Translating Science-Based Restoration Strategies into Spatially-Explicit Restoration Opportunities

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SFEI AQUATIC SCIENCE CENTER

THE DELTA PLAN (2013)

"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."

THE DELTA PLAN (2013)

"In the long term, restoring spatial patterns at ecologically appropriate scales can promote the **"self-repair"** of ecosystem processes and functions and **increase resilience to stressors.** Consequently, this approach could reduce the operating and maintenance costs of restoration in an era of limited resources."

MOYLE ET AL. (2012)

" Allowing **natural processes** to perform as much of the work as possible is an economical and **sustainable** way to make changes in the Delta. ."

WATER CODE SECTION 85302 (2009)

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

THE DELTA PLAN (2013)

"Achieving the coequal goal of ecosystem protection, restoration, and enhancement means successfully establishing a **resilient, functioning estuary and surrounding terrestrial landscape** capable of supporting viable populations of native resident and migratory species with diverse and biologically **appropriate habitats, functional corridors, and ecosystem processes.**"

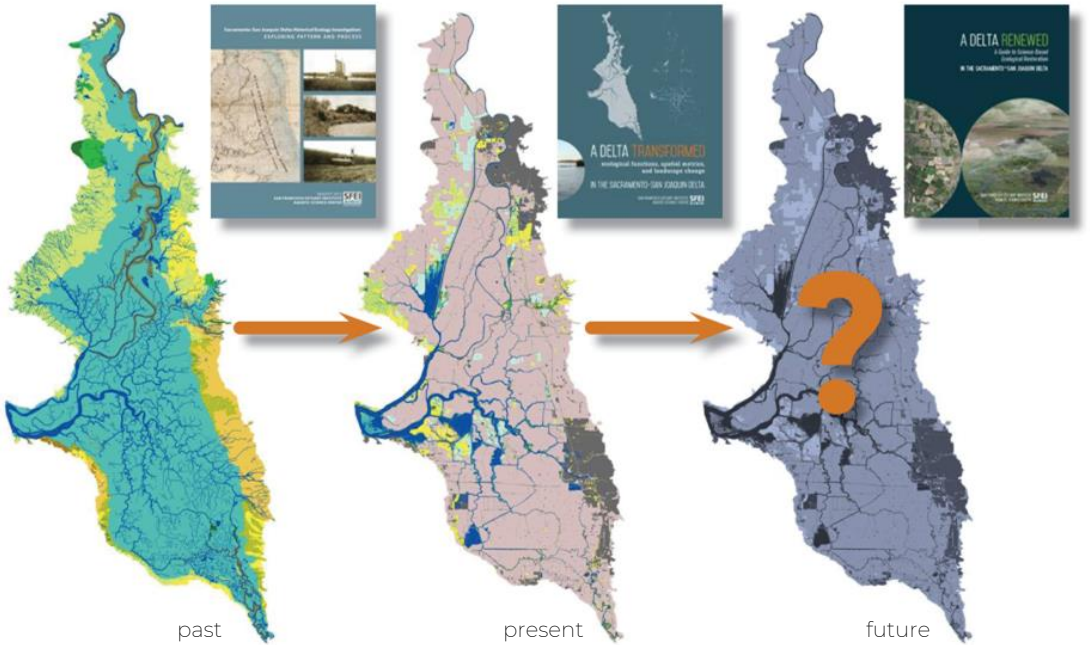
THE DELTA PLAN (2013)

"Decisions about land acquisitions for restoration must address how small parcels that become available for restoration might be **connected and combined** to maximize ecological benefits over the **long term**"

- Which functions should be restored?
- How large is large?
- What should be connected to what?
- How does this look different in different parts of the Delta?
- How do we make the system resilient to future stressors including climate change

The Delta Landscapes Project

The Delta Landscapes Project
How Do We Create A Desirable, Healthy Ecosystem in the Future Delta?



Goals and tenets:

- Emphasize **process-based** restoration of desired **ecosystem functions**
- Help us to think **holistically**
  - Benefit multiple species guilds
  - Benefits to people
  - Watershed connections
- Help us to think **large-scale and long-term**

funded by **CA Department of Fish & Wildlife**

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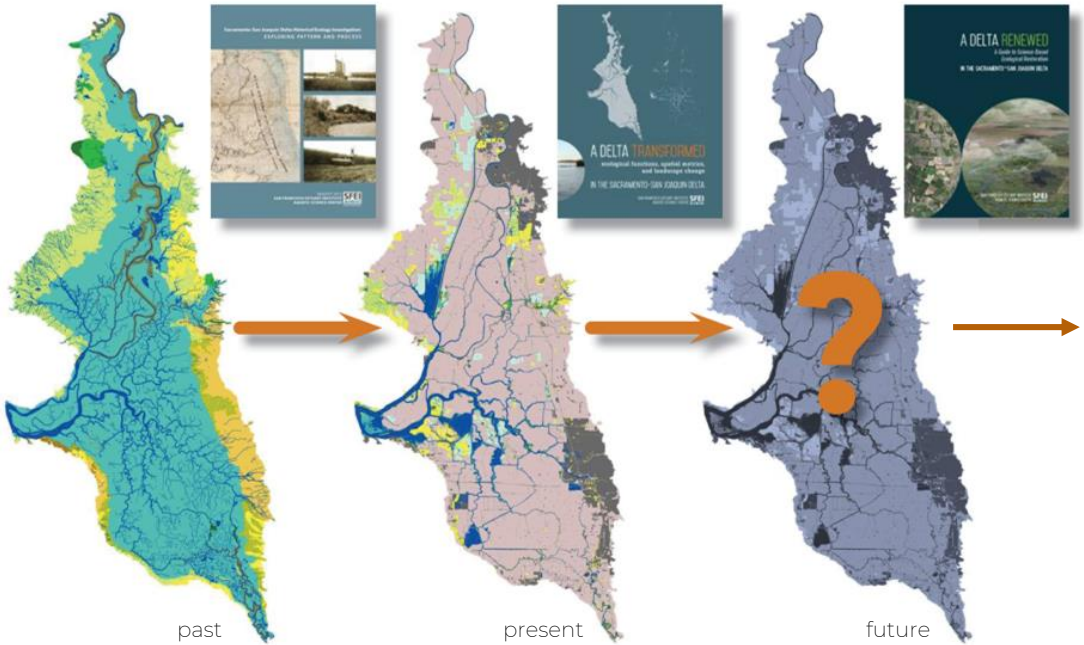

- How do we apply compiled science to actual **conservation planning**?
- How do we apply it **consistently** & **transparently**?

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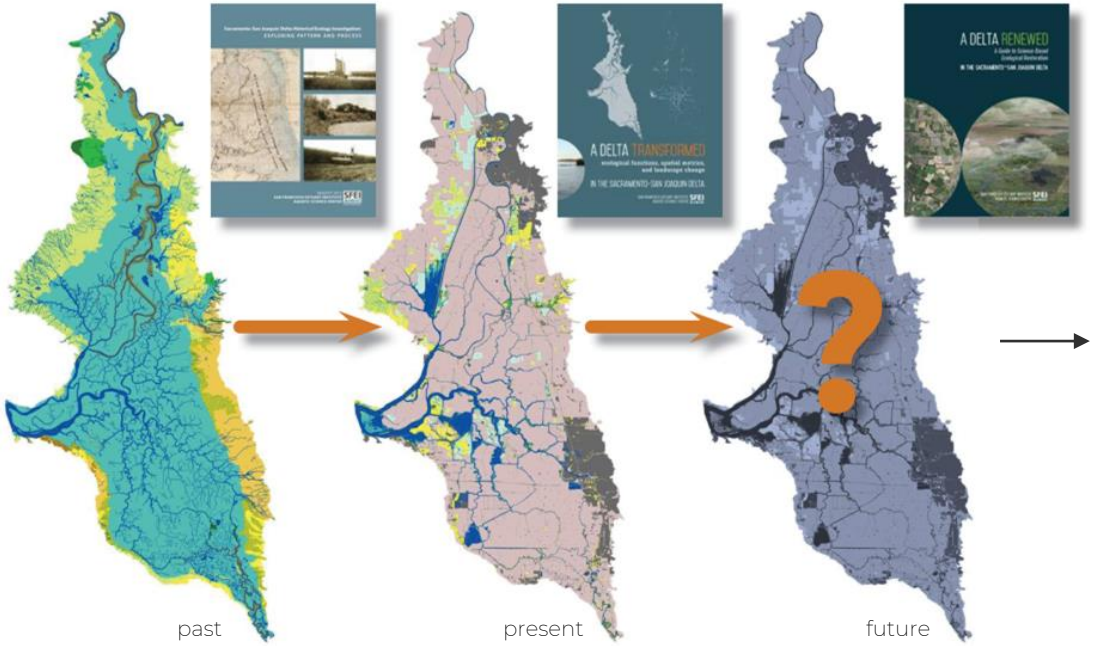
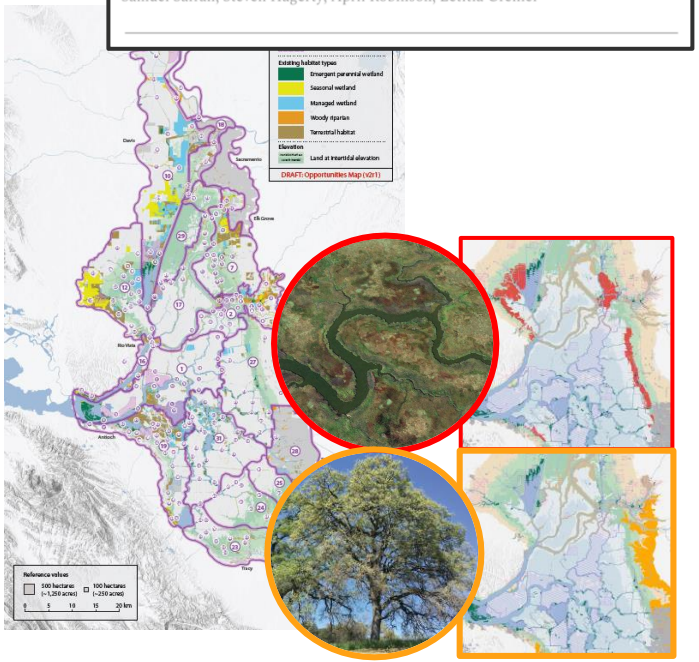


