Plant Materials and Establishment Techniques for Revegetation of California Desert Highways

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ABSTRACT

Soil erosion can be severe along desert roadsides, especially after new construction. Container plantings and direct seedings of available plant materials have not always provided needed long-term erosion control. In 1978 the California Department of Transportation contracted with the U.S. Department of Agriculture, Soil Conservation Service, to test new plant materials for roadside revegetation in the desert environment. Direct seedings of herbaceous perennials were largely unsuccessful. Red brome (Bromus rubens), an annual grass, showed potential. Seedings of woody plants were more successful. Desert saltbush (Atriplex polycarpa), Marana fourwing saltbush (Atriplex canescens) and Casa quailbush (Atriplex lentiformis) established good stands at three of the five planting sites. Desert encelia (Encelia farinosa), big sagebrush (Artemisia tridentata), California buckwheat (Eriogonum fasciculatum), and Dorado bladderpod (Isomeris arborea) grew well at two of the five sites. These seven shrubs also performed well in container plantings. Woody plants that grew successfully from containers but not from direct seedings were desert broom (Baccharis sarothroides), shadscale (Atriplex confertifolia), bursage (Ambrosia dumosa), creosoto bush (Larrea tridentata), and rubber rabbitbrush (Chrysothamnus nauseosus). Wildlife depredation was the greatest cause of shrub mortality.

Survival of nonirrigated perennial vegetation planted along California highways has often been lower than expected. This is particularly true in the desert environment where little, if any, precipitation occurs during the hot summer months. In 1978, the California Department of Transportation (Caltrans), in cooperation with the FHWA, entered into a 5-year agreement with the U.S. Department of Agriculture, Soil Conservation Service (SCS), to gain information that could improve survival of seeded and planted material. Several problems were investigated under the agreement; however, only the portion of the project that dealt with the testing of plant materials and establishment methods along highways in the desert environment will be discussed.

Sites in the Mojave Desert were selected to adequately test plant materials within different rainfall areas as well as on representative desert soils. Plantings were made at five locations. A site along CA-14 near Lancaster is within the 8-in. (20.3-cm) mean annual precipitation (MAP) zone and the soil type is a coarse sandy loam. The Edwards Air Force Base site, approximately 20 miles (32 km) northeast of the Lancaster site, lies in the 5.5-in. (14-cm) MAP zone and the soils consist of fine sandy loams. A third location 7 miles (11.3 km) west of Ridgecrest on US-395 is on a sandy loam within the 5.5-in. (14-cm) MAP zone. The fourth site, also along US-395, is 22 miles (35.2 km) north of the Ridgecrest site within the 7.5-in. (19.0-cm) MAP zone and situated on decomposed granite. The fifth and driest site is 41 miles (55 km) east of Barstow on gravelly sandy loam in the 4-in. (10.2-cm) MAP zone. Temperatures throughout the desert range from a low of about 20°F (7°C) in January to over 110°F (43°C plus) during the summer.

The work consisted of two phases: (a) direct seedings of herbaceous and woody plants and (b) establishment of vegetation from container stock. More than 300 seeded plots and 2,000 container-grown shrubs were planted during the project.

METHODS

Standard planting techniques were used throughout the study with few variations (1). Any nonstandard system would have to show exceptionally good results to be incorporated into the Caltrans revegetation program. Plots were seeded at a rate of 20 lb/acre (22.5 kg/ha). Initially mixtures of shrub and herbaceous species were seeded together to observe what effect one species might have on another after germination. Because success of this method was limited, this procedure was abandoned and all species were subsequently seeded in individual plots.

Seed was both drilled and broadcast. At the start of the project, seedbed preparation consisted of disking and harrowing. Later when only single species plots were established, slope surfaces were roughened by a modified harrow. Straw was applied at a rate of 4,000 lb/acre (4490 kg/ha) and wood fiber and paper product at a rate of 2,000 lb/acre (2245 kg/ha). Fertilizer (16-20-0) at a rate of 250 lb/acre (280 kg/ha) was either broadcast with the seed before strawing or applied with the slurry of wood fiber or paper mulch. Plots were generally 10 x 20 ft (3 x 6 m) in size.

Seed of commercially available grass varieties was purchased. Early in the program shrub seed was purchased from native seed collectors, but as the study progressed seed was collected by project personnel. The main emphasis was on native plant materials. Some nonnative species were included for comparisons. Container stock was purchased during the first year of the study. In following years, container plants were raised from seed collected as part of the study (2,3). Propagation was done at the Antelope Valley Resource Conservation District Nursery near Lancaster and the SCS Plant Materials Center in Lockeford (4). Most desert shrub seed does not need treatment to encourage germination. For those few species that do, however, seeds were given appropriate hot water and cold stratification as recommended (5).

