Modeling Plant Community Types as a Function of Physical Site Characteristics

The Nature Conservancy
Sacramento River Project
500 Main St.
Chico, CA 95928

The Nature Conservancy
CALIFORNIA

Introduction:

Although the main targets of restoration on the Sacramento River are primarily fauna (e.g., bird communities, listed fish species, and the Valley Elderberry Longhorn Beetle), restoration efforts typically focus on planting vegetation and restoring physical processes, as it is assumed (but generally untested) that fauna will recover if suitable habitats and the processes that maintain them are restored. As vegetation is a critical component of wildlife habitat, it is essential to understand how and why riparian vegetation develops on a restoration site if we are to understand what factors affect the recovery of targeted animal species. More specifically, on the Sacramento River there is a critical need to better understand what factors influence the survival and growth of planted native species and the subsequent natural colonization and establishment of both native and non-native invasive species (NIS). It is well recognized that vegetation community response in riparian areas is driven by both physical parameters (e.g., soil characteristics, flood frequency, water availability) and biological factors (e.g., competition with or facilitation by NIS, dispersal of seeds by birds, insect herbivory) but the order of importance of these factors and how they vary with heterogeneous site conditions in lowland riparian floodplains of the Great Central Valley is unknown.

Horticultural restoration of riparian vegetation along lowland alluvial rivers is complicated by habitat mosaics created by fluvial processes. The dynamic erosional and depositional nature of meandering rivers, such as the Sacramento River, creates highly heterogeneous physical conditions on the floodplain as sediments are unevenly distributed across the landscape. Differences in soil stratigraphy and groundwater availability are recognized as having pronounced effects on the survival and growth of planted species (Alpert et al. 1999), yet few detailed studies have evaluated how planted species respond to the full range of local site conditions found in floodplain settings.

Several studies conducted on lowland rivers of the Great Central Valley of California examined factors affecting the performance of planted species in the first few years following planting (Griggs et al. 1993, Hujik and Griggs 1994a, 1994b, Griggs and Peterson 1997, Alpert et al. 1999), however, very little work has been done to characterize longer-term response. It is important that longer-term response be studied, especially given that the short-term response studies took place during the maintenance phase (the first two to four years) of the restoration projects. Maintenance activities during early establishment of the planting, including irrigation and herbicide application, provide native plants with a competitive advantage over non-native invasive species that naturally recruit to these sites (Griggs and Peterson 1997, Alpert et al. 1999), but this advantage may be lost when maintenance activities cease. It is critical therefore to monitor longer term response of planted species at horticultural restoration sites.

This project represents a preliminary effort to identify how local site characteristics affect the long-term vegetation community composition at horticultural restoration sites along the main stem of the middle Sacramento River, CA. Our study complements previous work that examined how Valley Oaks (*Quercus lobata*) faired at six restoration sites following the cessation of maintenance activities (Griggs and Golet 2002). Collectively these studies are helping define restoration planting designs for sites that vary in their physical conditions.

Methods:

We conducted surveys at 106 long-term plots on four restoration sites planted between 1990 and 1994 (Fig. 1). Table 1 provides information about the restoration sites sampled.

Soil stratigraphy was characterized as part of the initial site assessments preformed to inform restoration planting designs. This was done by classifying soils at 1 foot intervals according to the soil science standard texture by feel method (Fig. 2). In addition to characterizing soil type, we recorded the following parameters: soil depth, refusal condition, number of texture changes, and total number of textures. Soil samples were taken with a 15-foot hand auger in late summer (July-September).

During the summer of 2001, 4-7 years following completion of restoration activities (when the plants were 8-11 years old), the long-term plots were revisited to assess the success of the planting. The vegetation cover was classified by a qualitative evaluation of tree density and cover into three general community types: forest, savanna, or grassland. Figures 3 - 7 illustrate representative examples for each community type.

To better understand how vegetation community types are distributed on floodplain habitats with varying stratigraphic profiles we classified soil cores into one of four categories: 1) soils > 15' deep, 2) depth to gravel refusal encountered within 15', 3) depth to groundwater refusal encountered within 15', and 4) depth to sand refusal encountered within 15'. In the case of gravel refusal the substrate encountered was too densely packed to drive the hand auger into, so soil profiles beyond a gravel layer could not be characterized. Soil cores also could not be extracted when groundwater or sand was reached because the sediments did not adhere to the auger. We also examined the frequency of cover types according to soil depth.

Results and Discussion:

Our results suggest that both refusal condition and soil depth have some utility in predicting vegetation cover class (Figs. 8 & 9). We found that the relative frequency of forest cover increased directly with soil depth, but decreased with very deep soils. No forest cover type seen on any plot where borehole refusal was due to gravel except on very deep soils. Deep gravels do not appear to limit the ability of a site to support forest if the groundwater level is less than 15' from the surface. However, even if the soil is uniform and deep a forest cover is unlikely to develop if the groundwater level is more than 15' from the surface. The frequency of grassland cover increased with decreasing soil depth over gravel. The highest frequency of forest cover type (57%) was in moderately deep soils in which groundwater was encountered in < 15'. Savanna cover was dominant (60-70%) and grassland was common (25-40%) on very deep soils (>15') regardless of refusal condition and on plots were borehole refusal was due to sand.

Patterns of restoration plantings growth and density were also noted to generally follow landform features. Forest cover was more frequent in abandoned channel locations and adjacent to the current river channel. The thick forest cover then grades to savanna, or grassland towards the center of the corresponding point bar depending on the thickness of the fine-textured overburden. Savanna cover also dominates floodplain areas back from the river that do not have obvious channel meander features. Grassland dominates any floodplain area that has a significant gravel component at, or near, the surface.

