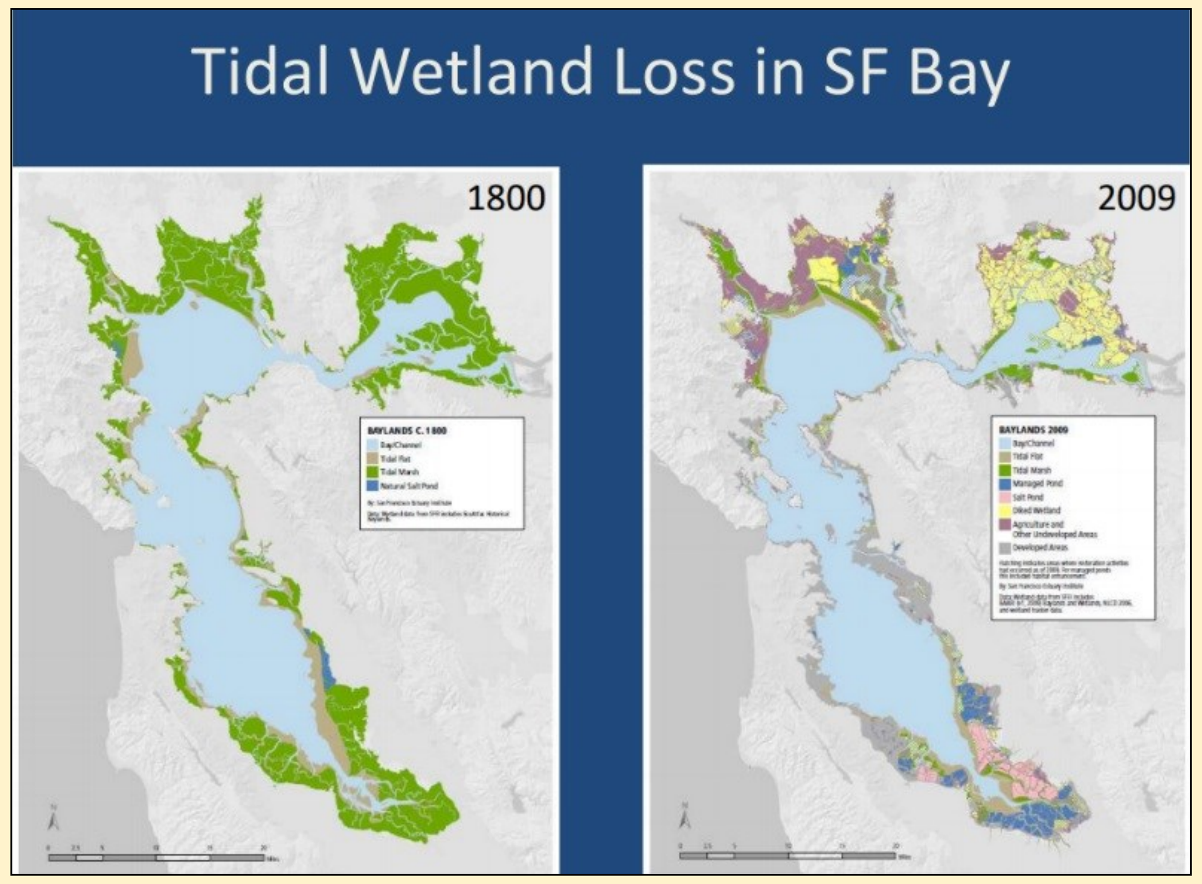
Saving Our Wetlands

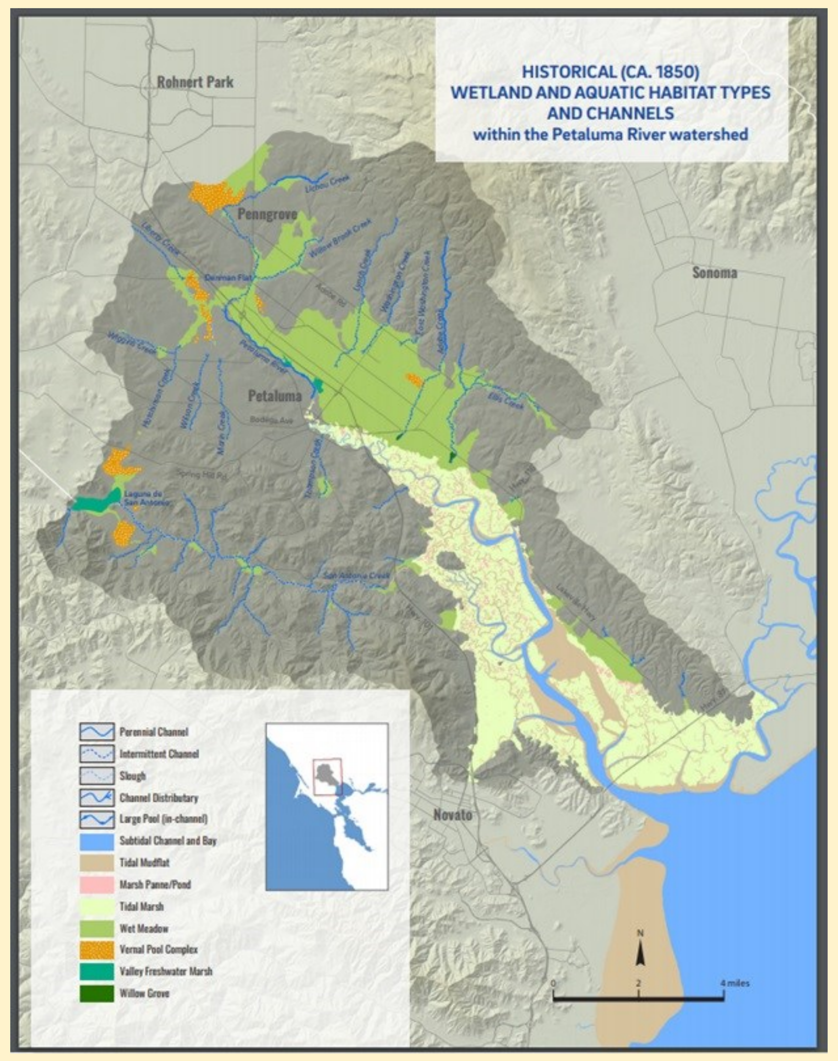


SF Bay shores were historically lined with ~770 square miles of salt marshes, but diking and land filling to create urban zones, salt production ponds, and farm land reduced these by 80-90% in the last 150 years. Although 5,000 hectares of these lost marshes have been restored, projected