Delta Landscape Change

Robin Grossinger

Letitia Grenier

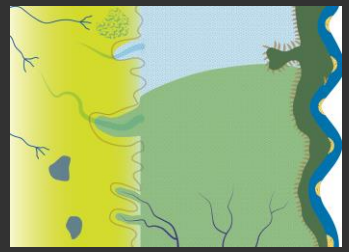
CO-AUTHORS:

Ruth Askevold

Julie Beagle

April Robinson

Sam Safran



SFEI-ASC

Delta Challenges Workshop
March 16, 2015

AQUATIC SCIENCE CENTER

- Massively transformed physical landscape (>100yrs ago)
- Has affected Delta's ability to support native plants and animals
- Implications not well understood functionally
- Need to improve ecological functions for native species in novel landscape
    - Reduction in freshwater flows
    - Invasion by nonnatives
    - Contaminants

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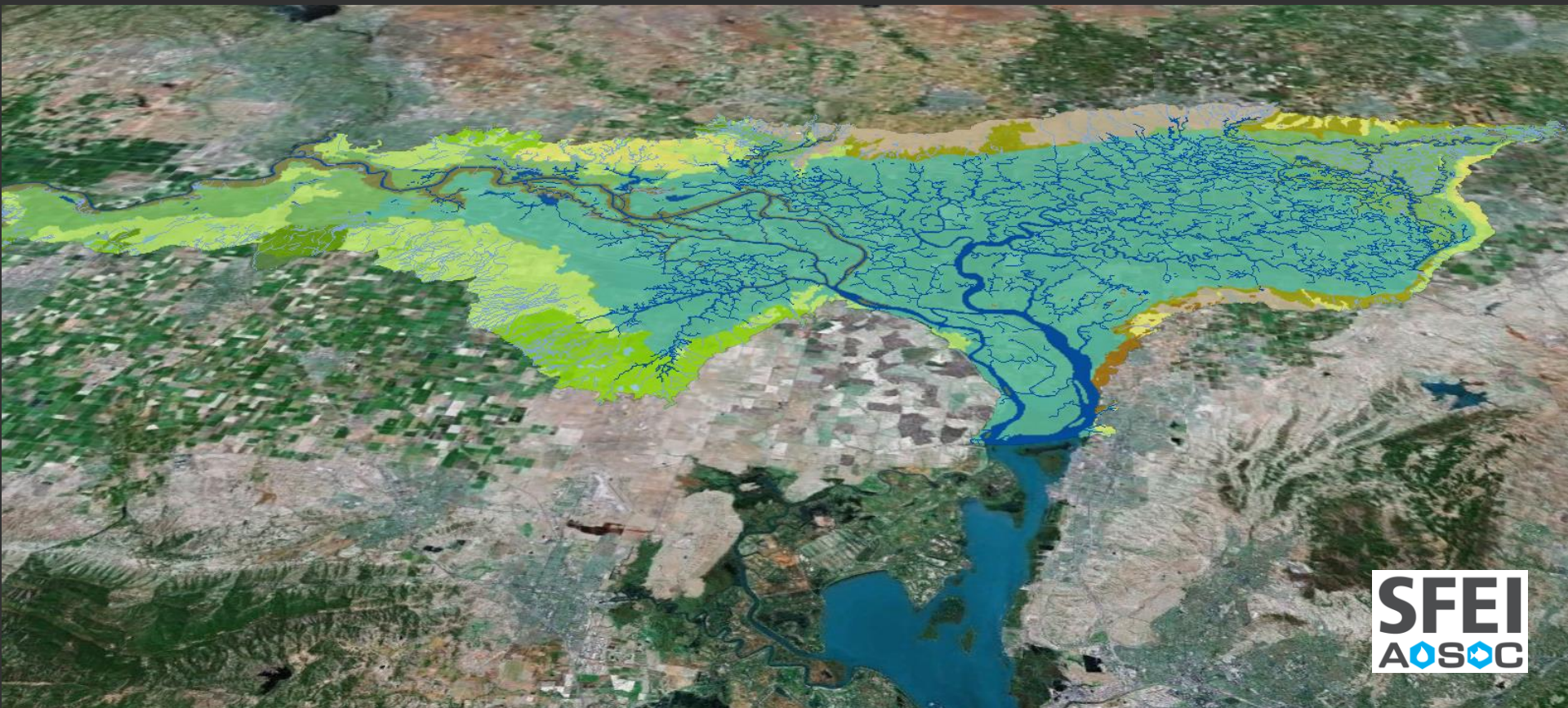
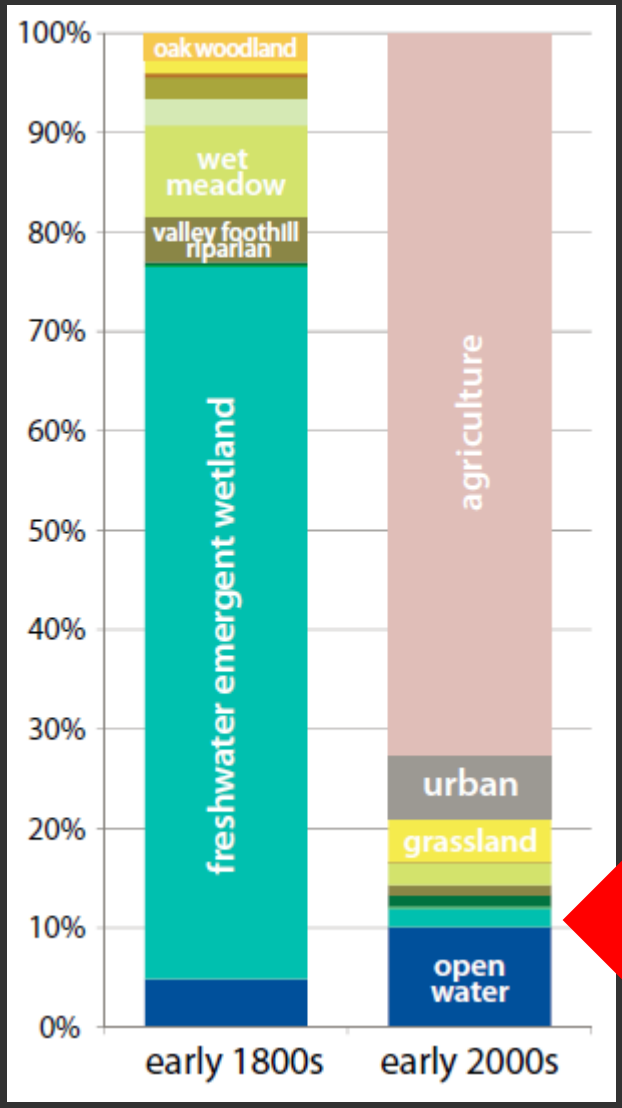
Habitats that dominated the landscape, such floodplains, marshes, and wide riparian forests, have declined precipitously in extent.

