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OFFICE OF TRANSPORTATION LABORATORY

REVEGETATION OF HIGHWAY SLOPES IN THE HIGH DESERT WITH NATIVE PLANT SEEDLINGS: INTERIM REPORT

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16. ABSTRACT

Revegetation of highway slopes in the California high desert is being done for erosion control, restoration of wildlife habitat, and improved aesthetics. Objectives are to compare the success of revegetating highway slopes using seedlings from three sources and to evaluate costs. Seedlings were from three sources:
1- Nonlocal seedlings were purchased from commercial nurseries in Utah and Washington, 2- nonlocally gathered seed was purchased from commercial nurseries in Utah and Washington and seedlings were raised locally at facilities in Owens Valley, California by Caltrans and others, and 3- seed was collected and seedlings were raised locally by Caltrans and others.

The completed research tasks of species selection, seed collection, seedling propagation, facilities augmentation, and planting seedlings on highway slopes are reported. Percentages of surviving seedlings as of October, 1985 are high. Raising seedlings locally can be done in a lathhouse in early spring for planting in late spring or early fall. Raising seedlings in the greenhouse at the Owens Valley Conservation Camp in winter was not feasible.

Four cut slopes along US 395 in Mono and Inyo Counties were planted with 1080 container-grown, native, woody shrubs. Species planted were big sagebrush (Artemisia tridentata), fourwing saltbush (Altriplex canescens), rubber rabbitbrush (Chrysothamnus nauseosus), gray ephedra (Ephedra nevadensis), and antelope bitterbrush (Purshia tridentata). For the first six months half the seedlings received supplemental water and half did not.

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CONVERSION FACTORS

English to Metric System (SI) of Measurement

Quality	English unit	Multiply by	To get metric equivalent
Length	inches (in)or(")	25.40 .02540	millimetres (mm) metres (m)
	feet (ft)or(')	.3048	metres (m)
	miles (mi)	1.609	kilometres (km)
Area	square inches (in^2) square feet (ft^2) acres	6.432×10^{-4} .09290 .4047	square metres (m^2) square metres (m^2) hectares (ha)
Volume	gallons (gal) cubic feet (ft^3) cubic years (yd^3)	3.785 .02832 .7646	litre (l) cubic metres (m^3) cubic metres (m^3)
Volume/Time (Flow)	cubic feet per second (ft^3/s	28.317	litres per second 1/s)
	gallons per minute (gal/min)	.06309	litres per second (1/s)
Mass	pounds (lb)	.4536	kilograms (kg)
Velocity	miles per hour (mph) feet per second (fps)	.4470 .3048	metres per second (m/s) metres per second (m/s)
Acceleration	feet per second squared (ft/s^2)	.3048	metres per second squared (m/s^2)
	acceleration due to force of gravity (G) (ft/s^2)	9.807	metres per second squared (m/s^2)
Density	(lb/ft^3)	16.02	kilograms per cubic metre (kg/m^3)
Force	pounds (lbs) (1000 lbs) kips	4.448 4448	newtons (N) newtons (N)
Thermal Energy	British termal unit (BTU)	1055	joules (J)
Mechanical Energy	foot-pounds (ft-lb) foot-kips (ft-k)	1.356 1356	joules (J) joules (J)
Bending Moment or Torque	inch-pounds (in-lbs) foot-pounds (ft-lbs)	.1130 1.356	newton-metres (Nm) newton-metres (Nm)
Pressure	pounds per square inch (psi) pounds per square foot (psf)	6895 47.88	pascals (Pa) pascals (Pa)
Stress Intensity	kips per square inch square root inch (ksi$\sqrt{in}$)	1.0988	mega pascals$\sqrt{metre}$ (MPa$\sqrt{m}$)
	pounds per square inch square root inch (psi$\sqrt{in}$)	1.0988	kilo pascals$\sqrt{metre}$ (KPa$\sqrt{m}$)
Plane Angle	degrees (°)	0.0175	radians (rad)
Temperature	degrees fahrenheit (F)	$\frac{+F - 32}{1.8} = +C$	degrees celsius (°C)

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INTRODUCTION

Project Overview

The initial stages of a research project on revegetating highway slopes in the California high desert were completed. The objective is to evaluate native seedlings for erosion control and environmental enhancement. The research is funded by the Federal Highway Administration (FHWA) and is being performed by the California Department of Transportation (Caltrans), Office of Transportation Laboratory (Translab).

Meaningful results of survival of woody shrubs requires three to five years of observation. Detailed analysis of results and an evaluation of costs will be included in a final report, after observations through June, 1988 are completed.

Four cut slopes along US Route 395 at three sites in Caltrans District 9 were planted with 1080 seedlings of container-grown, native, woody shrubs. Two groups of seedlings were planted: Fall, 1983 and Spring, 1984. The species were:

big sagebrush (*Artemisia tridentata*)
fourwing saltbush (*Atriplex canescens*)
rubber rabbitbrush (*Chrysothamnus nauseosus*)
gray ephedra (*Ephedra nevadensis*)
antelope bitterbrush (*Purshia tridentata*)

Figure 1 is a location map of the planting sites. Cut slopes, approximately twelve years old, were selected, where natural invasion of woody shrubs was progressing slowly.

Background, Objectives, Benefits

Revegetation of several highway cut slopes constructed in the early 1970's was not successful by using seeds of grasses and shrubs with different combinations of fertilizers and mulches. Trial plantings along US 395 in 1973 and 1974 of container-grown, native shrubs were successful, (Smith, Edell, and Jurak, 1). This research project began in November, 1982 as a result of the successful trial plantings by Edell and others.

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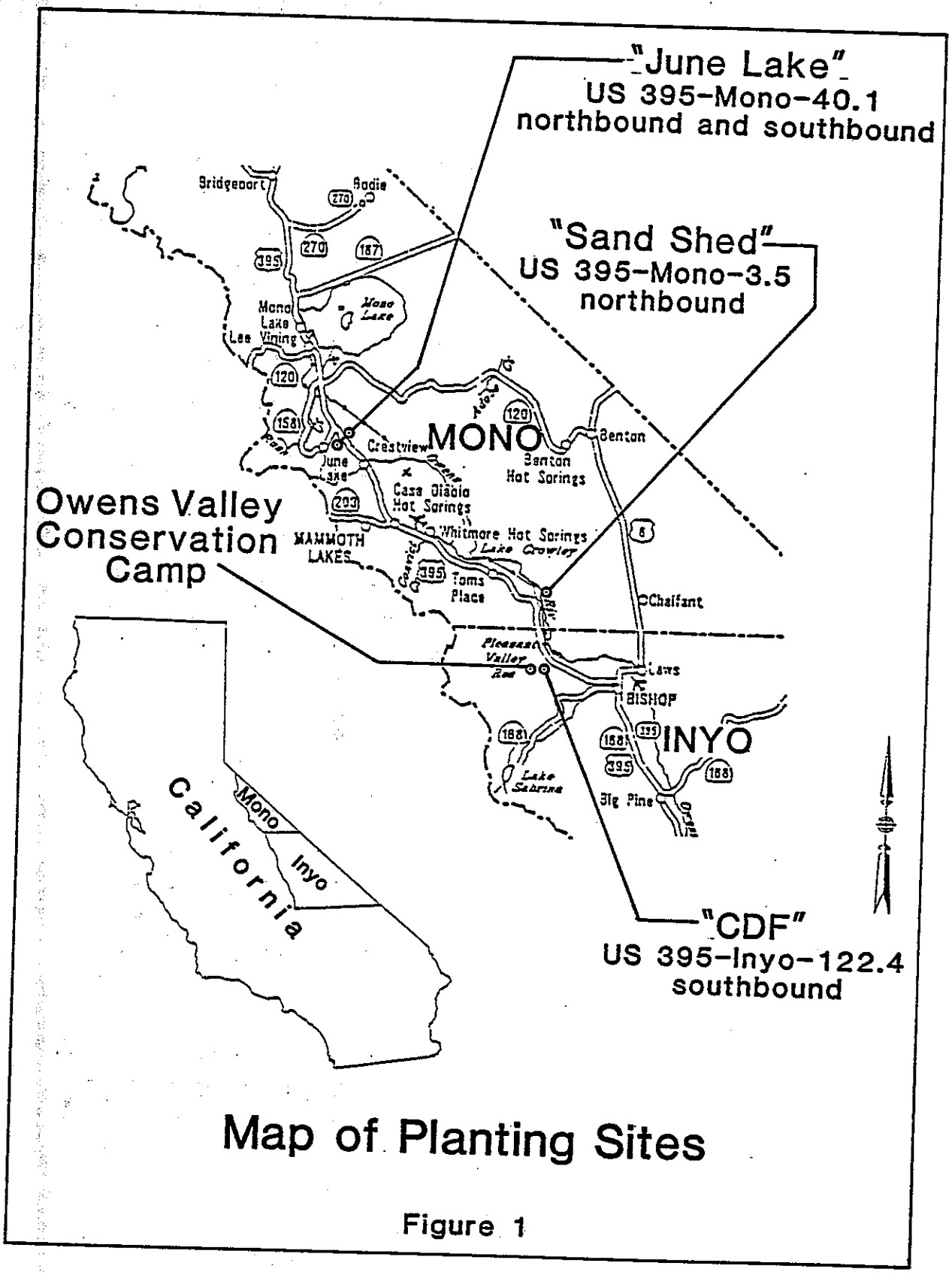

Map of Planting Sites

Figure 1

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The objectives of the research are to compare the success of revegetating highway cut slopes in the high desert of California using native seedlings from three sources and to evaluate costs.

The seedlings planted for research were from:

<u>seedlings grown nonlocally, purchased</u>, i.e., seed collected in the high deserts of Utah, Colorado, Nevada, or Washington and raised in commercial nurseries in Utah and Washington.

<u>seedlings grown locally from nonlocally gathered seed</u>, i.e., seed collected in the deserts of Utah, Colorado, Nevada, or Washington and raised at the Owens Valley Conservation Camp (OVCC) facilities by Caltrans and other agencies.

<u>seedlings grown locally from locally gathered seed</u>, i.e., seed collected in the California high desert and raised at the OVCC facilities by Caltrans and other agencies.

The benefits of successful revegetation are reduced slope erosion, dust control, restoration of wildlife habitat, and improved aesthetics.

<u>Interagency Cooperation</u>

The project is a cooperative effort among local, state, and federal agencies. An Interagency Committee was consulted regarding species selection, seedling propagation, and planting techniques. The Interagency Committee is a multidisciplinary team composed of people from:

City of Bishop
Counties of Inyo and Mono
Caltrans District 9
California Department of Corrections (CDC)
California Department of Forestry (CDF)
California Department of Fish and Game (DFG)
Los Angeles Department of Water and Power (LADWP)
United States Forest Service (USFS)
Death Valley National Monument
White Mountain Research Station, Univ. of Ca. Riverside
Soil Conservation Service, US Department of Agriculture

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Bureau of Land Management (BLM)

Cooperative Extension Service, Univ. of Ca., Davis

Caltrans, CDF, and CDC executed an interagency agreement to provide inmate laborers for collecting and processing seeds and raising seedlings locally. The agreement was in effect from July 1, 1983 through June 30, 1985. Greenhouse and lathhouse facilities were upgraded for propagating seedlings at the Owens Valley Conservation Camp, Round Valley. Space was provided for storage of and treatment of seeds. Access to facilities and selection of inmate labor was controlled by the CDC, because the camp is a minimum security prison. Collection of seeds and raising of seedlings was supervised by Caltrans District 9 and Translab personnel. Caltrans obtained permits from BLM, LADWP, and USFS for collecting seeds of native, woody shrubs. Caltrans District 9 and Translab personnel and inmates planted the seedlings on highway slopes. The USFS provided water before and at the time of planting.

Report Synopsis

The completed tasks of species selection, seed collection, seedling propagation, facilities augmentation, and planting seedlings on highway slopes are documented. The preliminary conclusions and recommendations do not give any comparisons among seedling sources, species, or treatments; however, there are conclusions and recommendations based on completed tasks. The status of the Fall, 1983 and Spring, 1984 seedlings is reported as a partial fulfillment of research objectives.

The report was reviewed extensively by people of many disciplines. Comments were incorporated when understanding was promoted. Species are spelled according to Munz and Keck. The convention of common names was used in the text, while tables and figures show both Latin and common names.

Member agencies of the Interagency Committee have implemented some of the findings of this research by planting at sites other than highway cut slopes. See Chapter 3, IMPLEMENTATION.

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PRELIMINARY CONCLUSIONS AND RECOMMENDATIONS

Conclusions

Operating the greenhouse at the Owens Valley Conservation Camp in winter was not feasible. Seedlings can be raised in early spring for planting in late spring or early fall. Seedlings raised in the winter in the greenhouse grew slowly. Seedlings started in spring, 1984 in the lathhouse caught-up with those started in winter, 1983 in the greenhouse.

Metal plant cages provide protection from browsing animals and mechanical stabilization of the slope by trapping sloughed sediment. Metal cages made from hardware cloth were visually more pleasing than yellow, plastic cages.

Recommendations

Metal plant cages should be at least 8 inches in diameter and 18 inches tall. A cage should be tied to a 2-foot lath driven one foot into the slope. Smaller cages will restrict shrubs.

Large seeds of woody shrubs should be seeded directly in roottrainers to reduce losses from transplanting from flats. Small seeds can be raised in flats then transplanted to roottrainers; however, planting several small seeds in roottrainers and thinning is recommended.

The sandy soil mixture used for the locally grown seedlings often collapsed during transplanting on slopes. A mixture should contain some loamy material (like humus) to aid in binding.

A preplanting irrigation should be done to reduce the chances of the root mass from wick drying.

The minimum spacing of seedlings on and between rows should be four feet. Spacing plants on slopes at less than four feet does not allow adequate room to work.

A soil probe should be used for watering the root mass in soils with slow percolation rates, instead of surface watering in basins. A soil probe can be made from a 3/8-inch diameter by 8-inch long steel spike attached to a sawed-off shovel handle.

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IMPLEMENTATION

Copies of this report will be given to the Federal Highway Administration and member agencies of the Interagency Committee.