Two types of containers were tested: gallon-can size and bookplanters [1.5 x 8 in. (3.8 x 20.3 cm) folding plastic plant bands]. When possible 20 shrubs of each accession were planted, 10 of each container type. For ease of evaluation, 10 shrubs were planted in each row. Plants were spaced 3 ft (0.91 m) apart and rows 5 ft (1.5 m) apart. Two ounces (57 g) of slow-release fertilizer (7-40-6)

were mixed with backfill material at the time of planting. All shrubs were watered immediately after planting. A portion of each shrub accession was irrigated monthly from May through October with one gallon (4.2 L) of water per plant. Holes approximately 12 in. (30.5 cm) deep were dug with soil augers or other common garden implements. Rodent protectors made of plastic mesh 3 in. (7.6 cm) in diameter and 15 in. (38.1 cm) high were placed around all shrubs planted in the second through fifth years because loss to rodents was high during the first year.

RESULTS

Except for some of the annual grasses, direct seedings of herbaceous plant material proved to be unsuccessful. Most of the more common annual and perennial grass varieties adapted to low-rainfall areas were tested. In 1979-1980, a year of abnormally high precipitation [13 in. (33 cm)], most grasses germinated. Annual grasses are opportunistic and take advantage of precipitation. Red brome (Bromus rubens), an annual grass, showed potential for revegetation. Perennial vegetation is preferred; however, a good reseeding annual grass has revegetative uses in the desert environment. Table 1 gives some of the grass varieties and their success.

TABLE 1 Herbaceous Plant Materials Established by Direct Seeding

Species	Ground Cover (%)		
	1st Year	2nd Year	5th Year
Agropyron elongatum (Largo tall wheatgrass) (P)	Trace	2	Trace
Bromus rubens (red brome) (A)	60	30	5
Bromus mollis (Blando brome) (A)	20	2	Trace
Lolium rigidum (Wimmera 62 ryegrass) (A)	30	0	0
Trifolium hirtum (rose clover) (A)	50	0	0
Vulpia myuros (Zorro annual fescue) (A)	80	30	Trace

Note: P = perennial, A = annual.

Several perennial grass species were planted as container stock. This technique has been used with some success to establish Indian ricegrass in the Great Basin (6). As part of this study several plants of each grass species were irrigated. No significant differences were seen between irrigated and nonirrigated plants. Container plants were tested to observe survival, seed production, and rhizome activity. Grasses survived better when planted from containers than when seeded directly. Performance, however, was not good enough to recommend the procedure as a standard practice. Grasses planted as container plants are given in Table 2.

Direct seedings of woody plants were much more successful than seedings of herbaceous species. On slopes where soils were deep or parent material fragmented, woody plants did become established. Indigenous woody species generally did best. Species classified as invaders were not easily established. Many climax species were also difficult to establish. Most successful were shrubs appearing naturally in an intermediate stage of succession.

Many invader or pioneer species are of the sunflower (Compositae) family. Plants of this family are prolific seed producers, but seed viability is short. Because seed germination of many composites is low, proper seedbed preparation is important.

TABLE 2 Herbaceous Plant Materials Established from Container Stock

Species	Survival (%)			
	2nd Year		5th Year	
	I	NI	I	NI
Agropyron elongatum (Largo tall wheatgrass)	33	0	33	0
Agropyron intermedium trichophorum (Luna pubescent wheatgrass)	33	0	33	0
Dactylis glomerata (Berber orchardgrass)	0	0	0	0
Dactylis glomerata (Palestine orchardgrass)	0	0	0	0
Oryzopsis hymenoides (Paloma Indian ricegrass)	20	0	20	0
Oryzopsis miliacea (smilo)	100	100	50	50
Sporobolus airoides (alkali sacaton)	67	100	67	50
Stipa speciosa (desert stipa)	33	0	0	0

Note: I = irrigated, NI = nonirrigated.

Rough seedbeds often provide favorable environments for light seed to lodge and germinate. If conditions are not right (old seed, smooth hard seedbed, or late precipitation) germination may not occur.

The saltbushes (Atriplex sp.) of the family Chenopodiaceae have been the most consistent and successful of all woody plants seeded. The seeds remain viable for several years and are large enough to be easily planted. Desert saltbush (Atriplex polycarpa) has consistently established stands at the Little Lake, Ridgecrest, and Lavic Road sites. Marana fourwing saltbush (Atriplex canescens) and Casa quailbush (Atriplex lentiformis) produced fair to good stands at the same locations. Desert encelia (Encelia farinosa) and big sagebrush (Artemisia tridentata), both members of the sunflower family, grew well at the Little Lake and Ridgecrest sites. Desert encelia has a large seed that is easily planted. Big sagebrush, however, has a small, light seed that is difficult to handle. California buckwheat (Eriogonum fasciculatum) and Dorado bladderpod (Isomeris arborea) grew well from seed at both the Little Lake and Ridgecrest sites. Of approximately 80 woody plant accessions seeded, only a few germinated and developed into matue shrubs. Table 3 gives the more successful species.