The historical Delta marsh was vast – > 20 times the size of Manhattan

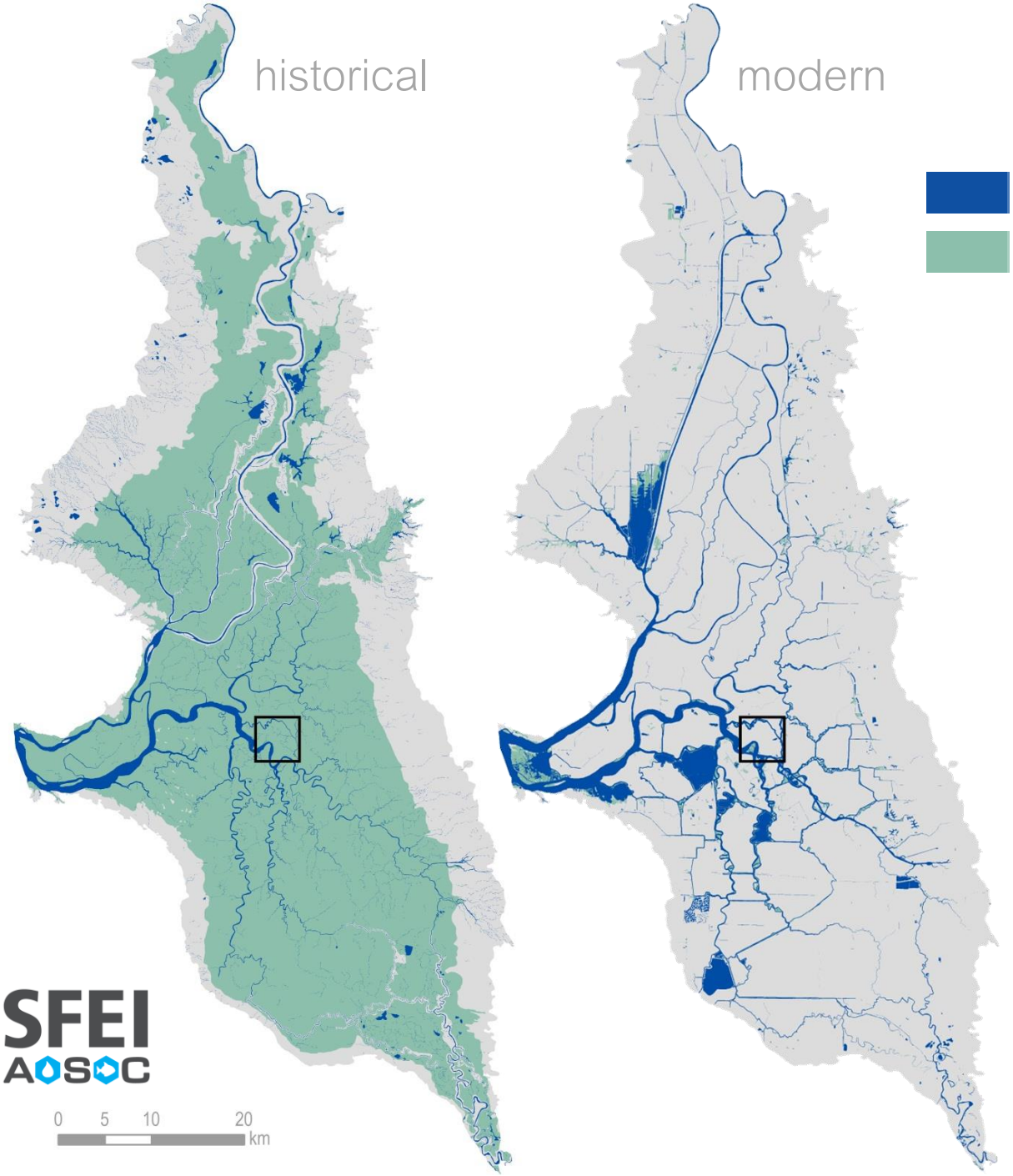


98% loss of historical freshwater wetlands

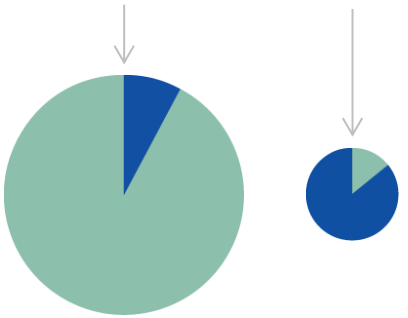


- from approximately 190,000 hectares to just over 4,000 hectares

73-fold reversal in the ratio between marsh and open water in the Delta



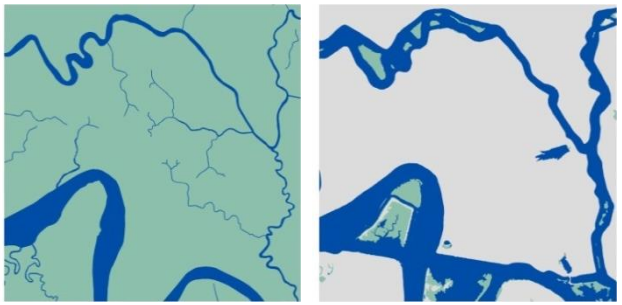
	historical	modern
open water	16,300 ha	26,600 ha
marsh	193,200 ha	4,300 ha



