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DEPARTMENT OF AGRONOMY AND RANGE SCIENCE
COLLEGE OF AGRICULTURAL AND ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION

DAVIS, CALIFORNIA 95616

Dec. 15, 1977

TO: Persons interested in desert shrubs:

Enclosed are 21 monographs concerning shrubs commonly found on the Mojave Desert. These are a numbered series titled Mojave Research Notes, reporting work accomplished for Bureau of Land Management contract (53500-CT4-2(N)).

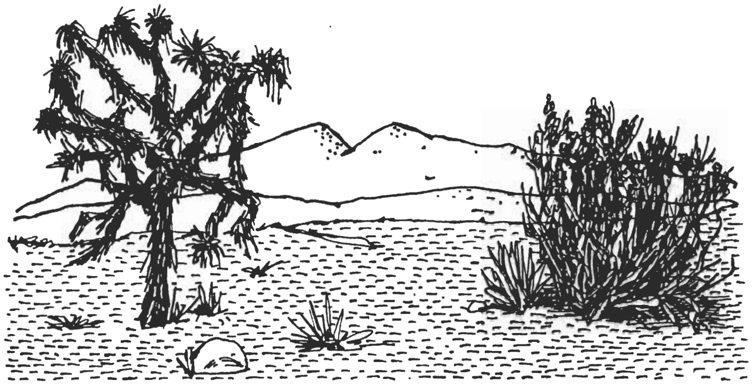
The contract is dedicated to learning more about desert shrubs which might be used for seedling disturbed sites in the Mojave Desert. The monographs include a description of the plant and a literature review as well as the results of our studies in seed collection, seed cleaning, seed germination including seed treatments and temperature requirements, and long term seed storage. Most include photographs of the seed, seedlings, and mature shrub.

I sincerely hope these will be of interest to you and your associates.

B L Kay
Burgess L. Kay
Specialist in Wildland Seeding

BLK:md

Enc.



Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

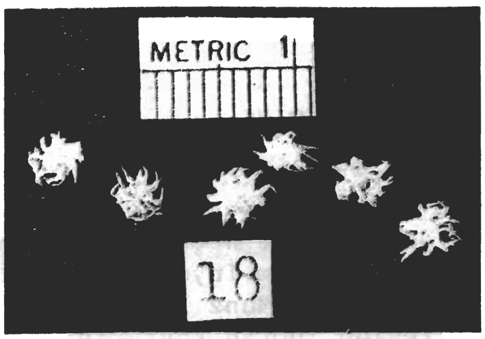
No. 1 BURROBRUSH August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

Ambrosia dumosa (Gray) Payne.

[Franseria d. Gray.]

Burrobrush, burroweed, sandbur, white bursage.



Top: Burs
Bottom: Seedling

Mature shrub, 27 cm tall, showing effect of browsing.

[1/]Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is Farm Advisor, UC Cooperative Extension, San Diego, CA.

This paper reports on work supported by the Bureau of Land Management -- Contract No. 53500-CT-4(N), Document Obligation No. 6809.

The following description of Ambrosia dumosa is adapted from McMinn (1951) and Munz (1974).

Family: Asteraceae (Compositae) Tribe: Heliantheae

Habit: Low, spreading, rounded, shrub; 20-60 cm high; grayish green; intricately branched white stems, young stems covered with appressed, stiff, short hairs, interwoven, bearing spines with age.

Leaves: Clustered, mostly 5-20 mm long, 8-11 mm broad; once to thrice-pinnate, with short, rounded lobes; covered with appressed, stiff, short hairs.

Flowers: Inconspicuous; staminate and pistillate heads intermixed in the terminal and lateral spikes of the panicle; staminate heads 3-4 mm in diameter, the free portions of the involucral bracts slightly longer than broad, acute, woolly, pistillate heads, usually with 2-flowered involucres, bracts fused to enclose the seed; flowering primarily Feb. to June and Sept. to Nov., or following rain.

Fruit: Fruiting heads 5-6 mm long, resembling cockleburs; spines broad, thin at bases, with upper surfaces deeply grooved, lower surfaces hooked, tapering at the apices; spines and involucre bearing-sticky hairs.

Abundant on well-drained soils through much of the southwest, Ambrosia dumosa is found in Creosote Bush Scrub and Joshua Tree Woodland communities of the Mojave and Colorado Deserts of California, from Inyo Co. south and east to Utah, Arizona, Mexico, and lower California (Munz 1974). Coville (1893), in his travels in the Death Valley region, noted that the burrobrush had practically the same altitudinal limits below 1070 m (3500 ft) (Munz, 1974)) as the creosote bush Larrea tridentata, being most common with Hymenoclea salsola in the upper part of the Larrea Belt of the Lower Sonoran Life Zone.

By virtue of its rhizomatous growth habit, similar to that of creosote bush, Ambrosia is an extremely long-lived shrub (Muller, 1953). The dense, rounded, younger shrubs (about 0.5 m diam.) become irregular as the individual aerial shoots die and an intricate crown of independently rooted shoots develops. This crown accumulates windblown sand and organic debris and allows the clone to spread to about 1 m in diameter. Chase and Strain (1966) and Weiland et al. (1971) had no difficulty in vegetatively propagating cuttings of Ambrosia. Lunt et al. (1973) determined that Ambrosia has a soil-oxygen requirement lower than that of Larrea.

Ambrosia is easier to establish by transplanting than spot seeding (Graves, 1976). Transplanting nursery-grown seedlings at two Mojave test sites following the coldest winter period (in February) resulted in 42 and 54% establishment. Success from spot seeding was 0 and 4% at the same sites. A one-time irrigation treatment did not improve results of either transplanting or spot seeding.

Wallace et al. (1973) found that plants of Ambrosia dumosa grown in soil collected from their native habitat gave much poorer yields in steam-sterilized soil than in unsterilized soil. Plant analysis revealed that phosphorus was deficient in plants grown on sterilized soil and these workers inferred that this deficiency might have arisen due to the absence of a mycorrhizal association in the steam-sterilized soil.

Bamberg et al. (1975) investigated the comparative photosynthetic production of Mojave Desert shrubs, and considered the adaptive strategy of Ambrosia to be drought-deciduous with high photosynthetic and transpiration rates during favorable conditions with some ability to withstand temperature stress when moisture is sufficient.

Clark et al. (1974) noted that A. dumosa appeared to transpire at a higher rate than Atriplex confertifolia or Atriplex hymenelytra. In a study conducted to determine ability to recover from drought conditions A. dumosa recovered from a soil moisture tension of -60 bars at 4, 8, and 16 days after onset. Plants irrigated at 32 days died. Complete leaf necrosis was observed at -60 bars.

The species is predominantly diploid, though chromosome numbers of n = 18, 36, and 54 have been recorded (Payne et al., 1964). The diploid form is that of the typical low, rounded, gray-green shrub described earlier, with delicate 2-3 pinnate leaves and a short spicate inflorescence. The less common polyploid form is a larger, darker-green plant with coarse bipinnate leaves and a much larger inflorescence (Geissman and Matsueda, 1968). The dominance of the diploid form supports its placement near the beginning of the evolutionary scheme for the genus (Payne et al., 1964).

Coville (1893) saw that horses preferred Ambrosia over all other desert shrubs for forage in the absence of grass. The shrub is a valuable forage plant on western rangelands, with nutritious burs and foliage (Stark, 1966). Constant trimming by desert animals gives Ambrosia the hedged, rounded form common in many areas. Welles (1961) noted in Death Valley "The close-cropped, hedged appearance of many Franseria plants in the vicinity of Cockscrew Spring had been puzzling for many years until June 13, 1957, when a chuckwalla was observed to crawl up into a Franseria dumosa bush and, spreading on all four legs, to move about on top of the plant in a sort of swimming motion, snipping off the newer shoots in a hedge-clipping effect. That explained to us for the first time why so many Franserias look the way they do."

Many annual plants appear to be dependent on Ambrosia, being found only under the shrub canopy in spite of a water-soluble toxic principle produced by the shrub that has been found to kill tomato seedlings in nutrient culture (Muller, 1953). The failure of this allelopathic substance was attributed to possible breakdown activity of the soil microflora or adsorption by colloidal components in desert soils. A few of the shrub dependent species are: Malacothrix californica var. glabrata Gray, Rafinesquia mexicana, Phacelia distans var. australis Brand, Ellisia membranaceae Benth, and Chaenactis fremontii Gray.

We used three collections of A. dumosa in seed studies. Burs tested by Williams et al. (1974) were collected near Lancaster in early June 1971 by a commercial seed collector. We hand collected a second sample from late maturing plants along the L.A. Aqueduct in late June 1973 (Kay, 1975). A third sample was harvested by Carl Rice of BLM in early June 1974, at which time the burs were dry and dropping from the shrubs. Generally no cleaning was attempted because of the spiny nature of the burs. The impurities were mainly male flower parts, present because male and female flowers are borne on the same raceme. Collecting burs from beneath the plants is impractical because the light burs are easily windblown, tending to collect under the bush for only a short time. Information on seed quality of these collections appears in Table 1.

Optimal germination temperatures were between 15 and 25 C, with no germination at 2 or 5 C (Kay 1975). The warmer spring temperatures used by Williams et al. (1974) in depth of planting studies are apparently responsible for higher reported emergence than a similar fall test (Kay 1975). The optimum depth of planting was 1 cm, with little or no emergence from 2 cm (Table 1).

Table 1. Information on seed quality from several sources.

Collection date	6/71	6/23/73	6/5/74
Seed weight	303,600/kg 138,000/lb	374,000/kg 170,000/lb	161,000/kg 73,000/lb
Purity	--	63%	64%
Fill	27%	16%	44%
Initial germination at	20% 17-21 C	8% at 20 C	8% at 20 C
Plantings in sand: Date	May	November	--
Emergence From 1 cm	16%, 9 days	1%, 20 days	--
Emergence From 2 cm	2%, 10.5 days	0	--

In testing the effects of various seed treatments, Graves et al. (1975) found that 7- and 14-day germinations were equally improved by activated carbon or stratification in moist sand at 2 C for 30 days resulting in 24% final germination of seed of 26% fill compared to 17% with untreated seed (Fig. 1). Heat treatments did not raise or depress the germination percentage significantly.

In a seed storage experiment the 1973 collection was treated with Phostox® and dried for 6 days at 35 C. Seed samples were then sealed in 60 one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C and twenty at -15 C. A fourth storage condition was bagging and storing in a seed warehouse in Davis, California. The storage was begun on December of 1973. The experiment was designed to provide yearly tests of germination for twenty years. The 1974 collection was treated similarly, however, the seed was divided up between thirty laminated plastic aluminum foil packets. Three groups of ten sealed packets were placed in temperatures identical to the 1973 collection storage. Again a warehouse treatment was set up. This experiment will provide yearly tests for ten years. The results of these germination tests to date are presented in Table 2.

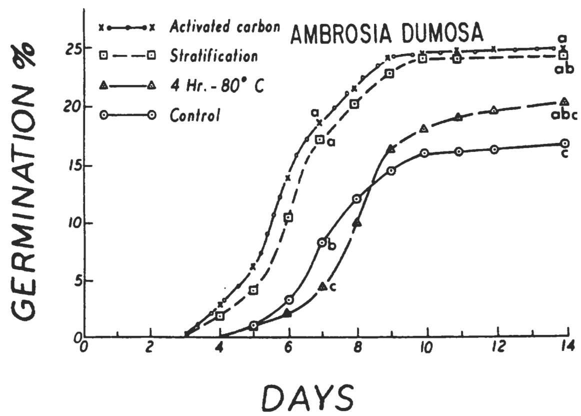


Fig. 1. Germination of burs, representing treatments that showed significant difference from the control. Germination at days indicated by the same letter are not different according to Duncan's NMRT ($P < 0.05$).

Table 2. Germination of two collections of Ambrosia dumosa under several storage environments over time.

	Months after initiation of experiment				
	0	13	18	30	43
1973 collection			-----%------		
Warehouse	5	8	6	8	5
room temp. (sealed)*		5	10	8	5
4 C (sealed)*		7	6	7	3
-15 C (sealed)*		7	7	6	7

	Months after initiation of experiment			
	6	11	23	36
1974 collection		------%------		
Warehouse	12	18	10	10
room temp. (sealed)+	18	16	14	15
4 C (sealed)+	12	12	8	9
-15 C (sealed)+	7	12	10	11

* Sealed at 4.1% moisture
+ Sealed at 5.1% moisture.

The data do not indicate that any one storage condition is better over this period of time. The rather low germinability of both collections has been maintained up to 43 months for the 1973 collection and up to 36 months for the 1974 collection. This may indicate that given a better quality seed sample it would store equally well. The 1971 seed collection was stored at 10 C in non-sealed plastic bags for 75 months and germination decline was minimal (20% to 18%). Germination is mostly during the second and third weeks at 15 C in moist paper towels.

