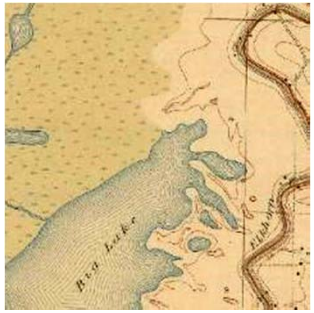
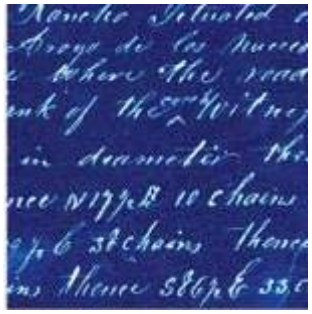
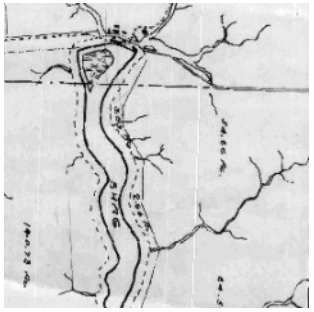
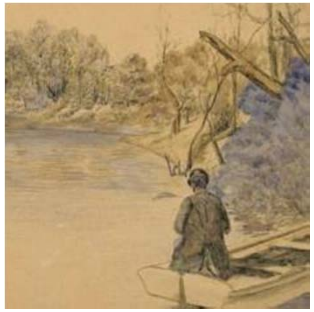




A DELTA RENEWED

A Guide to Science-Based Ecological Restoration in the Delta

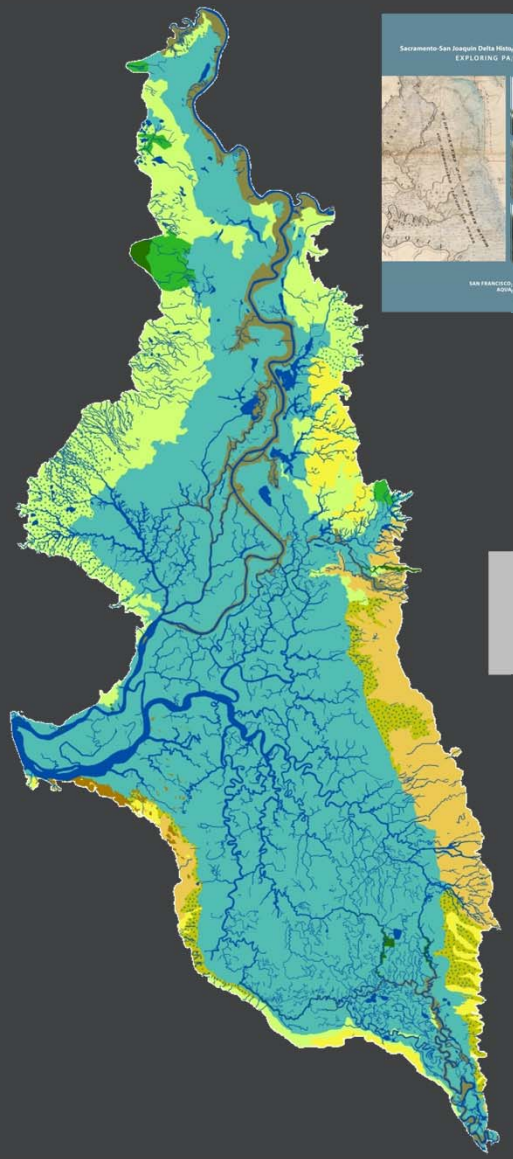
Letitia Grenier
Delta Landscapes Team

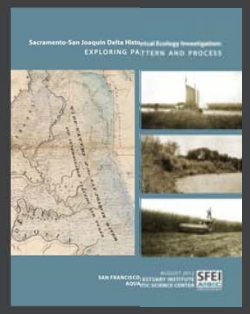
Delta Stewardship Council
September 30, 2016

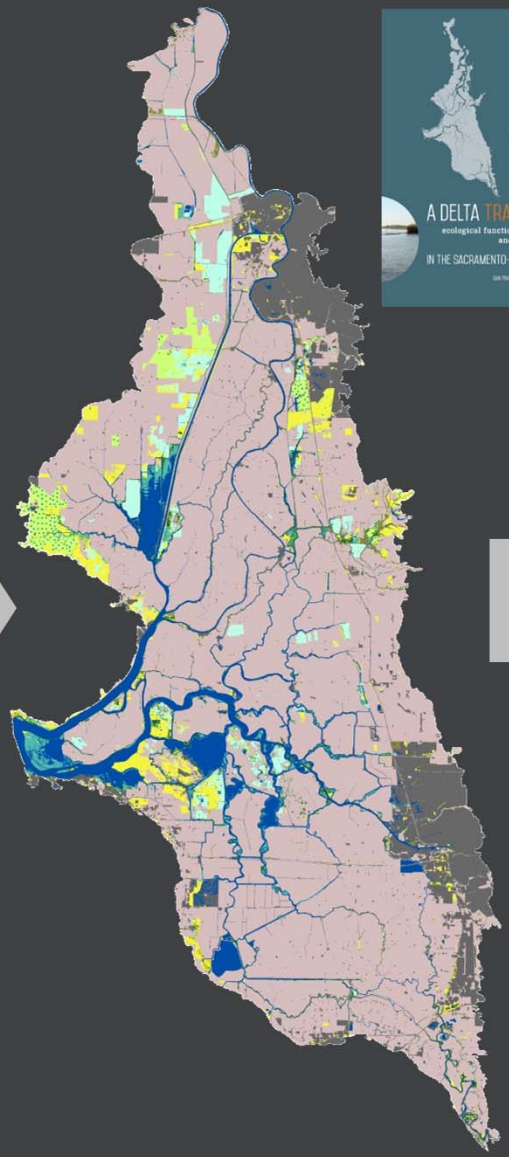
Funded by CA DFW Ecosystem Restoration Program

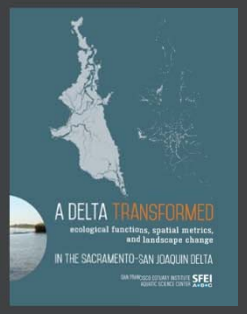
AQUATIC SCIENCE CENTER

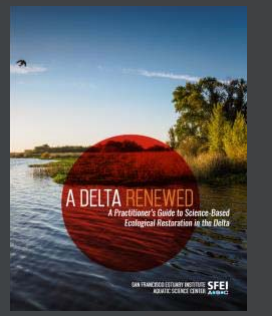
How do we create a desirable, healthy ecosystem in the future Delta?