100 : 1,182 100 : 16

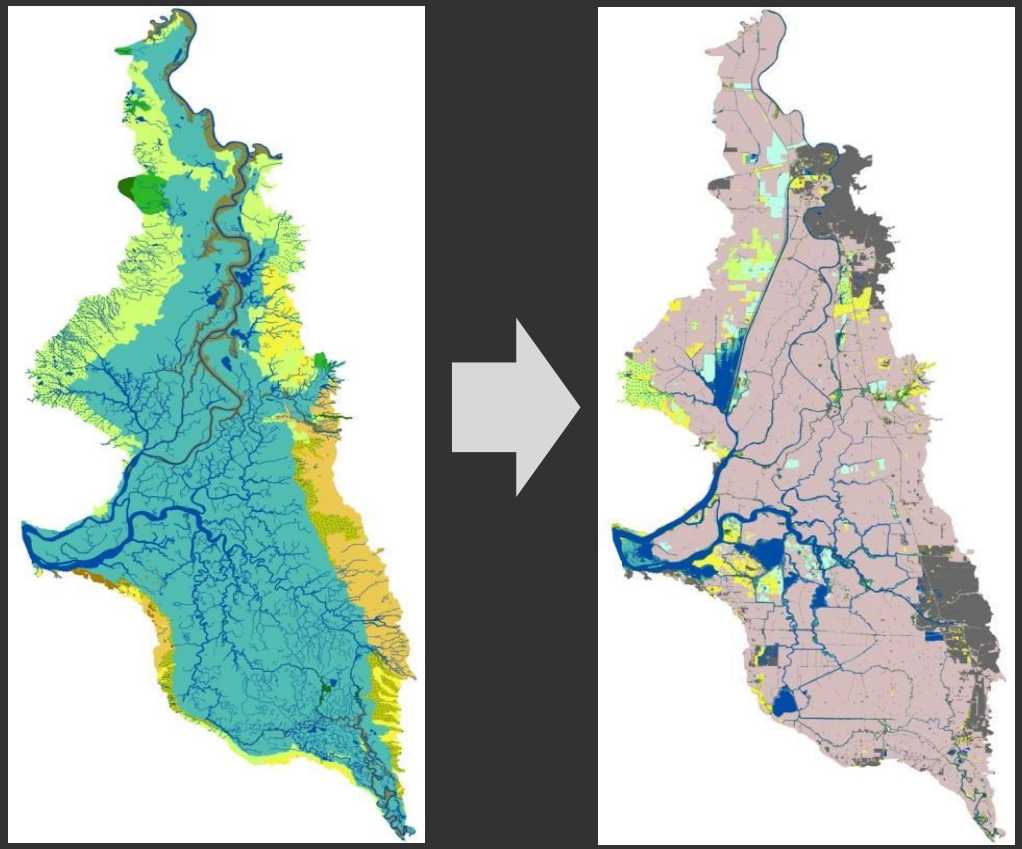
74x decrease in marsh to open water ratio

"channels in marsh" → "marsh in channels"



Wholesale ecosystem conversion from a variable and dynamic wetland landscape . . .

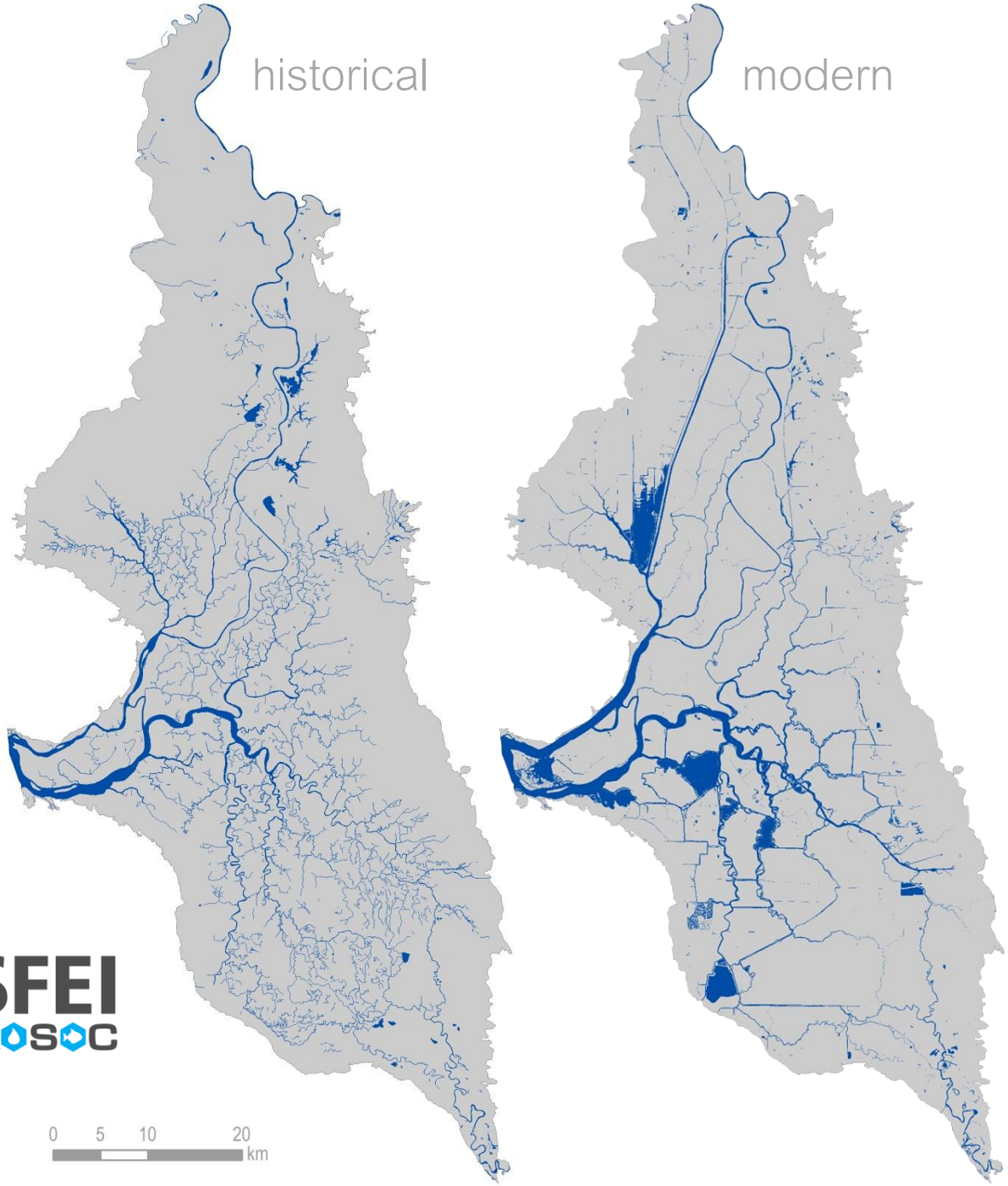
. . . to a dichotomous landscape of dry land and open water with engineered banks