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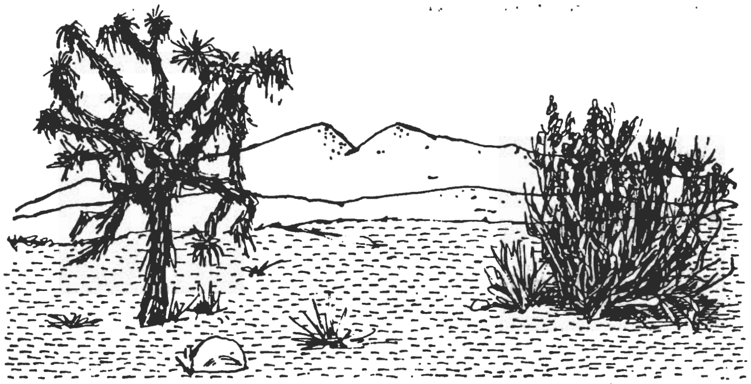

Mojave Revegetation Notes

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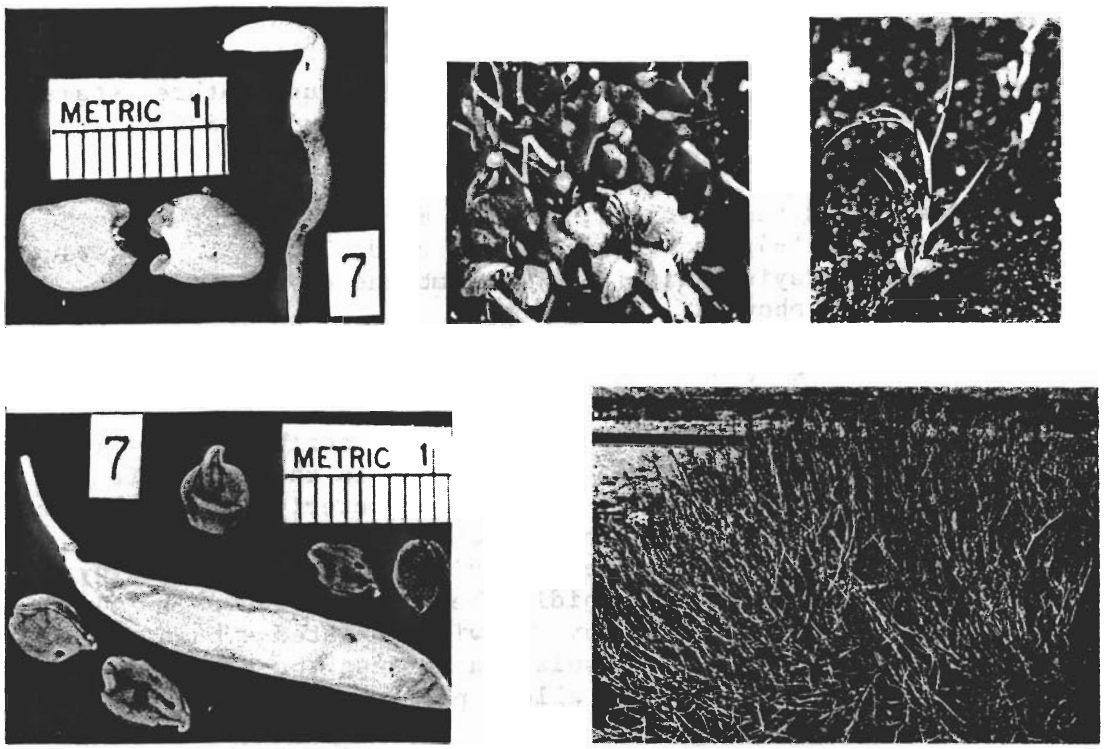
No. 2   ARMED SENNA (Cassia armata)   February 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Photos: Top left-pods and seeds; top middle-flower; top right-seedling Bottom left-cotyledons and seedling; Bottom middle-young plants; Bottom right-mature shrub (8 dm tall).

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

Cassia armata Wats.

Armed Senna, Bladder Senna, Spiny Senna.

Family: Leguminosae (Subfamily: Caesalpinioideae)

The following description is adopted from McMinn (1951).

Habit: Low bushes, usually 30 cm to over 1 m high; branches pale green, glabrous or sparingly pubescent, almost leafless.

Leaves: Plants leafless through much of the year, leaves appearing with flowers in the spring; about 12 cm long with leaflets in 2-3 scattered (not necessarily opposite) pairs; leaflets ovate to almost round, about 5 mm long, 4 mm broad, thick and fleshy with a few scalelike hairs; leaf rachis thick and fleshy, about 1 mm in diameter, prolonged 15-25 mm past the leaflets, enlarged at the apex into a sharp prickle or spine.

Flowers: Fragrant; yellow to salmon colored; solitary or several in the axils of the upper leaves; inflorescence resembling a raceme, 5-15 mm long; sepals about 3 cm long; petals 5-10 mm long; upper three stamens sterile and minute; flowers regular, not pea-like; appearing May to July.

Fruit: Linear pods, light tan in color; turgid, may be somewhat constricted between the seeds; 2.5-4.5 cm long, 4-7 mm broad, 3-6 mm thick; spinulose-tipped; seeds grayish, with a thick membrane covering a brown surface, irregularly obovoid, 7-9 mm long.

The armed senna, widespread in the Mojave and Colorado Deserts, is commonly found on the sandy soils or gravelly washes of the desert plains and hills below (3,700 ft) elevation (Munz, 1974). Described by Coville (1893), Cassia is a slow-growing plant, yet the wood is thin and soft surrounding a large pith - a form which is more characteritic of herbaceous plants. The leaves, also, are not obviously adapted (by hairs, scales, etc.) for arid conditions, and are present only during the spring rainy season, when they grow and transpire rapidly, becoming deciduous in the summer months. The stem, however, is covered with inflated tubular hairs which slow air movement, giving some insulation against the hot dry desert air. Chlorophyll in the stem epidermis allows photosynthesis to continue during the leafless period.

Dry pods, collected on the ground in August, 1973, were run once through a belt harvester and a fanning mill (equipped with a no. 14 top screen and a no. 18 bottom screen) to shell the seeds from the pods. This treatment yielded 2.87 kg of seed, 94% undamaged, 38,800 seeds/kg (17,600/lb). With a 75% germination, a "viable" seed weight of 15,400/kg (7,000/lb) was calculated (Kay, 1975). Though not found in stands, Cassia occurs on relatively accessible sites along the highway or road embankments. Pod yield is good, and pods are easily stripped from the plant when dry. Heavy seed crops may attract game animals (Stark, 1966). A July harvest would improve collection quality since it would allow the pods to be stripped from the plant, a much cleaner operation than the August ground collection.

The fairly large seed is easily handled, and produces a strong seedling, one of few desert shrubs which was able to emerge from a 4-cm depth (See Figure 1) (Kay, 1975).

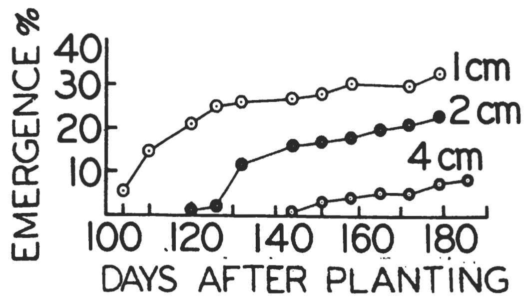


Figure 1. Emergence of Cassia armata from several depths of planting.

The hard seed coat apparently has a protective function, allowing the seed to remain unaffected through the winter in moist, cold soil. After establishing a long tap root, the seedling emerges in the spring. Germination is favored by warmer (15-20 C) springlike temperatures (Table 1). Seed planted in moist sand in Davis, California, on Nov. 8 did not emerge for 100 to 140 days depending on the depth of planting (Figure 1). Total emergence from a depth of 1 cm, under the stratification described above, was 34% with lower figures for 2- and 4-cm depths. When planting is done under optimal conditions, germination occurs in 2-5 days (Stark, 1966).

Table 1. Germination (percent) of Cassia armata at a range of constant temperatures*.

Degrees C	2	5	10	15	20	25	30	40
Germination %	0	0	5	10	12	5	7	0

* Courtesy of Dr. James A. Young, ARS-USDA Reno, Nevada.

In a seed germination experiment, seed was treated with Phostox after processing and dried at 35 C for six days. The seed was divided and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. The experiment was designed to provide germination tests on a yearly basis over a twenty year period. The results to date are presented in Table 2.

Germination increased in sacked warehouse storage in the first 13 months, but decreased in all sealed storage treatments. The increse was probably due to after-ripening requirements. The decrease was apparently due to increased percentage of hard seed in all the sealed samples, possible induced by the drying treatment. The relative percent of hard seed appears to be decreasing with time, and is greatest at the lowest storage temperature. Total viable seed remains very high at 43 months (88-94%) with no significance between storage treatments. After 43 months of storage, germination was most rapid in the first two weeks.

Table 2. Germination (percent) of seeds of Cassia armata.

Months	0	13	18			30			43		
**	G	G	G	H	T	G	H	T	G	H	T
Warehouse	75	85	82	5	87	75	6	81	83	5	88
Room Temp. (sealed)*	--	41	40	56	96	35	48	82	52	40	92
4 C (sealed)*	--	26	29	65	94	23	65	88	40	47	87
-15 C (sealed)*	--	35	33	61	94	22	68	90	38	56	94

* Dried to 5.5 % moisture
** G = germination, H = hard seed, T = total germination

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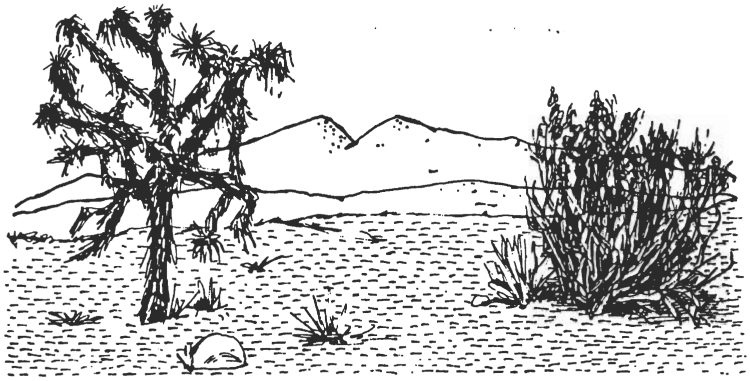
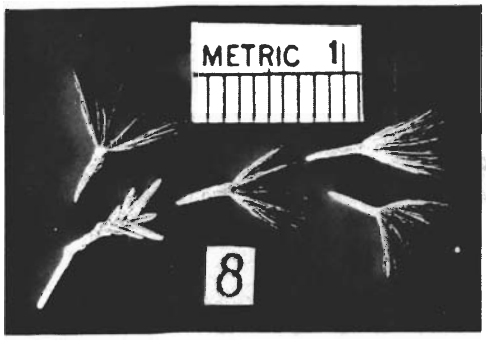


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 3 RUBBER RABBITBRUSH August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Chrysothamnus nauseosus (Poll.) Britton ssp. hololeucus (Gray) Hall & Clem.

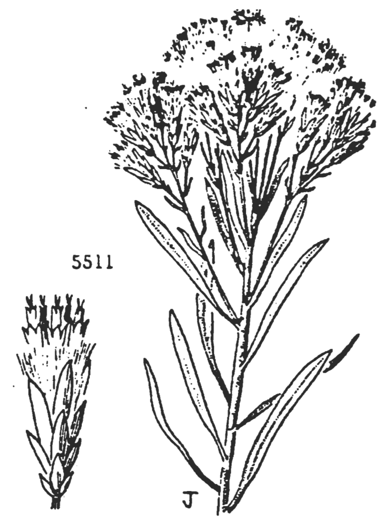
Family: Asteraceae (tribe: Astereae)

Photos: Top left-seeds (achenes); lower left-large seedlings; upper right-small seedlings-lower right-mature plants (up to 1 m tall).

1/ Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

Description adapted from Munz (1974) and McMinn (1951). Drawing is reprinted from Abrams and Ferris, ILLUSTRATED FLORA OF THE PACIFIC STATES, 4 Vols., with the permission of the publishers, Stanford University Press. Copyright © 1951, 1960 by the Board of Trustees of the Leland Stanford Junior University.



5511. Chrysothamnus nauseosus

Habit: Erect shrub, 5-20 dm high; numerous stems originating at the base, with pliable leafy branchlets, white, gray, or yellowish-green, densely white-woolly, wool not matted.

Leaves: Often sparse at flowering time; generally about 1 mm broad, 1-3 cm long, thread-like or broadly linear, white-woolly like the twigs, fragrant.

Flowers: Yellow heads in dense, rounded, terminal cymose clusters; usually 20-25 woolly involucral bracts, involucre 6-7 mm high, corolla 7-8 mm long, commonly 5-6 flowers; flowering in October and November.

Fruit: Hairy achenes, 5-angled.

A number of subspecies are found in different habitats: mountain rubber rabbitbrush (C. nauseosus ssp. salicifolius) at higher elevations, white rubber rabbitbrush (C.n. ssp. graviolens) on well-drained foothill soils, and alkali rubber rabbitbrush (C.n. ssp. consimilis) on valley and plains soils. White rubber rabbitbrush grows well on both acid and alkaline soils, but the others are adapted to alkaline soils (Plummer, 1977). The hololeucus subspecies can be found on sandy nonalkaline soils of high deserts 900-2,700 m (3,000-9,000 ft.) elevation, along the western ends of the Colorado and Mojave deserts, west to the Cuyama Valley and north to Mono County, as well as throughout Nevada (Munz, 1974).

Brought under study as a possible source of rubber following war-caused shortages in the early 1940's, the strongly scented rubber rabbitbrush proved unsuitable for domestication. Estimates by the Eastern Regional Research Lab (USDA) indicated that the total number of wild plants would not produce more than 30,000 tons of rubber (Trumbull, 1942). Chrysil, the non-latex rubber, is contained mostly in the cortex cells of basal stem parts which are 3 or more years old. An average of 2.83% rubber was determined in the hololeucus subspecies, found mostly near the soil level (Hall et al., 1919). Native Americans steeped the leaves and stems of this shrub species to brew a tea used to relieve colds and stomach disorders. Early pioneers made a yellow dye from various species of rabbitbrush (Bay, 1976). Though various species cause allergy in some people (Stark, 1966), the shrub might be useful along roadsides for reducing headlight glare (Bay, 1976).

