Developing Ecological Forecasting Capacity with HyspIRI

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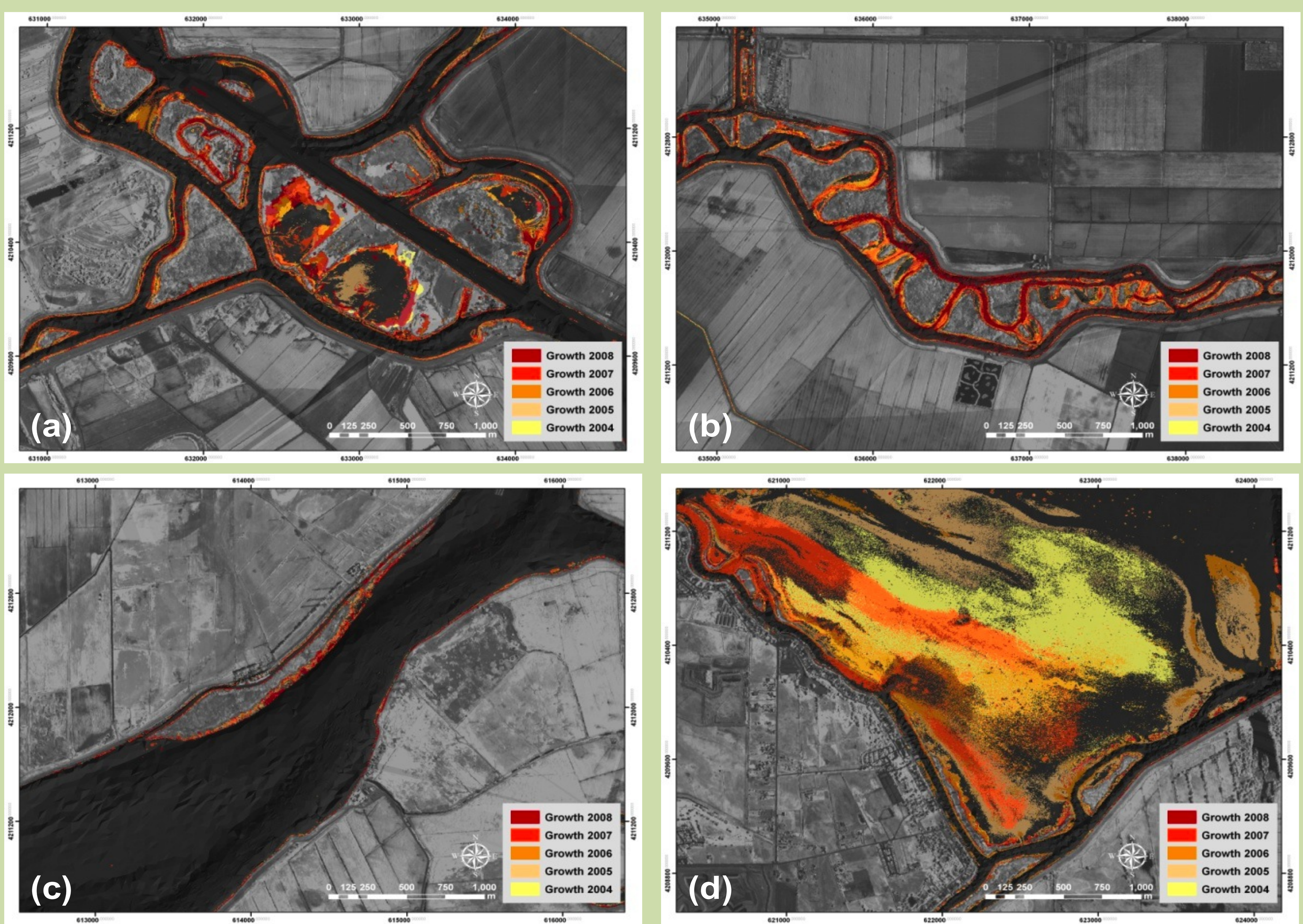
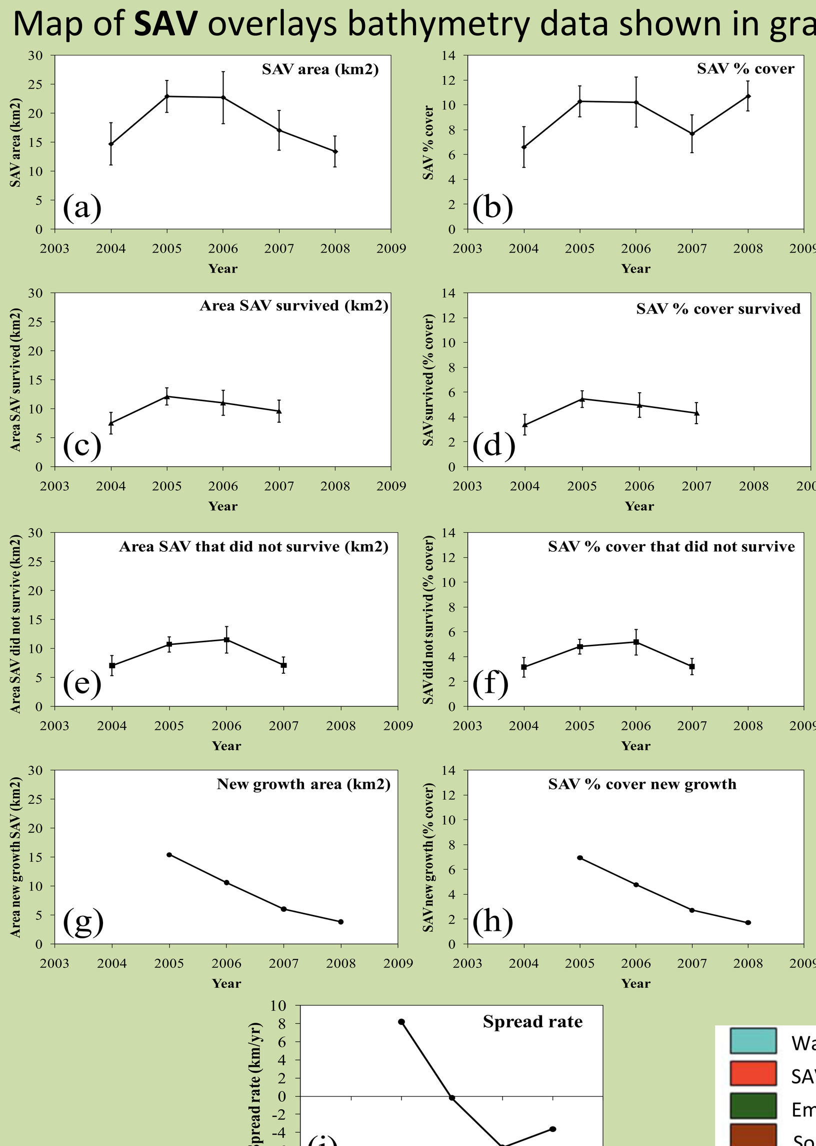
Ecological Forecasting: A NASA Earth science goal is to improve ecological forecasting tools that enable resource managers to promote sustainable development. Ecological forecasting is used to predict the consequences of climate and land use changes, based on knowledge of appropriate physiological and ecological processes required to exist in the physical environment. This goal requires modeling information about ecosystem responses to future conditions, which includes a requirement to monitor ecosystems over time at spatially explicit scales relevant to the processes, along with long term monitoring and prediction of weather/climate conditions and other information about environmental trends. **HyspIRI** will provide essential information for forecasting with high resolution imaging spectroscopy, multiband thermal imagery with 60 m pixels and the former with 19 day global repeat frequency at the equator and five day repeat frequency for the multiband TIR data. Together, these data provide essential information about the health and condition of ecosystems, including surface temperature, alongh with species and community based information that will allow detection of changes in composition.

