

Soil Considerations in Riparian Restoration

by John Zentner

Often overlooked or taken for granted, soil can determine the outcome of a restoration project.

We were recently asked by a large Federal agency to bid on the construction of a riparian landscape and, upon reviewing the project site, found that the proposed species list was dominated by plants that were native to soils completely different from those at the site. The remnant native vegetation on the site reflected a silty soil with a great deal of organic matter, typical of old delta soils in our region, while the planting list was made up of species typically found in relatively permeable, recent alluvium. When we pointed this out to the contracting officer and proposed to substitute, at no additional cost to the government, species truly native to the site, our proposal score was reduced for being “non-responsive.”

In this article, I will discuss the importance of soils in constructing riparian landscapes (by “constructing” I mean restoring, enhancing, or creating). The geographic focus is lowland central California, including the San Francisco Bay and Delta environs and the Central Valley, an area of approximately 50,000 square kilometers (about 18,000 square miles) and a complex variety of soils. Table 1 provides a summary, based on our experience, of the major soil types, their texture, and their typical vegetation. Figure 1 provides an idealized view of the position of these soils in the landscape.

Table 1 illustrates the importance of understanding soil texture and relative permeability in constructing riparian landscapes. However, despite the variety in the riparian landscape implied by this table, much of the planning for riparian construction in this region (and elsewhere) has been based on the assumption that all streamside soils are made up of recent al-

luvium, and that the plants that dominate these soils are suitable for any riparian site. In fact, riparian construction in this region probably occurs most commonly on smaller streams on sites that are not dominated by such soils. This being the case, ignoring local soil conditions both limits planting choices and dramatically reduces the likelihood of success, as borne out by the projects described below.

Our Natoma Station and Laguna Creek projects, both near Sacramento, are about 16 km (10 miles) apart but involved work in very different soils. The Natoma Station project was constructed on Willow Creek almost entirely on cobbles, an altered soil similar in permeability to rocky foothill soils. The planting plan called for a high proportion of deep-rooted trees such as white alder (*Alnus rhombifolia*) that either thrive in or tolerate extremely permeable soils. These were planted without planting amendments (such as fertilizer) and watered for two years with a drip irrigation system. Growth of these species has been extremely rapid (Figure 2).

The Laguna Creek project was constructed on an old terrace soil; the relatively impermeable portion of the soil extended from about 0.3 m (1 foot) from the surface to a depth of 12 m (40 feet). Generally, this landscape would have few trees in its native condition, but planning considerations (buffering and appearance) led to the planting of a fringing woodland. Our concern with planting a woodland on this site was heightened by our experience with remediation efforts for a nearby project on similar soils. At that site, of 350 trees and shrubs planted, only 45 (12 percent) had survived two years after planting. Most of the trees that had survived were still the

Table 1: Riparian soils, texture, and typical plants in central California

Soil type	Texture	Vegetation	Dominant Plants
Foothill	Rock	Deep-rooted Trees	<i>Alnus rhombifolia</i>
Very recent alluvium	Gravel and Sand	Deep-rooted Trees and Shrubs	<i>Baccharis viminea</i> , <i>Platanus racemosa</i>
Recent alluvium	Sandy Loams	Trees, Shrubs and Vines	<i>Salix hinsiana</i> , <i>Quercus lobata</i>
Alluvial fans	Mixed Loams	Trees and Forbs	<i>Salix goodingii</i> , <i>Quercus lobata</i>
Basin	Clays	Forbs and Grasses	<i>Eleocharis palustris</i> , <i>Carex praegracilis</i>
Delta	High Organic	Shrubs and Forbs	<i>Scirpus acutus</i> , <i>Cephalanthus occidentalis</i>
Old terrace	Impermeable Layers	Shallow-rooted Trees and Forbs	<i>Populus fremontii</i> , <i>Juncus balticus</i>
Altered soils	Variable	Variable	Variable

same height as when planted, about 0.3 m (1 foot), although they had all increased in stem diameter—the effect was something like a bonsai woodland.

Accordingly, at Laguna Creek, we began by searching out the few trees and shrubs native to old terrace soils and then selectively adding species found naturally on basin or delta soils. The trees and shrubs were concentrated in a narrow zone adjacent to the upper edge of the creek corridor where disturbance of the soil horizons (and, therefore, permeability) was at its greatest. Each tree or shrub was placed in a basin augured to a depth of 1.3 m (4 feet) with a 30-centimeter (12-inch) bit and a 1.0 m (3 feet) length of 10-centimeter (4-inch) wide, perforated PVC pipe buried in the basin to ensure adequate deep watering. We used a bubbler irrigation outlet on each basin (rather than a drip system) to ensure rapid filling of the basin and adequate water for penetration at depth. Even with a relatively site-specific planting list and these amendments, we lost about 30 percent of the trees and shrubs over the next five years, and growth has not been nearly as rapid as at Willow Creek (Figure 3).

