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## ESSAY

# Which Way to the Brave New Baylands?

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*“You have to fight ideas with ideas.”*

–Judith Layzer

The San Francisco Bay Area stands at a crossroads. One road leads to a San Francisco Bay (Bay) with an ecologically healthy, resilient shore consisting of protective wetlands, which invite recreation, and support diverse native wildlife. The second road leads to a Bay with open water lapping against levees and seawalls, with few places left for marshes, mudflats and their wildlife. We have already chosen the first road, as proven by rapid tidal marsh restoration toward the target of 100,000 acres to achieve ecosystem health as described in the *Baylands Ecosystem Habitat Goals* (Goals Project 1999). However, in the recently published *Baylands Goals Science Update* (Goals Project 2015) we are alerted that, if we continue with business-as-usual restoration, regulation, and management of the baylands, we may well find ourselves at the end of the second road.

Changing climate is rearranging the road map to achieving a healthy Bay shore. Sea-level rise looms the largest among the many threats to sustaining the baylands and their wildlife, and it is exacerbated by the reduction in suspended sediment observed around 1999 (Schoellhamer 2011). Without sufficient sediment, marsh surfaces cannot keep up with rising waters. There is a strong probability that these valuable ecosystems will go underwater over the course of this century.

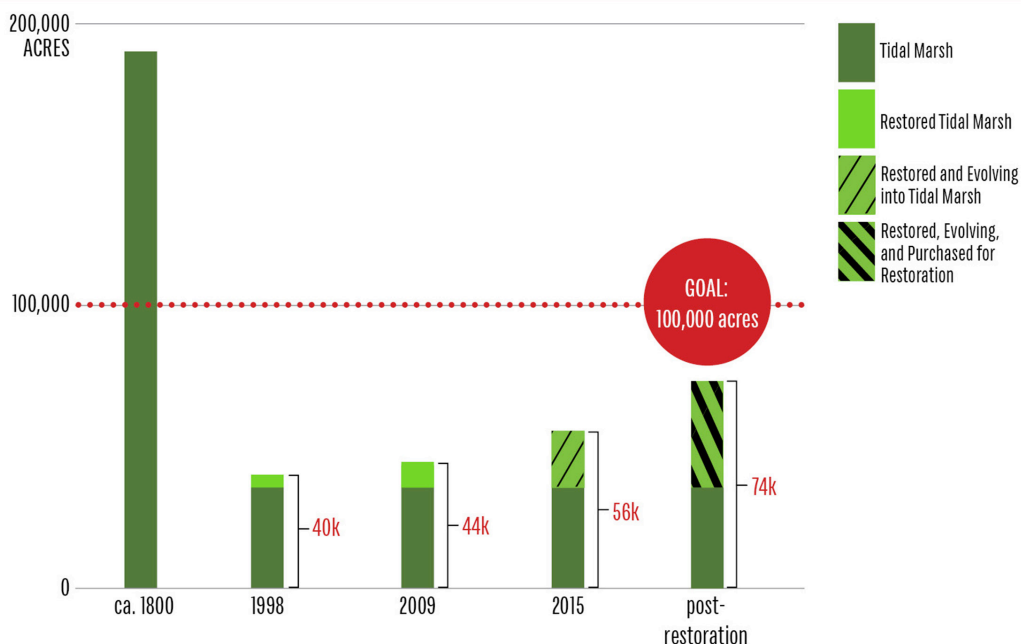
Tidal marshes are one of the most valuable ecosystems on the planet (de Groot et al. 2012). Marshes are natural infrastructure that is cost-effective compared to hard-engineering options (Jones et al. 2012) that provide the same benefits. The Bay's marshes are currently protecting the developed shoreline from erosion, purifying the water by assimilating and processing excess nutrients from urban areas and agriculture, fueling the food web with abundant primary production, sequestering carbon and contaminants,

supporting abundant wildlife (including endangered species), and providing places for recreation. All of these benefits, and especially shoreline protection, will become even more valuable as sea level rises, storms become more severe with higher waves, and the human population increases.

