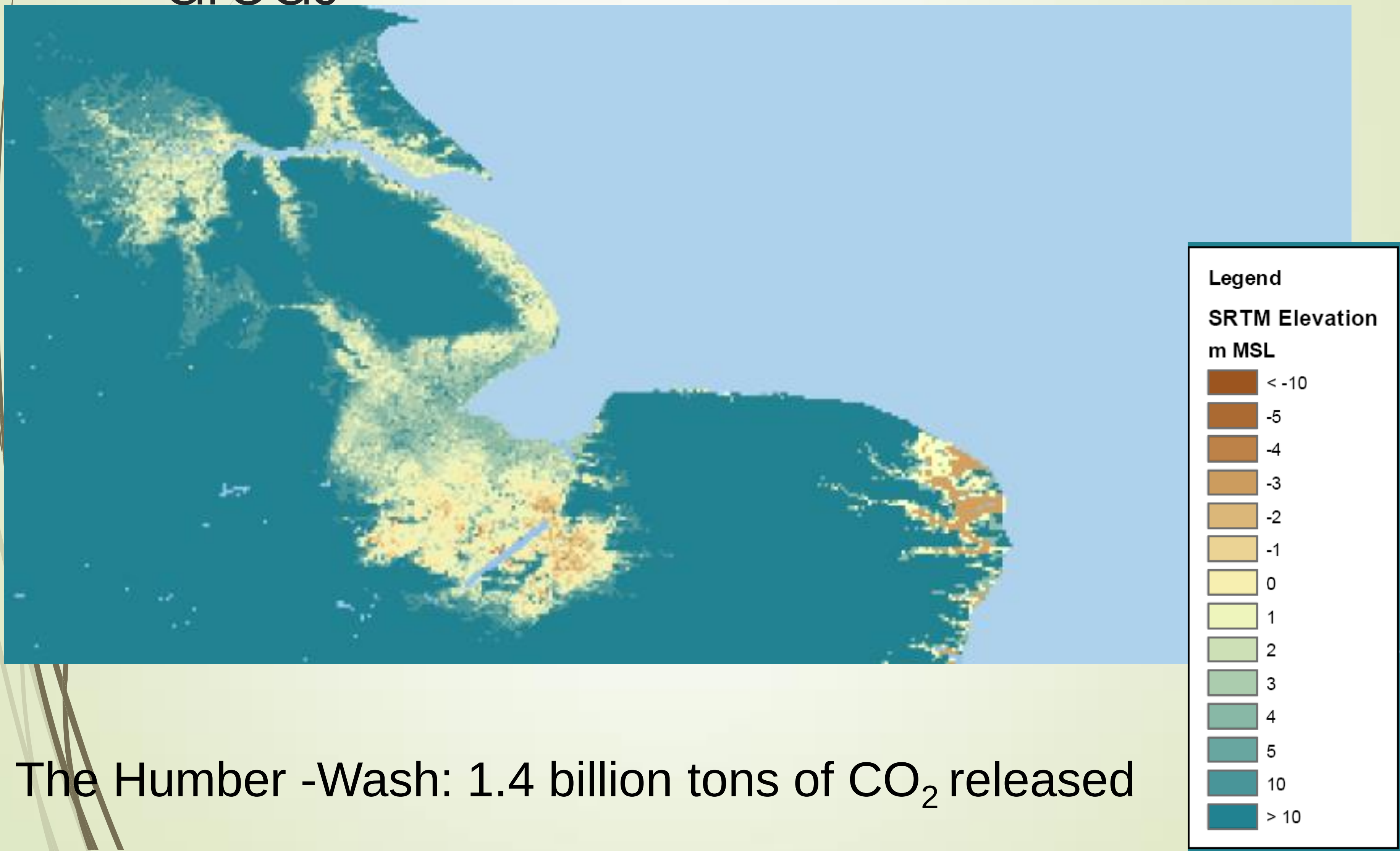
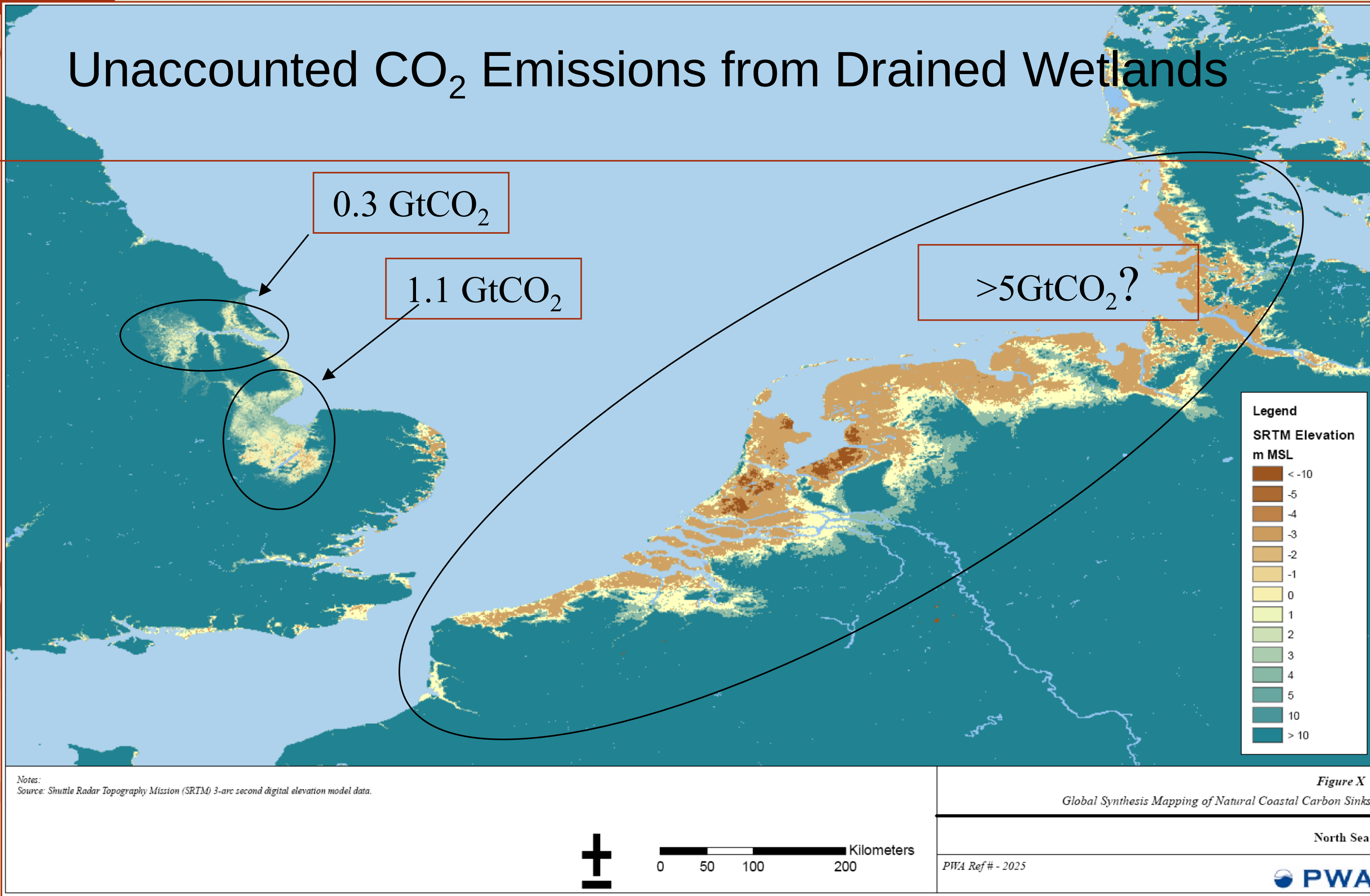


