Delta Landscape Metrics

Creating a Spatial Framework to Inform Restoration Planning

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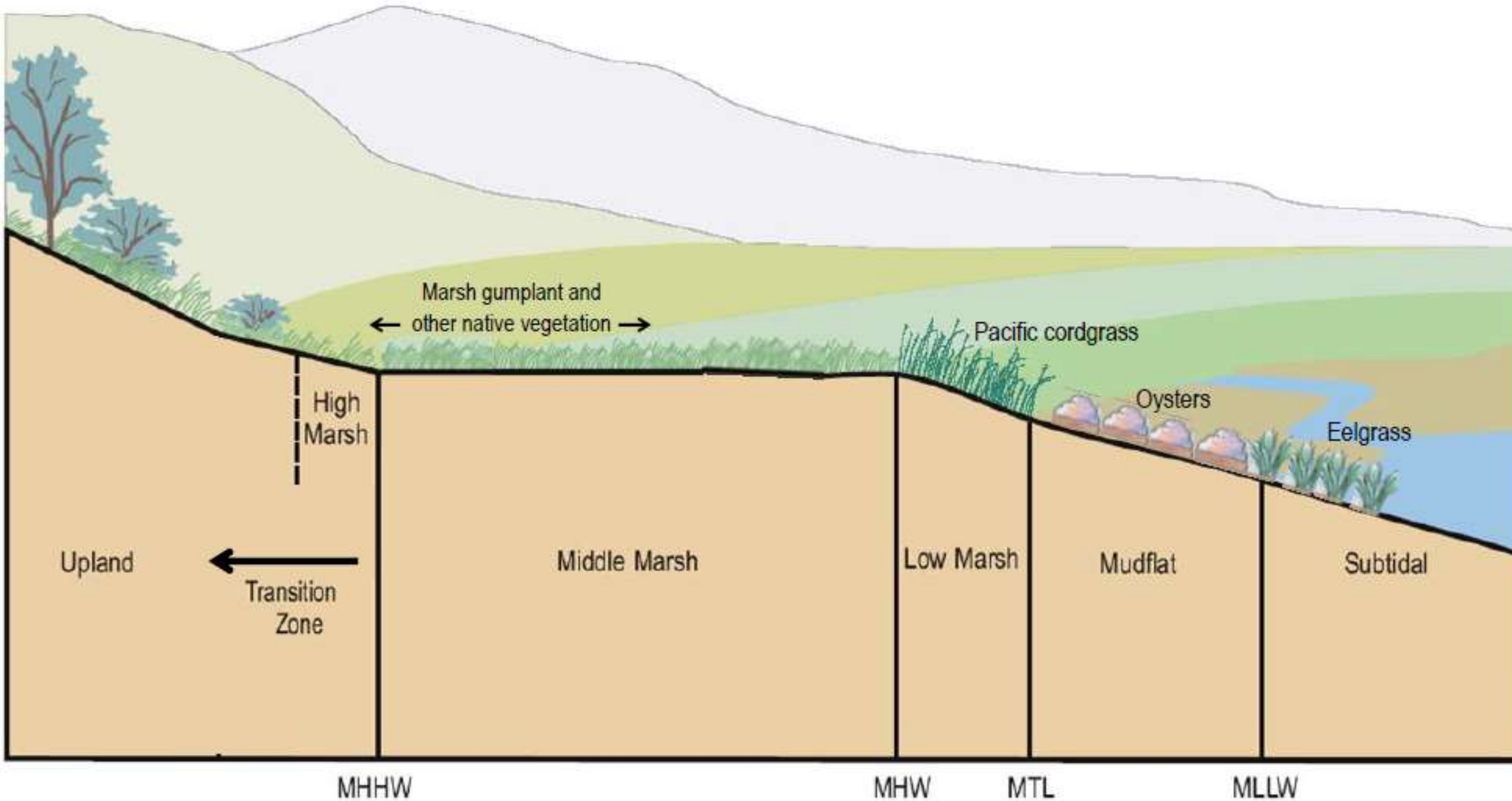
San Francisco Estuary Institute-Aquatic Science Center

Bay-Delta Science Conference
October 29, 2014

AQUATIC SCIENCE CENTER

Complete tidal wetland system



Baylands Goals Update Regional Recommendations

1	**Restore estuary-watershed connections.**
2	**Design complexity and connectivity into the Baylands [and Delta] landscape.**
3	**Restore and conserve complete tidal wetlands systems.**
4	**Plan for the Baylands [and Delta] to migrate.**

The Delta Landscapes Project

Management Tools for Landscape-Scale Restoration

Funded by the Ecosystem Restoration Program

ECOSYSTEM RESTORATION PROGRAM

CALIFORNIA FISH & WILDLIFE

SFEI ASC

A DELTA TRANSFORMED

ecological functions, spatial metrics, and landscape change

IN THE SACRAMENTO-SAN JOAQUIN DELTA

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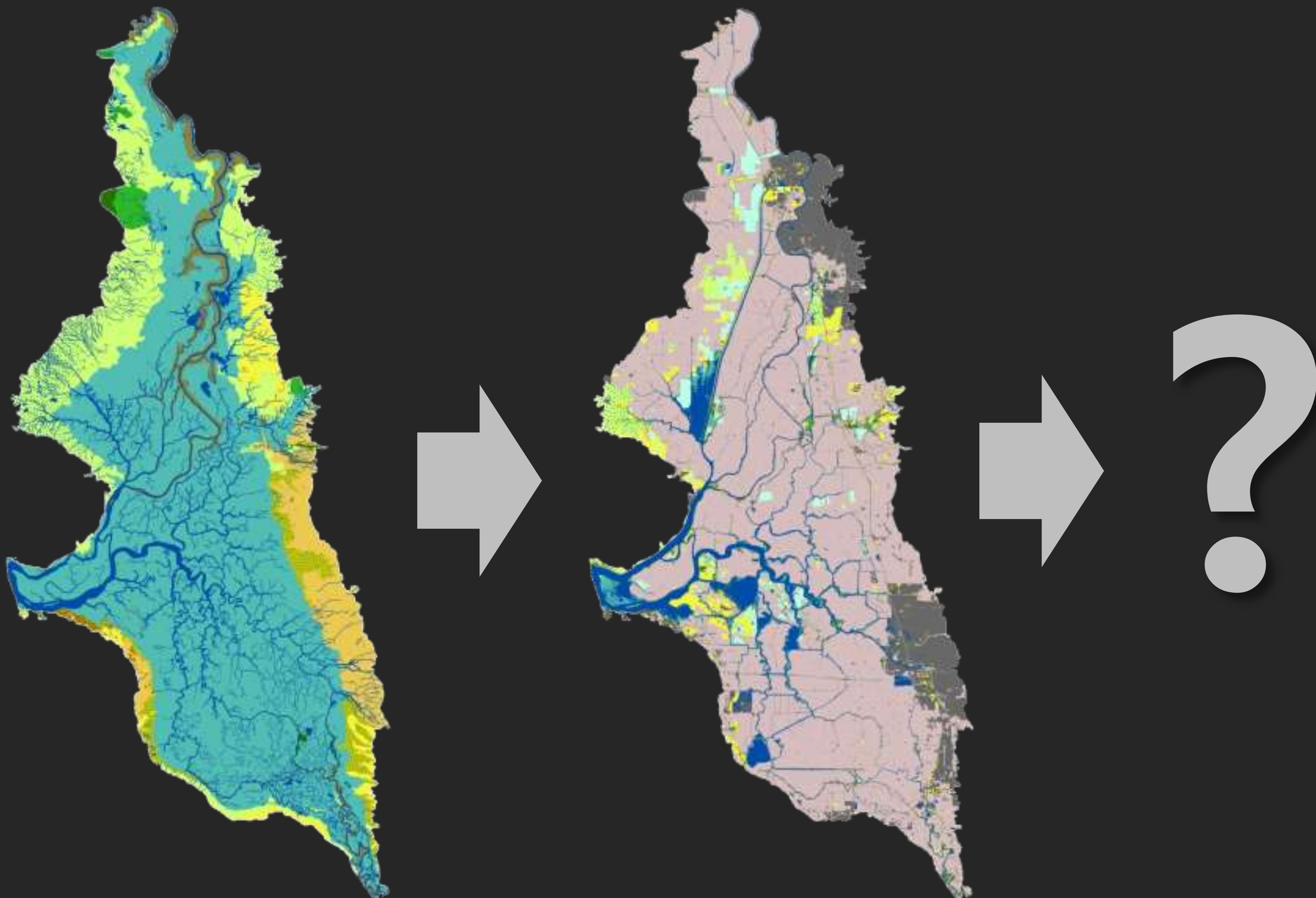
How do we create ecologically functional, resilient *landscapes*? (not just nice projects)



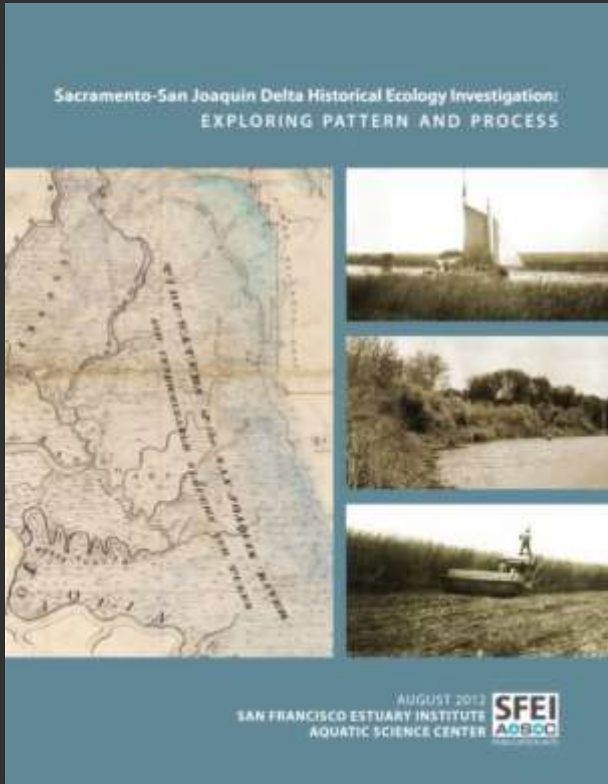
1. **Provide a framework that helps individual projects add up to a larger functional landscape** (pieces of the puzzle)

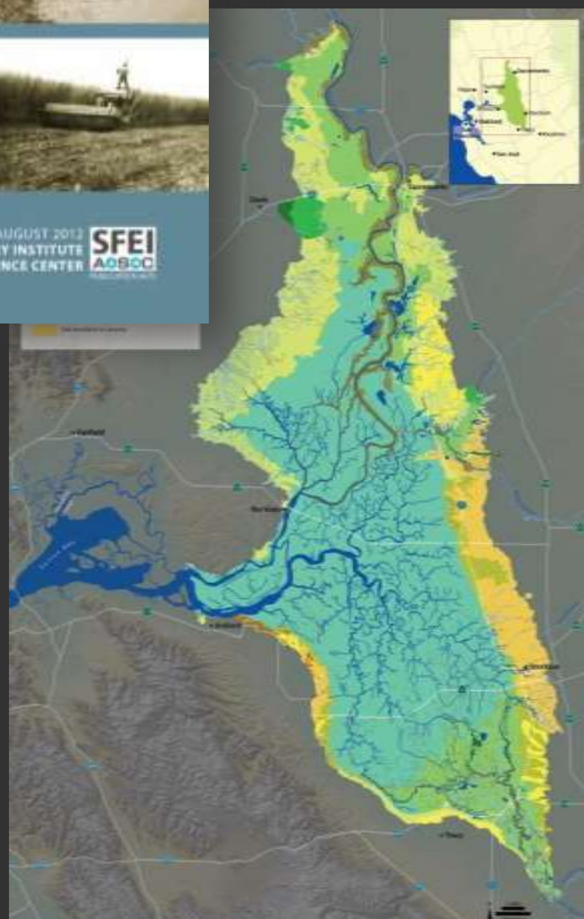
2. **Provide guidance for what kinds of projects make sense where** (avoid one-size-fits-all)

3. **Reduce conflicts and mistakes** (shared understanding of priorities and current science)

4. **Make better use of long-term physical/climatic trajectories** (work with processes, not against them)

5. **Meet landscape-scale species needs** (connectivity, migration)





Sacramento-San Joaquin Delta Historical Ecology Investigation: Exploring Pattern and Process

- Funded by Ecosystem Restoration Program (CDFG, NOAA, US FWS)
- Final Report/GIS Available: www.sfei.org/DeltaHEStudy
- Collaboration with KQED QUEST and Stanford's Bill Lane Center for the American West: science.kqed.org/quest/delta-map/

1. **Define target ecological functions**
2. **Identify associated system attributes (spatial metrics)**
3. **Quantify landscape change metrics**
4. **Describe subregional potential (physical drivers, opportunities)**
5. **Create conceptual Operational Landscape Units (e.g. “archetypes”)**
6. **Produce restoration guidelines and potential performance metrics**

Landscape Interpretation Team (LIT)