To achieve and sustain 100,000 acres of tidal marsh, we need to change how we think about the baylands, expand the audience for our concerns and the collaborators for our work, and re-consider what is feasible. This essay is a companion piece to the *Science Update*; it reflects my interpretation of the report and its implications, as a lead author and the Science Coordinator for the project.

### HOW THE BAYLANDS GOALS CHANGED OUR LANDSCAPE

The original *Baylands Ecosystem Habitat Goals* report sparked a change in how we think about the Bay shore. The maps in the report that quantified how much tidal marsh there used to be (190,000 acres circa 1800) and how much remained in 1998 (21%) inspired the acceleration of tidal marsh restoration. The size of the largest marsh restoration project increased by two orders of magnitude, and many of the government agencies responsible for stewardship of the Bay adopted the 100,000-acre goal into their policies. Figure 1 shows the rapid acceleration of tidal marsh restoration after the report was published. In the decades before 1998, about 4,000 acres of marsh had been restored. From 1999 to 2015, another 16,000 acres were restored to tidal action, and are either currently marsh or on a trajectory to

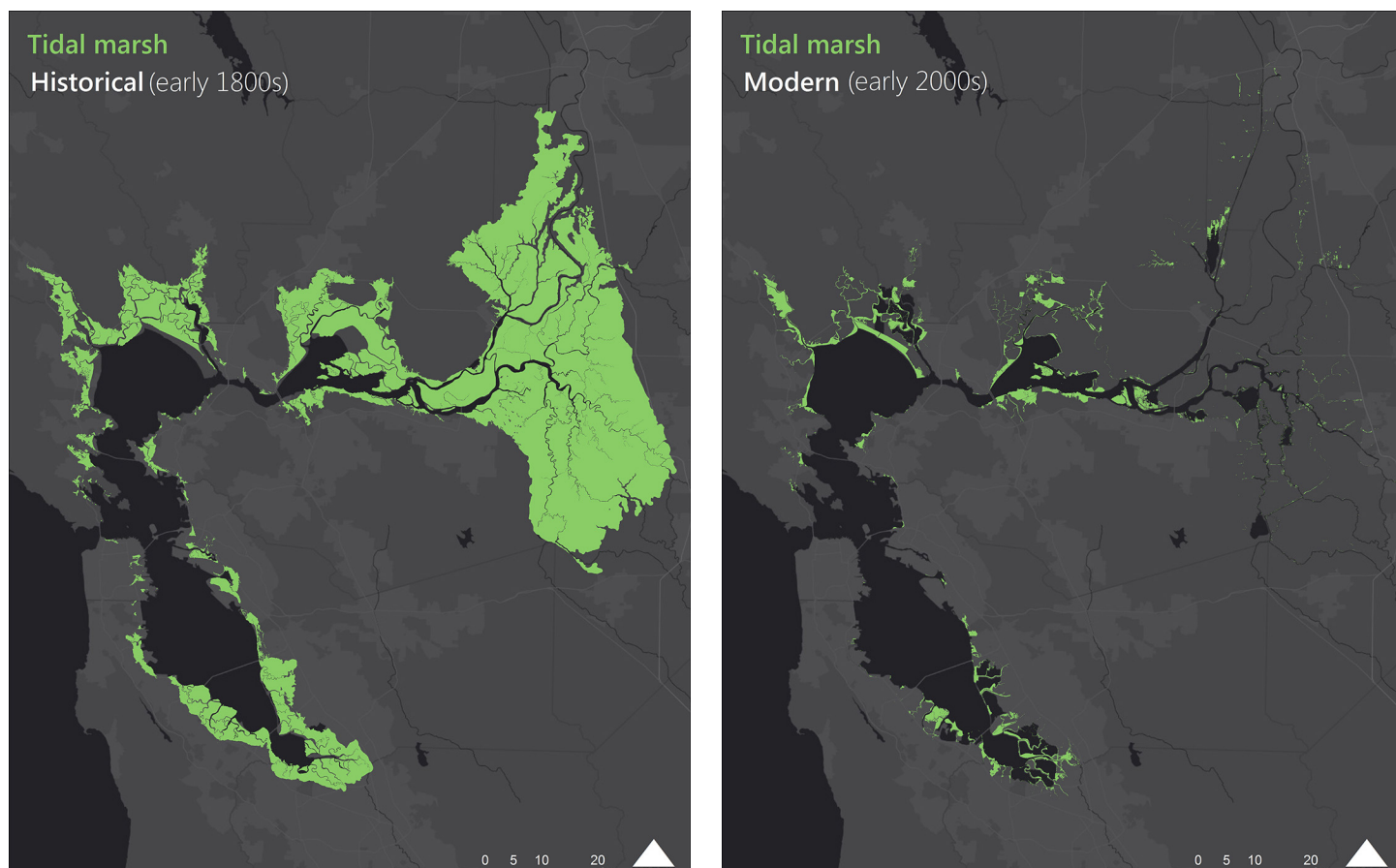


**Figure 1** Change in the number of acres of tidal marsh in San Francisco, San Pablo and Suisun bays. Note that Bay wetlands have not been mapped since 2009. Modified from Goals Project (2015) and SFEP (2015).

become marsh. An additional 18,000 acres were purchased and are in the pipeline for restoration. Thus, the total acreage restored or purchased for restoration in the 16 years after the original report was published is 34,000—an astoundingly large number compared to the earlier pace of restoration.

## HOW THE BAYLANDS GOALS RELATES TO THE DELTA

The Baylands Goals Project, both in 1999 and in 2015, focused on San Francisco, San Pablo, and Suisun bays. However, the main ideas in the *Science Update* apply to the Sacramento–San Joaquin Delta (Delta) as well. A Delta Goals Project could build from the approach and content of the Baylands Goals Project. In many ways, a Wetlands Goals Project is more called for in the Delta, where a whopping 98% of the remarkably large (nearly a half-million acres) historical