Palatability varies some, but most types in California are rated fairly low (Sampson and Jespersen, 1963). Hanks et al. (1975) described a paper chromatographic technique which distinguished palatable and unpalatable subspecies of rubber rabbitbrush. They proposed utilizing this kind of analysis to select palatable subspecies for range improvement projects and nonpalatable species for areas where animal use is to be discouraged. The terminal portions of the flower stalks and flower heads are the most palatable plant parts, receiving heaviest cropping by deer and antelope in the late fall and winter, especially after a rain or heavy frost (Leach et al., 1957).

The protein content of the fresh aerial foliage varies from a high of 20.7% at the immature stage preceding blooming to 5.9% at the mature stage following blooming. Protein digestibility for cattle varies from a high of 75% at the immature stage to 50% at the mature stage (National Academy of Sciences, 1971).

Plummer (1977) reports that rubber rabbitbrush will produce seed-bearing adults rapidly from seedlings. Good seed crops occur every year or two and the minimum fruiting age is two years. The feathered seeds are dispersed by the wind and establish on disturbed sites where competition is lacking. Collected seed needs only hammermilling before broadcast-seeding and a purity of 8 to 10% is sufficient (Deitschman, et al., 1974). In mixtures of grass, forbs, and other shrubs rabbitbrush should comprise no more than 20%.

In Utah some success in establishment on winter game ranges has been accomplished by aerial seeding (Dietschman et al., 1974). Whatever the seeding method, the seed should not be buried too deeply. Covering with 2 mm of soil should be adequate. Lindsey et al., 1977 showed vesicular arbuscular endomycorrhizae increased the survival and growth of rabbitbrush.

With shrubs growing in ravines and washes, old embankments, and disturbed soil, collection of the very light *Chrysothamnus* achenes could be simplified by a jeep-mounted vacuum harvester. Though a harvest in early November might be prefered, a collection from 14 plants along the old Los Angeles Aqueduct (Mojave Desert) in December of 1973 yielded 0.56 kg of achenes, 12% purity and 30% fill (Kay, 1975). The bristly nature of the achenes precluded cleaning. The pure-achene count of the collection was 5,000,000 achenes/kg (2,270,000/lb), with a maximum germination of 35% obtained at 10 C. Optimal temperature range between 5 and 15 C (Table 1). Higher germination of 63% has been reported with the cleaned seed count per kg ranging from 1,428,000 to 1,639,000 (Deitschman et al., 1974). Germination tests performed by J. A. Young (U.S.D.A., A.R.S., Reno, Nevada; personal comm.) have also shown that 20% is a common germination level for *C. nauseosus* subspecies.

Table 1. Effect of constant temperatures on germination of *Chrysothamnus nauseosus* spp. *hololeucus*.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	15	22	35	22	3	0	1	0

*Courtesy of Dr. James A. Young, ARS-USDA, Reno, Nevada.

The processed seeds of this collection in December of 1973 were treated with Phostox to protect against insect damage and separated into sixty lots each sealed in a one-gallon glass jar containing silica gel desiccant.

Twenty jars were placed in a freezer at -15 C, twenty were refrigerated at 4 C, and twenty were stored at room temperature. A fourth treatment consisted of storage in a cloth bag in a seed warehouse in Davis, California. The experiment was designed to provide yearly tests of the retention of germinability under these diverse conditions over a twenty year period. The results to date are presented in Table 2.

Table 2. Germination of achenes of Chrysothamnus nauseosus ssp. hololeucus subjected to several storage environments over time.

	Months after initiation of storage				
	0	13	18	30	43
Storage conditions			- % -		
Warehouse	22	26	10	0	0
Room temp. (sealed)*		30	21	25	11
4 C (sealed)*		20	26	22	22
-15 C (sealed)*		22	18	20	17

* Stored at a moisture content of 4.1%.

At 33 months, seeds stored in the warehouse were no longer germinable, although this treatment appeared adequate up to 13 months. Sealed storage at room temperature resulted in a 50% decrease after 30 months. Storage at 4 C and -15 C appears to preserve germination equally well within the limits of resolution of this test and has not resulted in a decrease from the initial value of 22%. There appears to be no after-ripening requirement for this seed collection. Seed removed from 4 C at 25 months and planted at 1 cm in moist sand at constant 15 C emerged 20% at 4-6 days. Seed germinated at 15 C after 43 months of storage emerged over a 3-week period with the highest rate during the second week for all storage treatments.

As a part of the sagebrush scrub community, the rabbitbrush is generally considered an indicator of range decline. The resprouting capability of the plant makes it difficult to eliminate from the range by fire or chemical means. Parker (1968) recommended 2,4-D Ester at 3.4 kg a.e./ha in 46 l oil or oil-water emulsion/ha as a chemical control. Applications should be made on 8 cm or longer new twig growth before moisture is depleted in the upper 20-25 cm of soil. For high kill, 2,4-D Ester at 2.2 kg/ha applied for 1 to 2 years after initial spraying, burning or mechanical top removal is necessary. Mohan (1973) reported consistent chemical control of both green and rubber rabbitbrush over a fourteen year period, providing there was at least 10 cm of new twig growth, adequate soil moisture, with 2.2 kg of acid equivalent 2,4-D ester per hectare.

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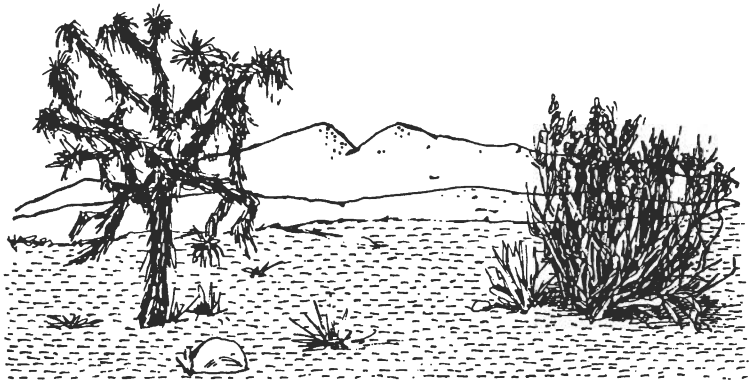


Mojave Revegetation Notes

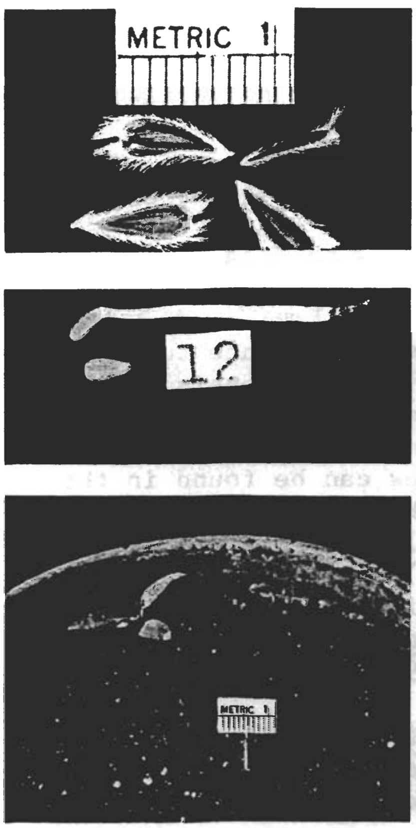
UC DAVIS AGRONOMY & RANGE SCIENCE

No. 4 Virgin River Encelia August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

Encelia virginensis A. Nels. ssp. actoni (Elmer) Keck.

Family: Asteraceae (Compositae), tribe: Helianthae.



Top-seeds; center, sprouted seed and cotyledons; lower-small seedling.

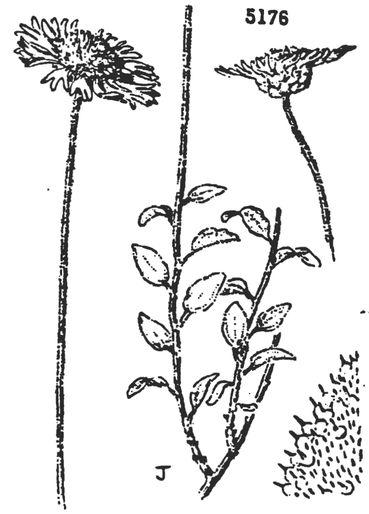
Mature shrub (8 dm tall)

Seedling 2.5 cm tall

1/ Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

The following description is adapted from Munz (1974) and Abrams and Ferris (1960). Drawing is reprinted from Abrams and Ferris, ILLUSTRATED FLORA OF THE PACIFIC STATES, 4 Vols., with the permission of the publishers, Stanford University Press. Copyright C 1951, 1960 by the Board of Trustees of the Leland Stanford Junior University.



Habit: Rounded, diffusely branching shrub, about 1 m tall; stems rough to the touch.

Leaves: Often yellow-green;alternate; commonly broadly ovate, 1.5 to 4 cm long and 3 cm broad, covered with fine grey hairs or velvety.

Flowers: Yellow heads; solitary at the tips of hairy peduncles; rays 10-60 mm long; sterile; flowering February to July.

Fruit: Bracts of the convex receptacle soft and shriveled, embracing the achenes, and falling with them; disk-achenes flat, egg-shaped with the distal end broader, 4-5 mm long, fringed with long hairs, without a pappus.

Virgin River encelia (ssp. actoni) bears a close resemblance to Encelia frutescens, distinguished by the presence of rays in E. virginensis and absence of rays and the scattered hairs with blisters at the base on the frutescens species. On desert slopes, dry washes, and ravine enbankments up to 1,500 m (5,000 ft) elevation, the actoni subspecies can be found in the western Colorado and Mojave Deserts from San Diego, Riverside, and Los Angeles counties to the Kern River Canyon, Owens Valley, White Mountains, Death Valley region, and adjacent Nevada (Munz, 1974). The flowering period is March to June (McMinn, 1951). Its common name, Virgin River encelia is derived from the type locality of Encelia virginensis ssp. virginensis, "The Pockets", Virgin River, Nevada (Abrams and Ferris, 1960).

Hand-harvest may be the only practical method of seed collection because Encelia tends to occupy more inaccessible areas of dry washes and ravine embankments. Since the achenes are easily blown from the plant after maturity, harvest timing is critical.

A late June collection of dry achenes was hand-harvested in 1973, yielding 1.96 kg of material of 24% purity. Plant and dry flower parts similar to the achenes in size and weight could not be effectively removed by cleaning. Final cleaning resulted in 86% purity and pure fruit weight was 477,000 achenes/kg (216,721/lb), with 77% germination and a fill of 86% (Table 1). Optimal germination temperature ranged over 10 -20 C (Kay, 1975). In emergence testing, Encelia seedlings emerged (total emergence = 57%) from a depth of 1 cm over a 10-day period (Fig. 1). Emergence from 2 cm was somewhat reduced and delayed, and no plants emerged from 4 cm (Kay, 1975).

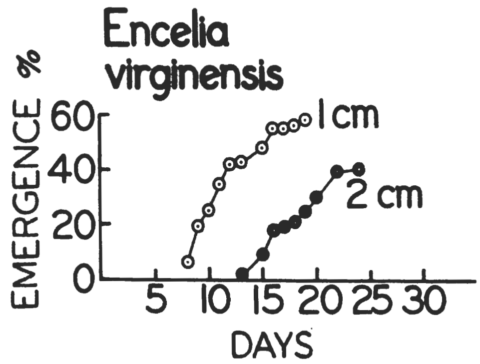


Figure 1. Effect of depth of planting on seedling emergence.

Table 1. Effect of constant temperatures on germination of Encelia virginensis spp. actoni.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	0	1	47	65	55	5	7	0

* Courtesy of Dr. James A. Young, ARS-USDA, Reno, Nevada.

After processing, the achenes were treated with Phostox and dried for 6 days at 35 C. The seed was then divided between sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C and the remainder at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. The experiment was designed to provide yearly tests of germination over a twenty year period. The results of tests to date are presented in Table 1.

Table 1. Germination of Encelia virginensis spp. actoni under several storage conditions over time.

	Months after initiaton of storage				
	0	13	18	30	42
			----%-----		
Warehouse	77	72	20	27	31
Room temp. (sealed)*		78	15	41	31
4 C (sealed)*		71	12	28	29
-15 C (sealed)*		80	14	26	33

* Sealed at a moisture content of 6.3%.

At 42 months there is no significant difference in germination between the storage conditions. At least 90% of the germination occurred in the first 7 days in all treatments. The data indicates a large drop in viability between 13 and 18-43 months. However, the latter three tests were performed by a registered seed analyst who suggests the variation between years may be due in large part to "sample variability due to lightweight and empty seed units". Therefore we can't be sure that the decline is significant. Also there is no measure of how many seeds are dormant.

