

THE CRESCENT BYPASS: A RIPARIAN RESTORATION PROJECT ON THE KINGS RIVER (FRESNO COUNTY)¹

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Abstract: The Kings River Conservation District planted over 1200 plants of 19 riparian species in the first of two phases of a riparian revegetation project in the San Joaquin Valley. To date, tree survival rates vary from 17 to 96 percent among species, with an overall rate of 62 percent. Shrub survival averages 57 percent and ranges from 23 to 73 percent. Factors affecting plant survival include soil quality, irrigation technique, climate, topography, weed competition, gopher and beaver depredation, vandalism, maintenance practices, and budget constraints.

The 1982-83 Kings River water year run-off, at 261 percent of average, ranked as the wettest year on record. In April 1983, the capacity of the North Fork to carry floodwater to the San Joaquin River was exceeded and floodwaters were diverted to Tulare Lake. Overall, 800,000 acre-feet of water was delivered to the basin, inundating 83,000 acres of productive agricultural land (KRWa 1984). To reduce up to 3 years of lost crop production, the Tulare Lake Reclamation District No. 749 (TLRD) decided to pump floodwaters from the Lake. Four pumping stations reversed flows through the South Fork to the North Fork of the Kings River through the Crescent Bypass, a 9.6 km man-made channel connecting the South Fork with the North Fork, and into the San Joaquin River. To accomplish flow reversal, channels and levees were enlarged and cleared. Many portions of the South Fork and a 4.8 km section of the Crescent Bypass were dredged and cleared of most vegetation.

In August 1984, a restoration agreement between the TLRD and the California Department of Fish and Game (CDFG) directed restoration of the impacted waterways. Much of TLRD's channel work benefited the Kings River Conservation District's (KRCD) flood channel maintenance program. Therefore, in April 1985, the KRCD assumed responsibility from the TLRD to mitigate those losses along the Crescent Bypass.

This paper reports on the first of two phases of a riparian revegetation project in the central San Joaquin Valley. Few riparian restoration projects in the San Joaquin Valley have been reported. We present methods, techniques, problems, and results for the practical field restorationist. This is Research Report No. 88-10

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Project Site

The Crescent Bypass is approximately 56 km south of Fresno, near the towns of Riverdale and Lemoore in Kings County, California. Rainfall averages near 17.8 cm and falls during the winter months. Temperatures exceed 38°C during the summer and occasionally drop below 0°C in the winter (USDA 1986).

The bypass was constructed in the 1920's to bypass floodwaters around a constricted reach of the South Fork and then into Tulare Lake. The 40 m wide channel runs principally north-south, the left bank facing northwest and the drier right bank facing southeast. The levee slopes are steep and vary from 2 to 10 m wide. The channel is uniform and water depth is normally 0.6-0.9 m deep. Over the years, dense riparian vegetation including willow, cottonwood, oak, elderberry, button-bush, blackberry, cattails and tules established themselves in the channel and along the banks, as determined from aerial photographs and remnant vegetation. After dredging and installation of the pump-back stations in 1983, only weeds, a few willow trees, and one cottonwood tree remained. Since the bypass no longer carries extreme flood flows, stringent channel and levee maintenance regulations (The Reclamation Board 1981) are eased. Numerous agricultural drains discharge into the bypass, some with an electrical conductivity (EC) of 25 mmhos/cm. Electrical conductivity of water in the bypass averages 2.4 mmhos/cm.

Soil EC along the right bank averages 7.2 mmhos/cm, (range of 3.9-10.8 mmhos/cm). Left bank soils average 1.7 (range of 0.6- 2.1 mmhos/cm). SAR values (Sodium Absorption Ratio, a measure of soil sodicity) in soils along the right bank average 10.7 meq/l (range of 4.9-15.1 meq/l), while left bank values range from 2.6 to 7.0 meq/l and average 5.0 meq/l. Soils vary along the bypass from sandy loams at the north end to heavy, poorly drained, clay barns at the south end. Values of soil pH range from 6.8 to 8.0.