TABLE 3 Woody Plants Established from Direct Seedings

Species	Avg No. of Plants/Plot[a]	
	2nd Year	5th Year
Artemisia tridentata (big sagebrush)	2	2
Atriplex canescens (Marana fourwing saltbush)	11	10
Atriplex polycarpa (desert saltbush)	110	75
Atriplex lentiformis (Casa quailbush)	3	3
Isomeris arborea (Dorado bladderpod)	20	15
Encelia farinosa (desert encelia)	3	3
Eriogonum fasciculatum (California buckwheat)	4	3

[a] Plot size = 10 x 20 ft (3 x 6 m).

A number of factors must be taken into account when considering a new plant for use in revegetation. If the goal is to establish vegetation by direct seeding, it is important that the plant selected possess seed of sufficient size to be harvested, cleaned, stored, and planted easily. Plants that do not have this characteristic must be outstanding to warrant the development of specialized handling equipment. Physical characteristics of the seed are not as important when container plants are used. Large volumes of seed are not needed to produce container-grown stock. During this study native species were the most successful from containers. Several woody species that did not become established from direct seedings did well from container

stock. The most economical way to establish vegetation is definitely through direct seeding. However, there are instances where the greater certainty of obtaining an established plant through the use of container stock will offset the cost.

Only 10 percent of the shrubs planted during the first year of the study survived. Rodents were primarily responsible for the high mortality. Other investigators have also experienced setbacks due to wildlife depredation (7). All plantings made after the first year were shielded by protectors. The devices used were constructed so that they could be quickly slipped over a plant and held in place by a wooden lath. Plant survival increased to about 75 percent overall. Rodents do some harm to the plastic protectors and shrubs, but damage is slight.

Of all shrub species planted from containers, the saltbush species showed the best growth and survival. Desert saltbush, Marana fourwing saltbush, and Casa quailbush were the outstanding shrub species planted. Fair to good performance was shown by several other woody species as well (Table 4).

TABLE 4 Woody Plants Established from Container Stock (Ridgecrest Site)

	Average Survival (%)			
	2nd Year		5th Year	
Species	I	NI	I	NI
Artemisia cana (silver sage)	67	0	33	0
Artemisia frigida (fringed sage)	33	0	33	0
Artemisia tridentata (big sagebrush)	33	0	33	0
Atriplex canescens (Marana fourwing saltbush)	100	100	100	100
Atriplex confertifolia (shadscale)	100	100	80	80
Atriplex lentiformis (Casa quailbush)	67	100	33	50
Atriplex nummularia (Oldman saltbush)	100	100	67	50
Atriplex polycarpa (desert saltbush)	67	100	67	100
Atriplex torreyi (Torrey saltbush)	100	100	67	50
Baccharis sarothroides (desert broom)	100	100	100	100
Chrysothamnus nauseosus (rubber rabbitbrush)	100	67	100	67
Ephedra nevadensis (Nevada ephedra)	67	100	67	100
Ephedra viridis (green ephedra)	100	100	67	100
Eriogonum fasciculatum (California buckwheat)	33	50	33	50
Ambrosia dumosa (bursage)	67	100	67	50
Grayia spinosa (spiny hopsage)	67	0	0	0
Lycium andersonii (wolfberry)	100	50	33	50
Larrea tridentata (creosote bush)	100	75	100	75

Note: I = irrigated, NI = nonirrigated.

At the beginning of the study, container plantings were made in both the fall and late winter. Fall plantings were severely hurt by winter snows. Even though hard winters do not always occur, late winter or early spring plantings are less of a risk than fall plantings. Plantings after the first year were made in late winter.

CONCLUSIONS

No perennial grass performed well enough to recommend its use in a seeding mixture for the Mojave Desert. Several seeded perennial grasses germinated, but none could tolerate the droughty soil and intense heat. Annual grass and legume species, such as red brome, Zorro annual fescue, and Hykon rose clover, are the preferred herbaceous plants to seed because they are opportunistic and take advantage of moisture when it is available. For long-term erosion control it is best to revegetate with woody plants. The Atriplex sp. (Table 3) consistently produced good stands.

Direct seedings should be drilled wherever possible. Seeds broadcast onto the soil surface and covered with mulch have less chance of germinating than seeds incorporated in the soil. Fertilizer, such as ammonium phosphate sulfate 16-20-0, at a rate of 250 lb/acre (273 kg/ha) should accompany the seed.

Wood fiber and paper mulch products do not provide as effective a mulch as straw (8). Straw, however, can be readily blown from the site if it is not secured. Applying hydromulched wood fiber or paper product over the straw at a rate of 750 lb/acre (818 kg/ha) will hold the straw in place. Straw applied at a rate of 2 tons/acre (1.96 metric tons) has proved satisfactory. Container-grown shrub plantings usually become established more quickly than direct seedings. Several species (Table 4) can be planted with a high probability of success. The type of treatment (irrigation, container size, and so forth) at the time of planting is less important than the condition and vigor of the plant material. Rodent protectors are necessary and should be included as a part of any planting.

Irrigation did not increase the survival of most shrub species. It might, however, be helpful during the establishment year if precipitation is abnormally low. Shrubs that performed best were those naturally adapted to the desert environment. Plantings should be made in late winter or early spring. Shrubs that are planted during this period will have sufficient time to acclimate themselves before the onset of the hot summer.

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