Drainage is wide spread in coastal areas

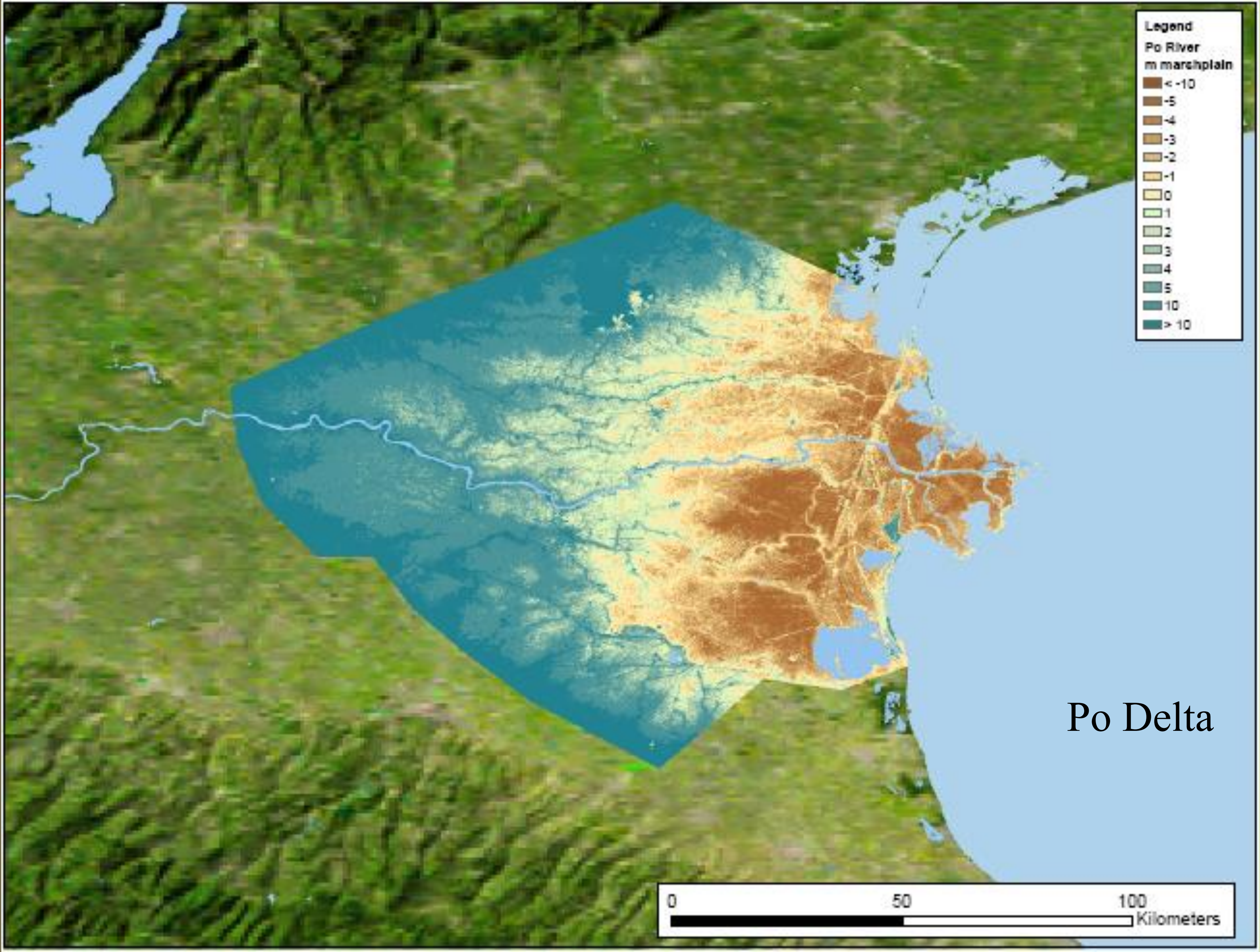


The Humber -Wash: 1.4 billion tons of CO_2 released

Unaccounted CO_2 Emissions from Drained Wetlands




Vistula Delta
Legend
Vistula River
m marshplain
< -10
-5
-4
-3
-2
-1
0
1
2
3
4
5
10
> 10
0
50
100
Kilometers


Legend
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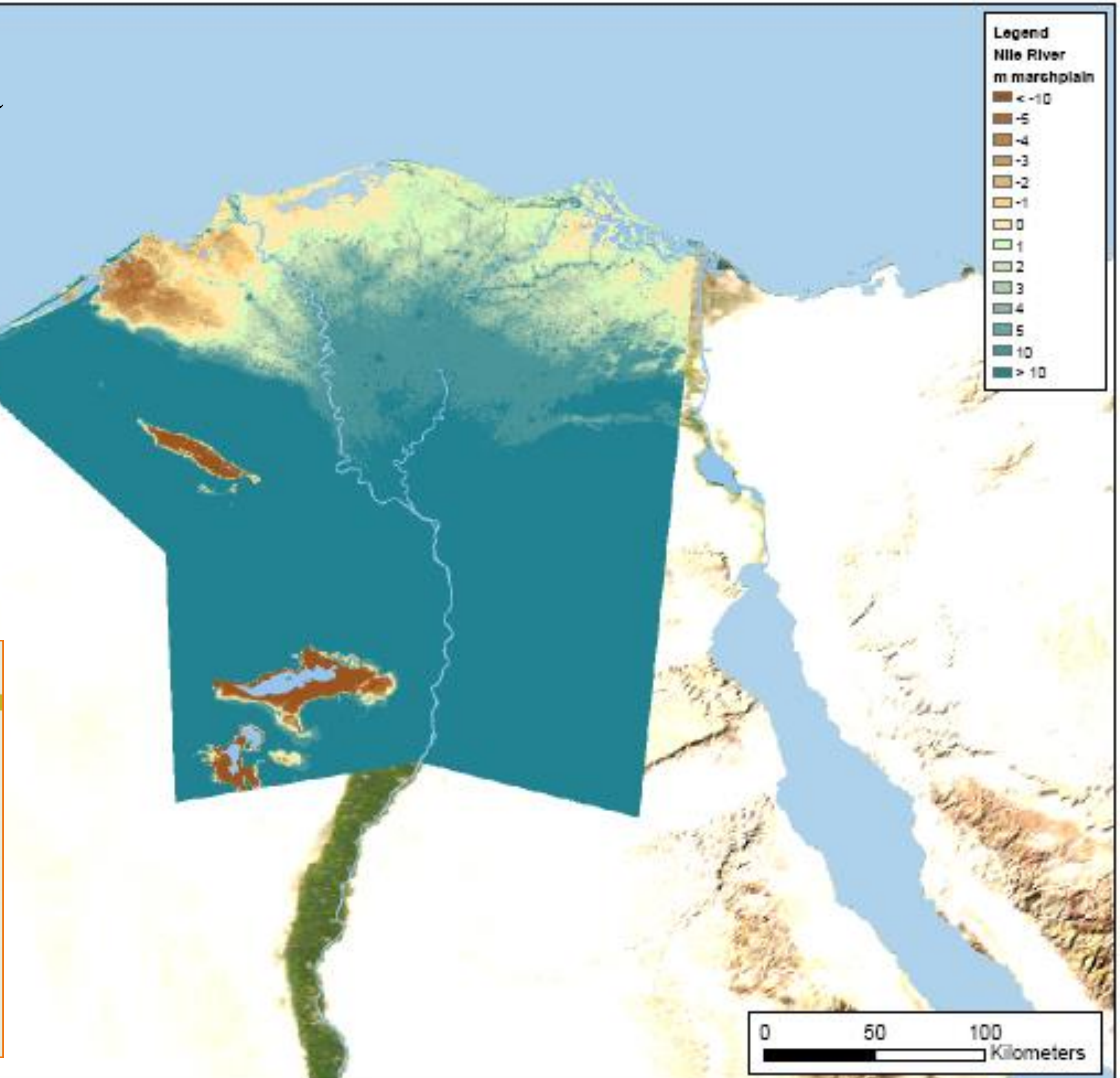
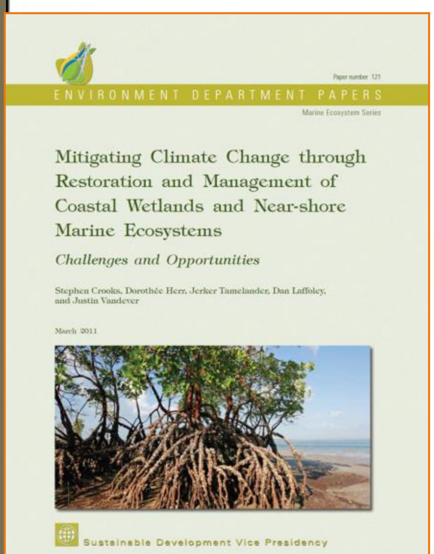
> 10
0
50
100
Kilometers

Po Delta

Nile Delta

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March 2011

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PLOS ONE

Estimating Global "Blue Carbon" Emissions from Conversion and Degradation of Vegetated Coastal Ecosystems

Linwood Pendleton[1¶], Daniel C. Donato[2*¶], Brian C. Murray[1], Stephen Crooks[3], W. Aaron Jenkins[1], Samantha Sifleet[4], Christopher Craft[5], James W. Fourqurean[6], J. Boone Kauffman[7], Núria Marbà[8], Patrick Megonigal[9], Emily Pidgeon[10], Dorothee Herr[11], David Gordon[1], Alexis Baldera[12]

Table 1. Estimates of carbon released by land-use change in coastal ecosystems globally and associated economic impact.