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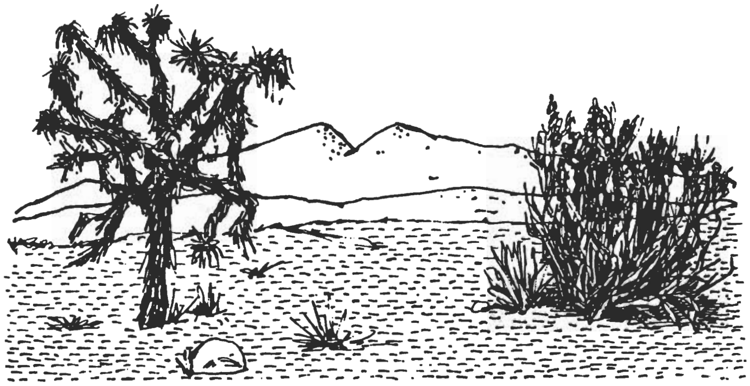
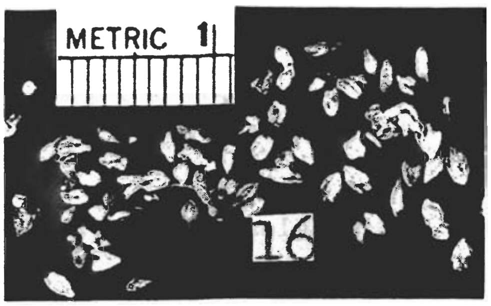


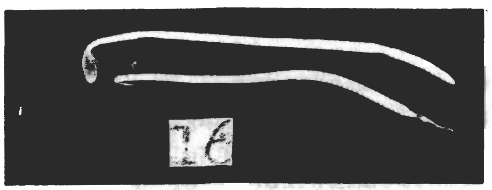
Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 5 CALIFORNIA BUCKWHEAT August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

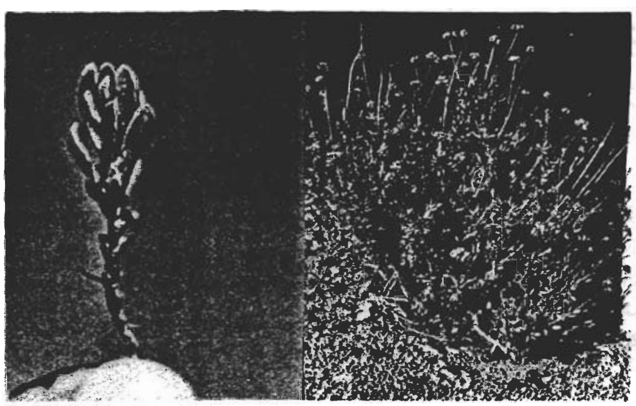




Eriogonum fasciculatum Benth. ssp. polifolium (Benth.) S. Stokes.

California Buckwheat, Flat Top

Family: Polygonaceae



Photos: Top left - seeds (achenes)
Middle left - seedling with cotyledons
Lower left - Seedling (3 cm)
Lower right - mature shrub (3 dm tall).

1/ Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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Habit: Low, spreading shrub, 30-60 cm high; numerous slender, flexible, somewhat decumbent stems branchlets loosely hairy to smooth; reddish outer bark thin and exfoliating.

Leaves: Foliage distinctly grayish; leaves sessile, evergreen, in alternate bundles; oblong to linear; 6-15 mm long; covered with dense short hairs above margins rolled inward.

Flowers: Borne in white or pinkish bundles at end of naked stalks 8-10 cm long; 4-9 unequal, simple or branched rays in an umbel, borne on terminal, leafless peduncles 3-10 cm long; involucres sessile or short-stalked with 5 short acute teeth; involucre and calyx hairy; about 3 mm long; flowering April to November.

Fruit: Light brown achenes, lanceolate-ovoid, 3-angled, glossy, about 2 mm long.

Most species of Eriogonum are valued as bee plants (McMinn, 1951) or for their horticultural possibilities. Buckwheat is the third most valued honey plant after white sage and black sage (Jepson, 1951). The small, evergreen shrub is browsed to some extent by domestic and big game animals, being especially important for deer on their winter range (Sampson and Jespersen, 1963). The polifolium subspecies, with its elongated peduncles and congested inflorescence, is characteristically found on dry slopes below 2100 m (7,000 ft) elevation, from the sagebrush scrub to the pinyon-juniper woodland. Subspecies polifolium is adapted to many soil types of the western desert country (Stark, 1966), and is found in the Mojave and Colorado Deserts, to the San Joaquin Valley and Inyo County as well as interior cismontane southern California, east to Utah, and in Baja California (Munz, 1974).

The California Division of Highways, Southern California, has used California buckwheat for roadside seeding; i.e. after chilling seed to 1 C for one month, four sacks per acre were seeded and raked in (Stark, 1966). Seeding of this plant on steep road cuts for erosion control is common. Dodder (Cuscuta spp.) has been found to parasitize Eriogonum (Everett, 1957).

Achenes persist on the plant during the summer, allowing for some flexibility in harvest time, which may be best planned for September or October. In an August 15, 1973 collection (Kay, 1975), 2.5 kg of dry fruits were hand-harvested. A belt cleaner was used to break up the headlike clusters and partially remove the achenes from the persistent involucres. Cleaning, done with a fanning mill (No. 8 top screen and No. 1/25 bottom screen), produced 0.46 kg of achenes of 55% purity; 2% germination; 1,180,000 achenes/kg (536,700/ 1b) with 18% fill. Another sample collected

August 11, 1977 was similarly cleaned, but refined to 80% purity, and germinated 27% plus another 4% which appeared sound but did not germinate. Total volume reduction from the field collection of heads to the 80% purity sample was 95% compared to 90% in the first sample. Seed size was 1,480,000/kg (672,000/lb), or about 20% more seeds/lb. It appears germination is typically low in this subspecies from this location.

Ratliff (1974) reports achene weights of California buckwheat to vary from 525,800 to 1,085,000/kg (239,000 to 493,000/lb), no pretreatment necessary for germination, germination of from 20 to 40%, and low fruit fill.

In an emergence test with temperatures averaging 10 C, Eriogonum emerged rapidly from beds of washed plaster sand over 8 days. From a 1-cm depth, 8% emerged as opposed to 4% germination on blotters. Deeper planting (2 cm) retarded emergence and halved the total emergence (Figure 1). Optimum temperatures for germination range between 5 and 20 C (Table 1).

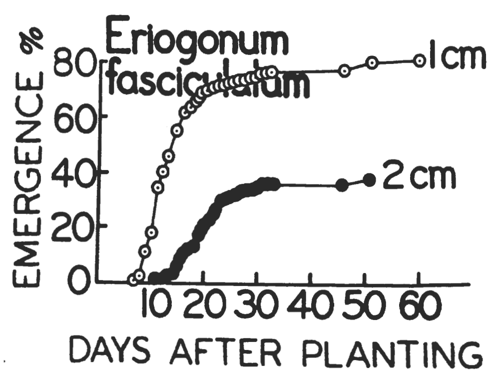

Fig. 1. Effect of depth of planting on percent and time of emergence.

Table 1. Effect of constant temperatures on germination of *Eriogonum fasciculatum* spp. *polifolium*.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	2	14	15	19	18	8	0	0

*Courtesy of Dr. James A. Young, ARS-USDA, Reno, Nevada.

In a seed storage experiment, the seed were treated with Phostox to prevent insect damage and dried at 35 C for six days. A portion of the seed was divided into lots which were sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging a lot of seed and storing in a seed warehouse in Davis, California. The experiment was designed to provide germination tests yearly over a twenty-year period. The results of these tests to date are presented in Table 2.

Germination has been somewhat erratic and at 45 months, there was no significant difference between storage conditions. Most of the germination occurred in the first 7 days of the 45 month test. Much of the variability may be due to the numerous lightweight and empty seeds. Apparently the 18% fill originally determined was not a representative sample, as some germination values have exceeded this. There appears to be an after-ripening requirement in this seed lot as germination was only 2%.

Table 2. Germination of Eriogonum fasciculatum ssp. polifolium under several storage conditions over time.

	Months after initiation of storage				
	0	13	18	33	45
Storage conditions			---%---		
Warehouse	4	10	5	17	11
Room temp. (sealed)*		5	25	12	7
4 C (sealed)*		15	14	26	14
-15 C (sealed)*		6	34	24	15

* Sealed at a seed moisture content of 7.3%

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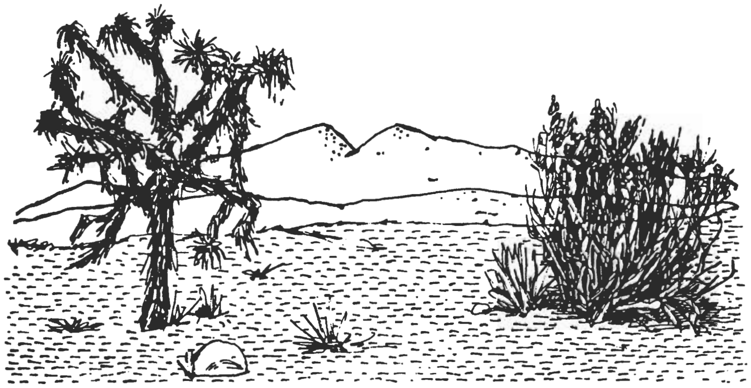
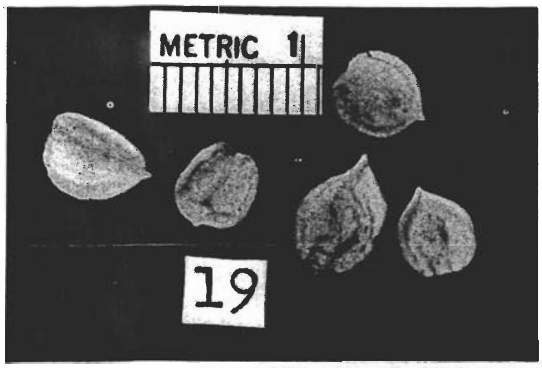


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 6 HOP-SAGE August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Grayia spinosa (Hook.) Moq.
[Chenopodium s. Hook.]

Hop-sage, Spiny Hop-sage, Winter Sage.

Family: Chenopodiaceae

Photos - Top-seeds; Bottom left to right - seedling with cotyledons; seedling, and mature shrub 0.5 M.

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CG4-2(N), Document Obligation No. 6809.

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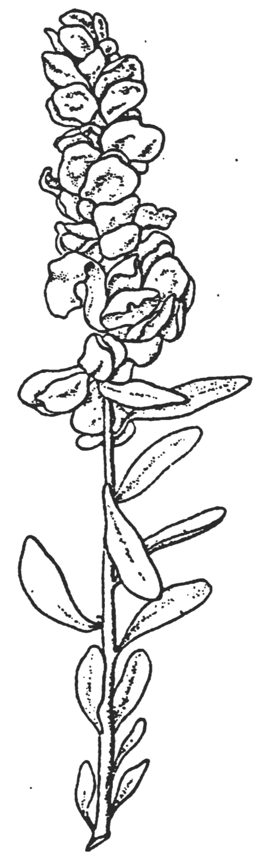

847. Grayia spinosa Moq.; fr. branchlet x 1.

Habit: Erect or spreading shrub, to 1 m high; diffusely branching, branches becoming spinescent with age; bark gray; entire plant densely white or rusty-hairy.

Leaves: Evergreen, sessile or very short-petiolate; alternate; oblanceolate with apices obtuse, margins in-rolled, mostly 10-25 mm long, 2-4 mm broad; somewhat fleshy.

Flowers: Small; greenish; monoecious or dioecious; staminate flowers in axillary clusters, calyx membranous, 4-to-5-parted, without petals; pistillate flowers mostly in dense terminal spikes, without calyx or petals, pistil almost enclosed by a pair of bracts folded along their midribs, forming a sac 6-14 mm in diameter; flowering March to June.

Fruit: In dense many bracted clusters; obovate or round; 4-8 mm in width; sessile, entire; notched at apex; often reddish-tinged; 4-angled; hairy; seed (achene) flat, brown, round, net-veined, about 2 mm broad.

Coville (1893) described, in his account of the plant communities of the Death Valley region, a Grayia "belt" in the upper portions of the Lower Sonoran Zone, extending from the upper limit of Larrea to well into the Creosote Bush Scrub at elevations as low as 800 m (2640 ft.). Other workers (Billings, 1949; Dayton, 1931) note that the spiny hop sage is one of few woody browse species found in both the sagebrush (Artemisia) and shadscale (Atriplex confertifolia) communities.

Grayia is found on the Mojave Desert, in the low mountains of Inyo County, in eastern San Diego County, in the Honey Lake Valley of Lassen County, from Siskiyou County north to eastern Washington and east to Wyoming and Arizona (Munz, 1974; Sampson and Jespersen, 1963). Though usually excluded from saline soils (Wallace et al., 1973), Grayia is common on alkaline soils of mesas and flats as well as in wetter sites, from 76 m (2,500 ft) to 2290 m (7,500 ft) elevation (McMinn, 1951; Sampson and Jespersen, 1963).

Soils under Grayia shrubs are frequently high in potassium, as a result of mineral uptake, leaf abscission, and the subsequent decay of leaves (Richard, 1965). Wallace et al. (1973) studied cation contents of several desert shrubs. Grayia had a very high total cation concentration (417 me/100 g dry matter) in comparison with samples of winterfat, Ambrosia, Larrea, and Lycium. Of the five shrubs, Grayia had the highest concentration of K and Mg in leaves and stems.

A high browse rating (good to fair for sheep, goats, and deer) (Sampson and Jespersen, 1963) has led to interest in the possibility of seeding Grayia on desert rangelands (Wood et al., 1976). In fall, winter, and spring, the shrub is a real asset to range feed. Buds, leafy twigs, and the abundant sac-like fruits are taken, and moderate browsing of the branches appears to stimulate twig and leaf production (Sampson and Jespersen, 1963). National Academy of Sciences (1972) gives a crude protein content of 9% for the fresh aerial parts of spiny hop-sage. Protein digestability varies for sheep, goats and cattle from 55 to 60%. Calcium is relatively high at 1.1%, but phosphorus is low at 0.19%. The fresh pods (utricles) have a crude protein content of 20% and a TDN range of 86 to 104%. Dayton (1931) notes "the leaves and enormous quantities of seeds fall early and are collected by the wind into drifts under the bushes and in the hollows of the ground. When sheep are fed over such ground these piles are the first to disapear."