Translab compiled a slide presentation of the research project showing the greenhouse and lathhouse, planting and watering techniques, and research plots. Presentations were given to the Interagency Committee in Bishop on November 2, 1984 and also at the Native Plant Revegetation Symposium in San Diego on November 15, 1984. Copies of the slides and a script are available from Translab in Sacramento.

Due to the successes of propagating and planting native shrubs, Translab encouraged the Interagency Committee to extend the agreement with CDF and CDC on February 1, 1985 to continue using the lathhouse at the Owens Valley Conservation Camp. Surplus seedlings raised for the research plots and viable seed were planted at sites other than highway slopes in Inyo and Mono Counties.

The BLM planted seedlings and seed of sagebrush and gray ephedra in a remote area that recently burned. Another project was to restore a meadow that was stressed by sheep from overgrazing.

The LADWP planted seedlings of gray ephedra and rabbitbrush to revegetate a small roadside south of Tinemaha Reservoir. A 61 percent survival rate was reported by LADWP biologists.

The USFS revegetated 2 acres at the Convict Lake Campground using labor from the California Conservation Corps (CCC). Both seedlings and seed were planted of sagebrush, bitterbrush, desert peach (*Prunus Andersonii*), and curlleaf mountain mahogany (*Cercocarpus ledifolius*). Results of this project have not been gathered yet.

Translab will try to obtain more information regarding the above projects. Results will be published in the final report.

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SPECIES SELECTION, SEEDLING SOURCES, SEED TREATMENTS

Selection of Species

Field investigations to identify native species of woody shrubs were done by Caltrans District 9 personnel and other members of the Interagency Committee. Advice was also obtained from various experts on high desert flora. Table 1 shows the list of candidate species that was developed, (Munz and Keck, 2), (Clary, 3), and (Kay et al, 4, 5, 6). The species marked with an asterisk in Table 1 were both native to the California high desert and available from commercial nurseries.

Sources of Seed and Seedlings

Seedlings were from three general sources. Seedlings were:

1. grown nonlocally in Utah and Washington and were purchased from commercial nurseries,
2. grown locally, in California, from seed collected in Utah, Washington, Idaho, Nevada, and Colorado by Caltrans and others,
3. grown locally, in California, from seed collected in California by Caltrans and others.

Tables A-1 through A-5 in the Appendix show detailed data of sources (county, state, landmark, elevation), dates of seed collection, and dates of seedling propagation. Figure 2 is a map of sites for seed collected locally. In Table A-5 the sites are cross-referenced to Figure 2.

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Table 1

Species Considered for Research Plantings

* *Artemisia tridentata* (big sagebrush)
* *Atriplex canescens* (fourwing saltbush)
* *Chrysothamnus nauseosus* (rubber rabbitbrush)
* *Ephedra nevadensis* (gray ephedra)
* *Purshia tridentata* (antelope bitterbrush)

Atriplex confertifolia (shadscale saltbush)
Cercocarpus ledifolius (mountain mahogany)
Chrysothamnus teretifolius (rabbitbrush)
Coleogyne ramisissma (blackbush)
Ephedra viridis (green ephedra)
Eurotia lanata (winterfat)
Ericameria cooperi (Cooper goldenbush)
Eriogonum fasciculatum (California buckwheat)
Grayia spinosa (spiny hopsage)
Juniperus osteosperma (Sierra juniper)
Lupinus excubitus (Inyo lupine)
Menodora spinescens (spiny menodora)
Pinus jeffreyi (Jeffrey pine)
Pinus monophylla (pinyon pine)
Prunus andersonii (desert peach)
Psorothamnus fremontii (Fremont dalea)
Rosa woodsii (Woods rose)
Tetradymia glabrata (horsebush)
Tetradymia spinosa var. longispina (cottonthorn)
Yucca brevifolia (Joshua tree)

* species selected for research planting

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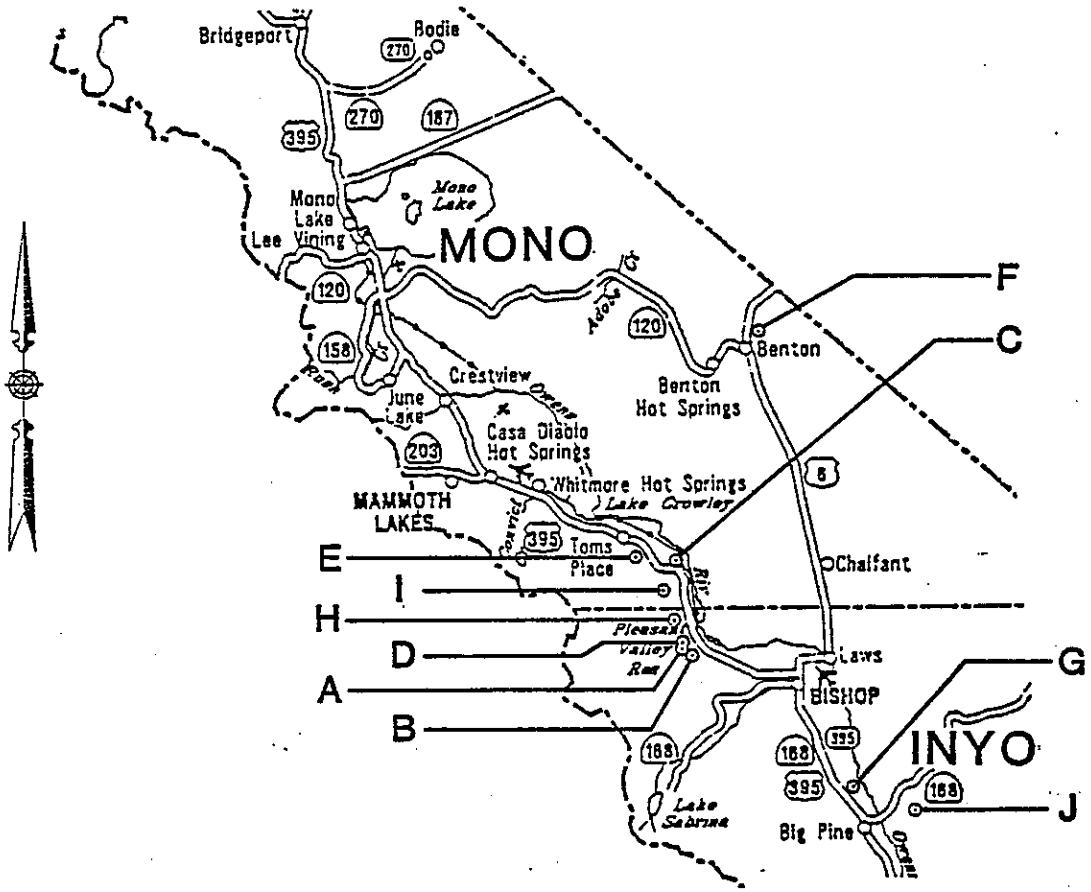
Site	Species
A	*Chrysothamnus nauseosus, Artemisia tridentata*
B	*Chrysothamnus nauseosus, Artemisia tridentata*
C	*Chrysothamnus nauseosus*
D	*Artemisia tridentata, Ephedra nevadensis*
E	*Artemisia tridentata*
F	*Ephedra nevadensis*
G	*Atriplex canescens*
H	*Purshia tridentata*
I	*Purshia tridentata*
J	*Atriplex canescens*



Map of Sites for "Seed Collected Locally"

Figure 2

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Seed Collection

Times of seed collection are in Table 2 and were followed as closely as possible, (Forest Service, 7) and (Vories, 8).

Table 2
Seed Collection Schedule

Species	Months to Collect Seed	Expected Viability
big sagebrush (*Artemisia tridentata*)	October to January	2 years
fourwing saltbush (*Atriplex canescens*)	October to March	6-7 years
rubber rabbitbrush (*Chrysothamnus nauseosus*)	October to March	1-2 years
gray ephedra (*Ephedra nevadensis*)	July	5 years
antelope bitterbrush (*Purshia tridentata*)	July to September	5 years

Caltrans District 9 obtained permission to enter and gather seeds of native shrubs in Inyo and Mono Counties from the BLM, LADWP, and USFS. Seed was collected either by Caltrans District 9 personnel or by inmates under the joint supervision of Caltrans and CDF personnel.

Mature plants with ripe seed were located. Seed was hand-stripped from plants and placed in bags. Alternatively, a large bag was placed over a branch and the plant was shaken vigorously, thereby freeing ripe seed and loosely attached plant parts. Whole plants were left in the ground.

Quantities of seed varied from several ounces to fifteen pounds, depending on species. There was enough seed to propagate seedlings for the research plots, except when there were losses from nonviable seed, depredation, damp-off disease, or transplanting from flats to roottrainers. See Figure 9 in Chapter 6 for numbers of seedlings planted and the "Notes" in

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Tables A-4 and A-5 in the Appendix for seed that did not emerge.

Treatment of Seeds

Immediately after collection, seeds were hand-sorted from plant parts and debris. Seeds of antelope bitterbrush were rubbed against a screen to remove debris. Cleaned seeds were spread out on a bench indoors and air-dried for several hours, (Forest Service, 7) and (Kay et al, 5). After drying the seeds were stored.

Short-term storage of seeds consisted of packaging cleaned, dried seed in labelled, cloth or paper bags and then securing the bags in a wooden locker (6' x 3' x 3') or in clean garbage cans (30 gallons) in the lathhouse office. The locker and cans were kept out of direct sunlight at ambient temperatures.

Fourwing saltbush seeds were given further treatment. The utricles (wings) were removed by running the seeds through a hammermill at the UC Davis Agronomy and Range Science Department, (Kay et al, 4). Another way to remove the wings was to manually scrub the seeds with a scrubber and board made by the Translab Machine Shop. A wooden block (1" x 2" x 6") and plywood board (3/4" x 16" x 16") with raised wooden sides (1" x 4" x 16", sloped at 45 degrees), were covered with rubber matting. The matting had parallel grooves and was from an automobile. The matting was stapled to the block and board and was aligned 90 degrees to the direction of scrubbing. A handful of seed was placed on the board in a single layer. Pressure and scrubbing action were applied to the block, thereby causing the wings to snag in the grooves and break off. Seeds were shaken off the board and the chaff was discarded.

Detailed information on seed quantities and resources expended will be reported in the final report. Sufficient seed collection, processing, and short term storage were accomplished to meet the needs of this research.

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PROPAGATION of SEEDLINGS

Facilities

Nonlocal seedlings were grown at commercial nurseries in Utah and Washington from seed collected in Colorado, Nevada, Idaho, Washington, and Utah. The seedlings were shipped to California by a commercial carrier via land. Seedlings were hardened in the lathhouse at the Owens Valley Conservation Camp before they were planted on the highway slopes.

Locally collected and nonlocally purchased seed were grown in a lathhouse and greenhouse at the Owens Valley Conservation Camp, Round Valley. Seedlings were hardened in the lathhouse before they were planted on highway slopes. Figures 3 and 4 are photographs of the upgraded facilities. Seedlings were raised by an inmate with practical nursery experience under the supervision of Caltrans, CDF, and CDC personnel.

Description and Operation of Lathhouse

A lathhouse 30 feet long by 12 feet wide by 8 feet tall was used. There were three benches inside. Two benches were 12 feet long by 3 feet wide; one bench was 30 feet long by 3 feet wide. All benches were 3 feet above a dirt floor.

The Spring, 1983 seedlings were consumed by rodents or birds one day in late July, 1983. Fine-meshed fiberglass screening was installed on the outside of the lathhouse by inmates to prevent further depredation. After the lathhouse was upgraded, only seedlings from nonlocally purchased seed were started in late August, 1983 for the planting in Fall, 1983. Commercial plants arrived in September, 1983.

An automatic irrigation system with mist nozzles was installed in the lathhouse. Seedlings developed damping-off disease while watering twice daily for 8 minutes. Watering with mist nozzles for short durations only wetted the top inch or less of soil in the roottrainers. Other watering schedules were tried. Longer duration watering flooded the benches and floor and induced fungal and moss growth. Subsequent watering was done

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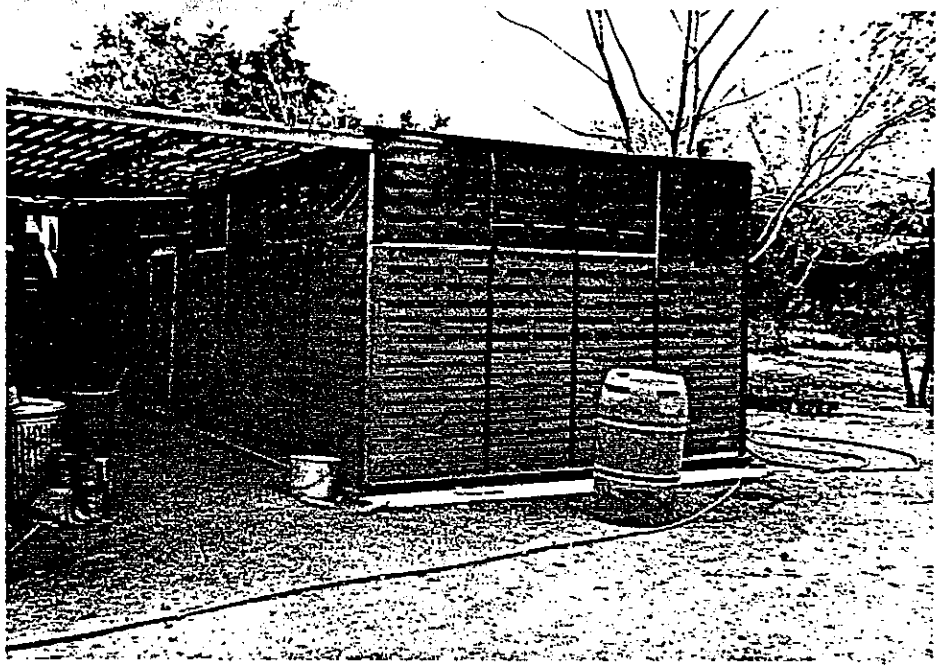