Stephanie Carlson (UC Berkeley)
Jim Cloern (USGS)
Brian Collins (University of Washington)
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Todd Keeler-Wolf (CDFW)
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Steve Lindley (NMFS)
Jeff Mount (UC Davis)
Peter Moyle (UC Davis)
Anke Mueller-Solger (USGS)
Eric Sanderson (Wildlife Conservation Society)
Dave Zezulak (CDFW)

Fish/Waterbird-specific
John Durand (UCD)
Jim Hobbs (UCD)
Carson Jeffres (UCD)
Dave Shuford (Point Blue)
Dan Skalos (CDFW)
Ted Sommer (DWR)

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
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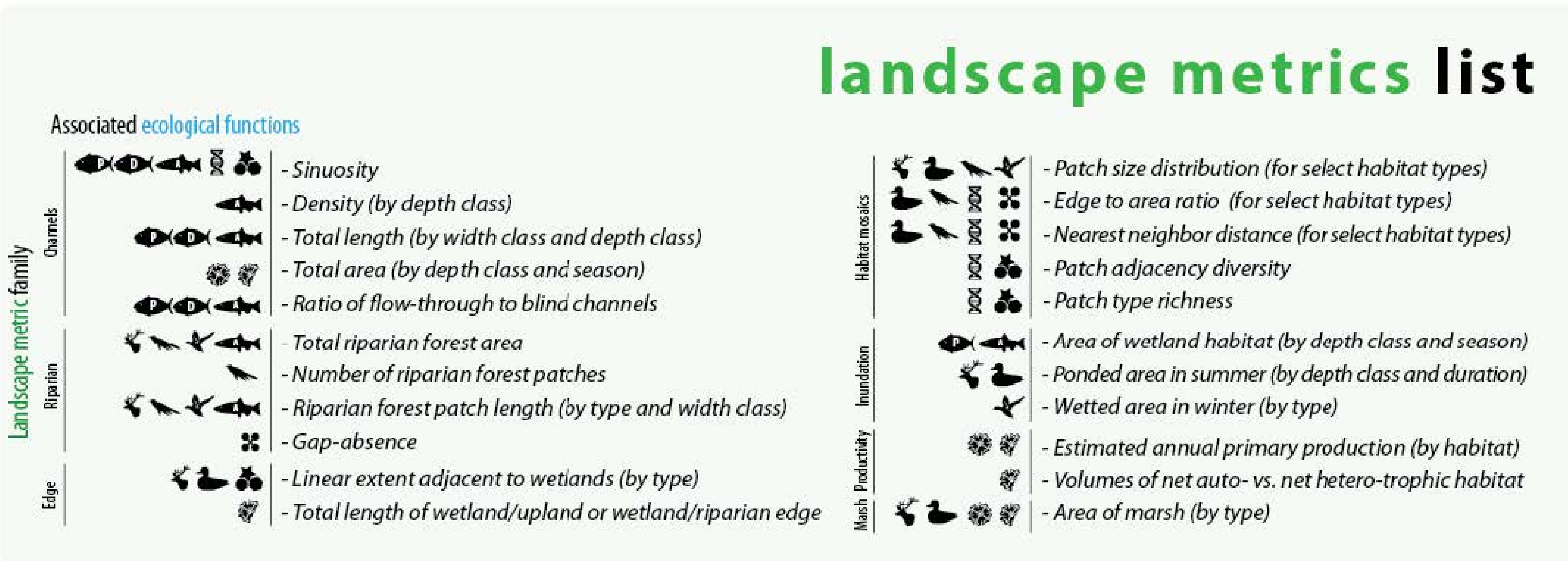
	Adjacency of marsh to open water by length and marsh patch size	Marsh core area ratio						
	Ratio of looped to dendritic channels (by length and adjacent habitat type)	Marsh fragmentation index						

Ecological Functions list (Task 3)

ecological functions **list**

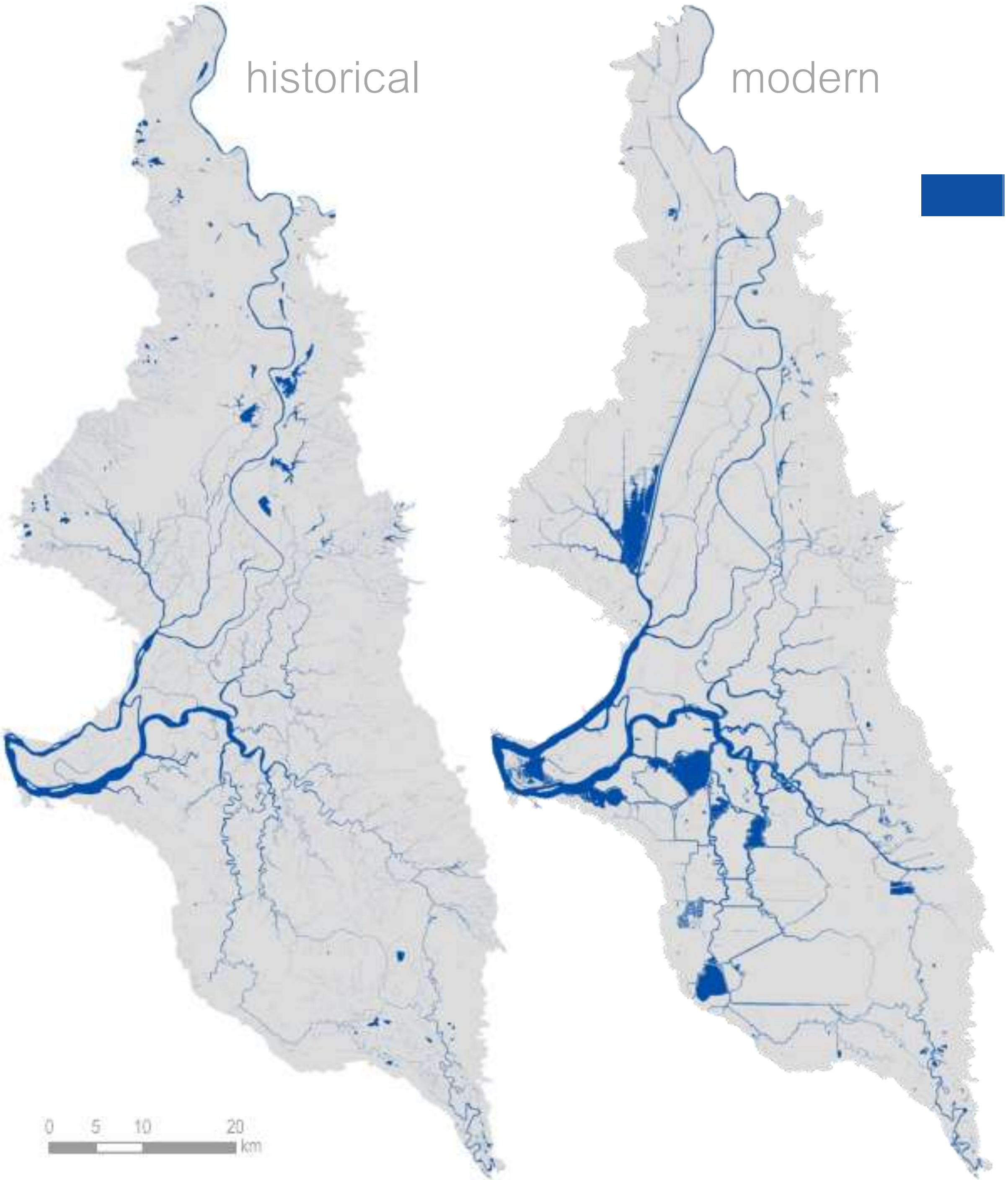
Habitat and connectivity for pelagic fish	Habitat and connectivity for resident mammals	Habitat and connectivity for native plants	Maintain genetic/pheno typic diversity	Nutrient movement and recycling
Habitat and connectivity for demersal fish	Habitat and connectivity for marsh birds	Habitat and connectivity for anadromous fish	Maintain connectivity for fragmented populations	Gross food supply
Habitat and connectivity for littoral fish	Habitat and connectivity for riparian birds	Habitat and connectivity for migratory waterfowl	Maintain diverse native communities	Net food supply

Landscape Metrics list (Task 3)



There has been a 73-fold reversal in the ratio between marsh and open water in the Delta, affecting the character and quality of aquatic habitats.

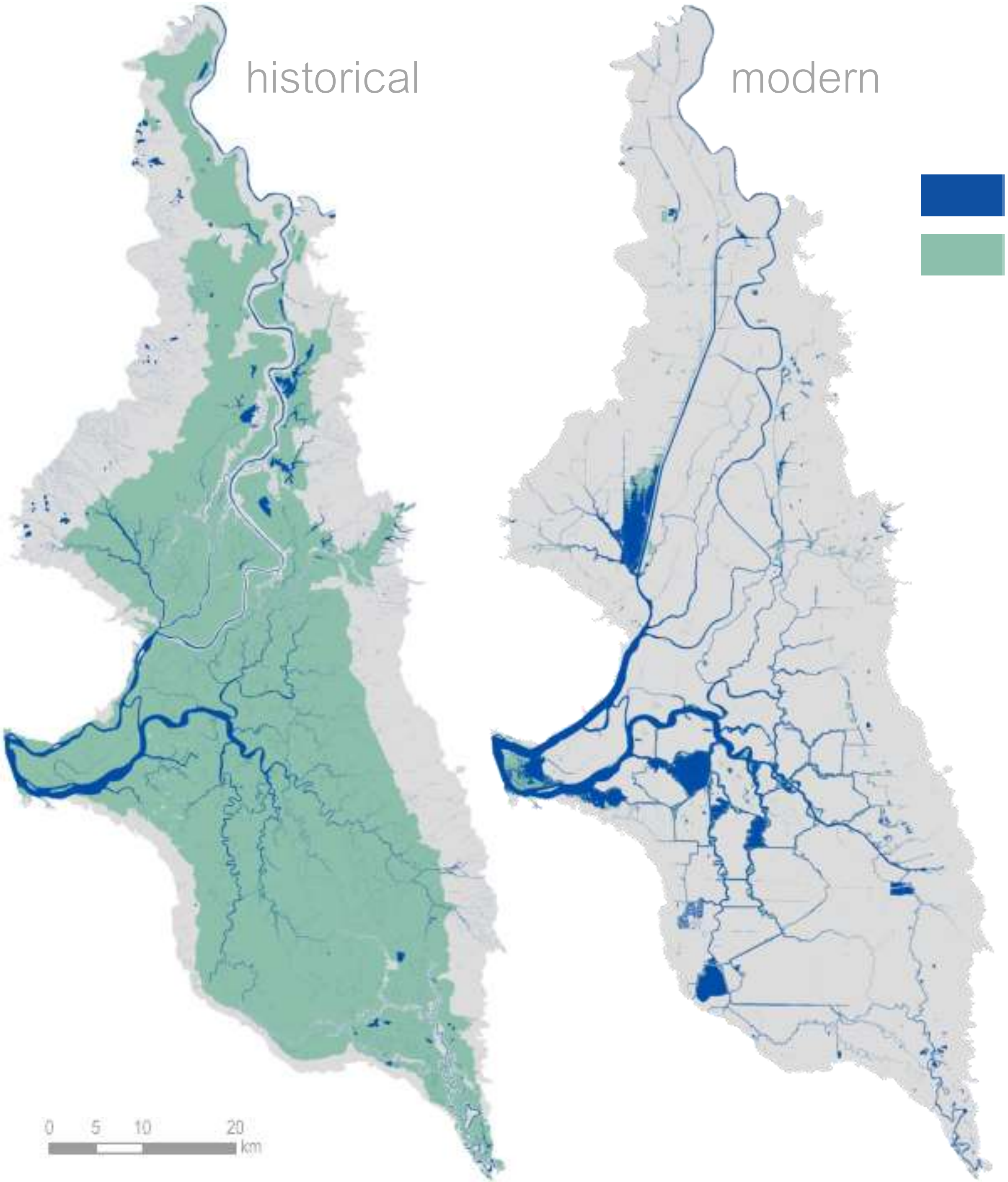
support for native fish



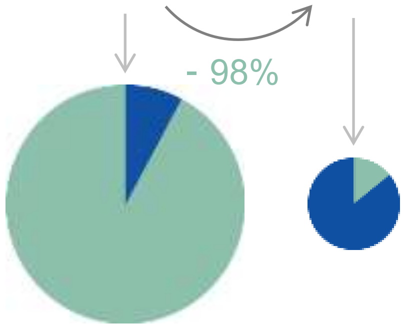
	historical	modern
open water	16,300 ha	26,600 ha

