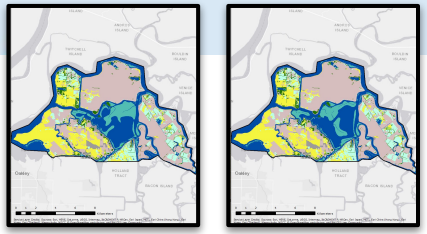
DELTA LANDSCAPES
SCENARIO PLANNING TOOL



February 3-4, 2021

SFEI | AQUATIC SCIENCE CENTER

SAN FRANCISCO ESTUARY INSTITUTE & THE AQUATIC SCIENCE CENTER

Agenda

1:30 - 1:35	Welcome
1:35 - 1:50	Introduction to the DLSPT
1:50 - 2:05	Scenario Design
2:05 - 2:15	Technical Tool Usage
2:15 - 2:35	Case Study Analyses and Outputs
2:35 - 3:05	Breakout Group Discussion
3:05 - 3:20	Q & A
3:20 - 3:30	Future Directions

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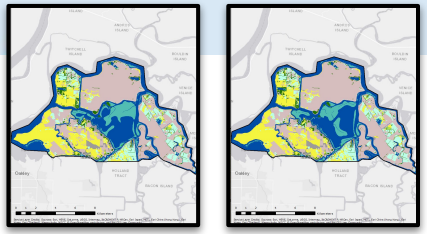
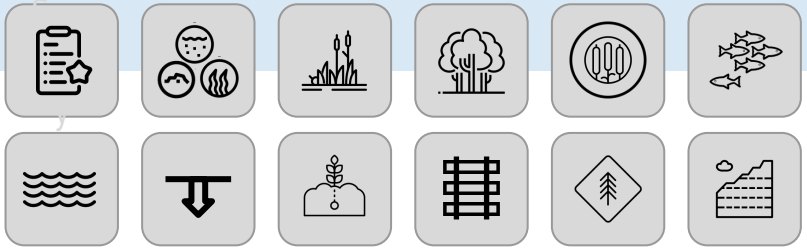
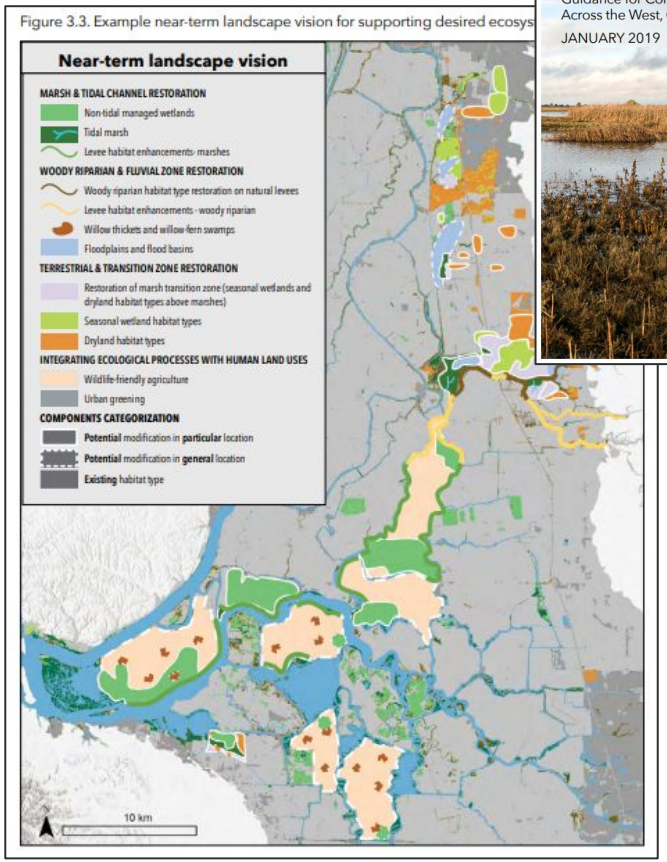
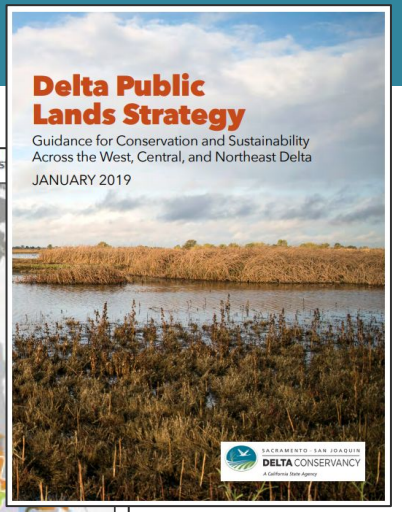




Need for tool

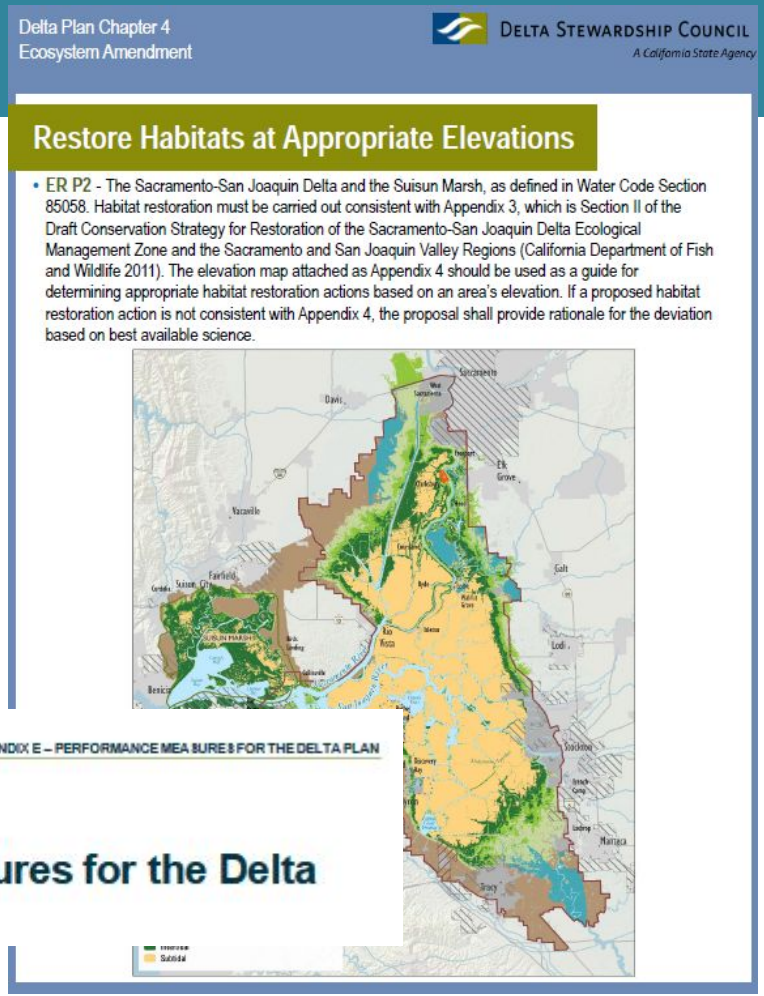
- **Regional restoration planning**
  - Need a simple and standardized way to
    - construct restoration scenarios
    - evaluate restoration scenarios
    - analyze cumulative impacts of multiple projects





Need for tool

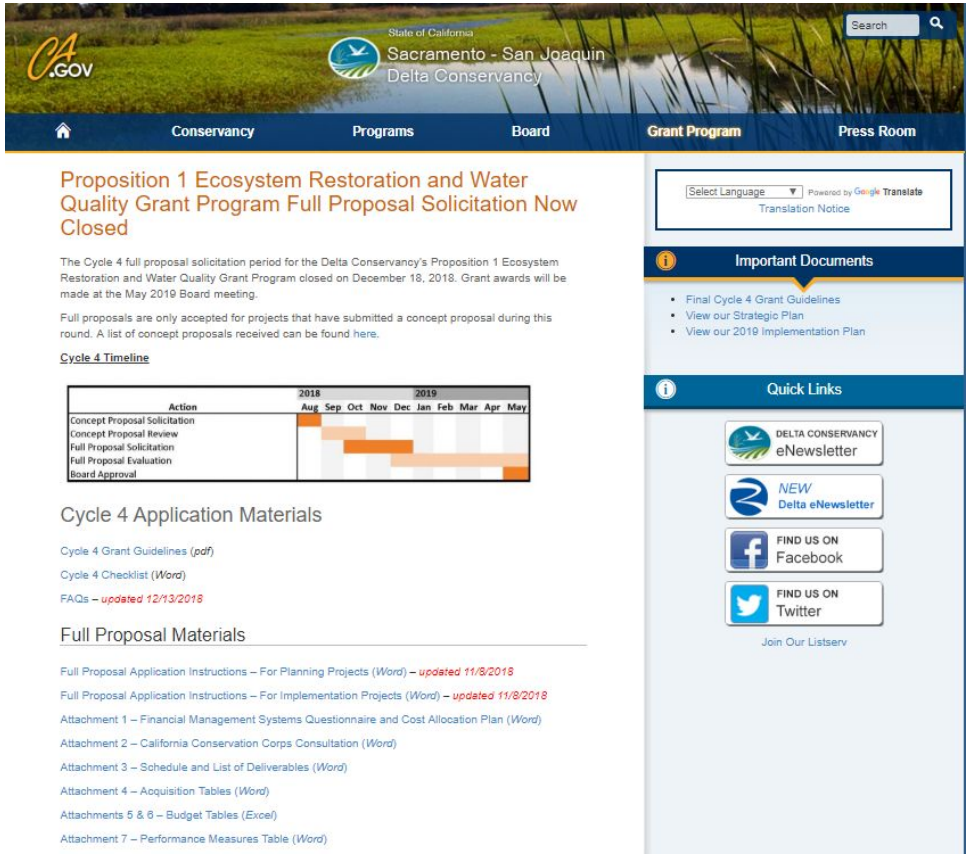
- Regional restoration planning
- Implementing the **Delta Plan**
  - A tool to promote & assist compliance with policies
  - A way to anticipate & measure the impacts of actions on performance measures



Need for tool

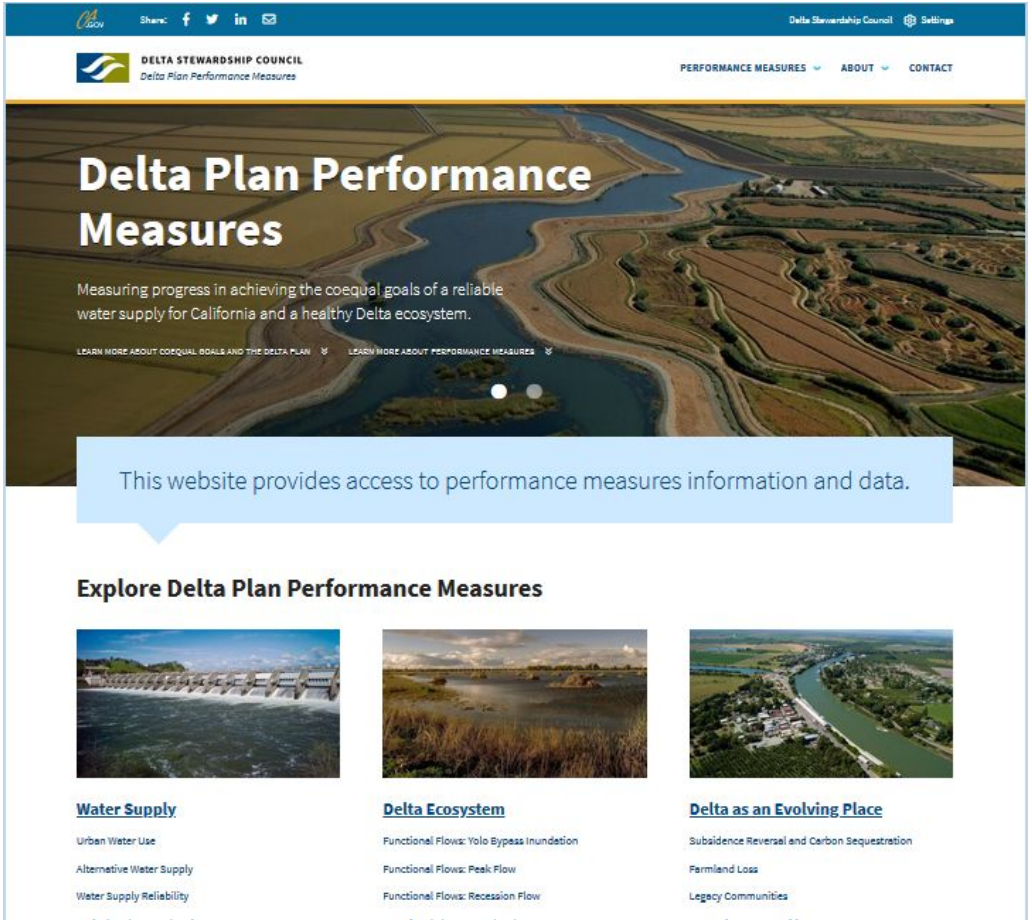
- Regional restoration planning
- Implementing the **Delta Plan**
- **Proposal evaluation**
  - Need a simple way to evaluate landscape-level impacts of proposed projects (for both applicants and reviewers)
  - Something to help set objectives (identify key metrics and expected outcomes)

Delta Conservancy- Prop 1 Solicitation (2019)
setting clear objectives not just best practice, but a requirement



Need for tool

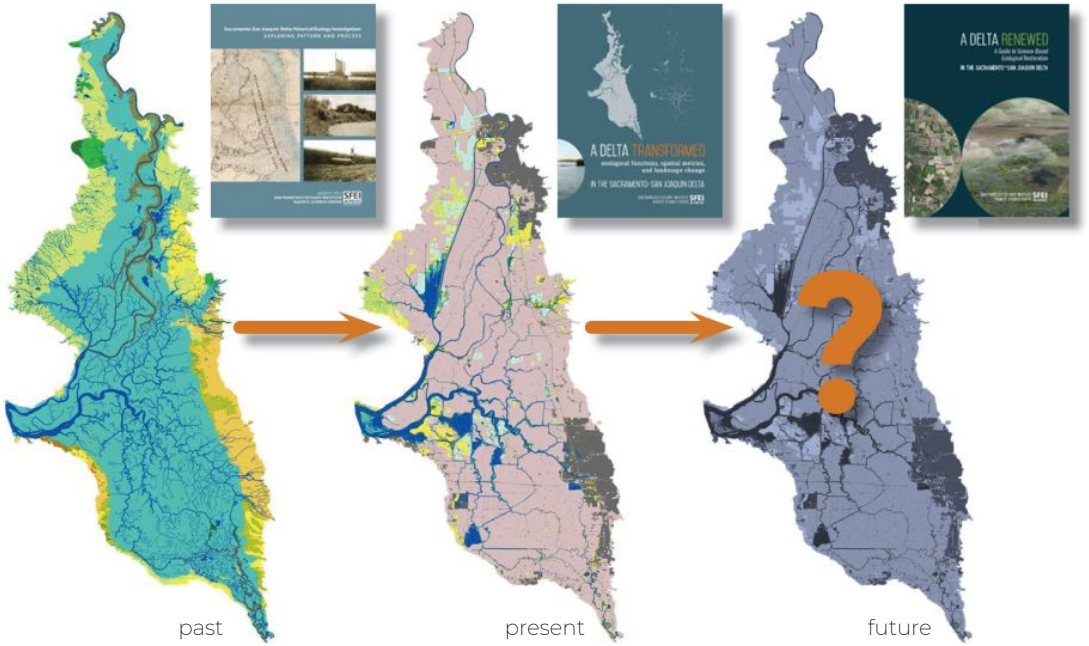
- **Regional restoration planning**
- Implementing the **Delta Plan**
- **Proposal evaluation**
- **Project tracking**
  - As projects are implemented need a tool that can help measure actual progress & performance (how does landscape actually develop?)



Project background

The Delta Landscapes Project

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



funded by **CDFW**

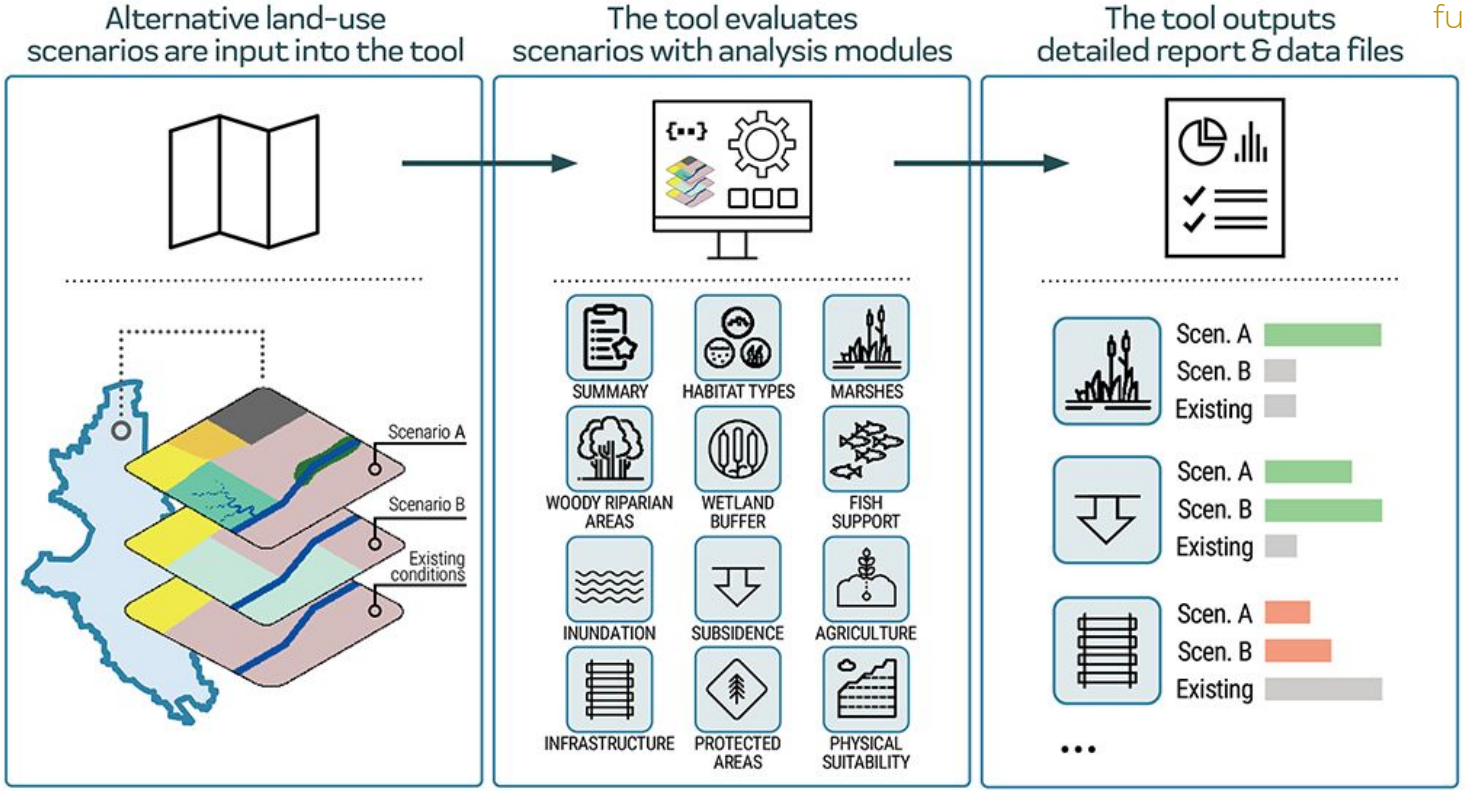
Goals and tenets of this approach:

- Help us to think at the **landscape-scale**
- 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**
  - Learn from past to inform future
  - Climate change resilience

DELTA LANDSCAPES SCENARIO PLANNING TOOL

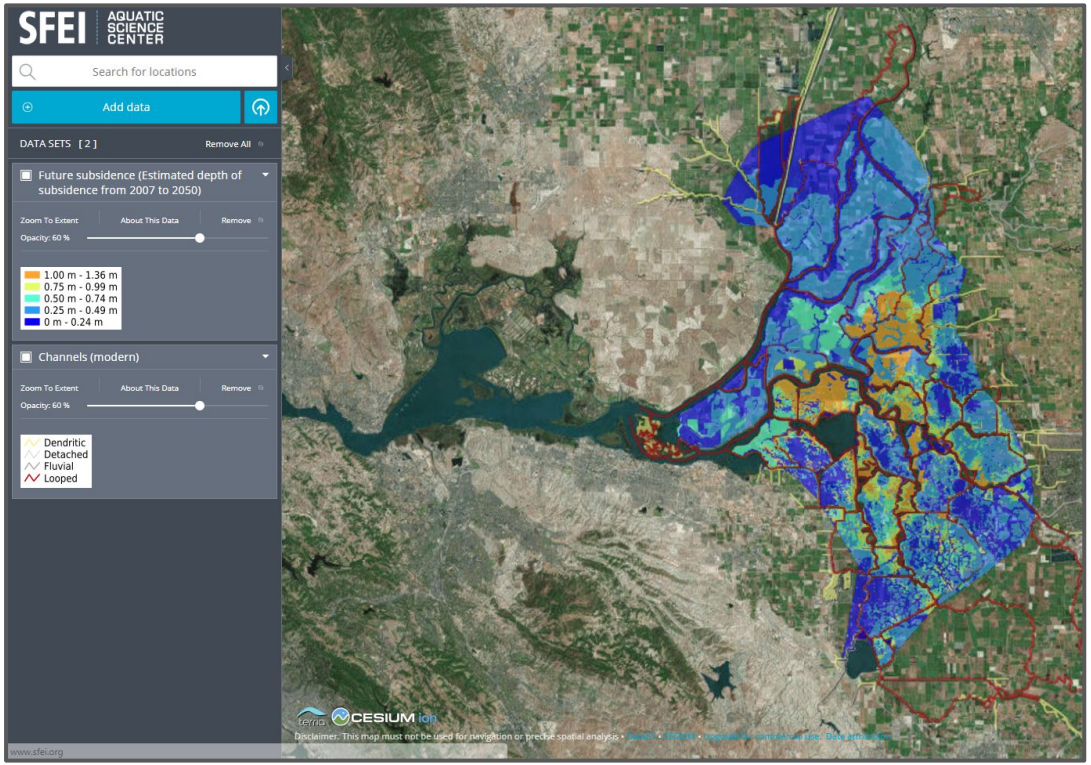
A standardized, science-based tool for analyzing and comparing Delta land-use scenarios.

funded by DSC



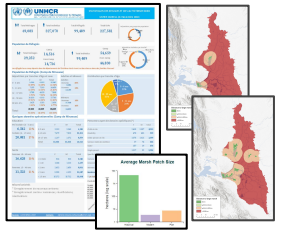
Guiding datasets

- Layers useful for landscape planning compiled & made available through **web-map**
  - Elevation
  - Public ownership
  - Historical & modern habitats
  - Landscape potential
  - Landscape connectivity
  - Infrastructure
  - Etc…



Tool outputs

Tool outputs



Reports can **compare up to 3 scenarios** (plus historical & modern)

Hist. vs. Mod. vs. EcoRestore

Delta Landscapes Scenario Plann

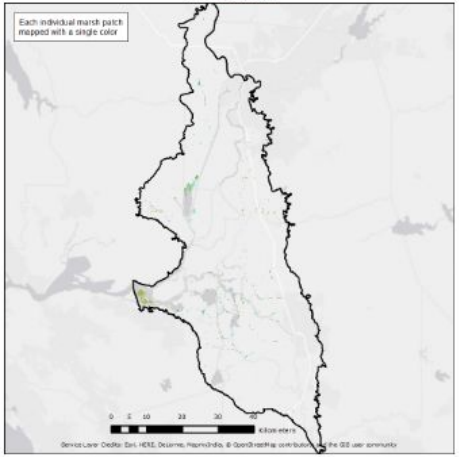
maps.californiawetlands.net/dlspt/projects/ecorestore/report/results.html

Landscape Scenario Summary (DRAFT)

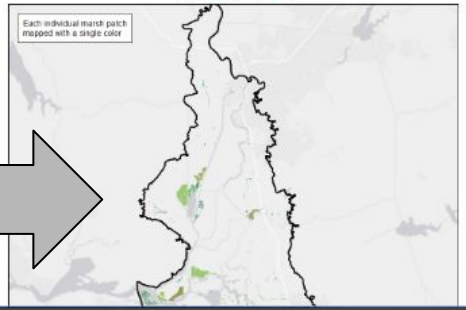
SELECT MODULE: Marsh Habitat

Print Report

3.2 - Modern



3.3 - EcoRestore



Marsh patch size

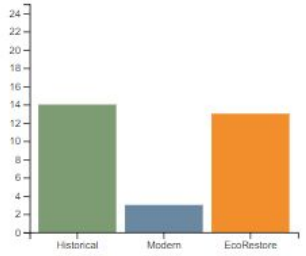
Large wetland patches support more habitat complexity, greater species diversity, and larger wildlife populations than smaller marsh patches. However, small marsh patches provide important ecological value as well, particularly in areas where they can serve as "stepping stones" providing ecological connectivity between large patches. Historically, the average size of marsh patches in this area of analysis was **4,494 ha**, today the average is **3.5 ha**. In EcoRestore the average marsh patch size is **8 ha**. Maps 1-3 of this section identify marsh patches in the historical Delta, the modern Delta, and EcoRestore.