3A Upgraded Lathhouse

3B Inside Lathhouse

Figure 3

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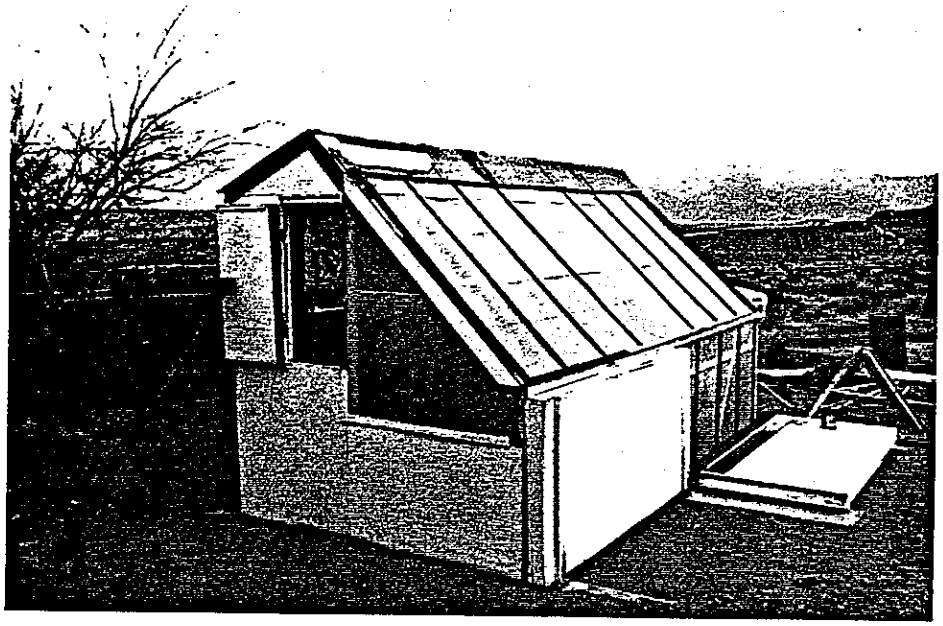
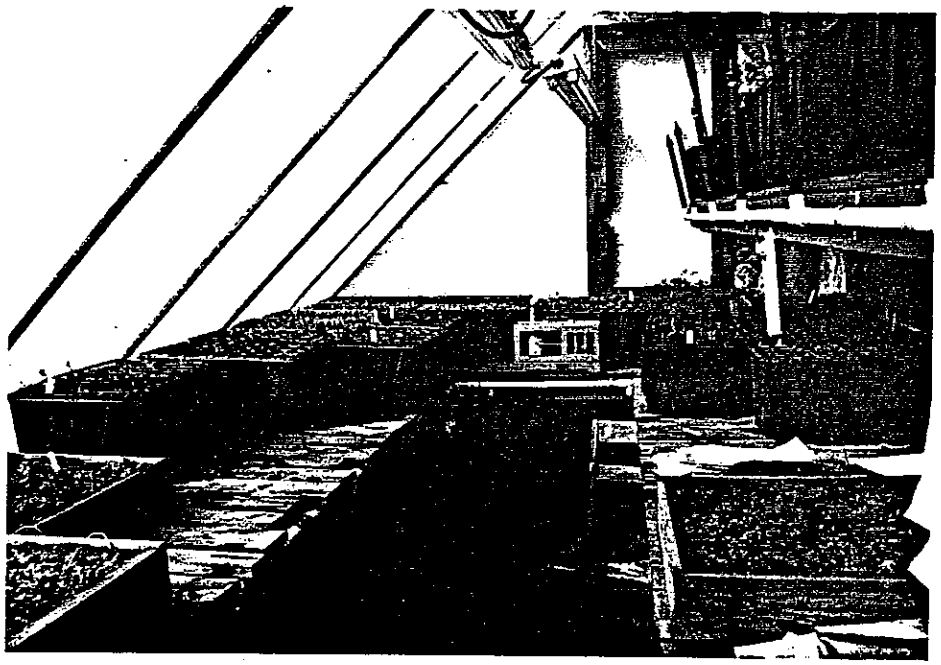


4A Upgraded Greenhouse



4B Inside Greenhouse

Figure 4

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manually on an as-needed basis by the inmate nurseryman. The automatic irrigation system was kept as a backup for rare occasions when the inmate nurseryman was not available. Besides caring for seedlings the inmate nurseryman recorded daily observations of temperature extremes, cloud cover, and precipitation.

Description and Operation of Greenhouse

A wooden-framed greenhouse 16 feet long by 7 feet wide by 8 feet tall was used. The greenhouse was operated by the inmate nurseryman under the supervision of Caltrans personnel. The structure was upgraded for raising seedlings during the 1983-4 winter for spring, 1984. Portions of the walls (north, south, and west) were made from translucent fiberglass sheeting with an extra layer of translucent plastic. The tilted ceiling was a double layer of translucent plastic. Portions of the plywood walls were insulated on the inside with fiberglass batts. The outside, west-facing wooden panels were hinged. During sunlit hours the panels were tilted down for passive solar heating of black, 55-gallon drums, which were under the benches inside. The drums were filled with water and antifreeze. A 1200-watt electric space heater was used during the coldest part of winter. There were hinged, wooden ports in the north- and east-facing walls and a wooden door on the south-facing wall for ventilation during the day.

There were two benches inside. A U-shaped bench was 13, 6, and 8 feet long by 30 inches wide and was 3 feet above a drained, gravel floor. The other bench was 11 feet long by 2 feet wide and hung above the east leg of the U-shaped bench. A recording thermograph was kept on the bench. The 24-hour temperature range was usually kept between 60 and 90 degrees Fahrenheit by using the heater at night and opening the vents during the day.

Fluorescent lights (full-spectrum) were installed to extend the photoperiod until 11 PM. An automatic irrigation system and an exhaust fan with a thermostatic switch were installed as backup features.

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Techniques

Antelope bitterbrush seeds were pretreated before planting in flats or roottrainers by COOL-MOIST STRATIFICATION, (Young and Evans, 9). Seeds were placed in plastic petri dishes (6-inch diameter with lids) in a refrigerator for 4 to 6 weeks. The petri dish was lined with moist charcoal and covered with an inert membrane (a disc of clean, panty hose) to keep the seeds out of the charcoal. One layer of seeds (approximately 100) was placed on the panty hose. Paper-towel discs were tried but did not work well, because mold grew on them. When white tips (root radicles) appeared, the seeds were planted either directly in bookbinder roottrainers or raised in flats and then transplanted to roottrainers. See Figure 5.

Seeds of the other four species did not require any special pretreatment. They were planted in flats and transplanted to roottrainers, or they were seeded directly in the roottrainers.

Wooden flats were fabricated by the inmate nurseryman. Two flats were (16" x 16" x 4") and one flat was (28" x 48" x 4"). See Figure 5. A 96-inch soil-heating cable (3 watts per foot) was placed on the bottom of the flats.

Roottrainers were made from black, molded plastic and were purchased. Roottrainers had 3, 4, 5, or 6 cells per bookbinder. The areal dimensions of cells varied from (1.5" x 1.5") to (2.0" x 2.5") and the depth varied from 7.5 to 10 inches. The bookbinders with four cells (2" x 2" x 9.5") were preferred, because they closely matched the dimensions of the planting dibble and fitted well in metal racks. The metal racks held 40 plants, (10 of the 4-cell bookbinder roottrainers). The planting dibbles and metal racks were designed and fabricated at the Translab Machine Shop.

The soil used in the flats and roottrainers was a mixture of 7 parts peat moss and 10 parts sand. The sand was purchased from a local quarry and the peat moss was purchased from a local nursery. Slow release fertilizer (Osmicote, 18-17-10) was added to the planting mixture according to the instructions.

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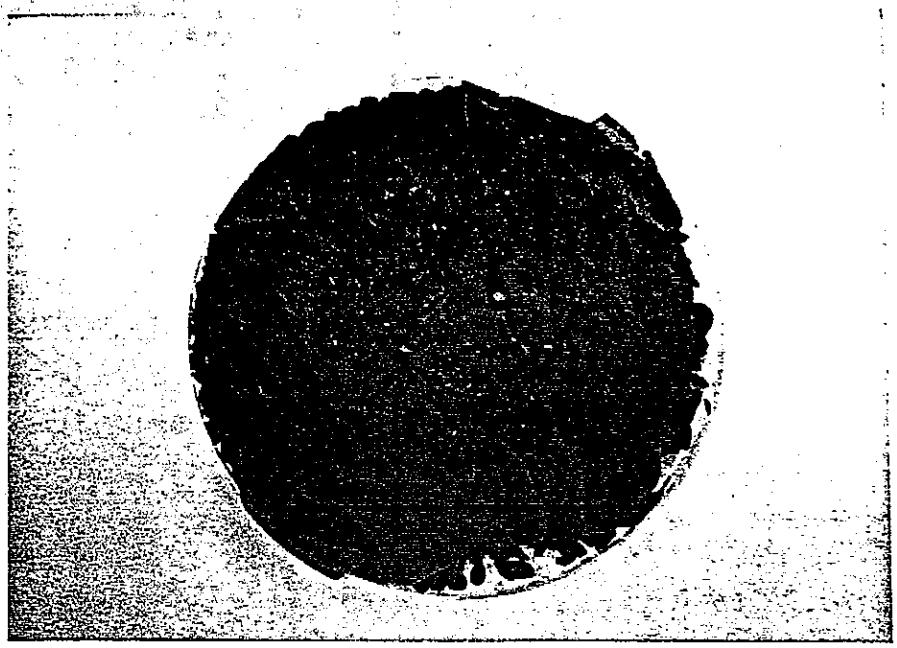
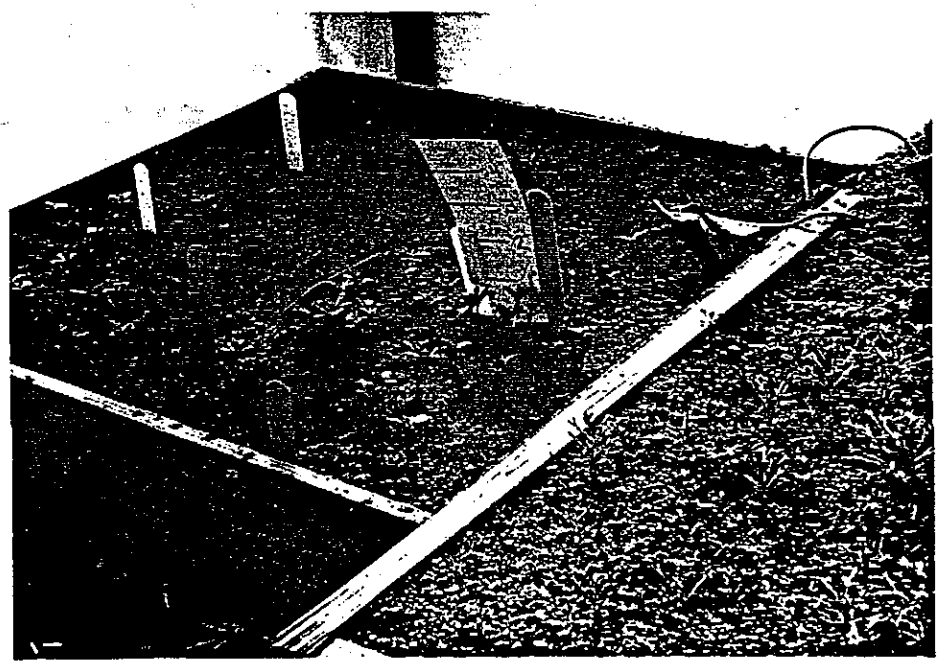


5A COOL-MOIST STRATIFICATION of Antelope Bitterbrush (Purshia tridentata)



5B Flat With Seedlings

Figure 5

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Observations

Transplanting from flats to roottrainers was generally successful. This practice was done for small, lightweight seeds of sagebrush and rabbitbrush and some of the larger seeds of bitterbrush.

The seeds of saltbush, ephedra, and bitterbrush are large enough for direct seeding in bookbinder roottrainers. Locally collected and nonlocally purchased seeds of rabbitbrush which were older than one year did not emerge. Emergence and seedling establishment of other shrubs was generally successful. Detailed germination testing was not done, because the seed lots were relatively small. Notes in Tables A-4 and A-5 in the Appendix state that emergence of seedlings varied from 7 to 18 days.

Figure 6 shows photographs of bitterbrush being transplanted to a roottrainer and 1-inch tall seedlings in a rack. Figure 7 shows sagebrush and saltbush seedlings in completed racks. Figure 8 shows rabbitbrush and ephedra seedlings in completed racks.

Seedling growth in the greenhouse was slow during January and February. After the plants were approximately 3 inches tall, they did not grow much taller. On two weekends in January, 1984 the inmate nurseryman was not available to tend the vents of the greenhouse. The temperature rose above 100 degrees Fahrenheit, and the automatic fan failed to operate. The seedlings appeared to be unaffected.

By late March, 1984 temperatures in the lathhouse were above freezing. Seedlings were transferred to the lathhouse to harden, where they resumed growing for one to two months. Generally, seedlings were healthy by planting time. There were no major losses in the lathhouse during March and April, 1984.

