CALFED Progress Report
California Sea Grant College Program

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Project Information

ProjectNo_2C R/SF-10 **StartDate_3a** 09/01/2005 **EndDate_3b** 12/31/2008
ProjectTitle_4 Determining the Factors Controlling Site Invasibility to (I)Lepidium latifolium(/I)

CALFed Fellow contact information

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Additional Research Mentors and Community Mentors

Additional Research Mentors_8

Additional Community Mentors_9

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Project Objectives: Please type your responses, and answer the questions in a style appropriate for laymen.

ProjectObjectives_10

Perennial pepperweed is a noxious, nonnative weed that infests the San Francisco Bay/Sacramento-San Joaquin River Delta system. Effective management of this weed will require a better understanding of its distribution and ecology. This project will use several years of airborne remote sensing data to create detailed, accurate maps of perennial pepperweed in the Bay/Delta. Inferences about the habitat requirements and spread characteristics of perennial pepperweed will be drawn from the resulting maps. This research will benefit managers by aiding the containment and control of existing infestations; and predicting which sites will be vulnerable to future invasion, identifying when spread is most likely to occur, and determining when management should be timed for optimal effectiveness.

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

(I)Lepidium(/I) was mapped with hyperspectral image data of the Rush Ranch Open Space Preserve in Suisun Marsh, the Greater Jepson Prairie Ecosystem on the northwest side of the Delta, and 5 image dates of Bouldin Island in the central Delta. These successes demonstrate that it is possible to detect (I)Lepidium(/I) with hyperspectral remote sensing data, at least at the local scale. Additional work to map this species at the Cosumnes River Preserve in the northeast Delta, however, has not been successful. Comparisons of the image data and of the classifier behavior at these three sites illustrate that mapping success depends not only on the traits of the species to be mapped, but also on the characteristics of the habitat it invades. Specifically, detectability and, thus, mapping success decline with increasing site complexity (i.e., species, structural, spectral, and landscape diversity). The maps generated for Rush Ranch and Jepson are being used by the Solano Land Trust to develop weed management plans at these sites.

Research used remotely sensed products to study the ecology of (I)Lepidium(/I). A habitat model was created to map susceptibility to future invasion at Rush Ranch, using presence/absence data extracted from the hyperspectral (I)Lepidium(/I) classification and predictors from a LiDAR (light detection and ranging) digital elevation model. Results show that (I)Lepidium(/I) may spread 20-fold to cover 25% of the preserve; it colonizes sites that minimize stress associated with brackish wetlands: occurring along the marshland-upland margin and on the natural levees along channels.

Hyperspectral data was used to map (I)Lepidium(/I) phenologies (i.e., vegetative, flowering, fruiting, senescent) at 2 sites. Phenology was highly variable, was successfully characterized by the hyperspectral data, and was related to remotely sensed environmental variables. At both sites, the more advanced phenology occurred in the interior of patches, suggesting an effect of intraspecific competition; and at lower convexities, shallower slopes, and higher elevations, suggesting a response to water availability, both flooding and water limitation. Temporal variation in phenology was monitored and related to hydrologic variables. (I)Lepidium(/I) phenology strongly tracked hydrology; wetter years delayed phenology.

(I)Lepidium(/I) spread was characterized from 5 image dates (2004-2008) of Bouldin Island. At sites with pre-existing infestations,

spread was linear and the area invaded doubled over 4 years. At a site that was colonized during the time series, there was logistic spread with a 30-fold increase in area. (I)Lepidium(/I) dispersed up to 215m a year, with averages of 5-53m. Greater than expected spread occurred in years with wet springs.

The dispersal observations from Bouldin Island are parameterizing a simulation model of (I)Lepidium(/I) spread. Preliminary results indicate that temporal variation in dispersal does not substantially reduce spread rates relative to the fastest constant dispersal scenario. Corridors increase spread rates when the initial distribution is localized and when it is allowed to disperse far/fast enough

PROJECT MODIFICATIONS: Please explain any substantial modifications in research plans, including new directions pursued. Describe major problems encountered, especially problems with experimental protocols and how they were resolved. Describe any ancillary research topics developed.