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Methods

In fall 1985, a pilot project was conducted to determine the conditions influencing plant growth and survival. Four species of shrubs (275 cuttings and 118 containers) were planted at 0.16-km intervals along both the left and right banks (viewed downstream), 0.6 to 4.6 m above the water table. Four species of trees (52 containerized plants) were planted only in select sites along the levee (due to levee maintenance requirements), and in a 0.2 ha impacted site at the north end of the bypass, known as Ron's Park. Only 16 plants were watered throughout the summer due to manpower limitations. Plants were irrigated with buckets using water from the bypass, the quantity determined by the size of the berm around each plant, [generally, 19 to 38 L (5 to 10 gal)].

In January 1987, the first phase of the project was implemented, but constrained by a limited budget. The Site Revegetation Plan called for vegetation to be established every 183 m along the 4.8 km section of the bypass. Twenty-three shrubs and trees were planted in each of 28 plots, with 14 plots per bank. Each plot was 12-30 m long and 366 m apart. A total of 641 shrubs and 144 trees was planted in the plots, select areas along the bypass, and Ron's Park. Container stock was mostly 1 gal and a few 5 gal pots, except for the POTR & POFR trees which were 15 gal containers (table 1). RUUR and CEOC were planted as 25-38 cm cuttings taken from new and old growth stems.

Most were pencil size to 1.3 cm diameter; however, some of the CEOC cuttings were as thick as 4 cm. Cuttings were dipped in IBA (indole-3- butyric acid) rooting powder before planting in a rebar-augered hole. Plants were placed in two or three offset rows, with different species of vines, shrubs, and trees mixed to create structural and species variations. Increased plant diversity helps define species tolerant to environmental conditions and (rodent) depredation (ILR 1979). Plants were installed on the lower portions of the levee to avoid drag-grading during levee maintenance. Berms were constructed around each plant and the weeds tilled within each basin. All plants were irrigated weekly from June through October with good quality water from a nearby well.

About 50 large and small POFR and tree willow (SASP) cuttings were planted irregularly along the northern 1/3 of the bypass. The large pole cuttings (12.5 cm by 213 cm) were sunk into holes angled to the water table. Smaller cuttings (1.3 -5 cm by 91-152 cm) were simply pushed into the soil near the water table.

Table 1 —Trees and shrubs planted along the Crescent Bypass in Phase I.

		Number of Plants Ron's Park& Select		
Trees		Acronym	Plots	Areas
Box Elder	<i>Acer negundo</i>	ACNE	6	11
White Alder	<i>Alnus rhombifolia</i>	ALRH	7	16
Oregon Ash	<i>Fraxinus latifolia</i>	FRLA	5	16
Black Walnut	<i>Juglans hindsii</i>	JUSI	2	7
Sycamore	<i>Plantanus racemosa</i>	PLRA	4	12
Fremont Cottonwood	<i>Populus fremontii</i>	POFR	7	20
Black Cottonwood	<i>Populus trichocarpa</i>	POTR	3	7
Valley Oak	<i>Quercus lobata</i>	QULO	4	17
		Total	38	106
Shrubs				
Wild Clematis	<i>Clematis lasiantha</i>	CLLA	4	0
Golden Current	<i>Ribes aureum</i>	RIAU	56	3
California Rose	<i>Rosa californica</i>	ROCA	63	1
Woody Rose	<i>Rosa woodsii</i>	ROAO	79	0
Elderberry	<i>Sambucus mexicana</i>	SAME	131	0
Snowberry	<i>Symphoricarpos rivularis</i>	SYRI	108	2
Wild Grape	<i>Vitus californicus</i>	VICA	26	0
Buttonbush ¹	<i>Cephalanthus occidentalis</i>	CEOC	88	7
Wild Blackberry ¹	<i>Rubus ursinus</i>	RUUR	63	10
		Total	618	23

¹ Planted as cuttings.

