COYOTE CREEK (SANTA CLARA COUNTY) PILOT REVEGETATION PROJECT[1]

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Abstract: The Santa Clara Valley Water District, located in Northern California, is currently evaluating a pilot riparian revegetation project on a 1.6 ha (4 ac) site adjacent to Coyote Creek in the south San Francisco Bay Area. Specific techniques used during the design, site preparation and installation of 3640 plants (including seed planting locations) are described. This paper reports on the analysis of 1 year's data, comparing the survival of various types of plant materials for each of the 15 native plant species installed. Plant survival is evaluated for portions of the site irrigated by overhead sprinklers versus flood irrigation. Weed control techniques and plant protection measures are also discussed.

The Santa Clara Valley Water District and the U.S. Army Corps of Engineers are in the process of designing and constructing flood control facilities on the lower portion of Coyote Creek. This project will involve the construction of earthen high flow bypass channels and earthen levees along a 9.6 km (6.0 mi) stretch of the creek. Mitigation measures proposed to compensate for the removal of approximately 15 percent of the existing riparian trees in the project area include the creation of 13.0 ha (32.5 ac) of new riparian habitat on the flood plain within the project levees.

Goals and Objectives

The Coyote Creek Pilot Revegetation Project has been designed to accomplish the dual goals of 1) creating 1.6 ha (4 ac) of flood plain riparian forest habitat as partial mitigation for flood control project impacts, and 2) serving as a test site for determining the most effective, efficient and economical means of re-establishing riparian vegetation on the additional 11.4 ha (28.5 ac) of required mitigation habitat.

Fifteen species of native riparian trees and shrubs were installed on the site in the winter of 1986-87 and are being monitored yearly in order to 1) determine the most successful or other suitable alternative types of plant material (propagules) for each species; 2) determine the most cost-effective means of establishing each plant species; 3) test the relative success in achieving plant establishment through various irrigation options; 4) identify the best management practices for controlling the growth of weeds; and 5) test rabbit and rodent control measures.

Project Location and Site Conditions

The pilot revegetation project is located on fallow agricultural land in north San Jose (due west of the City of Milpitas and east of Alviso). It is north of Highway 237 and south of Dixon Landing Road (see figure 1). The revegetation site is adjacent to the existing cottonwood-dominated riparian forest bordering the banks of lower Coyote Creek. Upon completion of the flood control project this revegetation site will lie within the flood control levees and will be bounded by the creek to the east and a high flow bypass channel to the west (see figure 2).

The climate of the Santa Clara Valley at the south end of the San Francisco Bay is a Mediterranean type with wet winters and dry summers. The project area is typical of the valley floor climatologically with 35.6 cm (14 in) average annual rainfall. During the 1987-88 year 25.3 cm (10 in) of precipitation was recorded at the site.

The ground water level at the revegetation site has been monitored by the Coyote Creek Riparian Station (CCRS) since January 1987. Water levels are being recorded semimonthly by 15 piezometers. The lowest ground water reading was a depth of 2.67 m (105 in) on March 30, 1988 and April 15, 1988. The highest level recorded was a depth of 1.35 m (53 in) on May 8, 1987.