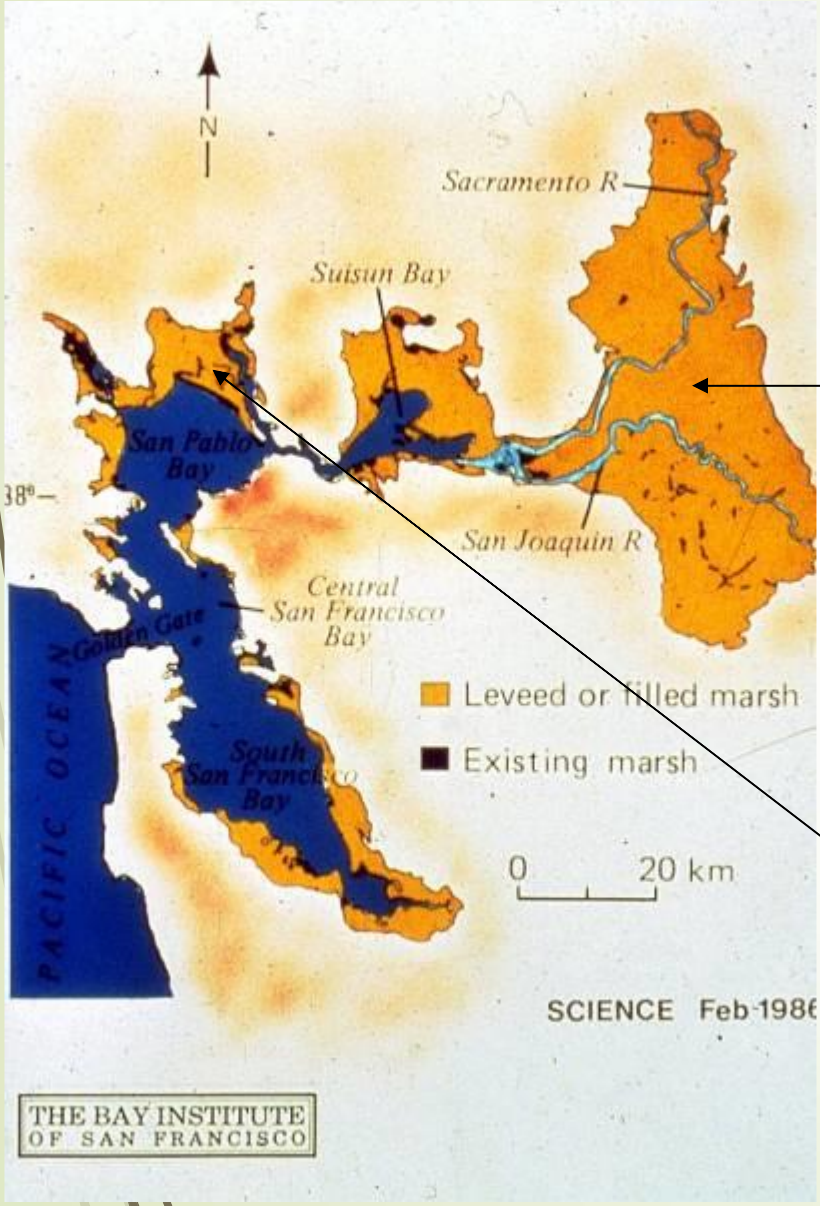
	Inputs			Results	
Ecosystem	Global extent (Mha)	Current conversion rate (% yr^{-1})	Near-surface carbon susceptible (top meter sediment+biomass, Mg CO_2 ha^{-1})	Carbon emissions (Pg CO_2 yr^{-1})	Economic cost (Billion US$ yr^{-1})
Tidal Marsh	2.2–40 (5.1)	1.0–2.0 (1.5)	237–949 (593)	**0.02–0.24 (0.06)**	**0.64–9.7 (2.6)**
Mangroves	13.8–15.2 (14.5)	0.7–3.0 (1.9)	373–1492 (933)	**0.09–0.45 (0.24)**	**3.6–18.5 (9.8)**
Seagrass	17.7–60 (30)	0.4–2.6 (1.5)	131–522 (326)	**0.05–0.33 (0.15)**	**1.9–13.7 (6.1)**
Total	33.7–115.2 (48.9)			**0.15–1.02 (0.45)**	**6.1–41.9 (18.5)**