Marshes that are greater than 100 ha are more likely to support high densities of marsh birds (Spautz and Nur 2002; Spautz et al. 2005) and marshes greater than 500 ha are more likely to support dendritic channel networks (SFEI-ASC 2014), although other factors including hydrology and habitat quality are also important. EcoRestore would **increase** the number of large patches greater than 100 ha by **10** and would **increase** the number of large patches greater than 500 ha by 3.

Marsh patch size metrics

	Historical	Modern	EcoRestore
Number of large patches (>100 ha)	14	3	13
Number of large patches (>500 ha)	11	1	4
Average marsh patch size	4,494 ha	3.5 ha	8 ha
Maximum marsh patch size	110,527 ha	719 ha	1,336 ha
Total area of large patches (>100 ha)	192,475 ha	1,122 ha	6,064 ha
Total area of large patches (>500 ha)	191,962 ha	719 ha	3,664 ha

Number of large marsh patches (>100 ha)



Tool modules: Summary

Goal: Rapidly compare scenarios to historical/current conditions & to each other across all modules.

Primary analyses:

- Summary table & comparison

Considerations:

- Value judgements?

Key inputs/parameters
- Results from all modules

Key outputs
- Summary table

Scenario positively affects metric (relative to current conditions)
Scenario does not alter metric
Scenario negatively affects metric (relative to current conditions)
★ Indicates which scenario most improves each metric (all metrics will be marked with stars if only evaluating one scenario)

	Historical	Modern	Scenario A		Scenario B		Scenario C	
Marsh habitat								
Patch size: number of large marsh patches (>100 ha)	1	0	1		2	★	2	★
Patch size: number of large marsh patches (>500 ha)	1	0	0		0		0	
Patch size: average marsh patch size	55,266 ha	2.9 ha	8 ha		7 ha		8 ha	★
Patch size: maximum marsh patch size	110,527 ha	44 ha	403 ha	★	275 ha		335 ha	
Patch size: total area of large patches (>100 ha)	11,210 ha	0	403 ha		397 ha		483 ha	★
Patch size: total area of large patches (>500 ha)	11,210 ha	0	0		0		0	
Patch nearest neighbor distance: average distance to nearest large marsh patch (>100 ha)	0.073 km	15 km	3.6 km		3.2 km		3.0 km	★
Network connectivity: probability that randomly placed marsh birds (Black Rails) can reach each other via dispersal	36%	2.25×10^{-3}%	3.79×10^{-3}%	★	3.61×10^{-3}%		3.80×10^{-3}%	★
Core to edge area ratio	10 : 1	0.085 : 1	0.95 : 1		0.93 : 1		1.2 : 1	★

email tech@sfei.org for help

Tool modules: Marsh habitat

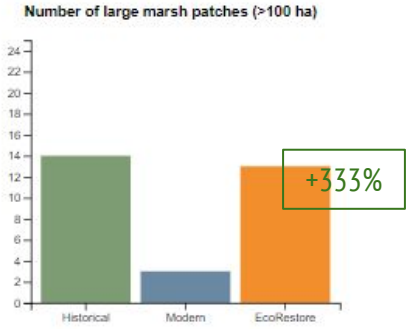
Goal: Analyze key metrics re. the marsh network and its ability to support marsh wildlife.

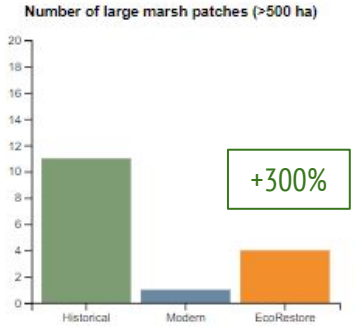
Primary analyses:

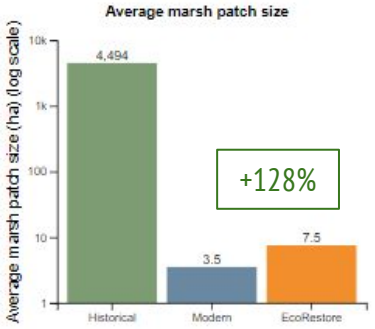
- **Marsh patch size**
- Marsh connectivity
- Marsh shape

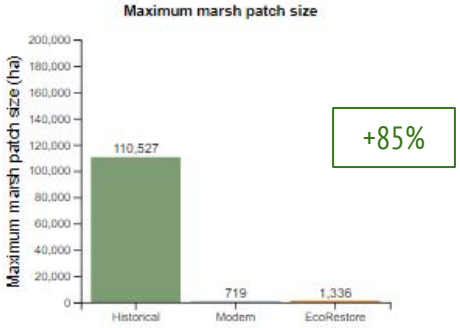
Key inputs/parameters
- Patch aggregation threshold

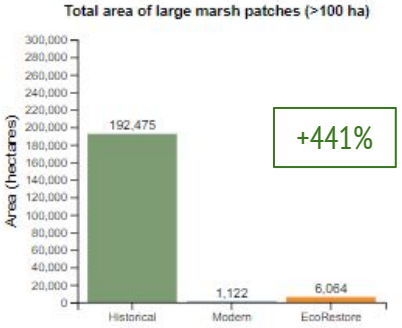
Key outputs
- Marsh patches (.shp)

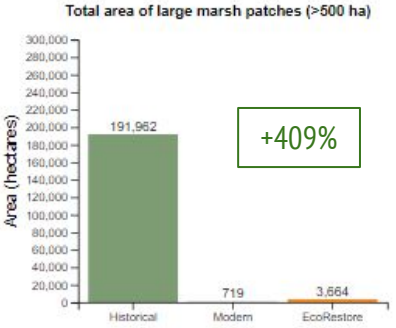












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A Delta Renewed: example landscape configuration guidance

Provided **landscape configuration guidance** related to each strategy

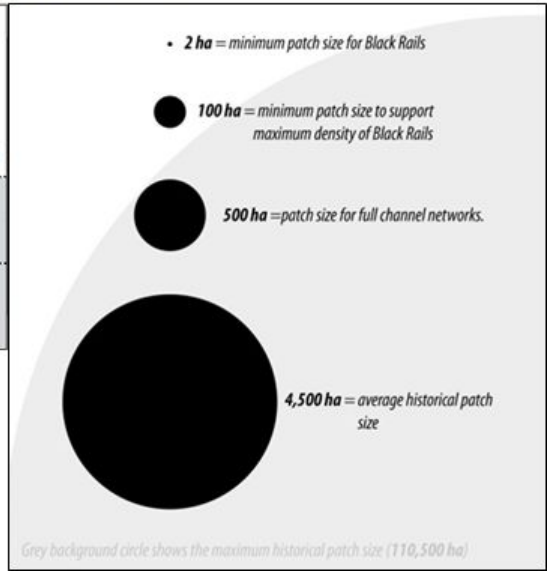
LANDSCAPE CONFIGURATION & SCALE GUIDELINES

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]



e.g., How **large** should marshes be?

Tool modules: Woody riparian habitat

Goal: Analyze the extent & patch size of woody riparian habitats for their ability to support riparian wildlife

Primary analyses:

- Total area
- Patch size

Considerations:

- Add riparian width?

Key inputs/parameters
- Patch aggregation threshold

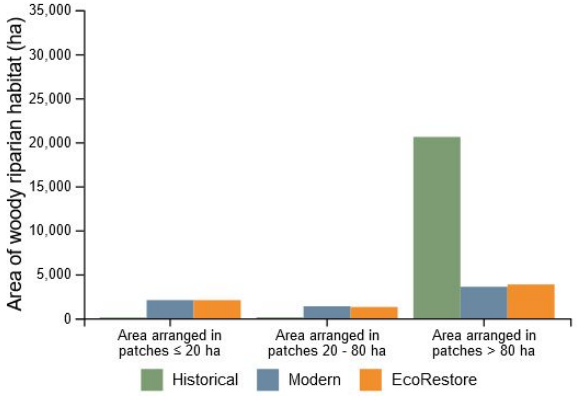
Key outputs
- Riparian patches (.shp)

Woody riparian habitat patch size

Large riparian patches likely support more habitat complexity, greater species diversity, and larger wildlife populations than smaller patches. Historically, the average patch size of woody riparian habitat in this area was **867 ha**. In the modern Delta the average woody riparian patch size is **6 ha**. EcoRestore would increase the average size of woody riparian patches to **7 ha**. Historically, **99.0%** of woody riparian habitat was found in patches larger than 80 ha (the minimum size researchers have defined as optimal to support the state-listed Western Yellow-billed Cuckoo in California; Laymon and Halterman 1989). In the modern Delta, **51.0%** of woody riparian habitat is found in patches larger than 80 ha. EcoRestore would increase this percentage to **53.4%**. The table and chart below also quantify the percentage of woody riparian habitat arranged in patches at least 20 ha in size, which is deemed "marginal" habitat for cuckoos (patches smaller than 20 ha are considered "unsuitable").

Woody riparian patch size distribution

Total woody riparian area (hectares) arranged in patches	Historical	Modern	EcoRestore
≤ 20 ha	94 ha (0.45%)	2,068 ha (29%)	2,066 ha (29%)
20 - 80 ha	113 ha (0.54%)	1,368 ha (19%)	1,289 ha (18%)
> 80 ha	20,604 ha (99%)	3,582 ha (51%)	3,845 ha (53%)



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Tool modules: Fish support

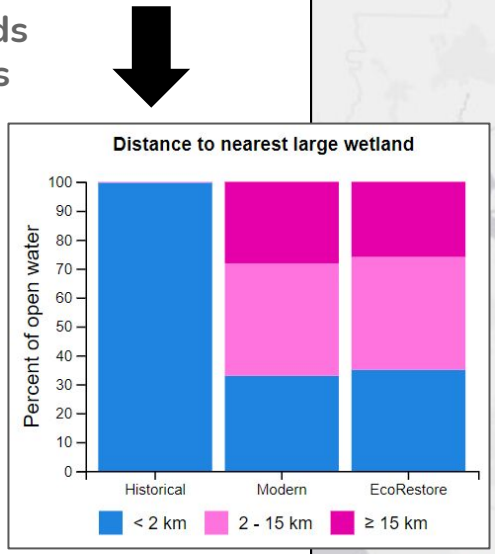
Goal: Highlight changes to wetlands and open water that affect support for fish in the Delta

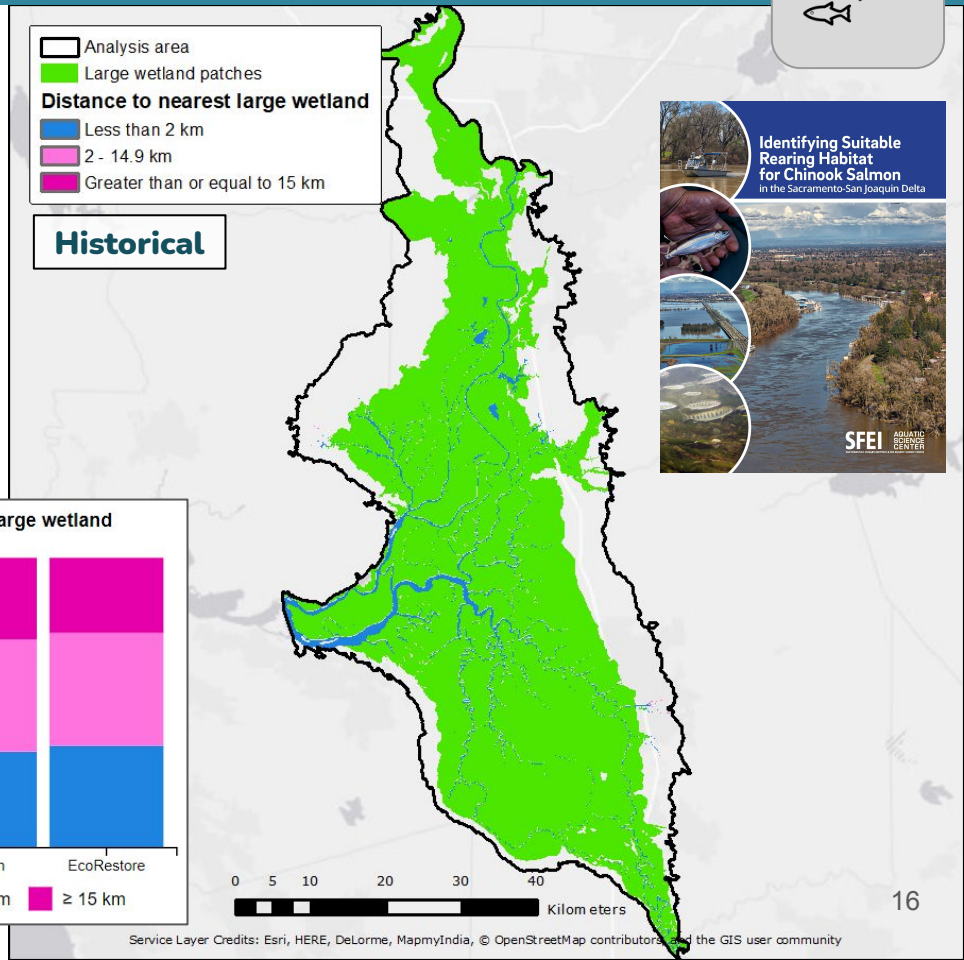
Primary analyses:

- Marsh area and marsh to open water ratio
- **Connectivity of large wetlands along fish migration corridors**
- Channel edges
- Water temperature

Key inputs/parameters
- Salmon daily movement distances

Key outputs
- Distance to nearest wetland (.tiff)





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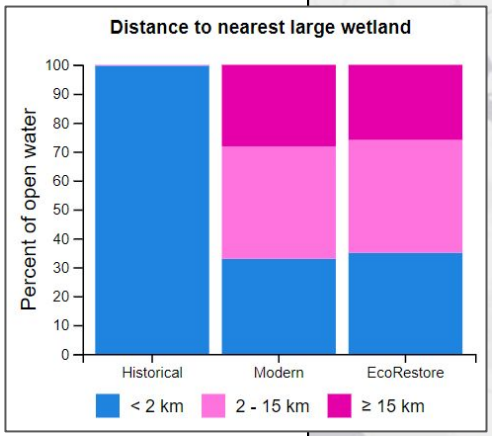

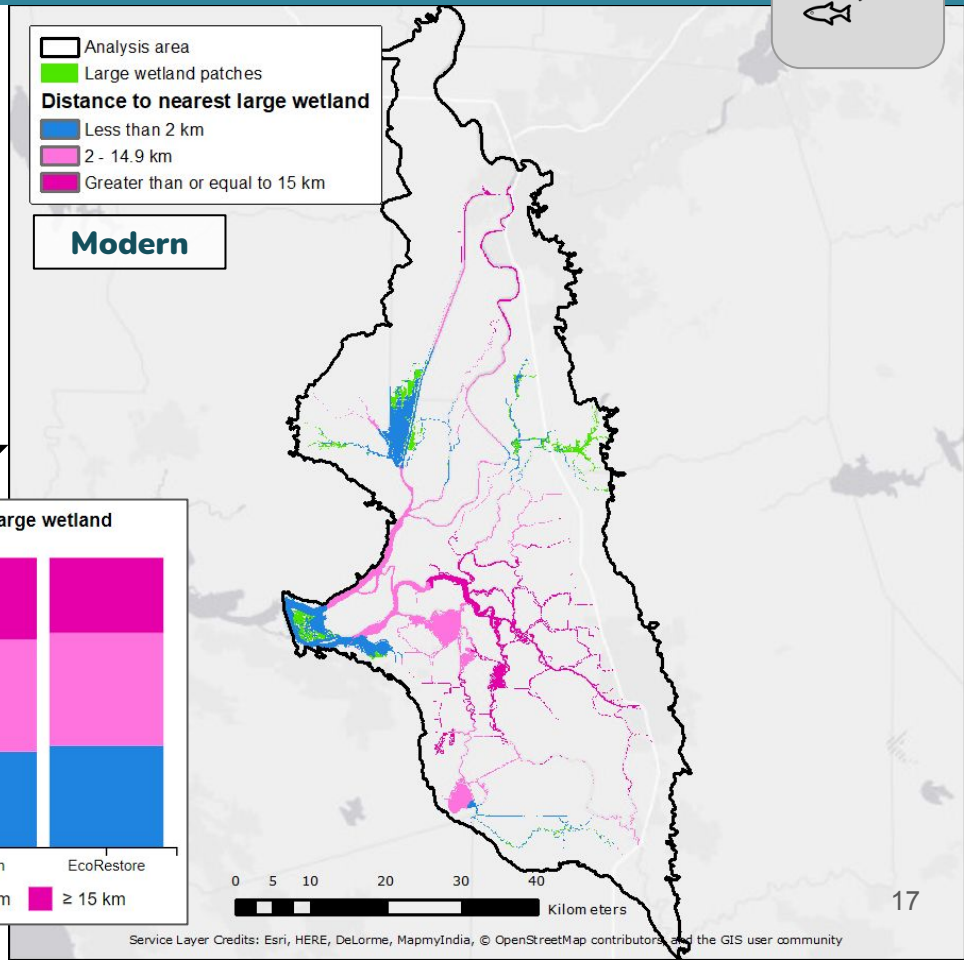

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Key outputs
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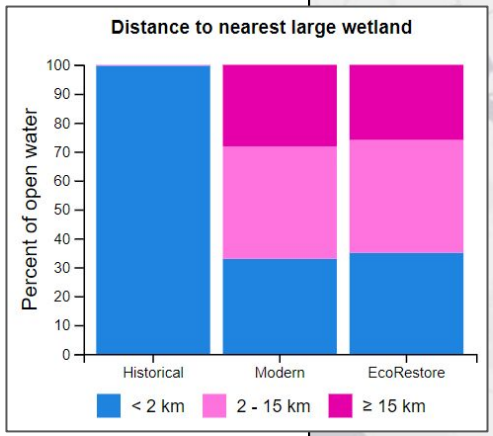
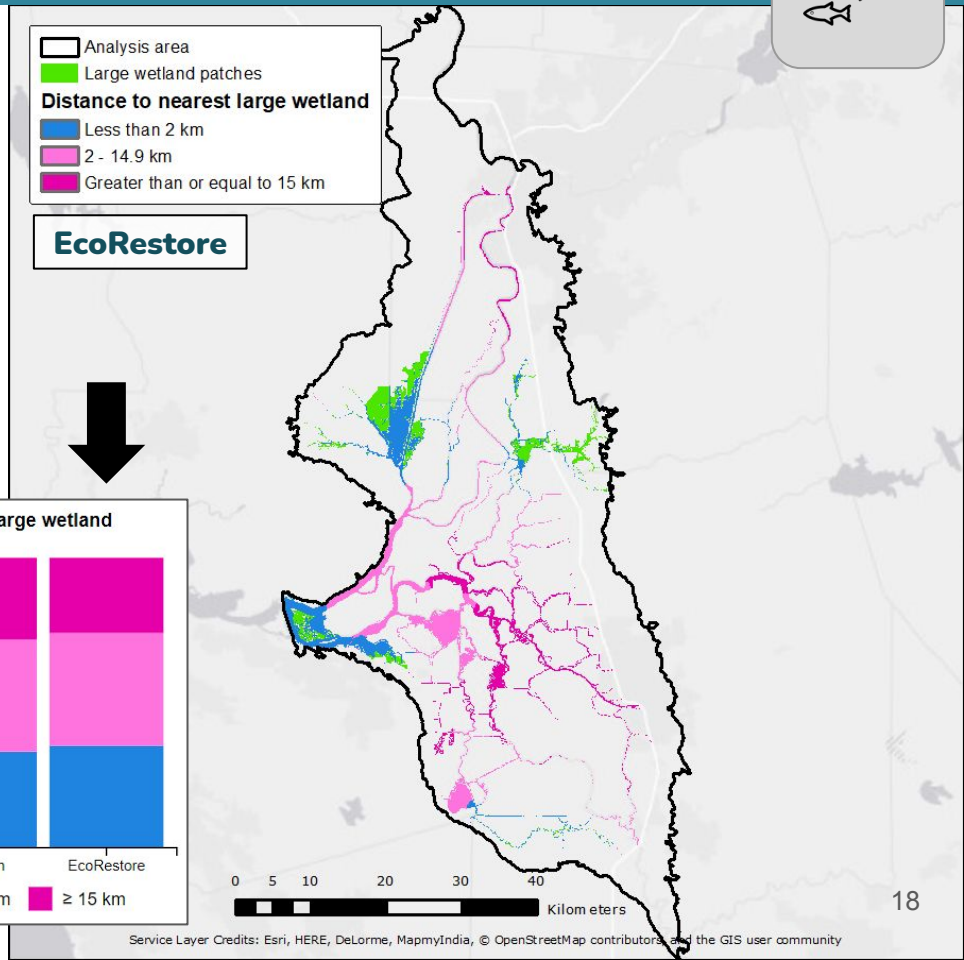




Tool modules: Subsidence

Goal: Summarize what portion of subsided lands are covered by land uses that halt subsidence & how it might take to reach sea level in different areas via reverse subsidence.