Vegetative propagation of Grayia spinosa has been studied by Weiland et al. (1971). Some cuttings from the field were rooted, but optimal rooting conditions were determined with material from glasshouse or lathhouse-grown plants, chilled at 4 C before cuttings were taken. Dipping the stem pieces into Hormodin 2 powder and then placing them in vermiculite in a lathhouse was most successful; mist was also satisfactory.

Seeds collected from the ground in the Mojave Desert on June 24, 1973, were cleaned by a fanning mill (No. 36 top screen and No. 8 bottom screen) to yield 1.82 kg of utricles of 74% purity, 76% fill (Kay, 1975). Utricle (bracted seed) weight was 506,000/kg (230,000/lb), and initial germination (at 17 C) was 42%. Smith (1974) reports a utricle weight range of 337,900 to 369,900/kg (153,600 to 168,000/lb). and a pure seed range of 869,000 to 932,800/kg (395,000 to 424,000/lb). The thorny nature of the shrub makes hand-harvest difficult, but a jeep-mounted vacuum harvest, 2-3 weeks earlier would have resulted in a much cleaner collection.

Wood et al. (1976) found that spiny hop-sage seed germinated rapidly at constant temperatures of 10 and 15 C. Results by Young, using seed described above from Mojave Desert also germinated best at constant temperatures of 10 and 15 C (Table 1). Wood et al. (1976) found seed from the Mojave Desert germinated at 40 C, whereas seed from Nevada did not. After two weeks of alternating-temperature exposure, optimal germination occurred at regimes from 5 /10 to 5 /30 C, reflecting the adaptation to cold arid environments, where the germinating shrub seedling would have moisture available in late fall or early spring. Tests of wetting and drying cycles indicated that any temporary wetting of the soil could initiate germination. High germination was recorded at osmotic stress as great as -12 and -16 bars, produced with polyethylene glycol. The bracts may help regulate the osmotic potential of germinating seeds, for the high germination at low osmotic potentials did not occur with threshed seeds. When NaCl was used to create osmotic stress, salt toxicity became apparent at potentials below -12 bars.

Table 1. Effect of constant temperatures on germination of Grayia spinosa.*

Temperature C	2	3	10	15	20	25	30	40
Germination %	6	4	74	70	46	30	36	20

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada

When planted in washed plaster sand kept at 10 C, Grayia spinosa emerged rapidly over 13 days (total emergence = 38%) from a depth of 1 cm (Figure 1). Deeper planting delayed and reduced emergence (Kay, 1975). Wood et al. (1976) found that planting either threshed or bracted seeds at a depth of 0.5 cm resulted in greatest seedling establishment, while broadcasting threshed seeds on any soil surface and bracted seeds on smooth or packed surface produced very low or no seedling establishment. Seedling establishment was 18% for broadcast bracted seeds.

After processing, the seed was treated with Phostox to prevent insect damage and dried at 35 C for six days. Seed was sealed in each of sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of cloth bag storage in a seed warehouse in Davis, California. The experiment was designed to provide germination tests yearly for a twenty year period. The results of these tests to date are presented in Table 2.

It appears that sealed storage functions equally well at all temperatures to preserve the germinability of the seed. Warehouse storage has resulted in a two-thirds reduction in germination.

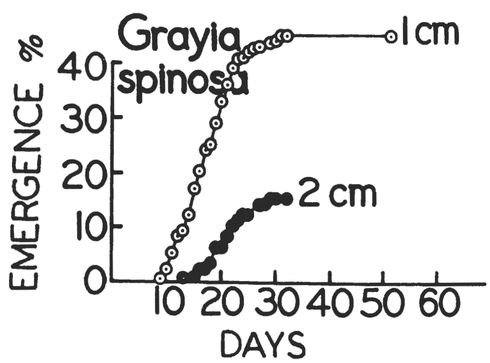

Fig. 1. Effect of depth of planting on percent and time of emergence.

Table 2. Germination of seeds of Grayia spinosa under several storage conditions over time.

	Months after initiation of storage				
Storage conditions	0	13	18	30	42
			----%----		
Warehouse	42	38	50	22	15
Room temp. (sealed)*		55	50	51	55
4 C (sealed)*		48	52	47	55
-15 C (sealed)*		44	50	50	57

* Sealed at 5.1% moisture

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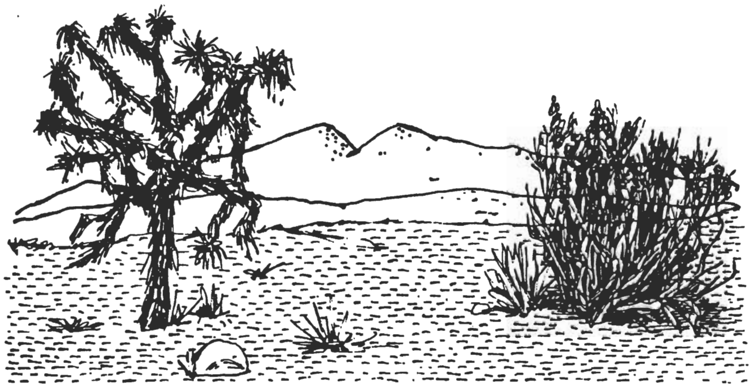
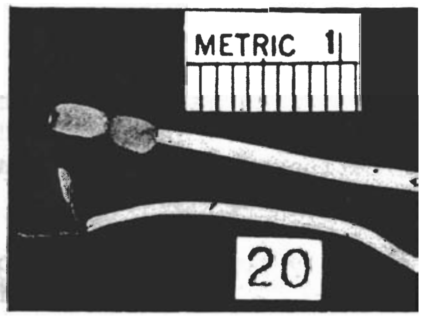


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 7 WHITE BURROBUSH August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Hymenoclea salsola T.& G. var salsola

Family: Asteraceae (compositae).

White Burrobush, Burrobush, Desert Pearl.

Photos: Top left - achenes; top right - cotyledons and hypocotyl
Lower left - seedling; lower right - mature branches and flowers.

[1/] Wildlands Seeding Sepcialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

The following description is adapted from Munz (1974) and McMinn (1951).

Habit: Erect or spreading twiggy bush 6-10 dm high; twigs light tan; bark grayish; growing shoots sparsely hairy.

Leaves: Few, alternate, mostly 1-4 cm long; some pinnatifid and consisting of 3 or more divisions, others entire and threadlike; lacking hairs above, densely appressed-hairy below, margins rolled backward; often resinous.

Flowers: Inconspicuous heads, in spikes or small terminal clusters, staminate and pistillate heads intermingled; pistillate involucral bracts large, about 4-8 mm broad, overlapping like shingles, broadly fan-shaped, papery; flowering March-July.

Fruit: Wings of the fruiting involucre kidney-shaped to circular, spirally arranged; seeds borne in the bracts, fused.

The genus Hymenoclea (Greek, hymen, membrane, and kleio, to close, (Munz 1974)) has two recognized species. Hymenoclea salsola is a polymorphic spring-flowering species which has been separated into three varieties by Peterson and Payne (1973). Geissman and Toribio (1967) have shown a close phylogenetic relationship between Hymenoclea and Ambrosia, supported by similarities of plant components.

Hymenoclea salsola is commonly found on sandy soils of desert washes, alluvial plains (Benson and Darrow, 1954), and alkaline sites (Munz 1974). As a member of Creosote Bush Scrub, Shadscale Scrub, and Joshua Tree Woodland communities, the range of the burrobush extends from northern Inyo County to the Colorado Desert, west to the Cuyama River and the head of the San Joaquin Valley, into Nevada, southern Utah, Arizona, and Lower California at elevations from below sea level to 1,500 m (5,000 ft) (Munz 1974). The shrub occurs from the lower to upper limits of the Larrea belt, sometimes into the Upper Sonoran Zone (Coville, 1893).

Vasek et al. (1975) considers Hymenoclea to be a short-lived perennial of the Pioneer Shrub category in plant succession on disturbed sites in the Mojave Desert. Its ability to colonize disturbed sites in the Mojave Desert makes it a prime candidate for revegetation recommendations.

For citrus growers in the Imperial and Coachella Valleys of California, Hymenoclea may be of significance as a native host to a sheath nematode. Hemicycliophora arenaria, a USDA class-A pest which has been quarantined on infested ranches, and has been found parasitizing and producing galls on the roots of Hymenoclea salsola (McElroy et al., 1966). The pollen from the burrobush is said to be an important cause of hayfever (Munz, 1974).

Vegetative propagation of Hymenoclea cuttings has been studied by Chase et al. (1966). Optimum conditions were found to be treatment with 200 ppm indoleacetic acid and culture in vermiculite under continuous light with moderate bottom heat.

Of seed collected in the Mojave Desert on June 25, 1973, 2.7 kg of achenes of 54% purity and 85% fill had a pure fruit weight of 83,400/kg (37,890/lb) (Kay, 1975). this ground-collected seed lot was very trashy, and had to be cleaned by running the material through a fanning mill equipped with a No. 30 top screen and a No. 10 bottom screen. Collecting 2-3 weeks earlier with a vacuum harvester would have allowed a much cleaner harvest from the plants since the achenes are light and easily windblown.

These achenes had a 67% initial germination, tested under 28 days, 20 C, dark conditions. In another test, optimal germination temperature (75% germination) was shown to be 20 C (Table 1).

Table 1. Effect of constant temperatures on the germination of *Hymenoclea salsola*.*

Temperature C	2	5	10	15	20	25	30
Germination %	2	0	4	59	75	66	40

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

The effect of depth of seeding was shown by planting at various depths in washed plaster sand in November 1973 (Fig. 1). Temperatures for the initial period averaged 10 C. *Hymenoclea salsola* emerged rapidly from a 1-cm depth. Total emergence was 48% over 13 days. From the 2-cm depth, emergence was reduced to 11% (Kay, 1975).

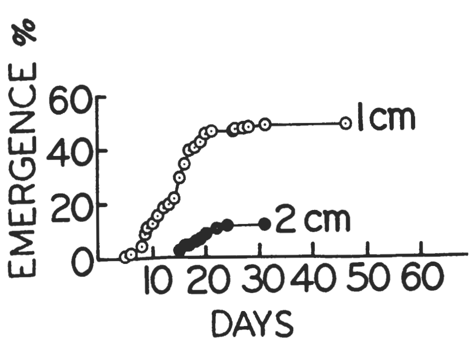


Figure 1. Effect of depth of planting on percent and time of emergence.

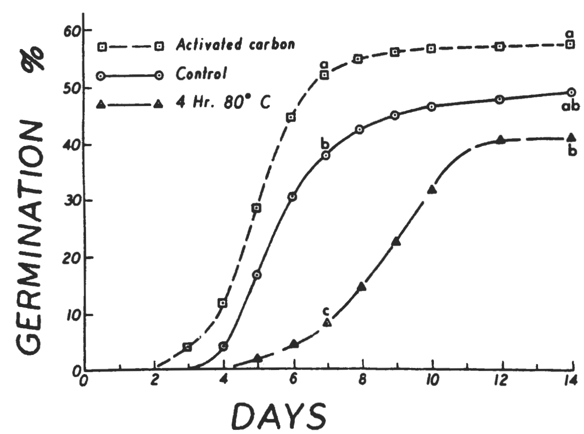


Figure 2. Effect of two seed treatments on germination

Williams et al. (1974), using seed from a commercial collector, had similar results in emergence tests, with 74% (median emergence time: 6.0 days) emerging from 1 cm and 28% (median emergence time: 7.5 days) from 2 cm. That test also was conducted with washed plaster sand, but the planting in spring (May) may have improved the temperature regime. The commercial seedlot showed (56,000 achenes/kg) with 67% fill and 57% germination (median germination time, 5.0 days). A tetrazolium test for live embryos indicated 70% live seed.

In studying the affects of various seed treatments on Hymenoclea achenes, Graves et al. (1975) found mixing the achenes with moistened 12 X 50 caliber activated carbon improved germination while a 4-hour 80 C treatment reduced germination (Fig. 2).

In a seed storage experiment the processed achenes were treated with Phostox and dried at 35 C for six days. The achenes were divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. The experiment was designed to provide tests of germination on a yearly basis over a twenty year period. The results of these tests to date are presented in Table 2.

Table 2. Germination of achenes of Hymenoclea salsola var. salsola stored in several environments.

	Months after initiation of storage				
	0	13	18	30	43
Storage conditions			---%---		
Warehouse	68	69	68	46	50
Room temp. (sealed)*		66	53	39	58
4 C (sealed)*		66	58	43	61
-15 C (sealed)*		65	56	42	62

* Sealed at 4.2% moisture

The germination has been somewhat erratic. There was a decline in germination at 30 months followed by an increase at 43 months, by which time the germination of the warehouse-stored achenes was significantly lower. Under sealed conditions the decline of germinability is minimal at 43 months. Germination is the most rapid in the first seven days in all treatments (20 C in rolled towels).

Another seed lot, collected in 1971 by a commercial seed collector, was stored in non-sealed containers at 10 C. Germination declined from 57% when placed in storage in March 1972 to 9% when tested in September 1977.