The lesson here is this: soil amendments can provide conditions that will support species that might not be strictly native to a site, but this approach can be risky. And, in planning for soil amendments, it is important to distinguish between the soil *substrate* (the relatively shallow part of the soil that supports most of the biological activity) and the *subgrade* (that portion of the soil, or even those elements, that determine the physical attributes of the soil, such as permeability to water and other geotechnical properties). Generally, modifying the substrate is much less troublesome than modifying the subgrade, and far more likely to enhance project success.

Many riparian construction projects begin with excavation to establish required grades, and the result is a site on which the planting substrate is the relatively sterile subgrade. The application of topsoil, a substrate amendment that is becoming increasingly common in restoration, can be extremely beneficial in these cases. Our project at Green Valley Creek, near Fairfield, included the creation of a bypass floodway parallel to the existing

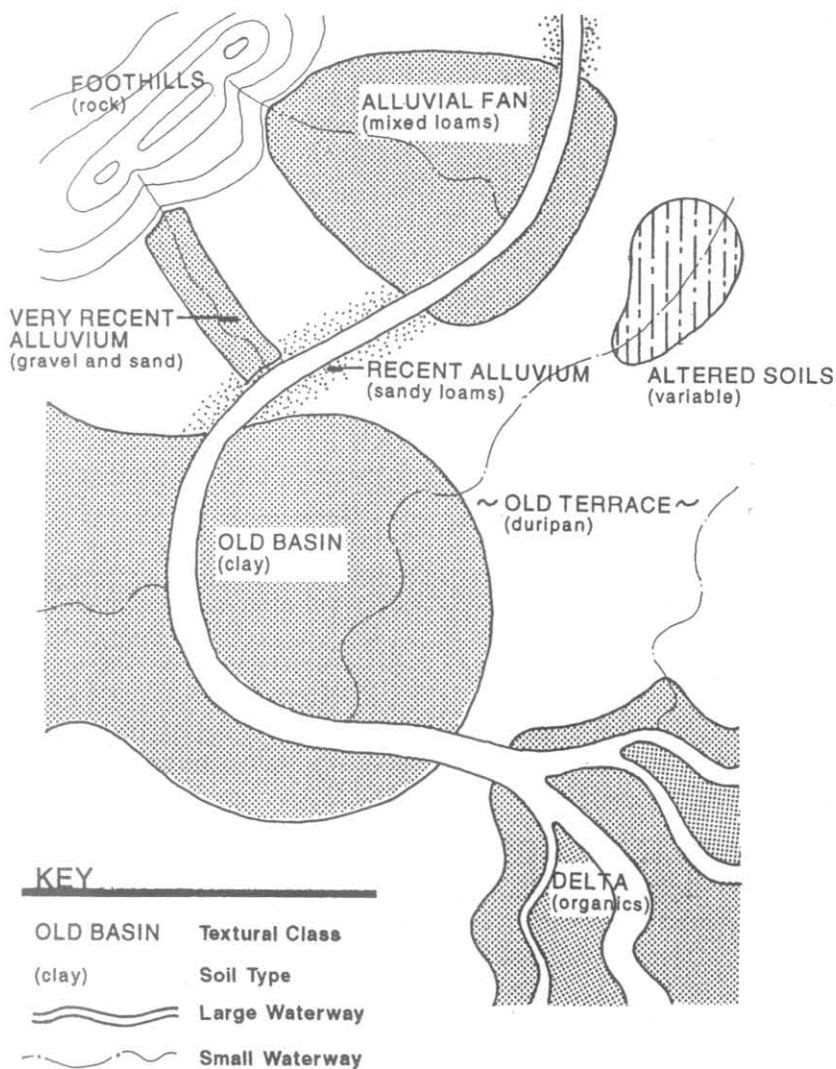


Figure 1. Schematic map showing idealized locations of soil types in central California relative to major landforms and water features.

creek that would provide riparian habitat. The floodway was excavated 2.3 m (8 feet) into a streamside terrace, leaving as the planting surface an ancient basin soil with extremely low levels of organic matter and little or no biological activity. The project specifications called for the application of 8 centimeters (3 inches) of topsoil salvaged from an adjacent riparian landscape, but before this step could be completed, winter arrived and all construction was halted. Wetland topsoil was applied along one reach, however, and the difference in species richness and cover between this reach and the untreated reaches after the first year was striking (Figures 4 and 5).