Primary analyses:

- Current extent of subsided lands
- **Extent of subsidence halting land uses**
- Approximate time to reach sea level with subsidence reversal wetlands

Key inputs/parameters

- Tidally referenced elevation (2017 LiDAR)
- Deverel et al. 2014 time to reach sea level

Key outputs

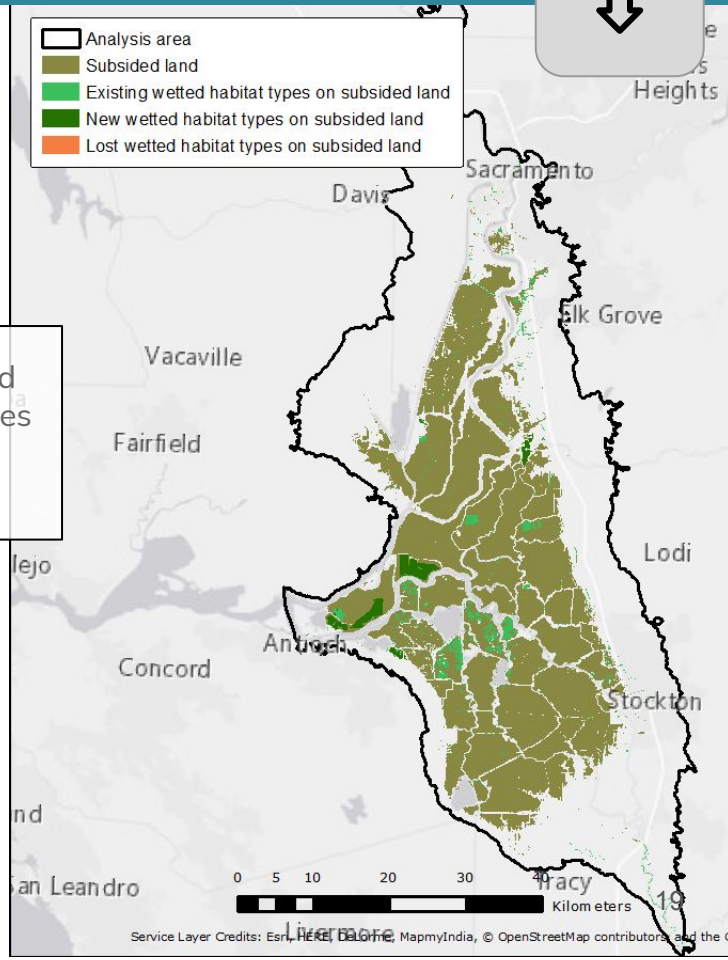
- Maps, text, charts, shapefiles

Considerations:

- Rice not captured

Subsided area covered by wetted habitat types

- **4%** Modern
- **6%** Ecorestore



Tool modules: Agriculture

Goal: Analyze the extent of agriculture and impacts due to alternative land use scenarios

Primary analyses:

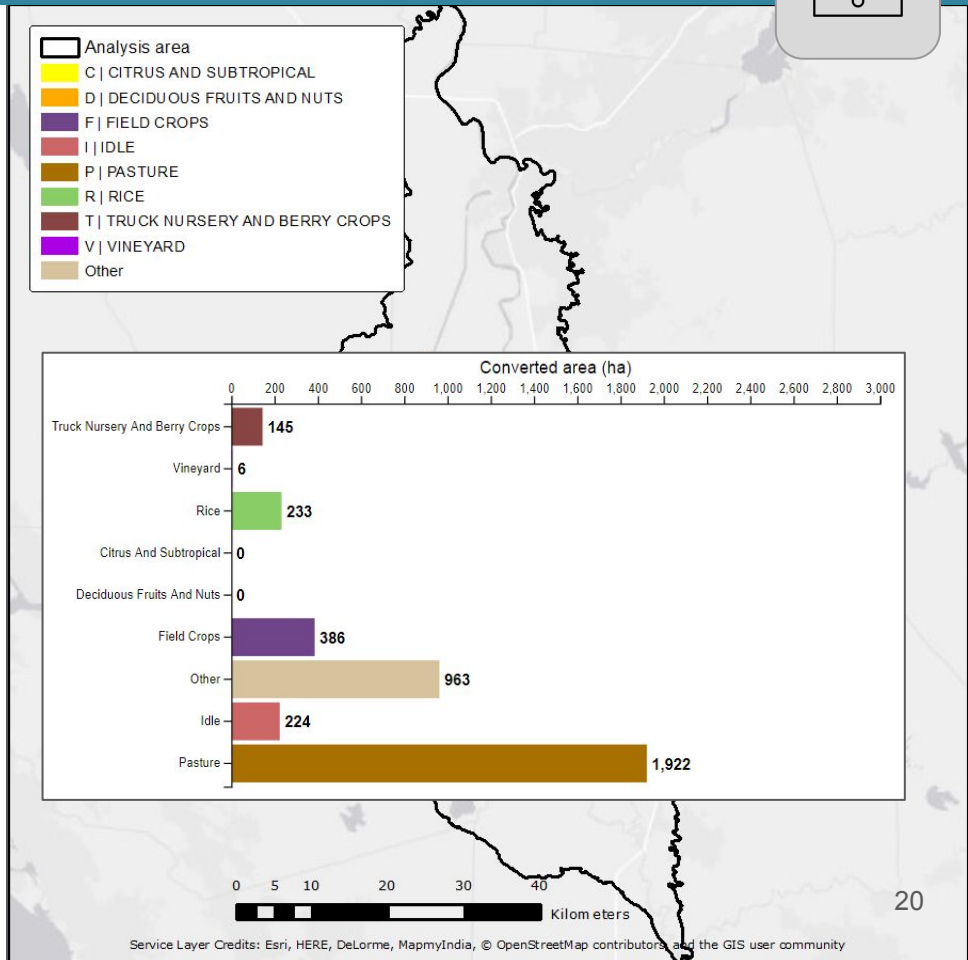
- Extent of agriculture
- **Change by crop type**
- Change by farmland grade

Key inputs/parameters

- Land use (VegCAMP)
- Crop types (Land IQ; DWR 2016)
- Farmland grades (FMMP 2016)

Key outputs

- Maps, text, charts, shapefiles



Tool modules: Infrastructure

Goal: Identify infrastructure that could be impacted by alternative land use scenarios because they are proximal to modified areas

Primary analyses:

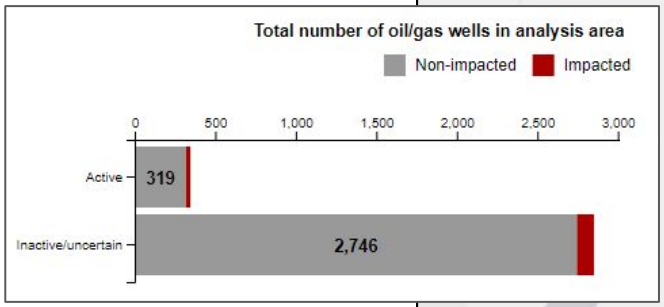
- Roads and railways
- Energy infrastructure
- Water diversions
- Levees

Key inputs/parameters

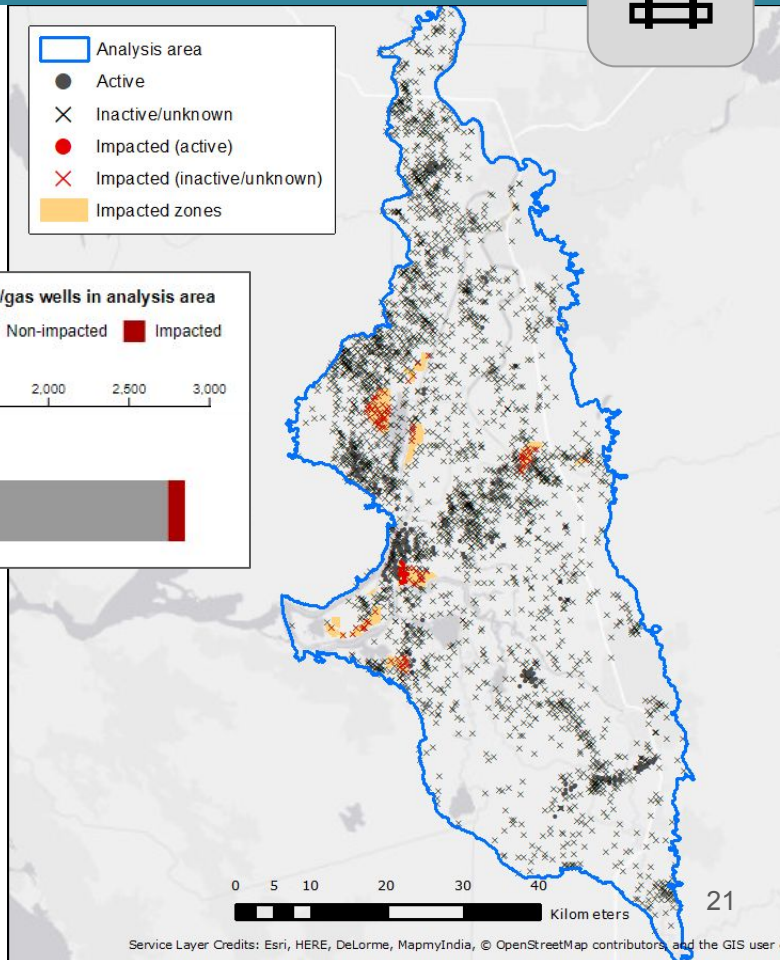
- Shapefiles: Roads, Rail, Oil & gas wells, Gas pipelines, Transmission lines, Water diversions

Key outputs

- Maps, text, charts, shapefiles



EcoRestore projects intersect **27 out of 346 active oil/gas wells**.



Tool modules: Protected areas

Goal: Identify protected areas & how they overlap with proposed land use modifications

Primary analyses:

- Protected areas extent and ownership
- Protection status and land use

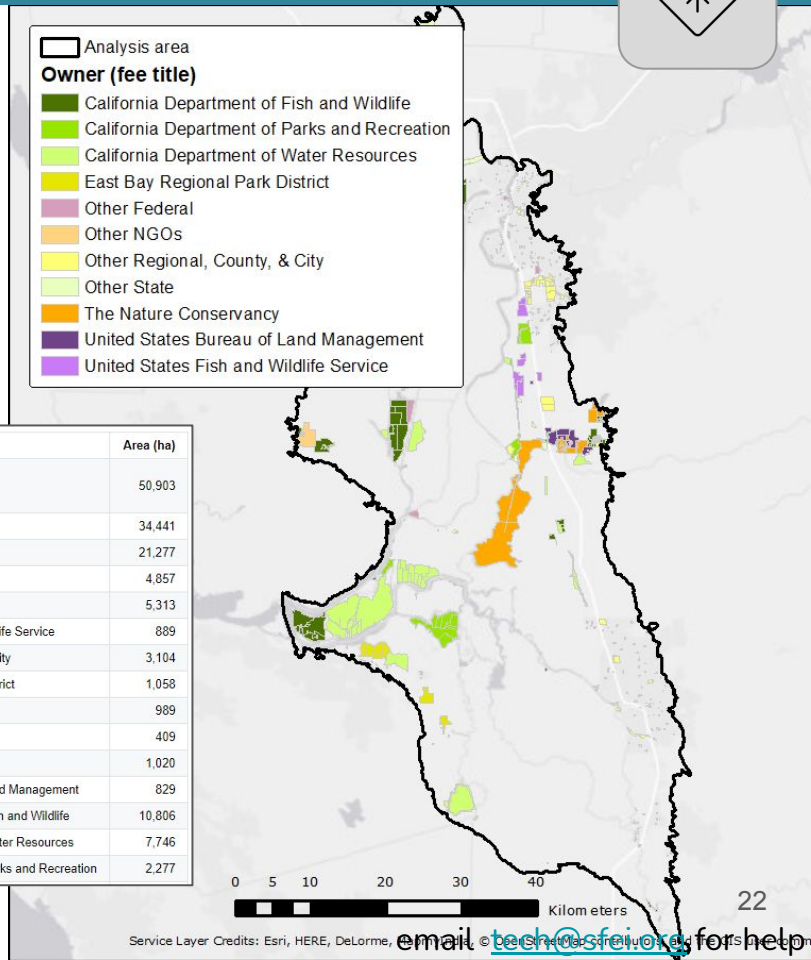
Key inputs/parameters

- Protection status (CPAD 2019 & CCED 2018)

Key outputs

- Maps, text, charts, shapefiles

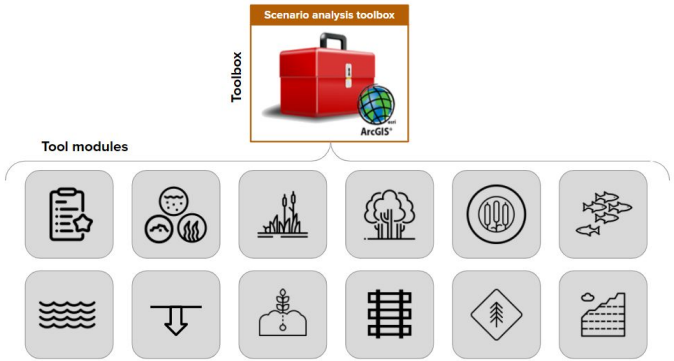
		Area (ha)
Area of protected areas under fee title or easement	-	50,903
Area by protected type	Fee title	34,441
	Easements	21,277
	Both	4,857
Area by owner (fee title)	The Nature Conservancy	5,313
	United States Fish and Wildlife Service	889
	Other Regional, County, & City	3,104
	East Bay Regional Park District	1,058
	Other NGOs	989
	Other Federal	409
	Other State	1,020
	United States Bureau of Land Management	829
	California Department of Fish and Wildlife	10,806
	California Department of Water Resources	7,746
	California Department of Parks and Recreation	2,277

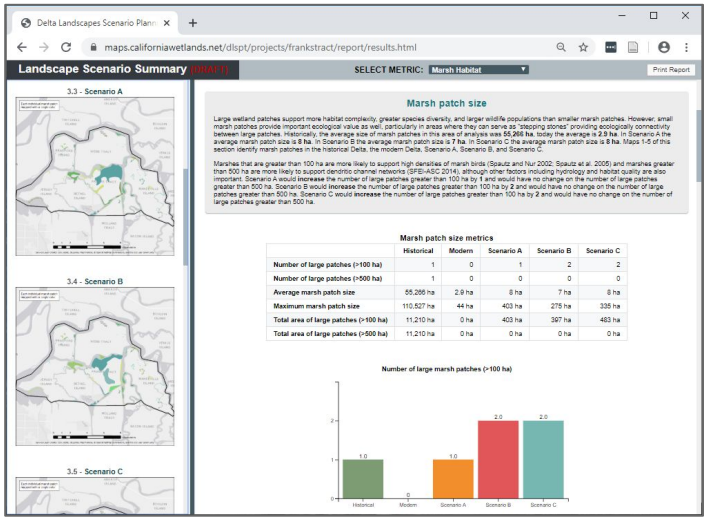


email tech@sfei.org for help

Delta LSPT current work

- New modules
  - Carbon/GHG (partly CDFW funded)
  - Economics
  - Recreation
- Full Legal Delta and Suisun Expansion
- Track landscape change (2002 - 2016 VegCAMP)
- Integrate with EcoAtlas - use to create baseline scenarios
- Outreach



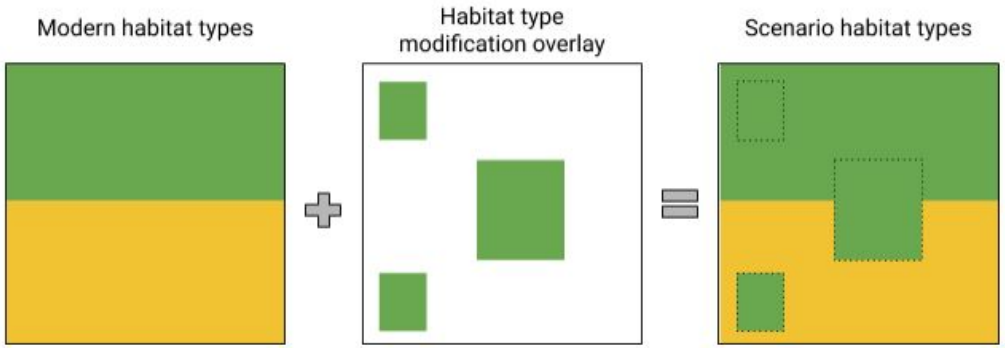


funded by DSC

Scenario Design

Scenarios

Overlays are the habitat changes which will be “burned” on top of the existing, modern habitat.



Each polygon should be assigned a habitat type that is recognized by the DLSPT. See the crosswalk table provided with the tool in in the User Guide.

Scenarios

Evaluate restoration actions and land use changes

- At a landscape scale, looking across individual actions
- Evaluating support for many different wildlife groups, and for critical physical and ecological processes
    - Initial modules and metrics focused on high priority ecological functions identified in the Delta Landscapes project

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

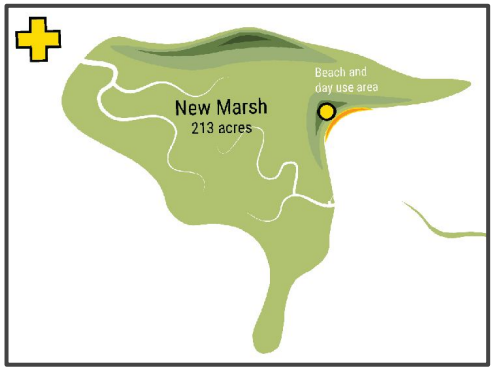
Maintains biodiversity by supporting diverse natural communities

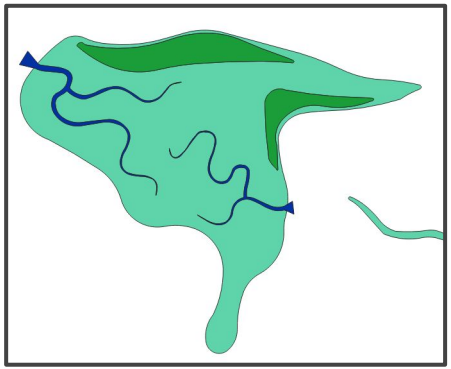
Productivity

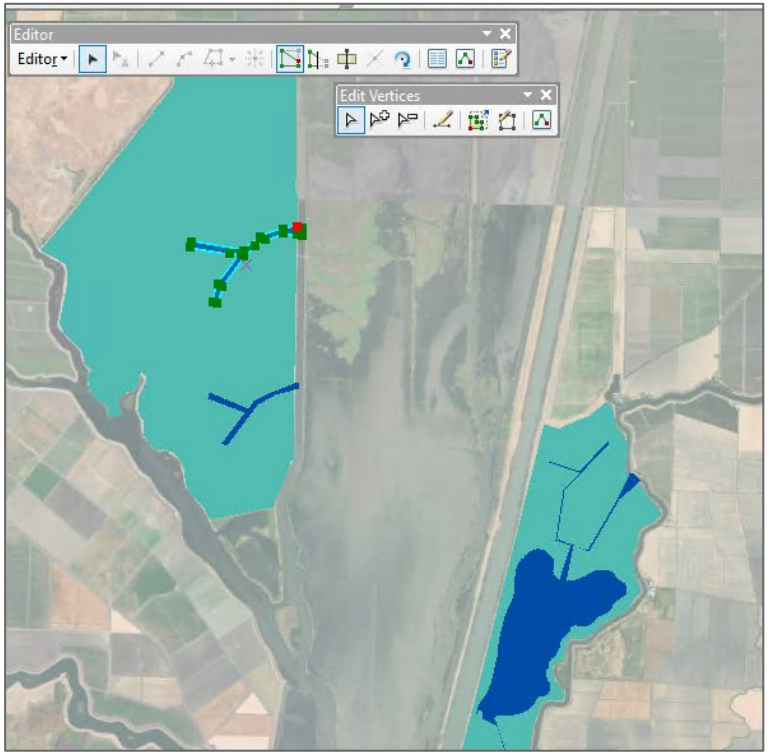
Maintains food supplies and nutrient cycling to support food webs

Creating scenario overlays

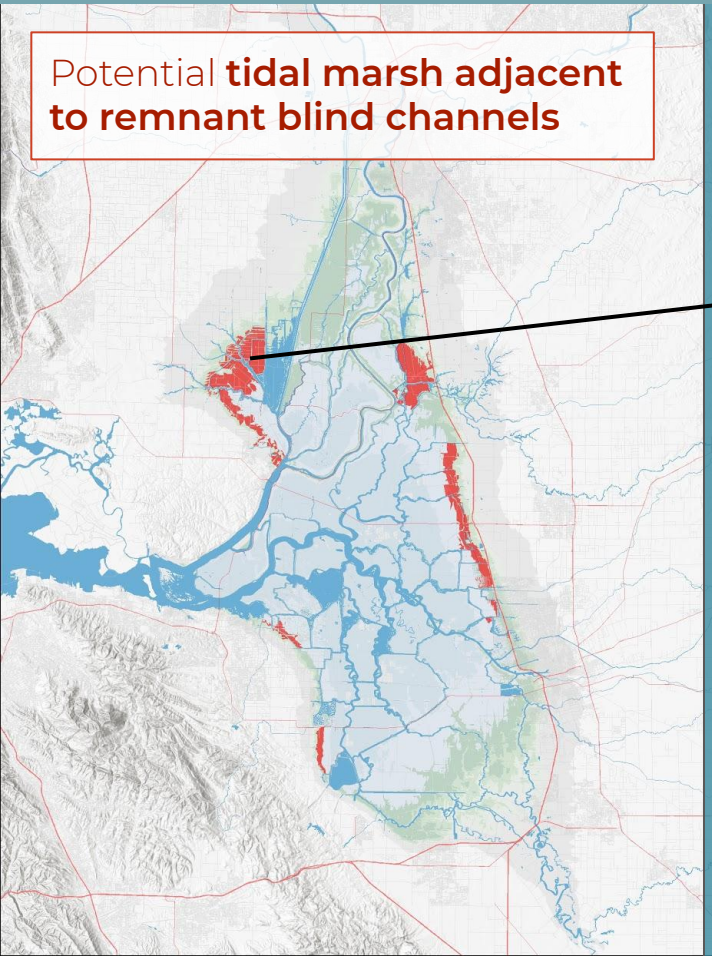
- Copying
  - Import existing spatial data from restoration designs.
- Editing
  - Copy polygons from modern layer into overlay layer. Edit shapes as desired.
- Drawing
  - Draw a new (or trace from plan/blueprint) polygon into overlay layer.