+ 63%

support for native fish



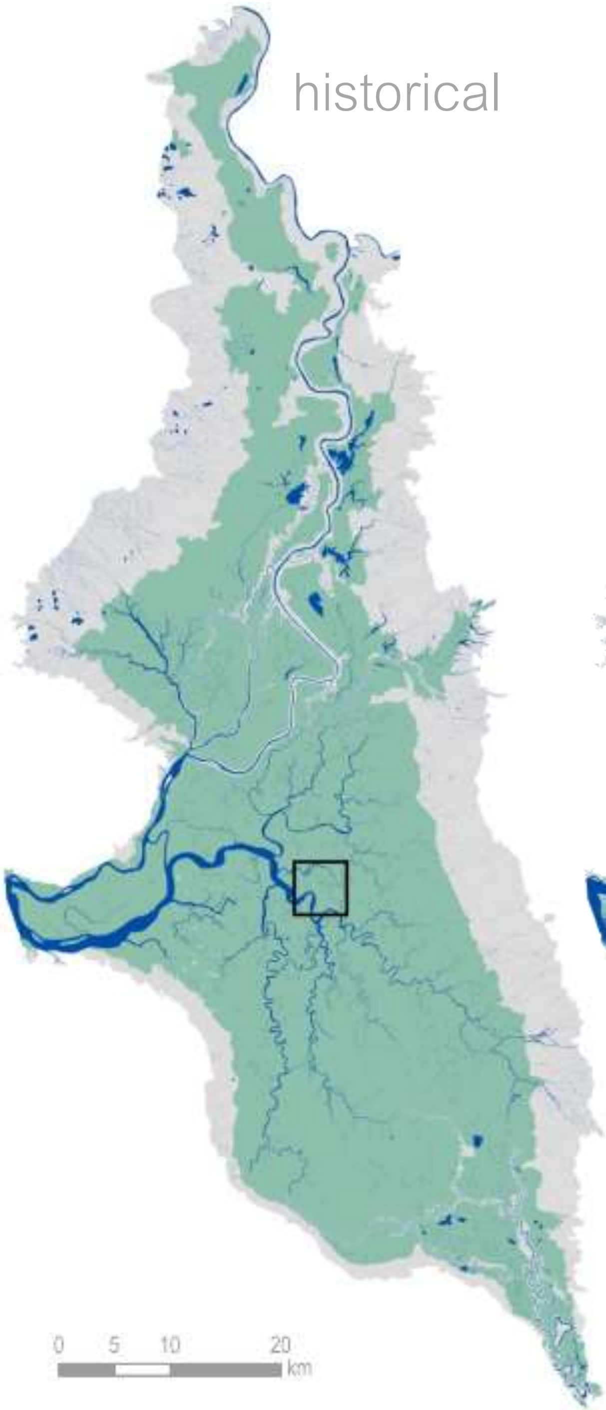
	historical	modern
open water	16,300 ha	26,600 ha
marsh	193,200 ha	4,300 ha

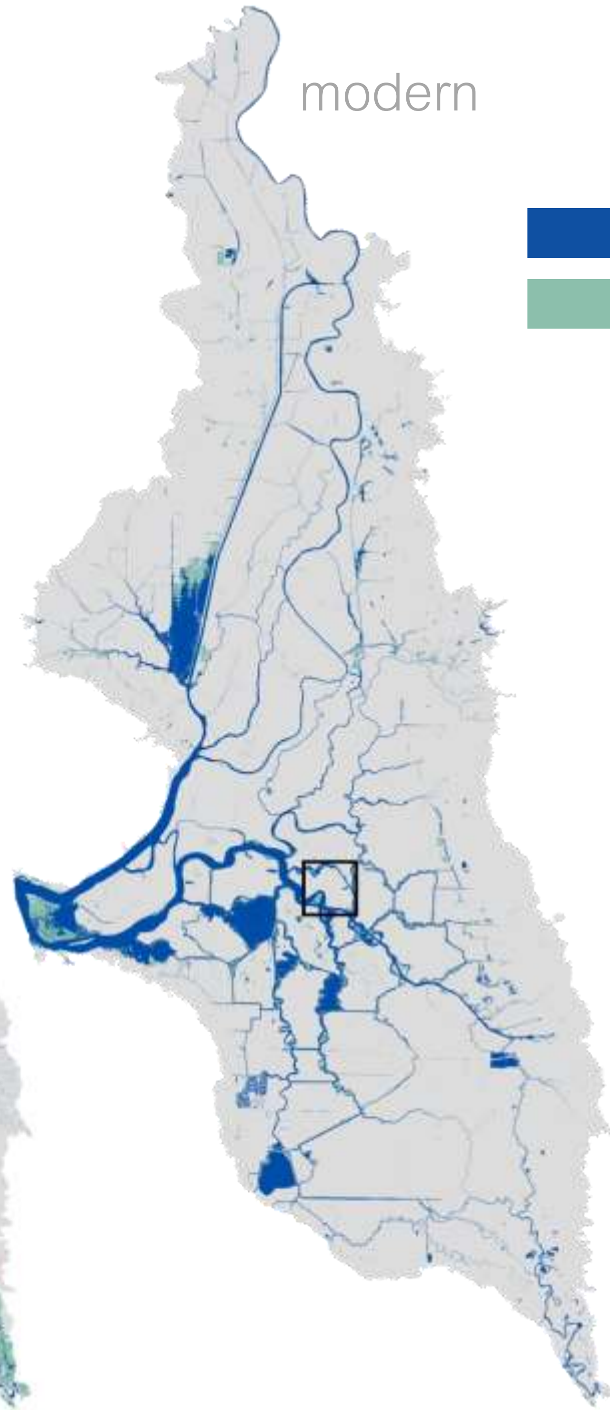


historical	modern
100 : 1,182	100 : 16

74x decrease in marsh to open water ratio

support for native fish





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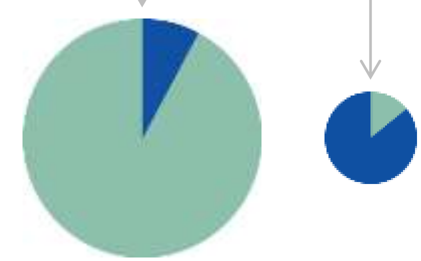

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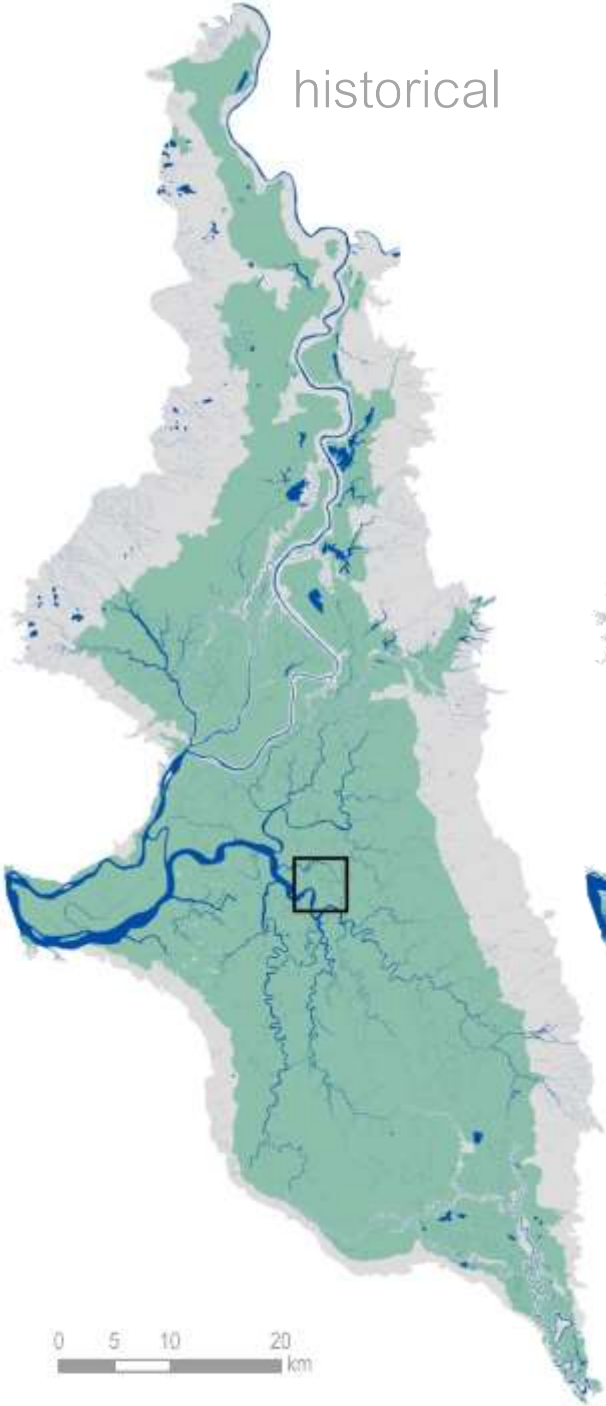
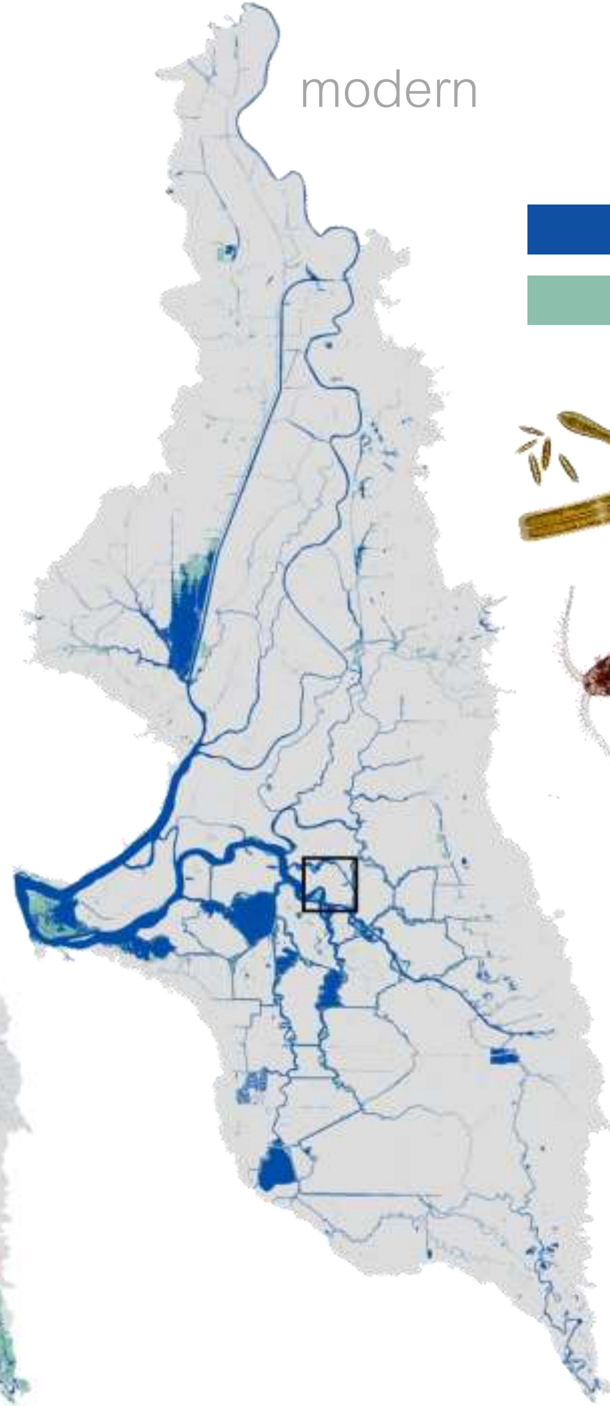
"channels in marsh" → "marsh in channels"