Modifications_12

No modifications since 10/2008 progress report.

BENEFITS AND APPLICATIONS: Suggest the relevance of these new findings to management. Describe any accomplishment, that is significant effects your project has had on resource management or user group behavior. CALFED is looking for "management cue" (see http://science.calwater.ca.gov/pdf/soemgmtcues.pdf).

BenefitsApplic_13

Management of invasive species can be improved with comprehensive maps of their distribution.
• (I)Lepidium latifolium(/I) is a problem weed invading California's Bay-Delta.
• Hyperspectral remote sensing offers the potential to map invasive weeds.
• (I)Lepidium(/I) has successfully been mapped with hyperspectral image data of several sites in the Bay-Delta (Rush Ranch Open Space Preserve, Jepson Prairie Preserve, Eastern Wilcox Ranch, Calhoun Cut Ecological Reserve, Barker Slough, Bouldin Island), and these infestation maps are being used by the Solano Land Trust to develop weed management plans at Rush Ranch, Eastern Wilcox Ranch, and Jepson Prairie Preserve.

Predictive distribution modeling identifies sites vulnerable to future invasion that should be prioritized for monitoring and control.
• At Rush Ranch, sites on the marshland-upland margin and the natural levees along channels are susceptible to invasion by (I) Lepidium(/I).
• (I)Lepidium(/I) only occupies 5% of its potential distribution at Rush Ranch.
• Hyperspectral and LiDAR remote sensing are valuable tools that may provide datasets for distribution modeling.

Continued...

PUBLICATIONS: List any publications, presentations, or posters that have resulted from this funded research. Give as many details as possible, including status of paper (e.g., in review; in press), journal name, conference location and date of presentation. Please note (as outlined in the conditions of the award) that each fellow is required to submit an abstract for an oral or poster presentation at each State of the Estuary conference and CALFED Science Conference during the duration of the fellowship.

Publications_14

PUBLICATIONS

Andrew, M.E. and S.L. Ustin (submitted). The effect of temporally variable dispersal and landscape structure on invasive species spread. Ecological Applications.

Andrew, M.E. and S.L. Ustin (submitted). Spatiotemporal variation in phenology of Lepidium latifolium: Effects of microtopography and hydrology. Ecography.

Andrew, M. E. and S. L. Ustin (accepted). Habitat suitability modelling of an invasive plant with advanced remote sensing data. Diversity and Distributions.

Andrew, M.E. and S.L. Ustin (2008). The role of environmental context in mapping Lepidium latifolium with hyperspectral image data. Remote Sensing of Environment. 112:4301-4317.

Hestir, E. L., S. Khanna, M. E. Andrew, M. J. Santos, J. H. Viers, J. A. Greenberg, S. S. Rajapakse, and S. L. Ustin (2008). Identification of invasive vegetation using hyperspectral remote sensing in the California Delta ecosystem. Remote Sensing of Environment. 112:4034-4047.

Andrew, M.E. and S.L. Ustin (2006). Spectral and physiological uniqueness of perennial pepperweed (Lepidium latifolium). Weed Science. 54:1051-1062.

PRESENTATIONS AND POSTERS

Andrew, M.E. and S.L. Ustin (in prep). Temporal variation in spread of the invasive Lepidium latifolium: Observations and a spatial simulation model. 22nd Annual Symposium of the United States Regional Association of the International Association for Landscape Ecology, USA. April 12-16, 2009. Snowbird, Utah, USA.

Andrew, M.E. and S.L. Ustin (2008). Ecological remote sensing of invasion by Lepidium latifolium. Contributed talk at 5th Biennial CALFED Science Conference. October 22-24, 2008. Sacramento, CA, USA.

Andrew, M.E. and S.L. Ustin (2008). Ecological remote sensing of invasion by perennial pepperweed. Contributed talk at 17th Annual California Invasive Plant Council Symposium. October 2-4, 2008. Chico, CA, USA.