rates of sea level rise threaten the Bay's remaining 13,209 hectares of marshes.

Wetlands filled and built upon

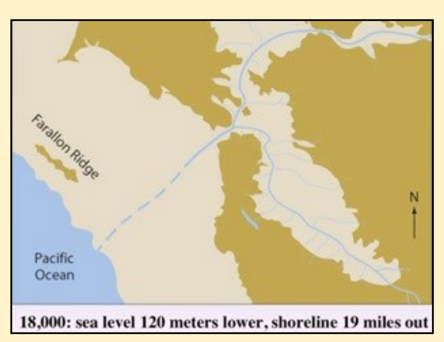
Salt production ponds

Wetlands diked and farmed



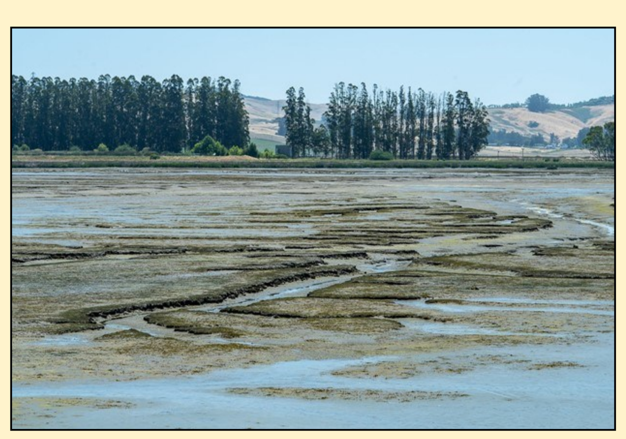
The historical wetland map above shows much of the lower elevations of the watershed were marsh and meadow wetlands before European settlers arrived.