freshwater wetlands has been lost (SFEI–ASC 2014; Figure 2). Indeed, before significant landscape alteration, the Delta was a vast wetland (Whipple et al. 2012), essentially one huge marsh, as opposed to the Bay, which then and now is mostly open water. Of course, the resource pressures and patterns of land ownership are different in the Delta, which adds additional challenges to those faced by the stewards of the Bay.



**Figure 2** Change in marsh extent across the entire San Francisco Estuary from before significant European development of the landscape (historical) to the most recent map data (modern). Modified from SFEP (2015).

Another difference is the pattern of endemism and focus on endangered species protection in each part of the San Francisco Estuary. Endemic species evolved in the Bay within isolated tidal marsh habitats. In the Delta, that same process occurred in the freshwater and low-salinity open-water areas. As a result, in the Bay, we have focused on conserving and restoring marshes (for endangered rails and mice) and in the Delta we have focused on conserving and restoring freshwater and low-salinity aquatic habitats (for endangered fish).

A more holistic approach to understanding and restoring the complete systems of both the Bay and Delta is now called for, based on the near consensus that single-species conservation does not provide the best overall outcome. This more holistic approach drives the thinking behind the *Science Update*.

### **RESTORE PROCESSES, NOT JUST HABITATS**

The approach behind the recommendations in the *Science Update* focuses on restoring physical and ecological processes, not just habitat structure. This shifts our perception of ecosystems from static habitat types that could be restored, and would remain that habitat in perpetuity, toward seeing ecosystems as the dynamic systems they are—able to evolve, move, and otherwise respond to changing conditions. By seeing ecosystems in this light, we can more easily foster resilience in tidal wetlands by focusing restoration efforts on the physical processes that create and maintain landforms and habitat structure. Similarly, we can focus on restoring the ecological processes that foster resilience in wildlife populations, rather than just achieving target numbers for population size (Beller et al. 2015).