Compare to national emissions from all sources

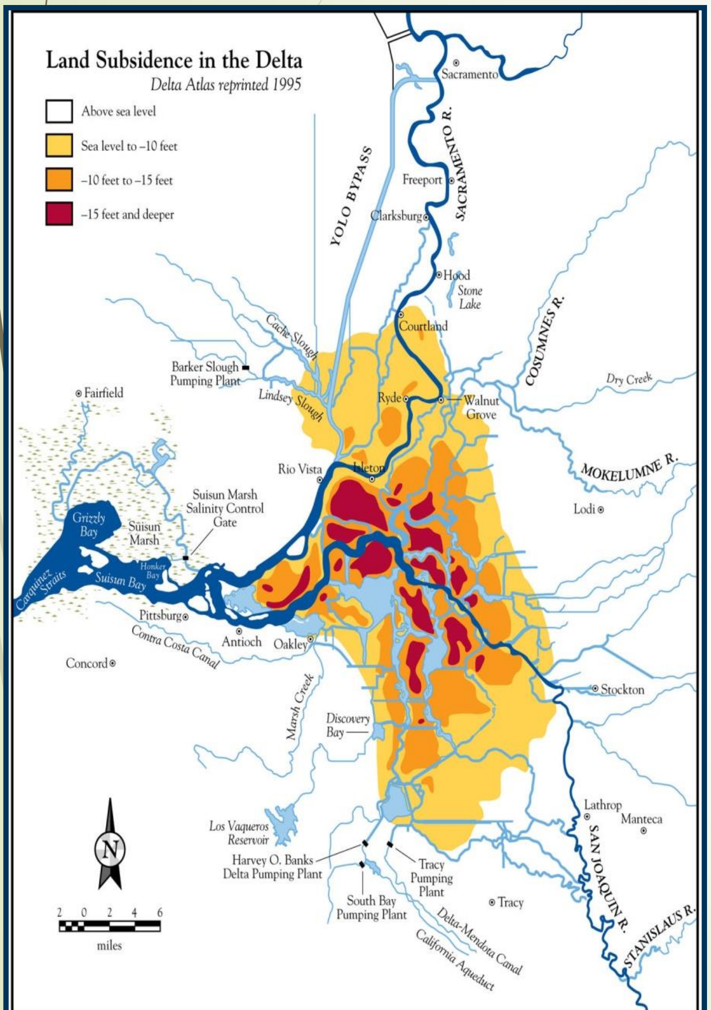
Poland

Japan

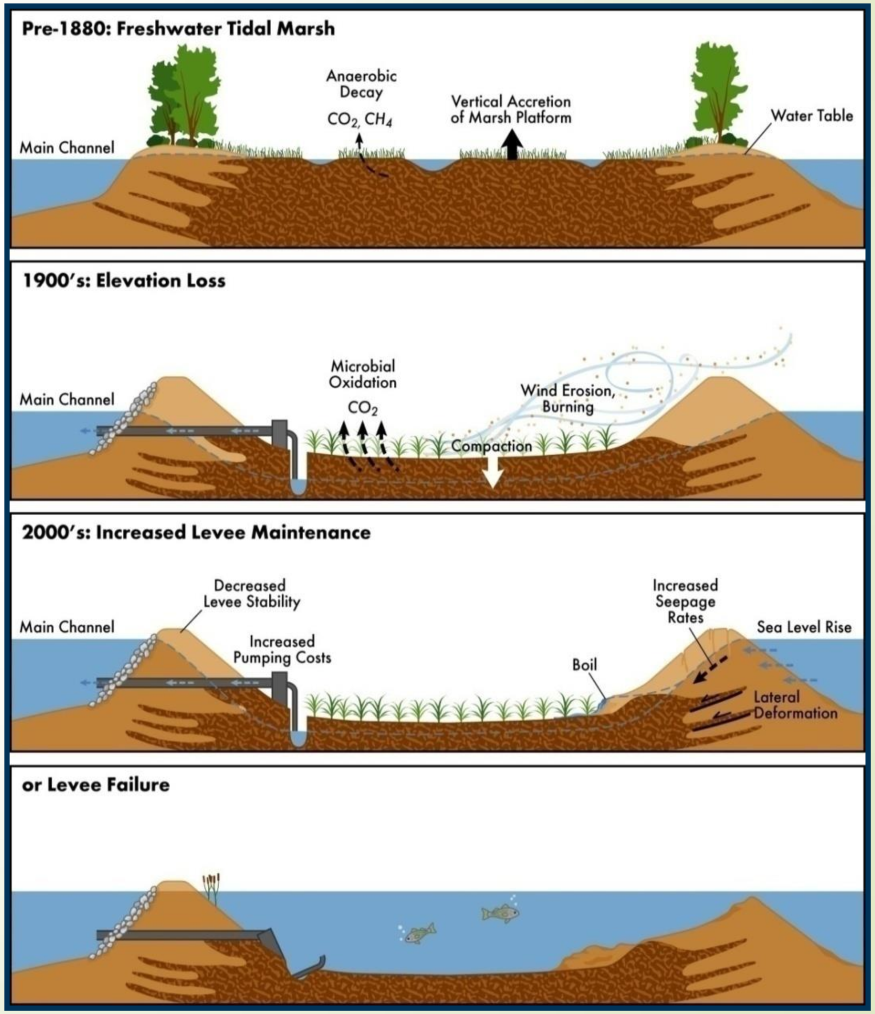
Historic San Francisco Estuary



Long-term release of carbon from organic soils



Sacramento - San Joaquin Delta



Emissions from One Drained Wetland: Sacramento-San Joaquin Delta

Area under agriculture	**180,000 ha**
Rate of subsidence (in)	1 inch

3-5 million tCO_2/yr released from Delta

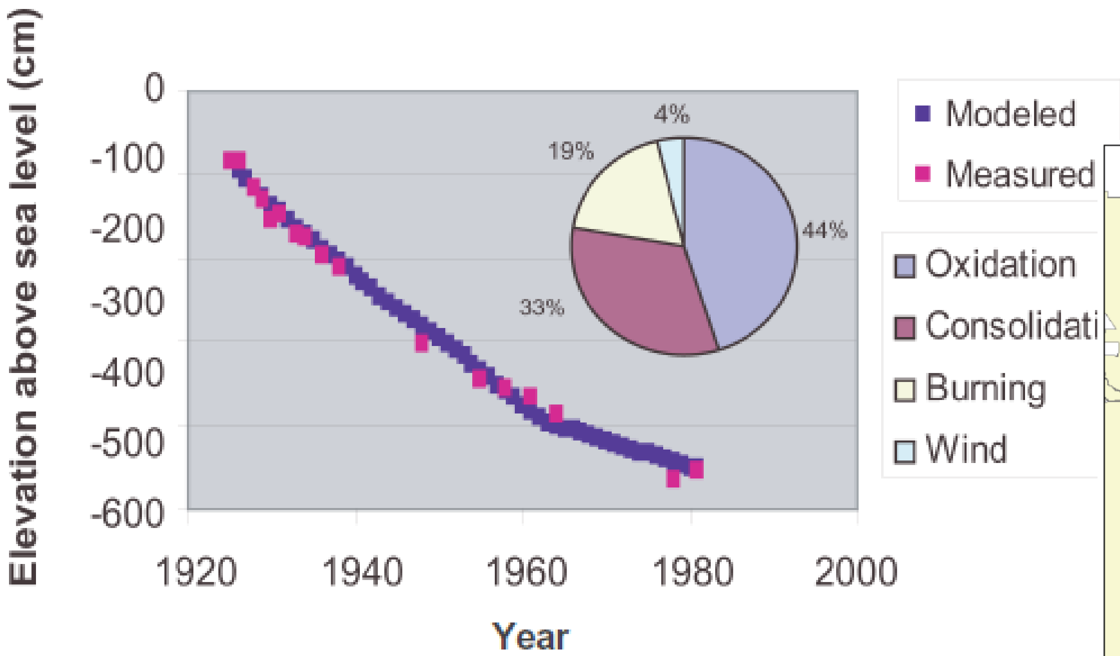
1 $GtCO_2$ release in c.150 years

4000 years of carbon emitted

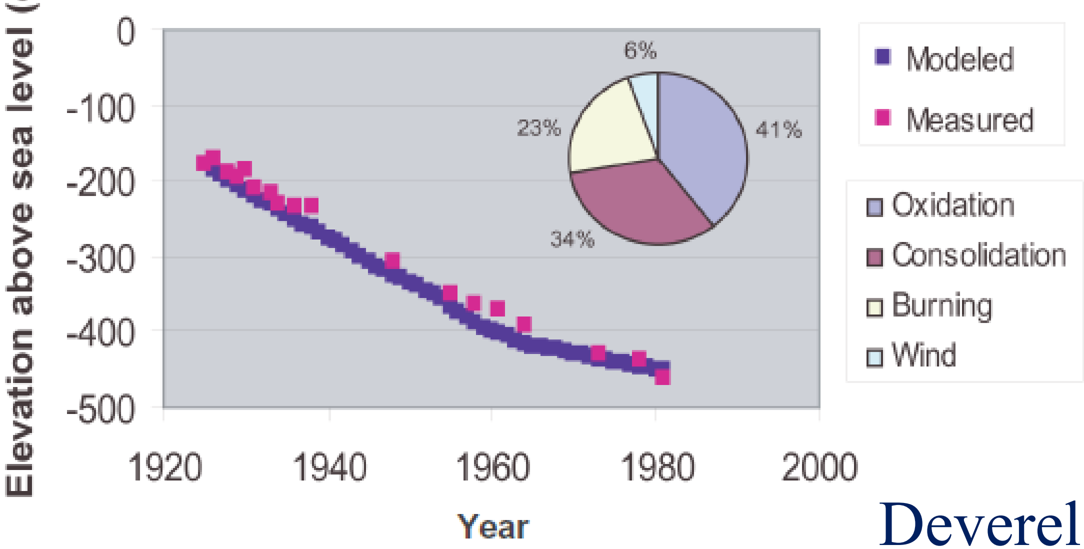
Equiv. carbon held in 25% of California's forests