This case study describes efforts to model changes in aquatic plant species composition in the 1800 km of waterways through the constructed earthen levee-maintained islands (~57) at the confluence of the Sacramento and San Joaquin Rivers. Ecological conditions of this, the largest estuary on the Pacific Coast of North and South America, are described as "an ecosystem in crisis" with the highest rate of introduced non-native species in the U.S.

Species invasion requires the ability to spread into new habitats and the persistence to survive in the new habitat

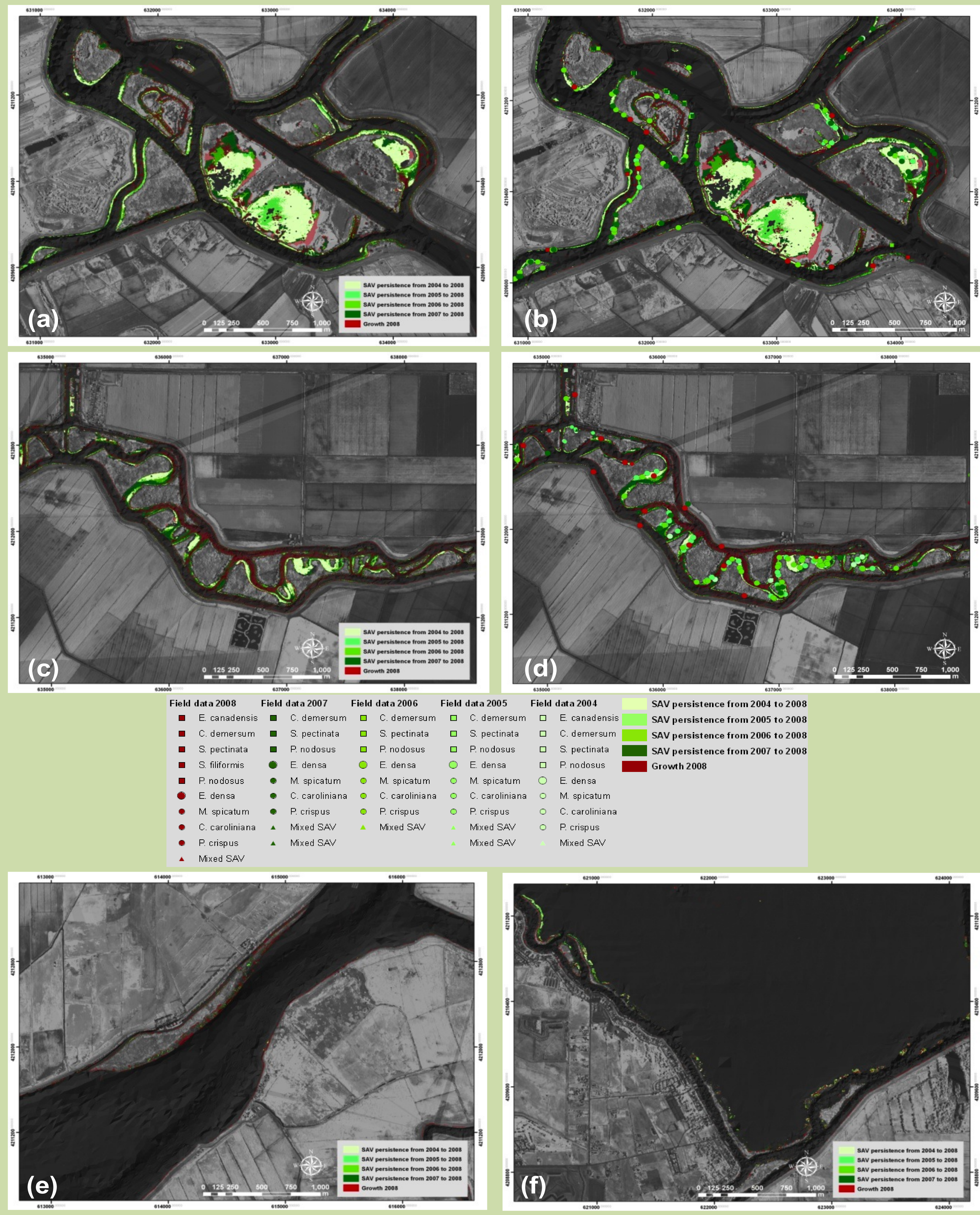


Variable yearly growth and spread over five years in the invasive submerged aquatic vegetation **(SAV)** community for different hydrologic habitats in the Sacramento-San Joaquin River Delta ecosystem: (a) inundated island, (b) narrow and shallow channel, (c) wide and deep water channel, and (d) Frank's Tract, an area receiving intensive management in 2007 and 2008. Map of **SAV** overlays bathymetry data shown in gray scale.