funded by **CDFW**

FINAL DRAFT Identifying, Mapping, and Quantifying Opportunities for Landscape-Scale Restoration in the Sacramento-San Joaquin Delta
Version 2.3, July 2018

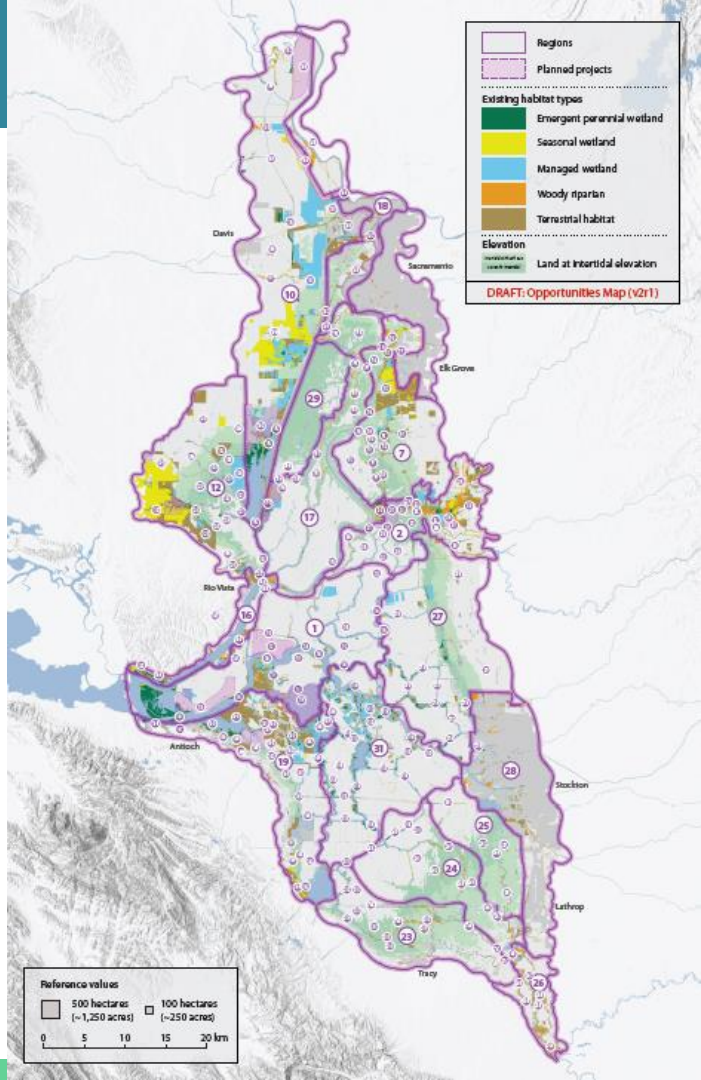
Prepared by the San Francisco Estuary Institute-Aquatic Science Center for the Delta Stewardship Council
Samuel Safran, Steven Hagerty, April Robinson, Letitia Grenier



funded by **DSC** & **MWD**

Today

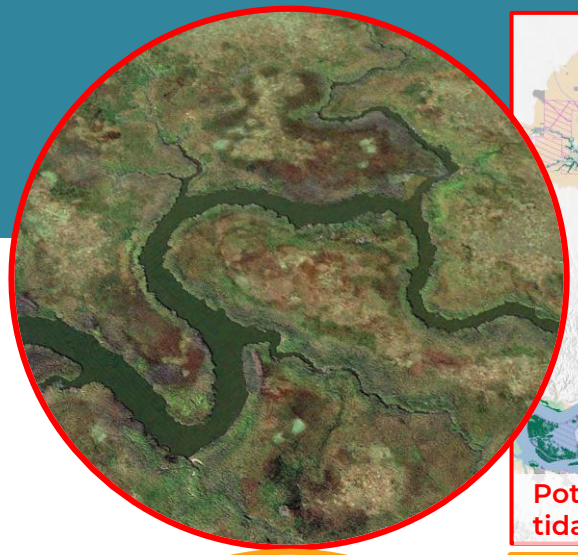
1. Provide **overview of approach** to modeling opportunities for landscape-scale restoration in the Delta
2. Highlight initial **applications**

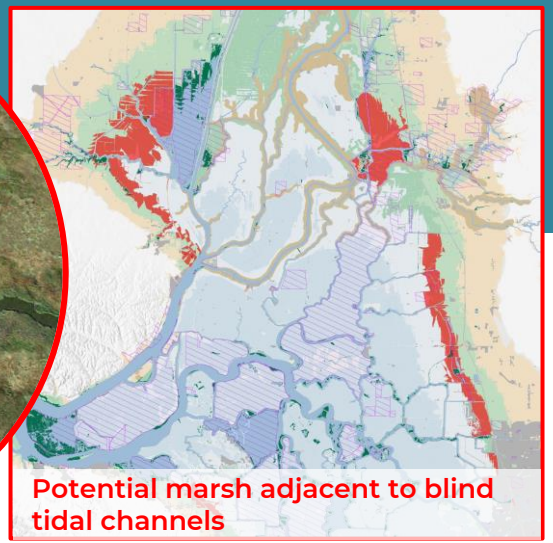


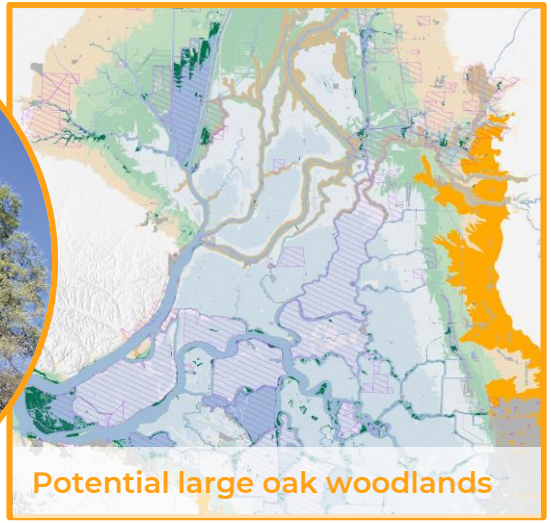
Identifying landscape restoration opportunities

How to use science-based strategies and guidelines compiled in *Delta Landscapes* reports to develop a landscape vision?

1. **Synthesized** *Delta Renewed* guidelines, strategies, and recommendations by function to create a "menu" of opportunity types
2. Systematically **evaluated** each opportunity type
3. **Summarized** opportunities by region and added components of existing plans







Ecological Functions Provided by the Delta

Fish

Provides habitat and connectivity for native fish

Marsh wildlife

Provides habitat and connectivity for native marsh wildlife

Waterbirds

Provides habitat and connectivity for native waterbirds

Riparian wildlife

Provides habitat and connectivity for native riparian wildlife

Edge wildlife

Provides habitat and connectivity for native edge wildlife

Biodiversity

Maintains biodiversity by supporting diverse natural communities

Productivity

Maintains food supplies and nutrient cycling to support food webs

1 Synthesizing opportunity types

How large should marshes be?

How far apart should marshes be?

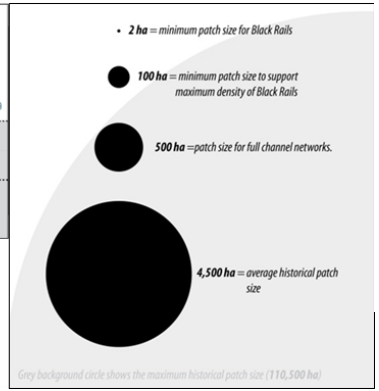
LANDSCAPE CONFIGURATION & SCALE GUIDELINES

4 Tidal marshes should be as large as possible

Though small marshes have some value, marshes should be as large as possible since the functions they support increase with size. For example, marshes as small as 1 ha can support some California Black Rails, but the density of rails is maximized once marshes reach approximately 100 ha in size. Blind channel length also increases disproportionately with marsh island area:[15] marshes larger than most that exist today are likely needed to maintain long, multi-order channel networks (see pp. 52-55).