Mallory Gilbert (1995) provides a useful summary of the advantages and disadvantages of topsoiling, including the use of both upland and wetland topsoils. Many of his concerns relate specifically to the introduction of weeds, a concern that is most germane to regions in which wetland weeds are common. Most areas in central California, in contrast, have relatively few wetland exotics, many rare native species that are adapted to disturbance in wet soils, and relatively low organic matter levels in most soils. Under these conditions, the addition of wetland topsoil may often be desirable on sites where construction results in a subgrade becoming the new soil surface.

The addition of organic matter alone may be another means of providing the benefits of surface organic matter without the risk of introducing troublesome exotics. Peter Wallace (1994) found that water levels fluctuate more widely and rapidly in constructed wetlands with low organic matter content than in wetlands with higher organic matter levels. Shapiro and Shapiro (1994) added a significant amount of organic matter in the form of composted sewage sludge to a constructed freshwater marsh in Oregon, and found that this reduced both water-level fluctuations and weeds. Apparently, the organic matter in the soil buffers the movement of water into and out of the soil, creating conditions that may favor native species over exotics. These properties can be useful in regions where climate-induced drawdowns are frequent and on soils with low organic content. However, the addition of organic matter cannot be used as a substitute for sound hydrologic planning in the hopes

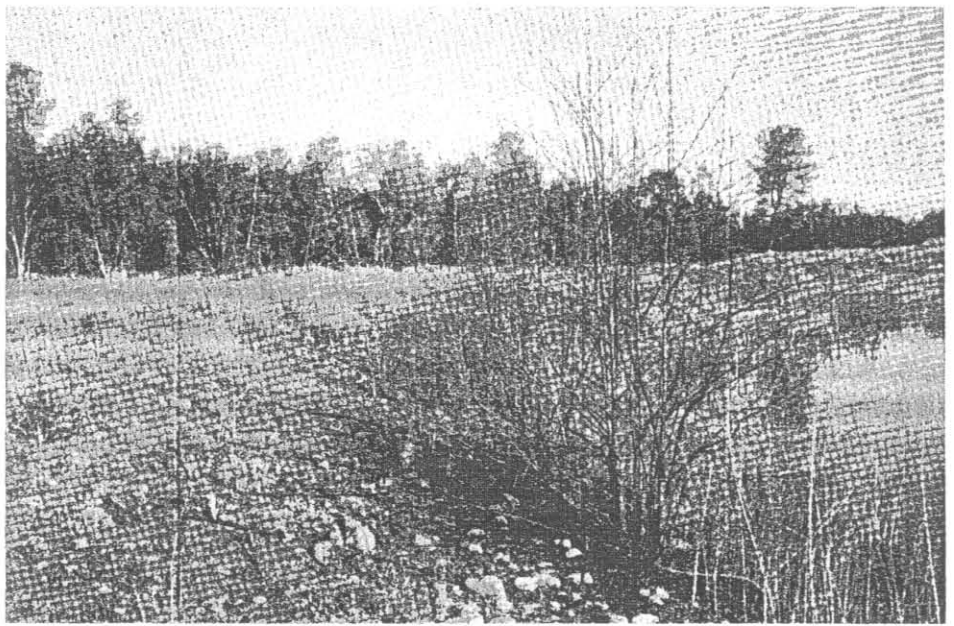


Figure 2. The Natoma Station site two years after planting. Trees such as white alder (*Alnus rhombifolia*), in foreground, that are well adapted to the highly-permeable substrate have grown rapidly. Photos by author