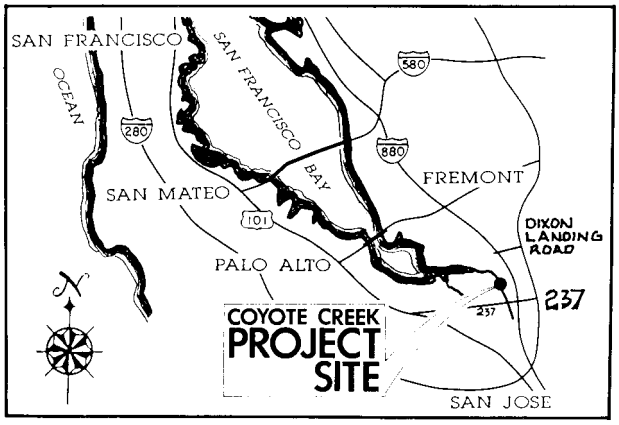

Figure 1— Location Map

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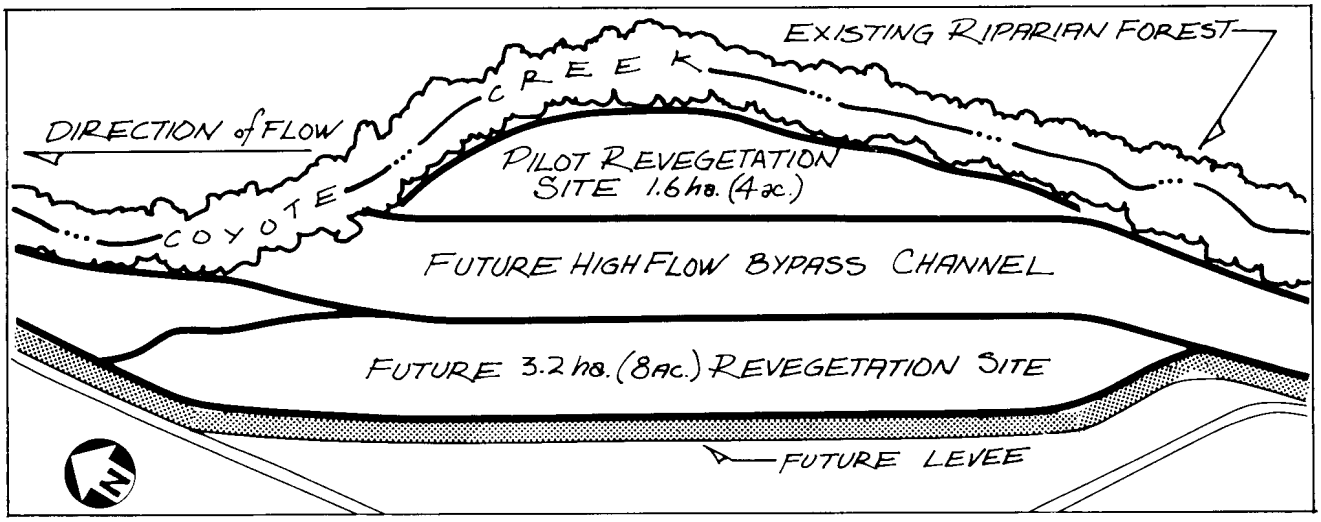

Figure 2– Site Plan

During the months of May, June and July the ground water level is at its highest. This is due to the ponding of water (for agricultural purposes) in the lower portion of Coyote Creek adjacent to the revegetation site. A flashboard dam, located a short distance downstream of the revegetation site, is usually installed in April and removed in November of each year.

The soil at the site is a fertile sandy loam with variable amounts of sand and silt. It is well drained and has an occasional clay lens at about 1.2 m (47.2 in).

Methods

The following tabulation presents the propagules that are being tested for each plant species:

Scientific Name	Common Name	Propagule
Acer negundo spp. *californicum*	California box elder	c,s,g
Alnus rhombifolia	White alder	g,t,l
Fraxinus latifolia	Oregon ash	b,g
Juglans hindsii	California black walnut	s,g
Platanus racemosa	Western sycamore	g
Populus fremontii	Fremont cottonwood	pc,c,l
Quercus agrifolia	Coast live oak	s,g
Quercus lobata	Valley oak	s,g,p
Salix laevigata	Red willow	c,l,g
Salix lasiandra	Yellow willow	c,l,g
Sambucus mexicana	Blue elderberry	l,c,s
Umbellularia californica	California bay	s,g
Artemisia douglasiana	Mugwort	l
Rosa californica	California rose	l,s
Rubus vitifolius	California blackberry	i

Key: b=bare root, c=cutting, g=1-gallon container, l=leach tube, p=4" pot, pc=pole cutting, s=seed, t=transplant

For each plant species one type of plant material was selected as the preferred propagule (listed first). The preferred propagule was the one considered to be highly likely to succeed and at the same time the most economical to install and maintain. Preference was given to planting more of the preferred propagules than the alternates.