Changes in % cover, survival, mortality, and new growth each year, based on 5 years of georectified annual acquisition (June) of hyperspectral imagery from 2004-2008. Results show interannual changes in growth and expansion that relate to both weather patterns and land management. (Santos, Greenberg, Khanna, Hestir & Ustin, unpublished results)

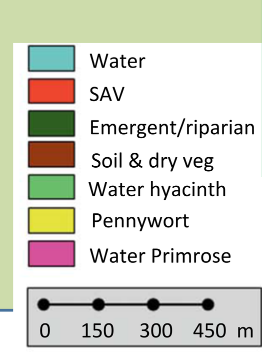
Maria J. Santos, Jonathan A. Greenberg, Shruti Khanna, Erin L. Hestir and Susan L. Ustin, unpublished results

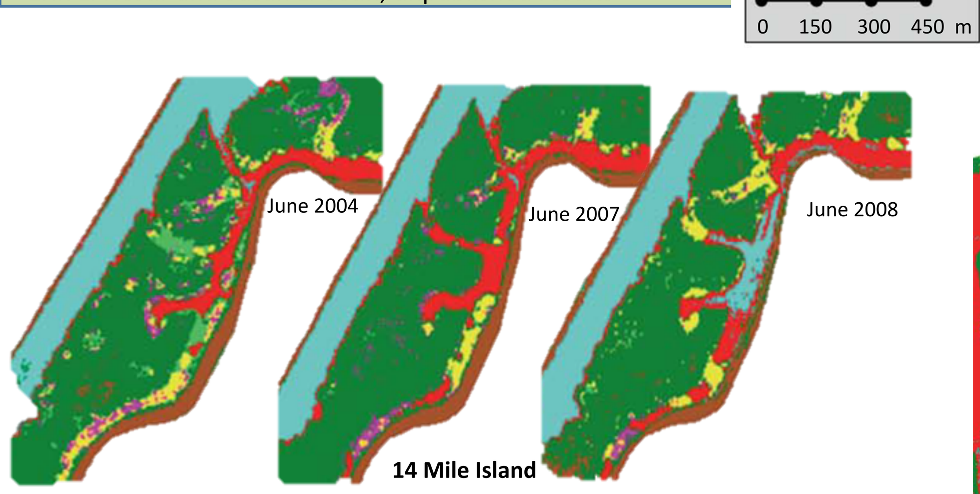


Persistence of the invasive submerged aquatic vegetation **(SAV)** community of the Sacramento-San Joaquin River Delta ecosystem: (a and b) inundated island and same area overlaid with field data, (c and d) narrow and shallow channels and same image overlaid with field data, (e) wide and deep water channel, and (f) intensively managed area in 2007 and 2008. Each color in classified image represents a year of SAV persistence: for 2004 to 2008 in light green, 2005 to 2008 in green, 2006 to 2008 in intermediate green, 2007 to 2008 in dark green and 2008 growth in dark red. Field data show native species with squares and non-natives with circles; colors match those of the distribution maps; Native species: *Elodea canadensis* (waterweed), *Ceratophyllum demersum* (coontail), *Stuckenia pectinata* (Sago pondweed), *S. filiformis* (fine leaf sago), *Potamogeton nodosus (*American pondweed), Invasives: *Egeria densa* (Brazilian waterweed), *Cabomba caroliniana* (Carolina fanwort), *Potamogeton crispus* (Curlyleaf pondweed), and *Myriophylum spicatum* (Eurasian watermilfoil).