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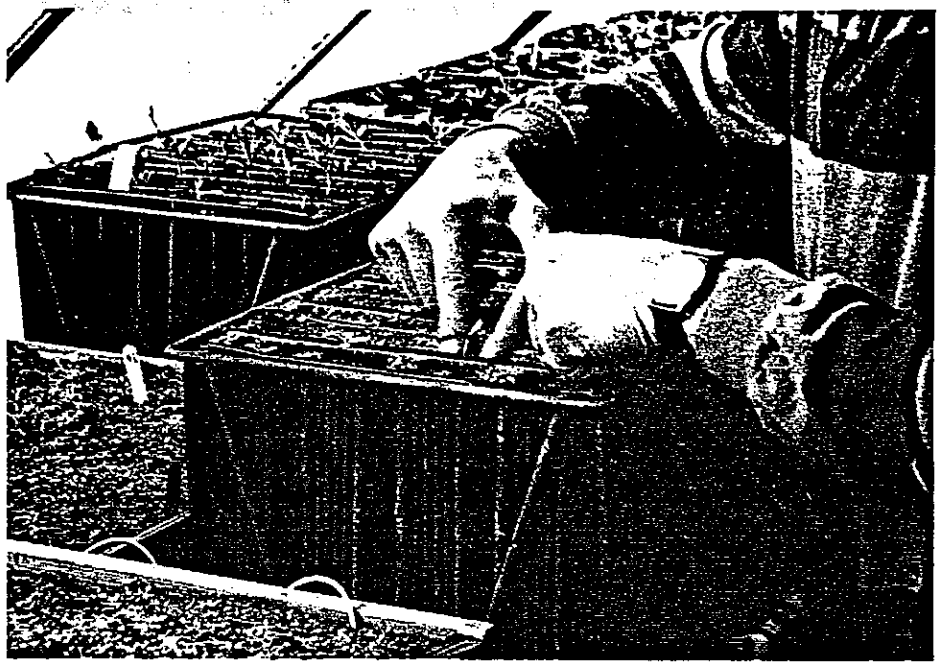
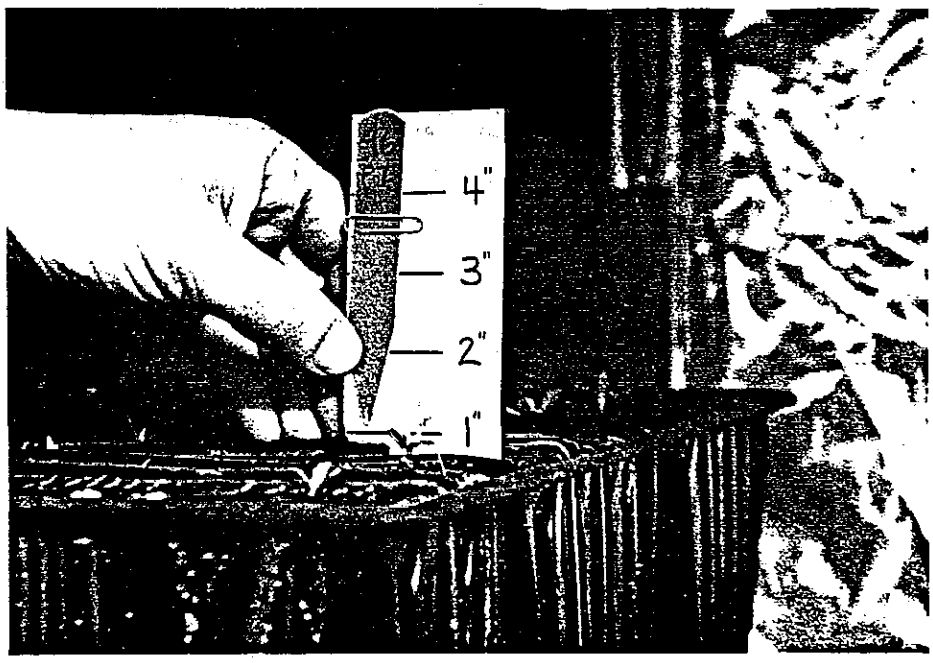


6A Transplanting Bitterbrush Seedlings



6B Bitterbrush Seedlings

Figure 6

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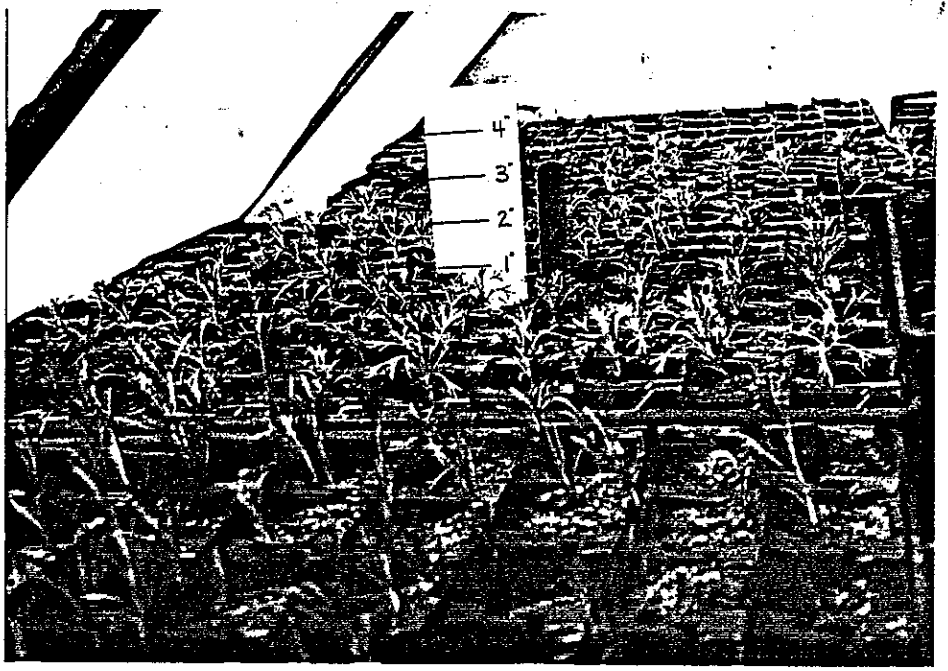

7A Big Sagebrush Seedlings (Artemisia tridentata)

7B Fourwing Saltbush Seedlings (Atriplex canescens)

Figure 7

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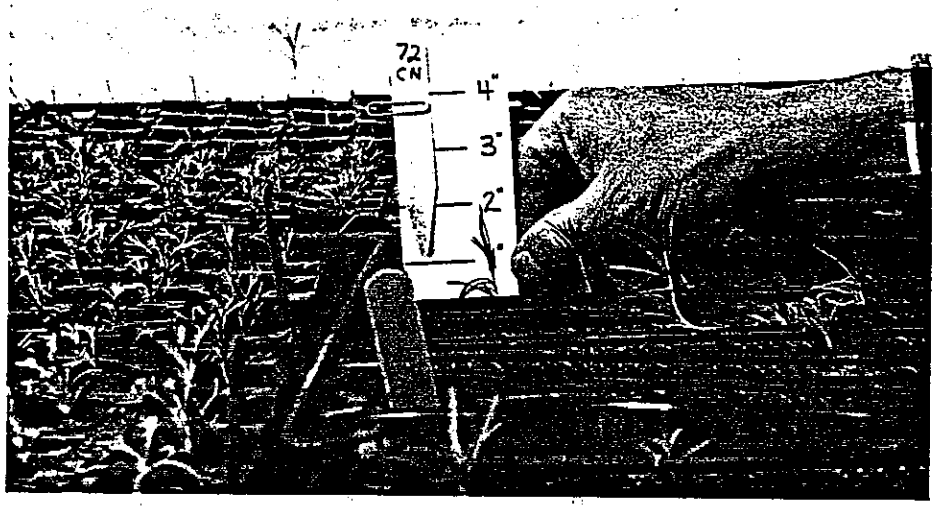
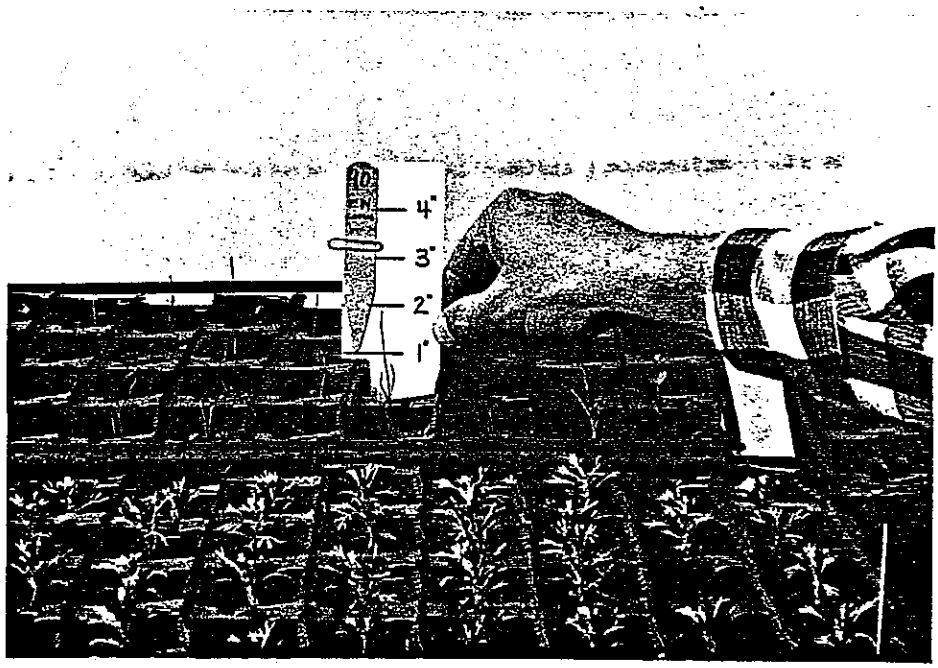


8A Rubber Rabbitbrush Seedlings (Chrysothamnus nauseosus)



8B Gray Ephedra Seedlings (Ephedra nevadensis)

Figure 8

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RESEARCH PLOTS

Site Characteristics

Highway cut slopes, approximately twelve years old, were selected for the research plots. Site characteristics are in Table 3. The slopes were mostly bare. Hydroseeding or other seeding techniques with seeds of woody shrubs and grasses were tried after the slopes were constructed in the early 1970's. The establishment of any vegetation was largely unsuccessful, except on the June Lake, southbound slope where there were some grasses. Natural invasion either did not occur or was not occurring very rapidly.

Table 3
Characteristics of Research Sites

site	elevation (feet)	slope angle (horiz:vert)	slope aspect (bearing)	soil type
June Lake (northbound)	7800	2 : 1	S 25 W	glacial till & volcanics
June Lake (southbound)	7800	1.5 : 1	N 25 E	glacial till & volcanics
Sand Shed	6000	2 : 1	S 60 W	welded rhyolite tuff
CDF	4200	1.5 : 1	N 60 E	welded rhyolite tuff

Soil samples were taken at each site. There were no distinct soil horizons, because the sites are cut slopes in parent materials. Nutrient tests were done by the UC Cooperative Extension Service, Davis; mechanical analyses were done by Translab. Table A-6 and Figures A-9 and A-10 in the Appendix show the nutrient test results and gradation curves,

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respectively. The soils at the June Lake sites are well-draining, decomposed granitic sands with some volcanic materials mixed by glacial action. The soils at the Sand Shed and CDF sites are poor-draining, welded, rhyolite tuff. The surface soil (top 2 inches) is very powdery and the soil below 2 inches is loosely cemented. Nutrient levels were low on all four slopes.

Planting Layouts and Dates

Before planting, a matrix was designed. The experimental layout was similar on each slope. Detailed layouts of each research plot showing seedling position, species, and source are in Figures A-1 through A-8 in the Appendix. Plants were randomly positioned on each row by source and species, so there would be a paired observation, i.e., a watered plant and a not-watered plant of the same species and source. Because of losses from nonviable seed, there were occasional substitutions of plants on the rows. The layout was designed on a row basis (half watered and half not watered), so that any differences between the upper and lower rows may be quantified.

Seedlings were planted in fall, 1983 and spring, 1984 on each of the slopes to address any differences in time of planting. Planting dates, relative plot positions on slopes, plot dimensions, and plant spacing are in Figure 9.

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10/27/83 60 seedlings 20 AT, 20 PT, 20 CN (36' x 15') 3' centers	6/13/84 180 seedlings 74 AT, 67 PT, 39 CN (140' x 16') 4' centers

"June Lake" 395 northbound, Mono Co. post mile 40.1 ---> Bishop

6/13/84 180 seedlings 73 AT, 67 PT, 40 CN (68' x 36') 4' centers	10/26/83 60 seedlings 20 AT, 20 PT, 20 CN (36' x 15') 3' centers

"June Lake" 395 southbound, Mono Co. post mile 40.1 <--- Bishop

11/9/83 60 seedlings 20 AT, 20 EN, 20 CN (36' x 15') 3' centers	5/1/84 220 seedlings 75 AT, 38 AC, 53 CN, 54 EN (172' x 16') 4' centers

"Sand Shed" 395 northbound Mono Co. post mile 3.5 ---> Bishop

4/18/84 220 seedlings 61 AT, 60 CN, 60 AC, 39 EN (84' x 36') 4' centers	11/9,10/83 100 seedlings 20 AT, 20 CN, 20 EN, 40 AC (27' x 27') 3' centers

"CDF" 395 southbound, Inyo Co. post mile 122.4 <--- Bishop

CODES for species of plants:

AT = Artemisia tridentata (big sagebrush)
AC = Atriplex canescens (fourwing saltbush)
CN = Chrysothamnus nauseosus (rubber rabbitbrush)
EN = Ephedra nevadensis (gray ephedra)
PT = Purshia tridentata (antelope bitterbrush)

The above data show the planting dates, relative plot positions, numbers of species, plot dimensions, and plant spacing on the slopes. Orientation is facing the slope.

The total number of seedlings planted was 1080.

PLANTING DATES, PLOT POSITIONS, and NUMBERS of SPECIES

Figure 9

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Planting Procedure

The procedure for planting the native, woody seedlings was the same at all sites. There were two stages: site preparation (1-3 days) followed by planting (1-2 days). There was a 1-2 week period between stages for mobilizing tools, materials, and labor.

Site Preparation

1. Plant locations were laid out on the slopes and marked with a 2-foot lath. Alternating rows were staggered according to the pattern shown below. The Fall, 1983 seedlings were planted on 3-foot centers. The Spring, 1984 seedlings were planted on 4-foot centers. Planting on 4-foot centers provided more working space on the slopes than 3-foot centers.

```
upper   row 1      x   x   x   x  | x   x   ...   x
 rows   row 2        x   x   x   x |  x   x   ...   x
        row 3      x   x   x   x  | x   x   ...   x
        .                         |
        .                         |
        .                         |
lower   row n-1    x   x   x   x  | x   x   ...   x
 rows   row n        x   x   x   x |  x   x   ...   x
                   ----------------|-----------------
                   watered              not watered
```

2. Holes were excavated with either a two-man, gasoline powered auger or a manually operated clam-style, posthole digger. The hole dimensions were 6 inches in diameter by 12 inches deep. Soil was loosened approximately two inches below the 12-inch depth to accommodate root expansion.

