Soil Nutrient Dynamics and Biodiversity of Wetland Margins in an Agricultural Landscape

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Objectives

1. Construct a GIS database relevant to restoration of plant communities and soil nutrient retention along wetland margins in western Yolo County, using biophysical and socioeconomic data.
2. Collect field data on soil nutrients and biota, soil stratigraphy and vegetation from similar sets of sites queried from the GIS database, and aggregate GIS data on related landscape attributes.
3. Conduct statistical analysis of field data to detect factors contributing to differences among sites, and to predict field variables from the variables in the GIS database.
4. Initiate modeling approaches that will eventually allow evaluation of the tradeoffs in ecosystem services associated with restoration of wetland margins.

Approach and Procedures

This project focuses on managing the plant and soil biodiversity of wetland margins to increase soil retention of C, N and P, using approaches that give policy makers information on environmental performance of restoration projects, which is often assumed rather than quantified. This is relevant to federal programs (e.g., the Environmental Quality Incentives Program (EQIP)), and new policies that may increase "green payments" to landowners. Agricultural landscapes are mosaics of land use types and ownership, and soil serves as an interface and connection between agriculturally productive land and non-agricultural lands. Specifically, soil processes in wetland margins filter agricultural nutrients and pollutants, reduce erosion, improve water quality, provide reservoirs of biodiversity, and are important for human reliance on recycled water (Oki and Kanae 2006).

Our context is a California Central Valley landscape in western Yolo County, in which management of canal, slough and pond edges is largely under the control of individual landowners. Wetland margins usually support annual ruderal weeds, or no vegetation, depending on herbicide use. In Yolo County, however, restoration of farm edges with native perennial plants has been a priority of the Resource Conservation District (RCD) and other local stakeholders (Robins 2001).

The 150 km^2 study region includes both intensive agriculture and grazed grassland/oak savanna. GIS layers were used to categorize the landscape into land use units, placing random points across the study region. There were 14 variables in the data layer stack, including eight numeric variables (clay, silt, organic matter, pH, drainage rating, runoff rating, elevation, and aspect) and six discrete factor variables (presence of hydric soils in the map unit, classification as

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a wetland by the National Wetlands Inventory, the soil great group of the point, the land cover classification in both the NLCD and C-CAP inventories, and the presence and identity of oak woodland according to the FRAP Multi-Source Land Cover map). From the GIS, 2049 random points were selected which were within 10 m of streams and canals. We used a partitioning method of clustering, electing to fix ahead of time the number of partitions of the dataset to 5, a value which fit the logistical ability only to visit about 20-25 discrete sites for sampling.

Soil pit characterization and soil sampling took place from February to May, 2007. At each sampling site, a 50 m transect was established perpendicular to the waterway, running from the edge of the water into the adjoining field. Three pits were dug along this transect at a distance of 0.5 m, 4-12 m and 50 m from the water's edge. The soil profile at 0- to 100-cm depth was described for horizons, horizon boundaries, color, rock fragments, structure, consistence, clay films and redoximorphic features (Schoeneberger et al. 2002). Two soil cores also were taken on either side of the pit at 2 m in either direction. For four depths (0-15, 15-45, 45-75, and 75-100 cm) soil was analyzed for moisture, particle size, pH, nitrate, ammonium, Olsen P, total C, N, boron and exchangeable cations (Na, K, Mg and Ca). Additionally, the 0- to 15-cm samples were extracted for nematode taxa abundance (Barker 1985; Ferris and Matute 2003) and phospholipid ester-linked fatty acid (PLFA) analysis to characterize soil microbial communities (Bossio and Scow 1995).

Vegetative sampling and riparian characterization were conducted at each site from May to June of 2007: at the community level using the riparian greenline transect method (Winward 2000) to classify communities into the appropriate vegetation series (Sawyer and Keeler-Wolf 1995), then more detailed relevé plots of 15 to 100 m^2 for each of the three soil pit locations at each site, which included cover class data for each species (CNPS Vegetation Committee 2000). Additionally, the height, canopy dimensions and DBH (or basal diameter for shrubs) of all woody species 1.5m or taller was recorded within the 40 m reach of the riparian zone in order to calculate canopy cover and woody C sequestration. Physical characterization of watershed features was performed along a 40 m reach according to modifications of three methods for evaluating riparian/watershed health (Barbour et al. 1999; Prichard 1998; Ward et al. 2003).