These results combine with previous findings to produce a preliminary predictive model that relates soil stratigraphy and flooding frequency to plant community type (Fig. 10). We are currently using this model to help define what plant communities types are appropriate for horticultural restoration sites with varying local physical conditions.

We also examined the Glenn County Soil Survey (Fig. 11) to determine relevant characteristics of the Columbia Series soils in the Chico Landing Sub-reach with identifiable landforms and made the following associations with the vegetation community designations: 1) Silt loam 0-2% slopes (ChA) and silt loam moderately deep over clay loam 0-2% slopes (Ck) are associated with floodplain areas back from the river that do not have obvious channel meander features and are likely appropriate for forest cover. 2) Fine sandy loam 0-2% slopes (CeA) are associated with floodplain areas that do not have obvious channel meander features near the river channel and are likely appropriate for savannah. 3) Silt loam water table(?) 1-8% slopes (CpB) and Columbia soils channeled 0-10% slopes are associated with abandoned channels and likely appropriate for forest cover. 4) Silt loam moderately deep over gravel (Cm) are associated with floodplain soils that have a significant gravel component at, or near, the surface and are likely appropriate for grasslands. We conducted additional field data collection to supplement these associations and facilitate extrapolation of vegetation communities over large areas between data points.

We used the above methods to implement a significant shift from previous restoration planning protocol which typically occurred in a piecemeal fashion, proceeding slowly on a parcel-by-parcel basis. The new approach allowed us to develop coarse-scale coordinated planting designations for a total of 4255 acres over 23 separate units. The Chico Landing Subreach was an appropriate site to pilot test this model, as it is the focus of conservation actions among many different stakeholder groups. Forest cover was designated in abandoned channel and near-shore areas (CeA, CpB & CrB). Savanna was designated in high floodplain areas without obvious river meander features (ChA & Ck). Grassland was designated in locations where gravel is found in significant amounts at, or near, the surface (Cm). Additional refinements were made following a qualitative on-site assessment of flooding potential.

Recommended Future Work:

Future work should examine the proliferation and growth characteristics of individual species of plants, including both those that are planted and those that naturally recruit to the sites. Special attention should be paid not only to important native colonizers, but also to problematic non-native invasive species to gain a better understanding of factors that influence the successional pathways at these sites. Studies should examine grasses, sedges, and forbs as well as woody species.

More independent variables should be added to the modeling exercise (Table 2). However, before this is done additional biological and physical characterizations will have to be made of the sites. Incorporating floodplain elevation, and consequently the distance above groundwater, would improve the analysis. Steve Greco (University of California Davis) is developing groundwater and floodplain elevation models which we hope to incorporate in future applications of the predictive plant community type model.

In addition to local site conditions, landscapes variable should be characterized. This is important as variable outcomes in restoration may be attributable to both unmeasured environmental differences on-site, and fundamental differences in the landscape matrices within which projects are imbedded (Hansson et al. 1995). Furthermore, many ecological processes are highly responsive to the scale and location at which habitat and processes are altered (Wiens 1989). Only by adding landscape context can we begin to appreciate the full range of factors that influence restoration outcomes.

Quantification of community type characteristics that affect roughness values has also been identified as a priority, particularly as this information will inform efforts to better characterize the degree to which floodplain habitats of different vegetation cover types impede the flow of floodwaters during high flow events.

References:

Alpert P, FT Griggs & DR Peterson 1999. Riparian forest restoration along large rivers: Initial results from the Sacramento River Project. Restoration Ecology 7:360-368.

Golet GH, DL Brown, EE Crone, GR Geupel, SE Greco, KD Holl, KA Hoover, DE Jukkola, GM Kondolf, EW Larsen, FK Ligon, RA Luster, MP Marchetti, N Nur, BK Orr, DR Peterson, ME Power, WE Rainey, MD Roberts, JG Silveira, SL Small, JC Vick, DS Wilson, & DM Wood. Using science to evaluate restoration efforts and ecosystem health on the Sacramento River Project, California. Pages __-__ *in* PM Faber (editor), Proceedings of the Riparian Habitat and Floodplains Conference, March 12-25, 2001, Sacramento, CA. University of California Press. *In press.*

Griggs FT & GH Golet. 2002. Riparian valley oak (*Quercus lobata*) forest restoration on the middle Sacramento River. Pages 543-550 *in* RB Standiford, D McCreary, & KL Purcell, (technical coordinators), Proceedings of the fifth symposium on oak woodlands: oaks in California's changing landscape. October 22-25, 2001, San Diego, CA. Gen. Tech. Rep. PSW-GTR-184. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture.

Griggs FT, V Morris and E Denny. 1993. Five years of valley oak riparian forest restoration. Fremontia 22:13-17.

Griggs FT and DR Peterson. 1997. Evaluation of techniques and costs for valley oak riparian forest restoration on the Sacramento River. USDA Forest Service Gen. Tech. Rep. PSW-GTR-160. Albany, CA: Pacific Southwest Research Station, Forest Service, U.S. Department of Agriculture

Hansson L, L Fahrig, & G Merriam (eds.) 1995. Mosaic Landscapes and Ecological Processes. Chapman and Hall, London.

Hujik P, and FT Griggs. 1994a. Cutting size, horticultural treatments affects survival and growth of riparian species (California). Restoration and Management Notes 13:219-220.

Hujik P, and FT Griggs. 1994b. Field-Seeded Riparian trees and shrubs thrive in non-irrigated plots (California). Restoration and Management Notes 13:220-221.

Wiens JA. 1989. Spatial scaling in ecology. Functional Ecology 3:385-387.