3. After excavation, the holes were filled with approximately 1.5 gallons of water. This preplanting irrigation was done to wet the surrounding soil to prevent "wick drying" of the soil and root mass.

4. Because the percolation rates exceeded 4 hours (Sand Shed and CDF soils), the next day approximately one pound of soil

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amendment was placed at the bottom of each hole (one 50-pound bag of Nitrohumus per 60 holes). In the field the measure used was approximately 1.5 handfuls of Nitrohumus per hole. Nitrohumus was derived from domestic sludge and contained 0.70 per cent total nitrogen and 1.75 per cent available phosphoric acid.

5. The remainder of the hole was backfilled with a mixture of native soil from the diggings (no particles larger than one inch) and peat moss (1/2-gallon loose measure). The mix ratio was approximately three parts native soil to one part peat moss. The backfilled mixture was compacted by hand.

6. A 2-foot lath was placed in the center of each planting location, and the sites were left in this condition for 1-2 weeks to mobilize tools, materials, and labor.

7. A post-mounted rain gage and a minimum-maximum thermometer were installed at each site.

Planting

1. A seedling was selected and its location was found on the slope by referring to the detailed planting layout. The 2-foot lath was removed.

2. A dibble was pushed into the center of the planting location to the depth of the roottrainer.

3. A half pint of water (1/4 of a 1 pound coffee can) was poured around the dibble. The dibble was rotated and lifted slightly to wet the sides and bottom of the hole. After water seeped into the soil, the dibble was removed.

4. The plant was carefully removed from the roottrainer and placed in the hole, either by hand or with a trowel.

5. The soil was gently compacted around the plant to remove excessive voids, either by hand or with a trowel.

6. The plant was watered with 1/2 pint of water. To assure deep watering, a probe was pushed into the soil around the plant at least five times, taking care to avoid the roots. This practice was preferred to forming a basin (Fall, '83) and surface watering, due to the steep slopes and slow percolation rates. The probe was fabricated by the Translab Machine Shop. It is an

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8-inch long by 3/8-inch diameter steel spike attached on-center to a sawed-off shovel handle.

7. A metal cage was placed around each plant to discourage depredation by browsing animals. The cage was secured to the slope with a 6-inch steel, jute stake and was tied with 18- or 20-gage, plastic-coated wire to a 2-foot lath, which was driven one foot into the slope. The cages were designed by Translab and fabricated by inmates. A cage is a cylinder, 18-inches tall by 8-inches in diameter. The material is 1/4 x 1/4 inch, galvanized hardware cloth. The ends of a 30-inch long piece of the material were fastened with four, number 2 hog rings to form the cylinder. Yellow, plastic cages (3-inch diameter by 1-foot tall) were tried on the Fall, 1983 plots. They were unsightly and restricted the growth of the shrubs.

8. After all the seedlings were planted and secured with cages, they were each given one additional quart of water. The total water given to each plant at planting time was 1.5 quarts.

9. The lath were numbered sequentially at each site.

10. The outside halves of the Fall, 1983 and Spring, 1984 plots were tagged with green surveyor's flagging to identify the plants for supplemental watering.

11. Initial measurements were recorded of seedling height and spread (maximums, measured to nearest inch).

Figures 10 and 11 show the revegetated slopes at each site.

Plant Establishment

At six week intervals from the dates of planting until November, 1984, half the plants at each site were given one quart of water, using the soil probe. The watering rig was a skid-mounted, 100-foot hose and reel with a battery powered, 3-gallon per minute, diaphragm pump. Three, plastic 55-gallon drums held water. The watering rig was hauled in a 3/4-ton pick-up truck. See Figure 12.

The plants did not receive any further care. There was no replacement planting or weeding.

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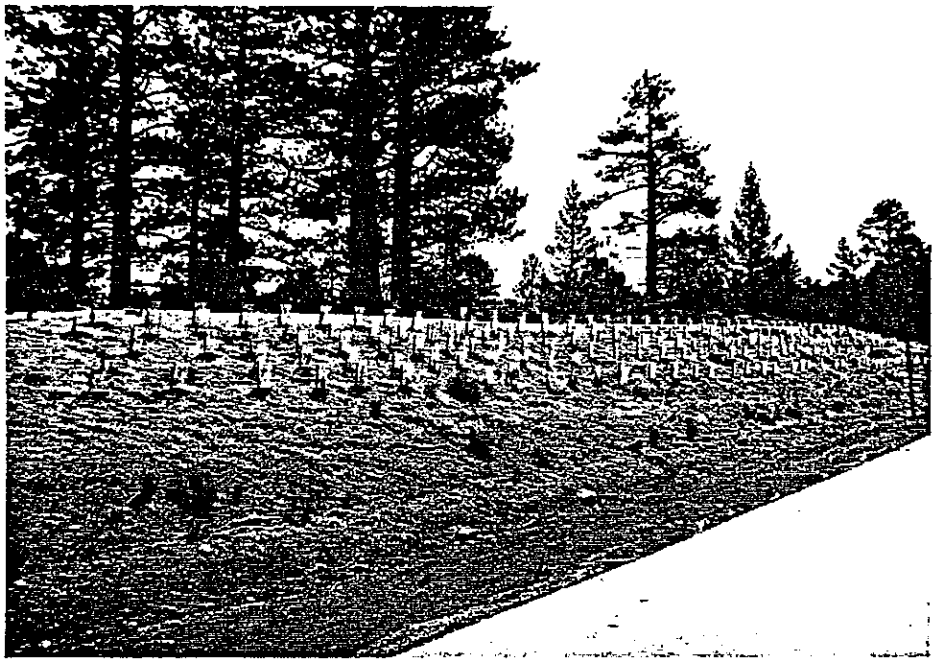
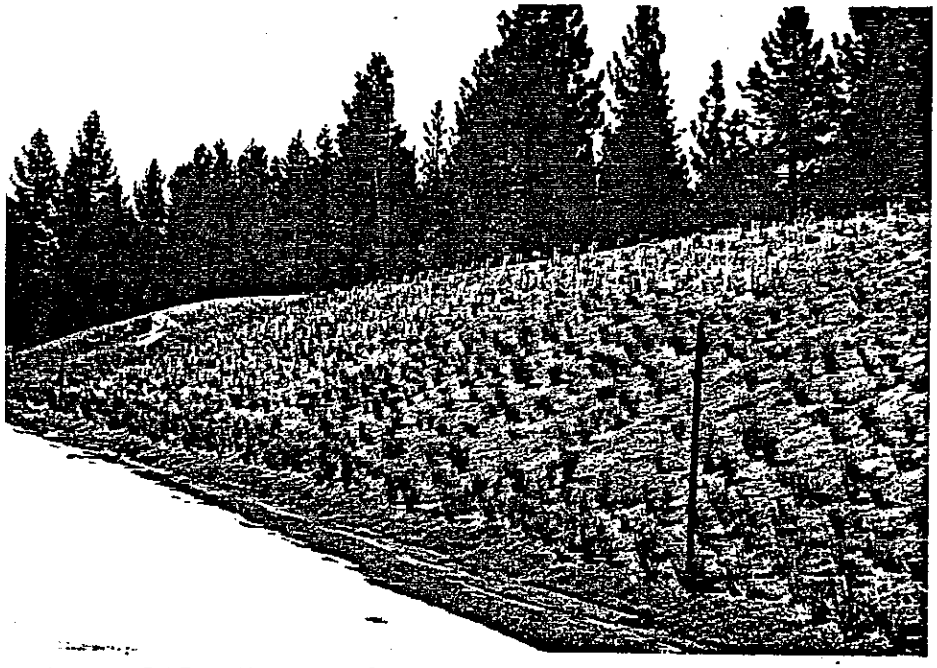


10A June Lake, Northbound Site



10B June Lake, Southbound Site

Figure 10

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11A Sand Shed Site

11B CDF Site

Figure 11

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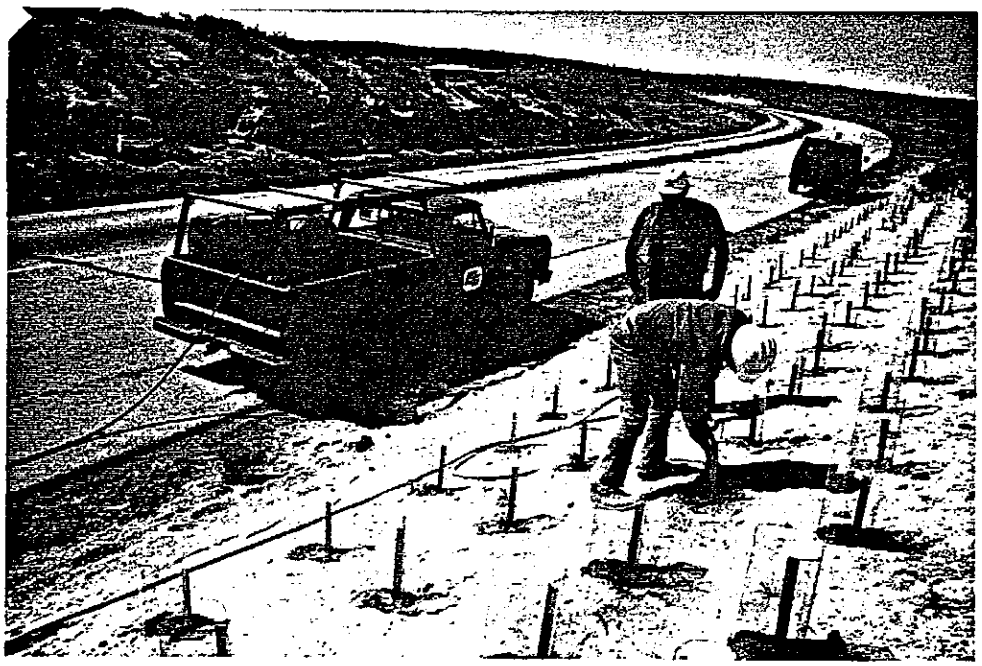

Watering Rig

Figure 12

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INTERIM RESULTS

Weather

The results are based on two years of observations, from November, 1983 through October, 1985. The Fall, 1983 plots have experienced two annual cycles of weather and the Spring, 1984 plots have experienced one winter and two summers. Both cycles of weather were nearly normal for the arid, eastern Sierra Nevada regions. Temperatures ranged from several degrees below zero to above 100 degrees Fahrenheit. Precipitation (as rain) was below 12 inches; precipitation was normally snow or rain at the June Lake and Sand Shed sites and mostly rain at the CDF site. Wind speeds varied from calm to strong gale, zero to approximately 35 miles per hour. A detailed discussion of weather will be presented in the final report.

Plant Habitat and Stresses

The surviving plants are providing habitat for flying and crawling insects, fungus, reptiles, and other animals. After a cycle of growth, several plants (sagebrush and rabbitbrush) flowered and set seed. Species which were not planted grew in many of the cages, and in most cases seemed to compete well with research plants. Seeds of tumbleweed (*Salsola kali var. tenuifolia*), apparently wind-borne, sprouted and grew inside several cages at the CDF site. The tumbleweeds are growing fast and seem to be doing better than research plants.

The potential causes of seedling mortality were transplant shock, lack of water from drying winds, and extreme temperatures. Browsing animals were apparently discouraged by the metal plant cages. There was some depredation from burrowing animals. Some plants were crushed, apparently vandalized, where cages were missing. Some cages were blown away by strong winds on the northbound plots at June Lake.

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Status - October, 1985

The survival rates of the 1080 seedlings are good so far. Percentages of surviving seedlings are in Table 4. The percentages are based on the totals planted (not always equal, see Tables 5 through 8) by source, time planted (Fall, 1983 or Spring, 1984), and Both plantings. Sources are: x = nonlocal, y = nonlocal grown locally, z = local grown locally. An 'N' entry means no seedlings were planted, due to stresses of nonviability of seed, transplant shock, water, or weather. Conclusions regarding sources, species, etc. will be in the final report.

Table 4

Percentages of Surviving Seedlings, October, 1985

	source x			source y			source z		
species	Fall	Spring	Both	Fall	Spring	Both	Fall	Spring	Both
AT	55	96	77	N	90	90	N	94	94
AC	90	96	95	25	100	42	N	94	94
CN	84	79	81	N	100	100	N	88	88
EN	N	96	96	30	93	74	N	N	N
PT	73	54	61	N	67	67	N	58	58

CODES for plant species:

AT = big sagebrush (*Artemisia tridentata*)

AC = fourwing saltbush (*Atriplex canescens*)

CN = rubber rabbitbrush (*Chrysothamnus nauseosus*)

EN = gray ephedra (*Ephedra nevadensis*)

PT = antelope bitterbrush (*Purshia tridentata*)

Tables 5 through 8 show detailed counts of dead, blooming, dry, and normal shrubs at each site (sub groups) by species and treatment (watered or not). 'Dry' was recorded for live seedlings 50 percent or more dry. 'Normal' was established by comparing plants similar to research seedlings near the sites. The subtotal alive is the sum of dry and normal seedlings. The subtotal planted is the sum of dead, dry, and normal seedlings. Additionally, counts of totals alive and planted (source groups of watered and not) by species are reported.

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Table 5

June Lake Northbound - October, 1985 Status

Fall, 1983 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	0	3	1	9	10	10	x+xw	20	14
ATxw	6	2	0	4	4	10			
PTx	3	0	0	7	7	10	x+xw	20	11
PTxw	6	0	0	4	4	10			
CNx	4	0	1	5	6	10	x+xw	20	12
CNxw	4	0	0	6	6	10			

Spring, 1984 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	0	5	0	10	10	10	x+xw	24	23
ATy	2	5	0	13	13	15	y+yw	25	22
ATz	3	3	0	9	9	12	z+zw	25	21
ATxw	1	8	0	13	13	14			
ATyw	1	6	0	9	9	10			
ATzw	1	6	0	12	12	13			
PTx	5	0	0	10	10	15	x+xw	28	18
PTy	1	0	0	8	8	9	y+yw	16	11
PTz	6	0	0	3	3	9	z+zw	23	11
PTxw	5	0	1	7	8	13			
PTyw	4	0	0	3	3	7			
PTzw	6	0	0	8	8	14			
CNx	4	0	0	6	6	10	x+xw	21	15
Cnz	1	2	0	9	9	10	z+zw	18	17
CNxw	2	1	0	9	9	11			
CNzw	0	5	0	8	8	8			

Note: subscripts x, y, z refer to no supplemental water.
subscripts xw, yw, zw refer to supplemental water.