The map above shows the **tidal and nontidal wetlands decreased** over the last two centuries. Of the original 5,000 acres marsh only about 2,000 acres are still considered tidal estuary marsh, but it is still the largest and best-preserved ancient salt marsh on the West Coast. Wetland loss has greatly reduced habitat for a number of plants and animals and has also impaired numerous ecosystem services such as floodwater storage and fine sediment retention.

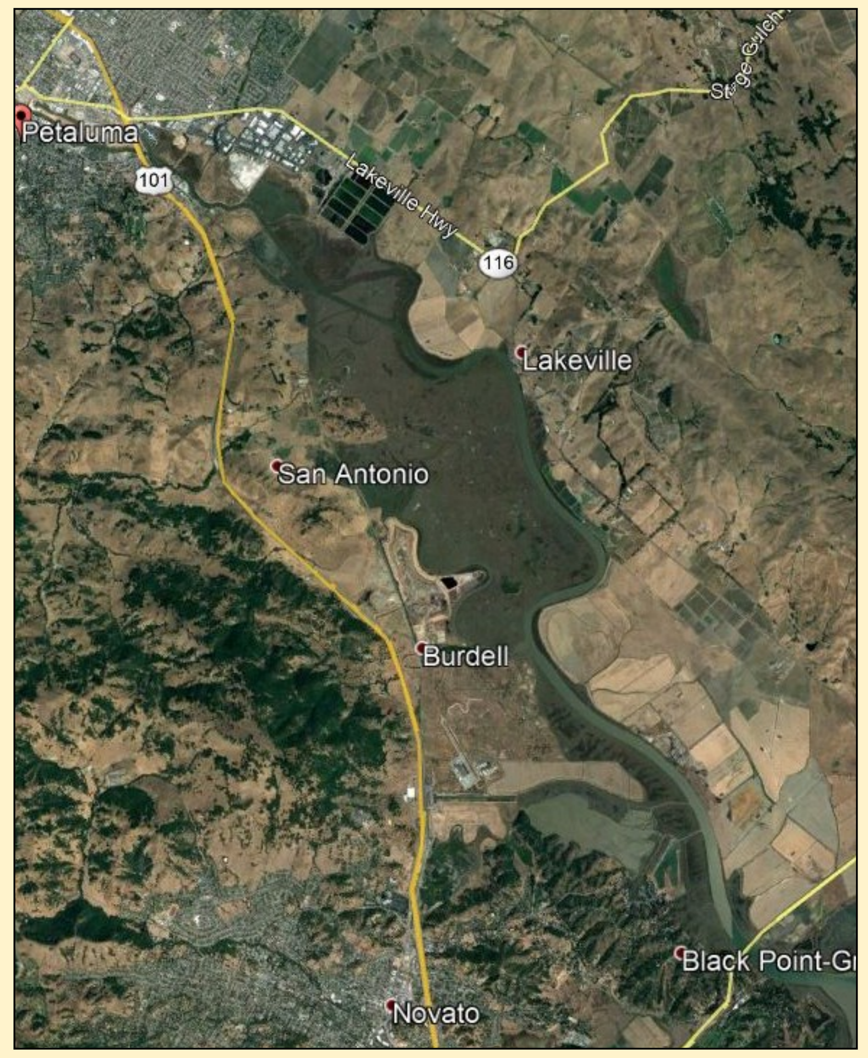


Twenty thousand years ago, the Pacific coastline was 27 miles west of the Golden Gate, with coastal hills whose tops are now the Farallon Islands. As the great ice sheets began to melt, around 11,000 years ago, the sea level started to rise. By 5000 BC the sea level rose 300 feet (90 m), filling the valley with water from the Pacific. The valley became a bay, and the small hills became islands.