Accommodation space: 3 billion m^3

Mildred

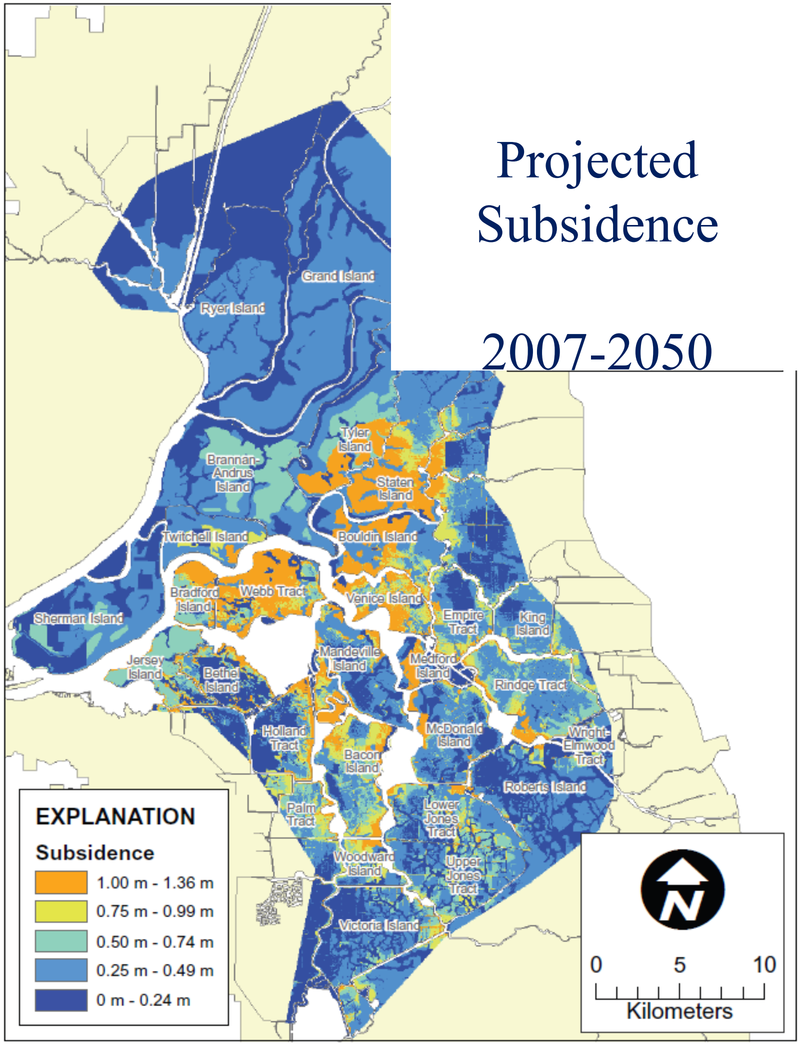


Lower Jones



Projected Subsidence

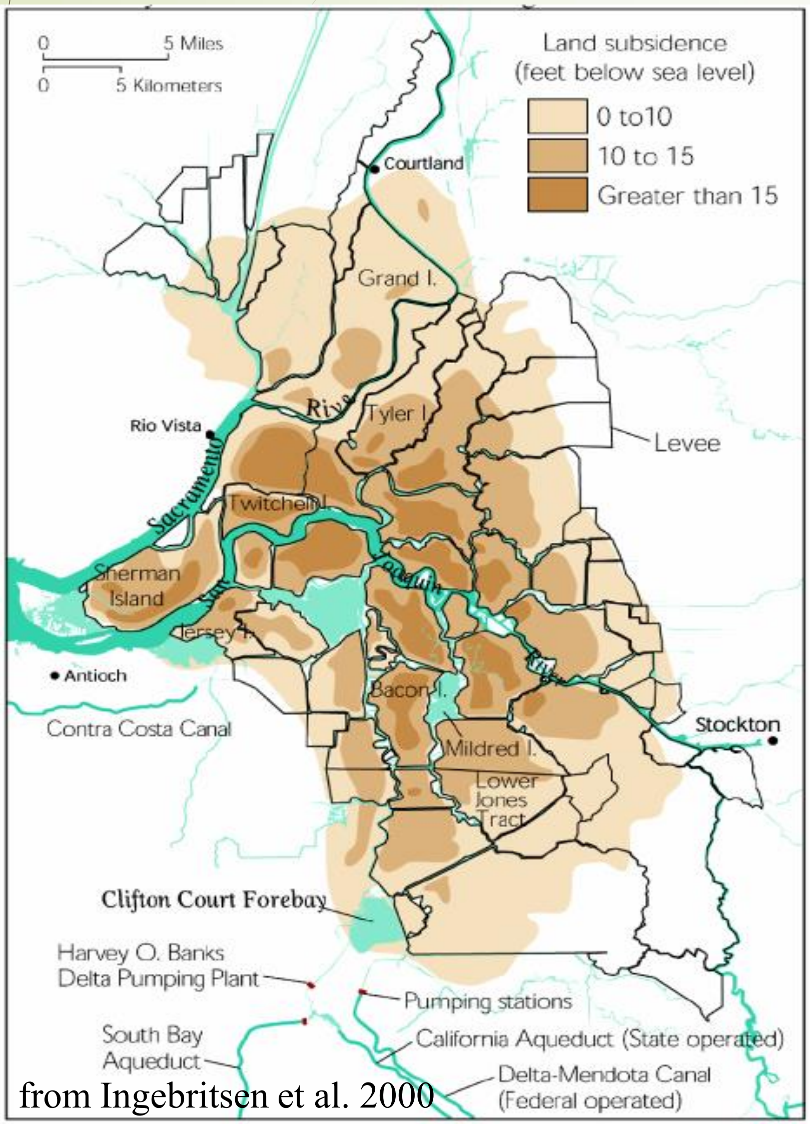
2007-2050



Deverel and Leighton 2010

Subsidence of SJ-Sacramento Delta Peatlands

Problem



from Ingebritsen et al. 2000

Solution

Carbon Capture Wetland Farm Bio-Sequestration

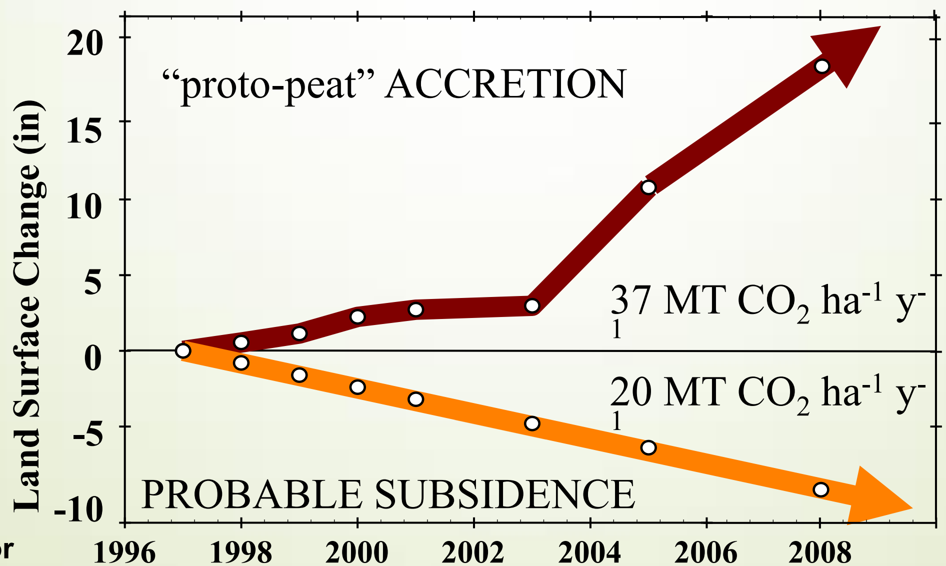
Stops peat oxidation and accretes “proto-peat” rapidly

Continuously submerged about 1 ft

Low oxygen conditions

Balance between plant growth and reduced decomposition

Average annual soil sequestration: $1\ kg\ C\ m^{-2}\ yr^{-1}$ in soil



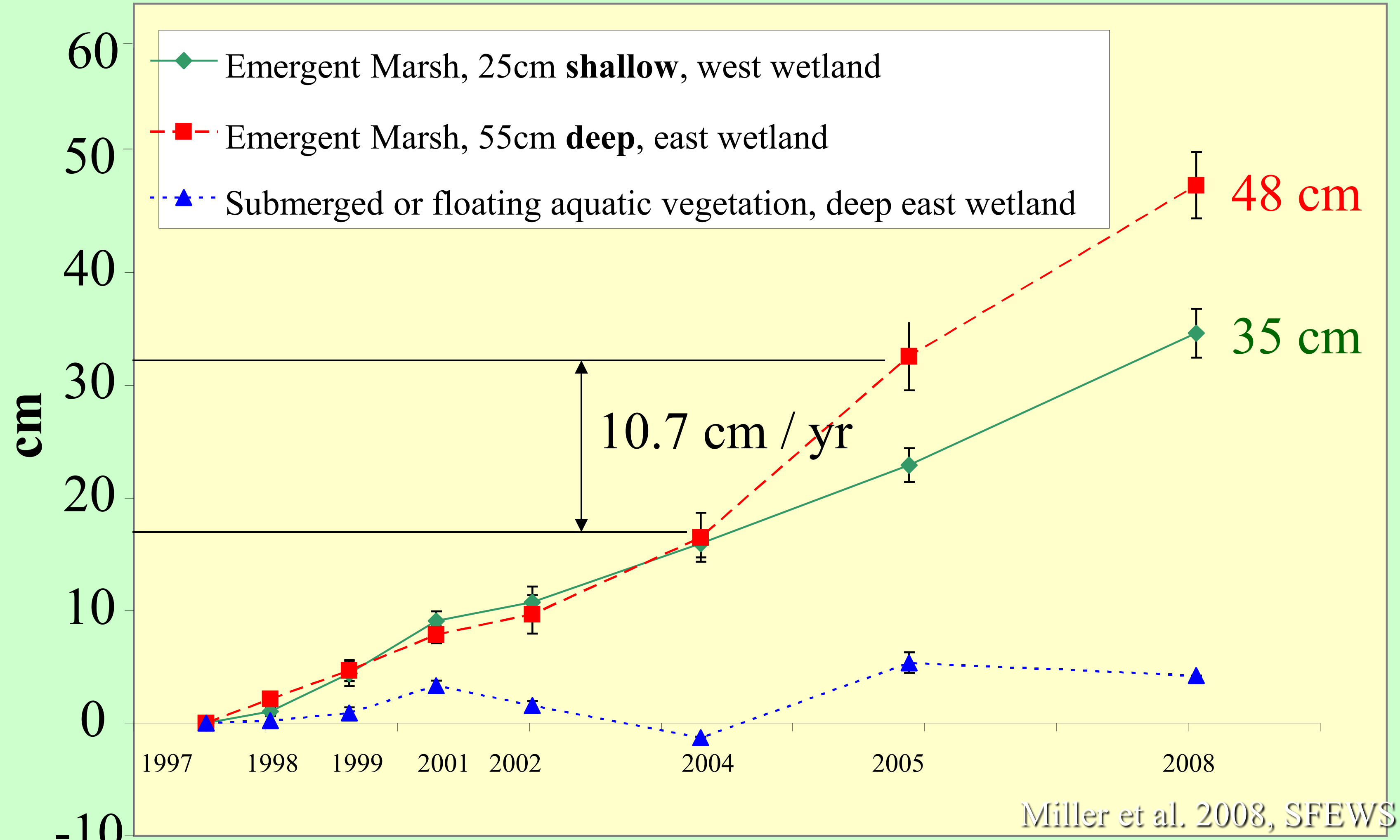
USGS
U.S. Department of the Interior
U.S. Geological Survey