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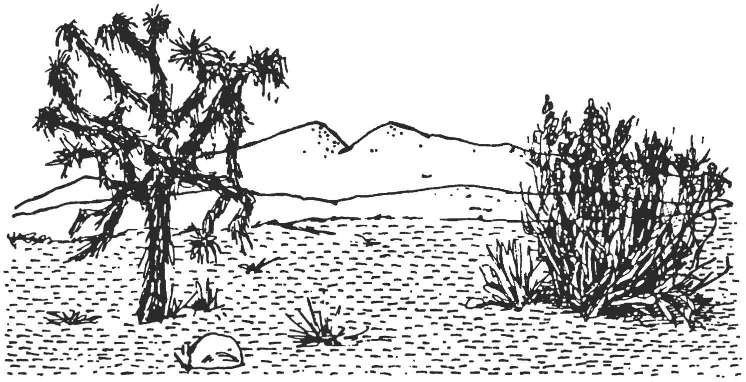


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

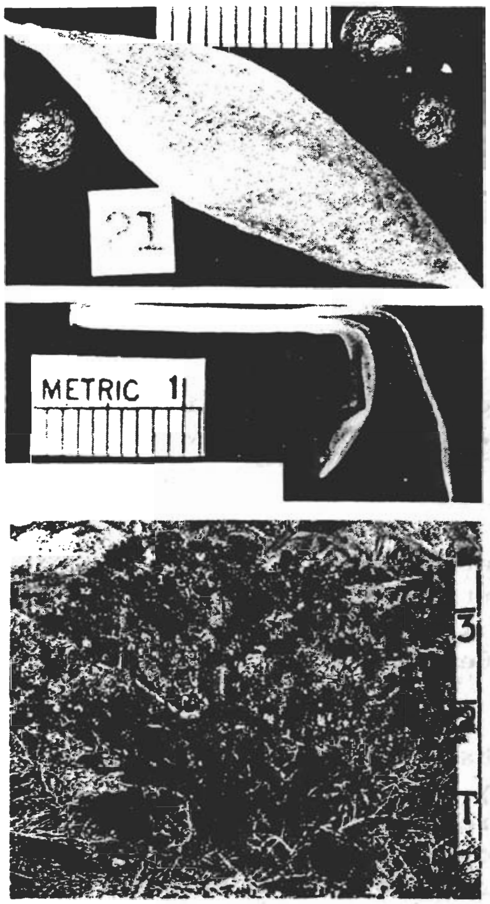
No. 8 BLADDERPOD August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

Isomeris arborea Nutt.
[Cleome Isomeris Greene.]

Bladderpod, Burrofat

Family: Capparidaceae



Top to bottom-seeds and pod, cotyledons and hypocotyl, and mature shrub (one m tall).

Mature stem and pods

Seedling

[1/]Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

The following description is adapted from Munz (1974) and McMinn (1951).

Habit: Rounded shrub, 1-1.5 m high; ill-scented; widely branching; hard yellow wood; branches densely covered with short erect hairs.

Leaves: 3-foliate or simple below flower-clusters; evergreen; alternate; leaflets oblanceolate; 1.5-3 cm long, 4-7 mm broad, with a short, sharp point; rounded at base, greenish-yellow, short-petiolate, petioles about 1 cm long.

Flowers: Regular; large; yellow; in terminal bractate racemes; 4 sepals, united at base, not shed; 4 petals, distinct, about 1 cm long; 6 stamens, stamens distinct, long, protruding, ovary superior, single-celled; flowering February to March and through the year.

Fruit: Oval or broadly elliptical inflated bladder-like capsule, 4-6 cm long, 1-1.5 cm wide, abruptly tapering at apex, gradually tapering into a stalk (1.5-2 cm long) at the base; seeds round, smooth, slightly smaller than peas, brown with some mottling, 6-7 mm long, with prominent incurved embryo.

A component of the coastal scrub community from San Luis Obispo County to Lower Calif. (on sub-alkaline sites such as coastal bluffs and hills or stabilized dunes), Isomeris arborea is also found in the dry washes of the Creosote Bush Scrub and Joshua Tree Woodland in the western Mojave and Colorado Deserts of California (Munz, 1974). Isomeris is used for roadside plantings in the California deserts (Stark, 1966) and seems well suited to this use in that Kay (1975) found shrubs to be more common in disturbed soils of embankments or land-fill along the L.A. Aqueduct (Mojave Desert) than in the surrounding Creosote Bush Scrub.

Mathias et al. (1968) lists this species as being drought and wind tolerant and recommends it for ornamental plantings below 670 m (2200 feet) in California's middle elevation desert of southern California. Chan, et al. (1971) found bladder-pod to be suited for landscape direct seeding (fall) without irrigation in the deserts and Central Valley regions of California.

Tobiessen (1971) pointed out, however, that Isomeris arborea cannot survive the low water potentials attainable by true xerophytes, but rather survives in the desert by being able to tap free-energy water under sandy washes and depressions with its deep, fast-growing tap root system. In periods of extreme drought, transpiration is reduced to some extent by shedding of leaves. The remaining leaves are usually xeromorphic.

Results of nutritional analysis of Isomeris pods indicate a high protein content (37%) with relatively high percentage of arginine, aspartic acid, glutamic acid, and leucine (Nat'l Acad. Sci., 1972).

Mature, moist pods were harvested along the L.A. Aqueduct in late June, 1973, yielding 9.0 kg of dry pods. After shelling in a belt harvester, the material was passed once through a fanning mill (No. 14 top screen and No. 8 bottom screen), yielding 4.3 kg of cleaned seed with 99% purity (Kay, 1975). An overall net yield of 47%, with 15,500 seeds/kg (7,027/lb) of 96% fill, was recorded. The processed seeds were a mixture of 12% white and 88% black seeds; although white seeds had 70% fill they had a low (5%) germination compared with the 40% germination of the combined lot of seeds and were probably immature. On the basis of 40% germination, there were about 6,200 "viable" seeds/kg (2,800/lb).

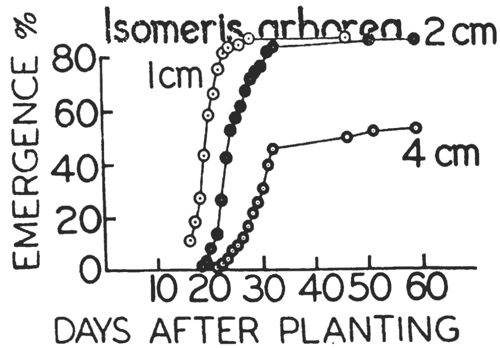


Figure 1. Effect of depth of planting on percent and time of emergence.

In emergence testing, the large seeds of Isomeris produced vigorous seedlings from all planting depths (Kay, 1975). Emergence (86%) was highest for the 1-cm depth of planting and was completed in 7 days; seeds at other depths emerged over 20 days, 85% from 2 cm and 52% from 4 cm, all higher than the 40% achieved on blotters (Figure 1). The washed plaster sand used for the test is obviously a better environment for germination and growth, although an after-ripening requirement of stratification (the seed was tested 4 mos. post-harvest) may have been satisfied. Results of the emergence testing demonstrate the suitability of Isomeris for dryland plantings, especially where seed must be drilled deeper into the soil to reach an effective moisture source. Optimal germination temperatures range between 5 and 15 C (Table 1).

Table 1. Effect of constant temperatures on germination of Isomeris arborea.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	15	48	59	69	25	6	1	0

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

In a seed storage experiment, the processed seed was treated with Phostox to prevent insect damage and dried at 35 C for six days. The seed was then divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperture, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. This experiment was designed to provide germination tests on a yearly basis for twenty years. The results to date are presented in Table 2.

After 43 months of storage no difference was found between storage conditions. The germination levels subsequent to the initial value are higher and many indicate an afterripening requirement. Germination is nearly complee at 14 days, with about half in each of the first two weeks (15 C in a rolled towel).

Table 2. Germination of seeds of *Isomeris arborea* in several storage conditions over time.

	Months after initiation of storage				
	0	13	18	30	43
Storage conditions			%		
Warehouse	38	76	65	72	75
Room temp. (sealed)*		69	85	84	68
4 C (sealed)*		68	81	83	71
-15 C.(sealed)*		69	78	79	67

* Seeds sealed at 6.1% moisture.

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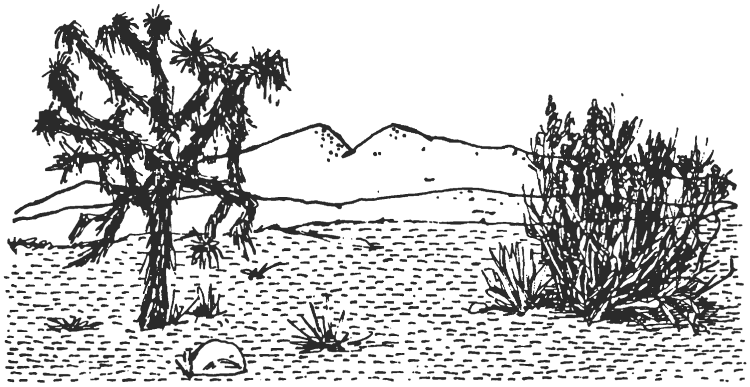

Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 9 CREOSOTE BUSH February 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

Photos: Top left-seed capsule and mericarps; Middle left-cotyledons and hypocotyl; Bottom left-cotyledons and first true leves; Top middle-seedling; Top right-mature shrub (2m tall); Bottom right-flowers and fruit.

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

Larrea tridentata (Sesse & Moc.) Cov. [Sometimes incorrectly referred to as Larrea divaricata, a South American species (Munz, 1974)].

What does it look like?

The following description is adapted from McMinn (1951).

Habit: Erect, diffusely branching evergreen shrub, branches (1-3 (4) m long; strongly scented, resinous; heavy root crown, main stems arising from the base at an angle; branches slender, brittle, simple or somewhat branched, with dark, glutinous or corky nodal rings.

Leaves: Opposite, bipinnate leaflets: stalkless, lanceolate or oblong, indistinctly 3-veined from the base, finely varnished to silky hairy or smooth, about 6-10 mm long, 3-4 mm broad.

Flowers: Yellow, regular, solitary; located on short side-branchlets. 5 petals, 6-10 mm long, turned sidewise like propeller blades; stamens each with a scale attached to the filament, the scale irregularly slashed; flowering after rain, Nov. to May.

Fruit: A globose hairy capsule, usually about 6-10 mm long, separating into 5 single-seeded, densely white or rusty-hairy mericarps.

Where does it grow?

The most prevalent scent of the North American deserts may be the penetrating odor of the creosote bush, the most common and widely distributed shrub of those regions. Larrea tridentata is dominant over great areas of desert below 5,000 ft elevation from Kern Co., in California, to Utah, Texas, and Mexico, in plant communities aptly described as Cresote Bush Scrub (Munz, 1974).

Though usually excluded from markedly saline soils (Benson and Darrow, 1954; Wallace et al., 1973), Larrea is adapted to many of the Southwestern soil types. "Larrea was not dominant where pH of the topsoil was 8.4 or above, or 173 ppm sodium or above" (Barbour 1969). The creosote bush is best suited to the well drained porous soils of sandy or gravelly mesas and gentle slopes; on such sites pure stands are not uncommon (Benson and Darrow, 1954; Went et al., 1959; Yang, 1950). A high soil-oxygen requirement accounts for the shrub's exclusion from poorly drained, fine-textured soils (Livingston, 1910; Lunt et al., 1973). "Caliche" hardpans are often present in Larrea-dominated areas (Gardner, 1951; Nichol, 1952;; Shreve et al., 1933). The extensive shallow root systems of Larrea allow it to occupy these caliche-underlain sites by absorbing any light rainfall which occurs (Cunningham et al., 1973; Cannon, 1911).

Beatley (1974) investigated the effects of rainfall on Larrea in Nevada. The shrub was found on sites with recorded rainfall as low as 118 mm (4.72 in.) and was absent where rainfall exceeded 183 mm (7.20 in.). Reproductive success, as shown by 20-60% seed germinability, was correlated with rainfall of 80-150 mm (3-6 in) during the seed production season. Shrubs growing in areas of high rainfall, or along water courses, developed diseased flowers. Higher or lower seasonal rainfall resulted in lower percentages of germinable seeds (0-20%).

What's it good for?

Standley (1920) described various uses of the creosote bush: "Flower buds, pickled in vinegar, are said to be eaten like capers. The plant is much used in domestic medicine, especially for rheumatism, a decoction of the leaves being employed for baths or fermentations. The decoction is said, also, to have remarkable antiseptic properties, and is said to be applied to bruises and sores. It is taken internally for gastric disturbances and venereal disease. A reddish-brown lac is often deposited on the branches by a small scale insect. This lac is used in many parts of Mexico for dyeing leather red, and the Coahuilla Indians of California employ it as a cement. The same Indians use a decoction of the plant for interstitial complaints and for tuberculosis. The Pima Indians of Arizona drink a decoction of the leaves as an emetic, and apply the boiled leaves as poultices to wounds and sores."

Colton (1943a, 1943b) investigated the economic possibilities of the lac insect on Larrea, and concluded that, although artifical cultivation seemed possible, the resin produced would be of little use as varnish (though having possibilities in making phonograph records) and the cost of collection economically prohibitive.

Nordihydroguaiaretic acid (NDGA), a white crystalline solid prepared from Larrea, has been used as an antioxidant in food but was discontinued following investigations of its safety (Grice et al., 1968; Cranston et al., 1947). Waller et al. (1945) showed that NDGA has powerful germicidal properties, as indicated by use of the plant by native peoples. Tsuchiya et al. (1944) demonstrated the antibiotic activity of the substance against certain bacteria in vivo. NDGA content may reach 10% in the leaves of the creosote bush, although California specimens average 4% NDGA at 4,000 ft elevation, and 6% at 1,500 ft (Grisvold, 1948).