2 Aquatic habitats have also undergone wholesale conversion

- Despite retaining some of the original system's template, i.e. sinuous channels and tidal flows
- Some dominant native aquatic habitat types have been nearly eliminated, while other novel types have been created

Most of the temporarily flooded habitat available to fish in the Delta has been lost.



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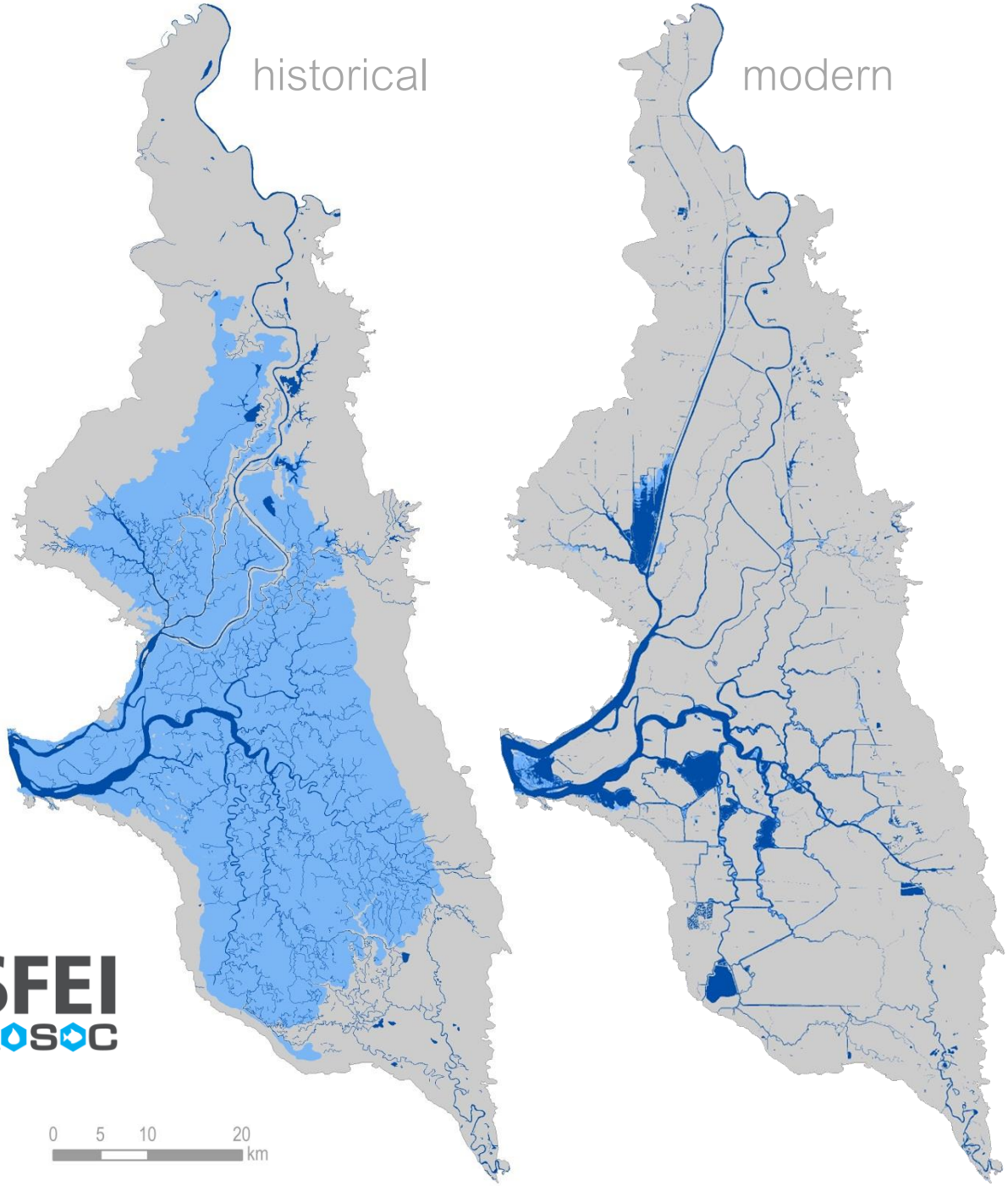
PONDS, LAKES, CHANNELS, FLOODED ISLANDS