support for native fish





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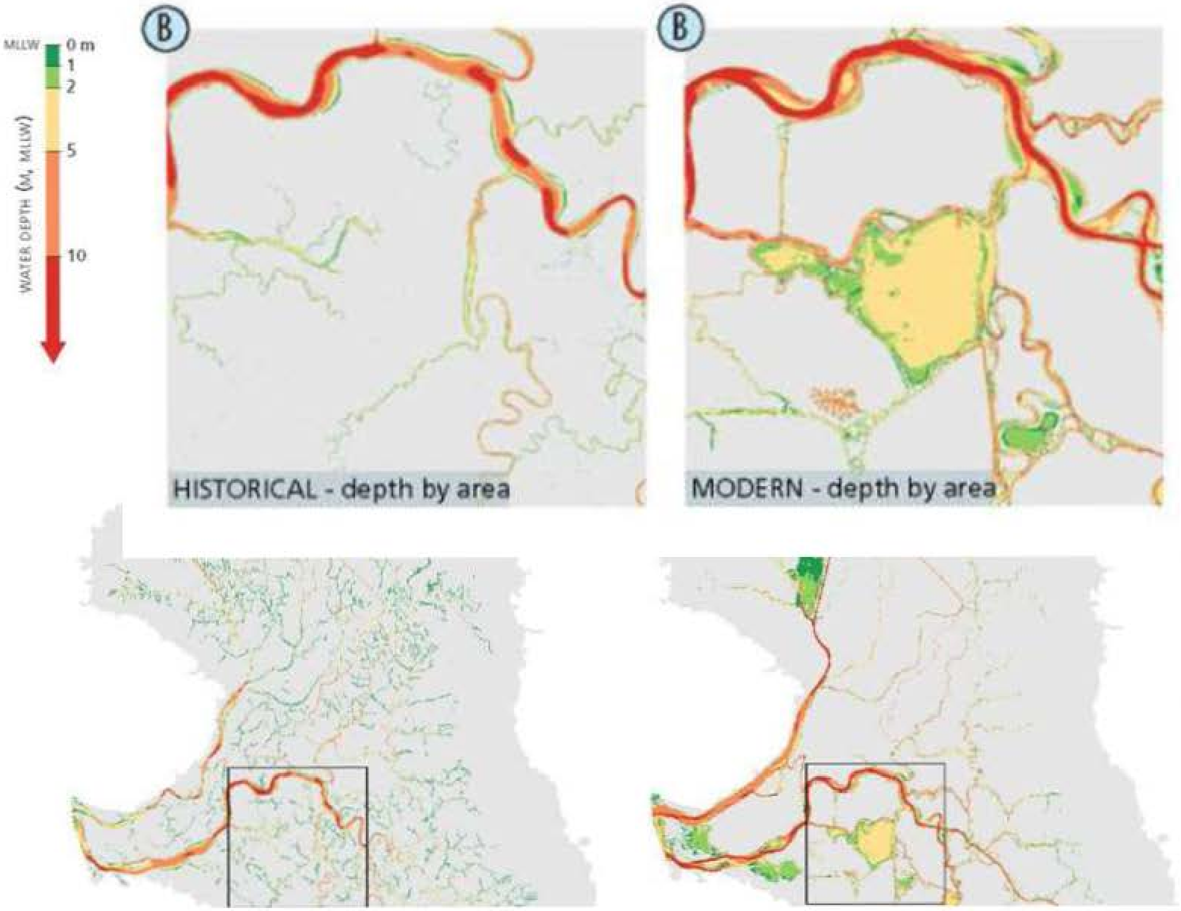
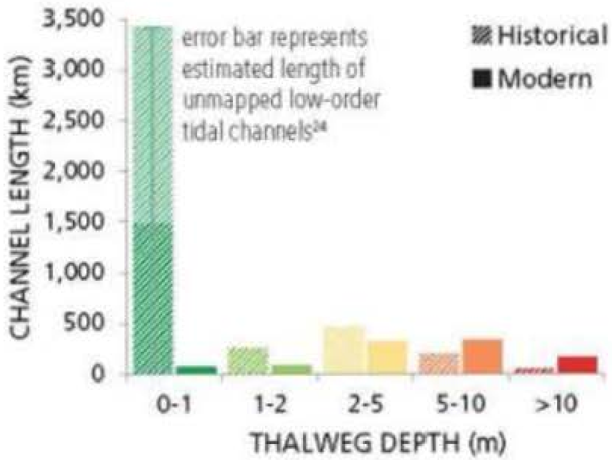
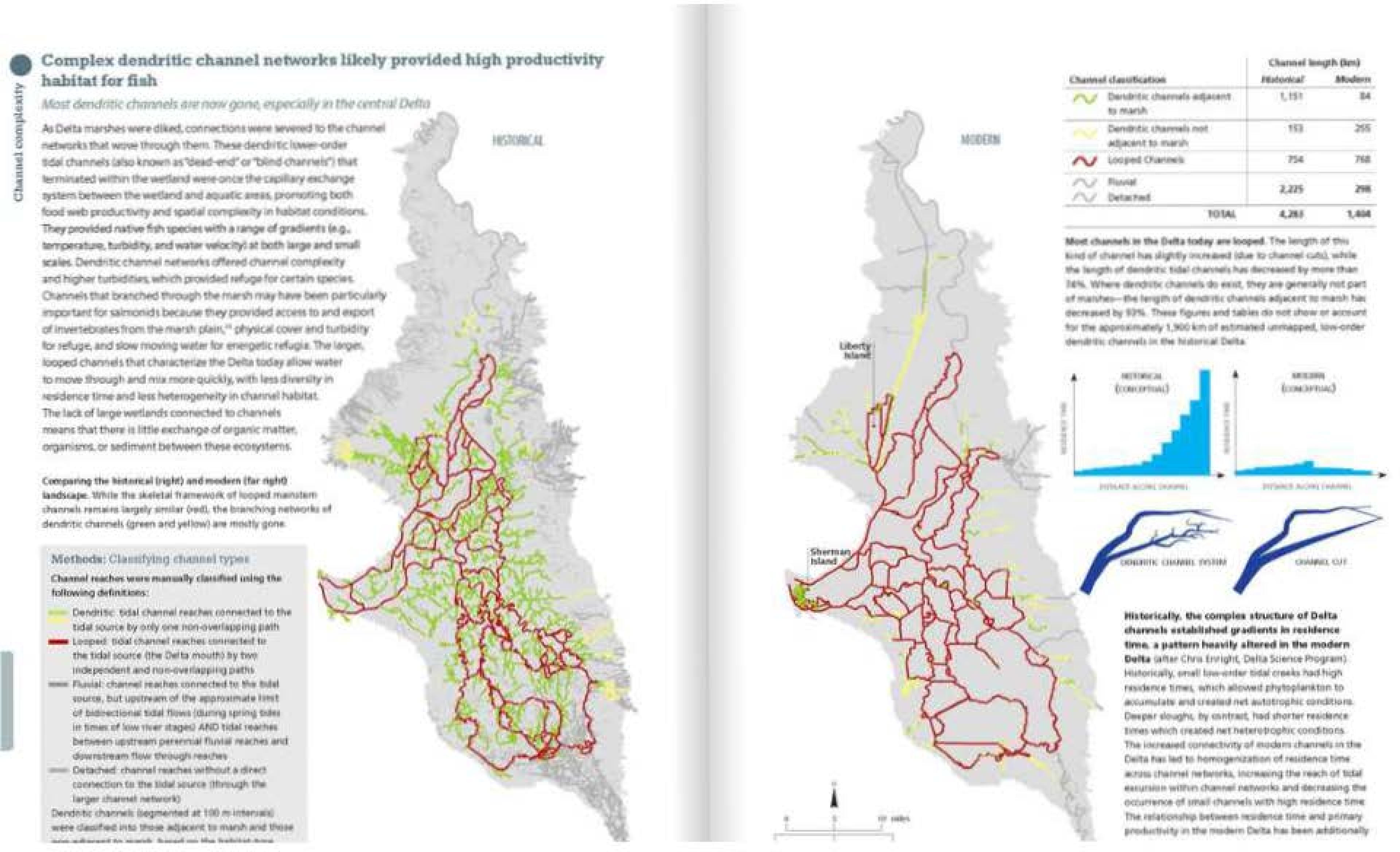
There is twice as much shallow-water habitat (<2m) in the Delta today as there was historically.





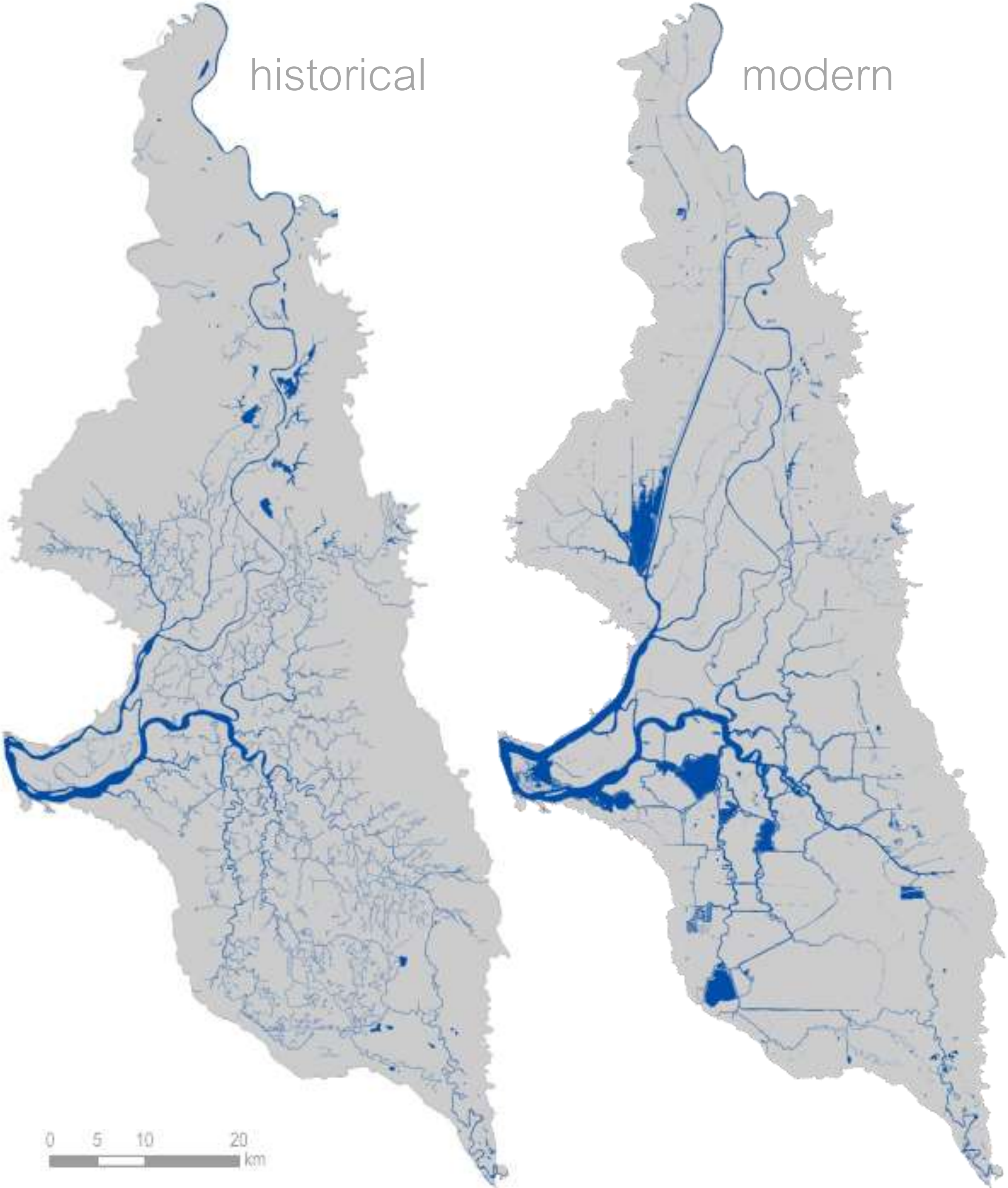
Historical DEM co-developed with UCDavis CWS (Fleenor, Whipple, Bell, et al.)

Complex dendritic channel networks likely provided high productivity habitat for fish.



