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Soils Influence Survival and Growth of Willow Posts at Streambank Restoration Project (Mississippi)

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Willow posts (*Salix* spp.) have been used extensively to stabilize eroded streambanks and thereby promote the restoration of stream corridors in the southern United States (Shields et al. 1995). They are an attractive bioengineering technique because of their durability in high-energy environments and their cost when compared standard erosion controls materials such as stone. Yet, despite reported successes using willow posts on many restoration sites, survival rates of less than 40 percent have been reported in northern Mississippi. The results of a recent greenhouse study, which looked at the effects of soil moisture on the growth and survival of black willow (*Salix nigra*) cuttings (Pezeshki et al 1998), led two of us (Pezeshki and Shields, Jr.) to suggest that the elevation along the bank, flooding, drought, and soil texture may all be factors affecting survival. Further field observations suggested to us that extreme soil moisture regimes as well as fine-grained soils (silts and clays) may be the primary factors accounting for low survival. With this in mind, we designed a field experiment to quantify the relationship between soil texture and moisture regime, and the physiological functions, survival, and growth of willow posts.

We conducted the field work at the Twentymile Creek restoration site in northern Mississippi, near the town of Baldwyn. During the winter of 1998, we harvested black willow from a local population. The posts were 9.8-ft long with a minimum basal diameter of 3 inches. On the same day as the harvest, we dug pilot holes on 3-ft centers, and planted the willow posts so that approximately 40 percent of the post remained aboveground. Next, we established four transects perpendicular to the creek and extending from the toe of the streambank to the edge of the planting zone. Along each transect, we established three plots—one at each of the elevational extremes and one at the middle elevation. Each plot was approximately 100 ft^2 in size and contained 12 posts. We began taking soil and plant measurements in the spring of 1998 and continued that work through the end of the growing season.

We used a laser particle-size analyzer to determine the particle size of soil samples taken from 15, 30, 60, and 90 cm depths in each plot. Using redox electrodes, a millivoltmeter, and calomel reference electrode, we took monthly readings of the soil redox potential (Eh). We also monitored groundwater on a monthly basis, using piezometers that we installed in the middle of each plot. We measured the height of each post at the beginning and the end of the growing season. We also used a portable photosynthesis system to measure the net photosynthetic output of mature, intact leaves. Once we had all the data, we used the general linear models procedure of the Statistical Analysis System (SAS 1994) to test for differences in means across both elevational and soil texture groups.

When we analyzed the data in terms of elevational groups (high, medium, low), we found that the soils were similar in texture. However, the low-elevation plots, which were closest to the water table, had the lowest Eh values (+233 mV) indicating moderately reduced soils due to saturated conditions. In contrast, the medium and high elevation plots had aerated soils with average depths to the water table of 4.5 ft and 5.6 ft, and Eh values of +483 and +521, respectively. Posts in the medium elevation averaged 3.2 ft of growth, 196 percent more than the 1.6 ft average for the low elevation plots and 154 percent more than the 2.1 ft growth recorded in the high elevation plots. The high elevation plots had the highest survival rate (67 percent) followed by the middle plots (50 percent), and the low plots (46 percent) (see Table 1a). The substantially greater height of posts growing at medium elevations is probably a response to the contrasting soil moisture conditions at high (droughty) and low (too moist) elevations (Shields et al., 1995; Pezeshki et al., 1998).

The effects of soil texture became apparent when we divided the plots into three groups according to particle size. Coarse-, medium-, and fine-textured soils contained 9 percent, 30 percent, and 74 percent fines, respectively. The depth to water table and soil Eh were similar across the groups. The three groups had soil Eh conditions indicative of aerated soils (529, 491, and 512 mV, respectively). We found that net photosynthetic rates, height growth, and survival rates were greatest in posts planted in sandy soils. Interestingly, soil texture appeared to have a greater influence on survival rates than plot elevation (see Table 1b).

In summary, survival and growth in willow posts appeared to be primarily dependent on soil texture as posts performed better in coarse soils than fine-grained soils. In addition, there are indications that post growth required abundant soil moisture and adequate drainage. Thus, soil texture and moisture regime along with Eh conditions and depth to the water table may serve as indicators of the potential for success of willow posts in streambank restoration projects. Anyone using willow posts in the manner described here should expect some losses; a survival rate of 50 percent is needed to provide good cover for streambanks after two years (Shields et al., 1995).

Variable	Post Location on the Streambank: Lower bank	Medium	Upper bank
Silt+Clay (%)	30	38	24
Water depth (ft)	.98 a	4.5 b	5.6 c
Eh (mV)	233.2 a	483.4 b	521.4 c
Height Growth (ft)	1.6 a	3.2 a	2.1 a
Survival (%)	46 a	50 a	67 a
Net carbon fixation (μ mol CO_2m^{-2} leaf s^{-1})	11.7 a	12.3 a	10.3 a

Table 1a, 1b. **Field data of post location (above) and soil texture (below) indicate soil texture (%), depth to water table (ft), soil Eh (mV), height growth (ft), survival (%), and net carbon fixation (μ mol CO_2m^{-2} leaf s^{-1}) for willow posts studied at Twentymile Creek restoration site, Mississippi. Means in each row followed by the same letter are not significantly different across groups at the $p<0.05$ level.**

Variable	Soil Texture: Coarse	Medium	Fine
Silt+Clay (%)	9	30	74
Water depth (ft)	5.6 ab	4.9 b	6.2 a
Eh (mV)	529 a	491 b	512 ab
Height Growth (ft)	8.0 a	6.3 a	6.7 a
Survival (%)	83 a	58 ab	50 b
Net carbon Fixation (μ mol CO_2m^{-2} leaf s^{-1})	11.0 a	7.0 b	9.7 ab

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