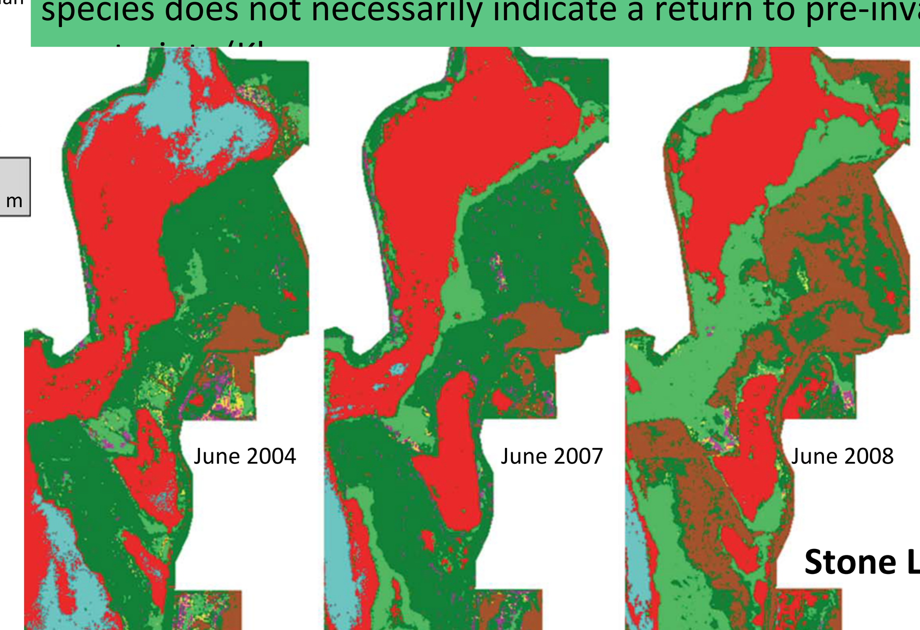
Successional pathways illustrate the predicted establishment, spread, and decline of water hyacinth in the S-S J River Delta. Changing interannual species composition. 14 Mile Island and Stone Lake Island support mixed communities of floating macrophytes. These islands have been intensively managed to remove invasives but nearly 3 weeks of freezing temperatures in winter 2006-2007 also contributed to the reduction. In 2004, **14 Mile Island** is dominated by the invasive Water hyacinth and Water primrose and the native Pennywort. By summer 2007 and 2008, the system had become less diverse, with Water hyacinth restricted to the main channels and Pennywort dominating the smaller and interior channels. (Khanna, Santos, Ustin & Haverkamp IJRS, 2011). The rapid spread of a native species does not necessarily indicate a return to pre-invasion conditions, possibly new conditions result in a release of population

Santos, Hestir & Ustin, Biol. Inv. (2012) 14: 717-733)