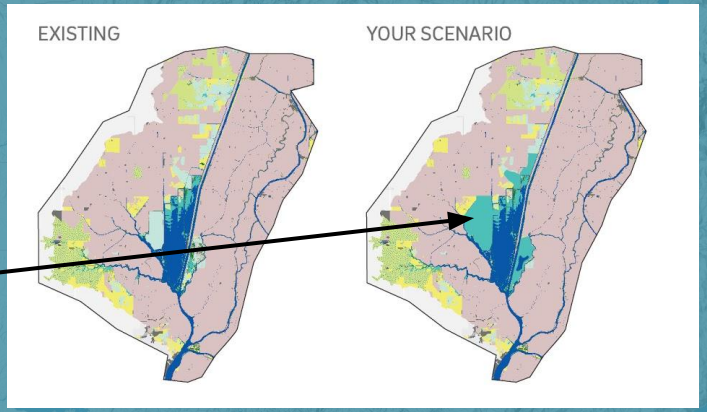






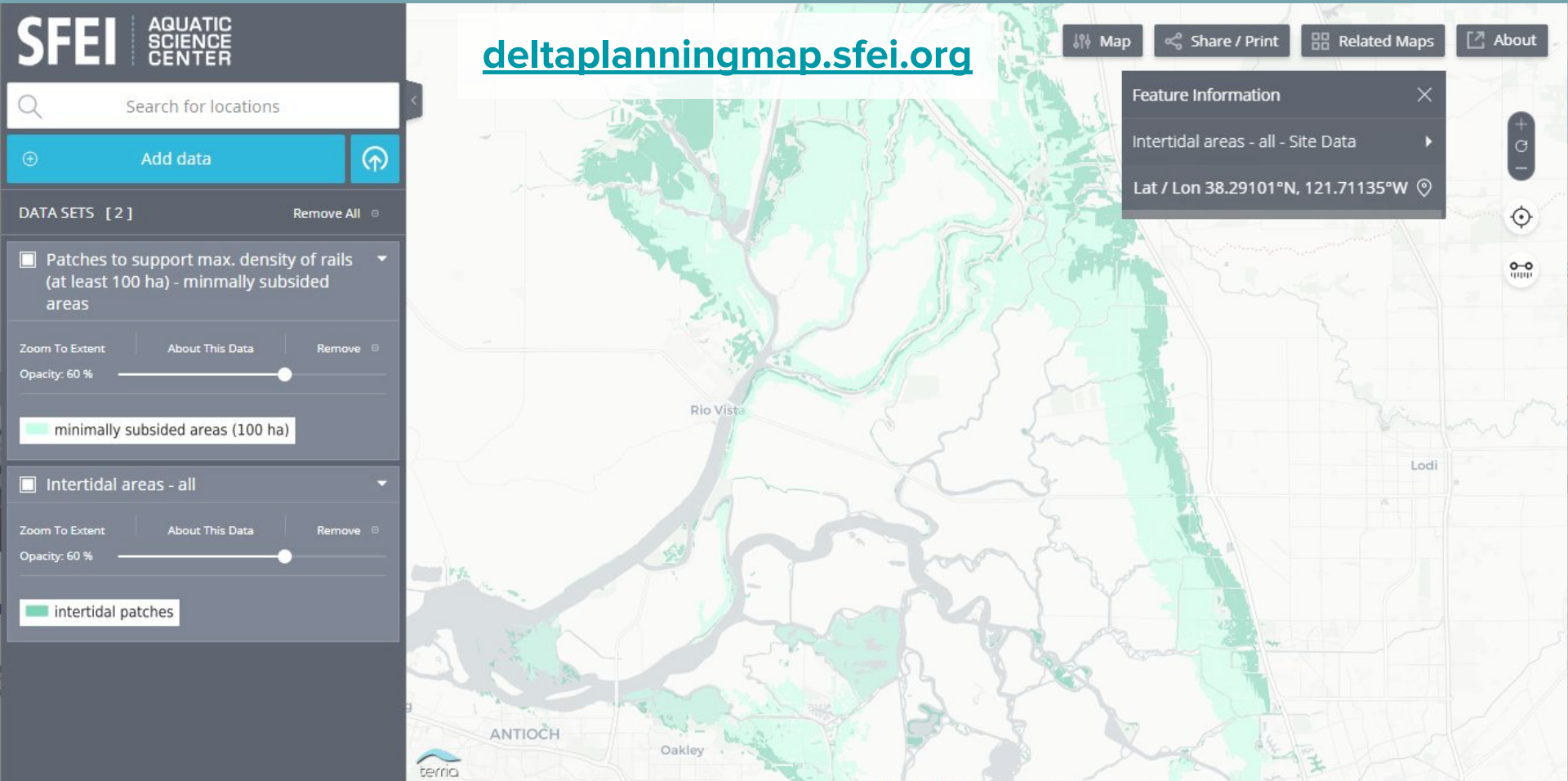
Resources for scenario development



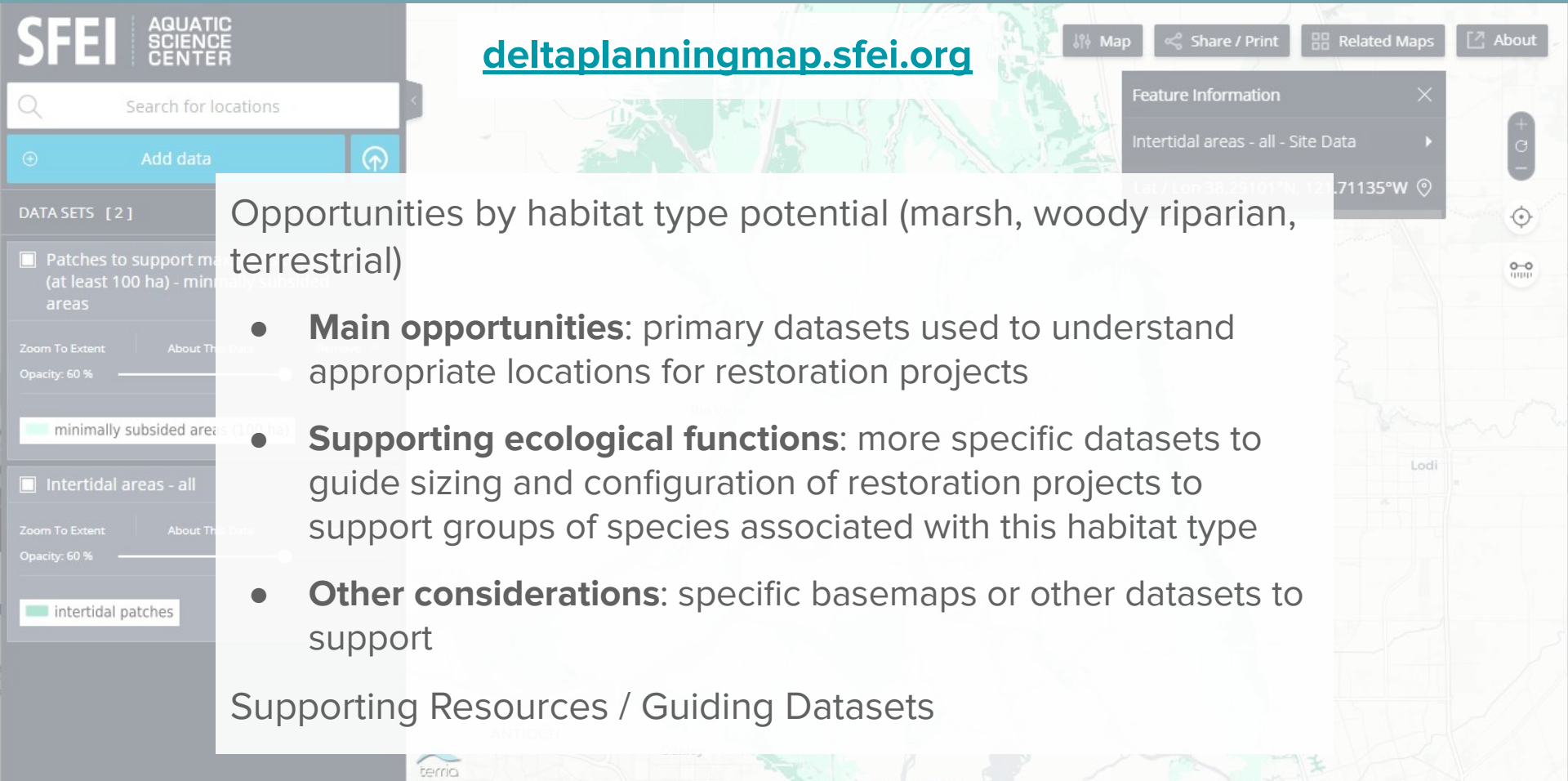


- The tool comes pre-packaged with four "**landscape potential**" layers, which identify restoration opportunities based on their elevation.
- To create scenarios, data can be selected and imported to a scenario shapefile (using copy/paste or clipping)
- Can build scenario by repeating this process within geography of interest for multiple opportunity types

Resources for scenario development



Resources for scenario development



deltaplanningmap.sfei.org

Opportunities by habitat type potential (marsh, woody riparian, terrestrial)

- **Main opportunities**: primary datasets used to understand appropriate locations for restoration projects
- **Supporting ecological functions**: more specific datasets to guide sizing and configuration of restoration projects to support groups of species associated with this habitat type
- **Other considerations**: specific basemaps or other datasets to support

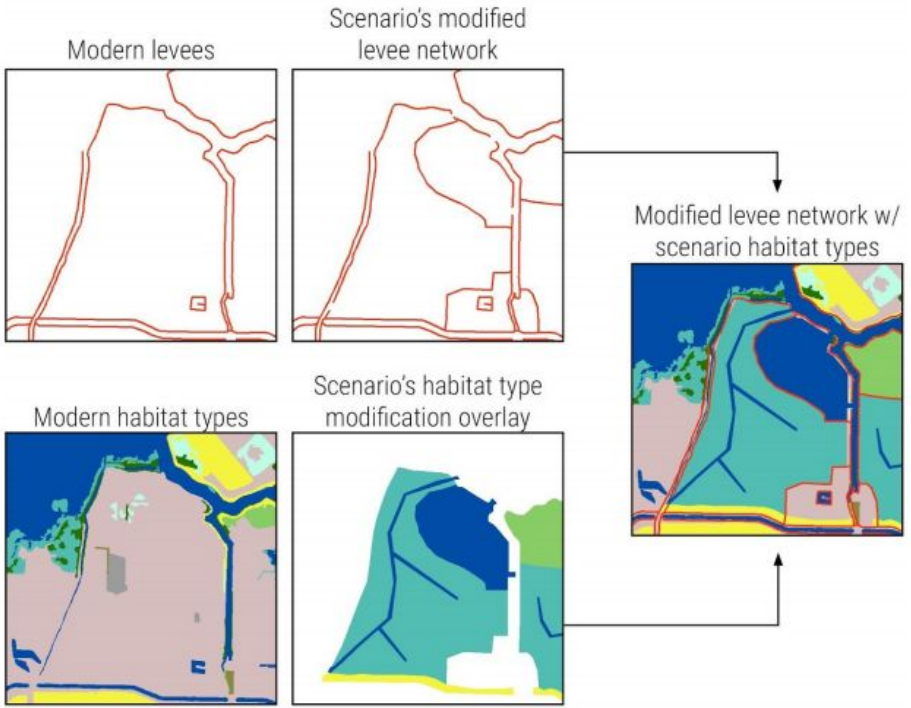
Supporting Resources / Guiding Datasets

Modified levee network

Unlike the habitat type modification overlay, the levee layer should represent the **final desired configuration of levees** in the scenario.

Optional, if not provided, no change from modern assumed.

Portions of the wetlands that are entirely “behind” the levee centerline are separated from the open water in the fish support module and are not counted as accessible/providing resources to fish.



Other considerations

Topology errors

There are minimal checks for topology errors in the current version of the tool. E.g. overlapping polygons will be double-counted.

Levees

Small offsets in levee position will be interpreted as removal and construction levees to account for this shift. As such, the new levee network is best created as a copy from and modification to the modern levees layer provided with the DLSPT.

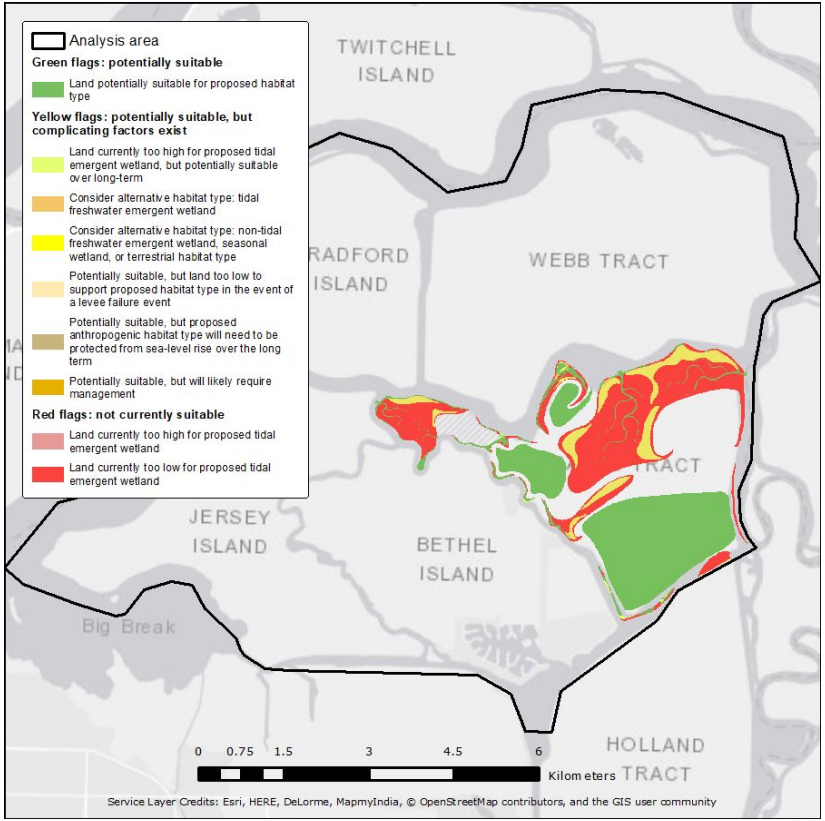
Physical suitability

The **physical suitability** module evaluates the suitability of a location in the Delta for proposed scenario land use modifications.

Red flags are combinations of habitat type and geomorphic zone that---based on the available elevation data and tidal datums---are not currently physically suitable.

Yellow flags are combinations that might possibly be physically feasible, but for which there are potential important complicating factors to consider.

This can be used to “check” for the feasibility of your scenario overlay (with some caveats).



Advanced options

Custom habitat types can be added to the crosswalk table. This involves adding a new row with the habitat type name-value then adding a non-null value (e.g. “1”) under each column for generalized habitat grouping to which it belongs (e.g. “terrestrial” or “riparian”).

➔ *This currently does not affect the summary table for habitat change or delta targets in the outputs.*

Custom input layers (beyond overlays and levees) can be modified by modifying the source code.

➔ *Some input types may be hard-coded to expected specific field names and values.*

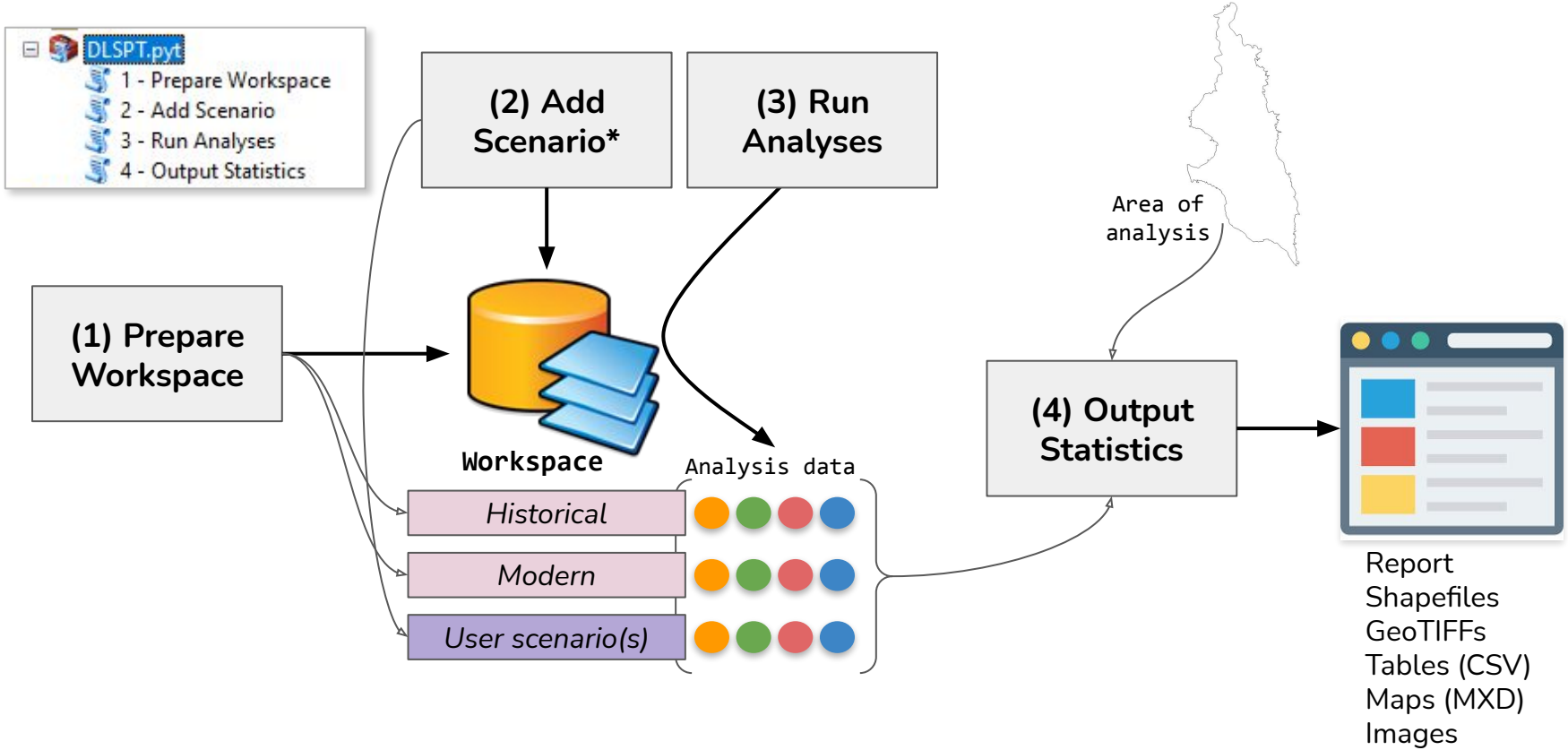
➔ *Modify at your own risk! Always create a backup before editing.*

Tool Demo

Workspaces

- **Single directory** with specifically-formatted outputs
  - File geodatabase and log file
  - Enforced same spatial reference system
  - All relevant inputs, outputs, and intermediary layers copied as they are brought in and/or processed.
- Workspace directory as **input parameter**
  - Automatically parse all relevant parameters and data from workspace
  - Minimize number of input parameters required
- Generally **not to be edited**

Tool workflow



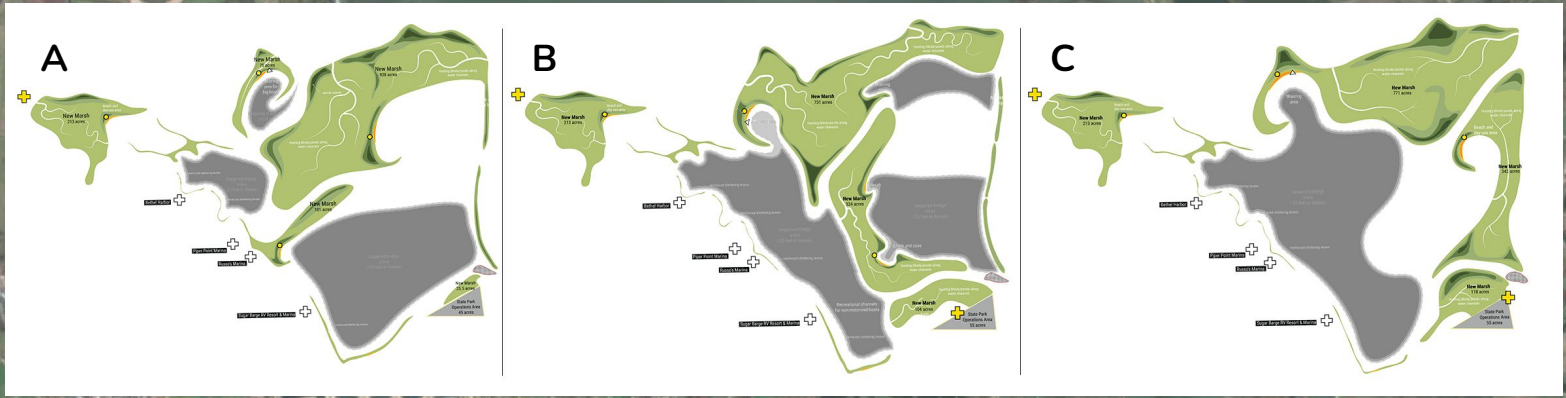
Franks Tract Futures

Franks Tract Futures

https://franks-tract-futures-ucdavis.hub.arcgis.com

Preferred Landscape Redesign Concept

- Developed by **CDFW**, **DPR**, and **DWR**, in partnership with **Environmental Science Associates**, **UC Davis**, and **Dangermond Group**
- Was narrowed down to three alternative concepts

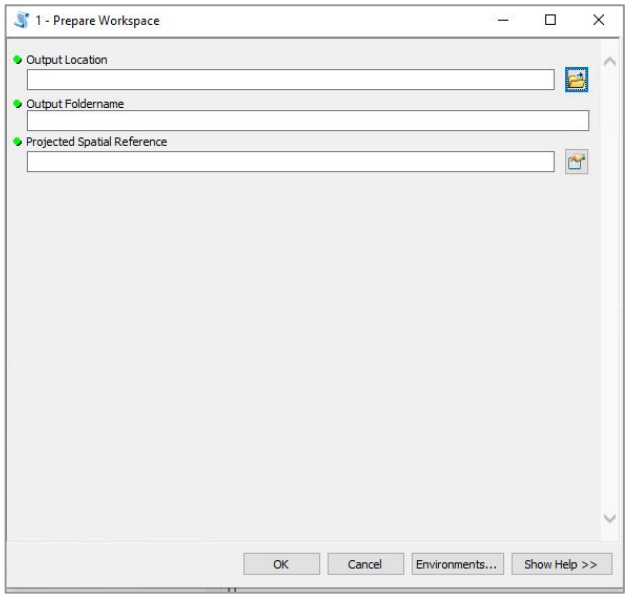


Running the tool: (1) Prepare workspace

Prepare Workspace: Creates workspace, prepares historical and modern scenarios

Workspace: Specially-formatted location (as file geodatabase) for all working files and analysis outputs.

- All inputs, once defined and copied into workspace, do not have to be defined again for other tools
- Internal tracking of scenarios and analyses that have been performed
- "***Plug-and-play***" behavior, as once pointed to workspace, other tools can automatically read statuses of scenarios and analyses run.



Running the tool: (2) Add scenario

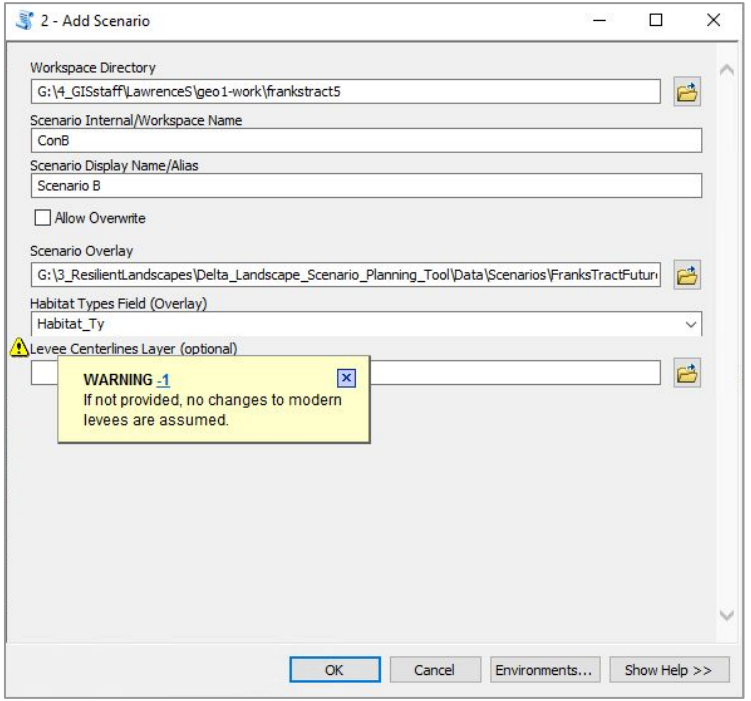
Run each time a scenario is added to the workspace.