Miller et al. 2008, SFEWS

Experimental Wetland "Peat" Accretion: Surface Elevation

Average gain of 2 inches per year

Average gain of 1 kg carbon per m^{-2} per year

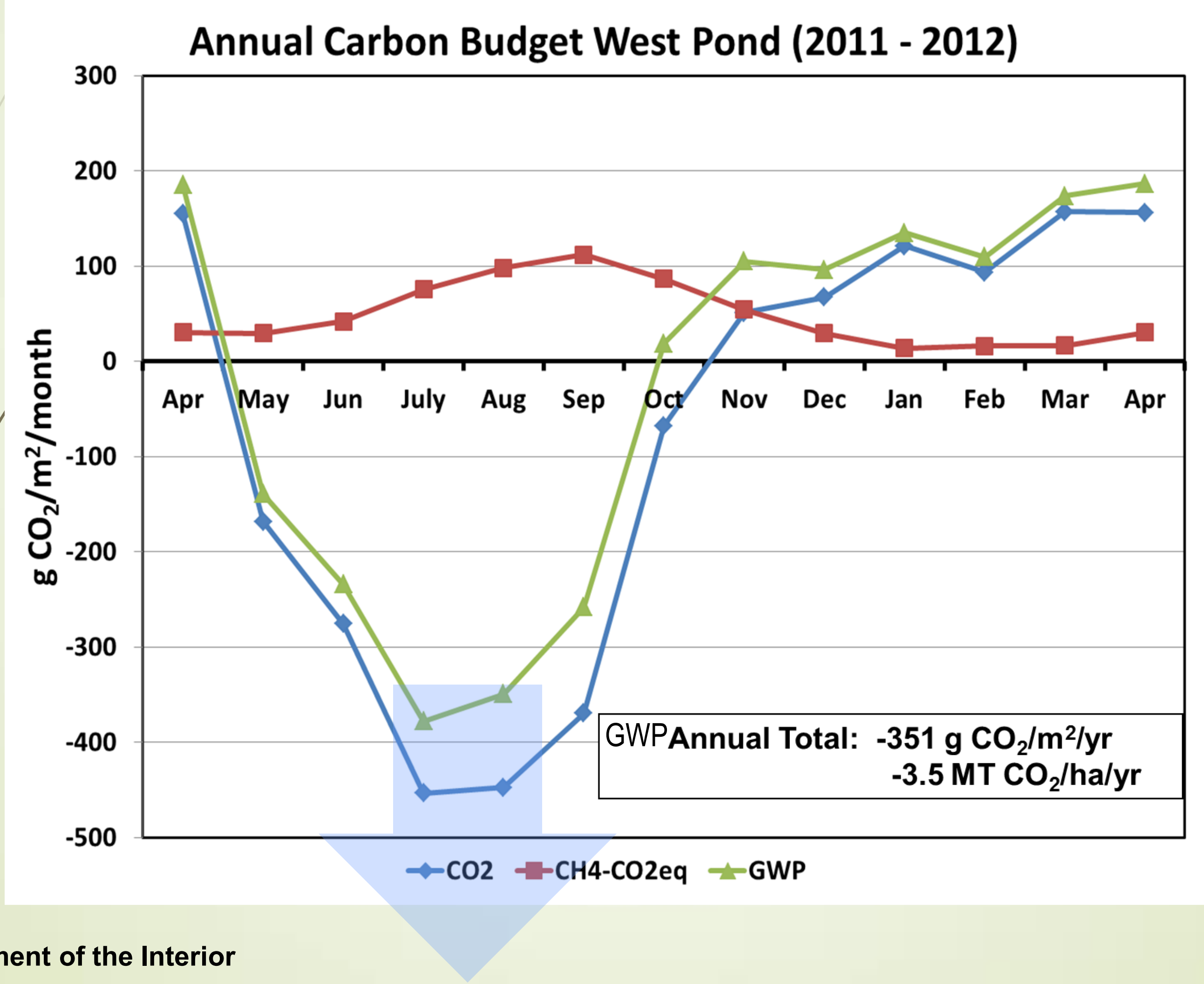


Net GWP Fluxes (from Eddy Covariance April 2011-2012)

Wetland — Corn

$$MT\ CO_2eq\ ha^{-1}\ y^{-1} = -10 + 6.5 + 0 - (25 + 2.5) = \mathbf{-31}$$

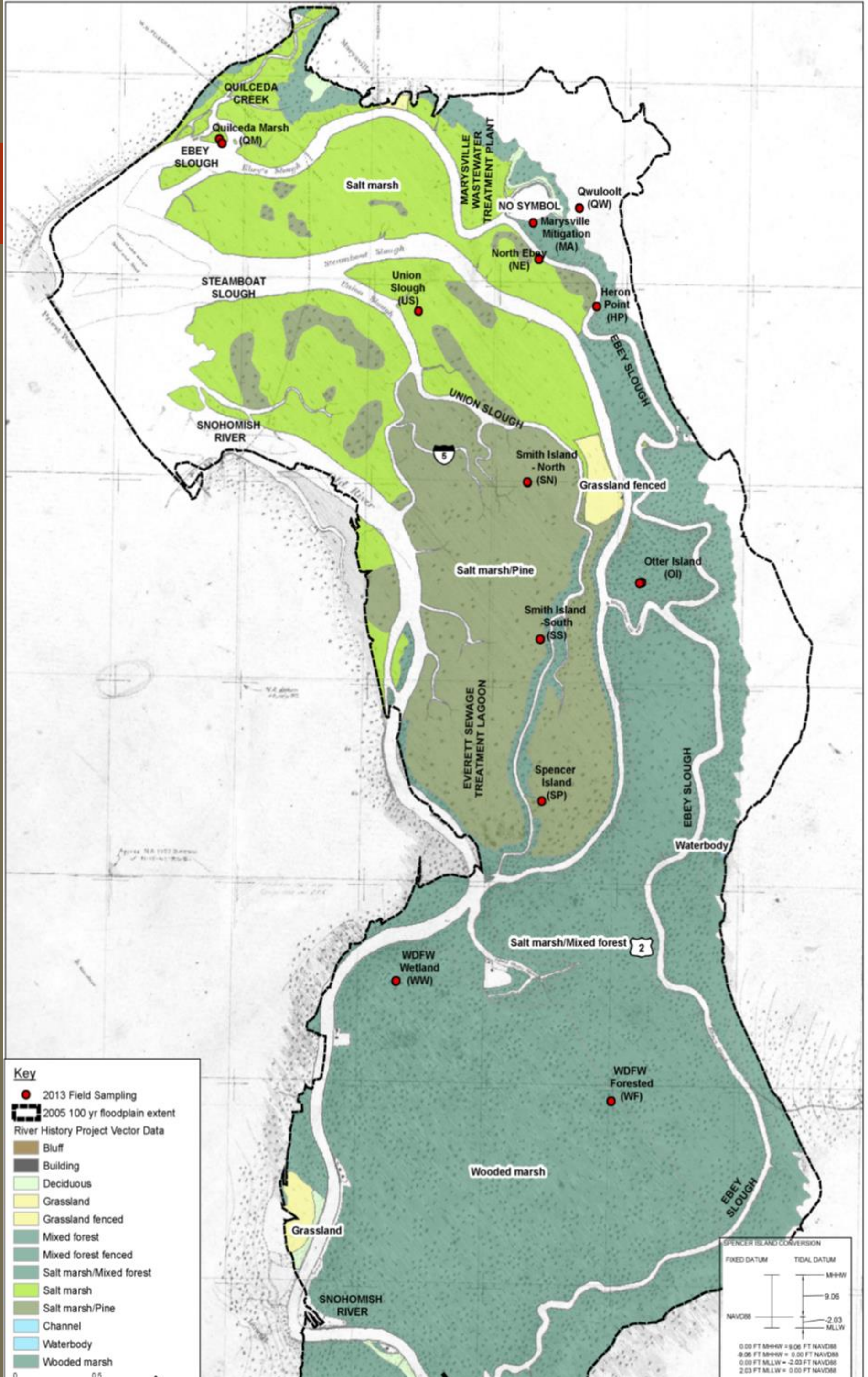
CO_2 CH_4 N_2O — CO_2 N_2O



USGS

U.S. Survey Department of the Interior

U.S. Geological



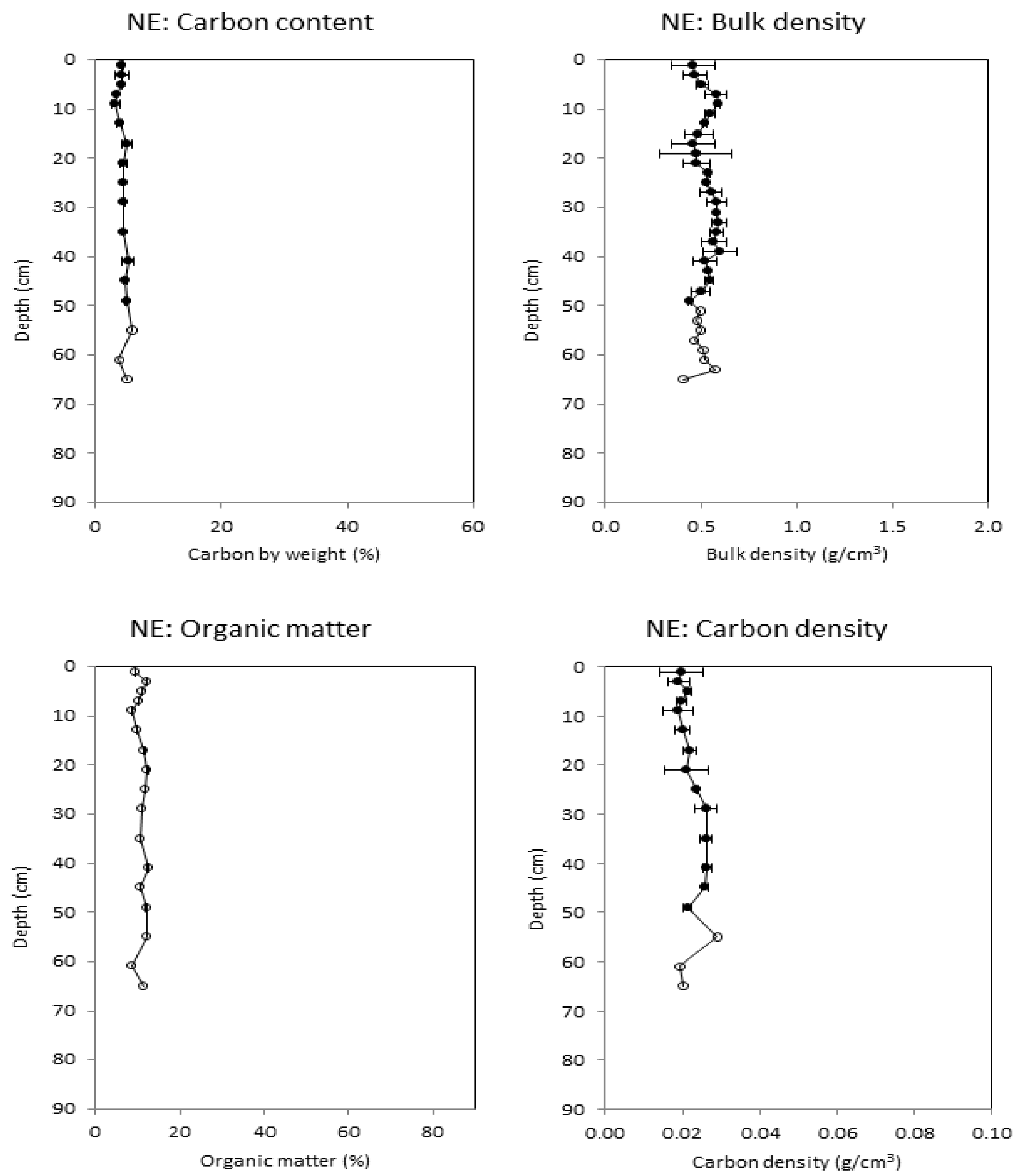
Snohomish Estuary
(draft data)