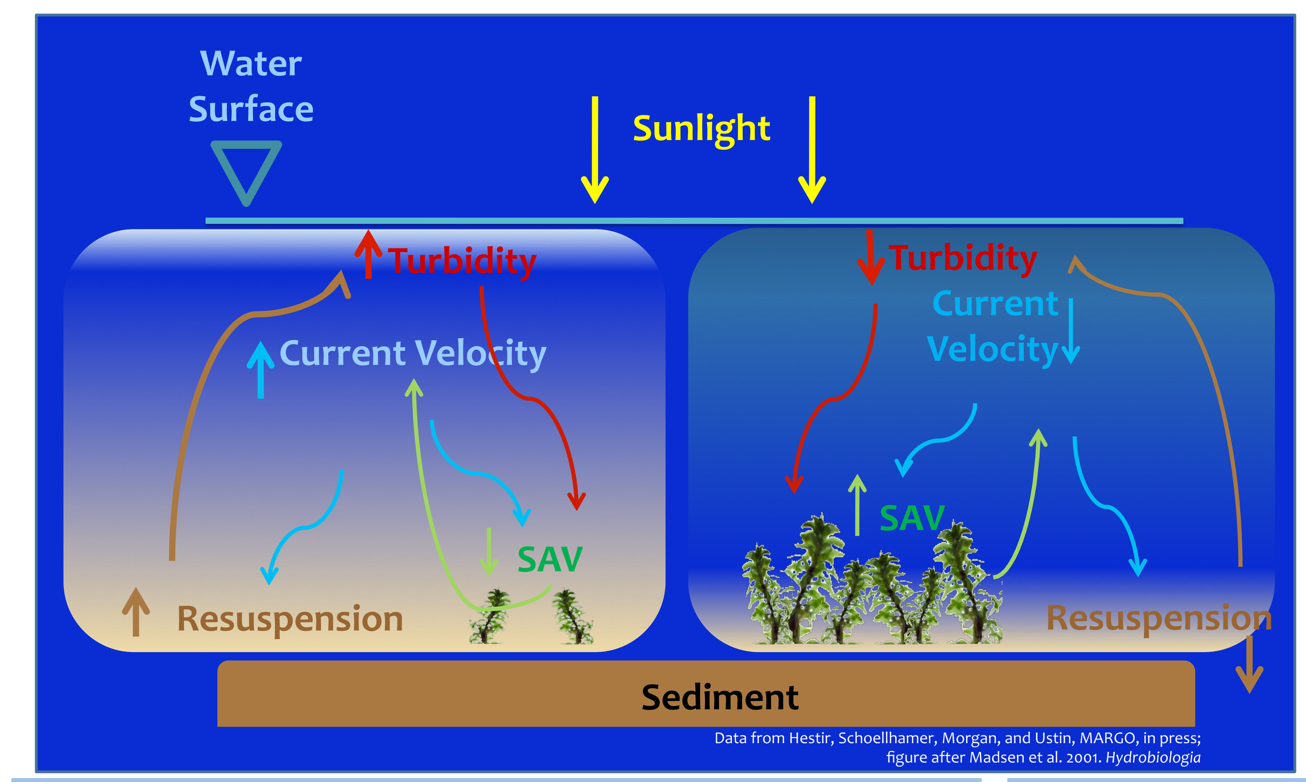
14 Mile Island



Stone Lake Island

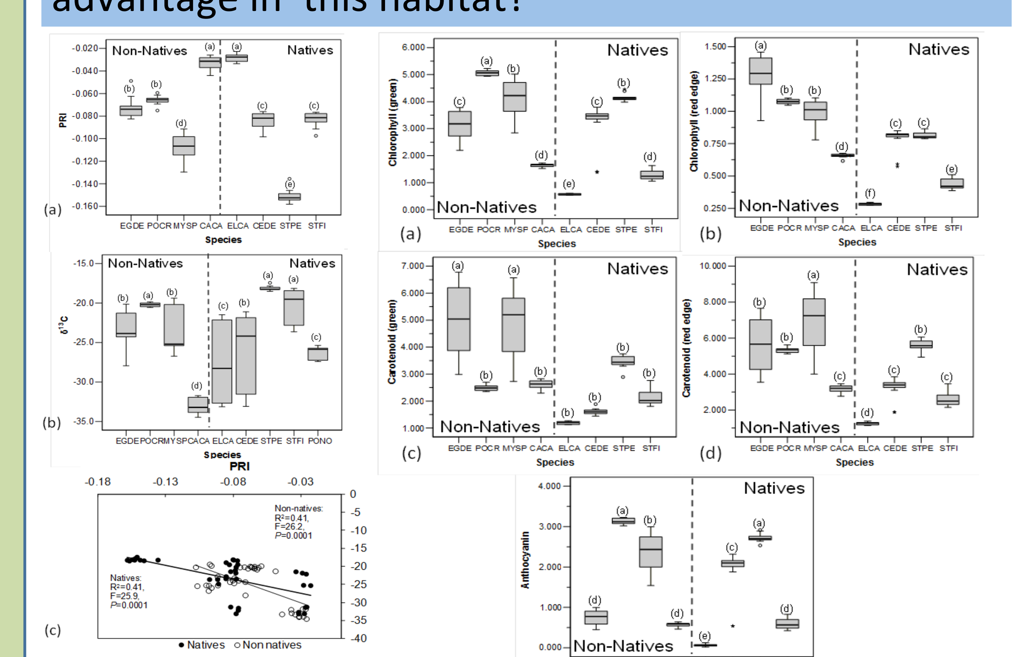
Stone Lake was actively managed to remove SAV, and a significant reduction in area of SAV in the shallow flooded regions is seen in 2008, with a large expansion of Water hyacinth further into the flooded areas and emergent marsh species (e.g., cattails and tules) in the wet margins. A build up of soil and plant debris now fills the higher elevations within the flooded island. (Khanna, Santos, Ustin & Haverkamp IJRS (2011) 32: 1067 — 1094).