Reference values

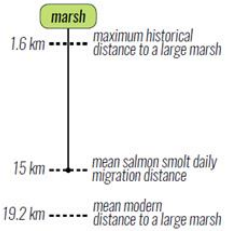
- **<1 ha** = 1 marsh patch size for Tricolored Blackbird nesting[16]
- **1 ha** = minimum marsh patch size for California Black Rail occupancy[17]
- **100 ha** = minimum marsh patch size for maximum Black Rail density[18]
- **500 ha** = approximate marsh area for a full channel network (based on historical landscape)[19]
- **4,494 ha** = average **historical** patch size (SD = 17,956)[20]
- **4 ha** = average **modern** patch size (SD = 24)[21]
- **110,527 ha** = maximum **historical** patch size[22]
- **749 ha** = maximum **modern** patch size[23]



5 Distance between tidal marshes should be minimized

Restoration plans should aim to decrease the nearest neighbor distance of Delta marshes and increase the proportion of marshes that occur in close proximity to large marshes. Marsh nearest neighbor distances should be informed by factors like animal dispersal distances. For example, because outmigrating juvenile salmon travel during the night and hold in low-velocity refugia habitats like marsh channels during the day,[24] they may benefit from gaps between marshes that are less than the distances they generally travel over a 24 hour period. Though historically the maximum distance between marshes was much less than this distance, today even the mean distance between marshes exceeds the mean distance smolts generally travel in a day.

- **0.2 km** = median natal Song Sparrow dispersal distance (San Pablo Bay)[25]
- **5 km** = mean Black Rail dispersal distance[26]
- **15 km** = mean salmon smolt daily migration distance[27]
- **0.3 km** = mean **historical** distance from one marsh to a sizeable (100 ha) marsh (SD = 0.4)[28]
- **19.2 km** = mean **modern** distance from one marsh to a sizeable (100 ha) marsh (SD = 11.1)[29]
- **1.6 km** = maximum **historical** distance from one marsh to a sizeable (100 ha) marsh[30]
- **61.4 km** = maximum **modern** distance from one marsh to a sizeable (100 ha) marsh[31]



from *A Delta Renewed* (strategies for re-establishing marsh in areas at intertidal elevation)

1 Synthesizing opportunity types

Habitat and connectivity for native fish and marsh wildlife	
Existing marshes in need of legal protection	x
Areas currently at **intertidal elevation** that could support marsh	x
Areas >100 ha (large enough to potentially support maximum densities of black rails)	x
Areas >500 ha (large enough to potentially support a dendritic channel network)	x
Areas adjacent to existing marshes to increase patch size and connectivity	-
Areas adjacent to remnant blind channel networks	x
Areas adjacent to tributaries with high inorganic sediment loads	x
Areas with undeveloped migration space and t-zone	x
Areas adjacent to potential woody riparian habitat	x
Subsided areas to prioritize for **reverse subsidence**	x
Minimally subsided and >500 ha	x
Minimally subsided and >100 ha	x
Minimally subsided and adjacent to potential woody riparian	x
Minimally subsided and likely to improve site hydrology (including channel network development)	x
Areas that would improve **marsh patch connectivity** at landscape scale	x
Locations where large marshes are needed to provide habitat and connectivity for resident marsh wildlife (as represented by black rails)	x
Locations where large marshes are needed to support the survival, growth, and movement of native fish (as represented by juvenile salmonids)	x
Opportunities to improve hydrodynamics through **reconfiguration of channel cuts**	x
Opportunities to create **water temperature refugia** through vegetative shading and connection to groundwater	-
Fluvial-tidal transition zones to prioritize for improved habitat conditions	x
Topographic lows at the sites of former lakes and flood basins, which could support long-duration inundation	-

Habitat and connectivity for waterbirds	
Existing wetland, aquatic and connected terrestrial habitat types in need of legal protection	-
Existing habitats of significant value to specific populations: Sandhill Crane roosting sites	-
Existing habitats of significant value to specific populations: Remnant riparian habitat likely to support old growth woody riparian forests	-
Opportunities for restoring wetland, aquatic and connected terrestrial habitat types	-
Wetlands of large size to support adequate food production for large flocks of waterbirds	-
Connected terrestrial habitats around the periphery of the Delta, including vernal pools and seasonal wetlands	-
Riparian forest habitat near marshes to support colonial roosting and cavity nesting birds	-
Opportunities to integrate waterbird habitat into human land uses	-
Wildlife-friendly ag: locations for foraging habitats in the form of short-stature managed wetlands or seasonally flooded agricultural fields	-
Wildlife-friendly ag: locations to offset lost agricultural waterbird habitat (from tidal marsh restoration) in other areas	-
Integrate habitat improvements in urban areas.	-

Habitat and connectivity for riparian wildlife	
Existing woody riparian patches in need of legal protection	x
Existing woody riparian patches that are historical remnants	x
Existing woody riparian habitats that are hydrologically connected	x
Remnant natural levee topography that could support new woody riparian habitat if re-connected to streams	x
Areas expected to enhance connectivity between existing wide patches of woody riparian habitat	x
Areas that could potentially support woody riparian patches that are large and wide	-
Areas that are adjacent to existing or potential marshes	-
Locations in the Central Delta that could support willow thickets	x
Locations in the Central Delta that could support willow-fern swamps	x
Areas that did not historically support woody riparian vegetation, but could now due to environmental changes	-
Opportunities to increasing support for riparian species along urban creeks	-
Opportunities to increase support for riparian species in agricultural areas	-

Habitat and connectivity for edge wildlife	
Existing terrestrial habitat types in need of legal protection	x
Remnant areas of high quality habitat	x
Large, minimally-isolated existing habitat patches	x
Rare existing habitat types	x
Existing habitat within current tidal-terrestrial transition zone	x
Opportunities to restore terrestrial habitat connectivity	x
Areas that would increase intra- and inter- habitat connectivity among existing modern habitats and protected areas	x
Areas that contribute to tidal-terrestrial transition zones and facilitate marsh migration	-
Areas that enhance connectivity to areas outside of the Delta, e.g. to Suisun Marsh, Coast Range, Foothills	x
Areas that enhance connectivity within, to and among natural landscape blocks from existing habitat and protected areas	-
Opportunities to restore rare or lost terrestrial habitat types	x
Opportunities to restore areas large enough to support desired ecosystem functions	x
Integrate ecological processes with human land uses	-

Biodiversity	
Areas that are critical to species covered in the Bay Delta Conservation Plan	x
Areas of modeled vernal pool habitat, or degraded vernal pool habitat	x
Areas in the West Delta that could support species not found in other parts of the Delta	x
Areas of the South Delta that support unique riparian species	x
Areas of the NW Delta periphery that support covered species	x
Areas important for covered species with limited ranges within the Delta that are not already covered by the steps above	x
Opportunities for very large areas of continuous habitat to support wide-ranging endemic and generalist species	-

2 Evaluating opportunities

1. **Synthesize** *Delta Renewed* guidelines, strategies, and recommendations by function to create a menu of opportunity types

LANDSCAPE CONFIGURATION & SCALE GUIDELINES

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Though small marshes have some value, marshes should be as large as possible since the functions they support increase with size. For example, marshes as small as 1 ha can support some California Black Rails, but the density of rails is maximized once marshes reach approximately 100 ha in size. Blind channel length also increases disproportionately with marsh island area:[15] marshes larger than most that exist today are likely needed to maintain long, multi-order channel networks (see pp. 52-55).

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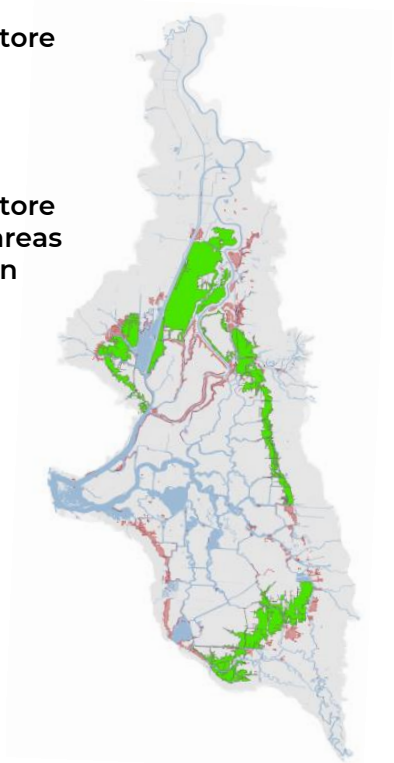
2. Systematically **evaluate** each opportunity type

Opportunities to restore marsh at areas of intertidal elevation (~33k acres)

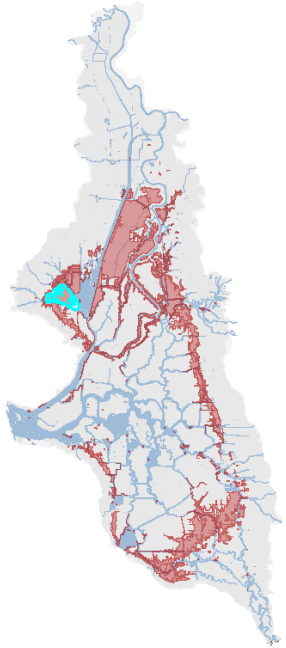
Opportunities to restore marshes >500 ha at areas of intertidal elevation (~27k acres)



2 Evaluating opportunities

- Simple ArcGIS models
- Primary inputs
  - Elevation
  - Landcover-historical & modern
  - Channel network
- Most outputs are annotated shapefiles

Opportunities to restore marsh at areas of intertidal elevation



Large (>100 ha)?