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Table 6

June Lake Southbound - October, 1985 Status

Fall, 1983 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	8	0	0	2	2	10	x+xw	20	4
ATxw	8	0	0	2	2	10			
PTx	1	0	0	9	9	10	x+xw	20	18
PTxw	1	0	0	9	9	10			
CNx	0	0	0	10	10	10	x+xw	20	19
CNxw	1	0	0	9	9	10			

Spring, 1984 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	1	1	0	12	12	13	x+xw	25	24
ATy	4	2	0	8	8	12	y+yw	24	20
ATz	0	0	0	11	11	11	z+zw	24	23
ATxw	0	2	0	12	12	12			
ATyw	0	5	0	12	12	12			
ATzw	1	0	0	12	12	13			
PTx	7	0	0	6	6	13	x+xw	28	12
PTy	4	0	0	6	6	10	y+yw	17	11
PTz	5	0	0	6	6	11	z+zw	22	15
PTxw	9	0	0	6	6	15			
PTyw	2	0	0	5	5	7			
PTzw	2	0	0	9	9	11			
CNx	1	1	0	9	9	10	x+xw	20	16
Cnz	0	1	0	10	10	10	z+zw	20	16
CNxw	3	0	0	7	7	10			
CNzw	4	1	0	6	6	10			

Note: subscripts x, y, z refer to no supplemental water.
subscripts xw, yw, zw refer to supplemental water.

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Table 7

Sand Shed - October, 1985 Status

Fall, 1983 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	2	5	0	8	8	10	x+xw	20	15
ATxw	3	4	0	7	7	10			
ENy	9	0	0	1	1	10	y+yw	20	2
ENyw	9	0	1	0	1	10			
CNx	0	0	5	5	10	10	x+xw	20	19
CNxw	1	0	5	4	9	10			

Spring, 1984 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	0	7	0	12	12	12	x+xw	25	25
ATy	0	3	0	13	13	13	y+yw	25	25
ATz	0	7	0	12	12	12	z+zw	25	24
ATxw	0	9	0	13	13	13			
ATyw	0	3	0	12	12	12			
ATzw	1	2	0	12	12	13			
ACx	0	0	7	8	15	15	x+xw	27	26
ACy	0	0	0	3	3	3	y+yw	6	6
ACz	0	0	1	1	2	2	z+zw	5	5
ACxw	1	0	3	8	11	12			
ACyw	0	0	0	3	3	3			
ACzw	0	0	1	2	3	3			
CNx	0	5	2	10	12	12	x+xw	25	22
Cnz	0	3	0	15	15	15	z+zw	28	25
CNxw	3	4	2	8	10	13			
CNzw	3	3	1	9	10	13			
ENx	0	0	2	11	13	13	x+xw	27	27
ENy	1	0	1	11	12	13	y+yw	27	26
ENxw	0	0	2	12	14	14			
ENyw	0	0	0	14	14	14			

Note: subscripts x, y, z refer to no supplemental water.
subscripts xw, yw, zw refer to supplemental water.

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Table 8

CDF - October, 1985 Status

Fall, 1983 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	4	2	0	6	6	10	x+xw	20	11
ATxw	5	2	0	5	5	10			
CNx	1	1	1	8	9	10	x+xw	20	17
CNxw	2	1	2	6	8	10			
ENy	7	0	0	3	3	10	y+yw	20	6
ENyw	7	0	0	3	3	10			
ACx	1	1	3	6	9	10	x+xw	20	18
ACy	8	0	1	1	2	10	y+yw	20	5
ACxw	1	0	1	8	9	10			
ACyw	7	0	0	3	3	10			

Spring, 1984 Plot

Sub Group	Dead	Bloom	Dry	Normal	Subtotal Alive	Subtotal Planted	Source Groups	Total Planted	Total Alive
ATx	1	6	0	9	9	10	x+xw	20	18
ATy	1	3	0	9	9	10	y+yw	20	18
ATz	0	2	1	10	11	11	z+zw	21	21
ATxw	1	6	0	9	9	10			
ATyw	1	5	0	9	9	10			
ATzw	0	2	0	10	10	10			
CNx	3	4	4	7	11	14	x+xw	28	21
CNy	0	0	0	2	2	2	y+yw	4	4
CNz	2	1	5	7	12	14	z+zw	28	25
CNxw	4	3	4	6	10	14			
CNyw	0	1	0	2	2	2			
CNzw	1	6	5	8	13	14			
ACx	0	0	3	12	15	15	x+xw	30	29
ACz	1	0	3	11	14	15	z+zw	30	28
ACxw	1	0	4	10	14	15			
ACzw	1	0	2	12	14	15			
ENx	1	0	4	5	9	10	x+xw	20	18
ENy	1	0	3	5	8	9	y+yw	19	17
ENxw	1	0	2	7	9	10			
ENyw	1	0	2	7	9	10			

Note: subscripts x, y, z refer to no supplemental water.
subscripts xw, yw, zw refer to supplemental water.

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APPENDIX

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Table A-1

Seedling Sources - Grown Nonlocally (purchased) (1)
Planted Fall, 1983

Species	Source	Date of Collection	Date of Propagation
Artemisia tridentata (big sagebrush)	Utah	1982	6/6/83
Atriplex canescens (fourwing saltbush)	(2)	(2)	5/23/83
Chrysothamnus nauseosus (rubber rabbitbrush)	Utah	1982	5/19/83
Purshia tridentata (antelope bitterbrush)	(3)	(3)	6/18/83

Notes : (1)Seedlings were purchased from Plants of the Wild, Tekoa, Washington. Price was $0.79 each.

(2) No data. Probable source is Colorado.

(3) No data. Probable source is eastern Washington, western Idaho.

Table A-2

Seedling Sources - Grown Locally from Nonlocally Purchased Seed,
Planted Fall, 1983.

Species	Source	Date of Collection	Date of Propagation
Atriplex canescens (fourwing saltbush)	Salt Lk Co.,UT Red Rock Canyon elev. 6000 ft. Lot # 22	11/4/77	8/29/83 (1)
Ephedra nevadensis (gray ephedra)	Lincoln Co.,NA elev. 4000 ft. Lot # 1588	2 / 83	8/29/83 (2)

Notes: (1) 9 days to emergence. Transplanted to roottrainers 9/14/83. Racks 6A, 6B.

(2) 11 days to emergence. Direct seeded in roottrainers. Racks 8, 62, 63, 64, 66.

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Table A-3

Seedling Sources - Grown Nonlocally (purchased) (1)
Planted Spring, 1984

Species	Source	Date of Collection	Date of Propagation
Artemisia tridentata (big sagebrush)	Carbon Co.,UT Hwy 123 elev. 6000 ft. Lot # 216	12/15/79	12/8/83
Atriplex canescens (fourwing saltbush)	Salt Lk Co.,UT Red Rock Canyon elev. 6000 ft. Lot # 22	11/4/77	12/8/83
Chrysothamnus nauseosus (rubber rabbitbrush)	Delta Co., CO elev. 6400 ft. Lot # 2022	3/14/83	12/8/83
Ephedra nevadensis (gray ephedra)	Lincoln Co.,NA elev. 4000 ft. Lot # 1588	2 / 83	12/16/83
Purshia tridentata (antelope bitterbrush)	Sanpete Co.,UT elev. 5600 ft. Lot # 1147	9/28/81	1/14/84

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Table A-4

Seedling Sources - Grown Locally from Nonlocally Purchased Seed
Planted Spring, 1984

Species	Source	Date of Collection	Date of Propagation
Artemisia tridentata (big sagebrush)	Wasatch and Morgan Co., UT elev. 6000 ft. Lot # 216	12/15/79	12 / 83 (5)
Atriplex canescens (fourwing saltbush)	Garfield Co., CO Red Rock Canyon elev. 6000 ft.	(1)	12 / 83 (6)
Chrysothamnus nauseosus (rubber rabbitbrush)	Sanpete Co., UT elev. 5500 ft. Lot # CHNA 1721	1982	12 / 83 (failed) (2)
Chrysothamnus nauseosus (rubber rabbitbrush)	Mesa and Delta Co.'s, CO elev. 4500-6500 Lot # CHNA 1817	1982	1 / 84 (failed) (3)
Ephedra nevadensis (gray ephedra)	Lincoln Co.,NA elev. 4000 ft. Lot # 1588	2 / 83	12/3/83 (7)
Purshia tridentata (antelope bitterbrush)	Sanpete Co.,UT elev. 5600 ft. Lot # 1147	9/28/81	12/2/83 (4)

Notes: (1) No data.

(2) Seed did not germinate locally. It was tested and found to be viable in October, 1982 by Native Plants, Inc. Racks 76, 77

(3) Seed did not germinate locally. Tested and found viable November, 1982 by Native Plants, Inc. Racks 71, 73, 75.

(4) Cool-moist stratification 12/283 to 1/27/84. Direct seeded in roottrainers. 5 days to emergence. Racks 98, 99.

(5) 7 to 11 days emergence. Transplanted to roottrainers 12/27/83. Racks 86, 87, 88 (37, 38, 40 plants) 2/29/84-OK.

(6) 8 & 9 days to emergence. Transplanted to roottrainers 1/10/84, 1/26/84, 2/6/84. Racks 93, 94.

(7) 11 +/- days to emergence. Direct seeded in roottrainers. Racks 89, 90.

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Table A-5

Seedling Sources - Grown Locally from Locally Collected Seed
Planted Spring, 1984

Species	Source	Date of Collection	Date of Propagation
Artemisia tridentata (big sagebrush)	Inyo Co., CA Lower Rock Cr. Round Valley 1 elev. 4600 ft. site D Figure 2	11 / 82	12/3/83 (1) 1/10/84 (2)
Artemisia tridentata (big sagebrush)	Inyo Co., CA Sawmill Rd/395 Round Valley 1 elev. 4600 ft. site B Figure 2	11/9/83	12/3/83 (3)
Artemisia tridentata (big sagebrush)	Mono Co., CA Sherwin Grd/395 elev. 6700 ft. site E Figure 2	11/9/83	12/3/83 (4)
Atriplex canescens (fourwing saltbush)	Inyo Co., CA Hwy 168 elev. 4500 ft. site J Figure 2	12 / 80	12/3/83 (5)
Atriplex canescens (fourwing saltbush)	Inyo Co., CA Hwy 168 elev. 4500 ft. site G Figure 2	10 / 81	8/29/83 (6)
Chrysothamnus nauseosus (rubber rabbitbrush)	Inyo Co., CA Round Valley elev. 4600 ft. site A Figure 2	1982	12/3/83 (7)
Chrysothamnus nauseosus (rubber rabbitbrush)	Inyo Co., CA 395/Sawmill Rd. elev. 4700 ft. site B Figure 2	11/9/83	12/3/83 (8)
Chrysothamnus nauseosus (rubber rabbitbrush)	Mono Co., CA 395/Sherill Rd. elev. 6000 ft. site C Figure 2	11/9/83	12/3/83 (9)

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Table A-5 (continued)

Seedling Sources - Grown Locally from Locally Collected Seed
Planted Spring, 1984

Species	Source	Date of Collection	Date of Propagation
Ephedra nevadensis (gray ephedra)	Mono Co., CA US 6/north of Benton site F Figure 2	7/30/82	8/29/83 (10)
Ephedra nevadensis (gray ephedra)	Inyo Co., CA Round Valley site D Figure 2	7/8,12/82	8/29/83 (11)
Purshia tridentata (antelope bitterbrush)	Inyo Co., CA Pine Creek elev. 7000 ft. site H Figure 2	8/3/83	12/14/83 (12)
Purshia tridentata (antelope bitterbrush)	Mono Co., CA Rock Creek site I Figure 2	8/3/83	12/14/83 (12)

Notes: (1) 10 days to emergence in flats. Died by 1/12/84.

(2) 17 days to emergence in flats. Transplanted to roottrainers on 2/8/84. Racks 81, 82 (40, 40 plants) 2/29/84-OK.

(3) 18 days to emergence in flats. Transplanted to roottrainers on 12/28/83. Rack 83 (37 plants) 2/29/84-OK.

(4) 8 days to emergence in flats. Transplanted to roottrainers on 12/22/83. Racks 84, 85 (40, 35 plants) 2/29/84-OK.

(5) 10 days to emergence in flats. Transplanted to roottrainers on 12/28/83, 1/17/84, 1/4/84, 1/26/84. Racks 91,92.

(6) Rodent damage. No plants left.

(7) Failed. Racks 71, 72.

(8) 8 days to emergence. Transplanted to roottrainers 1/84 ?, 1/24/84. Racks 74A, 78. (33, 40 plants) 2/29/84-OK.

(9) 10 & 9 days to emergence. Transplanted to roottrainers 1/25/84, 1/26/84. Racks 74B, 79, 80. (84 plants) 2/29/84-OK.

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Table A-5 (continued)

Seedling Sources - Grown Locally from Locally Collected Seed
Planted Spring, 1984

Notes (continued)

(10) 10 days to emergence. Transplanted to roottrainers. Rodent damage. None planted out.

(11) 10 days to emergence. Transplanted to roottrainers. Rodent damage. None planted out.

(12) COOL-MOIST stratification 12/14/83 to 1/27/84. 5 days to emergence. Direct seeded in roottrainers. Racks 95, 96, 97.