For tidal marshes and mudflats to be resilient, or able to continue to provide the functions we desire of them in the face of changes like sea-level rise, the natural processes that create and maintain them need to be intact or emulated by human activities. In particular, the watershed and tidal processes that deliver sediment to tidal wetlands are impaired and need to be restored. This means returning full tidal action to restored areas, which provides the tidal energy, varying water levels, and sediment from the Bay that allows accretion to maintain marsh surface elevation as sea level rises. Restoration practitioners have become adept at designing full tidal restoration, yet now tidal barriers are being suggested as an adaptation to sea-level rise. Such barriers would increasingly dampen tides as sea level rises, depriving marshes of critical accretion at the highest marsh elevations. High marsh is the zone most imperiled by sea-level rise, according to marsh-accretion models, and is also the most important for future marsh migration space and current high-tide refuge.

Up to this point, restoration has focused more on restoring tidal action, and much less on reconnecting watershed processes to tidal wetlands. With the risk of sea-level rise to marshes now clear, the importance of retaining local watershed sediment in adjacent marshes is paramount. This means reconnecting streams and rivers to the baylands. Levees and stormwater channels have disconnected nearly all fluvial sources from the baylands (<http://storymaps.sfei.org/flood-control/#>), so their water and sediment bypass the marshes. Watershed sediment has also been detained behind dams, in flood-control channels, and in stabilized channel banks. We need alternative approaches for managing watersheds to take better advantage

of freshwater and sediment resources and deliver them to the baylands, while improving stream health and resilience.

Freshwater, like sediment, is a critical resource for marsh resilience. Brackish and fresh tidal marshes can rise in elevation much more quickly than salt marshes, because they accumulate organic matter (peat) more rapidly. Freshwater sources are also critical for carrying sediment out of watersheds and into the baylands. Also, freshwater that enters the baylands from the watershed creates a gradient of salinity and wetland plant communities. Such gradients add landscape complexity that supports biodiversity in the estuarine-terrestrial transition zone and wildlife population resilience under variable hydrologic and temperature conditions. As demand for—and recycling of—freshwater increases, using streams, rivers, wastewater, and other runoff for ecological purposes, including building a resilient shore, becomes ever more important (EBDA 2015).

In addition to the physical processes of sediment and water described above, the recommendations in the *Science Update* focus on restoring ecological processes, rather than just habitat structure and wildlife population size. With growing pressures from climate disruption (that go well beyond sea-level rise) and increasing human population, baylands wildlife will more than ever need to be able to move between patches to find better conditions, recolonize areas of local extinction, and maintain gene flow. The analysis of marsh fragmentation is intended to foster restoration projects that create larger patches and deliberately fill in gaps with stepping stones. The ability to evolve in keeping with a changing environment is an often overlooked ecological process that is critical for the resilience of baylands wildlife. Large populations with high genetic variability will be better able to weather the projected increase in the severity of both storms and droughts, as well as days of extreme heat, to name a few challenges.

Key uncertainties discussed in the *Science Update*, yet not covered here, include climate change projections, marsh-accretion model outputs, and other future estimates. Our approach in the report is to describe the uncertainty and offer recommendations that will achieve the goal of a healthy Bay shore under a range of future scenarios.

## **CAN WE ACT FAST ENOUGH?**

Fully implementing the recommendations in the *Science Update* would be a win-win for our citizenry and the environment. This strategy is not only cost-effective compared to an alternative in which newly constructed infrastructure replaces some key services the baylands now provide, but also offers benefits that will be lost if walls replace wetlands. We still have time to retain large-scale baylands that can provide large-scale ecosystem services, including shoreline protection from erosion, support of native wildlife, waste assimilation and nutrient cycling, areas for recreation, and carbon sequestration. Aiming now for small fringing marshes as the eventual outcome would be to give up the fight too early. Rather, now is the time to focus on big changes that can lead to big solutions.

Though moving toward this vision is the clear choice, doing so quickly enough—before sea-level rise forecloses on the opportunity—is an enormous challenge. We will rapidly have to learn how to use natural processes to our advantage, develop new approaches to watershed management, revise or reinterpret policies, and increase restoration funding. Therefore, to keep our baylands resilient as sea-level rise accelerates more rapidly in the coming decades, we need to implement the recommendations in the *Science Update* immediately.

## ACKNOWLEDGMENTS

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