Large (>500 ha)?

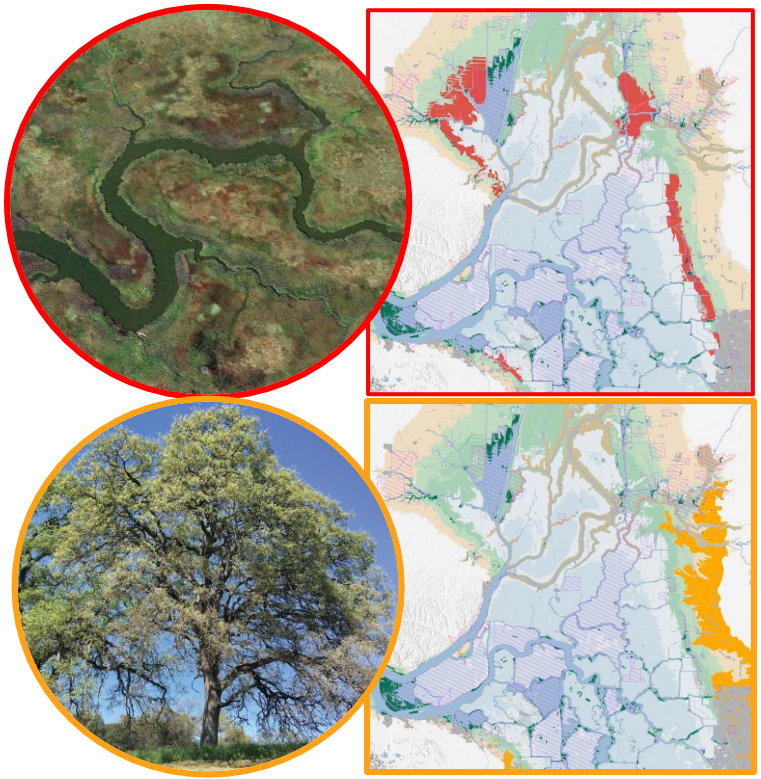
Remnant blind channel?

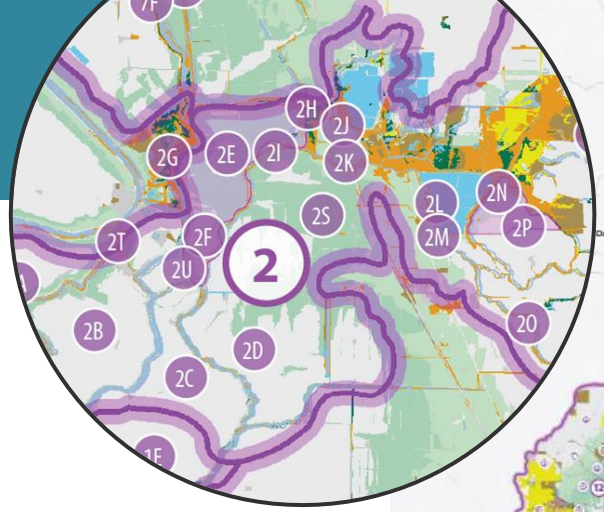
Quality migration space?

Potential woody riparian adjacency?

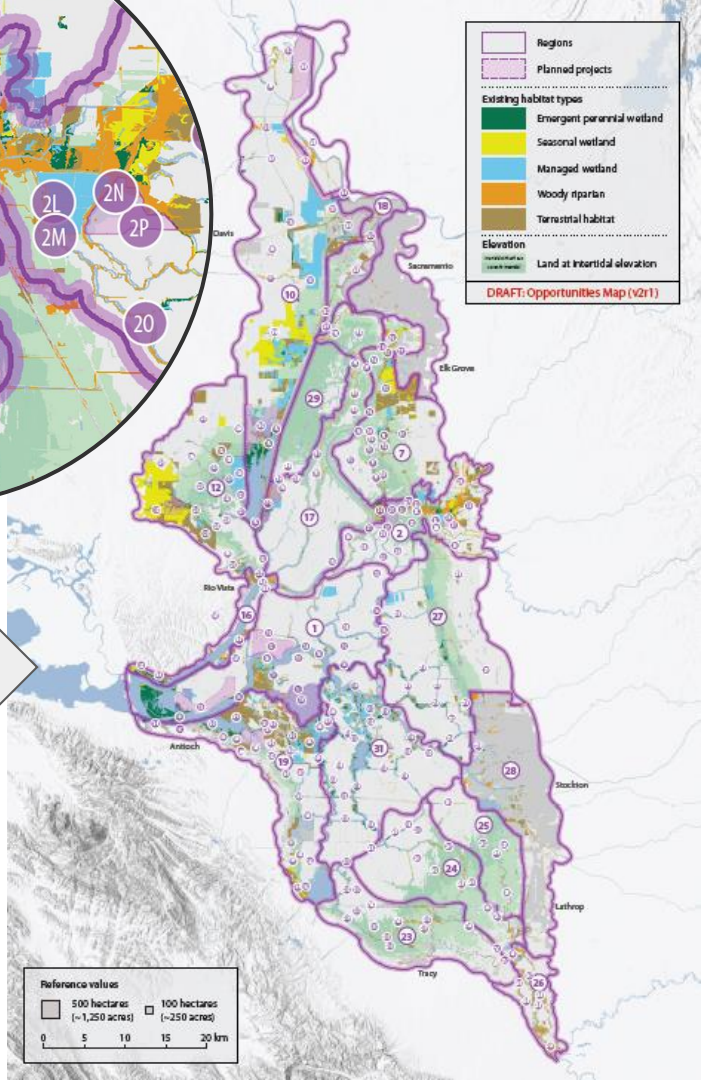
Patch_ID	tidal_patch_100ha	Intertidal_patch_500ha	Adjacent_to_remnant_blind_Channel	Contiguous_with_undeveloped_transgression_space	Adjacent_to_historical_riparian
263	1	1	<Null>	1	1
53	1	1	<Null>	1	1
154	1	1	1	1	<Null>
202	1	1	1	1	<Null>
183	1	1	<Null>	1	1
220	1	1	1	1	<Null>
229	1	1	1	1	<Null>
269	1	1	<Null>	1	1
254	1	1	<Null>	1	1
17	1	1	<Null>	1	1
7	1	1	<Null>	1	1
180	1	1	1	1	1
235	1	1	<Null>	1	1
193	1	1	1	<Null>	1
42	1	<Null>	1	1	<Null>
37	1	<Null>	<Null>	1	1
259	1	<Null>	<Null>	1	1
100	1	<Null>	1	1	<Null>
211	1	<Null>	<Null>	1	1
237	1	<Null>	<Null>	1	1
76	1	<Null>	<Null>	1	<Null>
227	1	<Null>	<Null>	1	1
268	1	<Null>	<Null>	1	<Null>
167	1	<Null>	<Null>	<Null>	1
217	1	<Null>	1	1	<Null>
44	1	<Null>	<Null>	1	<Null>
239	1	<Null>	<Null>	1	<Null>
163	1	<Null>	<Null>	<Null>	1
267	1	<Null>	<Null>	1	1
201	1	<Null>	<Null>	<Null>	1
120	1	<Null>	<Null>	<Null>	<Null>
12	1	<Null>	<Null>	1	1
242		<Null>	<Null>	1	<Null>

3 Summarizing opportunities by region





opportunities distilled into single map



3 Summarizing opportunities by region

Restore marshes on lands at intertidal elevation
- areas that are large enough to potentially support a dendritic channel network (>500 ha) include McCormack-Williamson Tract [2E] and the tract to the southeast [2S].
- both sites are adjacent to natural levee topography that could potentially provide transitions to woody riparian vegetation.
- MWT is also adjacent to a remnant blind channel network and, if restored, would enhance connectivity between existing small marsh patches at at Delta Meadows [2G] and MWT's east end [2H].
- the land at intertidal elevation at [2S] is contiguous with undeveloped upland areas.
- Delta Meadows and surrounding area supports side-flowering skullcap and mash skullcap [2G]