After initial losses, one inch mesh chicken wire three feet high, was placed around the base of most trees for beaver protection. Some of the wire was loosely placed around trees and some was placed close to the trunk, depending on the species, number of lateral branches, and tree size.

Baskets made of 1.3 cm wire mesh screen were installed around plants in one plot to test their effectiveness against gophers. They were twice as big as the plant container and buried with the top of the screen above the ground surface.

All trees and both ends of each plot were marked with fenceposts, protecting plants from drag-grading. The location of each plant was mapped and survival data (number surviving : number planted) was recorded monthly. Infrequent observations of the large pole cuttings were made throughout the season.

Results and Discussion

Pilot Project

Survival for the pilot study after one growing season was low. Only 11.5 percent of the trees and 4.2 percent of the potted shrubs survived for a total of 12 out of 170 container plants. No cuttings survived. Most of the mortality resulted from plants and plot markers being dragged off the levee by the Channels and Levees (C&L) maintenance crew. Additionally, several trees were justifiably removed during an emergency flood control operation. By the time irrigation began, only 16 plants remained. Even then, the irrigation water taken from the bypass was toxic to the young plants, containing EC's over 3500 mmhos/cm (unknown at the time). Insufficient manpower, conflicting time commitments, and budget constraints at the start of the project added to poor survival.

Phase I: Shrub survival

Phase I survival rates were substantially higher than those of the pilot planting. The survival rate for the shrub container stock was 57 percent after one growing season. Most plants (71 percent) died between the time of planting and July, while only 29 percent died over the summer (fig. 1). (Although irrigation started the beginning of June, survival data was not recorded until July.) We expected a higher mortality during the hot summer period. The shrub cuttings failed again despite increased care and maintenance. The short length of the cuttings combined with a lack of adequate water are likely causes. Because of the low survival of the cuttings, they are excluded from the survival rate calculations. Consequently, plant numbers between plots are inconsistent, ranging from 7 to 24 and averaging 17.5 plants per plot. Although the plants are still equally distributed along the length of the bypass, plots with few plants contribute to the large variation of interplot survival rates.

Stresses experienced prior to planting might explain some of the early mortality. Despite our efforts, non-acclimated and poor quality nursery stock was obtained from non-local nurseries shortly before planting. Furthermore, temperatures dropped below freezing for several nights before planting, freezing the potting soil, leaves, and buds of many plants.

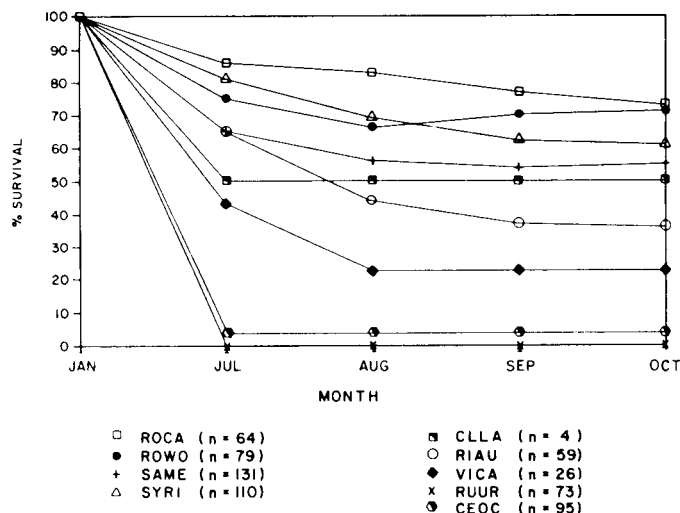


Figure 1— Shrub survival from time of planting to end of first growing season.

Soils exceeding 2 mmhos/cm are considered saline and can adversely affect plant growth. Soils with EC values between 8 and 12, classified as highly to very highly saline, can reduce plant growth 30 to 50 percent (Dargan et al. 1982). Soil tests showed EC's of 8.7 and 10.8 mmhos/cm in two of 4 soil tests along the right bank. The average survival rate for the right bank was 52 percent, while the left bank averaged 62 percent (fig. 2).