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

support for native fish

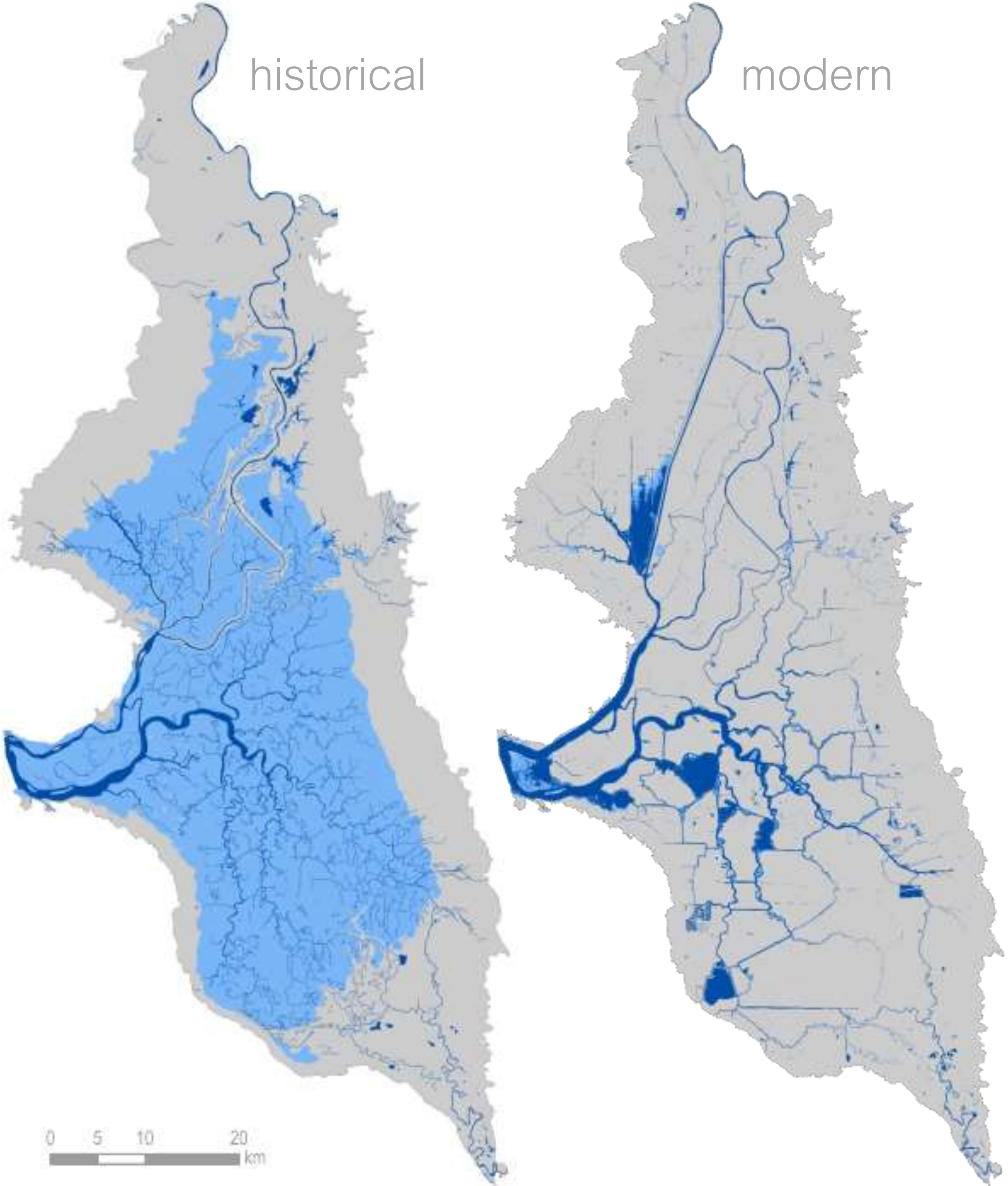


PONDS, LAKES, CHANNELS, FLOODED ISLANDS

Mostly perennial open water features

- variable depth

support for native fish



PONDS, LAKES, CHANNELS, FLOODED ISLANDS

Mostly perennial open water features

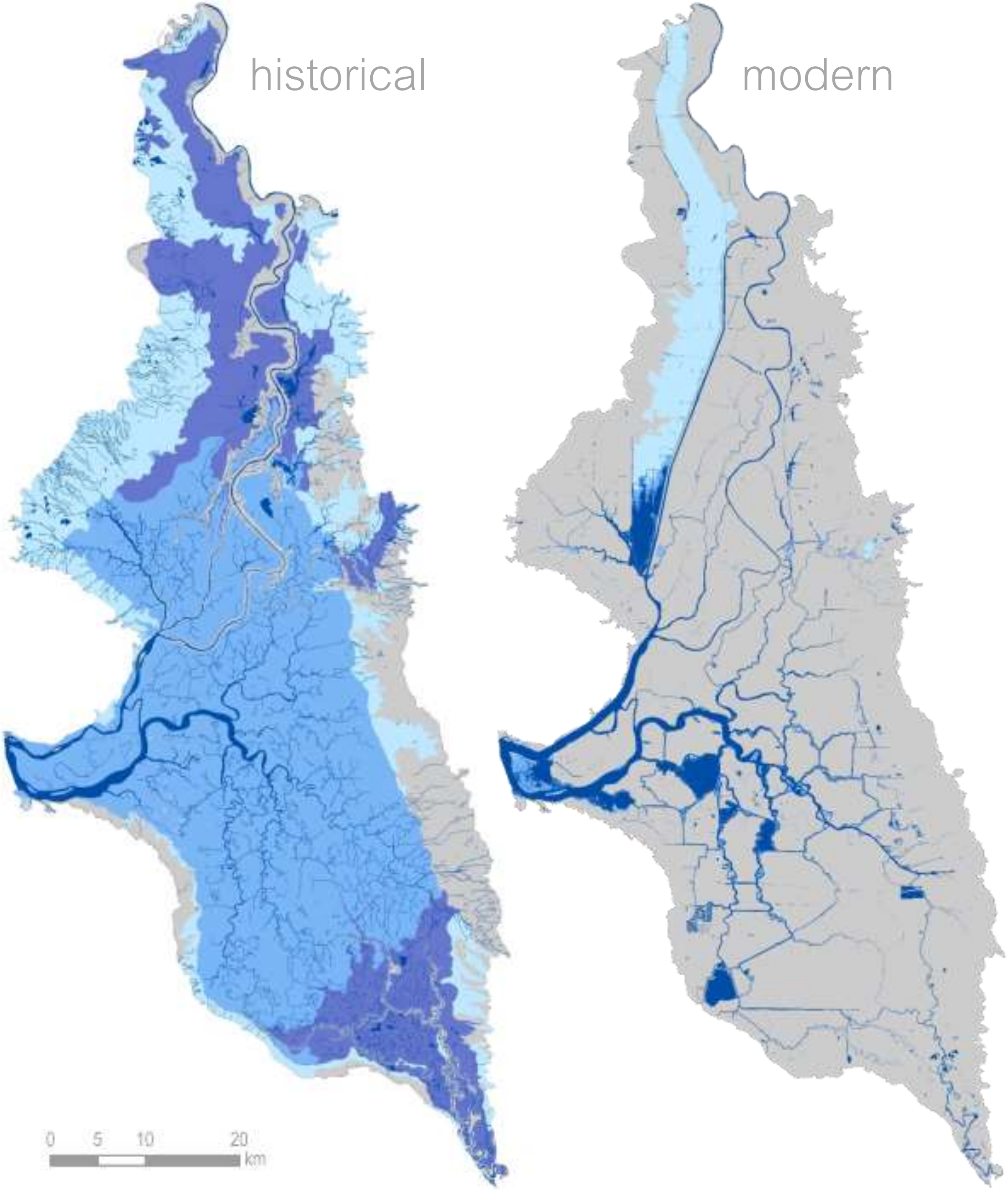
- variable depth

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)

support for native fish



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SEASONAL LONG DURATION FLOODING

Prolonged inundation from river overflow into flood basins

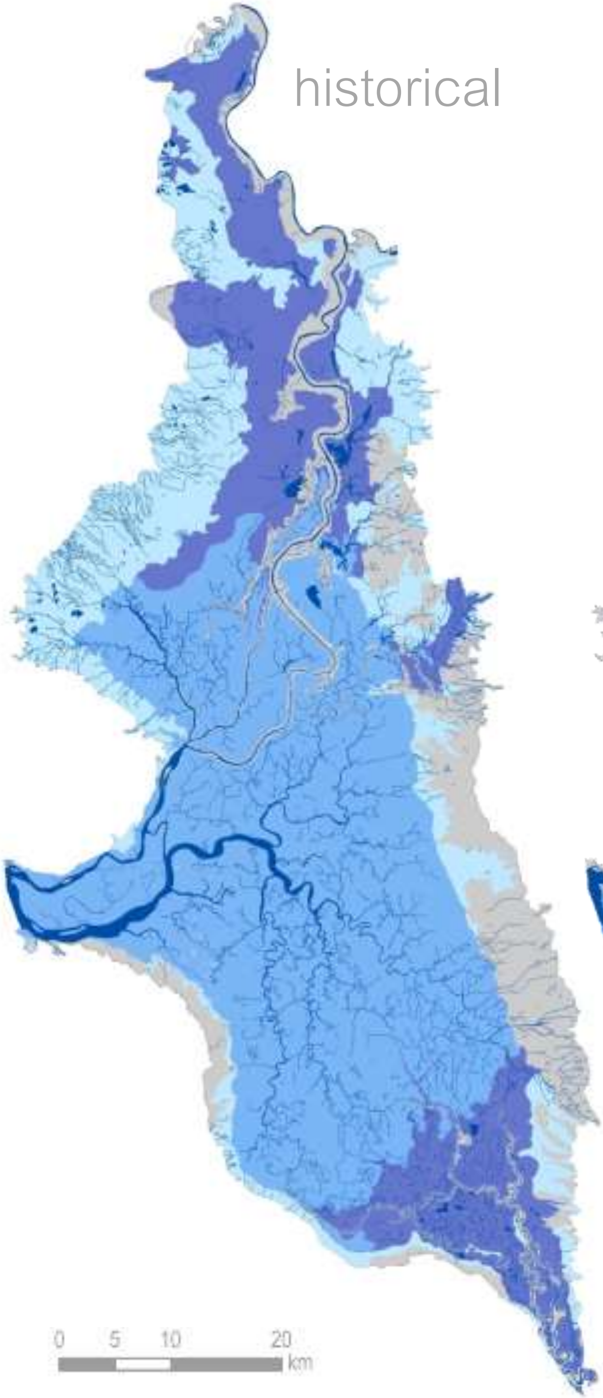
- low recurrence (~1 event per year)
- high duration (persists up to 6 month)
- generally deeper than ‘seasonal short-term flooding’

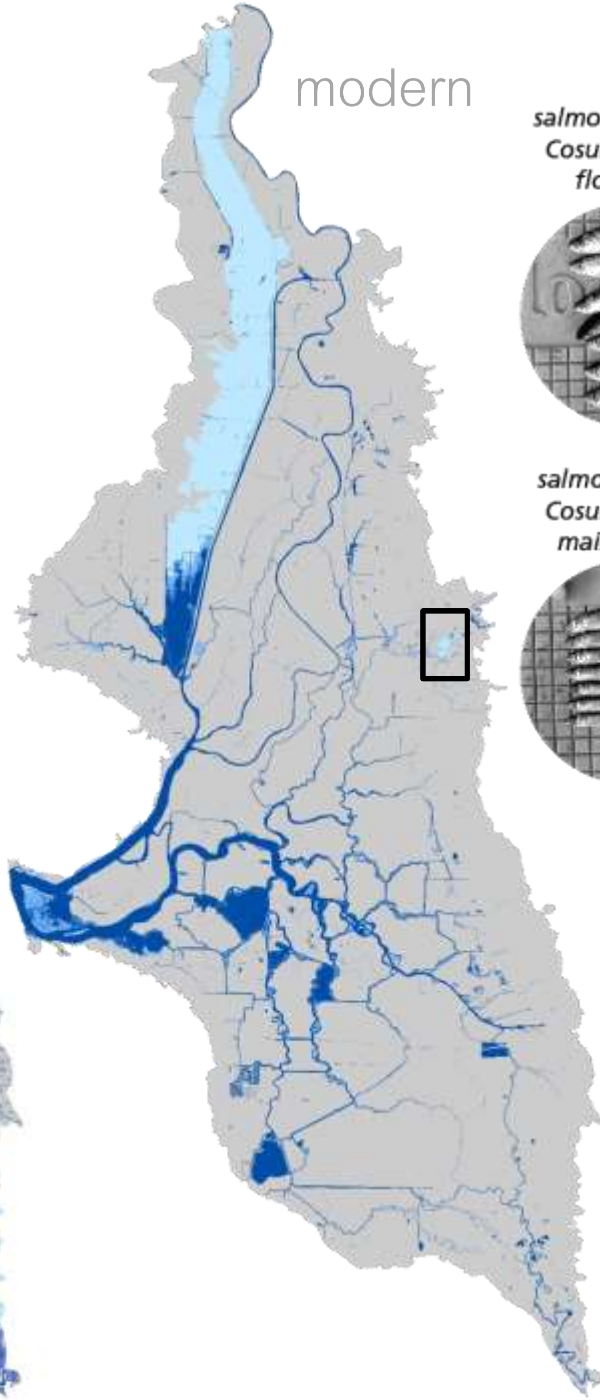
SEASONAL SHORT-TERM FLOODING

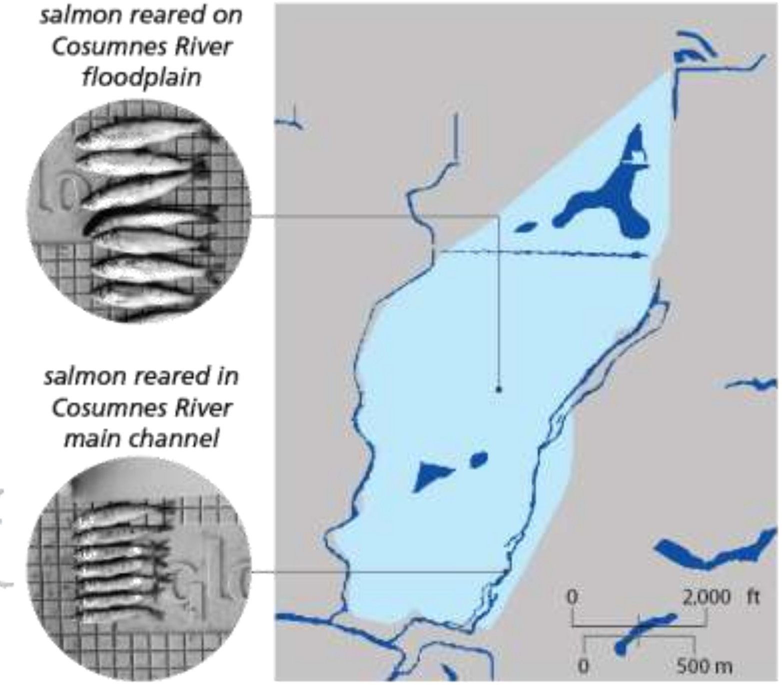
Short-term fluvial inundation

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

support for native fish







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).