*"Restore **large areas** of **interconnected habitats** within the Delta and its watershed by 2100"*

Water Code section 85302

*"Management plans and decisions need to be informed by a **landscape perspective** that recognizes interrelationships among patterns of land and water use, patch size, location and connectivity, and species success."*

Delta Plan

*"We propose that science that encompasses the multiple, interacting components of functional landscapes in the Delta will **foster resilient and enduring restoration and management outcomes that benefit both people and wildlife**."*

Wiens et al., The State of Bay-Delta Science 2016

California Delta, 2014
Image Landsat
Google earth

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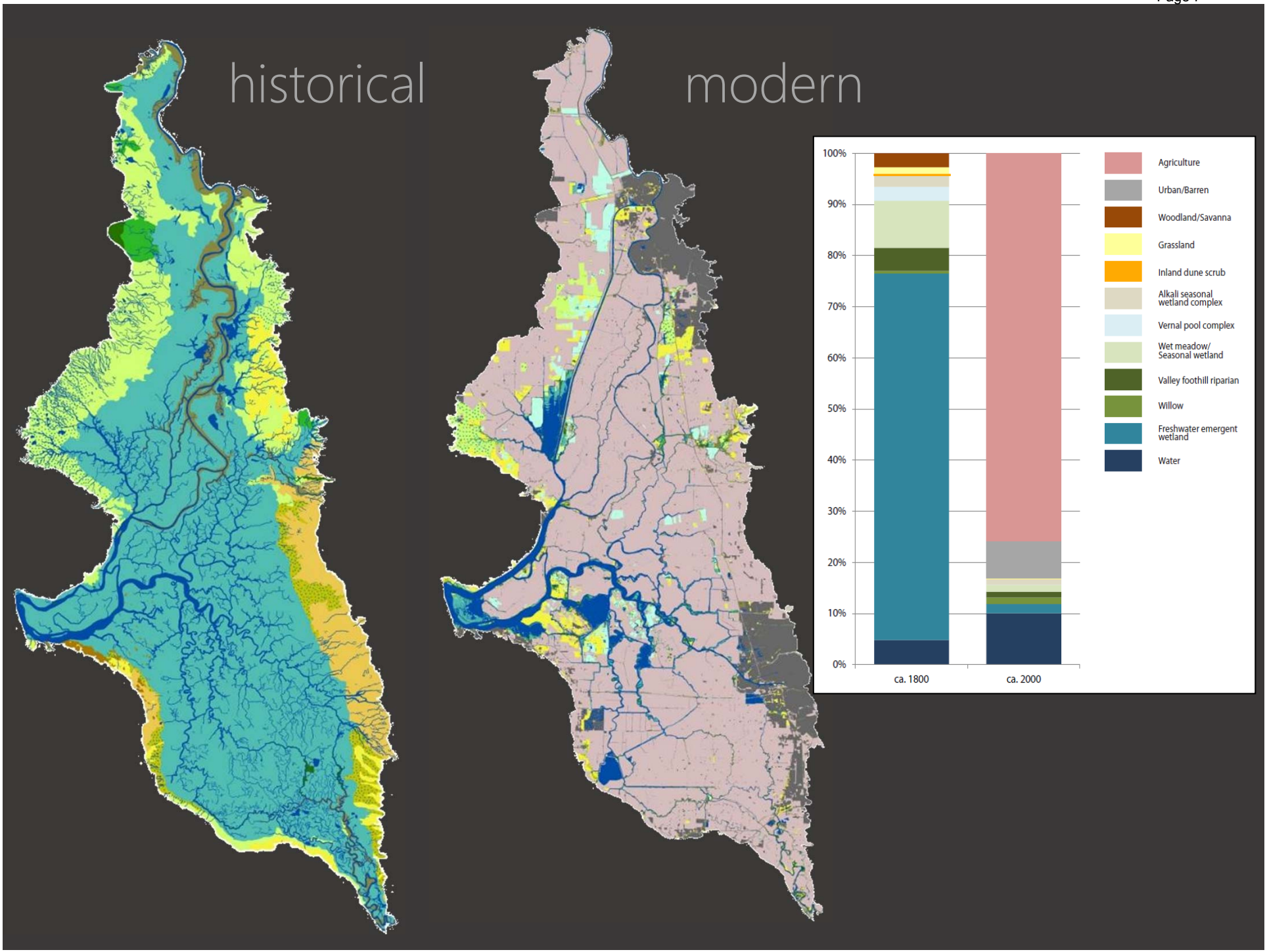
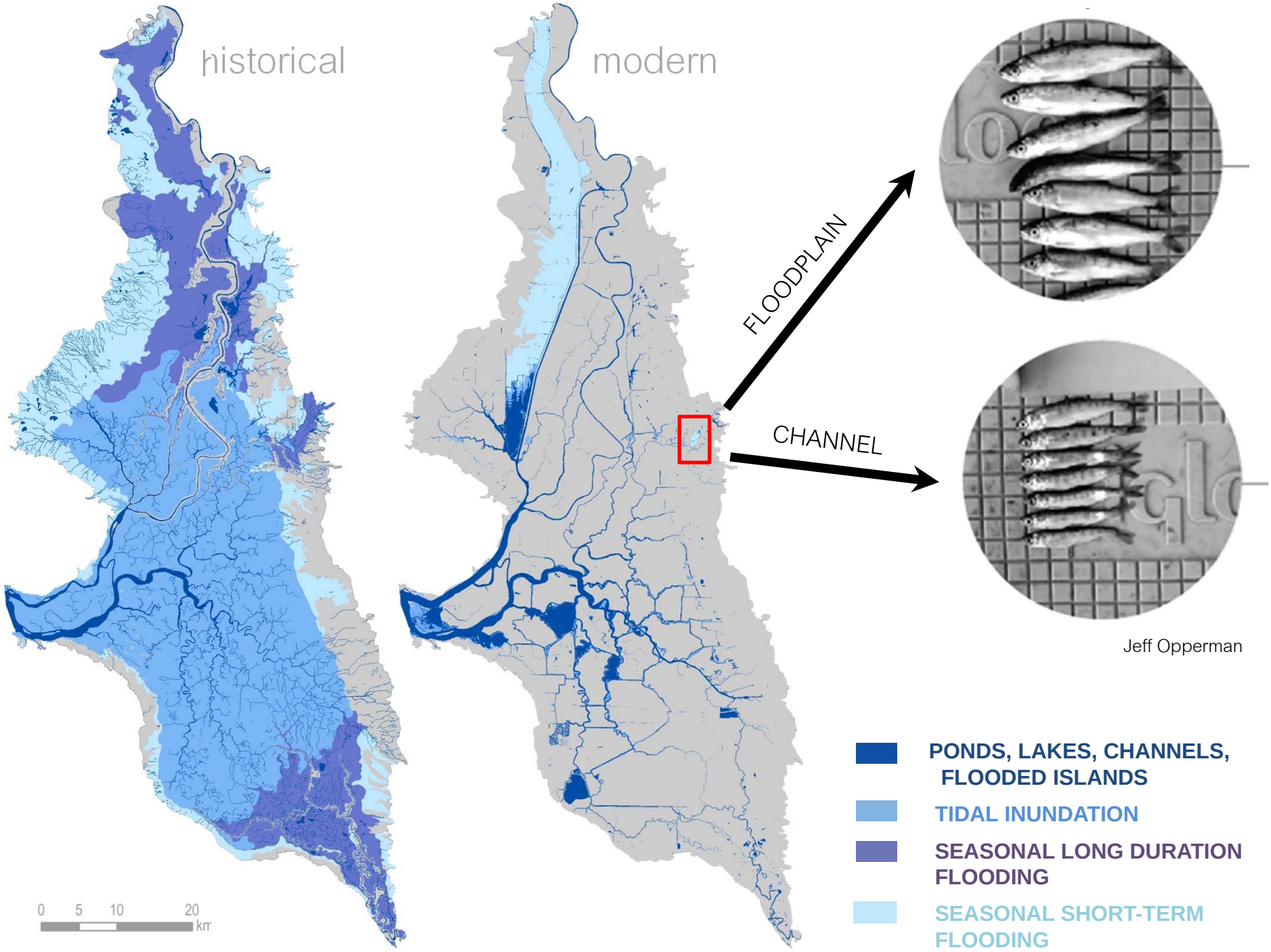
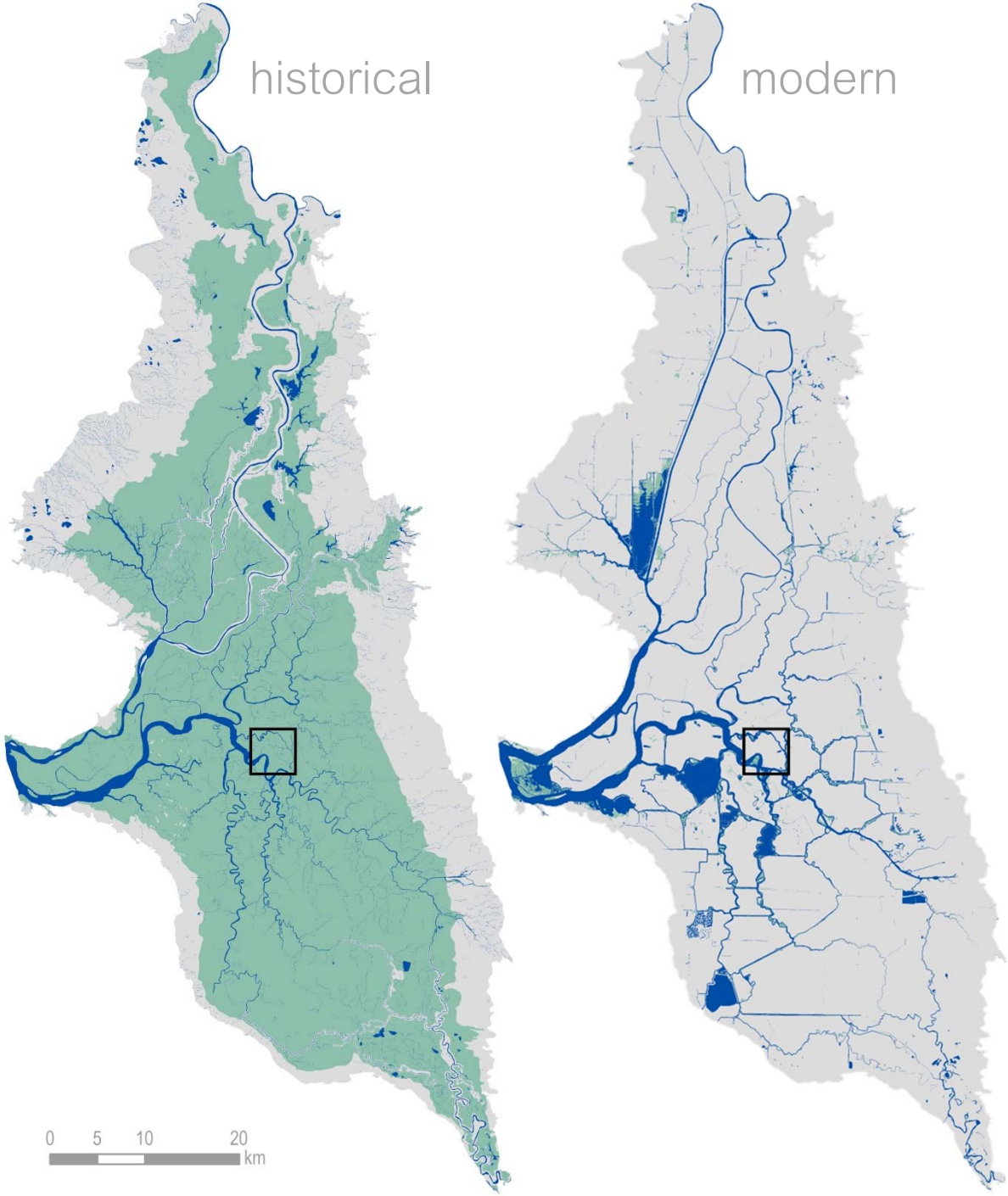
LEVEL	POPULATION						COMMUNITY	
THEME	Life history support					Adaptation potential	Food webs	Biodiversity
FUNCTION	Provides habitat and connectivity for fish	Provides habitat and connectivity for marsh wildlife	Provides habitat and connectivity for waterbirds	Provides habitat and connectivity for riparian wildlife	Provides habitat and connectivity for marsh-terrestrial transition zone wildlife	Maintains adaptation potential within wildlife populations	Maintains food supplies and nutrient cycling to support robust food webs	Maintains biodiversity by supporting diverse natural communities
METRICS	Inundation extent, duration, timing, and frequency	Marsh area by patch size (patch size distribution)	Ponded area in summer by depth and duration	Riparian habitat area by patch size	Length of marsh-terrestrial transition zone by terrestrial habitat type	To be addressed with qualitative conceptual models in Task 4.	Expected to be addressed with a related project.	To be addressed with qualitative conceptual models in Task 4.
	Marsh to open water ratio	Marsh area by nearest neighbor distance	Wetted area by type in winter	Riparian habitat length by width class				
	Adjacency of marsh to open water by length and marsh patch size	Marsh core area ratio						
	Ratio of looped to dendritic channels (by length and adjacent habitat type)	Marsh fragmentation index						