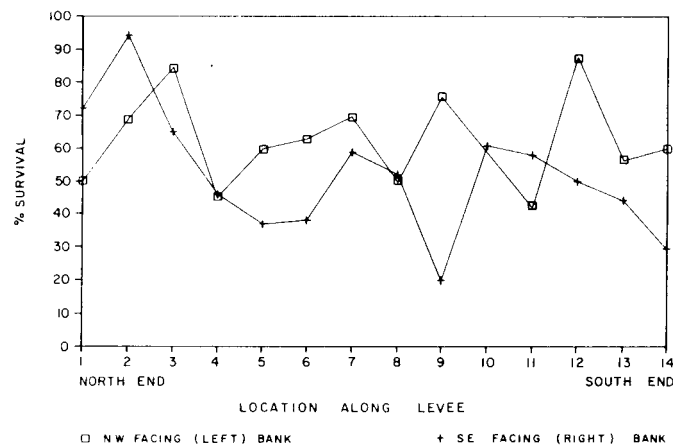


Figure 2— Shrub survival for each bank after first growing season.

The sandy loams at the north end differ from the silt barns and clay barns at the southern end. Although not reflected in the survival data, plant productivity is directly affected. In general, plants along the northern section of the bypass are much larger and healthier than those of the southern section. The transition is greatest between plots 4 and 9 on the right bank, and between 10 and 14 on the left. Fine textured particles of the clay loams inhibit development of mycorrhizae and are more limiting than soil fertility problems (Kozlowski 1987; Kramer 1987; Jorgensen 1988). Shrinking and swelling from electrostatic, osmotic, and hydrostatic pressures inhibit root formation and penetration, water uptake, and physiological plant processes. Furthermore, Frenkel and Meiri (1985a) state that a high sodium content (SAR greater than 5 meq/l) is deleterious to the physical properties of soils, resulting in a low infiltration rate of water, low permeability of the soil to water and gases, and poor structural quality of the media. High sodium content is also toxic to plants and will create physiological drought conditions (Dargan and others 1982; Emerson 1984; Frenkel and Meiri 1985a).

Aspect affects survival as well. The southeast exposure of the right bank increases evapotranspiration. As a result, salts accumulate in the root zone. In order to maintain a favorable salt and water balance in the root zone, thorough leaching is required (Frenkel and Meiri 1985b; Meiri 1984). Deep watering also enables root penetration through the soil profile to adequate available moisture near the water table, since upward capillary water movement is low for most soils (Helliwell 1986). Self-sustaining plants are the end result. Even though unfavorable salt conditions will always be present, the size of the watering basins, the amount of water applied, and the physical and environmental conditions associated with the site combine to directly affect plant growth and survival.

Although evapotranspiration is reduced on the cooler northwest facing left bank, other factors affected survival almost to the same extent. Public access to the left bank impacted several plots considerably. Most noticeable in plots 4, 5, and 6, plants were pulled up, trampled, and burned. Berms were destroyed and stakes broken or pulled out. Unauthorized use of levee roads, fence destruction, and various negative impacts from ATV (All Terrain Vehicle) enthusiasts are common, not only on the bypass, but along much of the river system. We feel posting more signs or increasing public relations would be ineffective and time consuming, as did Goldner (1981) who experienced similar problems.

Left bank plant survival was also influenced by the irrigation crew. The C&L maintenance staff was assigned irrigation responsibilities for the left bank, while Environmental Staff members irrigated the right bank. The objectives for involving the C&L staff were two fold: to

provide needed manpower, and to increase their awareness so that they would avoid our plots during their levee maintenance activities. Both objectives were met but to a limited extent. The C&L staff's relatively lower enthusiasm was evidenced by poor irrigation, weed control, and berm maintenance despite repeated reminders of their importance.