Restore marshes in subsided areas
- large minimally subsided areas include the land along Georgiana Slough [2A & 2B], North Mokelumne River [2B & 2C], and South Mokelumne River [2C & 2D]
- all of these areas are adjacent to potential woody riparian vegetation and located along tidal-fluvial transition zones
- restoring the minimally subsided area east of South Mokelumne River [2D] could improve site hydrology and the potential for coherent dendritic tidal channel network development
- restoring the minimally subsided area at the base of MWT [2F] could also improve improve hydrologic connectivity with areas at intertidal elevation and the potential for coherent dendritic tidal channel network development on the tract

Restore a network of large (>500 ha), well-distributed, and hydrologically-connected wetlands capable of supporting juvenile salmonid rearing and movement
- at least 2 sites needed within this region
- sites here should be tidal marshes with dendritic channel networks or seasonal floodplains
- substantial reverse subsidence efforts would be required to bring land surfaces up to intertidal elevation in portions of the region
- in the interim period these areas could still provide non-tidal marsh for other species guilds and possibly be managed to subsidize aquatic food w
management
- existing sites include the Cosumnes Preserve
- planned sites include the McCormack-Williamson Tract [2E]
- a strategically-located site would still be needed along the Mokelumne River (e.g., in the vicinity of Thornton [2O])

Build on the network described above by restoring large (>100 ha) and well-distributed marshes that enhance connectivity
- at least 3 sites would be needed in this region, though counting existing and planned sites, and assuming larger sites called for
additional site would be required to meet standards for marsh connectivity.
- if possible these marshes should experience periodic tidal or fluvial inundation, but could also be maintained in disconnected/
- strategic locations ultimately will depend on the location of other marsh restoration projects

Prepare existing public lands and acquire other lands along Mokelumne-Cosumnes courses to create a continuous
zone
- remove lateral and longitudinal barriers to tidal flows
- e.g., elevate I5 [2J], alter or remove levees to restore hydrological connectivity at Grizzly Island [2N]

Evaluate opportunities to improve tidal channel complexity and hydrodynamics through the removal or reconfigura
- example channel cuts marked with [2U]

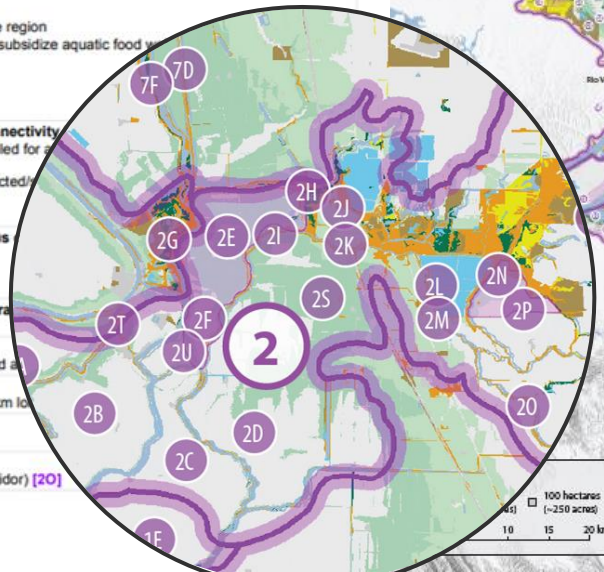
Protect and enhance existing remnant woody riparian patches
- portions of the existing woody riparian habitat in the area are potential historical remnants or are hydrologically connected a

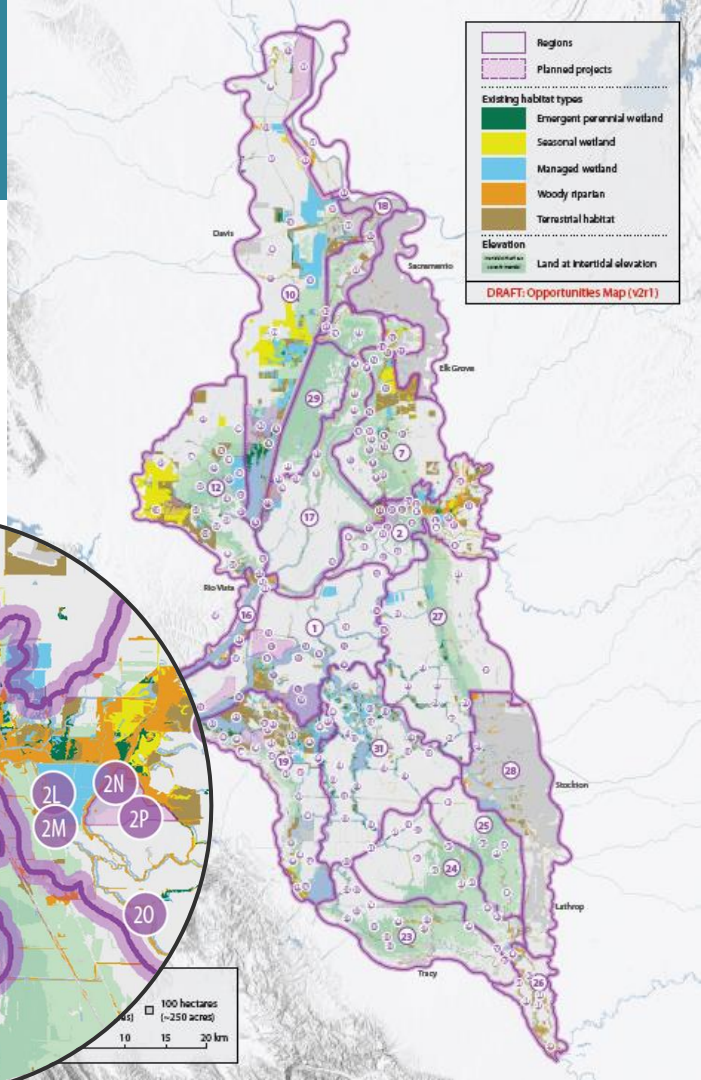
Remove levee along Mokelumne to restore wide corridor of woody riparian along south edge of tract [2I]
- remnant natural levee topography could be reoccupied to support a woody riparian corridor that is >100 m wide and >5 km lo

Enhance connection between riparian vegetation at MWT and Cosumnes Preserve
- notable gap around I5 (to have gap <100 m, break should not be much wider than highway itself) [2K]

Work to enhance riparian corridor between large/wide patches at Cosumnes Preserve and Tracy Lake
- artificial levee setbacks to allow riparian vegetation to reoccupy remnant natural levee topography (200- 600 m wide corridor) [2O]

Re-oak upland areas
- in agricultural areas plant oaks for hedgerows, shade trees, landscaping
- dedicated oak savannah restoration in protected areas (e.g., McFarland Unit [2Q] and Grizzly Island [2P])

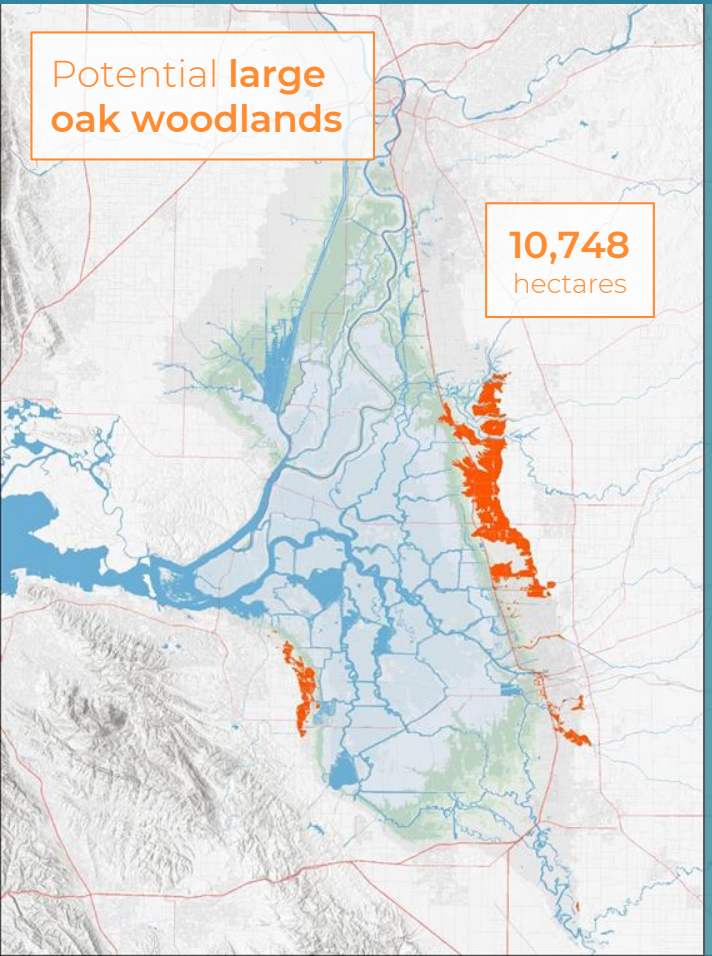




Current applications

- **Delta Plan Ecosystem Amendment** *(DSC)*
  - Understanding landscape potential important for setting high-level ecological restoration priorities
  - Compare landscape potential with conservation plans & objectives
- **Regional planning efforts**
  - Central Delta Corridor Partnership *(Delta Conservancy et al.)*
  - Northeast Delta Landscape Vision *(The Nature Conservancy)*
- **Landscape Scenario Planning Tool** *(DSC)*
  - Modeled opportunities guide scenario development & evaluation