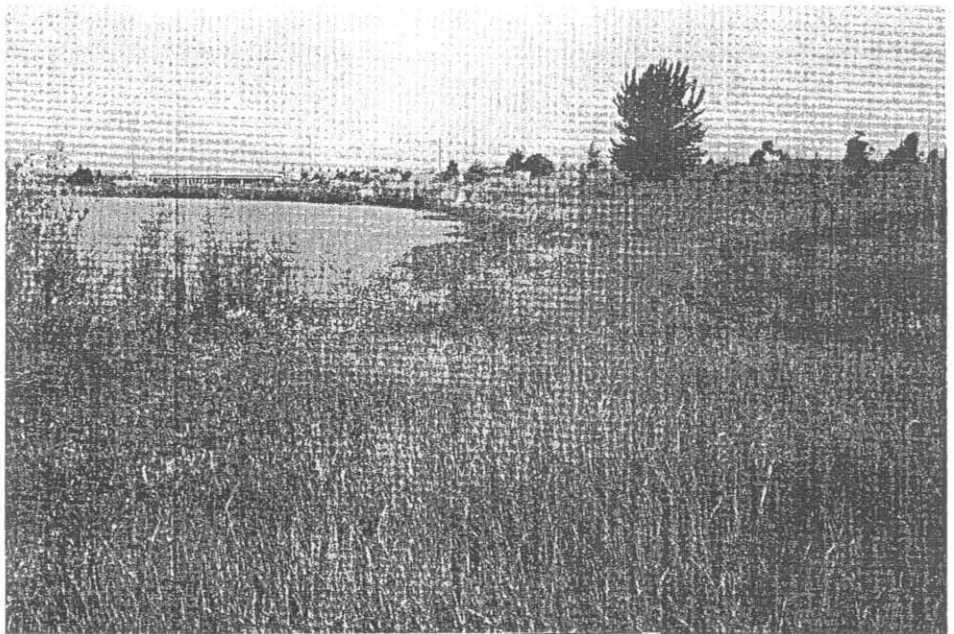
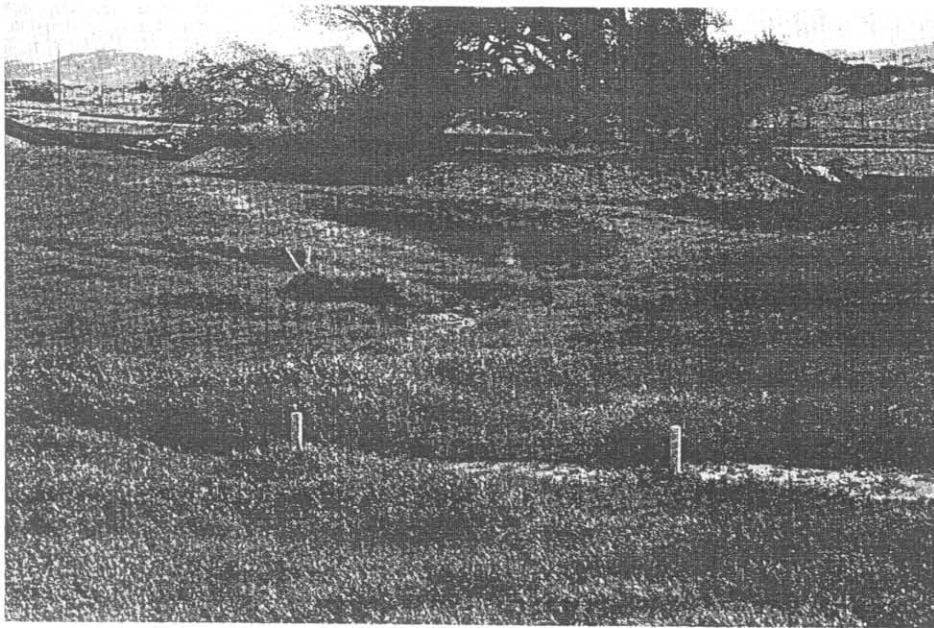


Figure 3. On impermeable, old-terrace soil at Laguna Creek, in contrast, growth of trees was slow despite heavy soil amendments and planting of trees selected for tolerance to relatively impermeable substrate, as evident in a photo taken five years after planting. The tall tree in right background is Fremont cottonwood (*Populus fremontii*), one of the few trees found naturally on these soils.

that the supplement will compensate for an inappropriate site.

In the same vein, subgrade amendments should be approached with caution. One of the least risky subgrade amend-

ments involves increasing permeability where such an increase does not jeopardize water retention. Our soil amendments to increase woody plant survival, at Laguna Creek, are an example. At another site, we



Figures 4 and 5. Topsoil application greatly accelerated revegetation on a site that was excavated down to subgrade along Green Valley Creek. Photos show the topsoiled reach (top) and the reach without topsoil (bottom) six months after construction.

built low weirs of lightly compacted cobble to promote ponding in a stream system and to provide a more suitable substrate for woody species on an old terrace soil. The trees not only provided needed woodland habitat on the site but also secured the weirs.

Significant issues arise, though, where subgrade amendments are undertaken to decrease permeability. On one project, for

example, to meet regulatory requirements, we constructed a pond and marsh system as a part of a larger riparian project in an area of highly permeable, altered soils. A small pond in the lowest portion of the project site appeared to mark an impermeable subsoil, and we based our design for the pond basin on what we took to be the elevation of this impervious layer. During construction the impermeable layer

proved to be thinner than expected and was punctured by a construction vehicle. Within ten minutes, the wetland basin (including a nursery area for salvaged plants) went from completely inundated to almost completely dry.

In this case, we remobilized and used bentonite worked into the surface of the basin along with local clays to create a sealed pond that has now retained water for seven years. However, as we learned from this experience, the emotional and financial consequences of a poorly-planned site design can be serious. Despite the apparent success of some products and strategies for amending soils, all sites must be examined with an understanding of the vegetation associations that would naturally occur on the site and the recognition that the success of the effort will ultimately depend on matching the vegetation to the site at the time of planting. Where this is impossible, it may be best to find an alternative site. In any case, projects that begin with a mismatch between the soils and the vegetation are almost certain to fail, while plans based on understanding of the relationship between plants and soils can produce exceptional and fulfilling results.

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