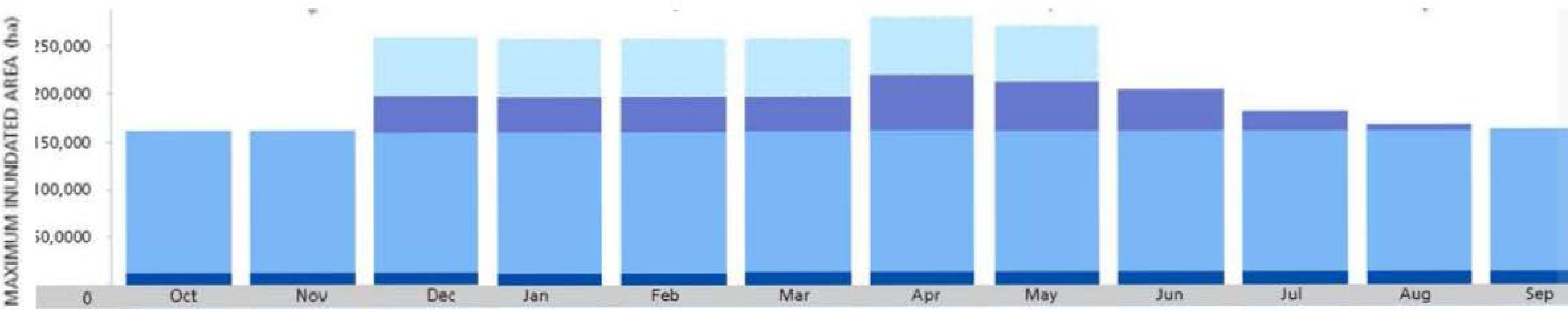
PONDS, LAKES, CHANNELS, FLOODED ISLANDS

TIDAL INUNDATION

SEASONAL LONG DURATION FLOODING

SEASONAL SHORT-TERM FLOODING

Native fish are adapted to a complex, variable landscape with extensive aquatic resources throughout the year.



SEASONAL SHORT-TERM FLOODING
Short-term fluvial inundation
- intermediate recurrence (~10 events per year)
- low duration (days to weeks per event)
- generally shallower than seasonal long-duration flooding

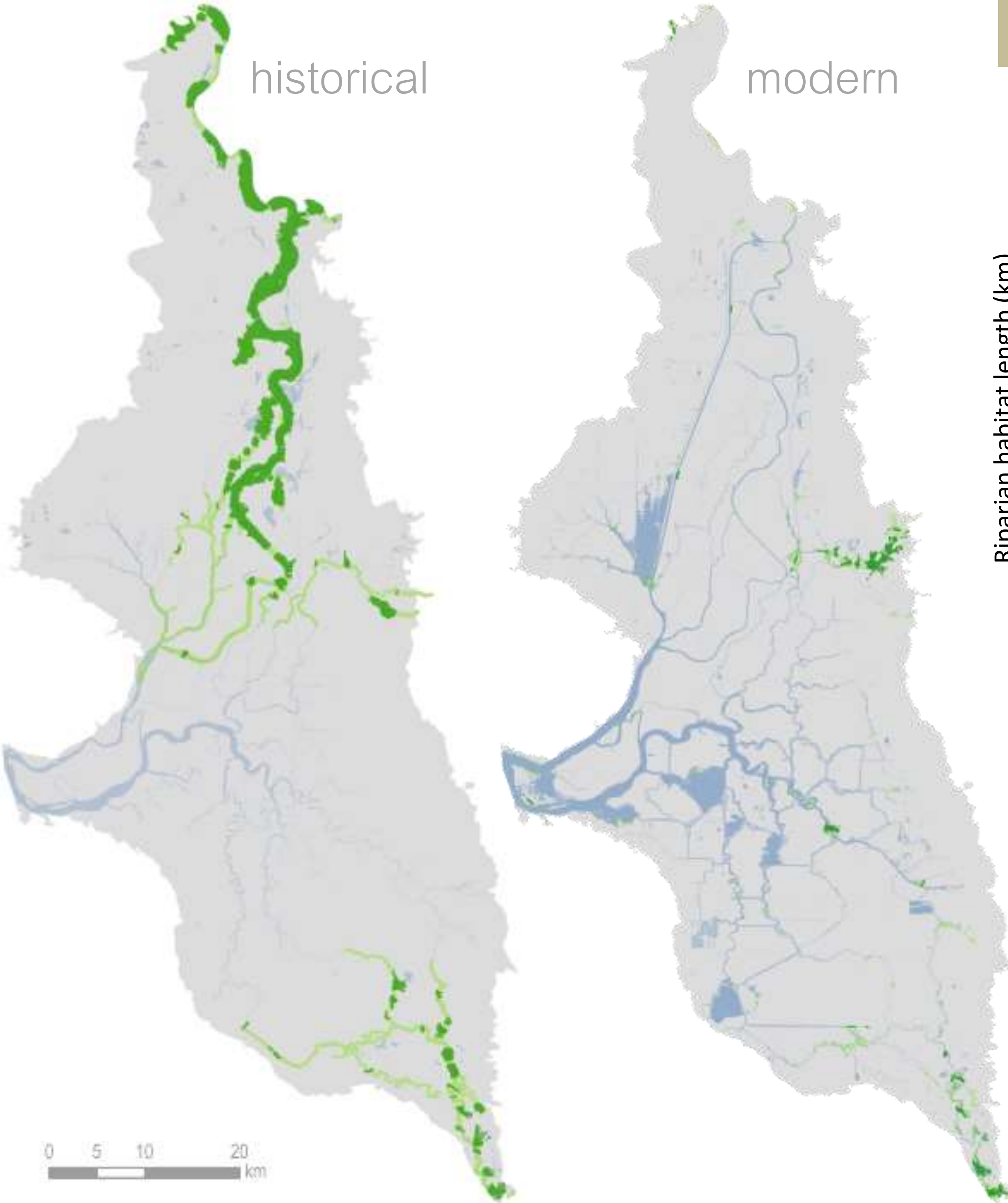
SEASONAL LONG-DURATION FLOODING
Prolonged inundation from river overflow into flood basins
- low recurrence (~1 event per year)
- high duration (persists up to 6 month)
- generally deeper than seasonal short-term flooding

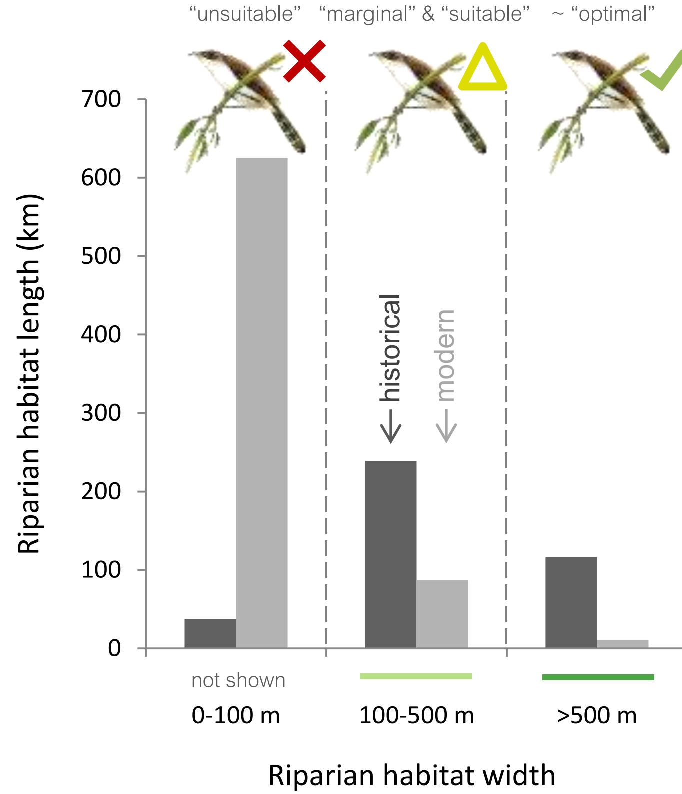
TIDAL INUNDATION
Diurnal overflow of tidal sloughs into marshes
- high recurrence (twice daily)
- low duration (<6 hrs per event)
- low depth ("wetted" up to 0.5 m)

PONDS, LAKES, CHANNELS, & FLOODED ISLANDS
Perennial open water features (with the exception of historical intermittent ponds and streams)
- recurrence not applicable (generally perennial features)
- high duration (generally perennial features)
- variable depth

There are a number of additional elements to a complete Delta ecosystem.

support for riparian wildlife





Majority of riparian habitat today is of "unsuitable" width to support yellow billed cuckoos (Laymon & Halterman 1989). Length of forest of "optimal" width has decreased by 91%

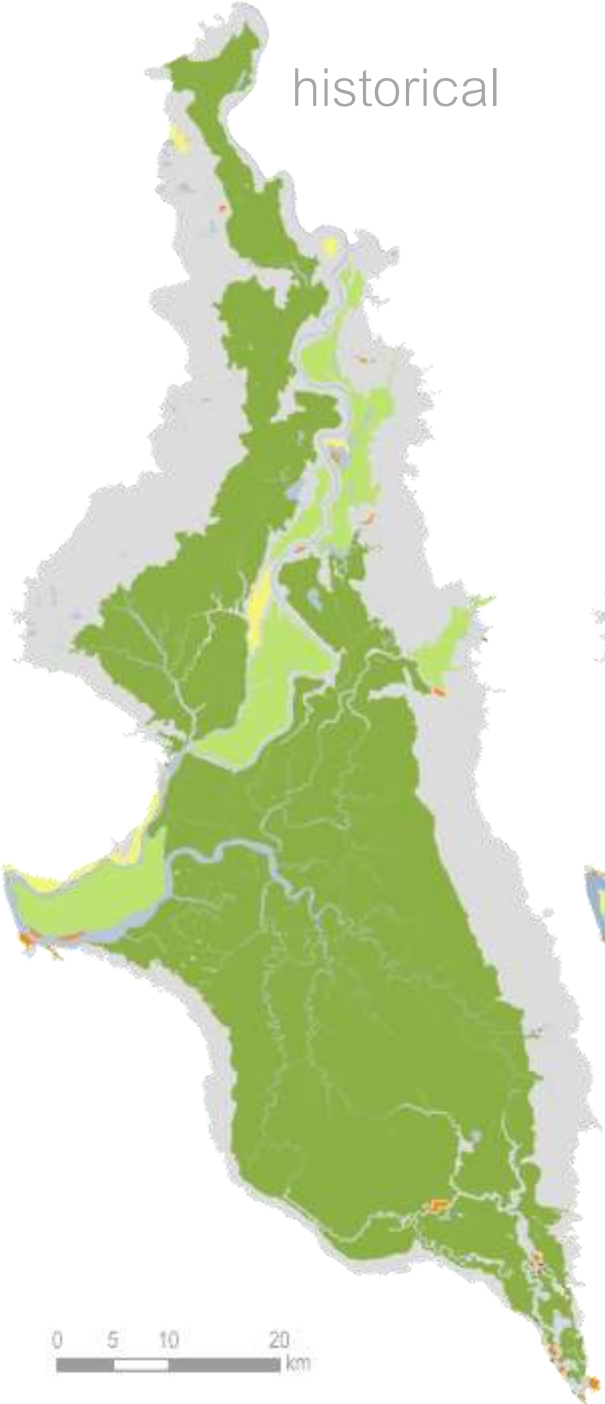
riparian forest width (transects)