Inputs:

- Scenario overlay (with name)
  - Polygons of changed habitat cover
  - Features attributed habitat type that must match from recognized list
- Optional levee layer
  - If not supplied, no change from modern is assumed

Processing:

- Adds scenario to workspace tracking
- Burns overlay on top of modern habitat
- Habitat change, levee change, and physical suitability analyses



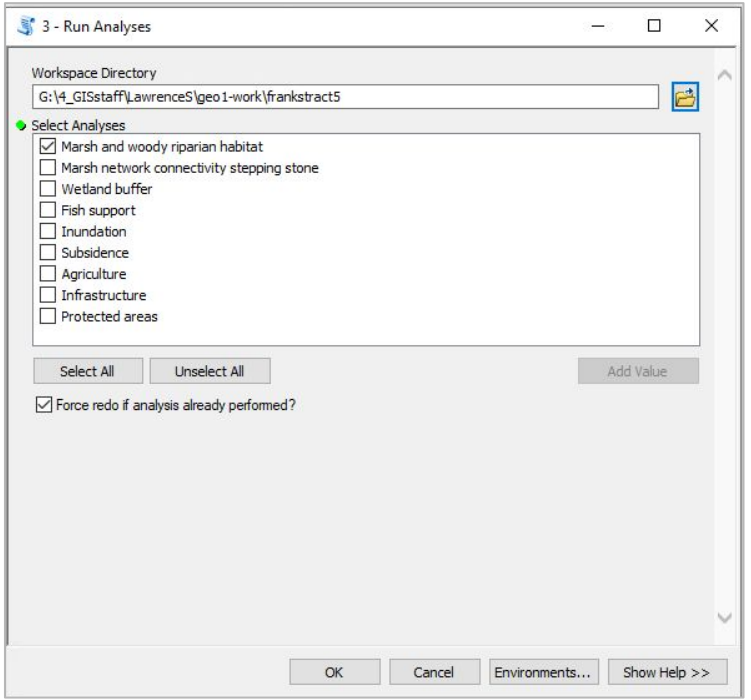
Running the tool: (3) Run analyses

Inputs: Simply point to the workspace and select analyses from list

Processing: Runs selected analyses on all scenarios in workspace

Times estimated from run on historical, modern, and EcoRestore
(Habitat and physical suitability run when adding scenario)

- Marsh and woody riparian habitat ~ 25 min
- Marsh network connectivity stepping stone ~ 45 min
- Wetland buffer ~ 5 min
- Fish support ~ 25 min
- Inundation ~ 5 min
- Subsidence ~ 5 min
- Agriculture ~ 5 min
- Infrastructure ~ 15 min
- Protected areas ~ 2 min

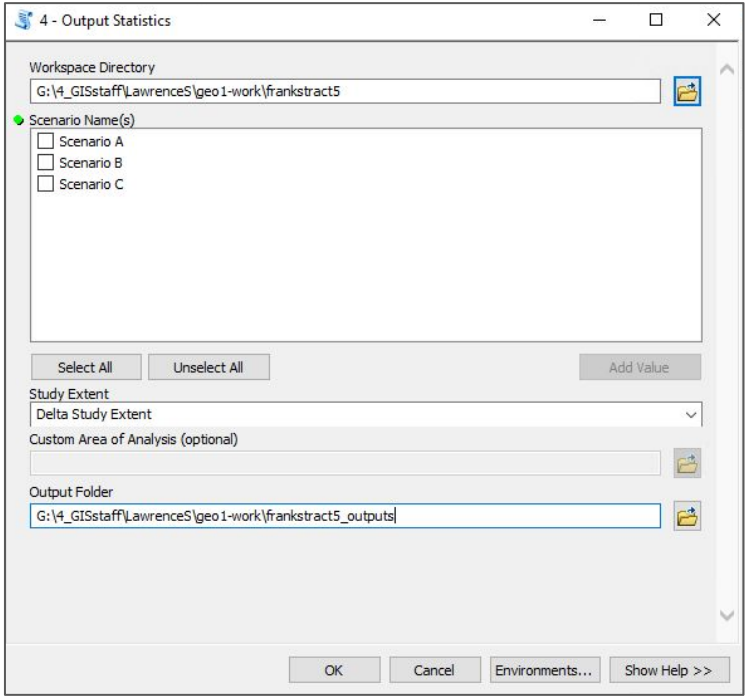


Running the tool: (4) Output statistics

Inputs: Select workspace and scenarios to analyze in detail

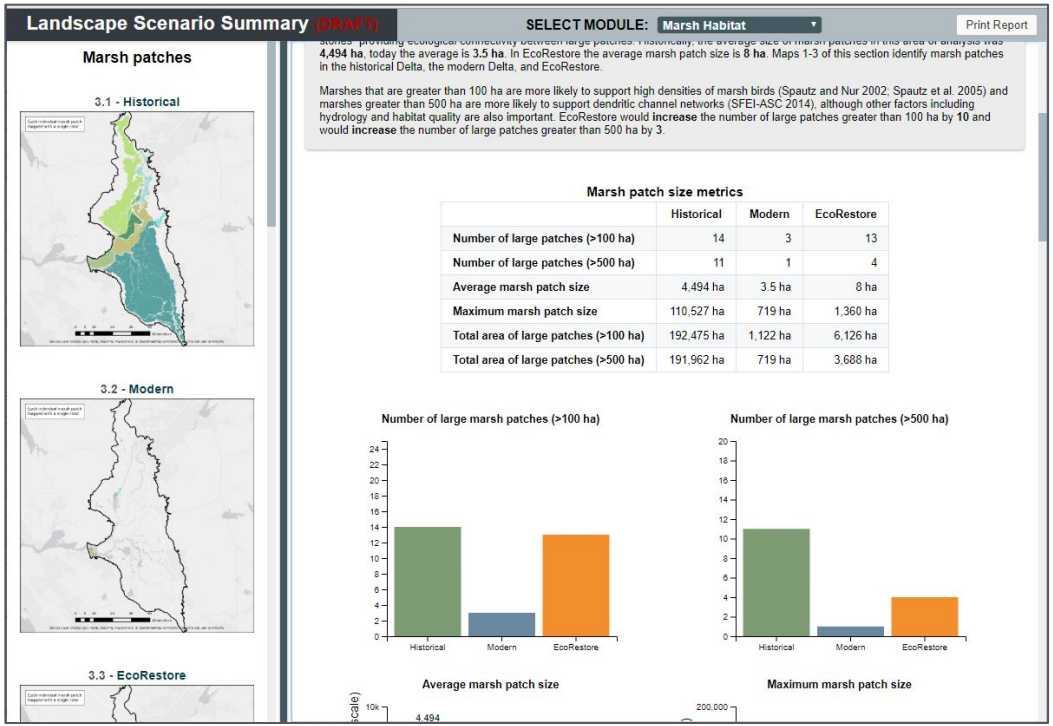
Processing: Clips all data and analysis outputs by area of analysis

Outputs: Extracts tables, data layers, and maps. Creates dynamically-generated and shareable report



Outputs

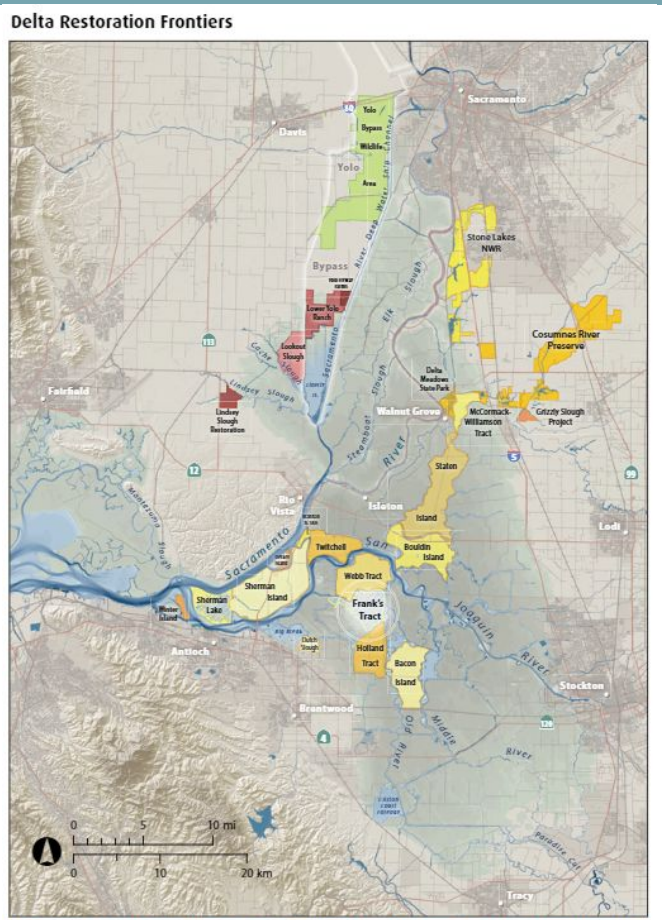
- **Spatial & tabular data**
  - CSVs, shapefiles, ArcGIS map documents
  - Clipped to ROI
- **Output report**
  - Interactive, offline, browser-based application
  - Dynamically-generated tables, graphs, map-images, and text
  - Shareable (just zip up report folder and send)



Analysis and Output

Franks Tract Scenarios Example

- Draft scenarios based on “Franks Tract Futures”, used for demonstration purposes
- About Franks Tract
  - Central Delta flooded island
  - Publicly-owned state recreation area
  - Popular spot for fishing and recreation
  - Relatively shallow subsidence



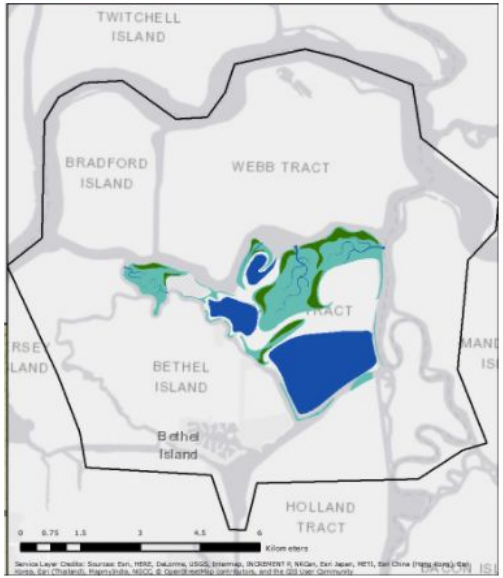
Planned restoration and fish habitat: Cache Slough (red); Yolo Bypass Wildlife Area (green); Bypass (white boundary) and public lands corridor (various shades of yellow). Map: Amber Manfree

Franks Tract Scenarios

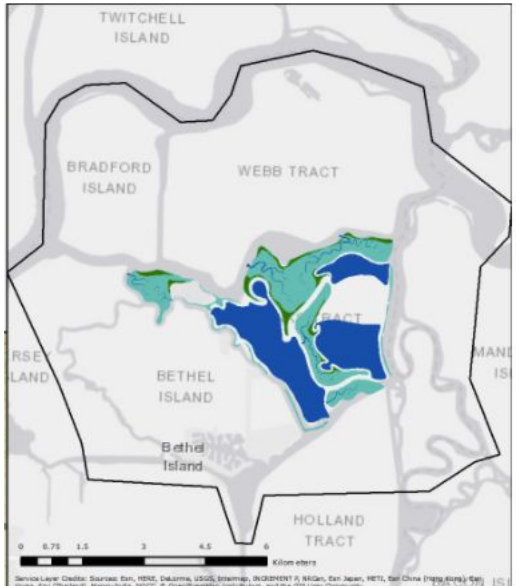
Habitat Type

- open water
- tidal freshwater emergent wetland
- non-tidal freshwater emergent wetland
- willow thicket
- willow riparian scrub/shrub
- valley foothill riparian
- wet meadow/seasonal wetland
- vernal pool complex
- alkali seasonal wetland complex
- stabilized interior dune vegetation
- grassland
- oak woodland/savanna
- agriculture/non-native/ruderal
- managed wetland
- urban/barren

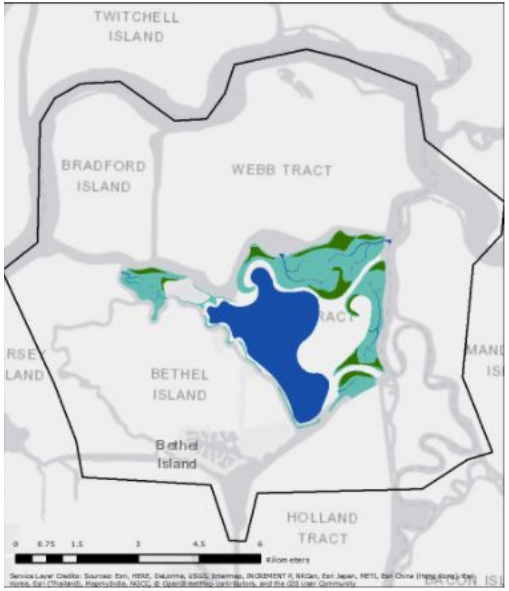
A: Scenario land use modifications



B: Scenario land use modifications

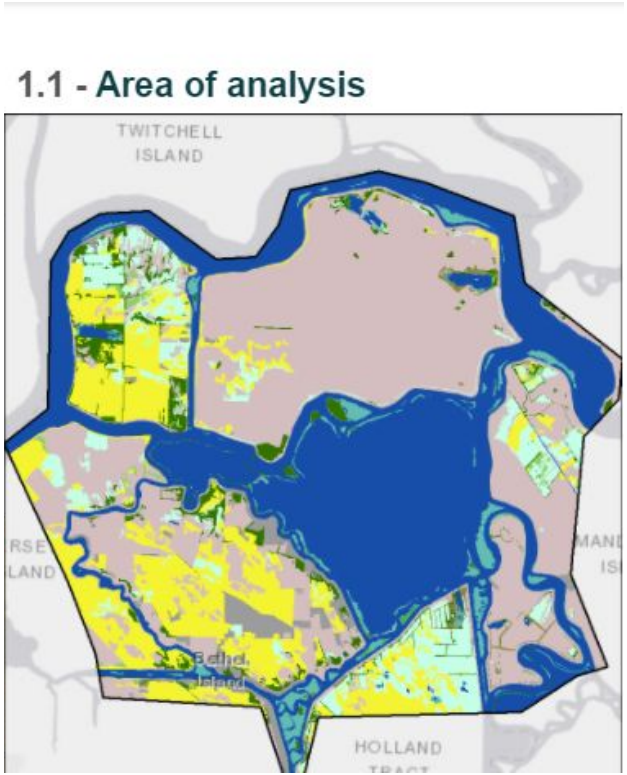


C: Scenario land use modifications



Area of Analysis

- Area of analysis determined by user
- Tool designed to be used at regional and landscape scales
- Boundary for this example includes Franks Tract and surrounding islands



Tool Modules

Toolbox

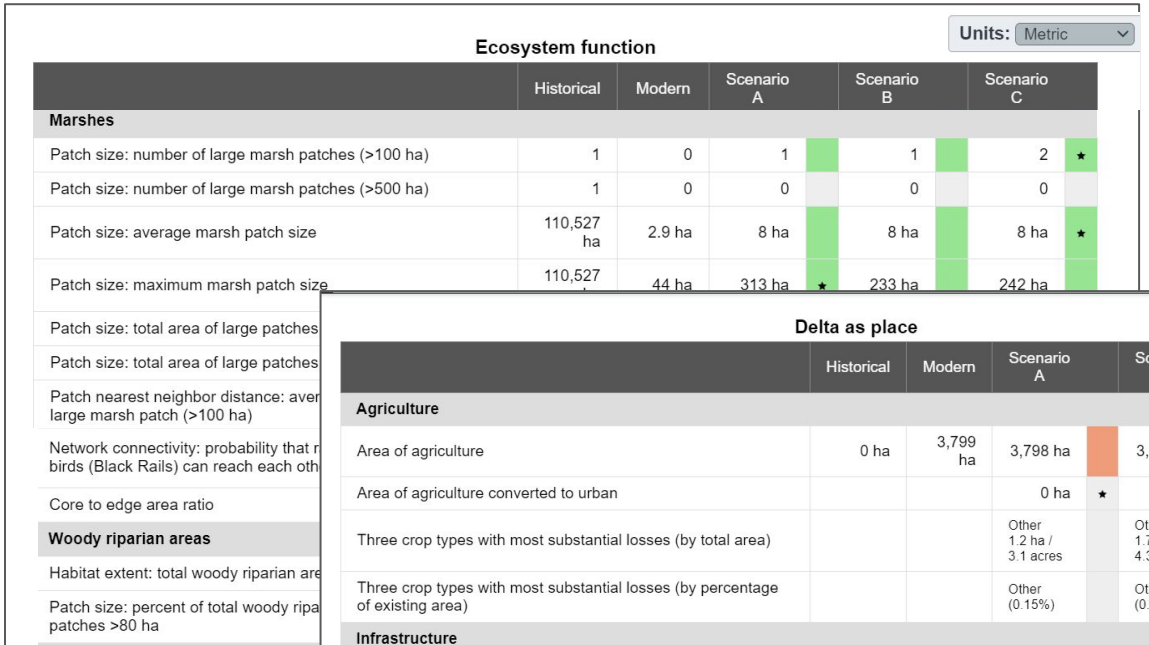
Tool modules

SUMMARY	HABITAT TYPES	MARSH HABITAT	WOODY RIPARIAN HABITAT	WETLAND BUFFER	FISH SUPPORT
INUNDATION	SUBSIDENCE	AGRICULTURE	INFRA-STRUCTURE	PROTECTED AREAS	PHYSICAL SUITABILITY

Tool Module: Summary

- Rapidly compare scenarios to historical/current conditions & to each other across all modules.
- Individual modules provide details and explanation

Scenario positively affects metric (relative to current conditions)
Scenario does not alter metric
Scenario negatively affects metric (relative to current conditions)
★ Indicates which scenario most improves each metric (all metrics will be marked with stars if only evaluating one scenario)



Units: Metric

Ecosystem function

	Historical	Modern	Scenario A	Scenario B	Scenario C
Marshes					
Patch size: number of large marsh patches (>100 ha)	1	0	1	1	2 ★
Patch size: number of large marsh patches (>500 ha)	1	0	0	0	0
Patch size: average marsh patch size	110,527 ha	2.9 ha	8 ha	8 ha	8 ha ★
Patch size: maximum marsh patch size	110,527	44 ha	313 ha ★	233 ha	242 ha
Patch size: total area of large patches					
Patch size: total area of large patches					
Patch nearest neighbor distance: aver large marsh patch (>100 ha)					
Network connectivity: probability that r birds (Black Rails) can reach each oth					
Core to edge area ratio					
Woody riparian areas					
Habitat extent: total woody riparian are					
Patch size: percent of total woody ripa patches >80 ha					

Units: Metric

Delta as place

	Historical	Modern	Scenario A	Scenario B	Scenario C
Agriculture					
Area of agriculture	0 ha	3,799 ha	3,798 ha	3,797 ha	3,798 ha ★
Area of agriculture converted to urban			0 ha ★	0 ha ★	0 ha ★
Three crop types with most substantial losses (by total area)			Other 1.2 ha / 3.1 acres	Other 1.7 ha / 4.3 acres	Other 1.1 ha / 2.6 acres
Three crop types with most substantial losses (by percentage of existing area)			Other (0.15%)	Other (0.20%)	Other (0.12%)
Infrastructure					

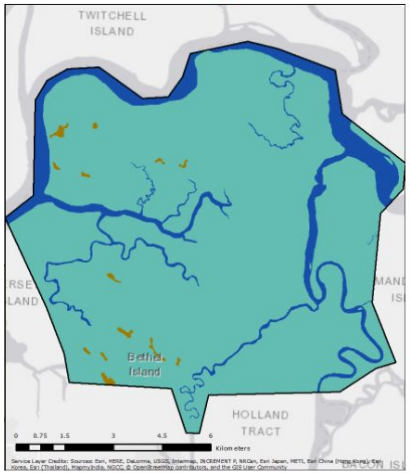
Key inputs/parameters

- Results from all modules

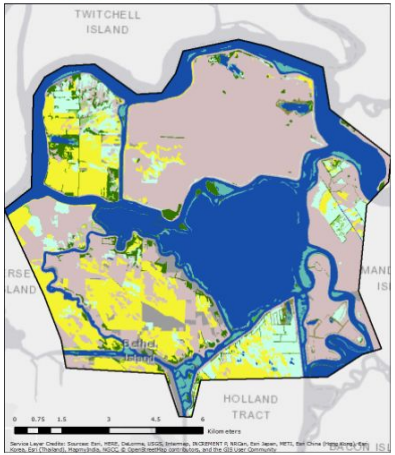
Tool Module: Habitat Types

- "Habitat types" based on vegetation, aquatic features, land use
- Important determinant of functions and species supported
- Connects to Delta Plan acreage targets

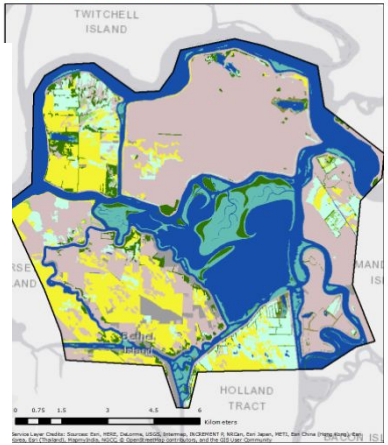
1 - Historical: Habitat types



2.2 - Modern: Habitat types



Scenario A: Scenario habitat types



Habitat Type

- open water
- tidal freshwater emergent wetland
- non-tidal freshwater emergent wetland
- willow thicket
- willow riparian scrub/shrub
- valley foothill riparian
- wet meadow/seasonal wetland
- vernal pool complex
- alkali seasonal wetland complex
- stabilized interior dune vegetation
- grassland
- oak woodland/savanna
- agriculture/non-native/ruderal
- managed wetland
- urban/barren

Key inputs/parameters

- Habitat type layers
- Regional acreage targets

Tool Module: Habitat Types

- All scenarios add tidal wetland and riparian shrub/scrub
- Scenario C adds the most of both habitat types
- Scenarios achieve 3.2 - 3.5% of Delta Plan tidal marsh target

Habitat type	Historical area (ha)	Modern area (ha)	Scenario A area (ha)	Scenario B area (ha)	Scenario C area (ha)	%-change (Scenario A vs Modern)	%-change (Scenario B vs Modern)	%-change (Scenario C vs Modern)
Open water	1,194	3,312	2,807	2,826	2,761	-15%	-15%	-17%
Tidal freshwater emergent wetland	9,164	274	690	714	729	+152%	+161%	+167%
Non-tidal freshwater emergent wetland	0	48	48	48	48	> -1%	> -1%	> -1%
Willow thicket	0	4	3	3	3	-33%	-12%	-29%
Willow riparian scrub/shrub	0	380	472	428	478	+25%	+13%	+26%

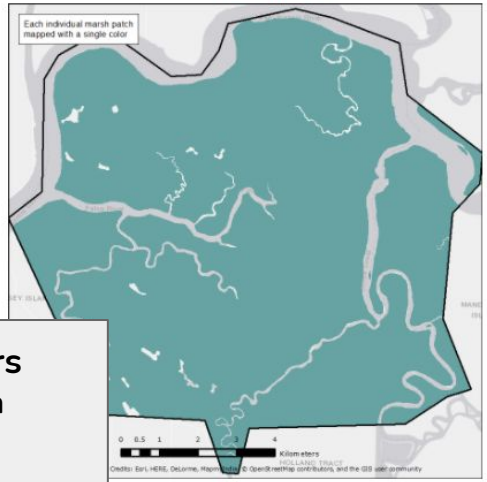
Tool Module: Marsh Habitat

- Support for marsh-associated wildlife
- Configuration of tidal freshwater emergent wetlands
  - Marsh patch size
  - Marsh connectivity
  - Marsh patch shape

