CALFED Progress Report
California Sea Grant College Program

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ProjectNo_2C: R/SF-25

TypeQuestionnaire_2B: Interim Questionnaire

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Project Information

ProjectNo_2C: R/SF-25 StartDate_3a: 7/1/09 EndDate_3b: 3/31/10
ProjectTitle_4: Modeling Physical Drivers and Age Structure of Cottonwood Forest Habitat: An Integrated Systems Approach

CALFed Fellow contact information

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Additional Research Mentors and Community Mentors

Additional Research Mentors_8

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

ProjectObjectives_10

The ultimate goal of this project is to improve the long-term prospects for restoring and protecting one of the signature species of the Central Valley's riparian ecosystem—the Fremont cottonwood. Toward this end, we will use an integrated systems approach, combining a model of the physical processes driving river channel migration and cottonwood habitat creation with a model of cottonwood population dynamics. Our models will focus on a 100-mile stretch of the Sacramento River from Red Bluff to Colusa. The Nature Conservancy, resource agencies and other stakeholders view this area as a prime site for conservation and restoration because the river still migrates naturally and is not confined by levees. Our models will be used to generate predictions of how cottonwood forests will fare in the future under various physical states, including different climate scenarios, flow regimes and floodplain sedimentation

Summary of progress in meeting each of these goals and objectives

ProgressSummary_11

In the second year of our project we developed an analytical approach to assess the effects of parameter uncertainty on our ability to predict Fremont cottonwood population dynamics using a mechanism-based model. This approach combined a global sensitivity analysis with Random Forest, a classification and regression technique, to rank parameter influence on model output and to quantify interactions among parameters. This analysis improved our understanding of the complex interactions among biotic and abiotic drivers in the Bay-Delta ecosystem. We were also able to rank model parameters according their effects on model predictions. These rankings were not only useful in understanding the system, but also provided a way of quantifying and ranking research priorities to ensure that future research efforts maximize the use of limited resources. We found that the three parameters with the greatest effect on model estimates of cottonwood patch occupancy were physical factors including the height of the capillary fringe, the rate of floodplain accretion, and the stage-discharge relationship. We also found that the interactions among certain parameter estimates lead to zero patch occupancy for many model runs. For example, seedlings were prevented from surviving to maturity in model runs with a capillary fringe of 30 cm or less, a slow seedling root growth rate of 2 mm/day and a low seedling tolerance to inundation of 30 days or less. Our analyses revealed non-intuitive patterns that underscore the importance of understanding the interactions among factors driving this complex system.

During this year we have also worked to disseminate our results and interact with colleagues who are continuing to gather data in the field. These efforts have included: 1) submission of a manuscript on the sensitivity analysis to Ecological Applications (submitted March 2010); 2) presentations at the Annual Meeting of the Ecological Society of America (Aug 2009), the American Geophysical Union Meeting (Dec 2009), and multiple invited seminars; 3) collaborations with colleagues at the University of California, Berkeley who are working on cottonwood populations on abandoned channels; 4) ongoing discussions with colleagues at the Nature Conservancy and the California Department of Water Resources to ensure that our models provide useful data for resource management and also inform future versions of the Sacramento River Ecological Flows Tool.

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

The six month work stoppage from December 2008 to June 2009 and the month-by-month planning constraints from July - February 2009 disrupted our project and required that we draw on funds intended for other purposes including faculty startup funds and funds awarded to the University of Idaho through the Experimental Program to Stimulate Competitive Research (EPSCoR). Due to funding uncertainty, we have modified our research plan to consist of discrete pieces of the project that can be completed on the timescale for which funds are currently available. The ultimate goal of our model is to predict the effects of altered river flow regimes, climate change, and restoration options on cottonwood populations on the Sacramento River. However, we cannot make reliable predictions until we have gone through the full process of model development, sensitivity analysis, research prioritization, model improvement and validation. We have completed the first three steps of this process and are currently working on model improvement and validation which we are scheduled to complete within the June 30 timeframe. Our ability to complete the project and make predictions about specific climate change and resource management scenarios will depend on funding beyond June 30.

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

The sensitivity analysis of our mechanism-based model of Fremont cottonwood population dynamics is informative to CALFED's efforts to restore the Bay-Delta ecosystem. Fremont cottonwood provide food, nesting habitat and cover for many species, including the golden eagle, Swainson's hawk and ladder-backed woodpeckers among others. In the Bay-Delta ecosystem Fremont cottonwood populations have declined due to floodplain conversion and widespread flow regulation, which influence the physical and biotic drivers of demography. Restoration of Fremont cottonwood populations will require an understanding of the interactions among the biotic and abiotic drivers in this complex ecosystem. The sensitivity analysis of our mechanism-based model identified physical factors including capillary fringe, stage discharge relationship and floodplain accretion rate as crucial in determining Fremont cottonwood recruitment and survival. We found that our ability to make large-scale predictions would be greatly improved by additional data on the spatial and temporal

variation in these physical factors. We also found that existing data on seed release timing and root growth rates are sufficient and the uncertainty around the estimates of these parameters have little effect on model precision. Future work will assess the effects of climate change and alternative resource management strategies on Fremont cottonwood populations in the Bay-Delta ecosystem.