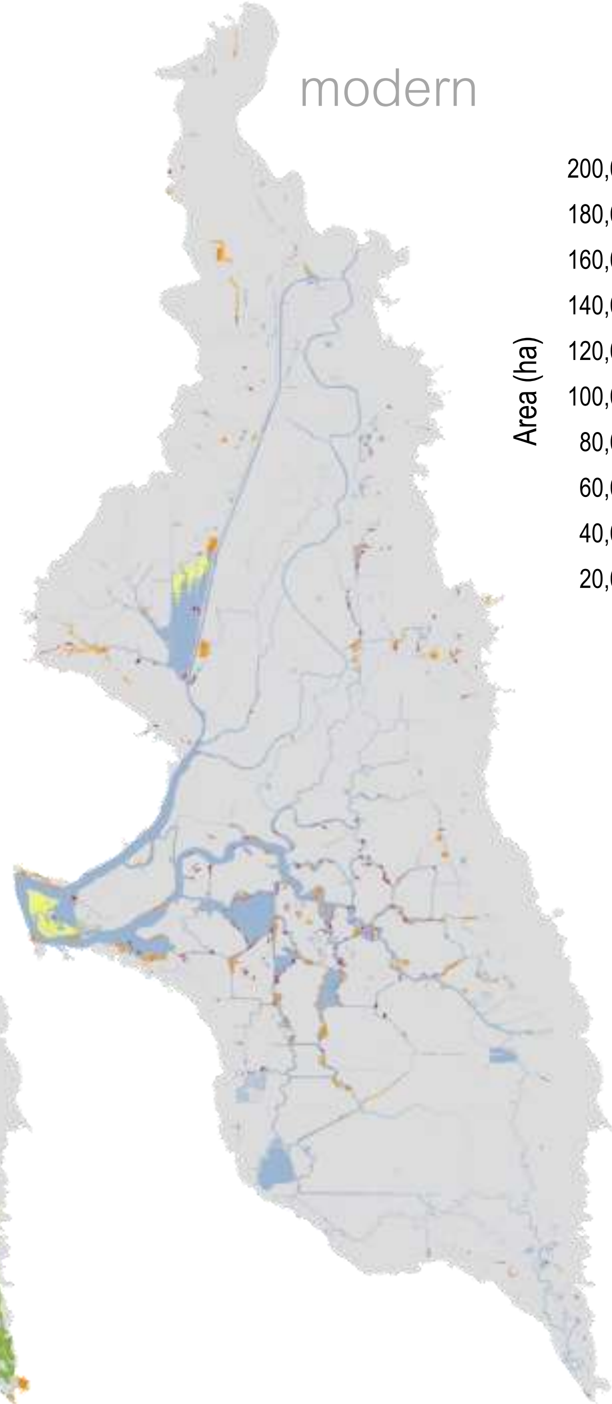
> 100 m wide

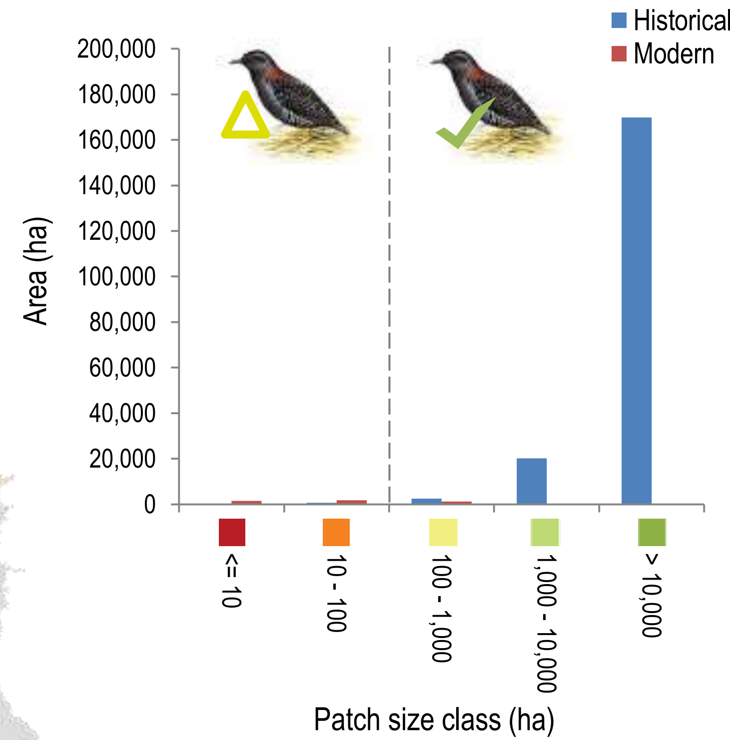
> 500 m wide

riparian forest < 100 m wide not shown

support for marsh wildlife







Marsh in patches large enough to fully support rails (based on Liu et al. 2012, Spautz & Nur 2002):

Historical: 192,000 ha

Modern: 1,000 ha

marsh patch size class (hectares)

- <= 10 ha
- 10 - 100
- 100 – 1,000
- 1,000 – 10,000
- > 10,000

Marsh-terrestrial transition habitats

The historical marsh-terrestrial transition zone was continuous and gradual

Today's marsh-terrestrial transition zones are fragmented

The transition zone between marsh and terrestrial habitats supported many wildlife species and ecological functions. Animals, organic matter, sediment, and water moved across this wide, complex, and heterogeneous area that supported a broad moisture gradient. Continuous transition zones bordered the Delta periphery and major riparian corridors. Most transition zones were wide and gradual, yet some were short and steep. This continuity and variability allowed diverse terrestrial wildlife to access wetland habitat, and was critical for the movement and dispersal of transition-zone obligates. The transition zone may have been particularly important to the endemic giant garter snake, which used aquatic habitats dominated by emergent vegetation from early spring to mid-fall, and drier, higher-elevation habitats during winter dormancy. Foraging birds and bats may have used seasonal wetlands at different times of the year depending on inundation and food production. In the modern Delta, the terrestrial edge is fragmented and narrow, providing less foraging access, cover, and movement corridors.

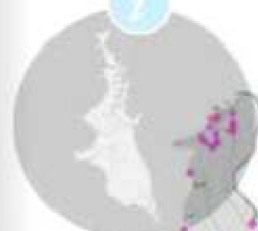
Marsh-terrestrial transition zones in the historical (right) and modern (far right) Delta, represented by pink lines. Historically, much of the marsh gradually transitioned to seasonal wetland, vernal pool, alkali wetland, or riparian forest. In contrast, the modern transition zone is discontinuous and rapidly shifts to mostly grassland. Modern grasslands are heavily altered habitats, and modern transition zones are often steep levees.

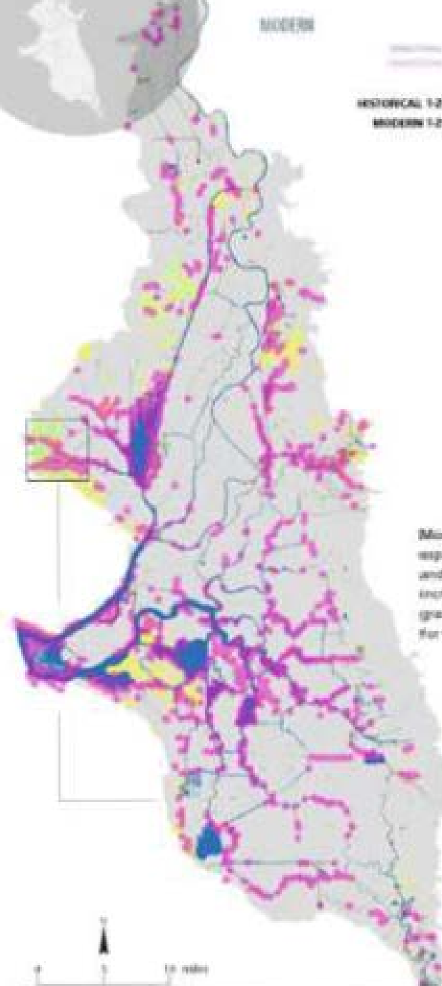
Methods: Marsh-terrestrial transition zone (T-zone)

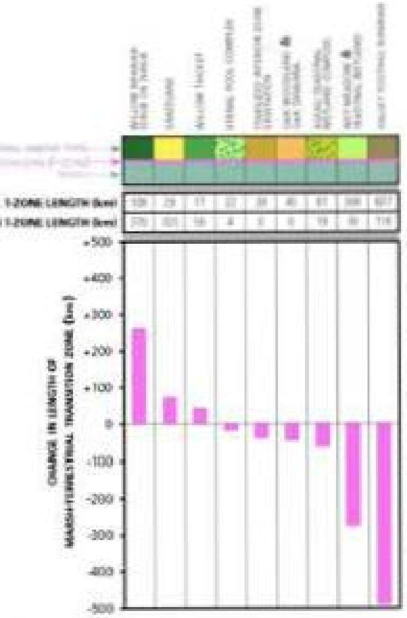
"**marsh**" includes both tidal and non-tidal freshwater emergent wetland

the "**marsh-terrestrial transition zone**" was mapped wherever marsh polygons and terrestrial habitat type polygons were adjacent to one another

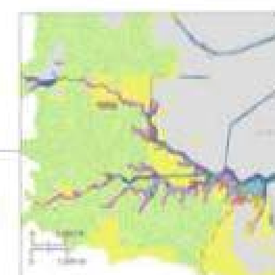
"**terrestrial habitat types**" include oak woodlands, seasonal wetlands, and riparian habitat types, among others (see list on top...







Most transition zone types are greatly reduced. A few types have expanded in quantity, but these tend to be relatively fragmented and disturbed. For example, although the extent of grassland has increased, modern grasslands are dominated by non-native annual grasses, which has changed the timing and availability of resources for wildlife.



The longest continuous unleveed marsh-terrestrial transition zone left in the Delta is along Lindsey Slough (above). This

THANKS

CDFW: Daniel Burmester, Carl Wilcox, Dave Zezulak

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

Cache Slough Team: Bruce Orr, Noah Hume (Stillwater); Stuart Siegel (ESA)
Lower Yolo Team: Curt Schmutte, Val Connor
TNC MWT: Leo Winternitz, Rodd Kelsey

The LIT
CDFW, ERP, DWR, SFCWA , TNC for funding

http://sfei.li/deltametrics

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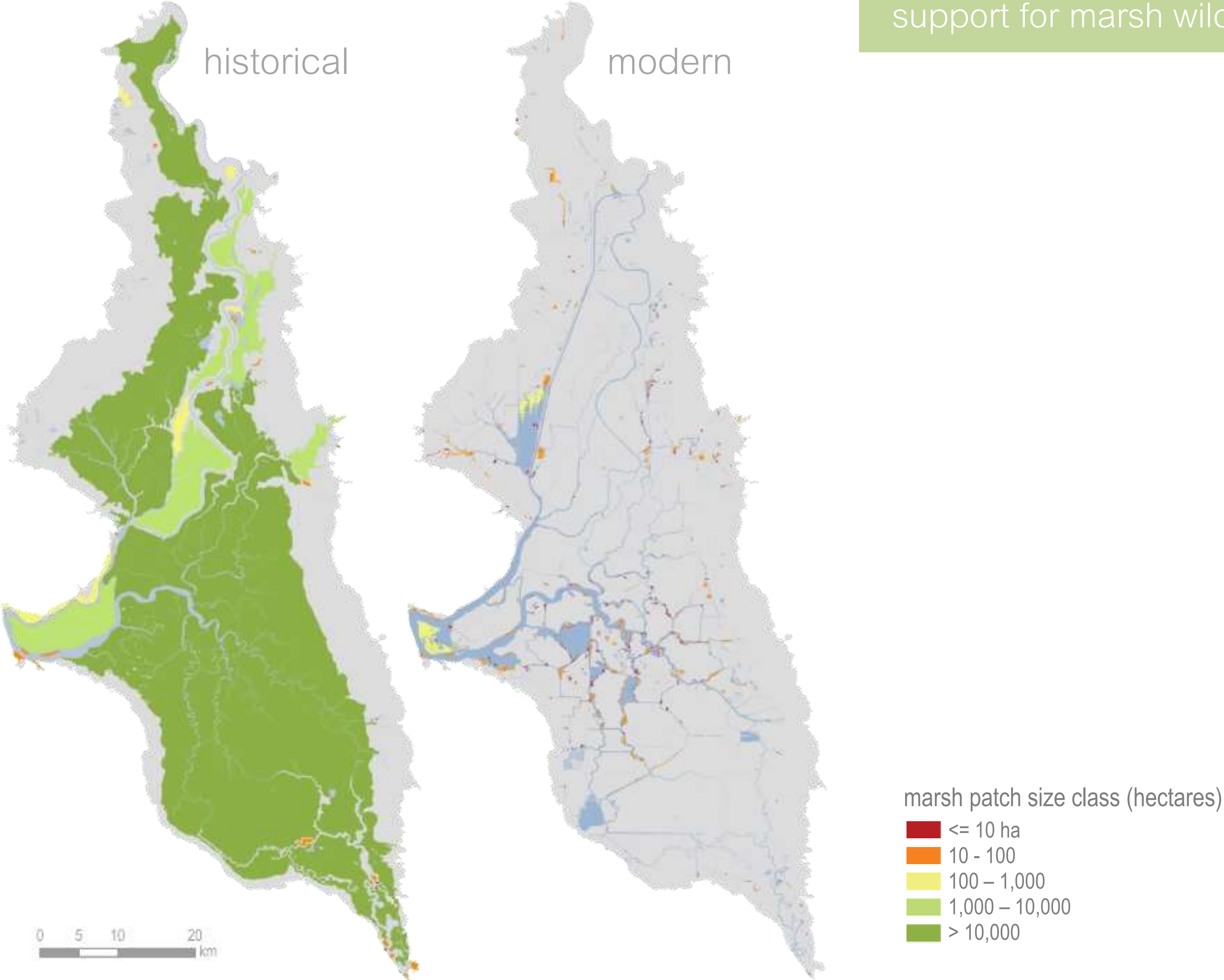
Support for:

- marsh wildlife
  - marsh patch size
- native fish
  - marsh:open water ratio
  - length of marsh-water edge
  - inundated areas
- riparian wildlife
  - riparian forest width
- edge wildlife
  - marsh-terrestrial transition zone

support for marsh wildlife



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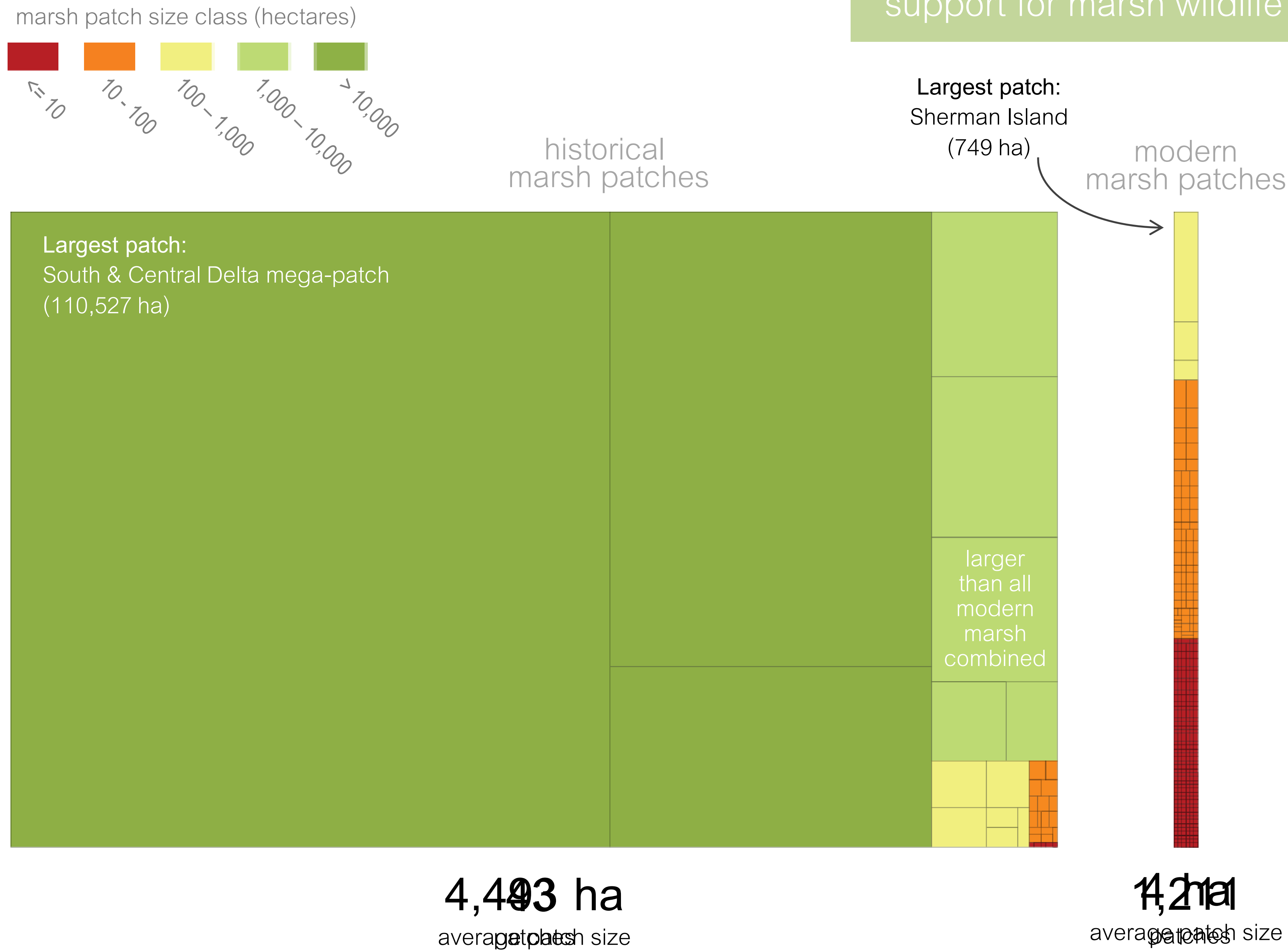

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FUNCTION	Provides habitat and connectivity for fish	Provides habitat and connectivity for marsh wildlife	Provides habitat and connectivity for waterbirds	Provides habitat and connectivity for riparian wildlife	Provides habitat and connectivity for 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
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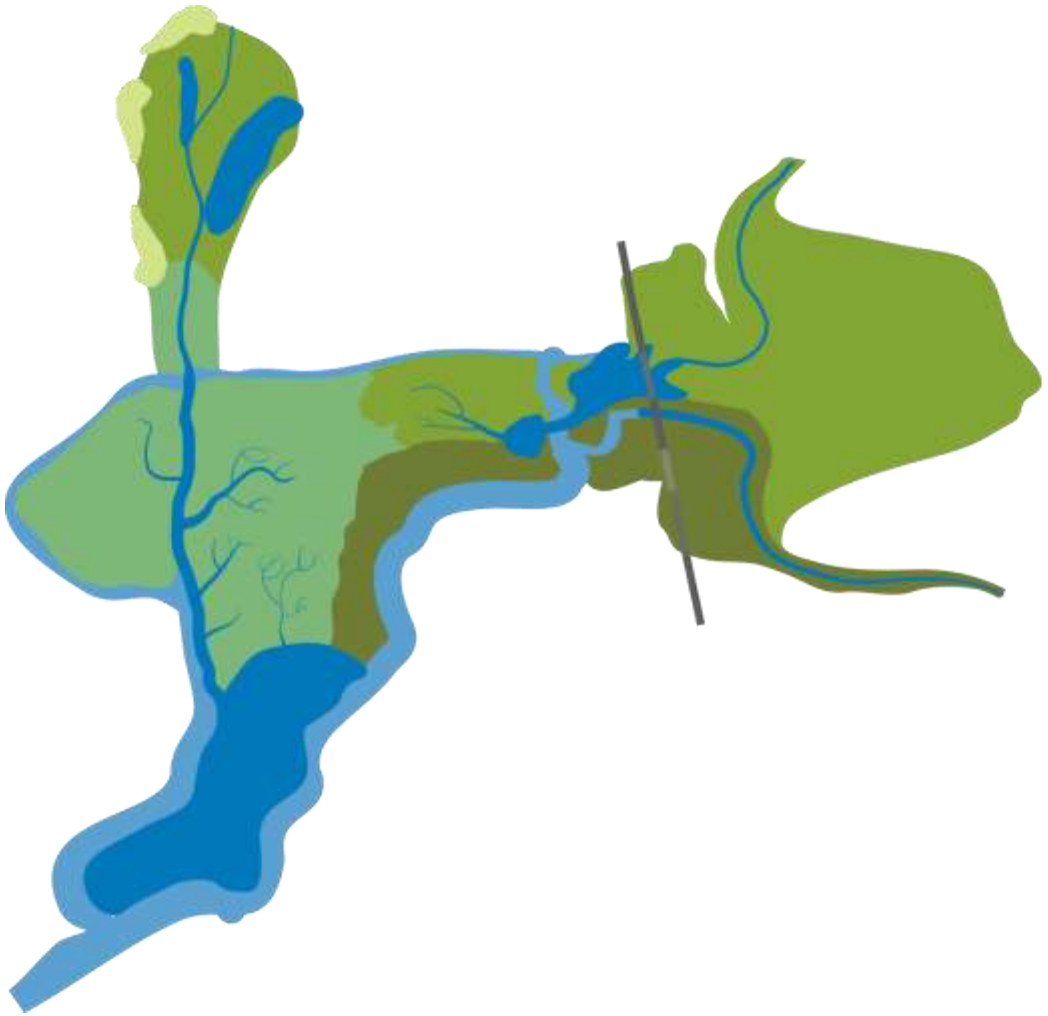
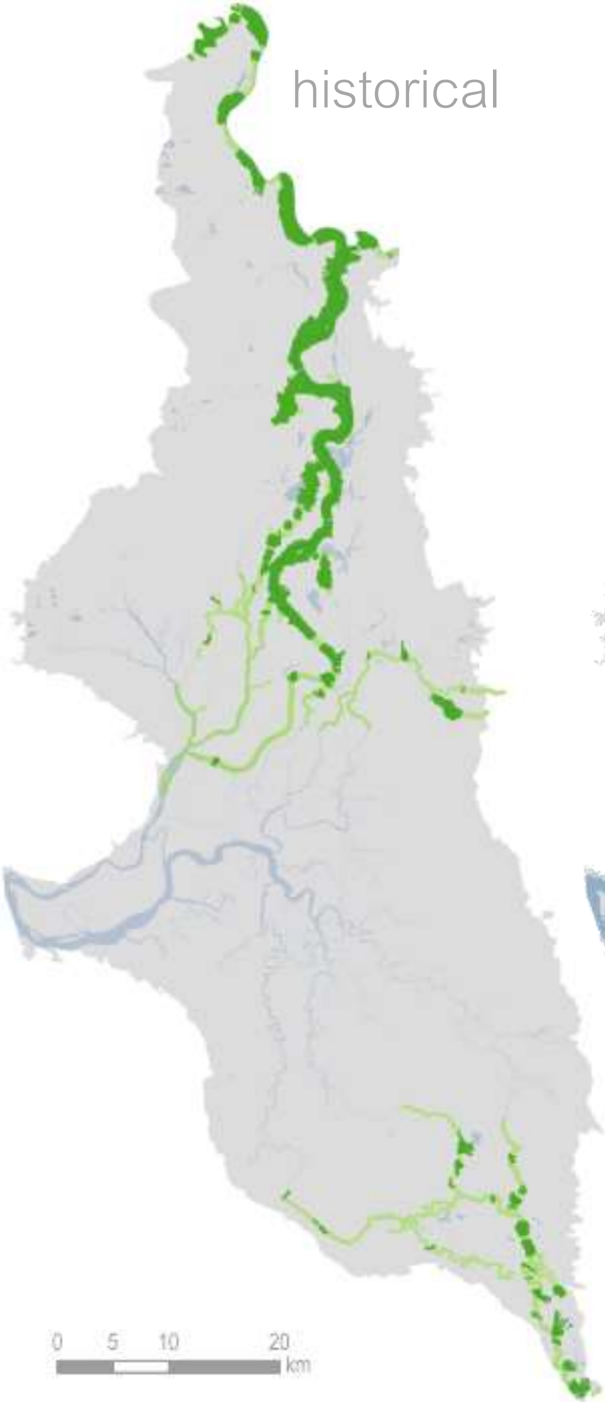
	Marsh to open water ratio	Marsh area by nearest neighbor distance	Wetted area by type in winter	Riparian habitat length by width class				
	Adjacency of marsh to open water by length and marsh patch size	Marsh core area ratio						
	Ratio of looped to dendritic channels (by length and adjacent habitat type)	Marsh fragmentation index						

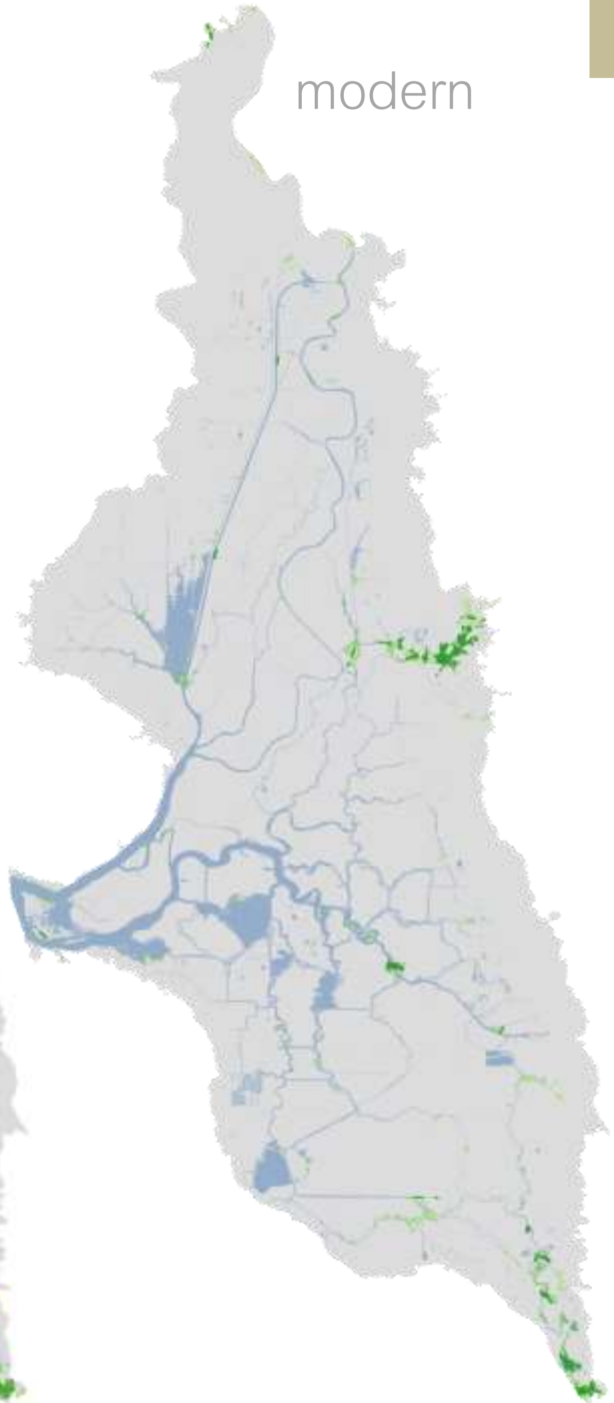
2100



Wide woody riparian habitat has declined by 72%.

support for riparian wildlife





riparian forest width (transects)

> 100 m wide

> 500 m wide

riparian forest < 100 m wide not shown