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Table A-6

Soil Nutrient Data

Sample	SP	pH	EC	Ca	Mg	Na	ESP	B	NO3-N	P	X-K	CEC	OM-1	Zn
1389	39	5.8	0.29	1.0	0.8	1.1	1	0.70	4.3	26.0	120	6.5	2.4	2.30
1390	24	6.0	0.19	0.6	0.5	0.8	<1	0.28	4.2	15.2	70	3.5	0.5	0.84
1391	28	6.0	0.25	0.7	0.5	1.3	2	0.14	4.3	13.1	75	3.0	0.4	0.70
1392	30	5.7	0.23	0.4	0.4	1.5	2	0.14	3.1	12.8	60	3.0	0.4	0.53
1393	36	5.5	0.22	0.7	0.4	1.1	1	0.14	6.3	23.0	60	4.5	1.1	0.90
1413	34	8.3	0.89	1.2	0.6	7.1	8	0.35	8.2	13.4	500	6.0	0.5	0.97
1414	46	8.4	0.80	0.7	0.4	6.9	11	0.21	5.0	7.4	515	4.0	0.1	0.45
1415	37	7.2	0.34	0.8	0.6	2.0	2	0.14	5.3	7.7	300	4.0	0.3	1.07
1416	50	8.6	3.70	2.0	0.7	37.	31	1.12	5.3	12.5	1080	9.5	0.1	0.61
1417	39	7.8	0.32	1.6	0.5	1.1	<1	0.14	5.9	5.5	135	2.0	0.1	1.91
18	39	5.1	1.13	7.7	2.4	1.2	<1	0.14	11.0	20.0	65	3.0	0.9	6.00
23	50	5.0	1.31	7.3	2.3	3.5	2	0.49	8.0	20.0	195	3.5	1.0	12.40
85	52	5.0	1.57	9.5	3.4	2.8	<1	0.56	8.0	23.0	200	3.5	1.8	14.30

Notes: 1. COLUMN HEADINGS and UNITS:

SP = saturation percentage, percent
pH = negative logarithm of hydrogen ion concentration
EC = specific conductance, millimhos per centimeter
Ca = calcium, milliequivalents per liter
Mg = magnesium, milliequivalents per liter
Na = sodium, milliequivalents per liter
ESP = exchangeable sodium, percent
B = boron, parts per million
NO3-N = nitrate nitrogen, parts per million
P = phosphorus, parts per million
X-K = exchangeable potassium, parts per million
CEC = cation exchange capacity, milliequivalents per 100 liter
OM-1 = organic matter, percent
Zn = zinc, parts per million

2. Sample 1389, June L. southbound, 20 feet from top of cut
3. Sample 1390, June L. southbound, spoils from 15x36 plot
4. Sample 1391, June L. northbound, spoils from 6x36 plot (lower rows)
5. Sample 1392, June L. northbound, spoils from 9x36 plot (upper rows)
6. Sample 1393, June L. northbound, 20 feet from top of cut
7. Sample 1413, CDF, 15 feet from top of cut
8. Sample 1414, CDF, spoils from 21x30 plot (lower rows)
9. Sample 1416, CDF, spoils from 6x30 plot (upper rows)
10. Sample 1415, Sand Shed, 25 feet from top of cut
11. Sample 1417, Sand Shed, spoils from 15x36 plot
12. Sample 18, planting hole 18, June L. northbound (plant died)
13. Sample 23, planting hole 23, Sand Shed (plant died)
14. Sample 85, planting hole 85, CDF (plant died)
15. All samples collected in January, 1984
16. Testing done by UC Davis, Agricultural Extension Laboratory

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The data below show the relative positions of the planting layouts on CUT slopes. Orientation is facing the slope.

Figure A-2 Layout A	Figure A-3 Layout C	Figure A-3 Layout D

"June Lake" 395 northbound, Mono Co. post mile 40.1 ---> Bishop

Figure A-4 Layout E	Figure A-2 Layout B

"June Lake" 395 southbound, Mono Co. post mile 40.1 <--- Bishop

Figure A-5 Layout F	Figure A-6 Layout G	Figure A-6 Layout H

"Sand Shed" 395 northbound Mono Co. post mile 3.5 ---> Bishop

Figure A-7 Layout I	Figure A-8 Layout J

"CDF" 395 southbound, Inyo Co. post mile 122.4 <--- Bishop

CODES for species of plants:

AT = Artemisia tridentata (big sagebrush)
AC = Atriplex canescens (fourwing saltbush)
CN = Chrysothamnus nauseosus (rubber rabbitbrush)
EN = Ephedra nevadensis (gray ephedra)
PT = Purshia tridentata (antelope bitterbrush)

CODES for sources of seedlings:

x = seedling grown nonlocally (purchased)
y = seedling grown locally from nonlocally purchased seed
z = seedling grown locally from locally collected seed

EXAMPLE: species — PTZ — source
74 — identification number

INDEX SHEET WITH CODES FOR PLANTING LAYOUTS IN FIGURES A-2 : A-8

Figure A-1

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Layout A - June Lake (S 25 W) - Planted 10/27/83

PTx	CNx	CNx	PTx	ATx	ATx	ATx	PTx	PTx	CNx	ATx	CNx
1	2	3	4	5	6	7	8	9	10	11	12
PTx	CNx	PTx	CNx	ATx	ATx	CNx	PTx	CNx	ATx	ATx	PTx
13	14	15	16	17	18	19	20	21	22	23	24
PTx	PTx	CNx	CNx	ATx	ATx	CNx	PTx	ATx	PTx	ATx	CNx
25	26	27	28	29	30	31	32	33	34	35	36
PTx	ATx	CNx	ATx	CNx	PTx	CNx	CNx	PTx	ATx	PTx	ATx
37	38	39	40	41	42	43	44	45	46	47	48
ATx	PTx	PTx	ATx	CNx	CNx	CNx	CNx	PTx	ATx	ATx	PTx
49	50	51	52	53	54	55	56	57	58	59	60
supplemental water						no supplemental water					

Layout B - June Lake (N 25 E) - Planted 10/26/83

PTx	PTx	ATx	CNx	ATx	CNx	PTx	PTx	ATx	CNx	CNx	ATx
1	2	3	4	5	6	7	8	9	10	11	12
CNx	PTx	ATx	CNx	PTx	ATx	PTx	CNx	PTx	CNx	ATx	ATx
13	14	15	16	17	18	19	20	21	22	23	24
ATx	CNx	ATx	PTx	CNx	PTx	ATx	CNx	ATx	PTx	PTx	CNx
25	26	27	28	29	30	31	32	33	34	35	36
PTx	CNx	ATx	ATx	PTx	CNx	CNx	PTx	ATx	ATx	PTx	CNx
37	38	39	40	41	42	43	44	45	46	47	48
PTx	CNx	PTx	CNx	ATx	ATx	PTx	ATx	CNx	CNx	PTx	ATx
49	50	51	52	53	54	55	56	57	58	59	60
no supplemental water						supplemental water					

LAYOUTS A and B

Figure A-2

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Layout C - June Lake (S 25 W) Planted 6/13/84

CNx	PTz	PTy	ATy	PTx	CNz	CNx	PTx	CNz	ATy	ATy	ATx	PTz	ATy	ATz	ATx	ATz	PTx
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
PTy	PTz	CNx	ATz	ATy	PTx	PTx	ATz	ATx	CNz	ATy	PTx	PTz	PTy	ATy	ATx	CNx	CNz
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
PTz	ATx	PTx	ATz	PTx	CNz	ATy	CNz	ATy	CNx	PTx	ATx	PTx	CNx	ATy	ATz	PTy	PTy
133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
ATy	ATx	CNx	PTy	PTz	PTx	ATz	PTy	CNx	ATx	CNz	PTx	CNz	ATz	ATz	ATy	PTx	PTz
169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186
ATz	PTz	ATy	ATz	PTx	PTy	CNx	ATy	ATx	ATy	CNz	ATx	CNz	ATz	CNx	PTy	PTx	PTz
205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222

no supplemental water

Layout D - June Lake (S 25 W) Planted 6/13/84

PTz	CNx	PTz	PTy	ATx	ATy	ATy	CNz	CNz	ATz	PTx	ATx	ATx	CNx	ATz	PTz	PTx	PTz
79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
ATy	ATz	ATx	CNz	ATz	ATx	ATy	PTz	PTx	ATz	CNz	PTy	CNx	PTz	CNx	PTx	PTz	PTy
115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
ATx	CNz	ATx	CNx	PTy	ATy	ATz	ATy	PTx	PTx	ATx	CNx	ATz	PTz	PTx	PTz	PTx	CNx
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168
PTy	ATx	PTz	ATx	ATx	ATy	CNz	PTy	PTx	PTz	ATz	CNz	CNx	PTx	CNx	ATz	ATz	ATy
187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204
PTx	PTx	ATz	CNz	ATx	PTx	PTz	ATx	CNx	PTy	ATz	ATy	PTz	ATx	ATz	ATy	PTz	CNx
223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240

supplemental water

LAYOUTS C and D

Figure A-3

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Layout E - June Lake (N 25 E) Planted 6/12/84

PTx	CNz	ATx	PTz	ATz	PTx	ATy	PTy	CNx	PTx	ATz	PTz	PTy	CNx	ATy	CNz	ATx	ATz
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78
PTz	ATx	PTz	CNx	PTx	ATx	CNz	ATy	ATz	PTx	PTy	PTz	CNx	ATx	CNz	PTz	ATy	ATz
79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	94	95	96
CNz	ATz	PTy	CNx	ATy	PTz	ATx	ATz	PTx	PTy	PTx	ATz	CNz	ATx	ATy	PTx	CNx	ATy
97	98	99	100	101	102	103	104	105	106	107	108	109	110	111	112	113	114
ATz	PTy	ATy	CNz	PTx	CNx	ATx	PTz	ATz	PTz	ATx	ATy	ATz	PTy	ATz	PTx	CNz	CNx
115	116	117	118	119	120	121	122	123	124	125	126	127	128	129	130	131	132
PTx	ATy	CNx	CNz	PTx	ATy	ATx	ATz	PTy	PTy	PTx	ATy	ATx	ATy	CNx	CNz	PTz	ATz
133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148	149	150
PTz	ATx	PTz	CNz	ATz	ATy	ATx	CNx	PTx	CNz	PTx	ATy	PTx	ATz	PTy	CNx	ATx	PTz
151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168
CNz	ATz	CNx	ATy	PTz	ATx	PTx	ATy	PTx	CNx	ATz	ATx	PTy	PTx	CNz	PTx	ATx	ATy
169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186
ATz	ATz	PTx	CNz	PTz	CNx	PTx	ATy	PTy	ATx	ATy	ATz	PTz	ATx	CNz	PTy	CNx	ATx
187	188	189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204
PTz	ATx	PTx	ATx	CNz	PTy	ATz	ATy	CNx	PTy	PTz	CNx	PTz	ATy	CNz	ATz	PTx	PTx
205	206	207	208	209	210	211	212	213	214	215	216	217	218	219	220	221	222
ATx	ATz	PTx	PTx	CNz	PTz	ATy	CNx	PTy	PTx	ATy	ATz	CNx	ATx	PTz	CNz	ATx	PTy
223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238	239	240
supplemental water									no supplemental water								

LAYOUT E

Figure A-4

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Layout F - Sand shed (S 60 W) - Planted 11/9/83

ATx	ENy	CNx	ENy	CNx	ATx	ATx	ENy	CNx	CNx	ENy	ATx
1	2	3	4	5	6	7	8	9	10	11	12
ENy	ATx	ENy	ATx	CNx	CNx	ATx	ENy	CNx	ENy	ATx	CNx
13	14	15	16	17	18	19	20	21	22	23	24
ATx	ENy	CNx	ATx	CNx	ENy	CNx	ATx	CNx	ENy	ENy	ATx
25	26	27	28	29	30	31	32	33	34	35	36
CNx	ATx	ENy	ATx	CNx	ENy	ENy	CNx	CNx	ATx	ENy	ATx
37	38	39	40	41	42	43	44	45	46	47	48
ENy	ENy	ATx	ATx	CNx	CNx	CNx	ENy	ATx	ENy	CNx	ATx
49	50	51	52	53	54	55	56	57	58	59	60
supplemental water						no supplemental water					

LAYOUT F

Figure A-5

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Layout G - Sand shed (S 60 W) Planted 5/1/84

ATz	CNx	ENx	ENy	ENy	CNx	CNz	ATy	CNx	ACx	ATx	ENy	ATz	CNz	ACx	ENx	ENy	CNx	ENx	ATx	ATy	CNz
61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	81	82
ATy	ENy	ACx	ENx	ACy	ATz	ATy	ACx	CNx	ATx	CNz	CNz	ENx	ATy	ATx	ATy	ENx	ATz	ACx	CNx	ACx	ENy
105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122	123	124	125	126
CNx	ATx	ATy	ENy	CNz	ACz	ACx	CNz	ATz	CNz	ENx	ENy	ACy	CNx	ATx	CNz	CNz	ENx	ACx	ATz	ACz	ATy
149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166	167	168	169	170
ATz	ATx	ENy	ATx	ATy	ENx	CNx	CNz	ATy	ENx	ACx	ACx	ACx	CNz	ATy	CNz	ATz	ACx	ATx	ENx	CNx	ENy
193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210	211	212	213	214
ENx	ATz	ACx	CNx	ACx	ACy	ENy	ATz	ATx	ATy	CNz	ENy	ACx	ENy	ATz	CNz	ATx	ATy	CNx	ATx	ENx	ATz
237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254	255	256	257	258

no supplemental water

Layout H - Sand shed (S 60 W) Planted 5/1/84

ATz	ENy	CNx	ENx	ATz	ATy	ACx	ATx	ENx	CNz	ATx	CNx	ATx	ATz	CNx	CNz	ENx	ENy	ACx	ATy	ACx	ATx
83	84	85	86	87	88	89	90	91	92	93	94	95	96	97	98	99	100	101	102	103	104
ATz	CNz	ATx	ATy	ACx	ENx	ENy	ATz	CNx	ATy	ATz	ATz	ATx	ENy	ENx	ACy	ENy	ATy	CNx	ACz	CNz	ACx
127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144	145	146	147	148
CNx	ATx	ATz	CNz	ENy	ATy	ENx	ATy	CNz	ENy	ACx	CNx	ACx	ENx	ATx	ACx	ENx	ENy	ATz	CNz	CNx	ATy
171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188	189	190	191	192
ACx	ENy	ATz	CNx	ENx	ATy	CNz	ENx	ACz	ATx	CNz	ATy	ATx	ACy	CNx	CNz	ACx	ENy	ATx	ATz	ENy	ENx
215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232	233	234	235	236
ENy	ATx	ATz	CNx	ENx	ENx	CNx	ACy	CNz	ACx	ATy	ATz	ATy	ENy	ACx	ACz	CNx	CNz	ENy	ATx	CNz	ENx
259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276	277	278	279	280

supplemental water

LAYOUTS G and H

Figure A-6

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Layout I - CDF (N 10 E) Planted 4/18/84