Mostly perennial open water features

- variable depth



PONDS, LAKES, CHANNELS, FLOODED ISLANDS

Mostly perennial open water features

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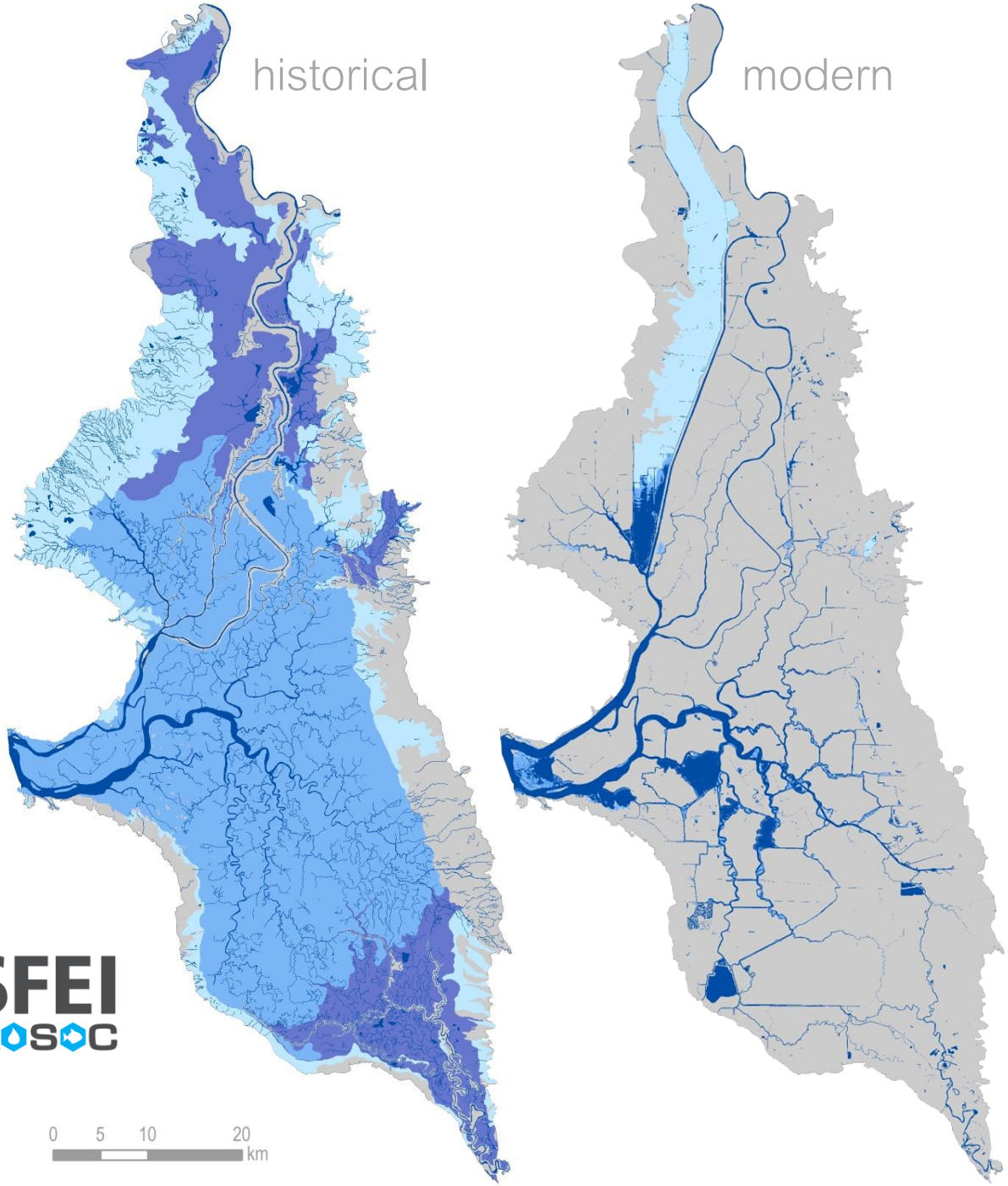
TIDAL INUNDATION

Diurnal overflow of tidal sloughs into marshes

- high recurrence (2x daily to monthly)
- low duration (< 6 hrs per event)
- low depth ("wetted" up to .5 m)



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SEASONAL LONG DURATION FLOODING

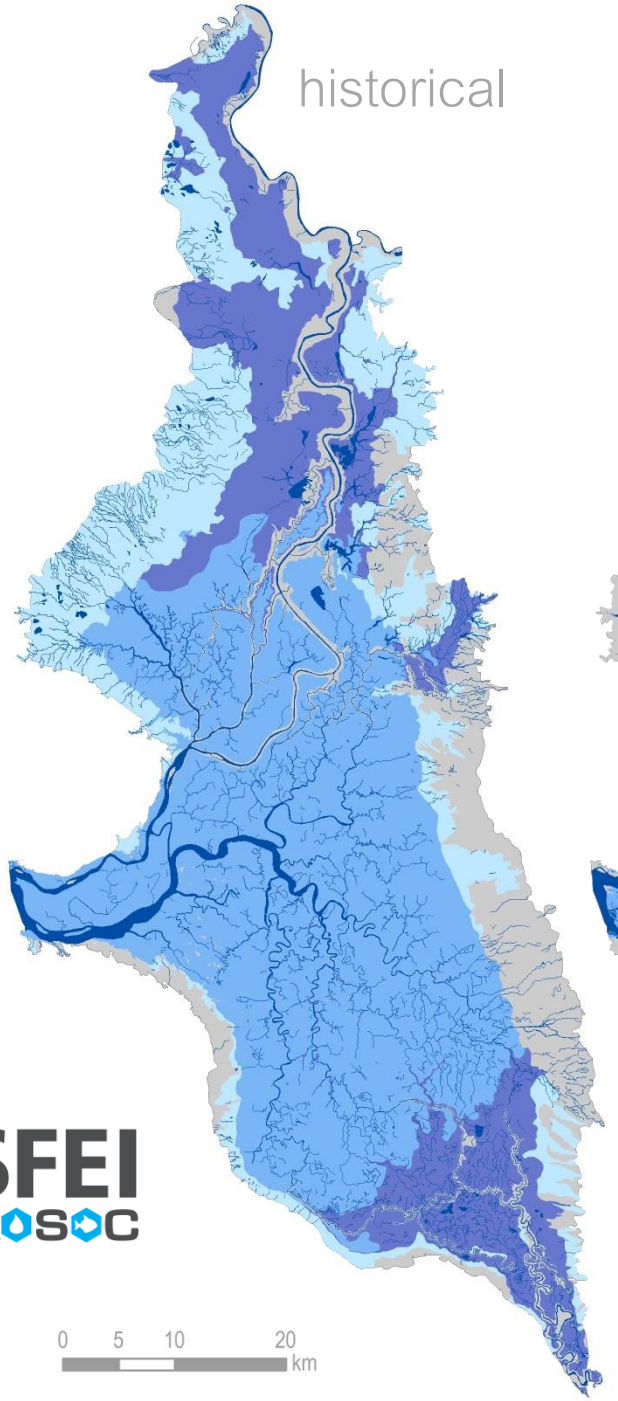
Prolonged inundation from river overflow into flood basins