- 4000 ha original marsh, 600ha remaining.
- Mostly converted to agriculture and abandoned agr (wet soils).
- Subsided by c.2m
- 4.4 Mt CO2 released since 1930 (conservative estimate).
- 2000 of readily restorable land, (1000 restoration planned) would sequester 1.5 Mt CO2
- Sea level rise would add to sequestration by restored wetlands.
- Snohomish represents about 10% of drained tidal marshes in Puget Sound (in progress)

Ebey Island

Natural restoration 1960s

Building soil 1.6 cm year



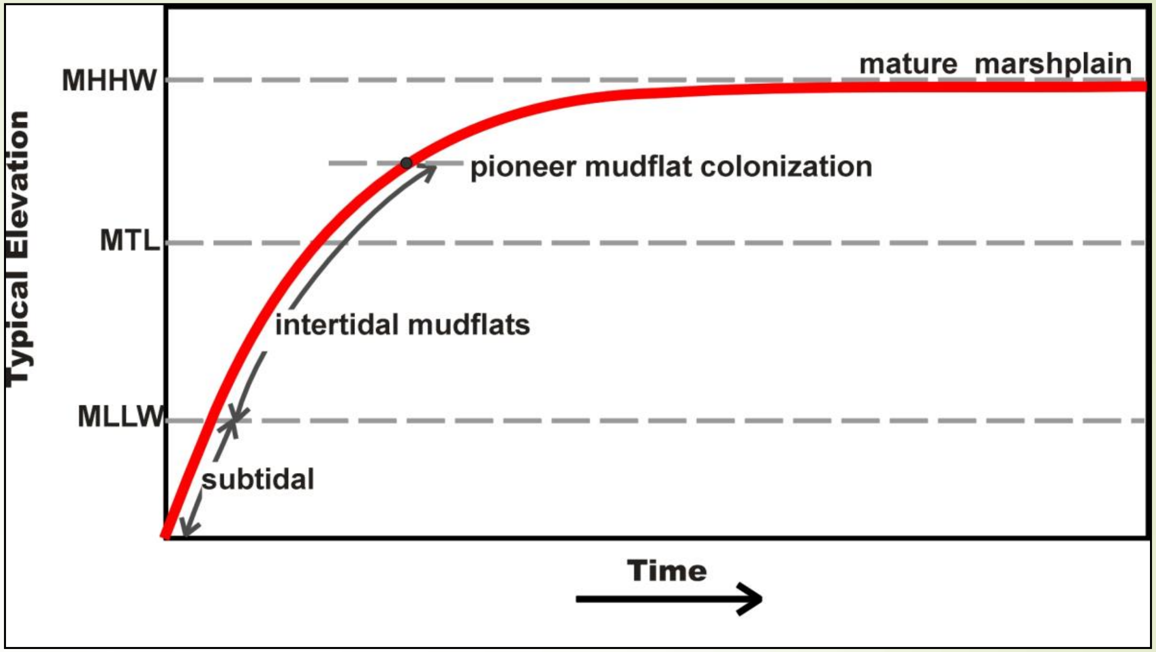
Snohomish Estuary: soil carbon sequestration (draft data)

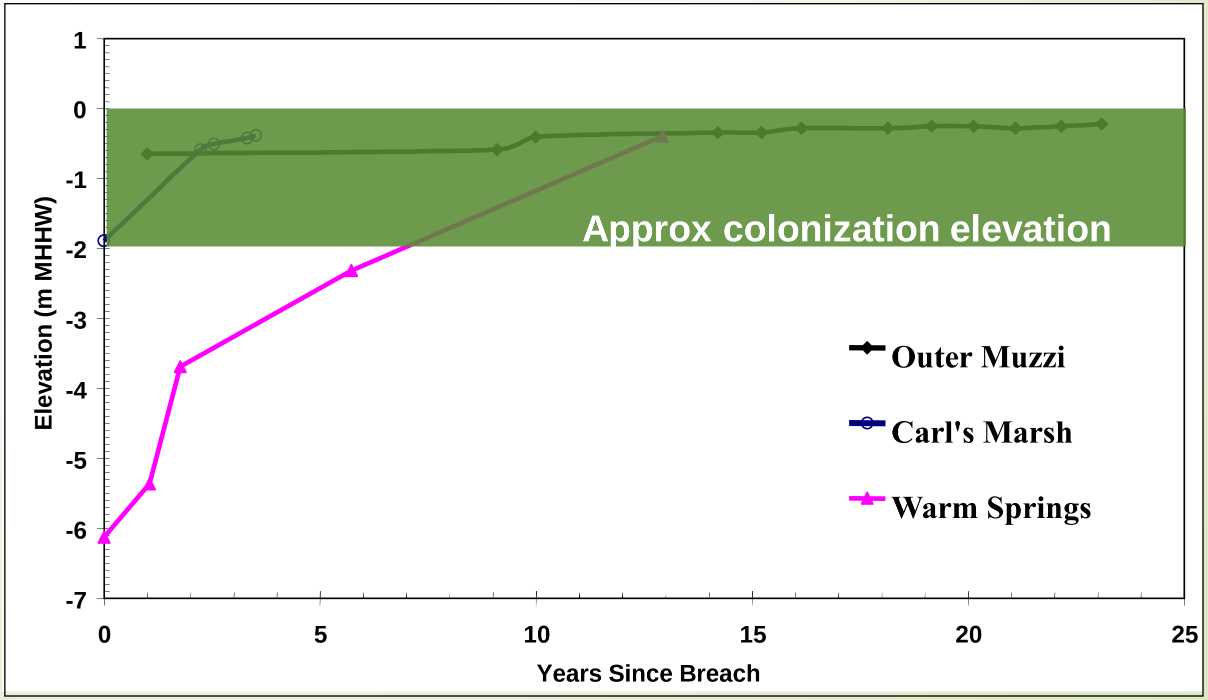
Site Name	Land for type	Sediment Accretion rate (cm / yr)	Carbon accumulation rates ($Mg\ CO_2/ha/yr$)
Quiladeda Marsh	Natural marsh	0.43	4.0
Heron Point	Forest wetland	0.18	2.0
Otter Island	Forest wetland	0.58	6.3
North Ebey	Restoring marsh	1.61	13.9
Spencer Island	Restoring marsh	0.35	3.3

What about remaining and restoring wetlands, and their response to sea level rise?

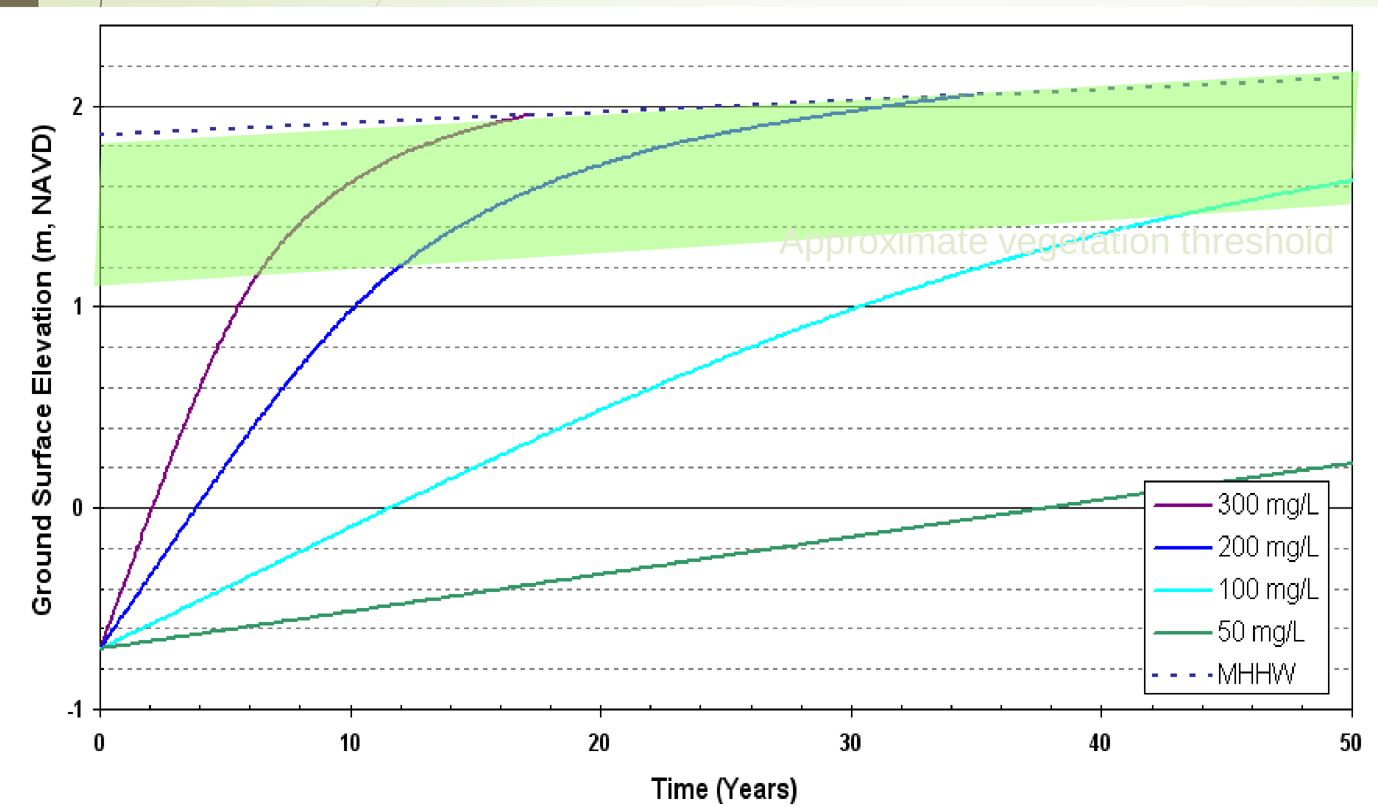
Marshplain evolution trajectory

- "A simple world"
- Temporal and spatial variability
- Limiting factors that could affect endpoint
  - Low sediment supply
  - Wind-waves