Delta Plan Ecosystem Amendment



Comparing landscape potential with conservation plans & objectives

MARCH 2017

SAN FRANCISCO ESTUARY & WATERSHED SCIENCE

Sponsored by the Delta Science Program and the UC Davis John Muir Institute of the Environment

RESEARCH

Population and Habitat Objectives for Avian Conservation in California's Central Valley Grassland–Oak Savannah Ecosystems

Ryan T. DiGaudio[1], Kristen E. Dybala[1], Nathaniel E. Seavy[1], and Thomas Gardali[1]

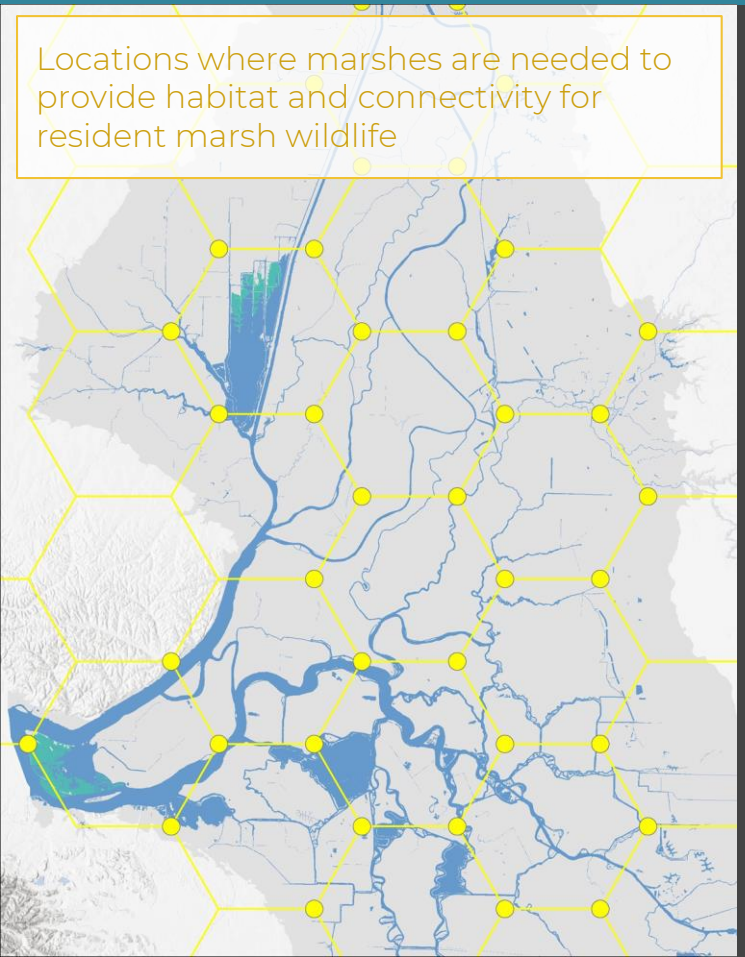
CVJV Conservation Objectives

(B) Grassland and oak savannah objectives, shown in hectares (acres)

	Short-term objective (10-year)		Long-term objective (100-year)		Estimated restoration needed (100-year)	
Region	**Grassland**	**Oak Savannah**	**Grassland**	**Oak Savannah**	**Grassland**	**Oak Savannah**
1° focus area	1,567,257	49,045	1,567,257	79,942	0	34,329
2° focus area	884,173	676,666	921,821	676,666	41,831	0
Total (acres)	2,451,430	725,711	2,489,078	756,608	41,831	34,329
	(6,057,615)	(1,793,270)	(6,150,646)	(1,869,619)	(103,367)	(70,917)

The Delta could potentially support **~30%** of objective

Regional planning efforts



Idealized network of functionally connected large marshes for black rails

(approximate marsh patch size at which rail densities plateau; *N. Nur, personal comm.*)

(mean black rail dispersal distance; *Hall 2015*)

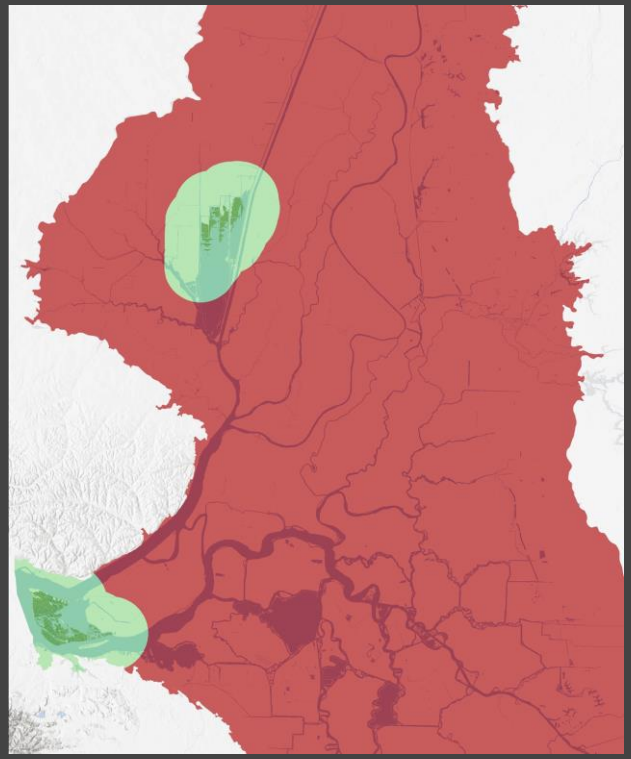
Hexagonal grid generates the least-dense possible network (each patch connected to three others)

Regional planning efforts (Central Delta Corridor Partnership)

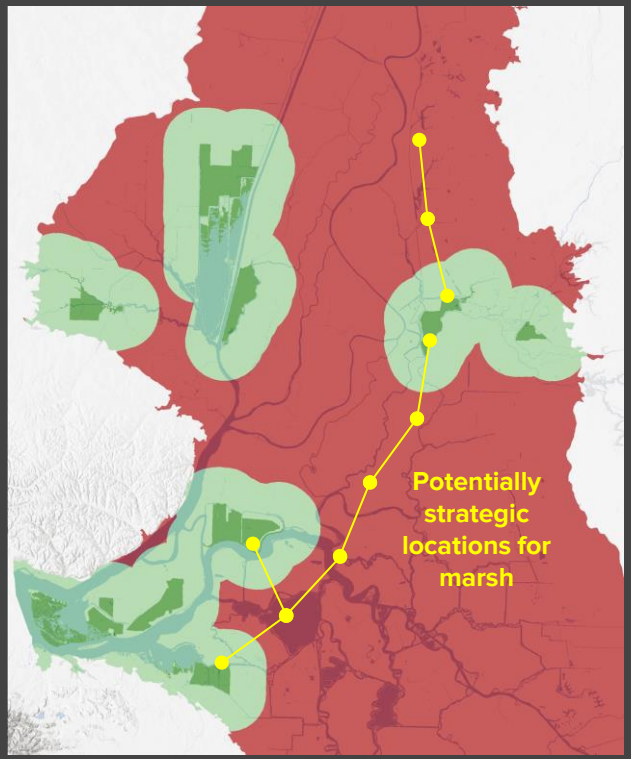
Large marsh patch
Functionally connected area

