MEMORANDUM

To:
Delta Independent Science Board
Delta Stewardship Council
980 9th Street, Fourteenth Floor
Sacramento, CA 95814

From:
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cc:
Carl Wilcox, Department of Fish and Game

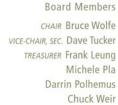**Re: Using Historical Landscape Analysis to Inform Restoration Strategies**

I. Summary of Current Research
The Aquatic Science Center (ASC) is currently mapping and documenting Delta habitat
patterns and characteristics as they existed prior to significant Euro-American modification.
This two-year project, funded by and in collaboration with the Department of Fish and Game
(DFG) Ecosystem Restoration Program (ERP), is developing a GIS database and
accompanying report (completion date at the end of 2011). We are documenting historical
characteristics of channels, tidal and nontidal marsh, seasonal wetlands, ponds and lakes,
riparian forest, and the upland ecotone. At this point in the project, we are synthesizing our
compiled maps, textual documents, photographs, and historical aerial photography into a draft
GIS of habitats and channels. We find that the historical data paint a rich picture of habitat
complexity at many spatial as well as temporal scales, where the Delta can begin to be seen as
a number of distinct landscapes, each with a different set of characteristics (Grossinger et al.
2010, Whipple et al. 2010). These initial findings are summarized in Section III below.

II. Rationale
Information about pre-modification Delta landscape patterns and functions may be useful to
the Independent Science Board in its review of the Delta Plan drafts and other restoration
planning documents. For a system as greatly changed as the Delta, improved understanding of
historical conditions can address uncertainties about ecosystem process and function (Dahm et
al. 1995; Swetnam 1999). Knowing what and where particular habitats existed historically
permits more effective restoration strategies with less risk of failure. At the same time, better
understanding of how physical drivers created and maintained target ecological functions can
lead to new strategies for sustainable habitat restoration (Kondolf et al. 2001, Walter and

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Merritts 2008). Additionally, moving toward a landscape that is more similar to that in which species of concern evolved (a system with strong seasonality, multiple physical gradients, and habitat complexity) may increase their competitive ability relative to non-native species (Moyle et al. 2010). The data we are compiling and synthesizing can be used to interpret the ecological functions of the historical landscape, to identify priority functions and locations, and to determine measures of restoration success (Mika et al. 2010, Atwater 2011). The goal is not to create a literal template from which to recreate the past, but rather to understand links between physical processes, associated habitats, and ecological functions more clearly. This project and possible future efforts to integrate the historical perspective with current planning efforts could help define design criteria and suitable locations for restoration actions.

III. Initial Findings Overview

Analysis of historical Delta habitats promotes the development of landscape-level parameters for ecosystem restoration design. Ongoing research shows the Delta prior to Euro-American modification as not only locally complex, but also predictably variable at the landscape scale, expressing many interacting processes across physical gradients. Delta landscapes were relatively stable, but with seasonally variable characteristics. The historical Delta can be divided into three primary landscapes, referred to here as the flood basins (North Delta), tidal islands (Central Delta), and distributary rivers (South Delta). Each primary landscape can be distinguished by characteristics such as vegetation patterns, relative tidal influence, channel plan form, stability of features, and hydroperiod.

The flood basins landscape characterized the North Delta, where the fluvial-tidal interface shaped and was influenced by the topographic and geologic environment, resulting in unique transitional habitats. One defining characteristic was a broad zone of non-tidal freshwater emergent wetland that graded into tidal freshwater emergent wetland. These wetlands were dominated by dense stands of tules, which reached heights of 10 to 14 feet. Relatively shallow perennial ponds and lakes occupied low-elevation, backwater positions behind natural levees. The basins were bordered by riparian forests along natural levees of the major channels, seasonal wetlands (including alkali and vernal pool complexes), or stream distributary "sinks" occupied by willow swamps. The riparian forests were of varied width, in some places mere strips and in others more than half a mile in width (Fig. 1). Due to the presence of large natural levees along major channels and broad zones of little or no channel with long distances to tidal sources, much of the flood basin wetlands were at least seasonally isolated from the tides. This was a landscape that depended on wet-season sediment-laden flood flows. Floodwaters consisted of annual flows from smaller upland systems such as Cache and Putah creeks and, in some years, overflow of the Sacramento River. These floodwaters formed what many referred to as large lakes within the basins; they often extended for many miles and persisted for several months. Nevertheless, parts of the basins did dry out in the summer, evidenced in part by the numerous fires referred to during the early settlement period, though not to the extent to preclude tule growth.

The tidal islands landscape of the Central Delta historically included roughly 200,000 acres of freshwater emergent wetland that was strongly influenced by tidal waters, being inundated by

monthly spring tides, if not more frequently. Channel density and sinuosity was greater than in less tidally dominated northern and southern parts of the Delta. However, related to inundation tolerances of wetland vegetation in fresh water, channel densities appear to have been considerably lower than those observed in brackish and saline marshes of the estuary downstream (Grossinger 1995, Pearce and Collins 2004). Unlike the flood basin landscape, natural levees were low and subsequently overflowed by tides and floods with greater frequency. High river stages often inundated entire islands. The flooding began as water backed through sloughs into island interiors, culminating as flood stages, sometimes boosted by a rising tide, flowed over the low natural levees. The process was less pronounced at the Delta periphery. Banks of tidal islands were generally characterized by wetland vegetation similar to that of the island interior. Tule covering the river banks was a common description. However, tule appears to have been less extensive in the tidal island landscape than in the flood basin landscape. Instead, willows, grasses, and even ferns as well as tule were dominant species.