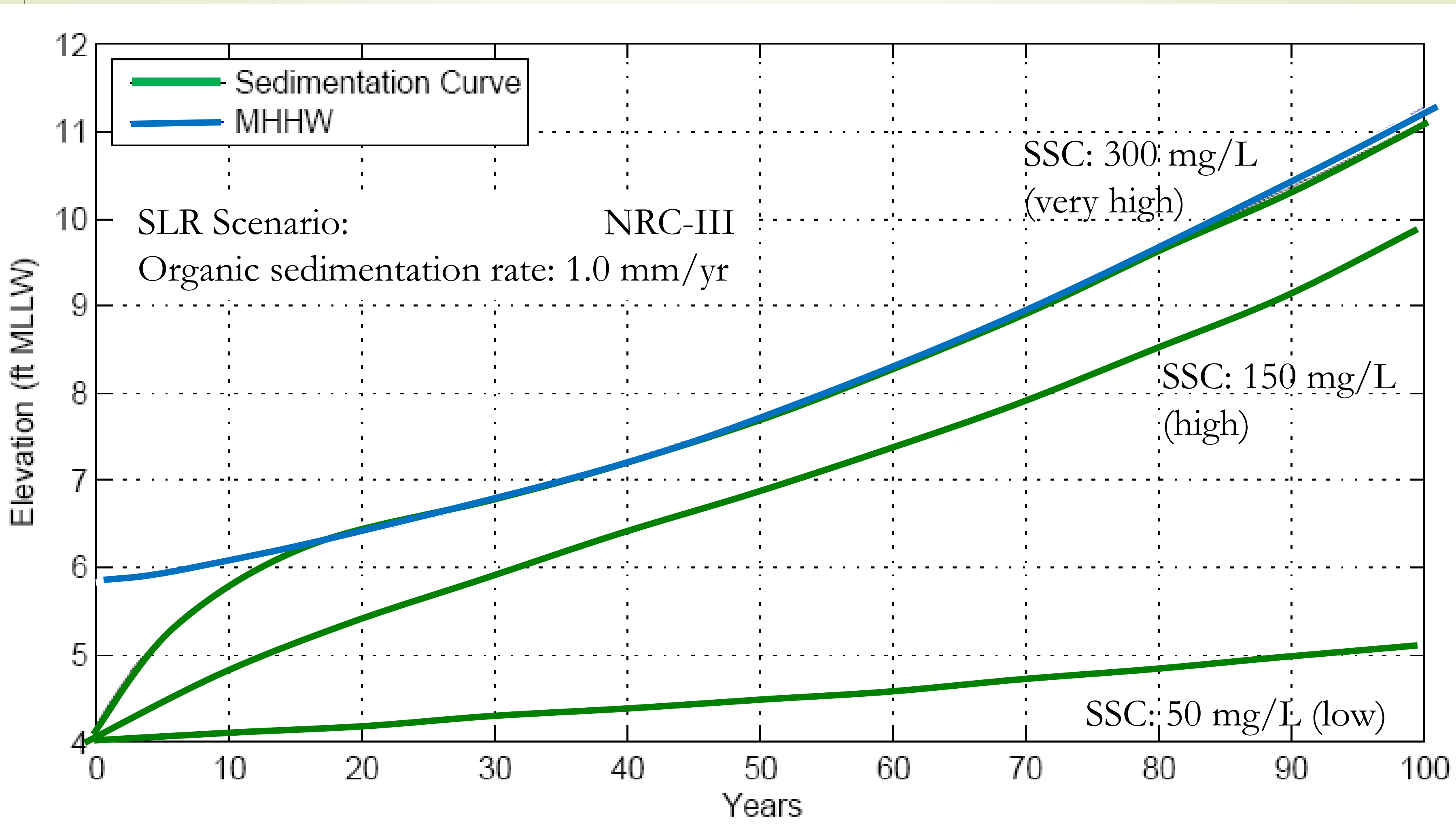


Wetland Sedimentation

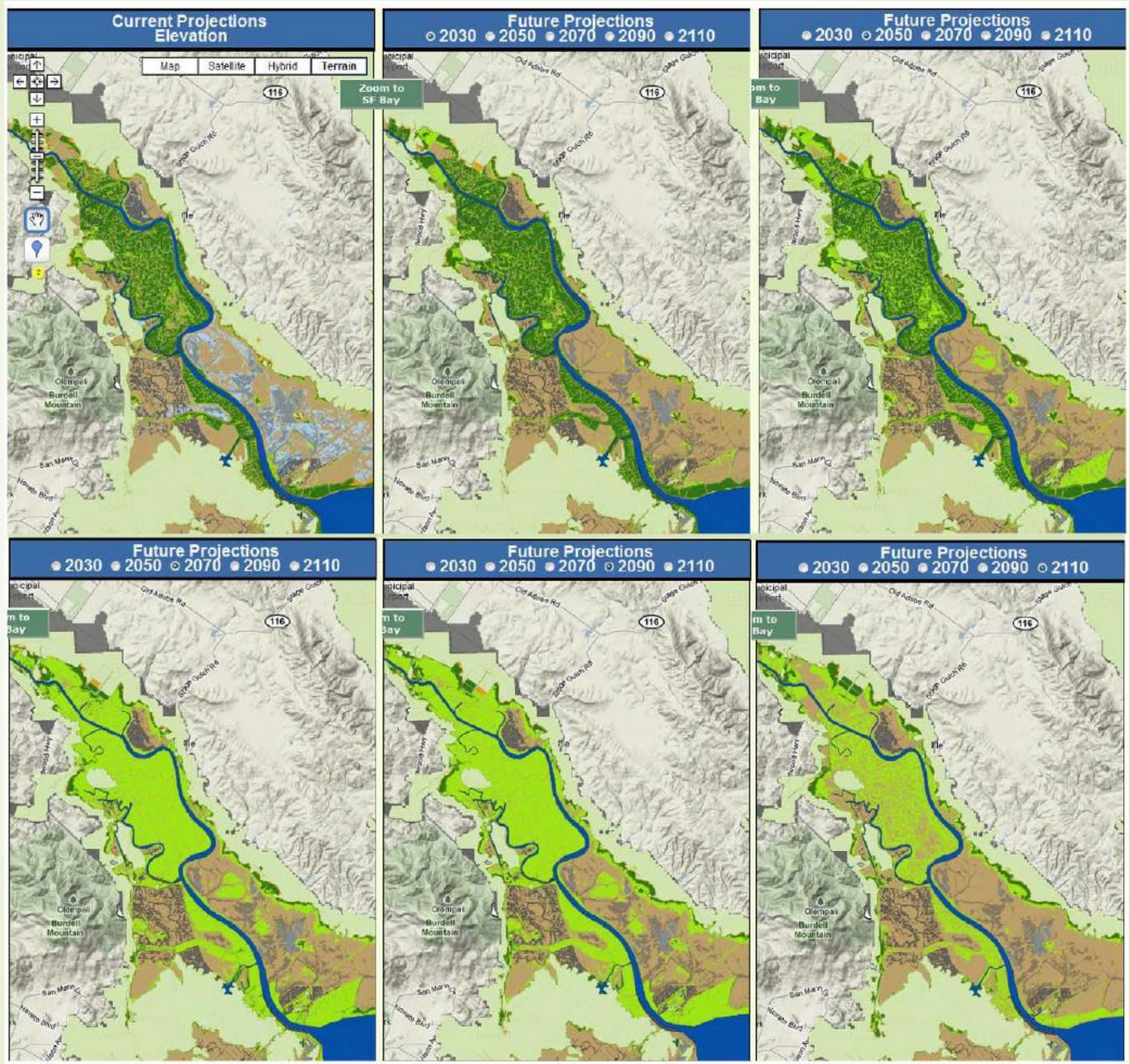


Using methods from Krone 1987.

Low Marsh Response to SLR for Ranging Sediment Availability



Modeled with Marsh98



Stralsburg et al. 2011

Conclusions

- Emissions from coastal marshes are significant.
- Distribution of ongoing and new emissions uncatalogued.
- Emissions from converted wetlands greater than restoring wetlands, though exceptions exist.
- Collection of Tier 2 emissions factors would inform regional accounting, refined for local ecological and activity conditions.

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