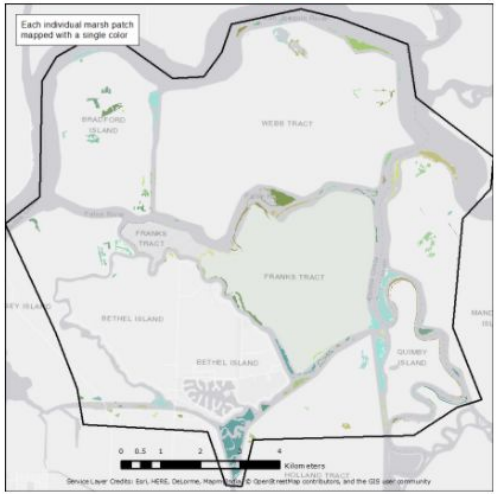
Key inputs/parameters

- Patch aggregation threshold
- Wildlife dispersal distance

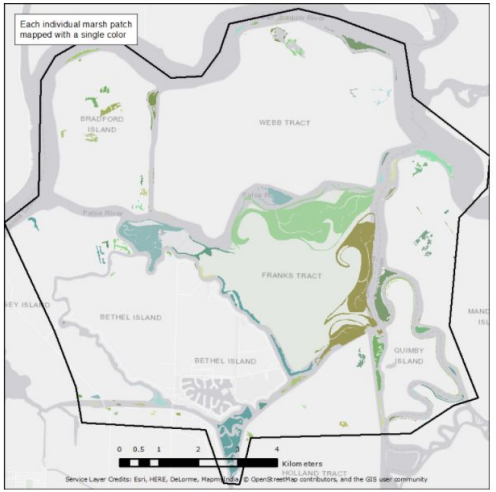
3.1 - Historical



3.2 - Modern



3.5 - Scenario C



Tool Module: Marsh Habitat

Large wetland patches support:

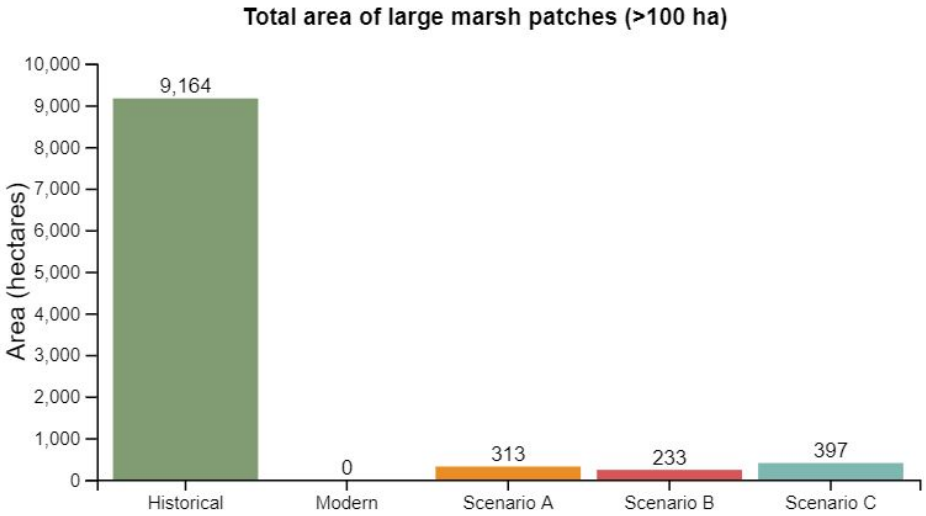
- More habitat complexity
- Greater species diversity
- Larger wildlife populations

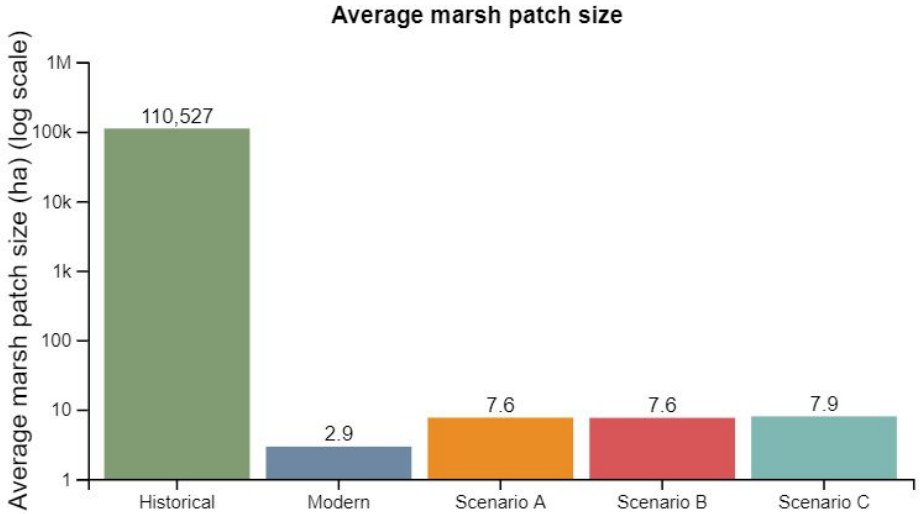
Marsh patch size metrics

	Historical	Modern	Scenario A	Scenario B	Scenario C
Number of large patches (>100 ha)	1	0	1	1	2
Number of large patches (>500 ha)	1	0	0	0	0
Average marsh patch size	110,527 ha	3 ha	8 ha	8 ha	8 ha
Maximum marsh patch size	110,527 ha	44 ha	313 ha	233 ha	242 ha
Total area of large patches (>100 ha)	9,164 ha	0 ha	313 ha	233 ha	397 ha
Total area of large patches (>500 ha)	9,164 ha	0 ha	0 ha	0 ha	0 ha

Tool Module: Marsh Habitat

- Scenario C adds 2 large marsh patch, A & B add 1 large patch
- Scenario C has the most marsh in patches greater than 100 ha
- All scenarios increase average and maximum patch size compared to modern, but a small fraction of historical condition





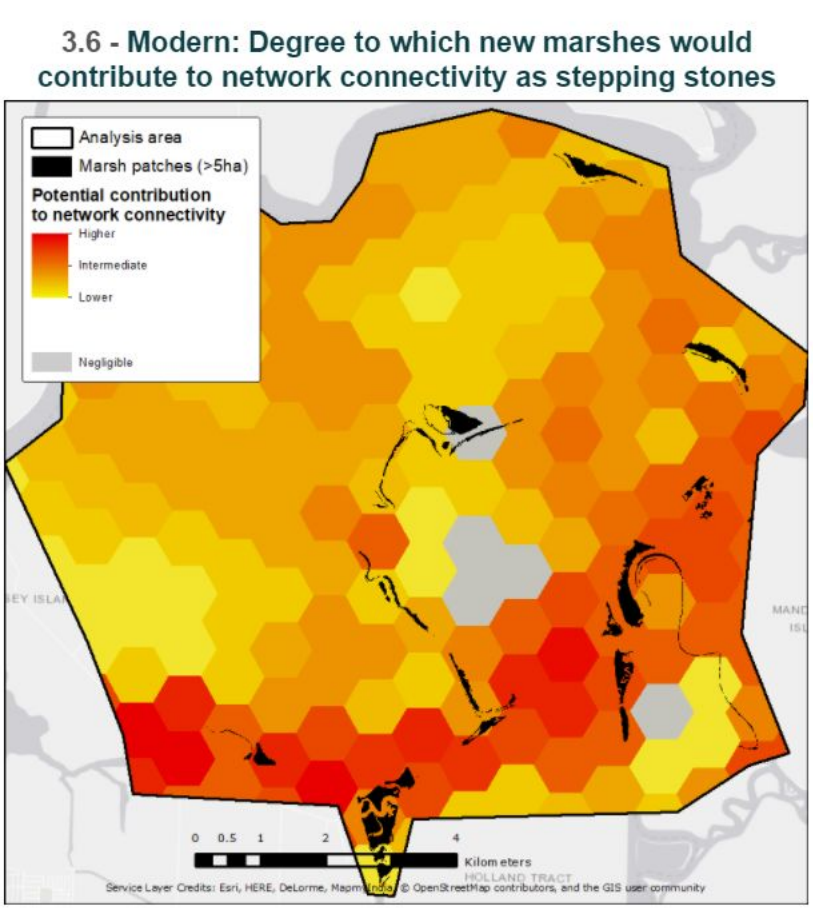
Tool Module: Marsh Habitat

Wetland connectivity supports:

- Wildlife dispersal
- Gene flow
- Population resilience

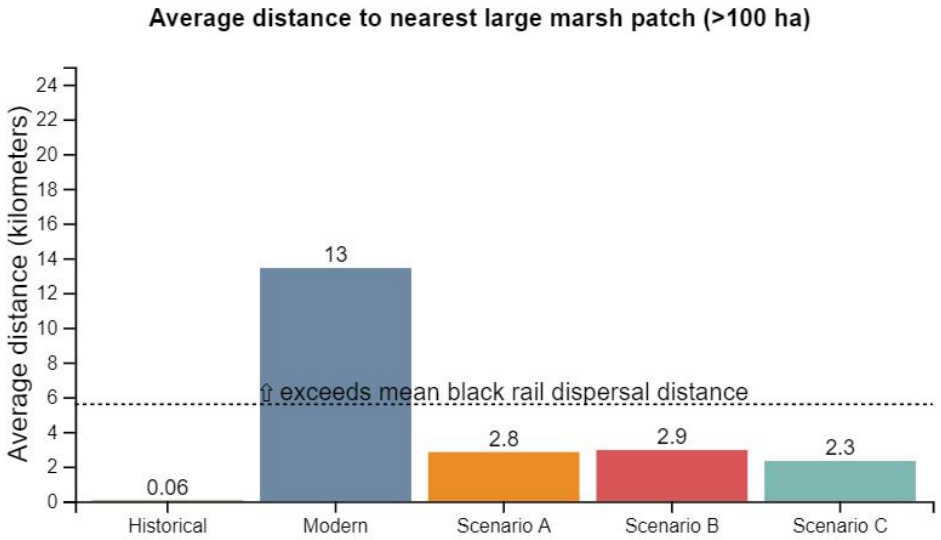
Assessed by:

- Nearest neighbor distance
- Network connectivity
- Stepping stone analysis



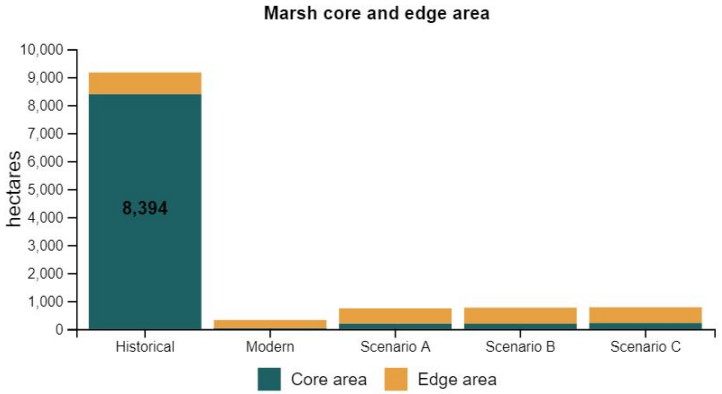
Tool Module: Marsh Habitat

- Large patches are sources for wildlife dispersal
- Compare the distance between marsh patches to the approximate mean black rail dispersal distance (5.6 km; Hall 2015).
- Decreasing the distance between marshes increases connectivity for black rails and other marsh wildlife
- All scenarios increase connectivity, Scenario C by the most

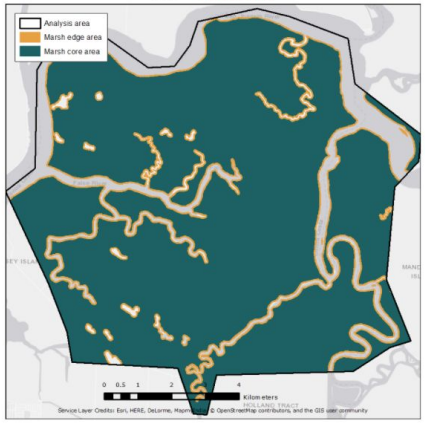


Tool Module: Marsh Habitat

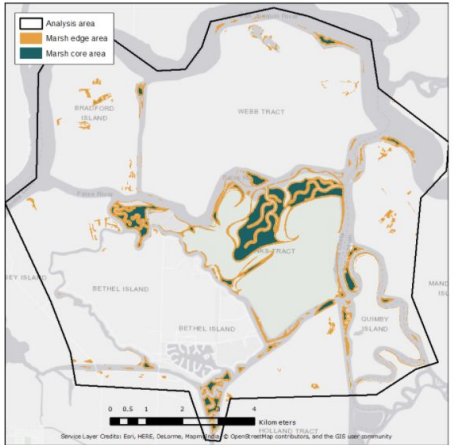
- Marsh patch shape affects habitat complexity, edge effects
- All scenarios increase core:edge ratio
- Scenario C increases core:edge ratio the most



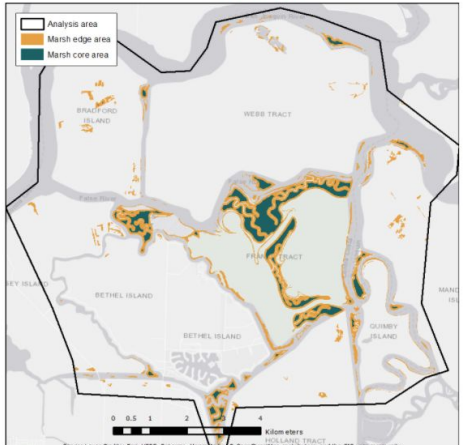
3.10 - Historical



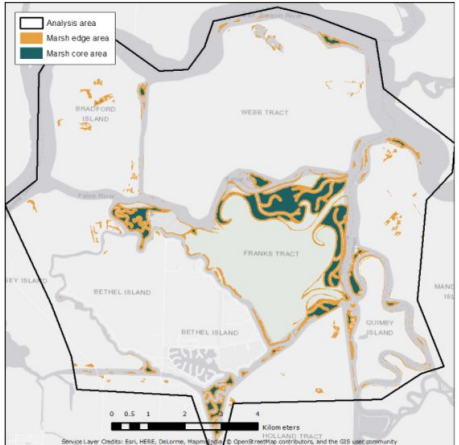
3.12 - Scenario A



3.13 - Scenario B



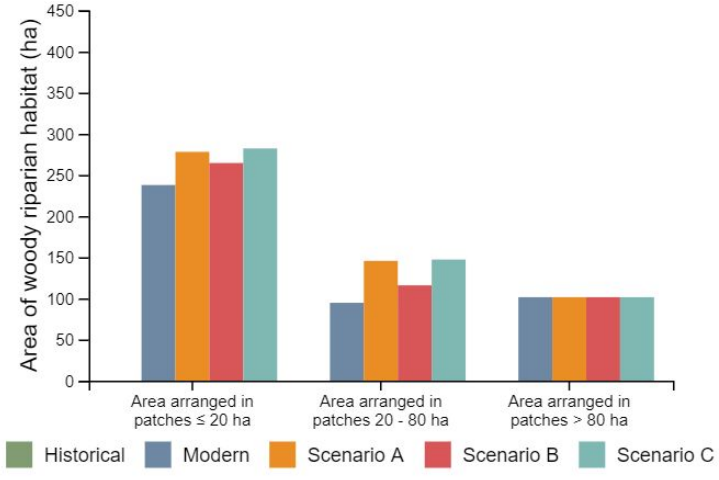
3.14 - Scenario C



Tool Module: Woody Riparian Habitat

- Support for riparian wildlife
- All scenarios increase extent and patch size
  - Riparian habitat not present here historically
- Scenario C increase riparian habitat extent most
- Scenario A increases average riparian patch size the most

	Historical	Modern	Scenario A	Scenario B	Scenario C
Total area (ha)	0	434	525	482	531



Key inputs/parameters

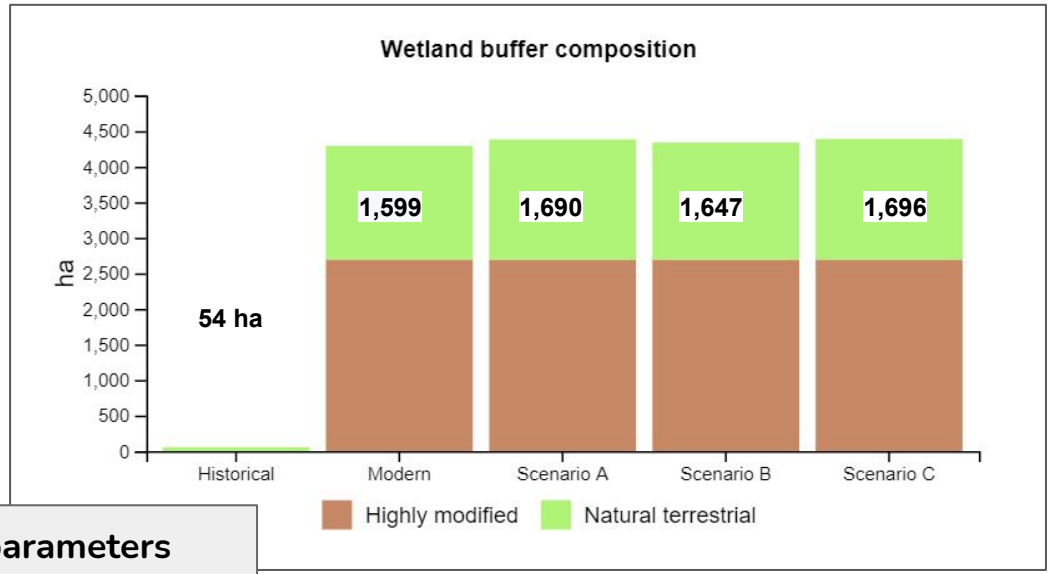
- Patch aggregation threshold

4.2 - Modern

4.3 - Scenario A

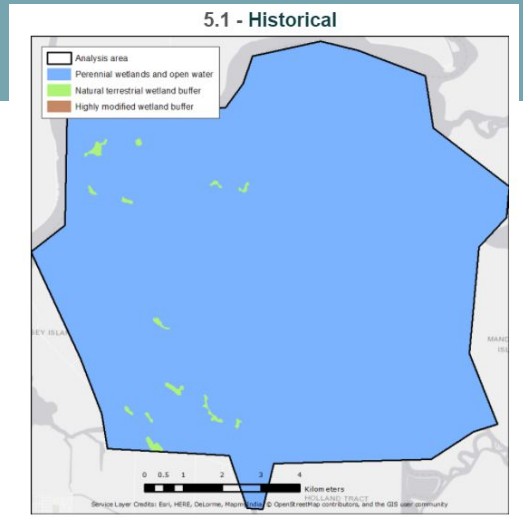
Tool Module: Wetland Buffer

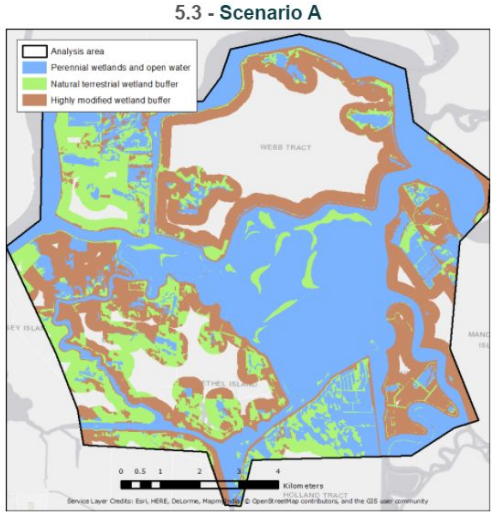
- Wetland buffer provides habitat and protection from stressors
- Distinguish between natural terrestrial and highly modified buffer types
- All scenarios add natural buffer, with Scenario C adding the most



Key inputs/parameters

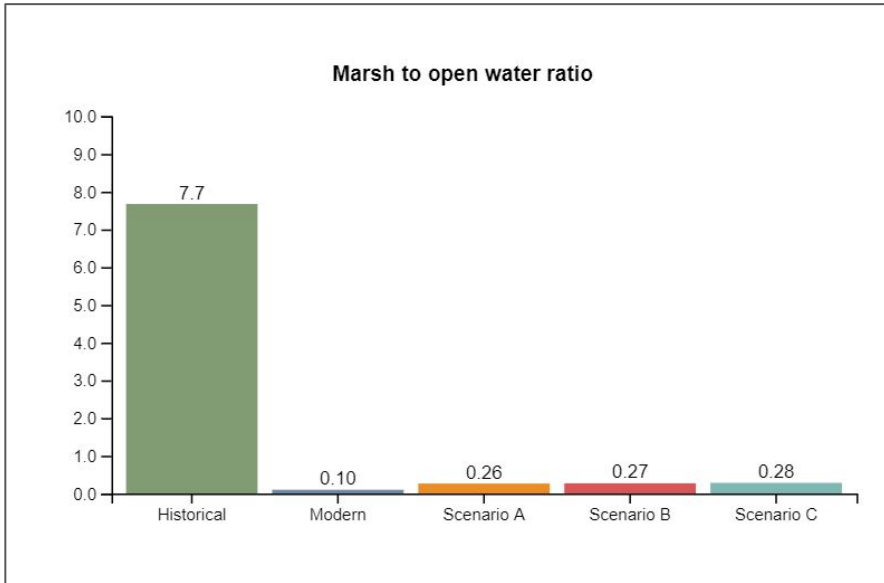
- Buffer distance





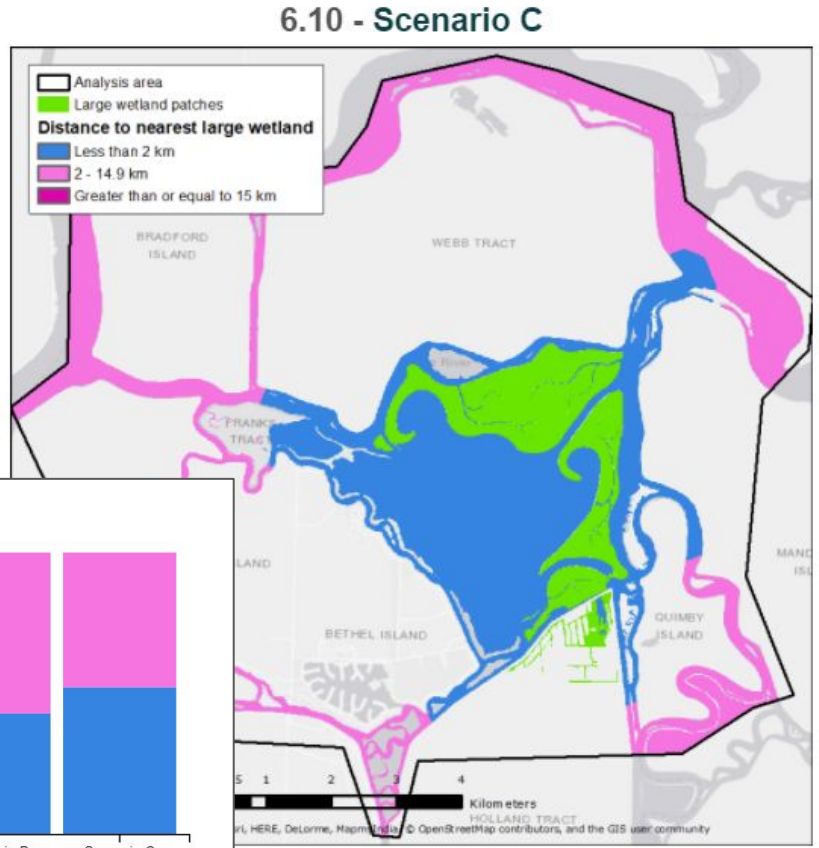
Tool Module: Fish Support

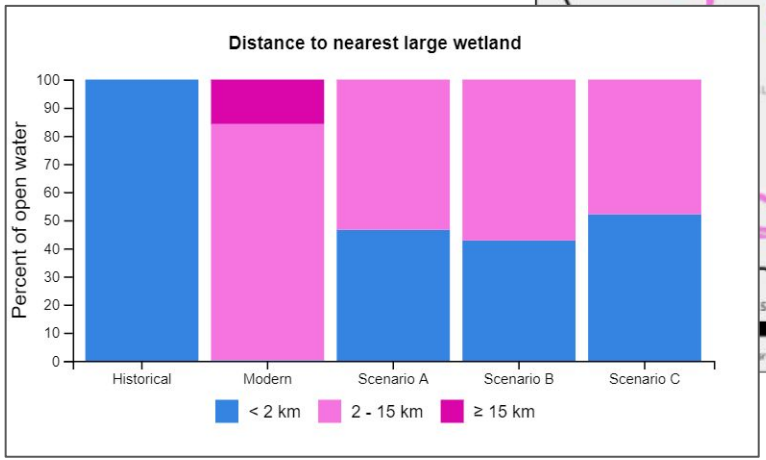
- Wetland, riparian and aquatic features contribute to support for native fish
  - Other modules also include benefits for fish
- Fish support analyses include:
  - Marsh to open water ratio
  - Connectivity of large wetland along fish migration corridors
  - Vegetated channel edges
  - Water temperature



