Remote Sensing of Canopy Leaf Area Index and Decadal Changes in Wetland Greenness in the Delta and Suisun Marsh

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Canopy leaf area index (LAI; one-sided leaf area per unit ground area) is a key instrumental variable used in models of plant-atmosphere carbon, water and energy exchange, greenhouse gas budgets and canopy-based wildlife habitats. Though extensively studied in upland terrestrial landscapes, this parameter remains largely uncertain in wetland ecosystems globally, which limits the capacity to up-scale functional properties of wetland vegetation to regional landscapes. This study assessed LAI in several natural and restored wetlands of the Sacramento-San Joaquin Delta, California, USA (the Delta) in growing seasons of 2013-2014 and tested the possibility to model LAI spatially using indicators of vegetation greenness (such as normalized difference vegetation index (NDVI)) from Landsat satellite images at 30m spatial resolution. Results indicate that field-measured LAI significantly correlated with a number of Landsat-based greenness metrics and that the goodness-of-fit in these relationships was improved by >50% by corrections to account for the fraction of non-vegetated surface cover at the pixel level. The analysis of temporal trajectories in the satellite-derived greenness metrics over 2000-present further revealed that a number of areas experienced declines in the peak-summer greenness, some of which could be explained by accumulation of dead biomass in some of wetland canopies, establishment of non-native species with different phenology and other factors that need further investigation. Overall, results indicate that despite relatively coarse resolution, Landsat satellite imagery is promising for monitoring of wetland dynamics and modeling of key canopy properties such as LAI in the Delta due to spectral sensitivity to wetland surface properties, instantaneous coverage of the study landscape and high quality of image time series in this region. Exploring this capacity further could greatly facilitate future efforts on monitoring and modeling wetland ecosystem services and restoration site trajectories and provide complementary capacity to circumvent the constraints on extensive field sampling.

Keywords: monitoring, "leaf area index", "remote sensing", canopy, vegetation, habitat, greenness

Poster Topic: Habitat Restoration: Tools to Restore

Direct Seeding for Habitat Restoration Projects

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The San Francisco Public Utilities Commission (SFPUC) is undertaking several habitat mitigation projects as a result of infrastructure repair and replacement activities in San Mateo, Alameda and Santa Clara Counties. A goal of the mitigation projects under the Bioregional Habitat Restoration (BHR) program is to restore upland, wetland, and riparian habitats within the greater San Francisco Estuary Watershed. Historically, the SFPUC sourced propagules (seeds or cuttings) from within local watersheds, grew these plants in a nursery, and then planted container plants within their restoration sites. In 2014, the discovery of *phytophthora,* a soil born pathogen, in restoration plantings caused the SFPUC to evaluate routes of introduction and decide to propagate onsite from direct seeding for the remaining plant installations. Challenges of direct seeding have included 1.) Responsibly collecting propagules from a drought stressed watershed. 2.) Determining an appropriate number of seeds to install in each planting basin. 3.) Providing shelter and irrigation for delicate seedlings.

To keep track of the collection efforts across multiple sites, years, and contractors, a database was developed to track propagule collection and avoid over-collection of any given target plant population. This GIS database allows for a collector to view location, number and phenology of plants observed or collected, last year a collection took place, collection quantities, and how many propagules may be available to collect from the site. The database format is a useful tool for managers to track propagule collection efforts.

Seeds per planting basin were determined based on nursery germination rates and protocols, and personal experience. Seeds were planted in the winter of 2014/15 and monitored in spring/summer 2015 for germination success and seedling survival. Results differentiate species with high and low direct seeding success rates. These results will help managers make decisions about future reseeding efforts across multiple mitigation sites.

Keywords: Propagule collection, direct seeding, habitat restoration, SFPUC BHR sites, *Phytophthora*

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