Planting Design and Layout

The revegetation site was divided into two major areas for the purpose of testing flood versus overhead sprinkler irrigation. It was intended that, to the extent possible, the northern area (Area A), and the southern area (Area B), would be similar in design. The use of symetrical and evenly spaced "test plots" was purposely avoided in order to achieve the desired result of a naturally appearing riparian community.

The site was divided into two planting zones; Zone 1 extending westward from Coyote Creek for a distance of 45.5 m (150 ft). and Zone 2 covering the remainder of the site west of Zone 1. This zonation was an attempt to incorporate the plant species' differences in moisture requirements into the design. Zone 1 plant species are typical of a mid-level flood plain terrace while the Zone 2 plant list represents the plant assemblage which might be expected on an upper-level flood plain terrace. Most of the plant species planted in Zone 1 currently occur along lower Coyote Creek. Selection of the Zone 2 list was based upon analysis of the floristic composition along other streams in the region.

Design considerations included planting those tree species which naturally occur together in associations to produce groves. Certain other tree species were either planted only as individuals (e.g. coast live oak),

or in single species groves (cottonwood, willow, alder and walnut) which is their more common pattern of occurrence. The shrub and groundcover species were planted either within, adjacent to, or connecting the groves of trees.

The groves composed of one tree species were planted only in Zone 1. Groves consisting of more than one tree species varied in their composition depending upon the planting zone. The following are the plant associations and the percent composition of each of the trees and shrubs planted in mixed species groves.

Plant spacing and planting density varied according to the species. Generally, plants were installed on 1.8-2.4 m (6-8 ft) centers. This close spacing will compensate for dieback and was also employed to provide enough of each propagule.

Site Preparation

The revegetation site was an abandoned orchard covered with tall, dense weeds. It was cleared in the fall shortly before planting. A track-laying tractor with a blade, a grader, and a backhoe with a box scraper (provided by the San Jose Department of Water Pollutions Control) were used to clear the weeds. A ridger behind a tractor was used to create the levees for the flood irrigation cells.

A wire mesh fence, 91 cm (3 ft) above and 76 cm (2.5 ft) below ground, was installed along the western boundary of the project site to restrict rabbit, rodent and human access. Invasive non-native plant species, including giant reed (*Arundo donax*) and tree tobacco (*Nicotiana glauca*), were removed followed by application of glyphosate (Roundup) where Sprouting occurred. Gophers and rabbits were trapped and removed from the site prior to plant installation.

Plant Association	Zone 1 (1st 45.5 m)	Zone 2 (>45.5 m)
Sycamore Assoc.	60 pct. Sycamore 5 pct. Ash 10 pct. Elderberry 20 pct. Box elder 5 pct. Bay	70 pct. Sycamore 20 pct. Elderberry 10 pct. Bay
Box elder Assoc.	50 pct. Box elder 20 pct. Elderberry 15 pct. Ash 15 pct. Bay	60 pct. Box elder 30 pct. Elderberry 10 pct. Bay
Valley oak Assoc.		70 pct. Valley oak 10 pct. Black walnut 5 pct. Ash 10 pct. Elderberry 5 pct. Willow

Plant Installation

Three-meter (10-ft) long pole cuttings were taken from nearby Fremont cottonwoods. Poles were no larger than 4.4 cm (1 3/4 in) in diameter with the branches and succulent tops pruned off. The poles were inserted into augered 1.8 m (6 ft) deep, 20 cm (8 in) diameter, holes which were then back-filled with "tamped-in" native soil.

Cuttings (approximately 1.2 m long) of cottonwood, box elder and willow were also obtained nearby. The slant-cut ends were dipped in rooting hormone just prior to installation. Transplants of white alder were taken from the gravel bar of a nearby creek, transported to the site and planted in native soil.