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

PHuabrlipceart,i oEn.Bs_.,1 J4.C. Stella, A.K. Fremier. (in review, Ecological Applications). Sensitivity analysis for complex models: a case
study of cottonwood populations in a dynamic riparian ecosystem
Stella, J.C., J.J. Battles, J.R. McBride, B.K. Orr. 2010. Restoration Ecology Riparian seedling response to experimental seasonal drought and applications to river restoration in a semi-arid ecosystem.
Stella, J.C., and J.J. Battles. (in press, Oecologia) How do riparian woody seedlings survive seasonal drought?
Stella, J.C., E.B. Harper, A.K. Fremier. 2009. Quantifying geomorphic process controls on riparian forest dynamics using a linked physical-biological model: implications for river corridor conservation. Oral presented at American Geophysical Union Fall Meeting, San Francisco, CA, December 15-19, 2009.
Harper, E.B., J.C. Stella, A.K. Fremier. 2009. Identifying data gaps and prioritizing restoration strategies for Fremont cottonwood using linked geomorphic and population models. Poster presented at American Geophysical Union Fall Meeting, San Francisco, CA, December 15-19, 2009.
Harper, E.B., J.C. Stella, A.K. Fremier. 2009. Ecologically meaningful sensitivity analyses: A case study of Fremont cottonwood (Populus fremontii). Poster presentation at the Idaho EPSCoR Annual Meeting, Moscow, ID. August 31, 2009.
Stella, J.C., E.B. Harper, A.K. Fremier, M.K. Hayden, J.J. Battles. 2009. Using a patch dynamics approach to model cottonwood forest populations in river floodplains Oral presentation at the Annual Meeting of the Ecological Society of America, Albuquerque, NM. August 2-7, 2009.
Harper, E.B., J.C. Stella, A.K. Fremier. 2009. Ecologically meaningful sensitivity analyses: A case study of Fremont cottonwood (Populus fremontii). Oral presentation at the Annual Meeting of the Ecological Society of America, Albuquerque, NM. August 2-7, 2009.
Hayden, M.K., J.C. Stella, J.J. Battles, S. Dufour, and H. Piégay. 2009. Drivers of pioneer riparian forest dynamics in abandoned channels: an alternate recruitment pathway? Oral presentation at the Annual Meeting of the Ecological Society of America, Albuquerque, NM. August 2-7, 2009.
Harper, E.B. 2009. Predicting the future of cottonwood stands in California's Central Valley. Invited speaker, Paul Smith's College, Division of Forestry and Natural Resources Seminar Series. Paul Smiths, NY. September 4, 2009.
Stella, J.C. 2009. A river runs through it: modeling and restoring riparian forests on dynamic floodplains. Invited speaker, Bowdoin College Biology Seminar Series. Brunswick, ME. September 24, 2009.
Stella, J.C. 2009. Abiotic Controls on Riparian Forest Development at Leaf to Landscape Scales. Invited speaker, Syracuse University Biology Seminar Series. Syracuse, NY. February 6, 2009.

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

Department of Environmental Science, Policy and Management. University of California, Berkeley. Laboratory space, library and administrative resources.
The Nature Conservancy, Chico, California. Scientific expertise and local knowledge of the middle Sacramento River, existing data, field logistical support, access to TNC properties, field lodging.
Dr. Hervé Piégay, National Center for Scientific Research (CNRS), Lyon, France. Collaborator working in abandoned channels of the middle Sacramento River.

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

Not applicable.

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

Keywords_17

Riparian vegetation, Fremont cottonwood, population model, river floodplain, ecogeomorphology, sensitivity analysis

PATENTS: List any patents associated with your project.

Patents_18

Not applicable.

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

Additions_19

COOPERATING ORGANIZATIONS continued…

Dr. Simon Dufour, Aix Marseille University, CEREGE CNRS, Aix en Provence, France. Collaborator working in abandoned channels of the middle Sacramento River and Ain River (France).

Dr. Matt Kondolf, Department of Landscape Architecture and Environmental Planning, University of California, Berkeley. Collaborator working in abandoned channels of the middle Sacramento River.

California Department of Water Resources, Red Bluff, CA. Existing data for middle Sacramento River, scientific expertise and local knowledge of the middle Sacramento River, access to CDWR properties, logistics support.

Dr. Alex Fremier, University of Idaho, Moscow, Idaho. Collaborator working in the middle Sacramento River and Ain River (France), GIS and spatial-data analysis.