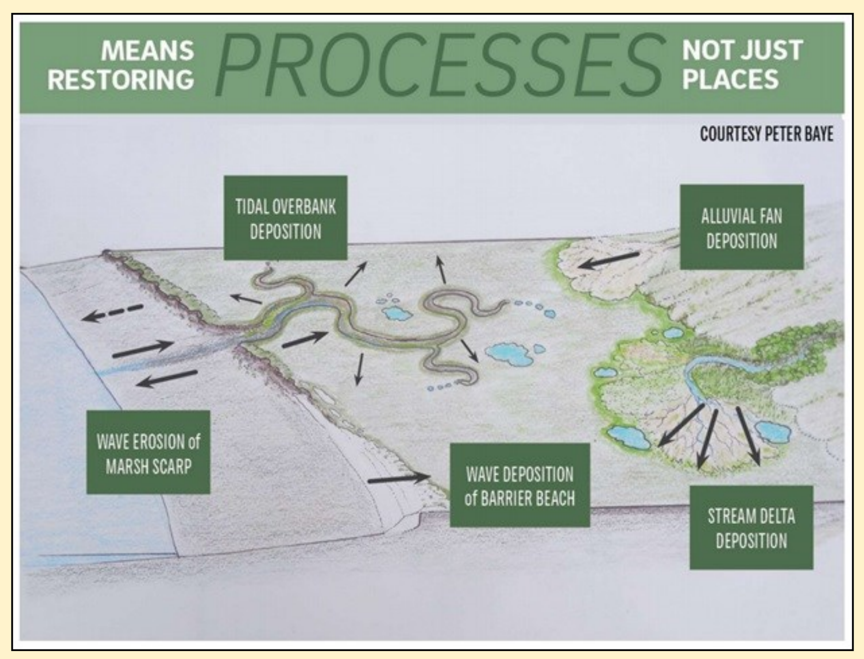
The historical map is the shape of SF Bay 1,000-3,000 years ago. The Sacramento and San Joaquin rivers carried huge flows of water and sediment down from the Sierra Nevada Mountains which accumulated along the shallow shores of the new bay, creating marshes and mudflats that supported plant and animal life. Most of the edges turned into marshes and estuaries with large transition zones between water and land. Even with slight recent sea level rise, the bay is smaller now than 150 years ago, due to development. Future map shows bay with 3 foot rise of sea level.

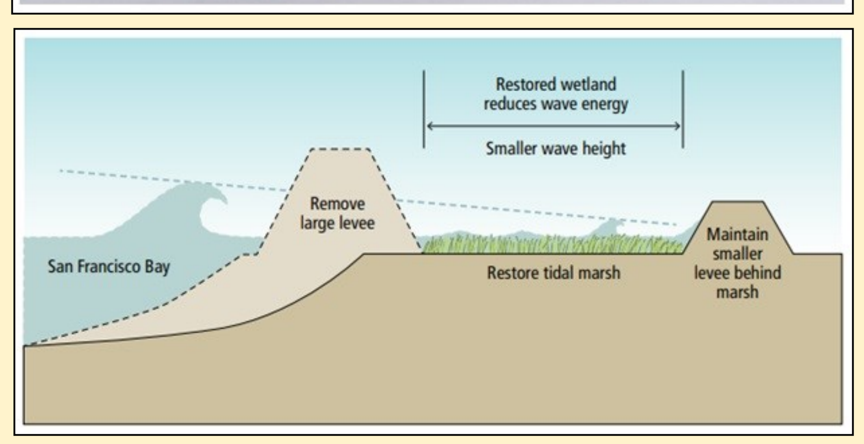


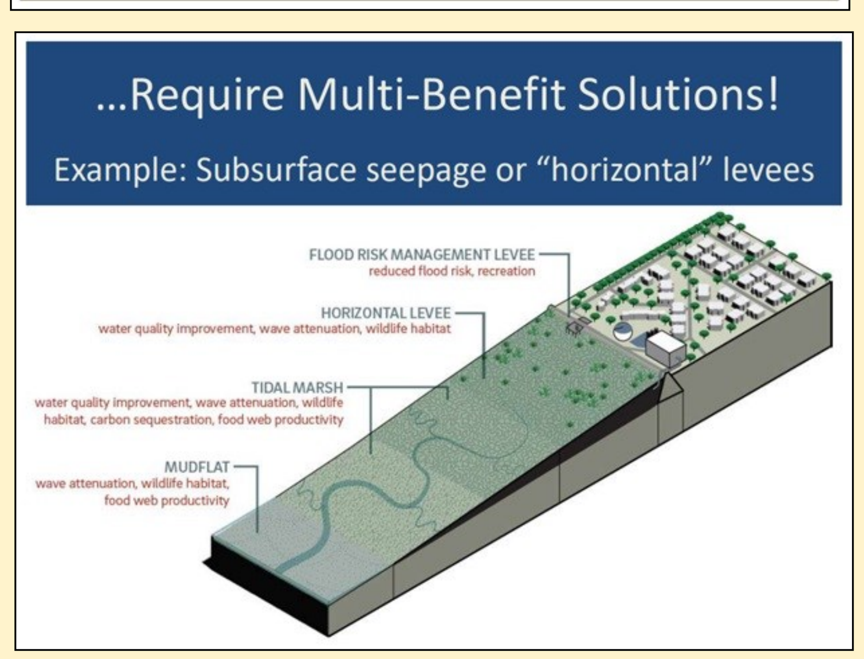
Climate Change is melting land ice adding water to the oceans and surface ocean water expands which increased temperatures (thermal expansion). Currently modeling predicts sea level rise will be about 2 feet by midcentury and 4-5 feet by end of century. Sedimentation will not keep up with rising water which means most of current marshland remaining in the SF Bay will become mudflat, including our Petaluma Marsh. Since marshes cycle more carbon than mudflats, our wetlands will store less and release more carbon dioxide to the atmosphere. Our entire Petaluma Marsh could one day look like Grey's Marsh (left).