Functionally disconnected area

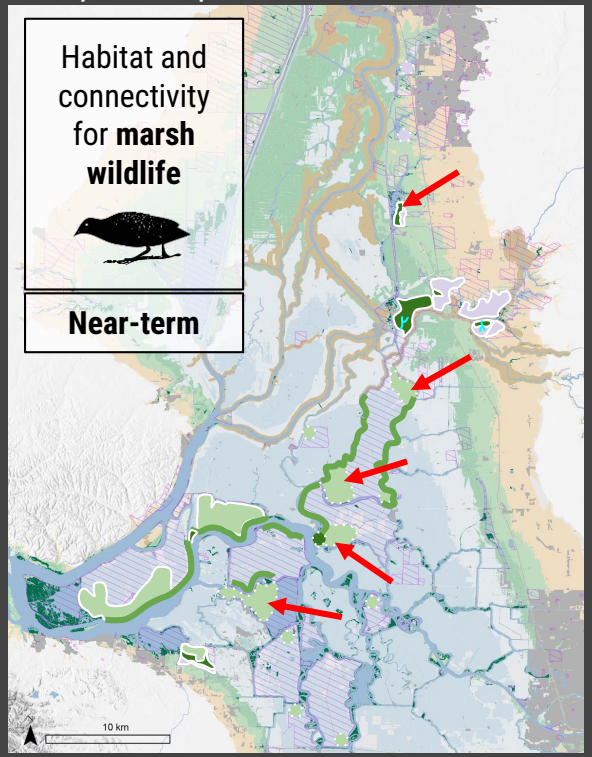
Connectivity: existing

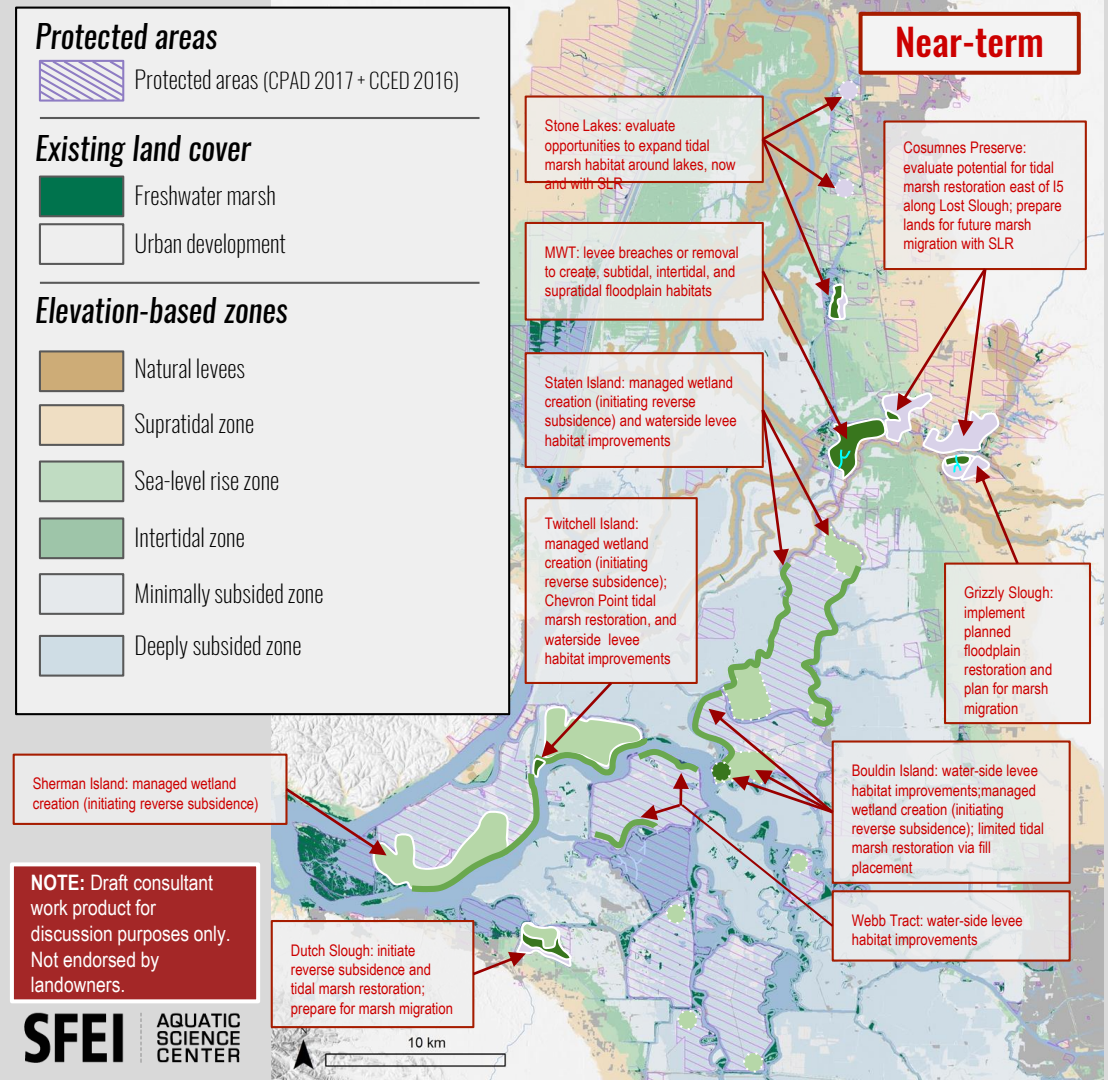


Connectivity: w/ planned EcoRestore projects



Example landscape vision





Habitat and connectivity for marsh wildlife

Restore **tidal marshes** on lands at intertidal elevation

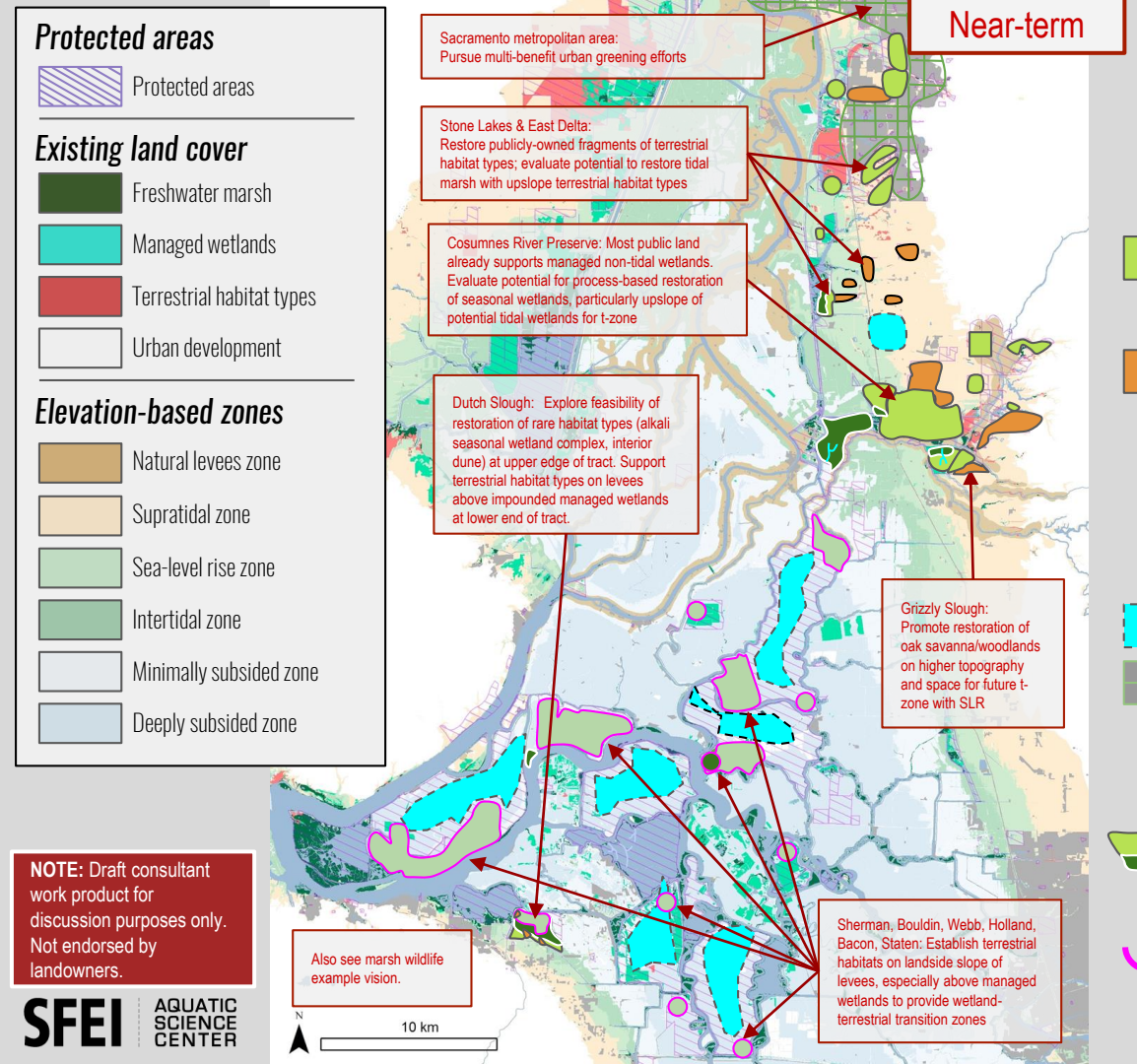
Maintain **non-tidal managed marshes** in subsided areas, which provide short-term benefits and (in some areas) could potentially support tidal marshes in the future through reverse subsidence efforts

Prepare lands in sea-level rise zone for **marsh migration** (interim habitat type dependent on landscape position)

Plan restoration efforts so that marshes are **large and connected** enough to provide full range of functions

- *Marshes large enough to support dendritic channel networks (>500 ha) at least every ~20 km*
- *Moderate marshes (>100 ha) at least every ~5 km to support marsh birds and other wildlife*

Where large-scale marsh restoration is not feasible, create more natural vegetated channel edges via levee modifications and other **channel margin enhancements** (e.g. planting benches)



NOTE: Draft consultant work product for discussion purposes only. Not endorsed by landowners.