historical
modern
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
ca. 1800
ca. 2000
Agriculture
Urban/Barren
Woodland/Savanna
Grassland
Inland dune scrub
Alkali seasonal wetland complex
Vernal pool complex
Wet meadow/ Seasonal wetland
Valley foothill riparian
Willow
Freshwater emergent wetland
Water

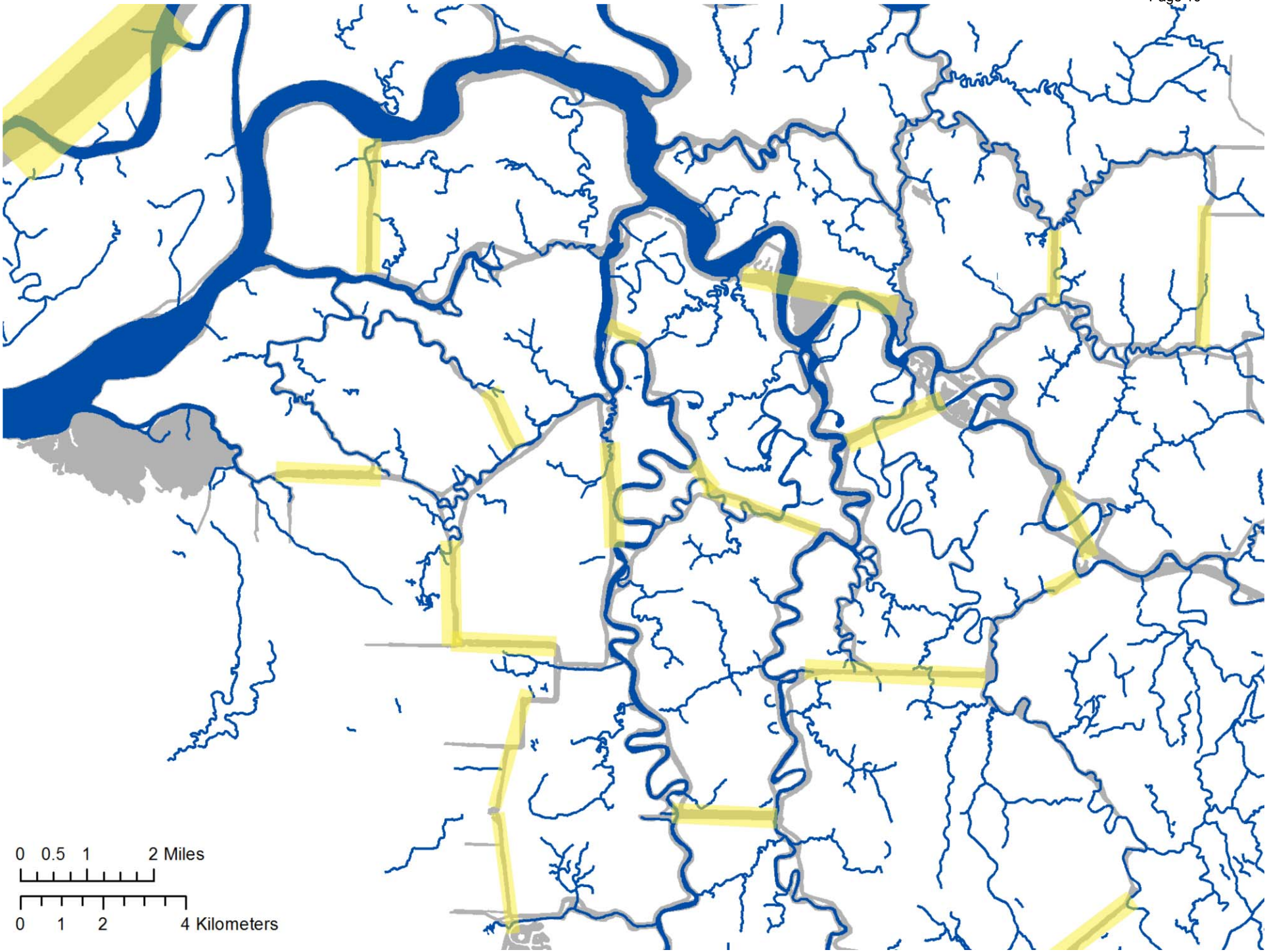


Jeff Opperman



marsh

98% loss of tidal marsh


0 0.5 1 2 Miles
0 1 2 4 Kilometers

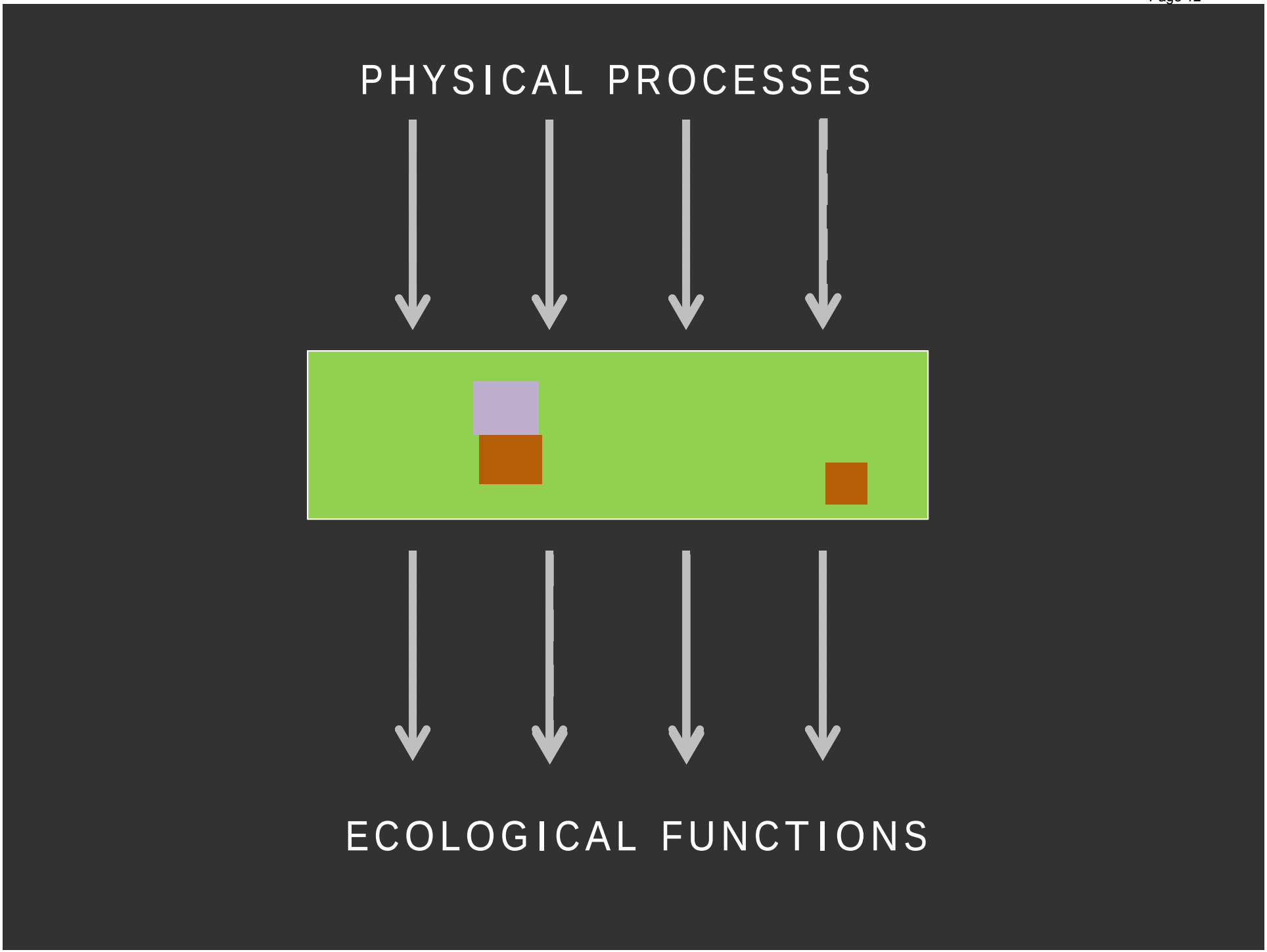
Landscape Resilience Framework

1	SETTING	Unique geophysical, biological, and cultural aspects of a landscape that determine potential constraints and opportunities for resilience
2	PROCESS	Physical, biological, and chemical drivers, events, and processes that create and sustain landscapes over time
3	CONNECTIVITY	Linkages between habitats, processes, and populations that enable movement of materials and organisms
4	DIVERSITY & COMPLEXITY	Richness in the variety, distribution, and spatial configuration of landscape features that provide a range of options for species
5	REDUNDANCY	Multiple similar or overlapping elements or functions within a landscape that promote diversity and provide insurance against loss
6	SCALE	The spatial extent and time frame at which landscapes operate that allows species, processes, and functions to persist
7	PEOPLE	The individuals, communities, and institutions that shape and steward landscapes

13

resilientsv.sfei.org

Beller E, Spotswood E, Robinson A, Anderson M, Grenier L, Grossinger R, Higgs E, Hobbs R, Suding K, Zavaleta E. *in prep.*