The second phase of the project is focused on just one restored wetland site. In 2000 to 2001, a ¼-mile reach of Union School Slough was excavated and graded to create a floodplain bench along the western bank, and was subsequently planted with native grasses, shrubs, and trees. Half of this restored area was later grazed by sheep and goats, while the other half has remained relatively undisturbed. Seven sampling locations were chosen for this site, three in the grazed section and three in the un-grazed section, and one location in the adjacent hayfield. At each sampling location, there are three sampling distances (at the channel's edge, on the floodplain bench, and on the upper bank). Sampling has begun for vegetation (litter and live biomass), soil emissions of CO_2 and N_2O, soil microbial biomass C and dissolved organic C (DOC) (Burger et al. 2005). This will also occur in March, and April/May. A LICOR 8100 automated soil CO_2 flux analyzer is collecting continuous data from one location for the entire winter, in order to correlate with the periodic gas sampling at all locations. Additionally, water samples of runoff from the hayfield are being collected throughout the winter with two ISCO automatic portable water samplers, and analyzed for nitrate, ammonium, phosphate, pH, EC, DOC, and sediment.

Results and Discussion

The activities involved in classifying land use types, sampling, and soil and plant analysis have occupied much of the first year. Preliminary analysis indicates that C sequestration is highest in plants and soil in bench habitats, and that biodiversity of plants and nematodes is fairly similar across land use clusters, except for a few relatively undisturbed sites in the uplands. Clustering of land use types appear at first glance to be slightly different when using the GIS data vs. the plant/soil sampling data. The input data for a landscape model (Catchment Modeling Framework) (Eigenraam 2005) has been assembled, which will eventually allow the identification of locations across the landscape that are most useful for restoration, based on their site characteristics.

References

Barbour, M.T., J. Gerritsen, B.D. Snyder and J.B. Stribling. 1999. *Rapid bioassessment protocols for use in streams and wadeable rivers: periphyton, benthic macroinvertebrates and fish,* Second Edition. U.S. Environmental Protection Agency; Office of Water, Washington, D.C.

Barker, K.R. 1985. Nematode extraction and bioassays, p. 19-35, In: *An advanced treatise on Meloidogyne*, C.C.C.K.R. Carter, J.N. Sasser (eds), Vol. 2. Raleigh: North Carolina State University Graphics.

Bossio, D.A. and K.M. Scow. 1995. Impact of carbon and flooding on the metabolic diversity of microbial communities in soils. *Applied Environmental Microbiology* 61:4043-4050.

Burger, M., L.E. Jackson, E.J. Lundquist, D.T. Louie, R.L. Miller, D.E. Rolston and K.M. Scow. 2005. Microbial responses and nitrous oxide emissions during wetting and drying of organically and conventionally managed soil under tomatoes. *Biology and Fertility of Soils* 42:109-118.

CNPS Vegetation Committee. 2000. CNPS Relevé Protocol. California Native Plant Society, Sacramento, CA.

Eigenraam, M., G. Stoneham, C. Beverly and J. Todd. 2005. Emerging environmental markets: A catchment modeling framework to meet new information requirements OECD Workshop on Agriculture and Water: Sustainability, Markets and Policies.

Ferris, H. and M.M. Matute. 2003. Structural and functional succession in the nematode fauna of a soil food web. *Applied Soil Ecology* 23:93-110.

Oki, T. and S. Kanae. 2006. Global hydrological cycles and world water resources. *Science* 313:1068-1072.

Prichard, D. 1998. Riparian area management: A user guide to assessing proper functioning condition and the supporting science for lotic areas. U.S. Department of the Interior; Bureau of Land Management, Denver, CO.

Robins, P., R.B. Holmes and K. Laddish. 2001. Bringing farm edges back to life, 5th Edition. Yolo County Resource Conservation District

Sawyer, J.O. and T. Keeler-Wolf. 1995. Manual of California vegetation, California Native Plant Society, Sacramento, CA.

Schoeneberger, P.J., D.A. Wysocki, E.C. Benham and W.D. Broderson, (eds.) 2002. *Field book for describing and sampling soils*, version 2.0. Natural Resources Conservation Service, USDA, National Soil Survey Center, Lincoln, NE.

Ward, T.A., K.W. Tate and E.R. Atwill. 2003. *Visual assessment of riparian health*. University of California, Agriculture and Natural Resources.

Winward, A.H. 2000. Monitoring the vegetation resources in riparian areas, General Technical Report. RMRSGTR-47. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT.

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