Leach tube super cells (3.8 cm [1-1/2 in] by 20 cm [8 in] plastic tubes) sometimes referred to as tubelings or liners, 1 gallon size container stock and 4-inch pots were installed directly into the native soil.

Most of the plants and cuttings, with the exception of the large pole cuttings, were individually protected with plastic photo-degradable forest tree protectors 12 cm (5 in) in diameter and 61 cm (24 in) tall to prevent browsing and girdling by rabbits or rodents. Additionally, each planting hole received a slow release fertilizer tablet.

Seeds of box elder, live oak, valley oak, walnut, bay and rose were direct seeded into protective collars (1 quart size cottage cheese containers with the bottoms removed) with 46 cm (18 in) tall aluminum insect screen cylinders attached (Chan and others 1977). A sterile soil medium was used in the top 8 cm (3 in) of the collars to reduce weed germination. Black walnut, coast live oak, valley oak and bay were planted with 3 seeds per planting location. Approximately 10 of the smaller seeds were planted within each collar.

Irrigation

Water is pumped from Coyote Creek with a gasoline pump into a 10 cm (4 in) mainline. Four manifold valves which serve 7.6 cm (3 in) aluminum irrigation pipe branch off the mainline for the sprinkler section, and are removed to feed the flood section cells. There are also two non-irrigated control areas. Irrigation during the first year was on a 1 to 2 week schedule during the spring and early summer, or as needed, and tapered off to every 3 to 4 weeks in the fall.

Weed Control

A variety of weed control measures and types of equipment are being tested for effectiveness and cost. Both fabric and bark mulch were used around some of the plantings. A combination of mowing, tilling, and hoeing has been used to control weed growth between the plantings. Roundup was also used in certain areas.

Results and Discussion

One year of maintenance, and analysis of monitoring data collected in the fall of 1987, have allowed us to make some preliminary observations about certain aspects of the project. The present analysis evaluates 1318 propagules irrigated by flooding and 2107 propagules irrigated by overhead sprinklers and excludes 215 propagules installed outside of these areas.

First Year Survival

Permanent grid lines running east-west across the revegetation site were established at 12 m (40 ft) intervals. This made it possible to relocate each plant without employing a rigid structure for the layout of the planting trials. During the first three years after installation, each plant will be inspected and evaluated in mid-fall as to survival, height, spread, vigor and type of any damage.

A comparison of survival (after one growing season) of all plant materials in Area A (flood irrigation) versus Area B (overhead sprinkler irrigation) shows that there were generally similar levels of survival. In the flood irrigation area, 73.1 percent survived, compared to 75.8 percent survival in the sprinkler irrigation area (table 1).

Certain propagules had a higher rate of survival under one irrigation method than under the other. California black walnut seed, cuttings of blue elderberry, and seed of California bay, had much greater survival in the sprinkler irrigated area. The cuttings and leach tube plants of Fremont cottonwood, 1 gallon and cuttings of willow, and leach tubes of mugwort all were clearly more successful in the flood irrigated area. One gallon coast live oak were also more successful in the flood irrigated area; however, because of the small sample size of this propagule, this difference may not be significant.

To evaluate survival among different propagules of each species, the data were combined for both irrigation techniques. Box elder seed and 1 gallon plants had a clearly greater survival rate than cuttings. White alder transplant survival was high compared with other propagules of this species. Oregon ash had a similar rate of survival for both bare root and gallon size plants. Seeds of California black walnut had a survival rate of about 20 percent less than 1 gallon material. Pole cuttings of Fremont cottonwood had the highest level of survival of the three types of propagules tested for this species. Because of the low numbers of 1 gallon plants of coast live oak, a determination of the significance of the disparity in survival between these and direct seeded propagules is not possible. For the same reason, the 100 percent survival of 4-inch pots of valley oak may not be significant when compared with the survival rates of the seed and 1 gallon material for this species. However, 1 gallon valley oak were clearly more successful than seeds. All willow propagules had a high level of survival. Blue elderberry leach tubes were much more successful than seeds and cuttings. One gallon plants of California bay and leach tubes of California rose had much greater survival than seed of these species. Although it was recorded that there was no survival of California rose seed when the trial plantings were monitored in the fall of 1987, field personnel have since noted germination of rose seeds in several of the collars in the spring of 1988.