PHYSICAL PROCESSES
ECOLOGICAL FUNCTIONS

Ecological Functions (DRAFT)

CONTINUED

SUPPORTING MARSH WILDLI

Recommendations

- ***Restore large areas of marsh, and protect existing large mars*** support sustainable wildlife populations, complex communities, complet on the marsh surface. See "marsh processes" strategy for guidance on
- ***Maintain, support, and, when necessary, mimic the natural pr*** persistence. In particular, flows and sediment that support channel form accretion. See oblique diagram, with more details in the "strategies sec
- ***Maintain complexity and diversity*** by having large marshes across microclimates and hydrologic patterns that exist in different parts of th structure, vegetative communities and habitat adjacencies. The South D marsh types found in the historical Delta are not well represented today
- ***Restore marshes near existing remnant and restored marshes*** increase connectivity to these marshes. The small remnant islands in th marshes in the Delta and may contain unique genetic diversity.
- ***Create redundancy in support for marsh wildlife*** by maintaining isolation between populations and patches to reduce the likelihood that invasive species) would lead to catastrophic loss.
- ***Maintain unleveed connections between marsh and open wate*** biota between habitats. Allows more productivity export, fish access to flooding gradients within marshes that influence vegetative structure a
- ***Restore complex dendritic channel networks*** that increase the a marsh and open water systems. The development of complex channel ne the right areas, with full connection to tidal action.
- ***Support landscape configurations that will allow connectivity*** near one another (see guidance for patch distances in strategies sectio supplemental resources and permeability to marsh wildlife (e.g., suppor waterbirds, in agricultural fields) between or adjacent to marshes. Well marsh wildlife movement, including dispersal and gene flow. This conne advantage of new areas as conditions change (e.g., marsh drowning, ne
- ***Restore, maintain, and protect long, continuous marsh tidal-*** complex ecotone (where appropriate). This will support marsh migratio acclimation and adaptation.

Short term to long term planning

Prioritize taking advantage of near term time-sensitive opportunities. Spe elevation that will be harder to restore as SLR increases. Don't foreclose o opportunities that are not feasible now. Future opportunities for marsh res along the Delta periphery, however there is a lot of uncertainty around pos marsh restoration on tidal prism. Major knowledge gaps: channel formatio on existing and planned marshes, thresholds for production and export (se

Intensive management may still be required, particularly in the short term, t commensalist predators, contaminants, etc. Hopefully the need for these in planning, but even if it doesn't, the chances that these intervetions will be su protect against/control invasive species, contaminants, etc. Interventions m will depend upon the location of marshes within the Delta. The specific spec position within the Delta, with respect to salinity and climatic gradients. (in

Re-establish marsh processes at intertidal elevations

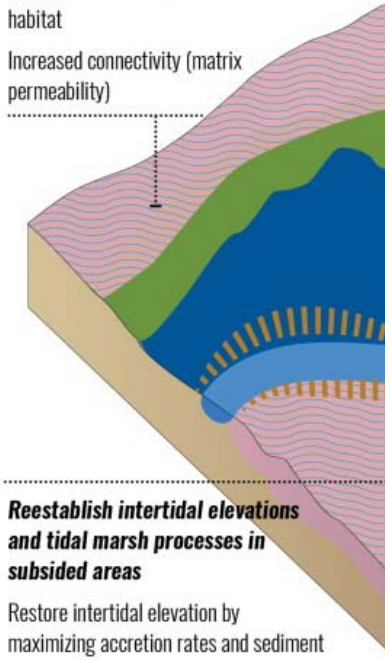
Elevation and hydrology to support emergent macrophytes

Hydrologic connectivity to support exchange of nutrients, sediment, production

Expand wildlife friendly agriculture

Additional food resources and habitat

Increased connectivity (matrix permeability)

