Sea Grant California

CALFED SCIENCE FELLOWS PROGRAM

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A Mechanistic Model to Evaluate and Improve Riparian Restoration Success

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Background

In California's Central Valley, freshwater diversions and land development have greatly reduced the extent and sustainability of native cottonwood and willow riparian forests, which provide critical habitats for many species of wildlife and offer other environmental benefits such as slowing erosion, maintaining soil quality and filtering pollutants.

The cumulative result of human activity in the region over the last century and a half has been the loss of about 90 percent of all riparian forests. Efforts are underway to protect and restore remaining forested areas, which are often fragmented and vulnerable to replacement by less ecologically beneficial vegetation.

(Above) Mature Fremont cottonwood tree with field researcher in foreground. (Right) Fremont cottonwood seedling. Photos this story: John Stella

Project

In 2002, John Stella, then a doctoral student in environmental science at UC Berkeley, won a CALFED Science Fellowship to study processes controlling seedling recruitment in the lower San Joaquin Basin of the Central Valley.

The results of this study have led to the development of an ecological model that simulates patterns of seedling recruitment. The model can be used to predict effects of alternative restoration strategies, making it possible to optimize restoration activities in terms of cost and ecological benefit.

The scientific focus of the project was to identify and quantify the most basic environmental factors necessary for sustaining near-channel riparian seedling recruitment for three dominant tree species: Fremont cottonwood, Goodding's black willow and narrow-leaved willow. Following a conceptual model of successful recruitment conditions developed in similar river ecosystems, Stella and his collaborators designed and conducted field studies on the Tuolumne and San Joaquin rivers in conjunction with laboratory experiments at UC Berkeley facilities.

Data from these studies were used to quantify the conceptual model, and recruitment predictions from the quantitative model were tested against independently observed field data. Though the recruitment model is still preliminary, there was good agreement between simulations and real observations.

Findings

The three primary factors found to limit recruitment success were:

1) An area's hydrology (i.e., seedbed soil moisture and bank elevation)

2) The timing and distribution of seed release, and

3) Seedling tolerance to water stress, caused by seasonally declining water tables.

The hydrology of a site was shown to "set the stage" for recruitment success. More specifically, seedling survival was positively correlated with soil moisture during the growing season and negatively correlated with bank elevation. Recruitment was most likely to be successful if seed release occurred when river flows were high, which maintained high soil moisture on sandbars and cleared other vegetation.

Air temperature was shown to influence the annual timing of seed release. Stella and colleagues adopted a "degree-day" model common in crop science to predict the

annual timing of peak seed release, and thus the best dates to release river flows for maximum seedling recruitment in the river corridor.

Another critical determinant of seedling survival was the rate of water table decline following peak river flows. Experiments showed that almost no seedlings are capable of surviving water table declines in excess of 6 centimeters per day.

Applications

The model that was developed allows resource managers and scientists to predict when and where seedling recruitment will be successful given certain assumptions about flow releases.

With this predictive ability, it is possible to:

1) Modify the timing and magnitude of river releases to boost survivorship of seedlings, and

2) Identify floodplain areas where seedlings are most likely to thrive given these releases.

Ultimately, it is hoped this type of predictive capacity will be used to make river flow releases more effective at promoting seed recruitment at a lower water cost, and that this ecosystem-based approach to restoration can complement ongoing species plans, such as for salmon.

In future work, Stella, now a postdoctoral researcher at UC Berkeley, will refine the recruitment model by conducting sensitivity analyses. He hopes to secure funding for collecting additional field data to further validate model output.

Tuolumne River riparian zone.

Mentors

Research: John Battles and Joe R. McBride, Department of Environmental Science, Policy and Management, UC Berkeley

Community: Duncan Patten, Big Sky Institute for Science and Natural History, Montana State University

Collaborations

The research summarized here was initiated in 2001 under a grant to Stillwater Sciences from the CALFED Bay-Delta Ecosystem Restoration Program and administered by the U.S. Fish and Wildlife Service.

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Dissertation

Stella, J.C. 2005. A Field-Calibrated Model of Pioneer Riparian Tree Recruitment for the San Joaquin Basin, CA. Department of Environmental Science, Policy and Management, University of California, Berkeley.

Publications and Presentations

Stillwater Sciences. 2006. Restoring recruitment processes for riparian cottonwoods and willows: A field-calibrated predictive model for the lower San Joaquin Basin. Prepared for CALFED Bay-Delta Ecosystem Restoration Program, Sacramento, California by Stillwater Sciences, John Stella, John Battles and Joe McBride, Department of Environmental Science, Policy and Management, University of California, Berkeley.

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The CALFED Bay-Delta Authority is a collaborative effort of more than 20 state and federal agencies with management or regulatory responsibilities for the San Francisco Bay-Delta system. The CALFED Science Fellows Program has been established to bring world-class science to all program elements to help achieve overall CALFED goals. California Sea Grant administers CALFED research projects towards those ends.

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