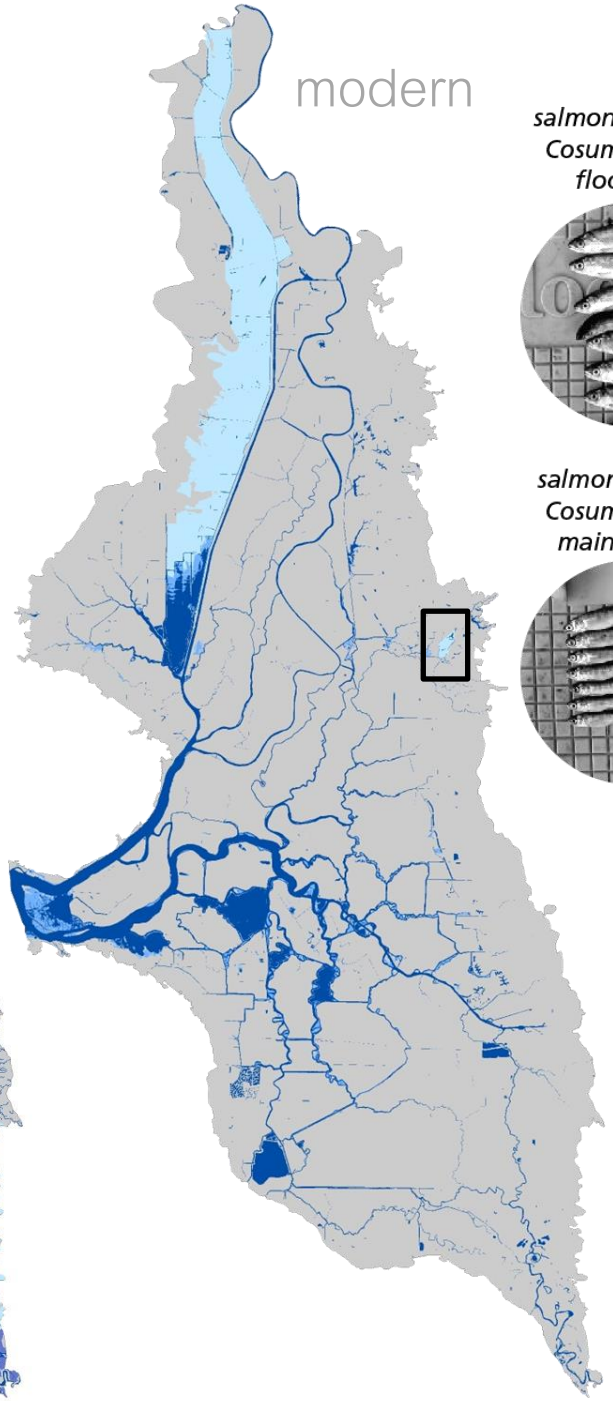
- low recurrence (~1 event per year)
- high duration (persists up to 6 month)
- generally deeper than 'seasonal short-term flooding'

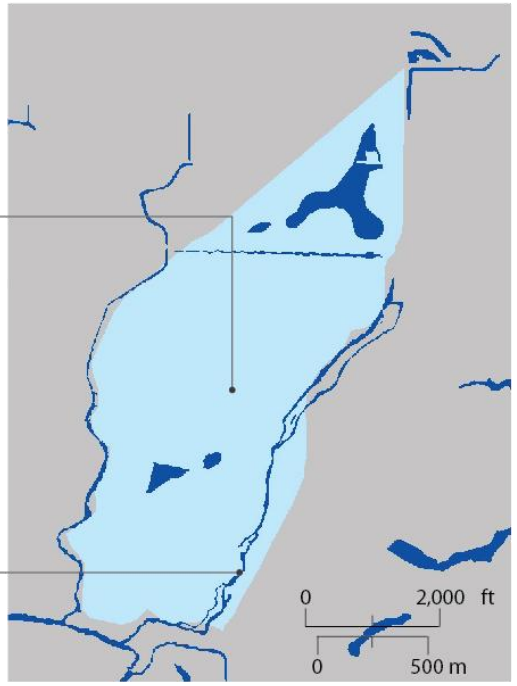
SEASONAL SHORT-TERM FLOODING

Short-term fluvial inundation

- can be multiple events per year
- low duration (days-weeks per event)
- generally shallower than 'seasonal long duration flooding'







photos by Jeff Opperman, 2006

Juvenile salmon reared in ephemeral floodplain habitats of the Cosumnes River have been found to grow significantly larger than juvenile salmon reared only within the Cosumnes River (Jeffres et al. 2008).