Depth To Groundwater

Water ponded in Coyote Creek by the agricultural dam and the subsequent rise in the ground water level during the summer is an unusual situation that could have adverse or beneficial effects on the survival and growth of the plantings at the revegetation site. Excavations of the root systems of certain tree species indicate that their roots have already reached saturated soil. If this is indicative of root development in general, the watering regime could be discontinued without significant loss of trees.

Weed Control

Abundant weed growth has resulted from the summer irrigation making weed control a formidable task. The weed problem may have been reduced by better site preparation such as discing or tilling several times during the growing season to exhaust latent seed in the soil, using pre-emergent herbicide, removing the top 30 to 40 centimeters of soil, and/or sowing a low growing herbaceous ground cover mix to out-compete the weeds.

The redwood bark mulch was somewhat effective in reducing weed growth and also made the pulling of weeds easier. However, numerous weeds grew through the mulch. The fabric mulch was ineffective as it covered too small an area and was anchored with soil which supported weed establishment. Flood irrigation deposited additional soil on top of the fabric mulch promoting the establishment of weeds whose roots then penetrated the fabric. A larger sized fabric mulch secured with wire staples would have been more effective.

A Bachtold High Weed Mower has proven to be the most effective weed control device for the site. The scythe is the next most useful weeding tool, especially for use in the flood irrigated cells where the ground is uneven and the cell ridges impede the mower.

April and May applications of Roundup resulted in initial dieback of the weeds. However, as a result of summer irrigation and a large seed bank in the soil, the weeds returned. Late summer applications of Roundup did not suppress the weeds on the site, probably due to the lateness of the application with respect to the growing cycle of the plants.

Table 1-Propagule survival in flood and overhead sprinkler irrigated areas.*

Species		Area A (flood)			Area B (sprinkler)			Total		
	Propagule	Number Planted	Number Surviving	(Pct)	Number Planted	Number Surviving	(Pct)	Number Planted	Number Surviving	(Pct)
Acer negundo	Cutting	47	16	(34.0)	81	23	(28.4)	128	39	(30.5)
	Seed	26	23	(88.5)	8	7	(87.5)	34	30	(88.2)
	1 gallon	36	29	(80.6)	45	38	(84.4)	81	67	(82.7)
Alnus rhombifolia	Leach tube	-	-		21	13	(61.9)	21	13	(61.9)
	Transplant	-	-		14	13	(92.9)	14	13	(92.9)
	1 gallon	22	16	(72.7)	58	38	(65.5)	80	54	(67.5)
Fraxinus latifolia	Bare root	25	24	(96.0)	46	40	(87.0)	71	64	(90.1)
	1 gallon	16	16	(100.0)	32	26	(81.3)	48	42	(87.5)
Juglans hindsii	Seed	39	10	(25.6)	62	36	(58.0)	101	46	(45.5)
	1 gallon	5	4	(80.0)	18	11	(61.1)	23	15	(65.2)
Platanus racemosa	1 gallon	337	324	(96.1)	429	375	(87.4)	766	699	(91.2)
Populus fremontii	Pole cutting	65	56	(86.2)	485	435	(89.7)	550	491	(89.3)
	Cutting	42	24	(57.1)	24	10	(41.7)	66	34	(51.5)
	Leach tube	6	1	(16.7)	17	0	(0)	23	1	(4.3)
Quercus agrifolia	Seed	150	57	(38.0)	12	4	(33.3)	162	61	(37.7)
	1 gallon	9	8	(88.9)	10	3	(30.0)	19	11	(57.9)
Quercus lobata	Seed	72	50	(69.4)	133	98	(73.7)	205	148	(72.2)
	4-inch pots	6	6	(100.0)	-	-		6	6	(100.0)
	1 gallon	133	123	(92.5)	202	187	(92.5)	335	310	(92.5)
Salix sp.	Cutting	49	45	(93.1)	79	54	(68.4)	128	99	(77.3)
	Leach tube	-	-		2	2	(100.0)	2	2	(100.0)
	1 gallon	31	29	(93.5)	63	41	(65.1)	94	70	(74.5)
Sambucus mexicana	Cutting	31	8	(25.8)	44	16	(36.9)	75	24	(32.0)
	Seed	29	1	(3.4)	21	0	(0)	50	1	(2.0)
	Leach tube	67	49	(73.1)	94	74	(78.7)	161	123	(76.4)
Umbellularia californica	Seed	12	0	(0)	21	5	(23.8)	33	5	(15.2)
	1 gallon	30	29	(96.7)	41	37	(90.2)	71	66	(92.9)
Artemisia douglasiana	Leach tube	13	10	(76.9)	8	3	(37.5)	21	13	(61.9)
Rubus vitifolius	Leach tube	6	0	(0)	9	2	(22.2)	15	2	(13.3)
Rosa californica	Seed	-	-		17	0	(0)	17	0	(0)
	Leach tube	14	6	(64.3)	11	7	(63.6)	25	13	(52.0)
TOTAL		1318	964	(73.1)	2107	1598	(75.8)	3425	2562	(74.8)