What change(s) allowed this ecosystem to become vulnerable to invasion?



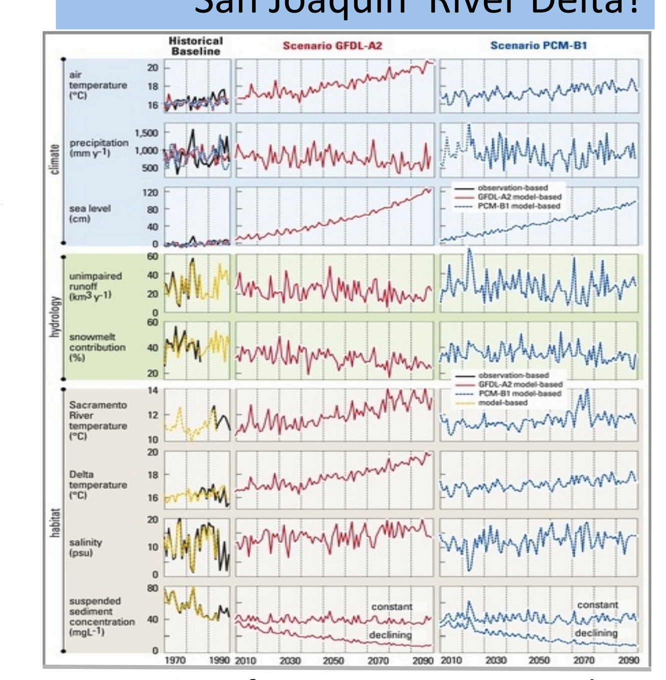
A Step change in turbidity following the 1983 El Niño floods established greater light penetration into the water, conditions more favorable to establishment of SAV (Hestir, Schoellhamer, Morgan, and Ustin, MARGO, in press).

What biological features provide selective advantage in this habitat?



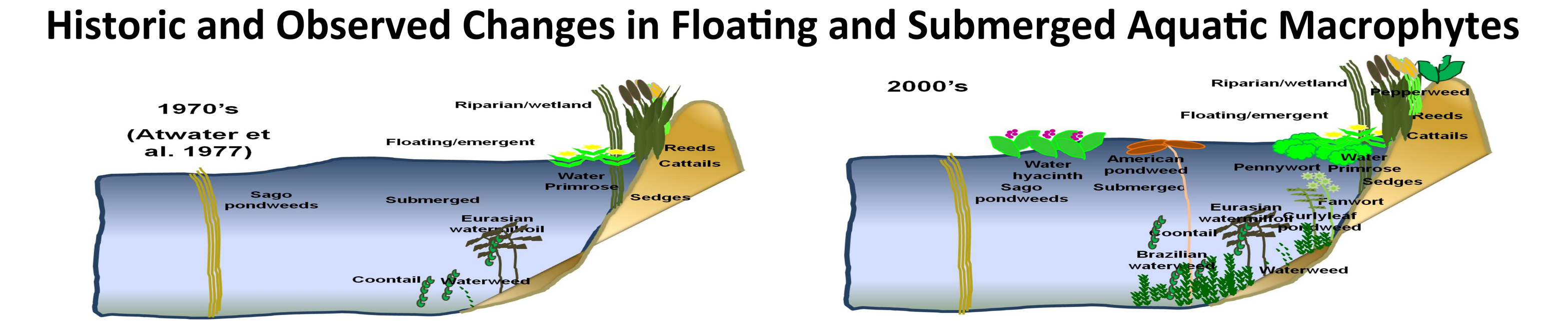
The invasive species have larger leaves, greater leaf area/ stem, higher concentrations of photosynthetic pigments per leaf area, and have C3 and facultative C4 photosynthetic capacity, indicating a greater growth potental compared to native aquatic macrophytes (Santos, Hestir, Khanna & Ustin, New Phytologist (2012) 193: 683–695).

What are the climate predictions for the Sacramento-San Joaquin River Delta?

