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The Influence of Aquatic vs. Terrestrial Production on Soil Invertebrate Communities in a Floodplain Ecosystem

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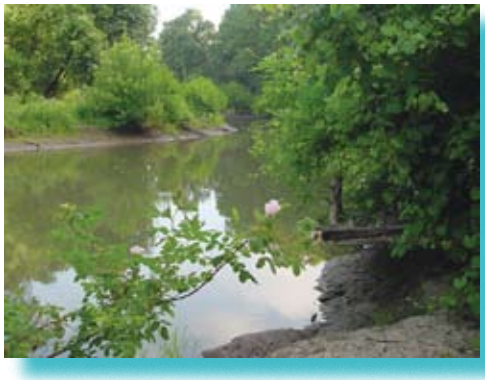

Riparian scene in the Cosumnes River Preserve. Photo: © Ingrid Hogle

Background

California's Central Valley has historically been the site of some of the largest expanses of riparian oak forests in all of North America.

Many of these forests have since been cleared to exploit fertile floodplain soils for farming. Dams, water diversions, levees and other flood-control structures have further starved the landscape of river meanders, flooding and silt deposition, contributing to yet more habitat degradation. The cumulative result of human activity is that more than 95 percent of these historic riparian forests have been destroyed, and the only undammed river on the western slope of the Sierra Mountains is the Cosumnes.

To protect this river and its surrounding habitats, The Nature Conservancy purchased old farm fields along the river and then breached a nearby levee to allow for a return of natural flooding and silt deposition. The Cosumnes River Preserve has since become a living laboratory for studying river and floodplain dynamics.

The project described here focuses on one important aspect of floodplain dynamics—that of maintaining and replenishing soils. This process has been relatively well documented for riparian forests, where flooding accelerates the decomposition of leaf litter and woody debris. This debris forms mulch that protects underlying soil from dehydration and sunlight. Bacteria decomposing the mulch help supply nutrients to plants. Sands and silts carried in floodwaters are a source of nitrogen and phosphorous.

Project

Sandra Clinton was awarded a CALFED Science Fellowship in 2003 to describe the processes that maintain soils in floodplain meadows and to answer questions such as, how are meadow soils replenished in the absence of leaf litter?

Riparian meadows are a natural part of the native river landscape. However, much of the meadowlands along the Cosumnes River are areas that were cleared for farming and thus no longer a source of leaf litter. One question for the preserve and others interested in restoring riparian habitats, is whether a hands-off approach to managing floodplain meadows—that is to let flooding do the work of restoration—is effective in terms of ensuring soil quality.

Clinton's research focused on the role of freshwater algae. Large mats of algae often grow in stagnant shallow pools of floodwater as the waters recede.

Clinton's working hypothesis, which her research substantiated, is that algae effectively are the "leaf litter" of floodplain meadows. Mats of algae act as mulch and, as with leaf litter, are degraded by bacteria whose byproducts supply nutrients to plants.

The experiment Clinton conducted to examine the algae hypothesis began with surveying fifteen 100-square-meter plots on the Cosumnes River Preserve floodplain before, during and after winter flood-

(Above) Flooded cottonwood grove in the Cosumnes River region. Photo: Sandra Clinton. (Left) Aerial view of the Cosumnes floodplain. Photo courtesy Center for Watershed Sciences, UC Davis (http://watershed.ucdavis.edu)

ing in 2003–04. The plots represented five sites with high rates of algal deposition, five sites with low rates of algal deposition, and five sites within riparian cottonwood forest. The initial sampling took place after the first heavy rains in November 2003, the second occurred between two winter floods in March 2004, the last when the ground was dry in June 2004.

At each plot and during each survey period, Clinton collected soil samples, counted soil invertebrates and documented the duration of flooding. In ongoing research, she is analyzing leaf litter and algae samples to estimate the amount of carbon deposited on the different habitat sites. (The amount of organic carbon is an estimate of the amount of energy available for plants and hence animals.)

Findings

All meadow plots:

- were wet from 14 to 21 days during the study period.
- were high in cations (calcium, magnesium, potassium and sodium), an indication of good soil quality.
- had relatively low amounts of sand, another indicator of good soil quality for this particular habitat. On average, sand comprised less than 20 percent of total soil material.

In contrast, cottonwood forest plots were wet 3 to 5 days; their soils were lower in cations, and sand comprised more than 75 percent of the total soil material. Cottonwood trees need sandy soil to grow, and they need only moderate flooding for seed germination.

Thirty-seven taxa of invertebrates were collected at the plots, the most common being worms, beetles, centipedes, spiders, mites and springtails. Meadow plots with high rates of algae deposition had as many invertebrates (especially worms) as forested areas, while meadow plots with smaller amounts of algae had fewer invertebrates. High invertebrate abundance (particularly worms) is considered an indication of good soil quality.

"Algae are an important source of organic matter," said Clinton, who at the time she received her CALFED Fellowship was a postdoctoral researcher in the department of integrative biology at UC Berkeley. She is now a researcher in the biology department at the University of North Carolina, Charlotte. "Algae do enrich soils as much as natural leaf litter in forests. We see this in cation levels and in the invertebrate communities."

Moreover, the duration of flooding appears to increase the amount of algae that is ultimately deposited, she said. This suggests that the pace at which meadow restoration occurs can be accelerated by ensuring areas are flooded for longer periods of time.

Implications

This research suggests that returning flooding to floodplain meadows will unto itself go a long way toward facilitating meadow restoration as it pertains to soil quality.

Mentors

Research: Mary E. Power, UC Berkeley
Community: Ramona Swenson, The Nature Conservancy

Collaborators

Cosumnes Research Group (http://baydelta.ucdavis.edu/)

Sandra Clinton. Photo: Tim Herrlinger

Presentations

Clinton, S.M. and M.E. Power. The influence of aquatic versus terrestrial production on soil invertebrate communities in a floodplain ecosystem. California Bay-Delta Science Conference, October 23–25, 2006, Sacramento, CA.

Clinton, S.M., G. Benigno, and M.E. Power. Soil invertebrate communities in meadow and forest habitats on the Cosumnes River floodplain. California Bay-Delta Science Conference, October 4–6, 2004, Sacramento, CA.

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CALFED BAY-DELTA PROGRAM

The CALFED Bay-Delta Program 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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