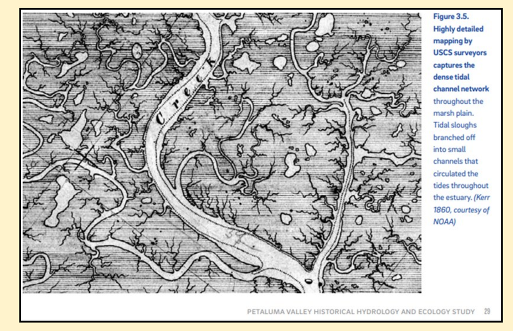
Our **Petaluma River and Marsh** have changed by human efforts after European settlement. Beginning in the late 19th century, thousands of acres of tidal marsh were diked and drained in an effort to reclaim lands for agricultural use. Construction of transportation corridors and industrial infrastructure further contributed to tidal wetland loss. The Laguna de San Antonio wetland complex was ditched and drained in the late 19th century, though highly modified wetlands still occupy several hundred acres at the head of San Antonio Creek. Before suburban development in the 1970s, the east side of Petaluma was a wet meadow and creeks spread out in deltas onto an alluvial plain. Besides the marshlands, the large wet meadow that occupied much of the valley floor east of the Petaluma River has been almost completely eliminated, as have the vast majority of vernal pool complexes throughout the watershed.







In images below, notice the **channel and vegetation patterns** that change with inches of elevation. As tides move in and out, birds and animals move between feeding ground and cover from predators.



The remaining 2,000 acres of original 5,000 acre **Petaluma Marsh is still the largest remaining intact salt marsh** in SF Bay. The marsh has three zones: **low marsh** of cordgrass or tules, which receives maximum submergence; a **middle marsh** of pickleweed, alkali bullrush, or cattails; and a **high marsh** of mixed native and nonnative vegetation rarely covered by tidal action. During extreme high tides, the surrounding uplands are a refuge for many marsh animals. The Petaluma Marsh also has a **diversity of fresh water, brackish water, and saltwater habitats** with a gradient from high salt in the SF Bay to low salt upriver with continuous tidal flow and robust ecosystem and food web. Numerous special status invertebrate, fish, amphibian, reptile, bird, mammal and plant species are known to occur within the Petaluma River watershed.

Protecting wetlands can, in turn, protect our health and safety by reducing flood damage and preserving water quality. Wetlands are among the most productive ecosystems in the world, comparable to rain forests and coral reefs. They also are a source of substantial biodiversity in supporting numerous species from all of the major groups of organisms – from microbes to mammals. Wetlands contain a disproportionate amount of the earth's total soil carbon; holding between 20 and 30% of the estimated 1,500 Pg (Picograms) of global soil carbon despite occupying 5–8% of its land surface.

From: Nahlik, A. M. & Fennessy, M. S. Carbon storage in US wetlands. *Nat. Commun.* **7,** 13835 doi: 10.1038/ncomms13835 (2016).