The distributary rivers landscape encompassed the South Delta, including the area where the three distributaries of the San Joaquin formed Union and Roberts islands. Here, a complex network of distributary channels with levees of variable height intersected the fluvial-tidal transition zone, likely causing floodwaters to be routed and channelized in ways different from the flood basins landscape. Some of the area between the distributaries was elevated above tidal levels by the sandy deposits left during flood stages. Some parts of the main channels, such as Old River near present-day Fabian Tract, carried large woody debris and were popular salmon fishing grounds for Native Americans and early explorers. In comparison to the flood basin landscape, a greater portion of the natural levee riparian vegetation was composed of willows and other shrubs. Broad areas of the landscape supported open oak woodlands. Habitat patch sizes were generally much smaller than in the other landscapes, as grassland, freshwater emergent wetland, seasonal wetlands, and intermittent and perennial aquatic habitats (side channels and oxbow lakes) formed complex mosaics at various scales. Tule dominated the freshwater emergent wetlands and became more continuous toward the lower elevation and more tidally-influenced parts of the landscape.

IV. Next Steps for Landscape-level Restoration Planning

These data begin to provide a landscape framework for identifying restoration strategies in the contemporary and projected future Delta. The science of restoration ecology has shown that selecting and prioritizing restoration actions within a unified landscape-level framework, using landscape ecology principles, is critical to re-establishing ecological functions (Greiner 2010). Current Delta restoration plans, including the ERP, express goals to restore large areas of interconnected habitats and employ conceptual models of drivers and stressors related to particular habitats in the process of evaluating restoration projects (CDFG et al. 2010). However, the fundamental issue of how to integrate this large-scale thinking with small-scale, on-the-ground restoration projects remains. For example, while the BDCP draft calls for target acreages of tidal marsh and riparian forest restoration, there is no guidance about the minimum patch size, necessary functional connections to other habitat types, or viable physical locations within the Delta to guide design, implementation, and monitoring. Similarly, while the re-

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creation of tidal channel networks is of recognized importance, there is little applicable information about appropriate channel density, and differences in density depending on landscape position, from which to calibrate project design and expectations for successful restoration. In the absence of a landscape perspective, there is significant risk of large investments of time and money toward restoration without substantial improvements in the development of self-sustaining ecosystems (Teal et al. 2009, Greiner 2010).

Stemming from conversations with scientists and restoration managers, we have identified needs for applying the historical data currently in development to restoration planning efforts (Fig. 2). The emerging landscape perspective can help provide a framework for selecting restoration actions and performance measures that recognize landscape context, differences among sub-regions of the Delta, and associated ecological functions. To develop these tools, we envision several steps:

1) Analysis of historical landscape complexity and connectivity using common landscape ecology metrics. Quantifying the historical habitat characteristics and detailing sub-regional variation will enable the setting of specific targets and performance measures for these higher level landscape characteristics.

2) Identification of ecological functions in the historical landscape and comparison to contemporary ones (e.g., Palmer 2008). This process would involve a team approach in which physical scientists work with biologists and landscape ecologists to determine which ecological functions of concern were provided where, how these functions compare to those provided today, and current general locations of promising restoration opportunity. This will give managers and landowners guidance about what kinds of projects make sense where, improving project outcomes and synergies among individual projects.

3) Calibration of current conceptual models and development of restoration design principles and guidelines. Restoration design criteria might include specific habitat mosaics for different landscapes and regions of the Delta. Landscape level criteria that should be evaluated include target habitat mosaic composition, patch size and shape, and connectivity within and between different habitat mosaics and landscapes. Consideration should also be given to the required scale of planned conservation areas to achieve sustainable ecosystem function (Simenstad et al. 2006).

4) Development of engaging visual representations of historical Delta landscapes and possible future scenarios, such as 3D graphics, animations, artwork, and web-based GIS. Such illustrations can be used not only as a tool to communicate goals to scientists and restoration managers, but to strengthen public understanding of the Delta ecosystem, how it has changed, and its future potential.

We look forward to conversations with members of the Delta Independent Science Board as we and others continue developing these ideas.
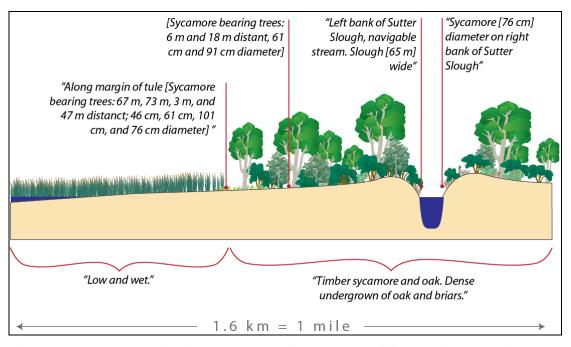
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Figure 1. A reconstructed mile of a General Land Office survey by William Lewis on November 27, 1859 shows the transition from tule to a riparian forest with sycamores along Sutter Slough.
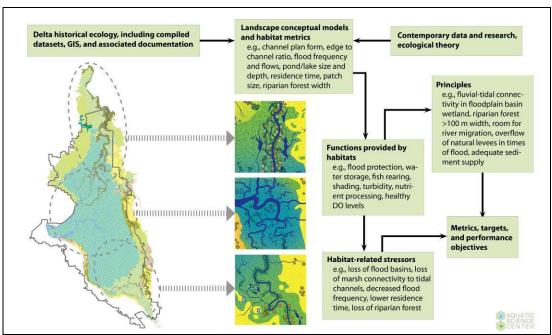
Figure 2. This conceptual diagram illustrates a key goal of Delta historical ecology research, which is to inform restoration planning by relating habitats, habitat mosaics, and landscapes to ecological function.

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