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km

PONDS, LAKES, CHANNELS, FLOODED ISLANDS

TIDAL INUNDATION

SEASONAL LONG DURATION FLOODING

SEASONAL SHORT-TERM FLOODING

Small marsh channels in a coherent network with likely high residence time exchanged for wider larger channels and flooded islands

Likely facilitated dominance by invasive aquatic weeds and lake fish that have severely altered the aquatic habitat structure and community ecology

Complex dendritic channel networks likely provided high productivity habitat for fish

Most dendritic channels are now gone, especially in the central Delta

As Delta marshes were diked, connections were severed to the channel networks that wove through them. These dendritic lower-order tidal channels (also known as "dead-end" or "blind channels") that terminated within the wetland were once the capillary exchange system between the wetland and aquatic areas, promoting both food web productivity and spatial complexity in habitat conditions. They provided native fish species with a range of gradients (e.g., temperature, turbidity, and water velocity) at both large and small scales. Dendritic channel networks offered channel complexity and higher turbidities, which provided refuge for certain species. Channels that branched through the marsh may have been particularly important for salmonids because they provided access to and export of invertebrates from the marsh plain,[10] physical cover and turbidity for refuge, and slow moving water for energetic refugia. The larger, looped channels that characterize the Delta today allow water to move through and mix more quickly, with less diversity in residence time and less heterogeneity in channel habitat. The lack of large wetlands connected to channels means that there is little exchange of organic matter, organisms, or sediment between these ecosystems.

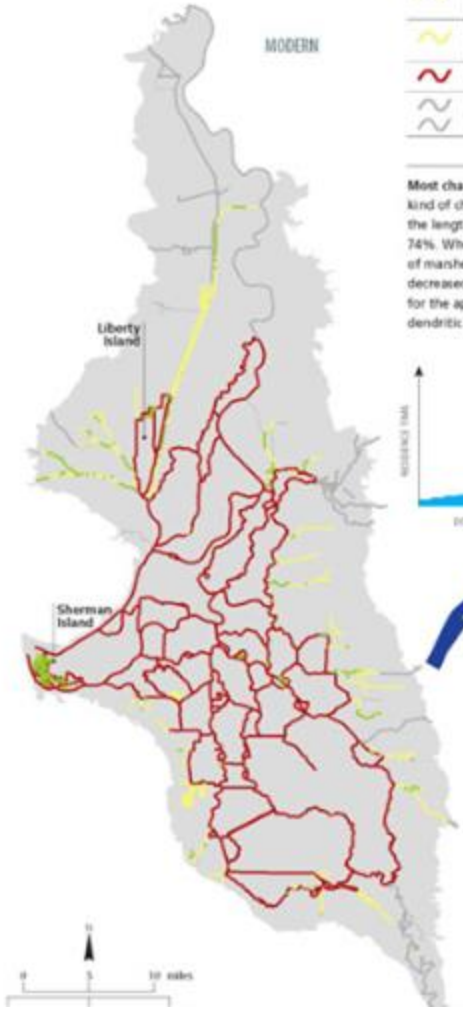
Comparing the historical (right) and modern (far right) landscape. While the skeletal framework of looped mainstem channels remains largely similar (red), the branching networks of dendritic channels (green and yellow) are mostly gone.

Methods: Classifying channel types

Channel reaches were manually classified using the following definitions:

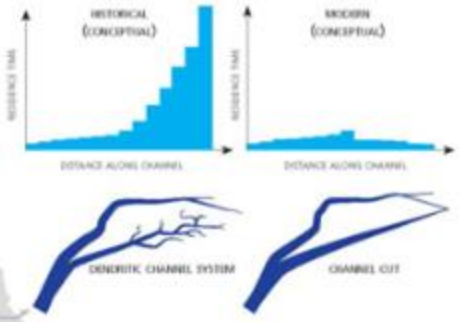
- Dendritic: tidal channel reaches connected to the tidal source by only one non-overlapping path
- Looped: tidal channel reaches connected to the tidal source (the Delta mouth) by two independent and non-overlapping paths
- Fluvial: channel reaches connected to the tidal source, but upstream of the approximate limit of bidirectional tidal flows (during spring tides in times of low river stages) AND tidal reaches between upstream perennial fluvial reaches and downstream flow through reaches
- Detached: channel reaches without a direct connection to the tidal source (through the larger channel network)

Dendritic channels (segmented at 100 m intervals) were classified into those adjacent to marsh and those not adjacent to marsh, based on the habitat type



Channel classification	Channel length (km) Historical	Modern
Dendritic channels adjacent to marsh	1,151	84
Dendritic channels not adjacent to marsh	153	255
Looped Channels	754	768
Fluvial / Detached	2,225	298
TOTAL	4,283	1,404

Most channels in the Delta today are looped. The length of this kind of channel has slightly increased (due to channel cuts), while the length of dendritic tidal channels has decreased by more than 74%. Where dendritic channels do exist, they are generally not part of marshes—the length of dendritic channels adjacent to marsh has decreased by 93%. These figures and tables do not show or account for the approximately 1,900 km of estimated unmapped, low-order dendritic channels in the historical Delta.



Historically, the complex structure of Delta channels established gradients in residence time, a pattern heavily altered in the modern Delta (after Chris Enright, Delta Science Program). Historically, small low-order tidal creeks had high residence times, which allowed phytoplankton to accumulate and created net autotrophic conditions. Deeper sloughs, by contrast, had shorter residence times which created net heterotrophic conditions. The increased connectivity of modern channels in the Delta has led to homogenization of residence time across channel networks, increasing the reach of tidal excursion within channel networks and decreasing the occurrence of small channels with high residence time. The relationship between residence time and primary productivity in the modern Delta has been additionally