Tool Module: Fish Support

- Scenario C has the greatest marsh to open water ratio
- Scenario B has the greatest extent of vegetated channel edge
- Scenario C has the greatest connectivity of large wetlands along migration corridor
- Scenario A has fewer wetlands near areas with high water temperatures





Key inputs/parameters

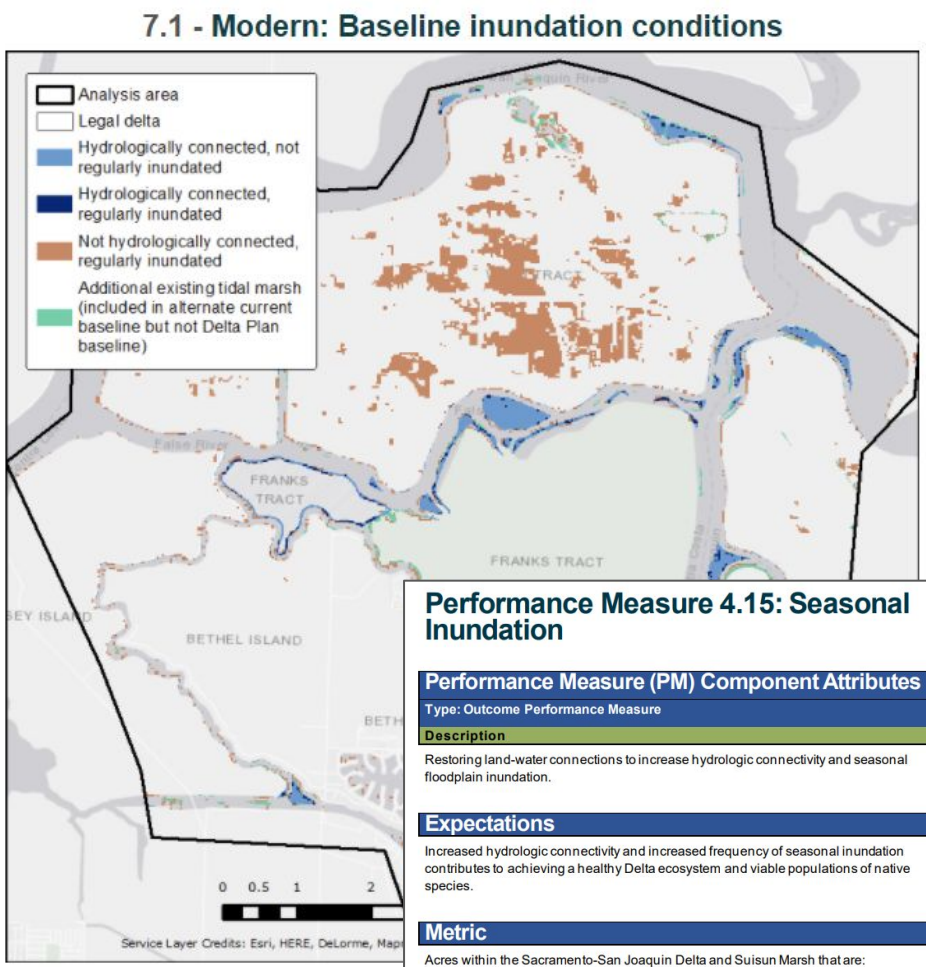
- Salmon daily movement distances
- Modeled water temperature (MWD, Anchor QEA)

Tool Module: Inundation

- Estimate current (baseline) extent of hydrologically connected and regularly inundation areas
- Infer changes in tidally connected and inundated areas
- Tool cannot estimate changes in hydrologically connected habitats or seasonal inundation from new fluvially-inundated floodplains
- Scenario C increases extend of tidally connected and inundated area the most

Key inputs/parameters

- Hydrologically connected areas (DSC)
- Regularly inundated areas (Pekel et al. 2018)



Performance Measure 4.15: Seasonal Inundation

Performance Measure (PM) Component Attributes

Type: Outcome Performance Measure

Description

Restoring land-water connections to increase hydrologic connectivity and seasonal floodplain inundation.

Expectations

Increased hydrologic connectivity and increased frequency of seasonal inundation contributes to achieving a healthy Delta ecosystem and viable populations of native species.

Metric

Acres within the Sacramento-San Joaquin Delta and Suisun Marsh that are:

1) Hydrologically connected to fluvial and tidally influenced waterways.
2) A floodplain [1] area that inundates [2] at least once every two years.

Metric will be evaluated annually.

Tool Module: Subsidence

- Subsidence increases flood risk, contributes to GHG emissions, and reduces the potential for restoring important intertidal habitat
- Analyses:
  - Current extent of subsided lands
  - Extent of subsidence halting land uses
  - Approximate time to reach sea level with subsidence reversal wetlands
- Currently only evaluates leveed islands, so Franks Tract scenarios do not alter subsidence

Extent of subsided land

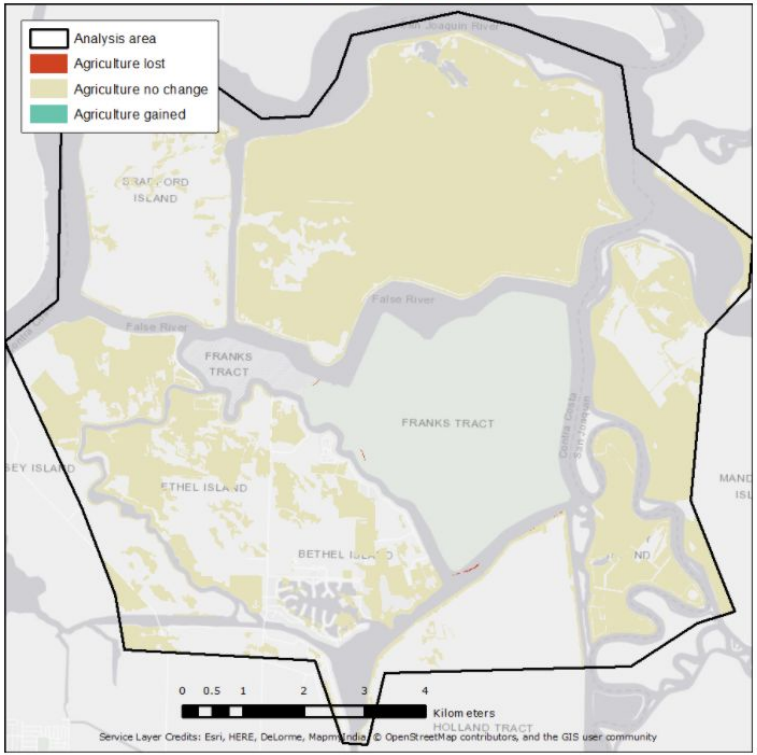
	Area (ha)
Shallowly subsided land (less than 2.5 m [8 ft] below MLLW)	1,306 ha
Deeply subsided land (more than 2.5 m [8 ft] below MLLW)	5,219 ha
Total area of subsided land	6,525 ha

Key inputs/parameters

- Tidally referenced elevation (2017 LiDAR)
- Deverel et al. 2014 time to reach sea level

Tool Module: Agriculture

- Agriculture is a key feature of Delta as place
- Analyses include:
  - Extent of agriculture
  - Change by crop type
  - Change by farmland grade
  - Extent of subsidence halting land uses
- Small changes in agricultural extent in all Franks Tract scenarios due to mapping artifacts, no real change

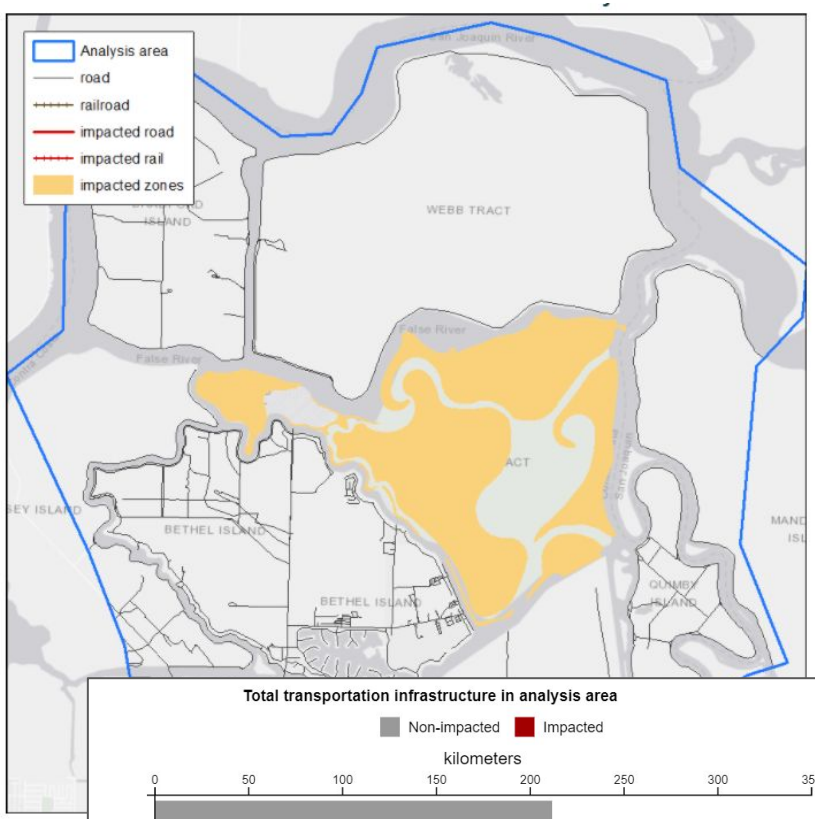


Key inputs/parameters

- Land use (VegCAMP)
- Crop types (Land IQ; DWR 2016)
- Farmland grades (FMMP 2016)

Tool Module: Infrastructure

- Identify nearby infrastructure that could be impacted by alternative land use scenarios, including
  - Roads and railways
  - Energy infrastructure (oil and gas wells, transmission lines)
  - Water diversions
- Scenario actions do not impact transportation or energy infrastructure

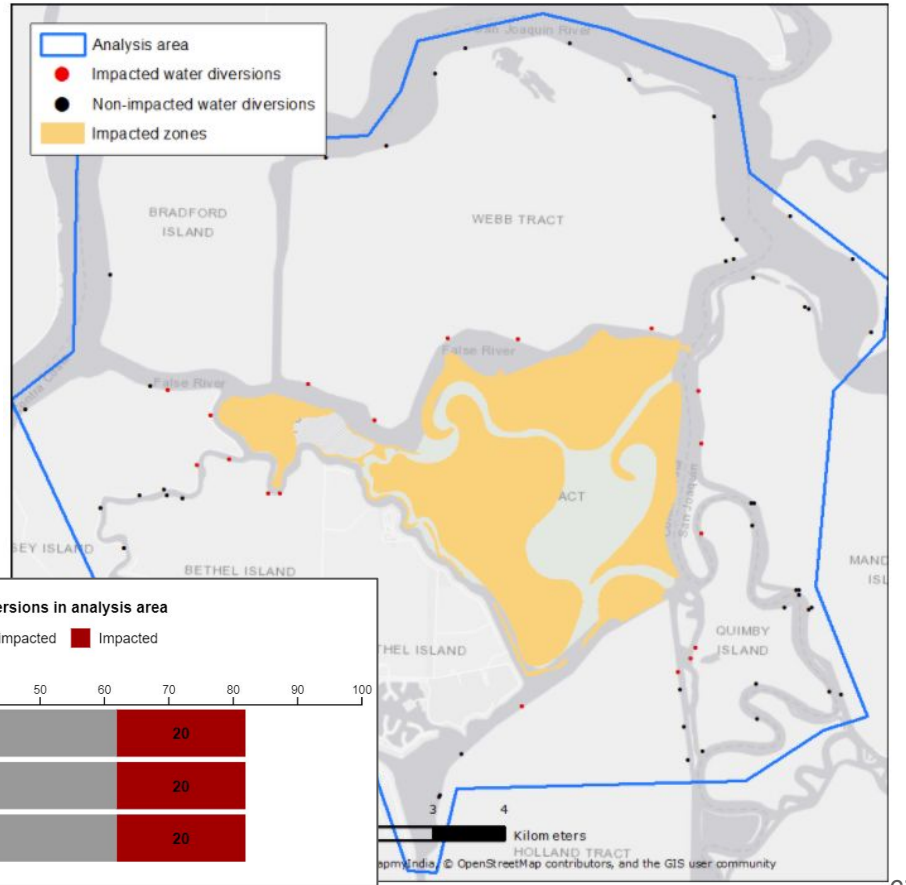


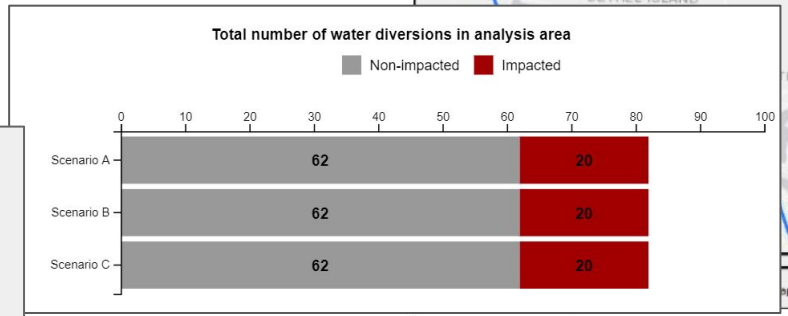
Key inputs/parameters

- Shapefiles: Roads, Rail, Oil & gas wells, Gas pipelines, Transmission lines, Water diversions

Tool Module: Infrastructure

- Scenarios could impact nearby water diversions (within 1 km)
- All scenarios have the potential to impact equal numbers of water diversions



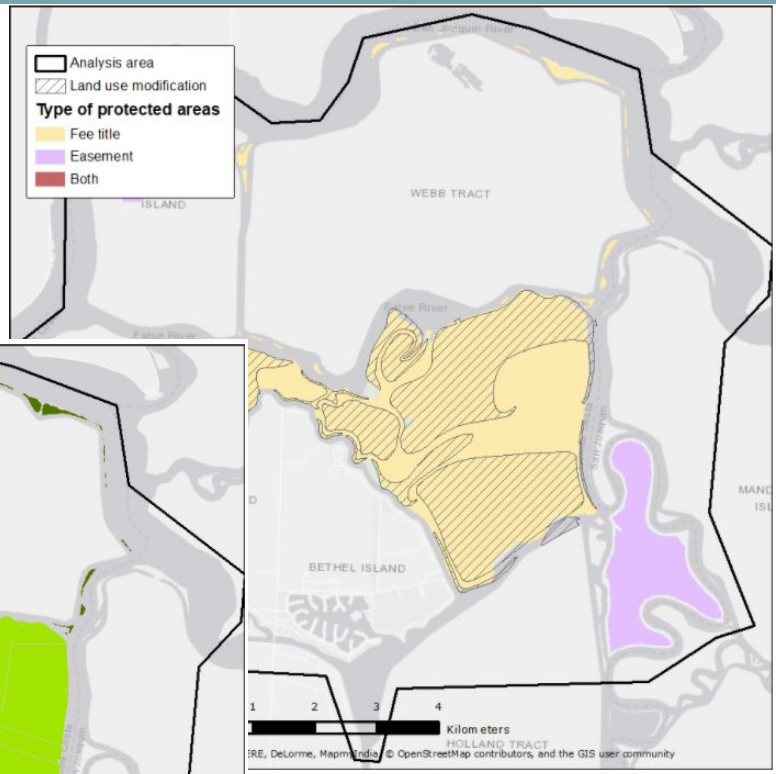


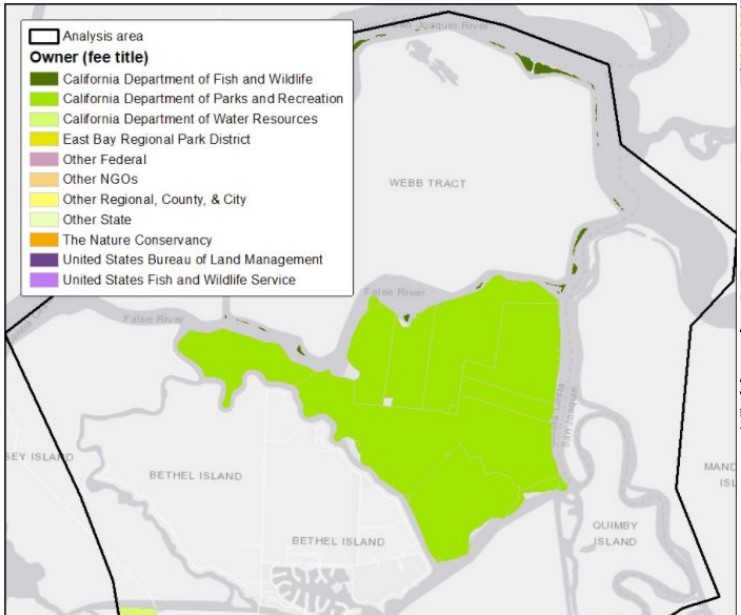
Key inputs/parameters

- Shapefiles: Roads, Rail, Oil & gas wells, Gas pipelines, Transmission lines, Water diversions

Tool Module: Protected Areas

- Identifies protected areas & how they overlap with proposed land use modifications
- Enable focusing conservation actions on public lands
- Scenario land use modifications all occur on public land owned by CA Dept of Parks and Rec



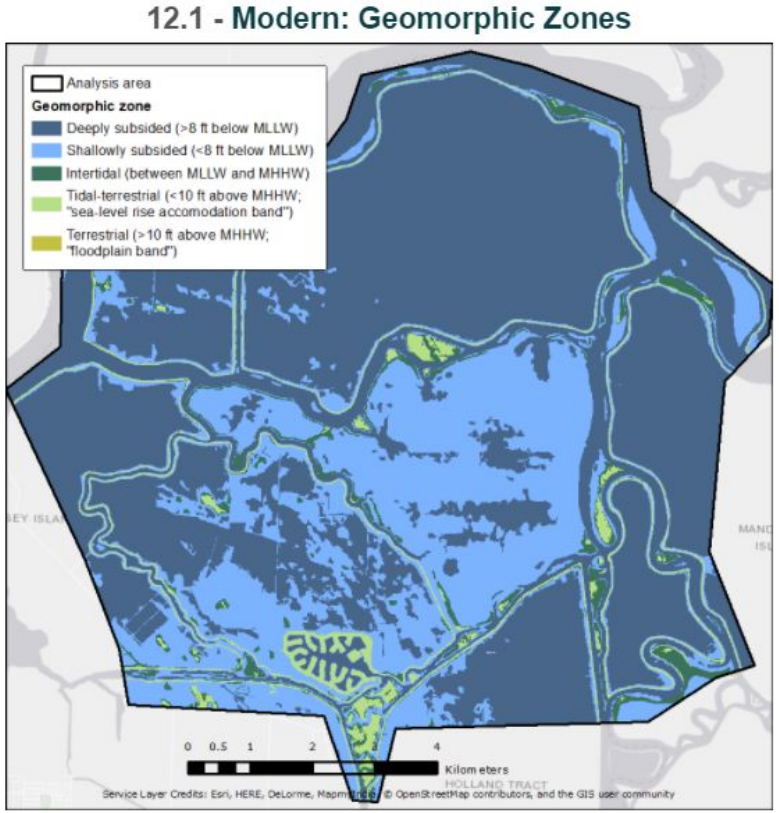


Key inputs/parameters

- Protection status (CPAD 2019 & CCED 2018)

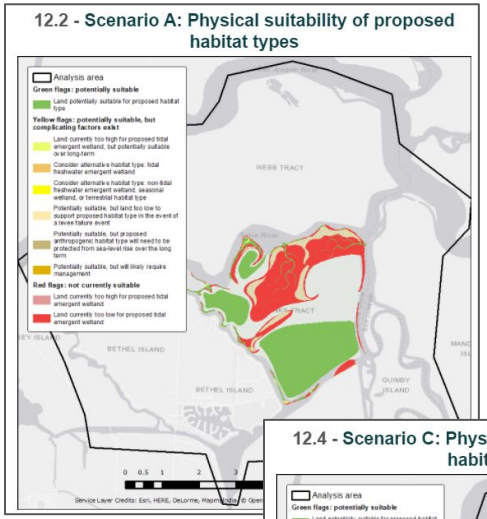
Tool Module: Physical Suitability

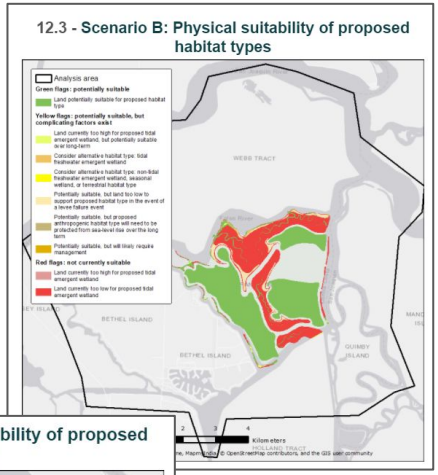
- Consider whether actions are appropriate for a site's particular landscape position.
- Important factors include elevation, degree of tidal and fluvial influence, salinity, soil type, and local effects of climate change
- Module assigns flags for unsuitable or potentially unsuitable actions
    - Mostly based on elevation

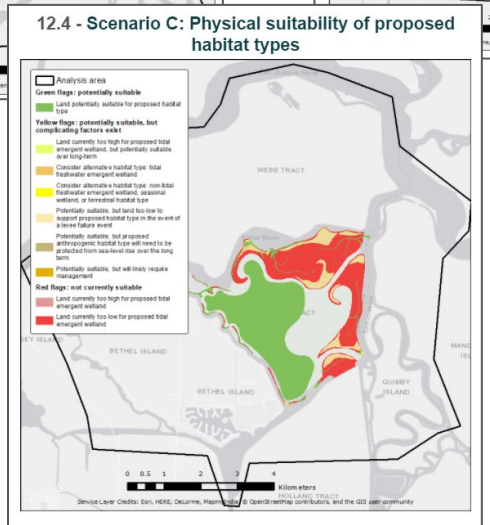


Frank's Tract Scenarios: Physical Suitability

- All scenarios have red and yellow flags
- Land currently too low in elevation to support proposed habitat types
- Restoration can still happen, but concerns about physical suitability will need to be addressed