The shrub was an important fuel source for Indians (Munz, 1974) and desert travelers. Coville (1893) noted that dead branches of the creosote bush were the major fuel source throughout much of the Death Valley expedition.

The palatability of the shrub is extremely low for all grazing animals (Sampson, et al., 1963) and it has been reported as poisonous to livestock (Pammel, 1911), though an edible livestock feed has been commercially produced (Duisberg, 1952). Fresh leaves have a protein content of 15.8%--dry weight basis (National Academy of Sciences 1971). The creosote gall midge (Asphondylia) produces marble-sized leafy galls on the stems, but only a few insects are known to feed on Larrea (Benson et al., 1954, Comstock, 1939; Comstock et al., 1940). The blacktailed jackrabbit (Lepus californica deserticola) actively trims lower twigs from the shrub, leaving them lying where they fall, and the woodrat (Neotoma) is responsible for some higher trimming, building up collections of stones, sticks, and creosote bush twig ends around its burrows (Jaeger, 1948). The most important herbivore is the kangaroo rat (Dipodomys meriami Mearns), which shows a high preference for creosotebush seeds and may be important to seed dispersal through storing seed in small, subsurface caches (Reynolds, 1950).

Planting Studies

Optimum germination conditions have been determined by Barbour (1968) to be darkness, 23 C, leaching the mericarps with running water, wetting and drying cycles, exposure to cold temperatures prior to sowing, and maintenance of the planting medium at near-zero osmotic pressure low in NaCl. Kay (1975) found the optimal germination temperatures to range from 15 to 25 C. Went, et al. (1949) correlated rainfall and temperature immediately following the rain with Larrea germination. If the temperature exceeded 30 C or fell below 10 C, there was no germination. Tests of hulled or unhulled seed of Larrea tridentata, subjected to various pre-planting treatments by Graves et al. (1975) suggest that planting hulled seed treated with thiourea may improve germination (Figure 1). The success of a 15-hr soaking treatment or mixing the seed with moistened 12 x 50 caliber activated carbon indicates that an inhibitor in the hull may limit germination. In contrast, Barbour (1968) found presence or absence of the mericarp about the seed had no effect on germination. Knipe and Herbel (1966) observed that extracts from Larrea divaricata carpels did not affect the total germination of seeds removed from the carpels although such seeds germinated faster.

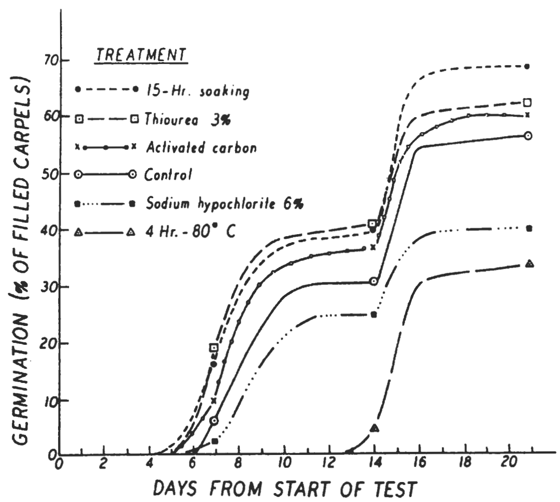

Fig. 1. Germination of seeds representing treatments that showed significant differences from the control (Graves et al. 1975). Temperatures were increased from 21C to 26C on the 14th day. Germinations at days indicated by the same letter are not different according to Duncan's NMRT ($P < 0.05$).

Seed collected in the Mojave Desert in August, 1973, had a purity of 56%. The cottony nature of the seeds prevented cleaning. Pure carpel weight was 180,000/kg (81,800/lb) with a fill of 56%, and initial germination was 17% (Kay, 1975). Though the carpels do remain on the plant after maturity, they eventually fall to the ground and are easily windblown. Carpels collected from the ground had only half the germination of the bush collection. All collections in the Mojave area had low germinations (2-17%) compared to New Mexico collections by Valentine (1968) of average 74%, varying from 55 to 90%.

The hull or mericarp may be removed from the seed by hammermilling at 1750 rpm on a 1/4-inch diameter screen and separating on a 2-screen clipper cleaner using a top No. 6 round screen and a No. 25 base screen. A belt harvester, used to shell alfalfa, was also used successfully by

Graves et al. (1974). Hammermilling yielded 87.5% compared to 67% from the belt harvester. However, seed damage and abnormal seedlings were greater from hammermilled seed. Hand-hulled seed had the best germination (Figure 2).

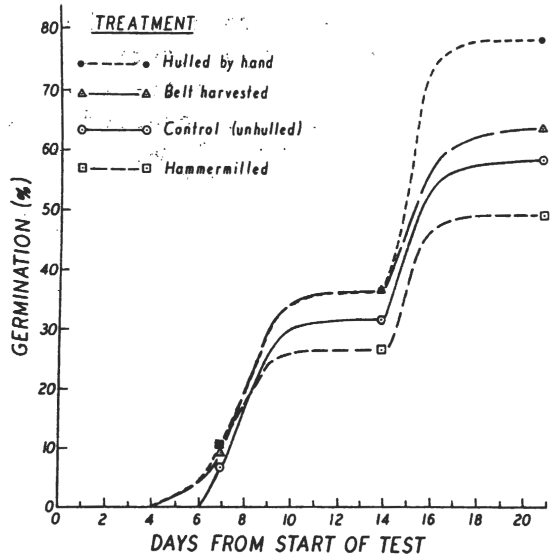

Figure 2. Effect of method of mericarp removal on seed germination of Larrea tridentata. Temperatures were increased from 21 C to 26 C on the 14th day. Germination has been corrected to a filled-carpel basis.

In a seed storage experiment the seed was treated with Phostox after processing to prevent insect damage and dried at 35 C for six days. The seed was divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. This experiment was designed to provide germination tests on a yearly basis over a twenty-year period. The results to date are presented in Table 1.

Table 1. Germination of seeds of Larrea tridentata stored in several environments at various times after initiation of storage.

	Months after initiaton of storage				
	0	13	18	30	43
Storage Conditions			---%---		
Warehouse	6	12	4	5	7
Room temp. (sealed)*		5	3	4	4
4 C (sealed)*		8	4	2	4
-15 C (sealed)*		6	2	2	3

* Seeds sealed at a moisture content of 3.7%.

Initial germination of this seed was only 17% and has declined under all storage conditions. At 13 months seed from warehouse storage showed a germination significantly higher than the other three treatments, possibly indicating that drying to 3.7% before storage was too severe and that 6%

should be used. At 30 months warehouse and sealed room temperature storage had significantly higher germinations, but were nevertheless unsatisfactorily low. Germination values at 18 and 43 months showed no significant difference between treatments. A seed sample used by Williams et al. (1974) had 74% filled seed, 60% live embryos (tetrazolium test), and germinations of 24% and 10% for untreated and treated (seed coat removed) seeds. A sample of this seed was stored in unsealed containers at 10 C for 75 months. Germination declined from the 24% mentioned above to 19% (plus 10% sound ungerminated seed). Valentine (1968) reported retention of 89.5% viability at 7 years. In germination tests at 25 C in rolled towels, most emergence occurred the first week.

In emergence testing in sand, Williams et al. (1974) recorded highest percentages (viable seed basis) for the 1-cm depth of planting, 82% in 9.0 days, and a 60% emergence (over 10.5 days) from a 2-cm depth. Went et al. (1949) reported that germination after rain in Death Valley occurred only where seed was covered with 1 cm of loose sand. Kay (1975) showed that Larrea did not emerge from any depth during the winter. This indicates a warm temperature requirement as described by Barbour (1968). Our revegetation studies in the western Mojave tend to confirm that warm temperature requirements are needed for seed germination, emergence, and seedling development. Spot seeding in early winter gave very poor emergence and no plant survival. Transplant survival after two years was also poor with only 12% recorded (Kay, 1976).

Cannon (1918) found 32 C to be optimum for root growth, and 15 C to be the lower limit for root growth efficiency. Barbour (1968) obtained maximum root growth at 29 C in a slightly acidic medium low in NaCl and near-zero in osmotic pressure. Water condensed on rocks from distillation in the soil and available soil water are major sources of water for Larrea, and soil temperature governs delivery rate of distilled water. A temperature range of 10 C with a 0-3 cm soil at a maximum of 36 -40 C is essential for significant distillation (Stark, et al. 1969).

Went et al. (1968) found that fungi have an important biological and mechanical role in desert soils. Sheps (1973) tied seedling survival to the presence of soil fungi in the desert litter. Desert litter, when added to field plots, aided in artificial establishment of Larrea; live seedlings dug up in the field had abundant mycelium, whereas dead ones had little or none. Valentine et al. (1968) studied Larrea establishment on rangeland in New Mexico. Pioneer plants lagged in attaining seed-producing size because of extensive rabbit clipping and trampling by livestock, resulting in very slow invasion of new territory at distances from seedbearing plants. Natural establishment along the fringes of a seed-bearing population can be quite rapid, although, as reported by Chew et al. (1965), the shrub has a relatively short seed dispersal distance. "Significant non-central tendencies in age distribution of most stands indicated that germination and survival are rare events, contributing to one-age or several-age stands" (Barbour 1969).

Can it be controlled?

Control of invading creosote bush is best accomplished along the margins of established populations. Phenoxy herbicides are not useful for killing this plant, although picloram is most effective, especially when applied in fall to kill regrowth following mowing (Valentine, 1970).

Schmutz (1967) has found that 2,4,5-T at 2.24 kg a.e./ha or Picloram at 0.56 kg to 1.12 kg a.e./ha applied as a foliar spray during rapid growth period will effectively control creosote bush in the Chihuahuan Desert. Further Fenuron at 4.48 kg active/ha applied as a broadcast granular treatment is an effective control.

Herbal and Gould (1970) obtained similar success using 2 grams active ingredient per meter of canopy diameter of Bromacil , Fenuron , Picloram , Fenuron TCA , Isocil and Dicamba . Each of these killed in excess of 80% of the plants on sandy loam soils. In aerial spray applications phenoxy herbicides and Amitrol were found to be ineffective while spray mixtures of 1.7 kg/ha of 2,3,6 TBA, Dicamba and Picloram produced a 70% defoliation.

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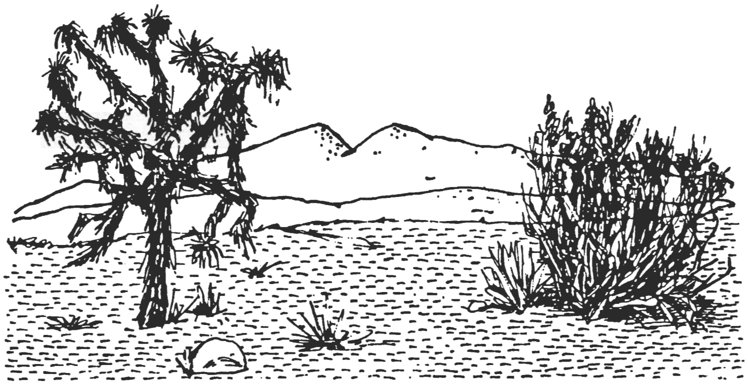
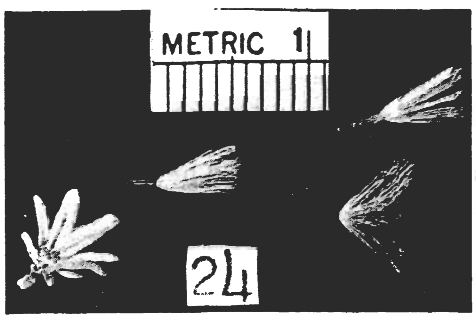


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 11 SCALE BROOM August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Lepidospartum squamatum (Gray) gray.

Scale broom, Wild asparagus

Family: Asteraceae (Compositae).

Top - seeds
Center - cotyledons and hypocotyl
Lower - seedling, 15 mm tall.

Top - closeup of stems and flower bracts.
Lower - mature shrub, 6 dm tall

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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The following description is adapted from Munz (1974) and McMinn (1951).

Habit: Rigid, broomlike, shrubs, 1-2 m high; many slender, erect branches with alternate entire leaves; young shoots tomentose and densely leafy, older stems and branches glabrate, green, with reduced leaves.

Leaves: Sparse on mature branches, scalelike, 1-3 mm long, alternate; dense on young branches, oblanceolate, 1 cm long or more, 1-3 mm broad, densely woolly, present at axils or nodes.

Flowers: Golden-yellow, bell-shaped heads, 5-8 mm high at flowering; terminal on elongated, scaly lateral branchlets or racemose or spicate along them; involucral bracts (phyllaries) 1-2 mm broad, 3-4 seriate; about 10-15 disc flowers; flowering June through December.

Fruit: Glabrous achenes, cylindrical, about 3.5 mm long, with a whitish pappus about 5 mm long.

One of two members of a genus whose name derives from the green lepis, scale, and sparton, broom-plant (McMinn, 1951), Lepidospartum squamatum can be found growing on sandy washes and gravelly plains in the desert, the chaparral, and the grasslands (Benson and Darrow, 1954). Though mostly inland, the scale broom is associated with Coastal Sage Scrub, Chaparral, Joshua Tree Woodland, and Creosote Bush Scrub communities below 1500 m (5,000 ft) elevation (Munz, 1974). Coville (1893) noted the occurrence of the shrub as "singular," being found along the southern and western edge of the Mojave Desert and in the intramontane region along certain sandy, dry washes. According to Benson and Darrow (1954), Lepidospartum squamatum is found in California, from Monterey to San Diego County, and in the western Colorado and Mojave Deserts (Kern Co.), in Baja California, and in Mexico. The preference for sandy soils is again exemplified by the shrub's abundance in the sand-dune area near San Gorgonio Pass.