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* Data for seed propagules refer to the number of seeded locations.

Irrigation

The economic and horticultural feasibility of flood and overhead sprinkler irrigation are being tested because direct individual irrigation methods (drip, bubbler, truck) have been tested and quantified in previous studies. Perhaps agricultural methods will prove to be less expensive.

Filling flood cells with water was laborious due to breaks in levees, abandoned subsurface drains from the old orchard, and irregularities in topography and flood cell design. Some species in the overhead sprinkler irrigation area developed leaf mildew.

Initial growth in the flood irrigation area subjectively appeared to be more rapid than in the sprinkler section. Most of the cottonwood pole cuttings were 3.6-4.6 m (12-15 ft) tall at the end of one growing season. We will be analyzing the data on growth rates of the trees after we collect another year's data.

Ongoing Monitoring

Changes in the vegetation at the site are being monitored in conjunction with a wildlife monitoring program being conducted by Harvey & Stanley Associates and CCRS. A systematic vegetation sampling program is being employed to document semiannual changes in canopy height, canopy cover, foliage density and diversity at different heights within the canopy and herbaceous cover.

The plantings at the revegetation site will be monitored annually for 2 more years. Survival and growth data will be evaluated at the end of the 3 year monitoring program. Figures 3-9 show some examples of plant growth as of August/September of 1988.