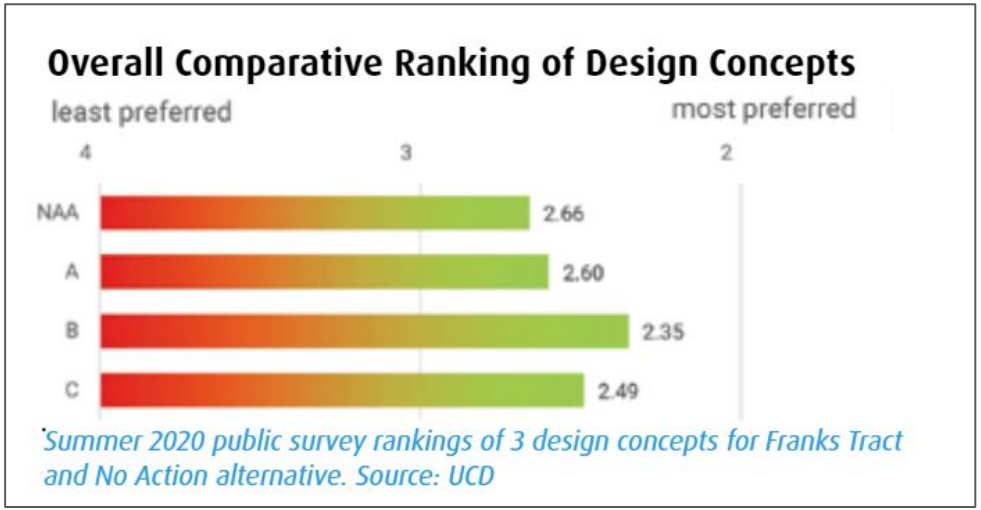
Frank's Tract Scenarios: Summary

- All scenarios:
  - Increase tidal freshwater wetland and willow riparian scrub/shrub
  - No impact on agriculture or transportation and energy infrastructure
  - Elevation raises questions about physical suitability

Scenario A	Scenario B	Scenario C
Maximum marsh patch size Amount of wetland area near areas of high water temperature	Percent of total woody riparian area arranged in large patches Average woody riparian patch size Extent of vegetated channel edge	Extent of marsh and woody riparian habitat Number of large marsh patches Marsh core:edge ratio Marsh connectivity Connectivity along corridor (fish) Extent of wetland buffer Marsh to open water ratio Area of inundation

Frank's Tract Scenarios: Other considerations

- Franks Tract Futures ranked Scenario B highest, followed by Scenario C then Scenario A
- Scenario B scored higher in metrics not well captured by DLSPT currently
  - Sportfish habitat
  - Boating access
  - Water quality



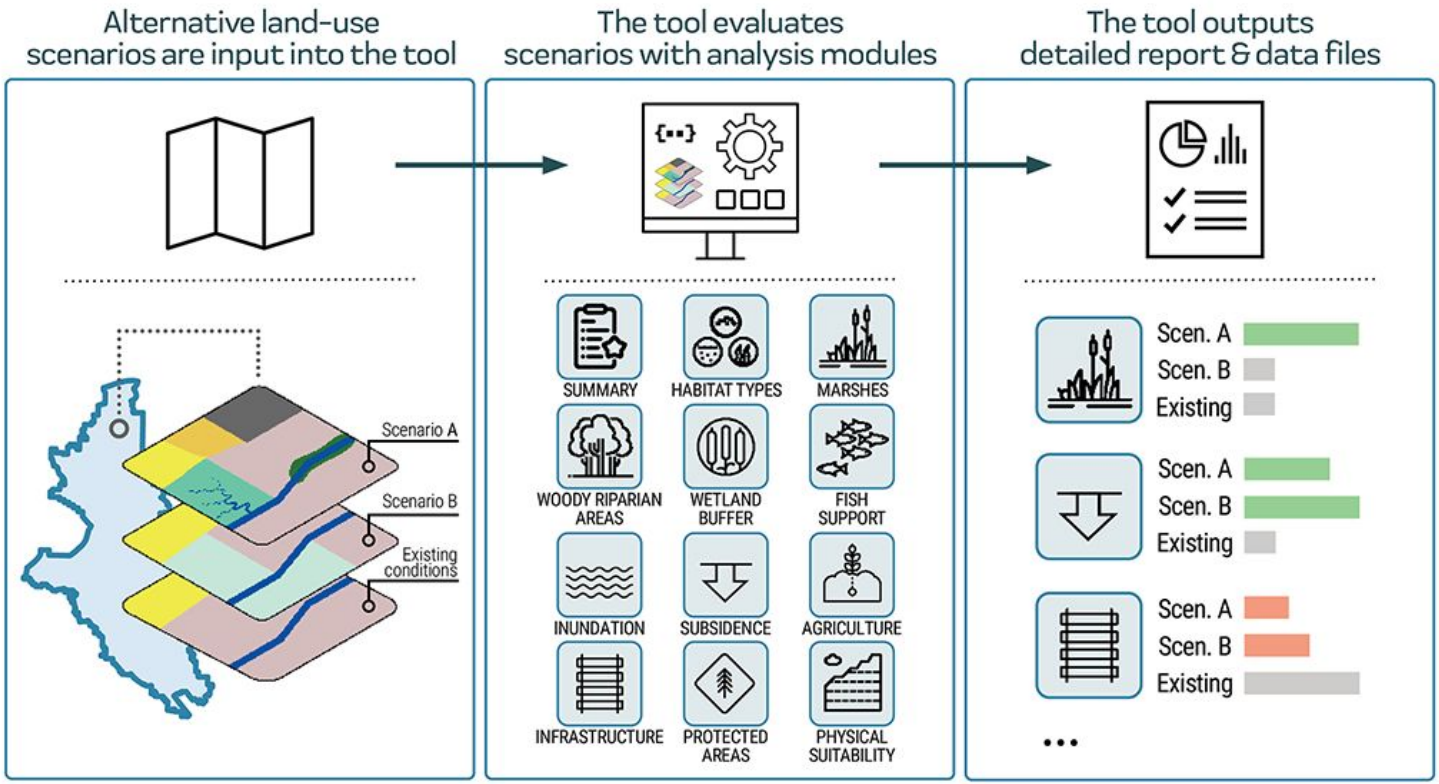
Summer 2020 public survey rankings of 3 design concepts for Franks Tract and No Action alternative. Source: UCD

High level Summary

- Tool is useful for understanding potential benefits of future scenarios, evaluating trade-off between multiple scenarios
- Assesses multiple benefits
- Historical and modern conditions provide important context
- Tool does not identify the best scenario, but highlights benefits to aid the user in making that decision
    - Not everything important is captured by the tool
    - User must determine how to weigh costs/benefits
- Modular development allows for future expansion of tool functionality
    - More analyses/modules currently under development
    - Interested in input on desired analyses

Future Directions

In-progress updates to the DLSPT



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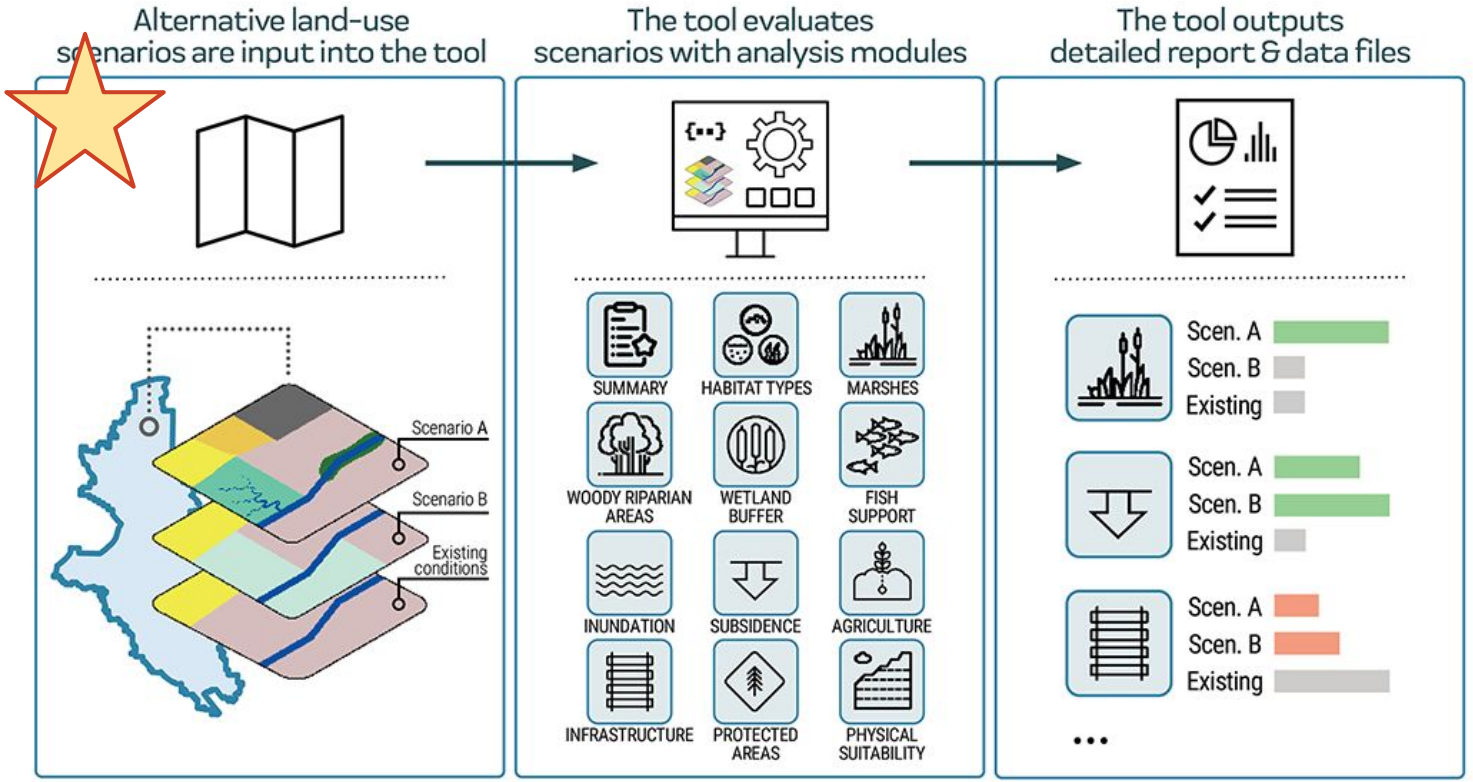
In-progress updates to the DLSPT



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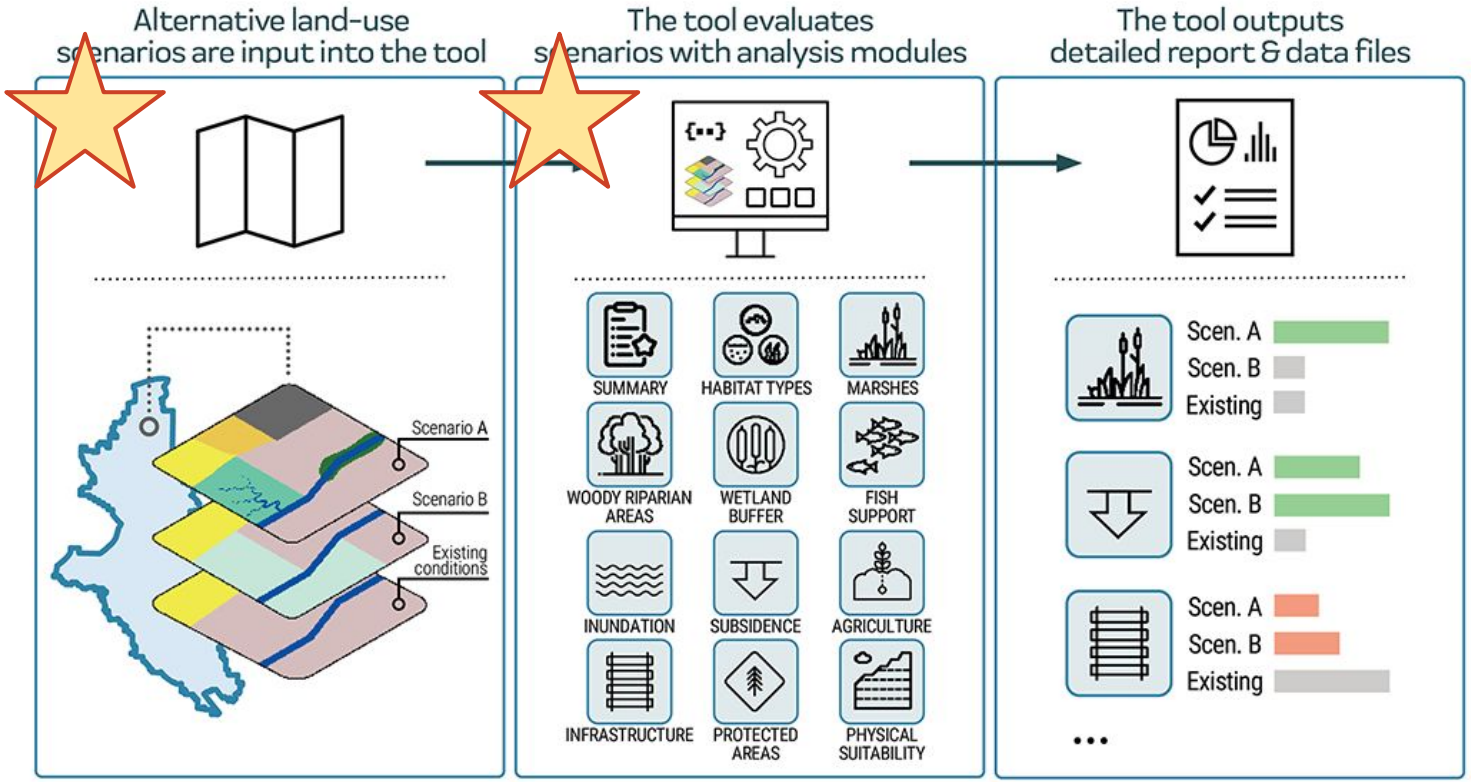
In-progress updates to the DLSPT



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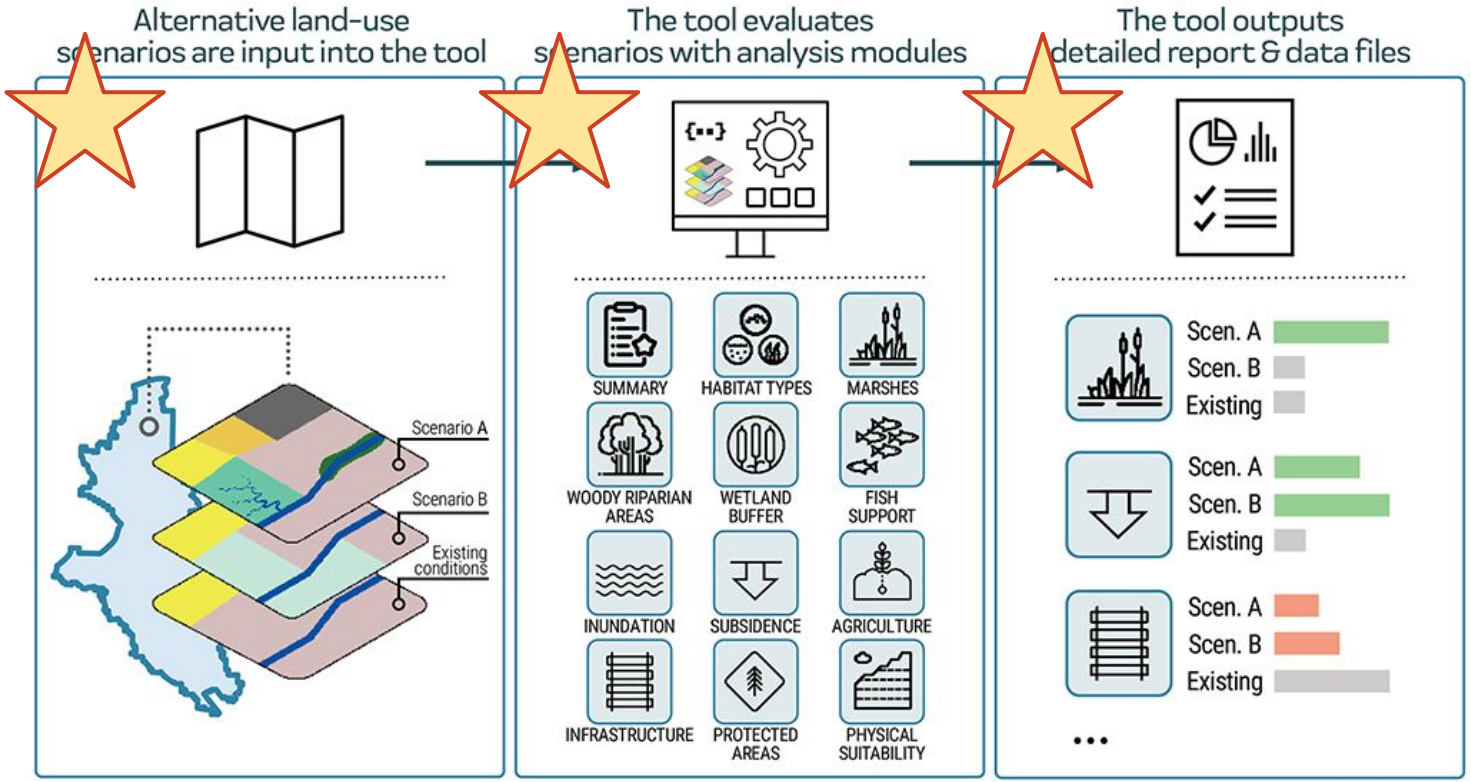
In-progress updates to the DLSPT



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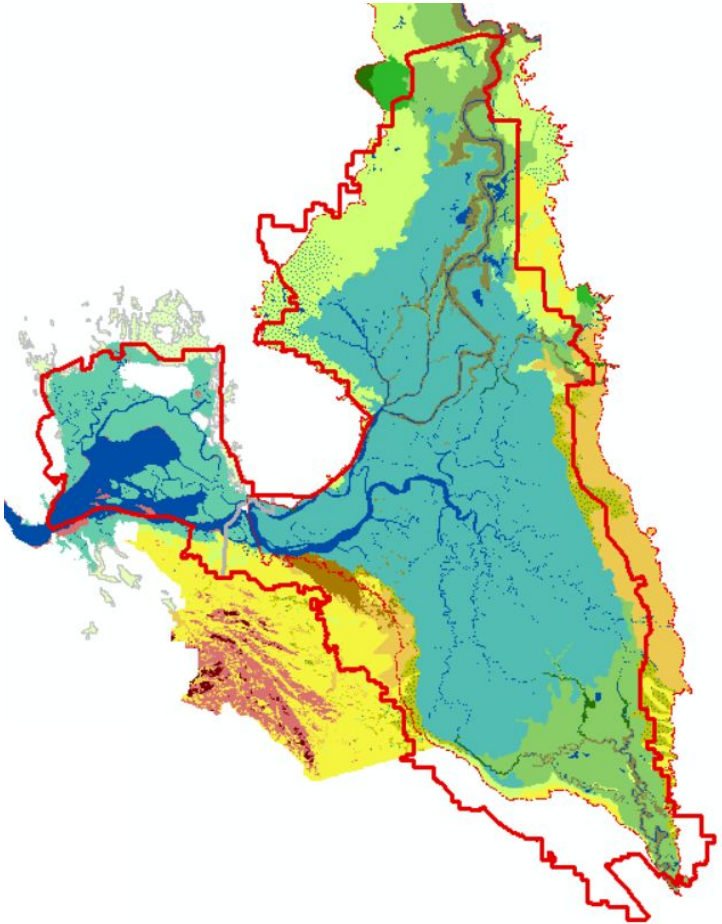
In-progress updates to the DLSPT

Expand spatial coverage

Update historical and modern habitat type maps to cover the full Legal Delta and Suisun

- Reconnaissance historical ecology
- Align Suisun vegetation mapping with habitat types used by the tool
- Run EcoRestore scenario over full spatial extent



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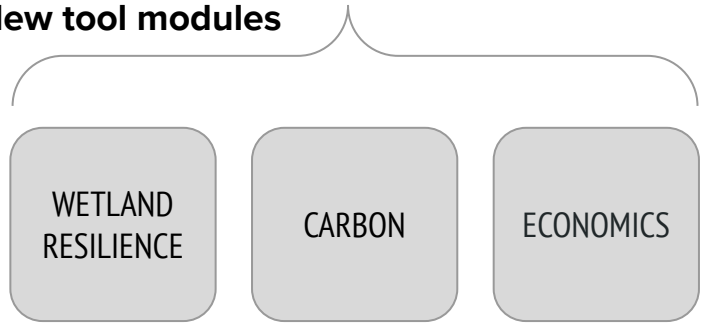
In-progress updates to the DLSPT

New analysis modules

1. Carbon module
   - Estimate carbon storage and methane flux using existing models and data
   - Report time-dependent results
   - Explore potential carbon market revenue
2. Economics module
   - Incorporate agricultural revenue and costs from DAP model (UC Merced)
   - Explore other economic factors to include in the tool
3. Wetland resilience module

New tool modules



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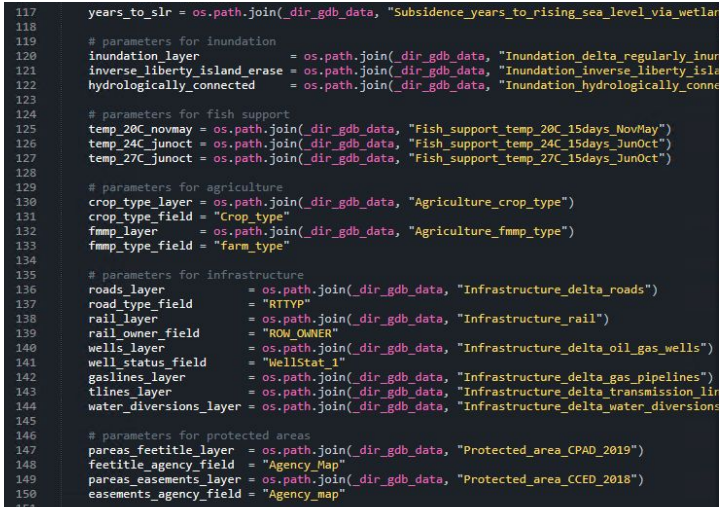
In-progress updates to the DLSPT

Technical improvements

- Update tool for ArcPro/Python3
- Reduce advanced licence dependencies
- Update CA Protected Areas Database (with GreenInfo Network)
- Integrate DLSPT with EcoAtlas Project Tracker



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inverse_liberty_island_erase = os.path.join(_dir_gdb_data, "Inundation_inverse_liberty_isla
hydrologically_connected    = os.path.join(_dir_gdb_data, "Inundation_hydrologically_conne

# parameters for fish support
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In-progress updates to the DLSPT

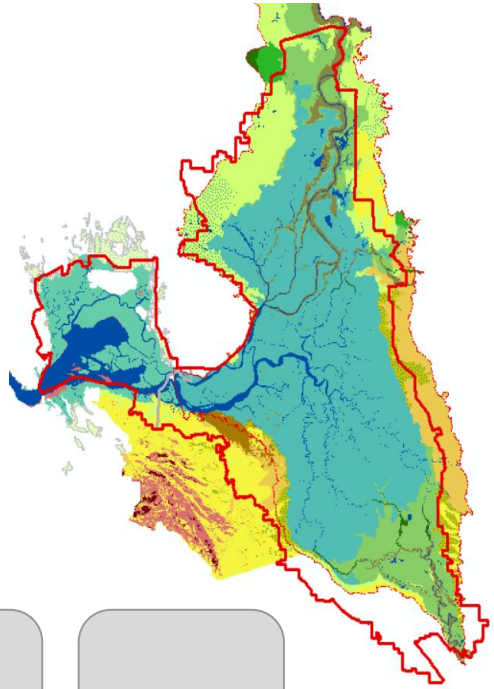
Ongoing work

Expand spatial coverage to Suisun

New analysis modules

Technical improvements

Outreach



WETLAND RESILIENCE

CARBON

ECONOMICS

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Thank you!

For more info, email Donna Ball (donnab@sfei.org) or Lydia Smith Vaughn (lydiav@sfei.org)

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