ENy	ACx	CNz	CNz	ATx	ENx	CNx	ATy	ACz	ACz	ATz	CNz	ATz	ENx	ACz	CNx	ATx	CNx	ATy	ATz	ACx	ACz
101	102	103	104	105	106	107	108	109	110	111	112	113	114	115	116	117	118	119	120	121	122
ATx	CNy	ATy	ENx	ACz	CNx	ATz	ACz	ACx	CNz	ENy	ENy	ATy	ATz	ENx	CNz	CNz	ATx	ACx	ACz	ACx	CNx
123	124	125	126	127	128	129	130	131	132	133	134	135	136	137	138	139	140	141	142	143	144
ATy	CNz	CNx	ENx	ATz	ACx	CNz	ACz	ENy	ATx	ACx	ATy	CNz	ACx	ENy	ACz	ATx	ENx	ACx	ATz	CNx	CNz
145	146	147	148	149	150	151	152	153	154	155	156	157	158	159	160	161	162	163	164	165	166
ATx	ATz	CNz	CNx	ACz	ATy	ENx	ACz	ENy	CNx	ACx	ATx	ACz	CNx	ACz	CNy	ENy	CNz	ATz	ATy	ACx	ENx
167	168	169	170	171	172	173	174	175	176	177	178	179	180	181	182	183	184	185	186	187	188
ACx	CNz	ATz	ENy	ACx	ACz	CNx	CNx	ATy	ATx	ENx	ENx	ACx	ATy	ATx	ENy	ACx	CNx	ATz	CNx	CNz	ACz
189	190	191	192	193	194	195	196	197	198	199	200	201	202	203	204	205	206	207	208	209	210
ATx	ACz	ENx	CNy	ATz	ATy	CNx	ACx	CNz	ENy	ACz	CNz	ATy	ENy	ATx	CNz	ENx	ACx	CNx	ATz	ACz	ACz
211	212	213	214	215	216	217	218	219	220	221	222	223	224	225	226	227	228	229	230	231	232
ACz	ENx	ACz	CNx	CNz	ATx	CNx	ENy	ACx	ATz	ATy	ACz	ATx	ATz	ATy	ENy	ENx	CNx	ACx	ACz	CNz	CNz
233	234	235	236	237	238	239	240	241	242	243	244	245	246	247	248	249	250	251	252	253	254
CNx	ATy	ACx	CNz	ATz	ACz	ENx	ATx	ENy	ACx	CNz	CNx	ACz	ACx	ATy	ENx	ACx	ENy	ATx	CNz	ATz	CNx
255	256	257	258	259	260	261	262	263	264	265	266	267	268	269	270	271	272	273	274	275	276
ATy	ATz	CNx	CNz	ACz	ACx	CNx	ENx	ENy	ACx	ATx	ACx	ACz	ATy	CNx	CNy	ATz	ENy	CNz	ATx	ENx	ACz
277	278	279	280	281	282	283	284	285	286	287	288	289	290	291	292	293	294	295	296	297	298
ENy	CNz	ACx	ATy	ATx	CNx	ENx	CNz	ACx	ATz	ACz	ENy	CNx	ACx	ATz	CNx	ATx	ATy	ACx	ACz	ENx	CNz
299	300	301	302	303	304	305	306	307	308	309	310	311	312	313	314	315	316	317	318	319	320
supplemental water											no supplemental water										

LAYOUT I

Figure A-7

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Layout J - CDF (N 10 E) - Planted 11/9-10/83

ENy	ATx	CNx	ACx	ACy	CNx	ENy	ACx	ATx	ACy
1	2	3	4	5	6	7	8	9	10
ENy	ACx	CNx	ATx	ACx	CNx	ATx	ENy	ACy	ACx
11	12	13	14	15	16	17	18	19	20
CNx	ACx	ENy	ATx	ACy	CNx	ENy	ACx	ATx	ACy
21	22	23	24	25	26	27	28	29	30
ENy	ACy	ACx	CNx	ATx	ENy	ACx	CNx	ATx	ACy
31	32	33	34	35	36	37	38	39	40
CNx	ENy	ACy	ATx	ACy	ACx	ACy	CNx	ATx	ENy
41	42	43	44	45	46	47	48	49	50
ATx	ACx	CNx	ACy	ENy	ACy	ACx	ATx	CNx	ENy
51	52	53	54	55	56	57	58	59	60
ATx	ENy	ACx	CNx	ACy	ACx	ACy	CNx	ATx	ENy
61	62	63	64	65	66	67	68	69	70
CNx	ACy	ACx	ATx	ENy	CNx	ACy	ACx	ENy	ATx
71	72	73	74	75	76	77	78	79	80
ACx	ENy	CNx	ATx	ACy	CNx	ENy	ATx	ACy	ACx
81	82	83	84	85	86	87	88	89	90
ACx	ACy	ATx	ENy	CNx	ENy	ACx	ACy	CNx	ATx
91	92	93	94	95	96	97	98	99	100
no supplemental water					supplemental water				

LAYOUT J

Figure A-8

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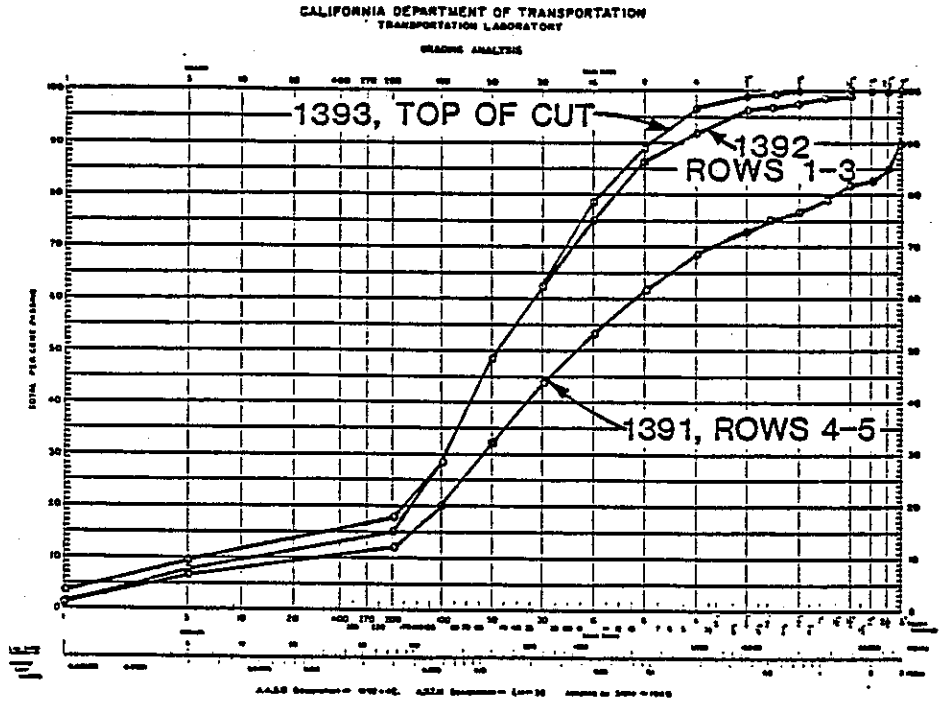
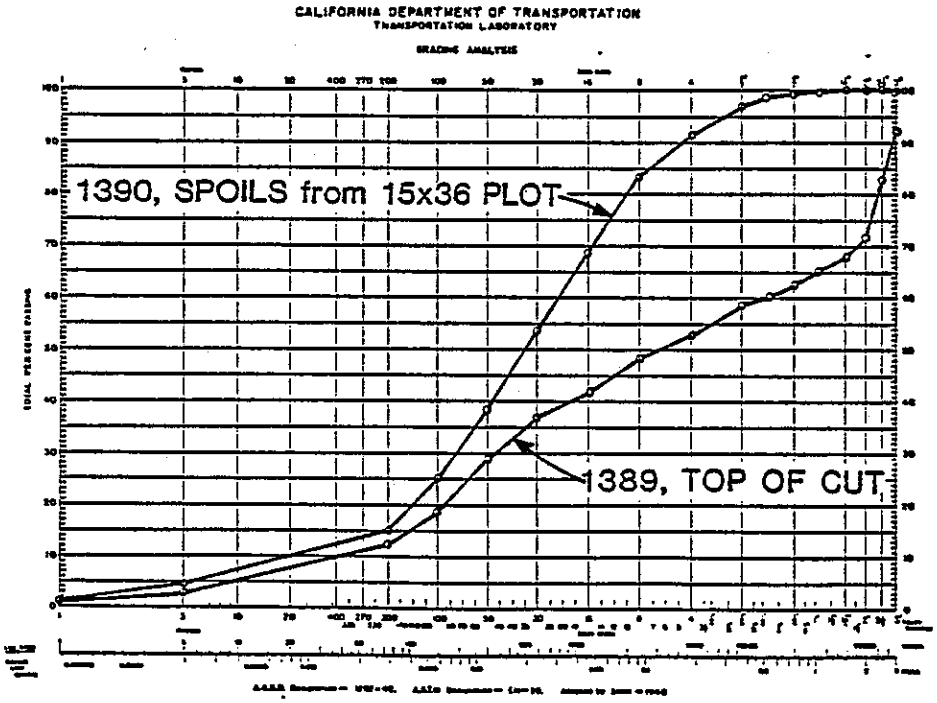
A-9A – June Lake Site, Northbound



A-9B – June Lake Site, Southbound



GRADATION PLOTS, June Lake

Figure A-9

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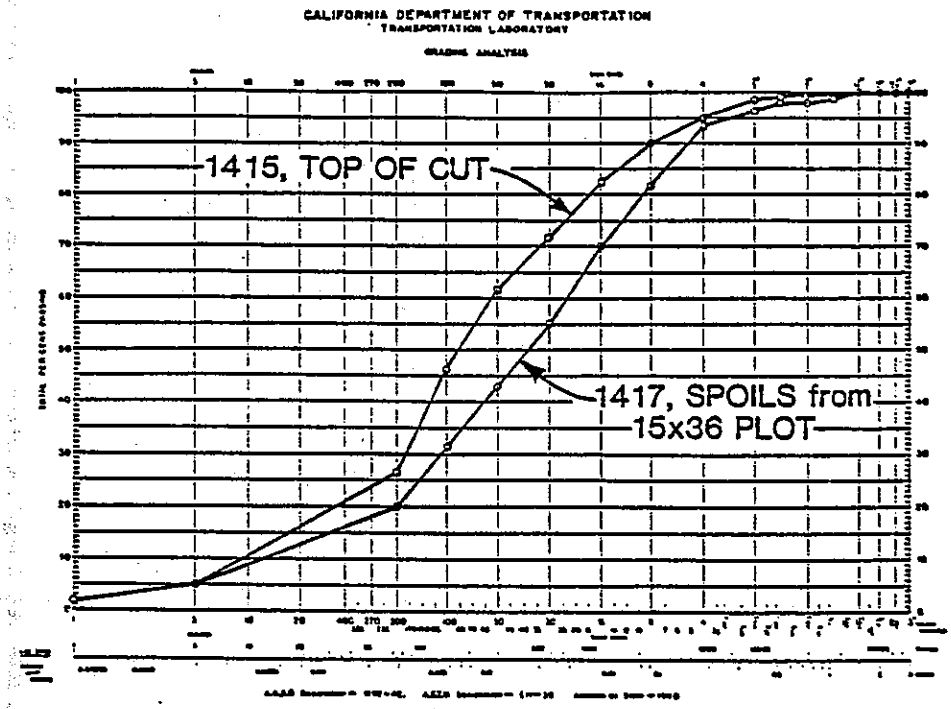
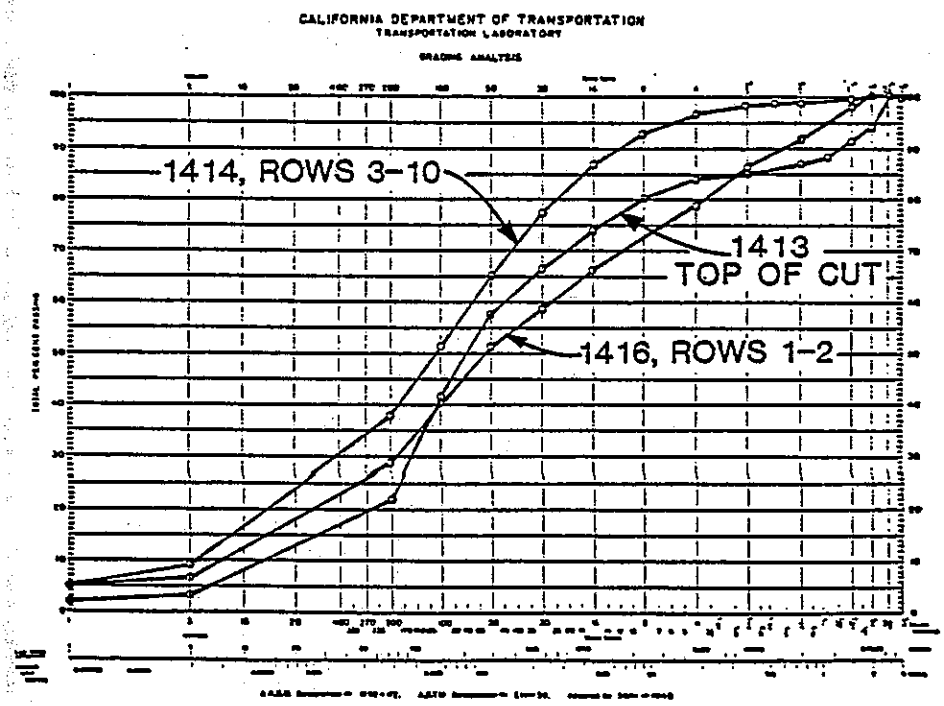
A-10A - Sand Shed Site



A-10B - CDF Site



GRADATION PLOTS, Sand Shed and CDF

Figure A-10

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