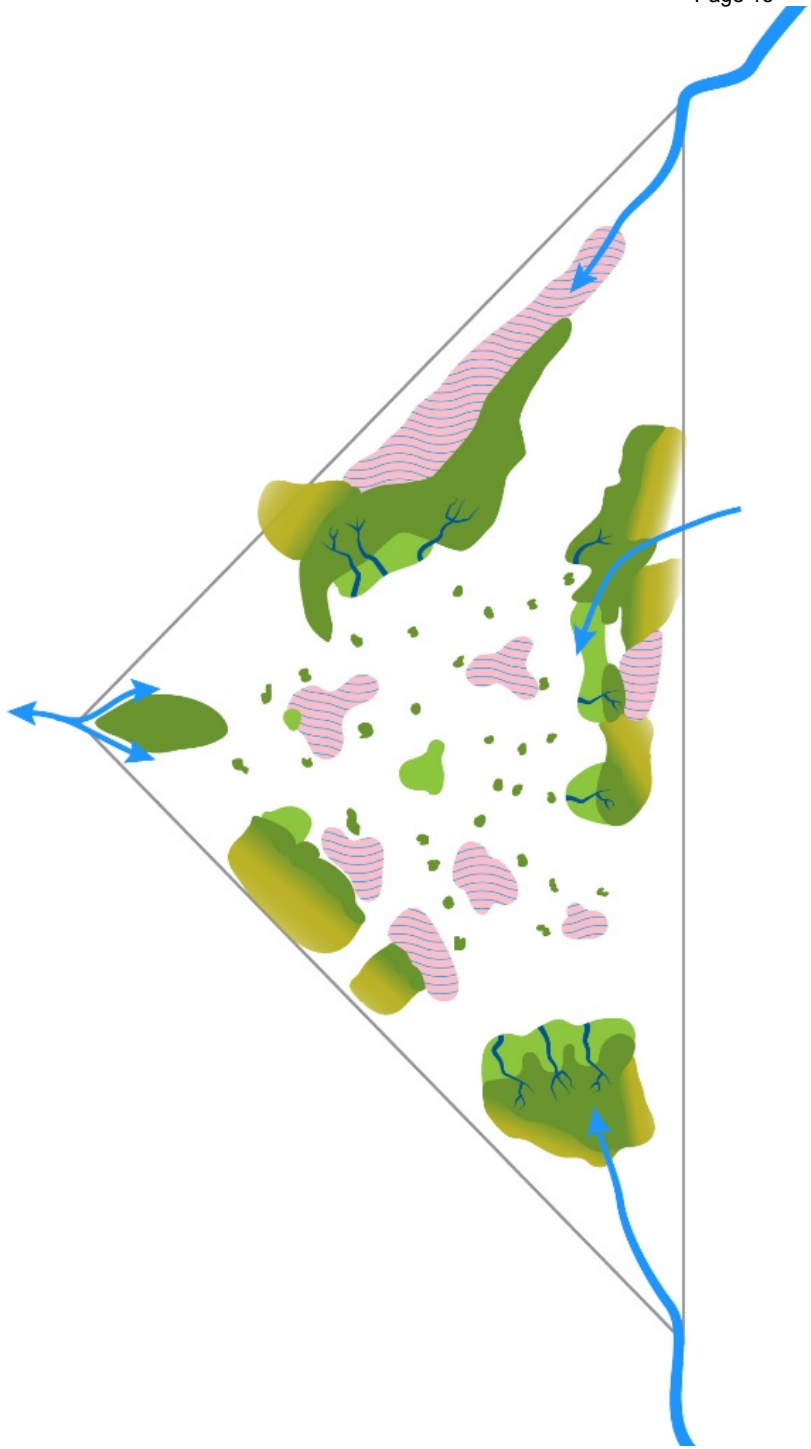


Reestablish intertidal elevations and tidal marsh processes in subsided areas

Restore intertidal elevation by maximizing accretion rates and sediment accumulation