Andrew, M.E. and S.L. Ustin (2008). Spatiotemporal characteristics of Lepidium latifolium invasion of the San Francisco Bay/Sacramento-San Joaquin Delta. Invited talk at Bay Area Lepidium Science and Management Symposium, September 10, 2008. Suisun City, CA.

Andrew, M.E. and S.L. Ustin (2008). Using hyperspectral and LIDAR remote sensing to study the distribution and phenologic stages of Lepidium latifolium. Contributed talk at 93rd Annual Meeting of the Ecological Society of America, August 3-8, 2008. Milwauke, WI.

Andrew, M.E. and S.L. Ustin (2007). The role of environmental context in mapping Lepidium latifolium with hyperspectral image data. Poster presented at 8th Biennial State of the San Francisco Estuary Conference. October 16-18, 2005. Oakland, CA, USA.

Andrew, M.E. and S.L. Ustin (2007). The role of environmental context in mapping Lepidium latifolium with hyperspectral image data. Contributed talk at 92nd Annual Meeting of the Ecological Society of America, August 5-10, 2007. San Jose, CA.

Andrew, M.E. and S.L. Ustin (2007). Hyperspectral detection of Lepidium latifolium at canopy, local, and regional scales. Contributed talk at AVIRIS Science Workshop, Jet Propulsion Laboratory. May 30-June 1, 2007. Pasadena, CA.

Andrew, M.E. and S.L. Ustin (2006). Mapping perennial pepperweed with hyperspectral imagery of the Sacramento-San Joaquin Delta. Poster presented at 4th Biennial CALFED Bay-Delta Program Science Conference. October 23-25, 2006. Sacramento, CA, USA.

COOPERATING ORGANIZATIONS: List those agencies and/or persons who provided financial, technical or other assistance to your project since inception. Describe the nature of their collaboration.

CoopOrganiz_15

California Department of Boating and Waterways – a grant from CDBW provides imagery of the Delta.
California Department of Food and Agriculture – provides boats and crews for fieldwork in the Delta, also the agency of my community mentors, Robert Leavitt and Steve Schoenig (now of DFG).
Solano Land Trust – collaborating to map Lepidium and other invasive weeds on SLT lands in the Bay Delta.
Cosumnes River Preserve and Information Center for the Environment – Collaborating with Dr. Joshua Viers to map Lepidium at the CRP. CRP has provided GIS data of Lepidium inventories on the preserve.
Delta Wetlands – provided access to Bouldin Island.

AWARDS: List any special awards or honors that you, or mentor or members of the research team, have received during the duration of this project.

Awards_16

KEYWORDS: List keywords that will be useful in indexing your project.

Keywords_17

hyperspectral; invasibility; invasion rate; landscape structure; Lepidium latifolium; light detection and ranging (LiDAR); perennial pepperweed; phenology; remote sensing; simulation model; species distribution modeling.

PATENTS: List any patents associated with your project.

Patents_18

Additions: Additional information can be added here. Please begin the text with the number of the question you are adding to.

Additions_19

Benefits and Applications, Continued.

Observing and modeling invasive species spread can prioritize when and where management should occur.

• Hyperspectral remote sensing is a very efficient tool for characterizing invasive species spread over broad scales.

• (I)Lepidium(/I) spreads extremely rapidly to dominate a site. Eradication should be focused on incipient invasions, especially those that are colonizing large areas of suitable habitat or corridors that connect invasible sites.

• Spread rates can be slowed effectively if control is performed in years that facilitate spread. For (I)Lepidium(/I), spread should be prevented especially in years with greater than average springtime precipitation.

Effective management must be scheduled with a consideration of species' phenologies.

• Different phenologies have different detectabilities and responses to control, determining mangement success.

• (I)Lepidium(/I) has considerable spatial and temporal variation in phenology, which is driven by water availability. Monitoring and management need to be performed earlier in drier and more stressful sites and years.

• (I)Lepidium(/I)'s phenological plasticity may contribute to its success as an invader.