Fig. on left: We want to restore **natural processes** that allows gravity and slow changes to develop a more resilient system that will be more efficient and cost effective in the long run. Historically, we have "controlled" water and land use by channelizing water flow, essentially removing all deltas, alluvial fans, and areas where water could spread out and drop sediment. Nature-based solutions include allowing water to spread into the marsh, adding water catchment basins that can help with groundwater recharge, and reforming alluvial fan areas to slow water down and spread sediment. Besides moving or removing dikes, research is being done using logs to create protected zones and hill systems to naturally spread sediment . All these systems require moving large amounts of sediment.

Fig. on left: Another proposal is to work with private landowners currently conducting agricultural activity in the lower Petaluma River to shift how they manage their dikes. Instead of building bigger, higher front dikes, experts are recommending moving the dike back and grading the land in front with a gradual slope that breaks of wave action and thus provides space for marsh habitat that slows water energy from reaching the main dike. In this version the new **"retreated" levee** can even be smaller and shorter than the original front levee.

Fig. on left: Another system proposed is the **"horizontal levee"** where sediments are loaded onto the land to create a gradual long slope. Other methods proposed include placing piles of dredge spoils where natural water flow will move the sediment and lay them down naturally where desired. Most of these concepts of meeting the challenge of rising sea level is to use sediments from dredging waterways and the bay and placing them where needed.

Poster created by John Shribbs
Images from: SFEI, Sonoma Land Trust Webinar, Google Earth

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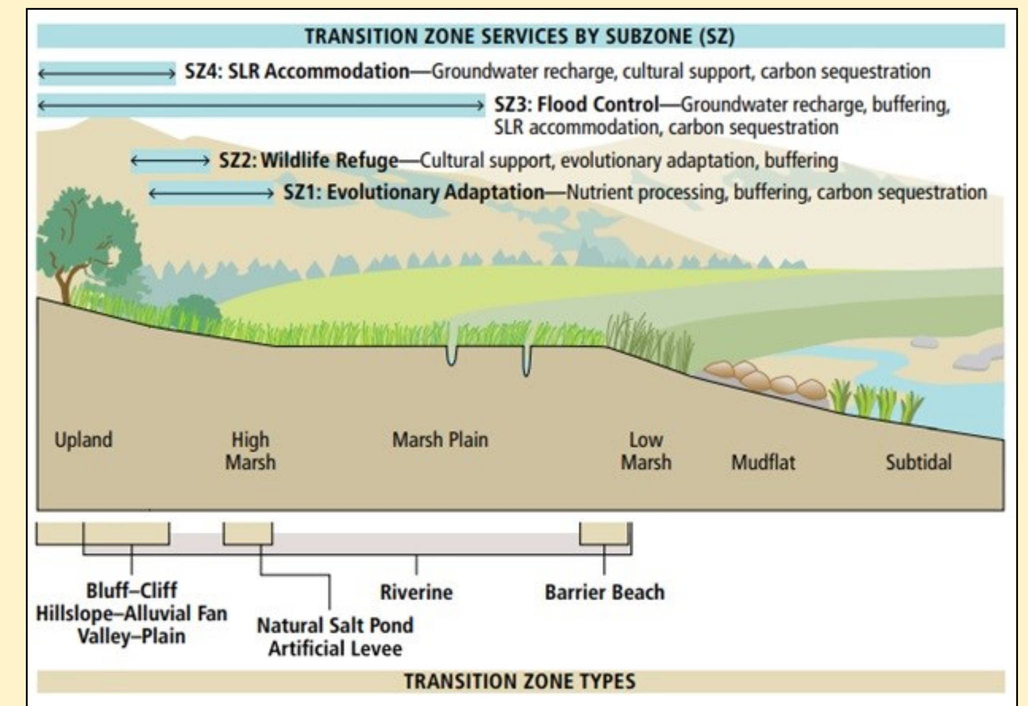
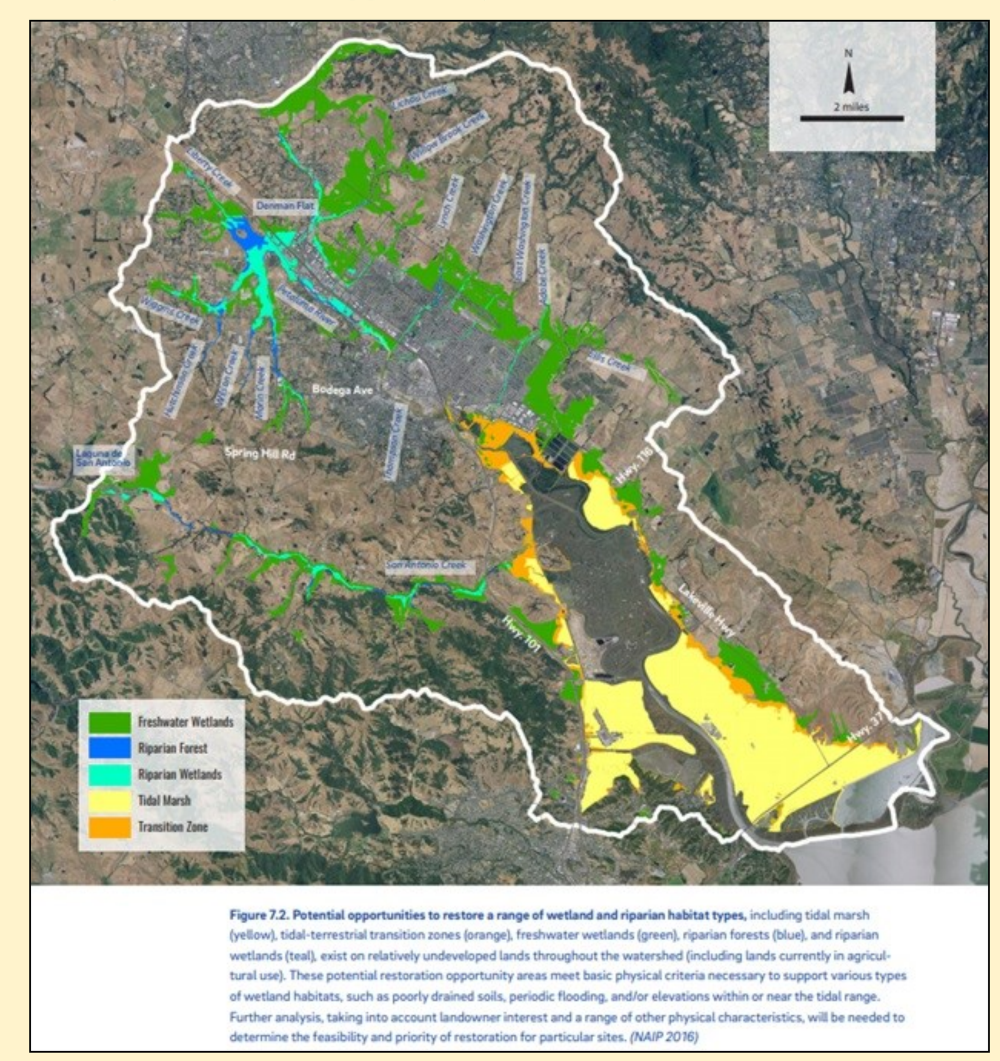