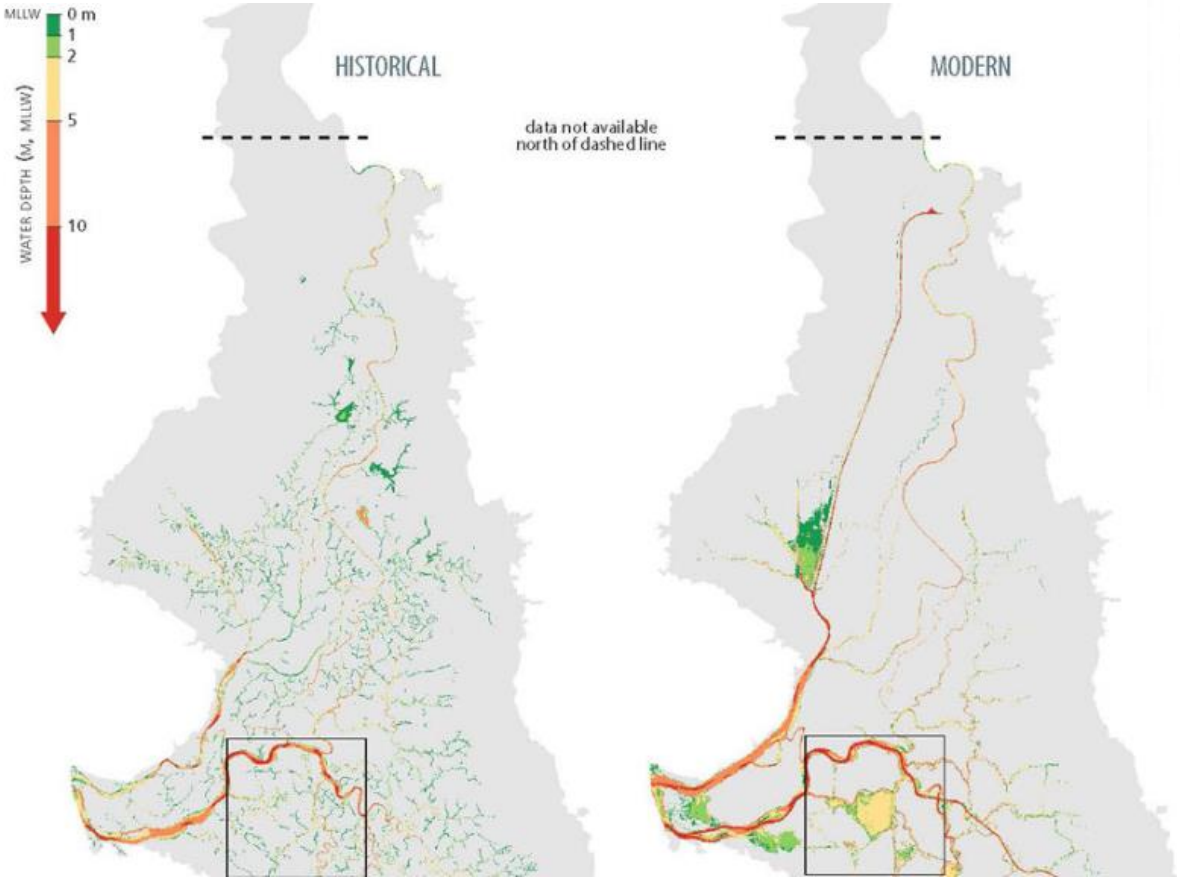
Over-connected, leveed channel network leading to highly altered physical processes that are critical to biological functions

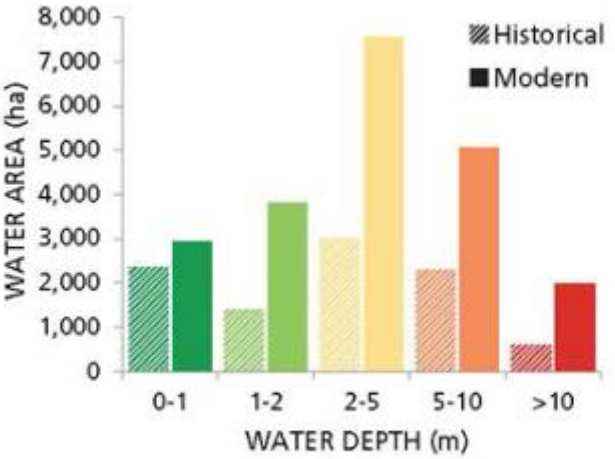
- water residence time
- tidal flows
- sediment transport and deposition
- salinity patterns
- terrestrial linkages

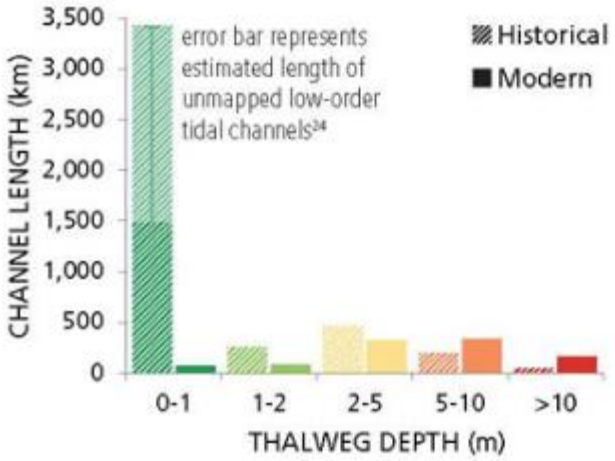
What does this add up to?

- Extreme loss of habitat extent, quality, heterogeneity, appropriate connectivity
- Loss of physical and biological processes that support ecological functions and resilience
  - The Delta no longer functions as a delta, spreading river and bay water and sediment across wetlands, floodplains, and riparian forests
  - Loss of exchange of materials and energy that affects the food web, water quality, and the future potential of these areas to be restored and provide habitat value

There is twice as much shallow-water habitat (<2m) in the Delta today as there was historically.







Historical DEM co-developed with UCDavis CWS (Fleenor, Whipple, Bell, et al.)

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What does this add up to?

- Probable loss of resilience and adaptive capacity in wildlife populations (just when they need it most)
  - Loss of habitat heterogeneity, longer distance to different
  - Loss of habitat options for surviving variability and extreme events
  - Loss of landscape that promoted phenotypic and genotypic diversity

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http://sfei.li/deltametrics
http://www.sfei.org/projects/delta-landscapes-project