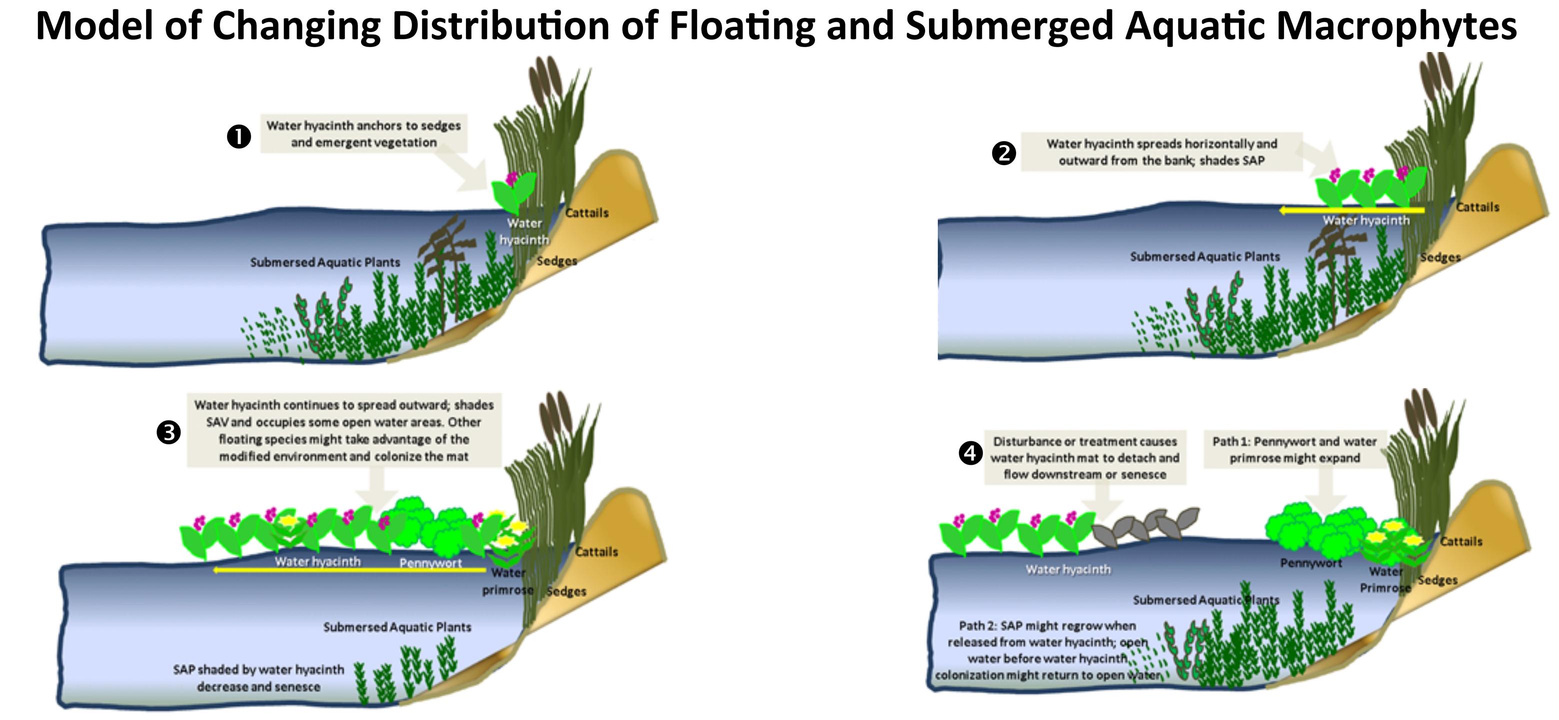


Significant increasing trends in temperature and salinity, combined with lower river flow rates will likely worsen ecological conditions in the delta. (Cloern, Knowles, Brown, Cayan, Dettinger, et al. (2011) Projected Evolution of California's San Francisco Bay-Delta-River System in a Century of Climate Change. PLoS ONE 6: e24465. doi:10.1371/

Historic and Observed Changes in Floating and Submerged Aquatic Macrophytes



Model of Changing Distribution of Floating and Submerged Aquatic Macrophytes



(Khanna, Santos, Hestir & Ustin, Biological Invasions (2012)14: 717-733).