Figure 22 Spatial relationships among transition zone types and subzones. Subzones 3 and 4 extend landward of the upland extent shown in this figure. The riverine type extends bayward to the limits of the effects of freshwater discharge on intertidal vegetation. The primary services of each subzone are shown in bold. Services common to all transition zone types, such as wildlife movement and landscape complexity, are not shown.

The image above of the **transition zones** in a marsh from aquatic to terrestrial shows the shifts in vegetation with elevation. Tidal flow creates a branch-like pattern of channels with slight changes in soil elevation having different water, salt, and organic concentrations. These environmental conditions change with tides twice every 25 hours based on sun and moon positions. Micro-scale changes in physical environment create micro-niches for plants, so you see strong association of vegetation patterns with this dendritic surface pattern of channels (see 2 images above left).

SF Bay has been categorized into designated units with several slated for restoration with the goal of 100,000 acres of restoration. Prior restoration efforts were mainly done by grading the land behind the dikes to allow more natural water flow patterns, breaking a dike barrier to allow water to flow tidally, and adding native plants to restore habitats. Sometimes just breaking the dikes and allowing nature to take its own course has given good results with water movement naturally making the changes which also bring in plant propagules to reseed the habitats. Natural systems can recover if given time and opportunity.



This is a map (from SFEI) of **potential areas of wetland restoration in the Petaluma Watershed**. These areas include the diked farmlands that will be overwhelmed soon with sea water, riparian corridors, and upper floodplain.