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Habitat and connectivity for edge wildlife

Restore a diverse matrix of appropriate **native terrestrial habitat types** around the Delta's perimeter, including:

- Seasonal wetland habitat types (e.g., wet meadows, alkali seasonal wetlands, and vernal pool complexes)
- Upland habitat types (e.g., oak woodlands, stabilized interior dunes, and grasslands)

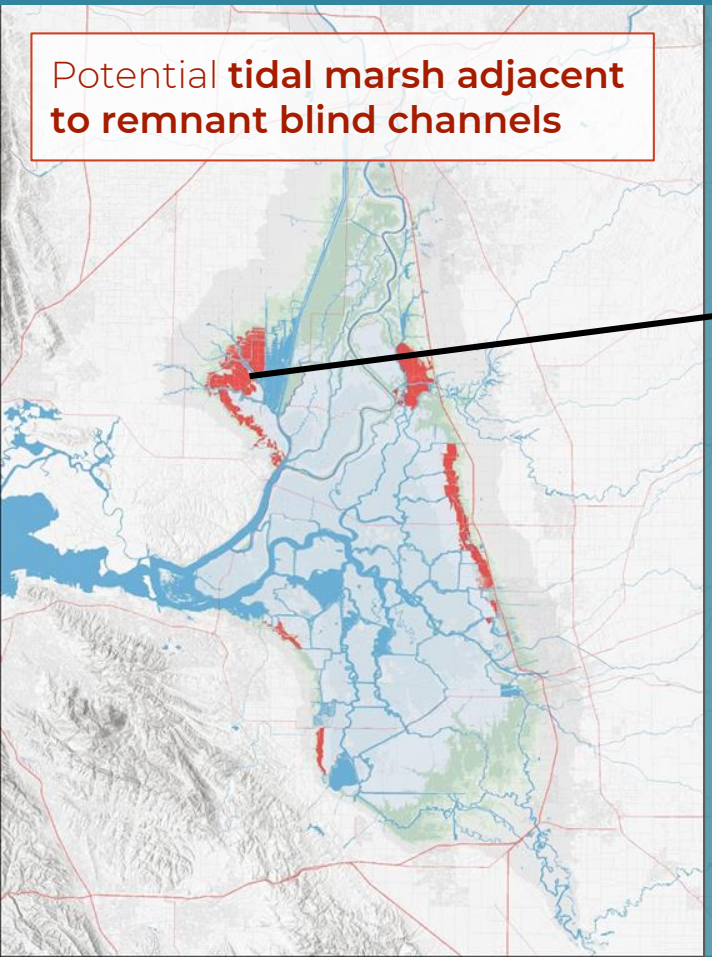
In areas where the outright restoration of terrestrial habitat types is not feasible, support edge wildlife through **novel approaches**, including:

- Wildlife friendly agriculture
- Urban greening

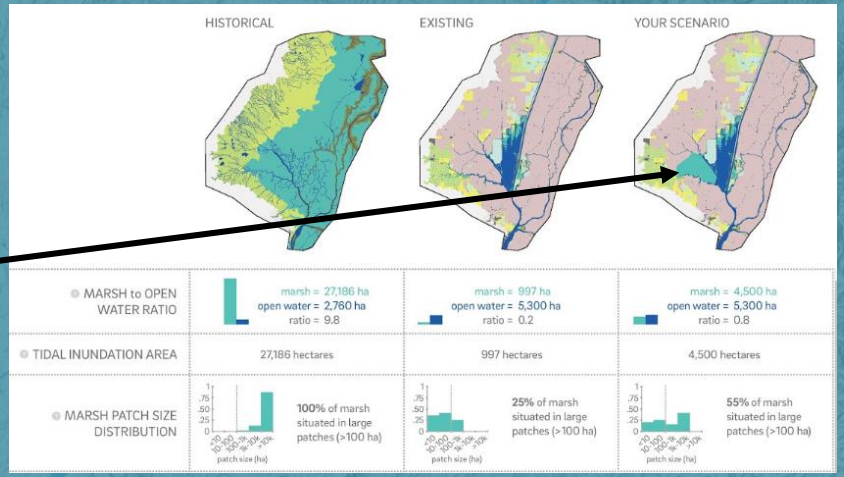
Recover **marsh-terrestrial transition zones**:

- Around the Delta's perimeter, prioritize the restoration of native terrestrial habitat types upslope of marshes
- In the subsided Delta, support terrestrial habitat types on levees above managed marshes

Delta Landscape Scenario Planning Tool



Tool mockup



- Tool to evaluate future landscape resotration scenarios
- Opportunity maps guide and provide **raw material** for the development scenarios

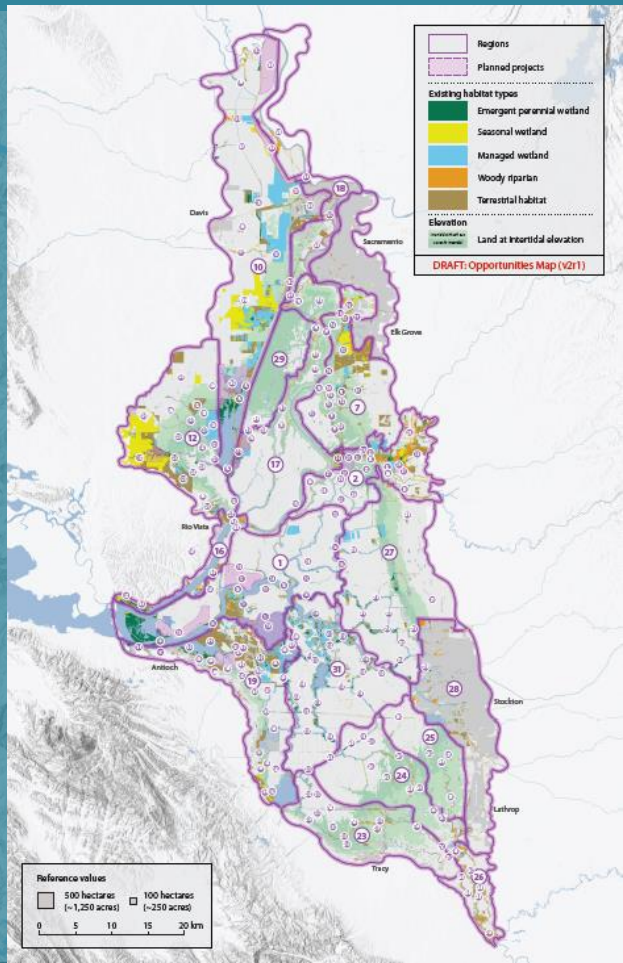
Next steps

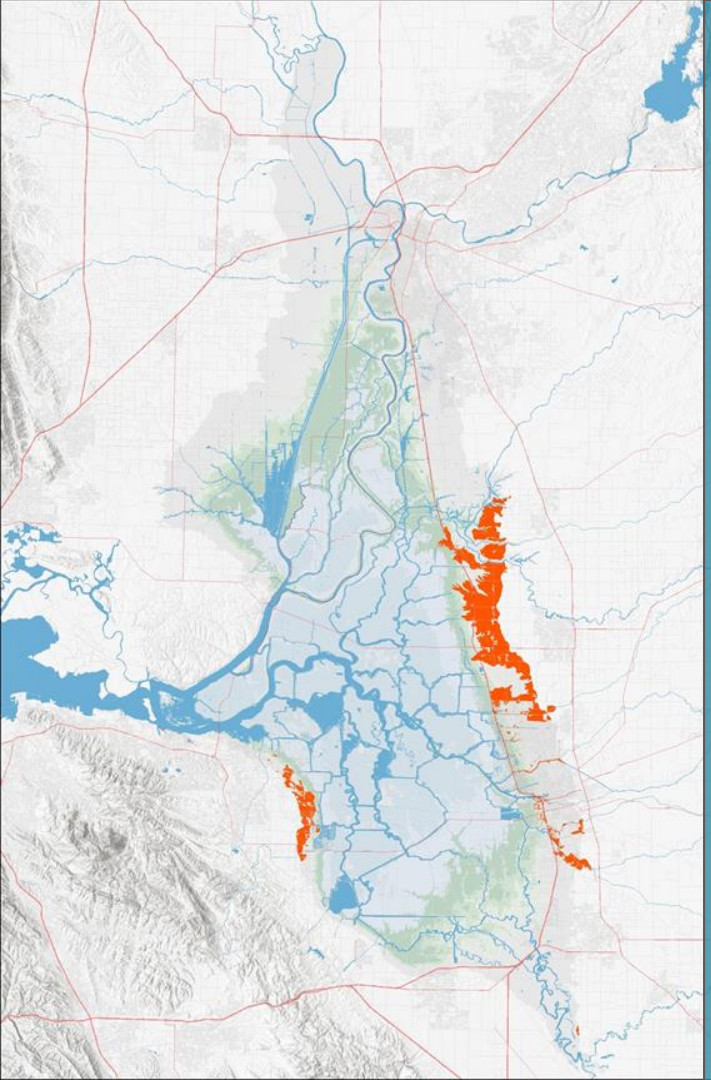
Near-term

- Continue making data available to conservation planning efforts (CDC & MWT efforts end Dec.)
- Re-run models using new tidally-referenced DEM

On the horizon

- Make layers available and continue their development through Delta Landscape Scenario Plannign Tool
- Meet with community to refine tool prioirities





Thank you:

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Funders

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California Department of Fish and Wildlife

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