Reestablish connection between streams and tidal floodplains

More dynamic, complex marsh habitats

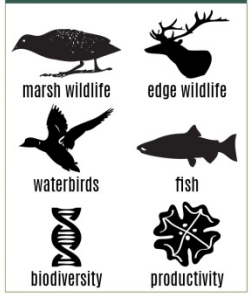


Process-based Strategies

RESTORE TIDAL PROCESSES

Reestablish tidal marsh processes in areas at intertidal

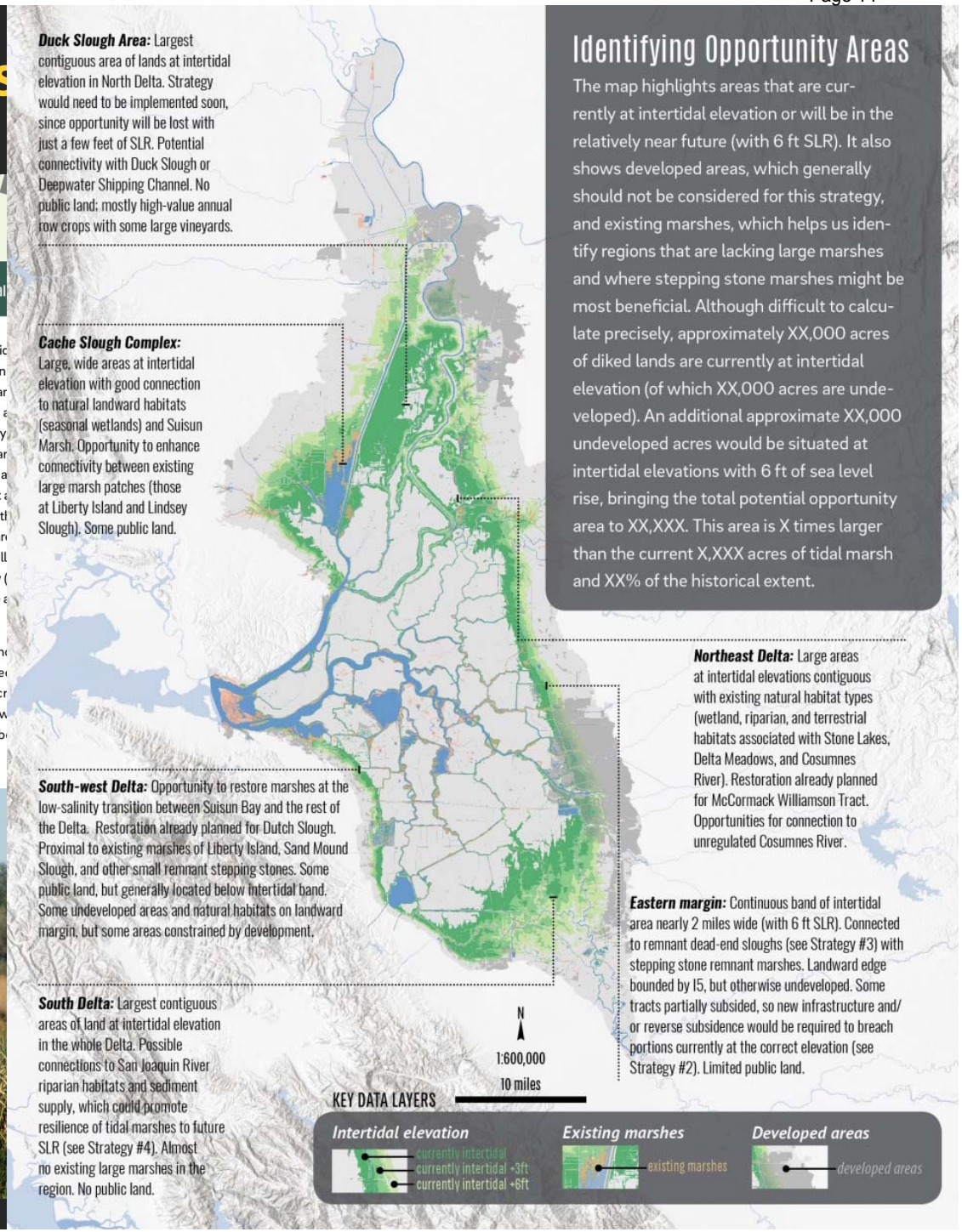
Supported Functions



Large swaths of land in the Delta currently are situated at intertic tions, but are separated from the tides by dikes and other human ture. These areas have the greatest potential to support tidal mar minimal management intervention. If connected to tidal action, a intertidal elevation would be inundated at a depth and frequency propriate for the establishment and persistence of emergent mar tion. The ebb and flow of the tides across intertidal areas would a processes such as sediment deposition, scour, and flooding that a to create channel networks, ponded areas, natural levees, and oth tant marsh features. However, the areas at intertidal elevation ar As sea level continues to rise, the areas at intertidal elevation will process generates opportunities to restore tidal marshes in new (areas in the future, but also increases the urgency to restore the a are currently intertidal while their elevation is still favorable.

Tactics for carrying out this strategy include: connecting lan intertidal areas to tidal action by removing or breaching leve ing other barriers to the exchange of water and sediment acr surfaces; and preventing the erosion of marsh edges using w energy breaks and other shoreline stabilization structures (b and non-living).

Caption. Aquatintur, sit earchilit preptiuntis quiam hilitatio is dolorrovid moluptatum eaquat. Onseque sequi debit doloribus exerior andio corro volum quo conem quae sequibusam, totatur? Xero erovidendi doluptur?



Duck Slough Area: Largest contiguous area of lands at intertidal elevation in North Delta. Strategy would need to be implemented soon, since opportunity will be lost with just a few feet of SLR. Potential connectivity with Duck Slough or Deepwater Shipping Channel. No public land; mostly high-value annual row crops with some large vineyards.

Cache Slough Complex: Large, wide areas at intertidal elevation with good connection to natural landward habitats (seasonal wetlands) and Suisun Marsh. Opportunity to enhance connectivity between existing large marsh patches (those at Liberty Island and Lindsey Slough). Some public land.

South-west Delta: Opportunity to restore marshes at the low-salinity transition between Suisun Bay and the rest of the Delta. Restoration already planned for Dutch Slough. Proximal to existing marshes of Liberty Island, Sand Mound Slough, and other small remnant stepping stones. Some public land, but generally located below intertidal band. Some undeveloped areas and natural habitats on landward margin, but some areas constrained by development.

South Delta: Largest contiguous areas of land at intertidal elevation in the whole Delta. Possible connections to San Joaquin River riparian habitats and sediment supply, which could promote resilience of tidal marshes to future SLR (see Strategy #4). Almost no existing large marshes in the region. No public land.

Identifying Opportunity Areas