Site specific problems affected many plots individually. Plot 4 on the left bank contained compacted soils and asphalt from an old bridge demolished during channel excavation. As mentioned, plots 4, 5, and 6 were impacted by fishermen. Plot 9 on the right bank had the highest EC's (10.7), worst sodicity (SAR=15.1), and a high clay content, resulting in a survival rate of 20 percent.

Finally, many plants were lost to gophers and rodents which chewed off either root systems or plant stems. Damage was worse in the clay soils where tunnel systems remain intact. There was no difference between the plot with gopher baskets and the rest of the plots. However, observations during the early stages of Phase 2 indicate that much of the early plant loss has been to gopher depredation.

Phase I: Tree Survival

Survival of containerized tree species was 62 percent. Of the mortalities, 83 percent died before July (fig. 3). Similarly, Anderson and others (1984) found that the majority of young POFR saplings on the Lower Colorado River died between November and July. POFRs and POTRs along the bypass survived better than other tree species. Beaver depredation was the only cause of their mortality. The beavers accessed trees by pulling down loose fitting screens. This prompted us to re-size the remaining screens. Fortunately, some of the stumps resprouted, resulting in increased mid-summer survival (fig. 3). With the exception of initial leaf burn on a POTR tree near a drain, the high salts and poor soil conditions have apparently not affected the cottonwoods. Once the roots reach the water table, growth and productivity is tremendous. Incidental observations of the POFR and SASP pole cuttings indicated similar growth with 2 to 3 ft branches by mid-summer. Similar results from Colorado were reported by Miller and Pope (1984). Unfortunately, most of our tree cuttings (unscreened) were depredated by beavers.

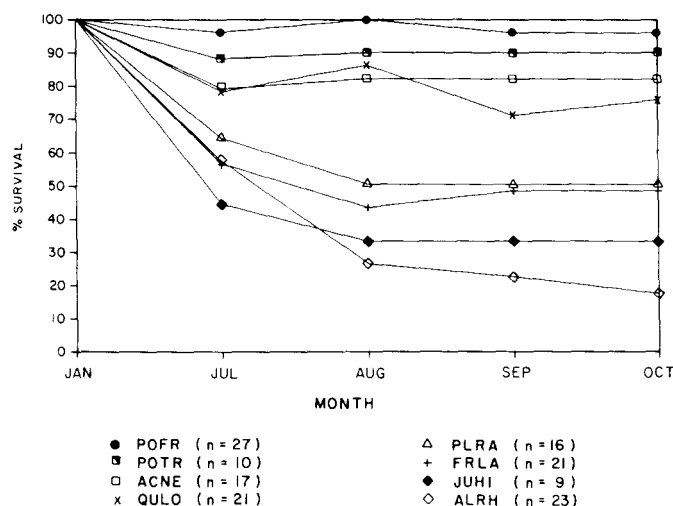


Figure 3— Tree survival from time of planting to end of first growing season.

ALRH and JUHI had the poorest survival rates. ALRH mortality is primarily attributed to the poor site conditions, most plants never recovering from transplant shock, beaver depredation, and in many cases, lack of adequate water. When planted in or very close to the water table, they did well. Soil condition was important to JUHI. They survived only in the sandy loams at the north end. Beavers did not damage JUHI or any other species not mentioned.

Further comparisons of the effects of site and soil conditions on survival within and among tree species is not attempted due to the low number of trees planted, inconsistent placement along the length of the channel, site specific differences, and beaver depredation.

Conclusions

Every planting year tends to become a pilot project because so much is learned from the previous year's effort. After the small "pilot planting", Phase I was the largest planting to date with the most learned. Benefitting from that, Phase II survival as of July 1988 was around 80 or 90 percent for both trees and shrubs. The kind of soluble salts, the soil texture, environmental conditions, and the nature of the plants are the most important factors determining plant growth. By developing the methods and techniques to more closely match the conditions of our revegetation site, we are increasing plant survival as well as our knowledge of restoration management. This benefits other restorationists, wildlife, and the diminishing riparian habitats of our environment.

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