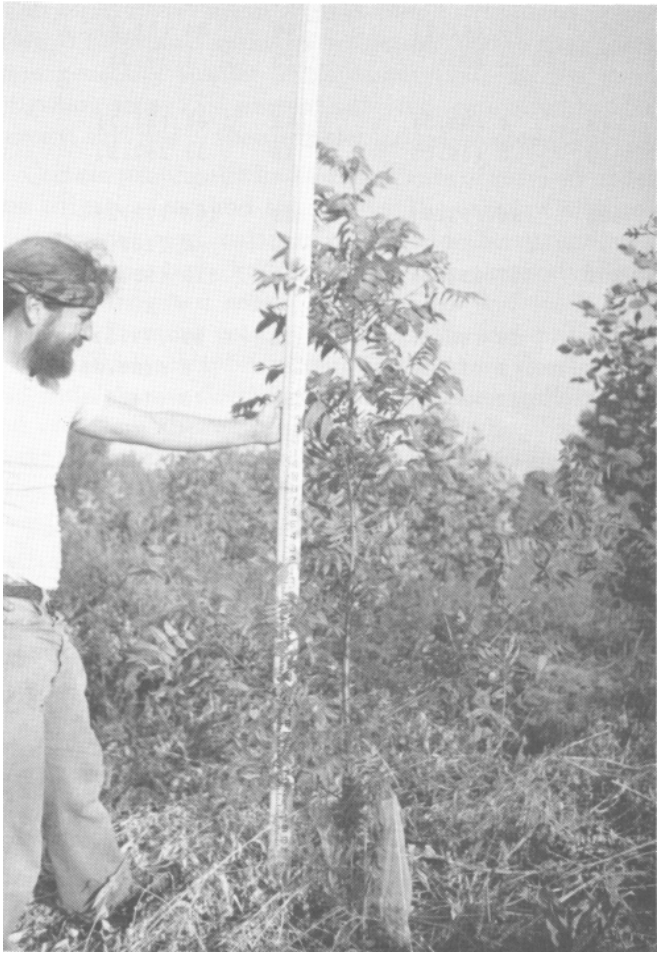

Figure 3– California Black Walnut from seed, 19 months after installation (2.0 m [6.8 ft], flood irrigation).

Figure 4– Flowering Ash from 1 gallon stock, 19 months after installation (2.6 m [8.5 ft], flood irrigation).

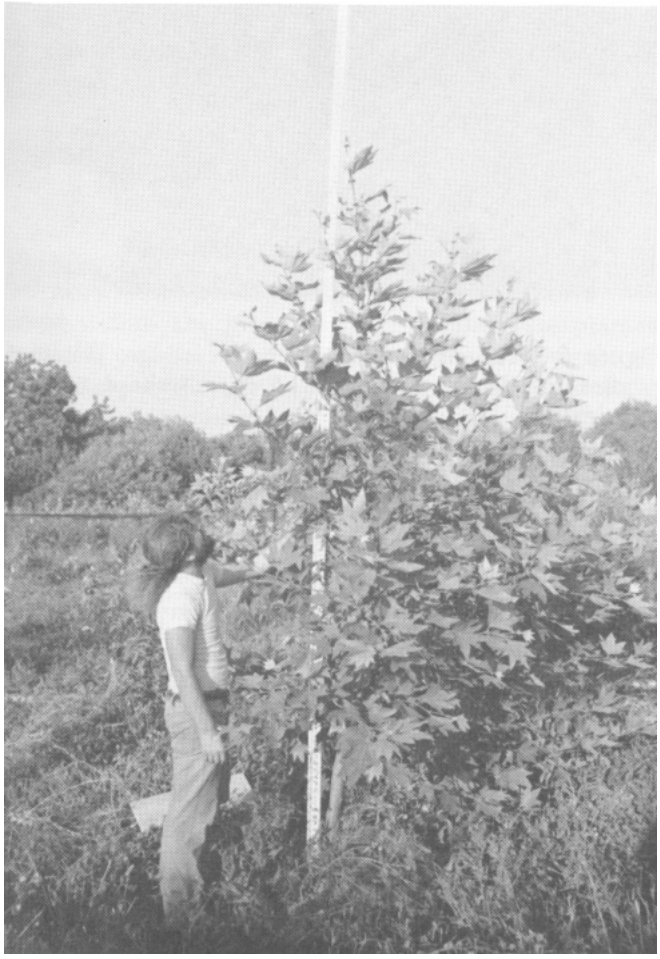

Figure 5- Western Sycamore from 1 gallon stock, 19 months after installation (3.3 m [11 ft], flood irrigation).

Figure 6- Valley Oak from 1 gallon stock, 19 months after installation (2.2 m [7.3 ft], flood irrigation).

Figure 7- Blue Elderberry from 1 gallon stock, 19 months after installation (flood irrigation, note fruit).

Figure 8- Western Sycamore and Blue Elderberry from 1 gallon stock, 19 months after installation (3.2 m [10.8 ft], overhead sprinkler irrigation).

Figure 9- Fremont Cottonwood pole cuttings, 19 months after installation (7.1 m [23.5 ft], overhead sprinkler irrigation).

References

Chan, F. J.; Harris, R.W.; Leiser, A.T. 1977. Direct seeding of woody plants in the landscape. Cooperative Extension Leaflet 2577, Div. Agric. Sciences, University of California, Davis. 13p.