The map highlights areas that are currently at intertidal elevation or will be in the relatively near future (with 6 ft SLR). It also shows developed areas, which generally should not be considered for this strategy, and existing marshes, which helps us identify regions that are lacking large marshes and where stepping stone marshes might be most beneficial. Although difficult to calculate precisely, approximately XX,000 acres of diked lands are currently at intertidal elevation (of which XX,000 acres are undeveloped). An additional approximate XX,000 undeveloped acres would be situated at intertidal elevations with 6 ft of sea level rise, bringing the total potential opportunity area to XX,XXX. This area is X times larger than the current X,XXX acres of tidal marsh and XX% of the historical extent.

Northeast Delta: Large areas at intertidal elevations contiguous with existing natural habitat types (wetland, riparian, and terrestrial habitats associated with Stone Lakes, Delta Meadows, and Cosumnes River). Restoration already planned for McCormack Williamson Tract. Opportunities for connection to unregulated Cosumnes River.

Eastern margin: Continuous band of intertidal area nearly 2 miles wide (with 6 ft SLR). Connected to remnant dead-end sloughs (see Strategy #3) with stepping stone remnant marshes. Landward edge bounded by I5, but otherwise undeveloped. Some tracts partially subsided, so new infrastructure and/or reverse subsidence would be required to breach portions currently at the correct elevation (see Strategy #2). Limited public land.

Process-based Strategies (DRAFT)

LANDSCAPE SCALE & CONFIGUR

4 **Marshes should be as large as**

Though small marshes have some valu
with their size. For example, marshes
reach approximately 100 ha in size. B
that exist today are liekly needed to m

Reference values

<1 ha = minimum marsh pato
1 ha = minimum marsh pato
100 ha = minimum marsh pato
500 ha = approximate marsh a
4,494 ha = average **historical** p
4 ha = average **modern** pat
110,527 ha = maximum **historical**
749 ha = maximum **modern** p

Reference values

1 ha = minimum marsh patch size for Black Rail occupancy
100 ha = minimum marsh patch size for maximum Black Rail density
500 ha = approximate marsh area for a full channel network (based on historical landscape)
4,494 ha = average **historical** patch size (SD = 17,956)
4 ha = average **modern** patch size (SD = 24)
110,527 ha = maximum **historical** patch size
749 ha = maximum **modern** patch size

4,50

- ***2 ha*** *= minimum patch size for Black Rails*

100 ha *= minimum patch size to support maximum density of Black Rails*

500 ha *=patch size for full channel networks.*

4,500 ha *= average historical patch size*

*Grey background circle shows the maximum historical patch size (**110,500 ha**)*

PRESENT

THANKS

CDFW: Daniel Burmester, Carl Wilcox, Dave Zezulak, Kevin Fleming

DSP: Peter Goodwin, Chris Enright, Anke Mueller-Solger, Cliff Dahm, Rainer Hoenicke

Landscape Interpretation Team science advisors

CDFW, ERP, DWR, SFCWA , TNC for funding

http://sfei.li/deltametrics

CALIFORNIA DEPARTMENT OF FISH & WILDLIFE

ECOSYSTEM RESTORATION PROGRAM
California Department of Fish & Game
National Oceanic & Atmospheric Administration
US Fish & Wildlife Service