We harvested dry achenes of the scale broom in December, 1973, along the old L.A. Aqueduct, 7 to 13 km (5-8 miles) north of Mojave (Kay, 1975). The bristly nature of the achenes prevented cleaning, with a resulting collection purity of 11%, 682,000 achenes/kg (310,000/lb) with 78% fill. A late October-early November harvest would apparently improve achene harvest, since 80% of achene production had been blown off by the wind in December. A jeep-mounted vacuum harvester would be an efficient means of collecting the light achenes in the shrub's common habitat of draws, ravines, washes, and old disturbed soil and embankments.

Germination of freshly harvested achenes (28 days in the dark at 20 C) was 58%. Optimum germination temperature was determined in the range 2-10 C, with highest percentage (64%) at 5 C (Table 1).

Table 1. Effect of constant temperatures on the germination of Lepidospartum squamatum.*

Temperature C	2	5	10	15	20	25	30
Germination %	52	64	57	31	22	5	4

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

Effect of depth-of-planting has been investigated. Kay (1975) showed that, from washed plaster sand at 10 C, emergence from 1 cm was 33% (Figure 1). Williams et al. (1974), using achenes with an initial 36% germination, demonstrated lower emergence (8%) from 1 cm at 17 -21 C. There was no emergence from 2 or 4 cm in either study. Because of the small size of the seed it may be desirable to cover it with much less than 1 cm of soil.

Graves et al. (1975) studied the response of Lepidospartum achenes to heat treatment. A 4-hour 80 C treatment reduced germination (Figure 2), whereas a 4-hour 60 C treatment had no effect on germination.

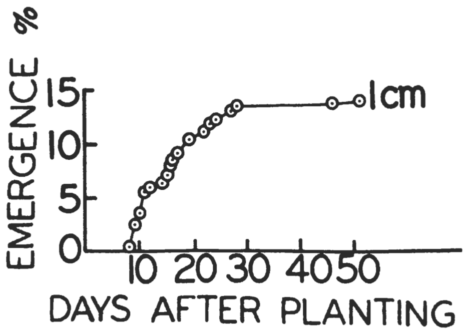

Fig. 1 Effect of depth of planting on emergence of L. squamatum. There was no emergence from 2 cm or deeper.

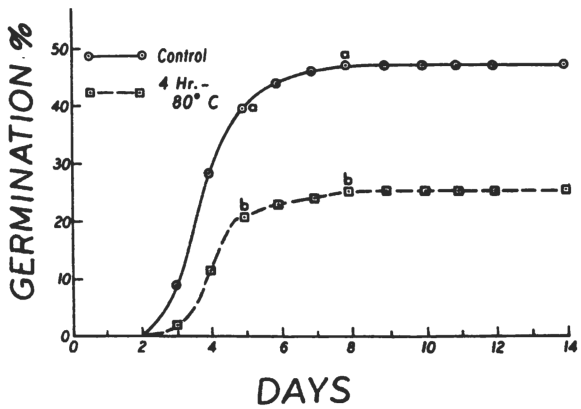

Fig. 2. Germination of achenes representing treatments that showed significant differences from the control. Germination values indicated by the same letter are not different according to Duncan's NMRT ($P < 0.05$).

In a seed storage experiment, the achenes were processed, treated with Phostox to prevent insect damage, and dried at 35 C for six days. The achenes were divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of sacking and storing in a seed warehouse in Davis, California. This experiment was designed to provide germination tests on a yearly basis for twenty years. The results of these tests to date are presented in Table 2.

Table 2. Germination of achenes of Lepidospartum squamatum stored under several environments over time.

	Months after initiation of storage				
	0	13	18	30	43
Storage conditions			--%--		
Warehouse	58	47	3	0	0
Room Temp. (sealed)*		28	12	16	8
4 C (sealed)*		19	16	14	11
-15 C (sealed)*		23	21	11	15

* Achenes stored at 3.2% moisture.

At 13 months germinability was best preserved under warehouse storage conditions while being reduced by about one-half in all other conditions. This decline may be due to excessive drying (3.2% moisture) before storing. Drying to 5-6% moisture is recommended. By 18 months, however, warehouse storage resulted in a drastic decline, and by 30 months had declined to zero. At 43 months, germination was best at -15 and 4 C. Room temperature is significantly lower than -15 C. Germination after 43 months of storage was most rapid in the first seven days for all sealed storage conditions, with a reduced rate the second week.

Another seed lot, collected near Mojave by a commercial seed collector in 1971, was stored in a non-sealed container at 10 C for 75 months. Germination had declined to zero from 36% when stored.

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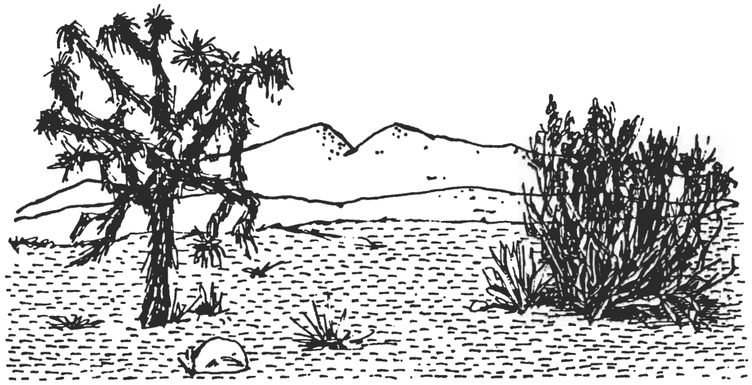


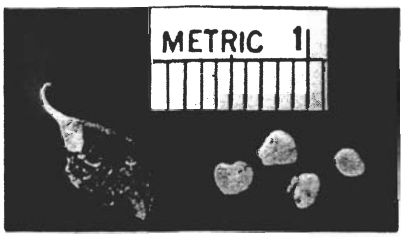
Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 12 August 1977

ANDERSON DESERT THORN

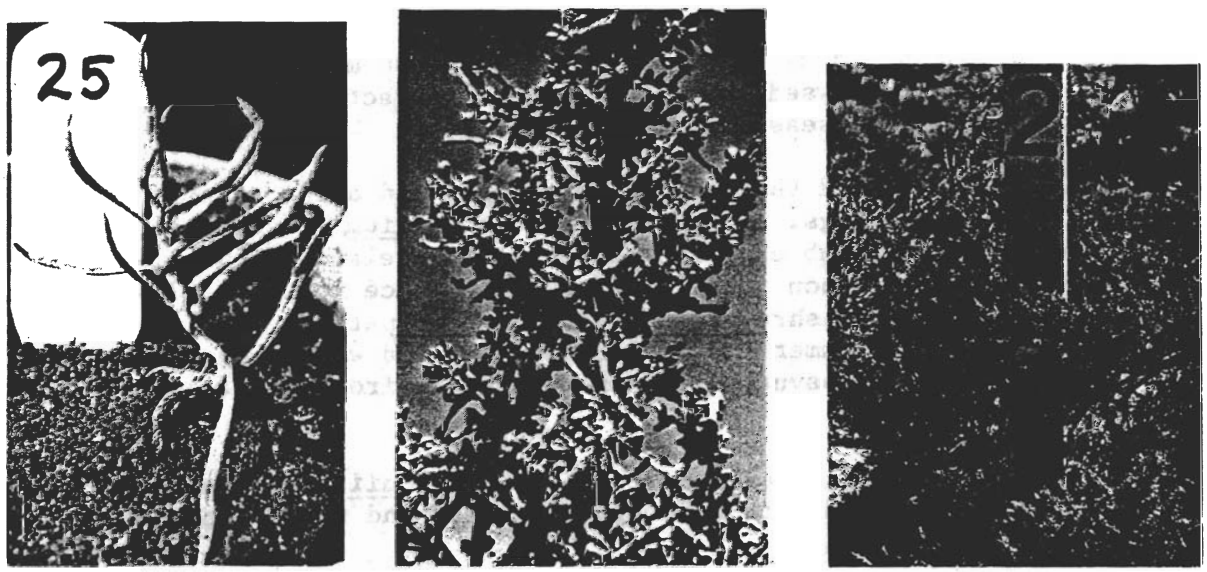
Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Lycium andersonii Gray.

Family: Solanaceae

Water jacket, Anderson desert thorn, Anderson Lycium, Box thorn, Wolfberry



Top: Shriveled fruit and seeds
Lower left to right: Seedling, branch and flowers, mature shrub 6 dm tall.

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

Description adapted from Munz (1974) and McMinn (1951).

Habit: Spiny, rounded shrub, 1-3 m high; intricately branched, usually without hairs; sometimes with needlelike spines, older branches often unarmed.

Seedling: Linear, succulent leaves, indented at midrib, recurving upward and at various angles.

Leaves: Solitary or in bundles, tapering to slender petioles; fleshy, almost without hairs, 3-15 mm long, tear-drop shaped, 1-3 mm in diameter.

Flowers: Whitish lavender, solitary or in pairs, pediceled; corolla narrow, tubular, 7-14 mm long, lobes mostly 5, 1.5-2.5 mm long, corolla sometimes fringed with short hairs; stamens and styles equal to corolla or slightly protruding; calyx cup-shaped, 1.5-3 mm long, irregularly 4-to-5-lobed; flowering March to May.

Fruit: Red, fleshy ovoid, 3-8 mm long, many-seeded, looks like a tiny eggplant.

Lycium andersonii can be found throughout the Lower Sonoran Zone (Coville, 1893), associated with the Creosote Bush Scrub, Pinyon-Juniper Woodland, Sagebrush Scrub, Chaparral, and Coastal Sage Scrub communities (Munz, 1974). On washes, mesas, and foothill slopes in the Mojave and Colorado Deserts, north to Mono County, occasinally in cismontane southern California, east to Utah and New Mexico, south to Mexico (Munz 1974), Lycium andersonii is widespread in the Southwest below 1830 m (6,000 ft) elevation. The shrub is lightly browsed by burros, and is attractive to quail and hummingbirds in various seasons (Stark, 1966).

Coville (1893) noted that Lycium andersonii had a characteristic hard wood with indistinct rings. His observation of Lycium leaves turning yellow and falling from the shrub early in the summer correlates with evidence that it possesses the C-3 carbon fixation pathway (Wallace et al., 1971). In contrast, certain desert shrubs possessing the C-4 pathway retain their leaves throughout the summer due to leaf anatomy and enzyme characteristics which permit active photosynthesis in hot, arid environments (e.g. Atriplex canescens).

Wieland et al. (1971) reported that L. andersonii rooted easily when stem cuttings were dipped into Hormodin 2 powder and then placed in vermiculite in a mist house.

Lycium andersonii has been reported on saline soils (Stark, 1966), though Wallace et al. (1971) described the species as being found further from saline areas than Lycium pallidum and Lycium shockleyi. The Anderson desert thorn tends to have an extremely high cation content, as determined by Wallace and Romney, 1971. The Ca content of the shrub is inversely related to Na content, with Ca being mostly transferred to the shoots. Ba accumulates in the roots, and Sr is found equally distributed between roots and shoots (Wallace et al., 1973).

Wallace et al. (1974) using data from the Rock Valley Area of the Nevada test site in the Mojave Desert estimated mean stem weight at 183g

(264 kg/ha) and the mean root weight at 251g (220 kg/ha).

We collected dry berries of Lycium andersonii, one of the few desert plants to produce a fleshy fruit, from the ground in August, 1973 (Kay, 1975). The gummy pulp of the fruit made processing difficult. Trash was removed by passing the berries through a fanning mill (No. 17 top screen, No. 10 bottom screen). Dirt and rocks were decanted, followed by a drying at 38 C to reduce the stickiness of the fruit. After being run once through a belt harvester, redried, and cleaned in a fanning mill (No. 8 top screen, No. 1/25 bottom screen, the collection had a 53% purity, 428,000 seeds/kg (194,373/ lb), with an undamaged seed count of 94%. For extraction on a large scale Rudolf (1974) suggested that berries be fermented, mashed in water, and then run through a hammer mill equipped with screens of suitable size. Collection two or three weeks earlier would have improved the harvest, but berry production was low and the spiny nature of the shrub made any collection laborious and difficult.

In depth of seeding test (1 cm, 2 cm, and 4 cm), Lycium cooperi and L. andersonii emerged only from 1-cm and then in low numbers spread over a long period of time (Kay, 1975). The slow emergence was probably due to the low winter temperatures. Optimum germination temperature for L. andersonii is 20 C (Kay, 1975).

After the seed was processed it was treated with Phostox to prevent insect damage and dried at 35 C for six days. The seed was divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. The experiment was designed to provide tests of germination on a yearly basis for twenty years. The results of germination tests to date are presented in Table 1.

Table 1. Germination of seeds of Lycium andersonii in several storage environments over time.

	Months after initiation of storage				
	0	13	18	30	43
Storage conditions			--%--		
Warehouse	9	10	7	4	5
Room temp. (sealed)*		10	8	2	4
4 C (sealed)*		8	6	2	6
-15 C (sealed)*		4	6	2	6

* Seed sealed at a moisture level of 9.4%

There is no significant difference between the different storage conditions. Germination is spread equally over a 30 day period at 20 C in rolled towels.

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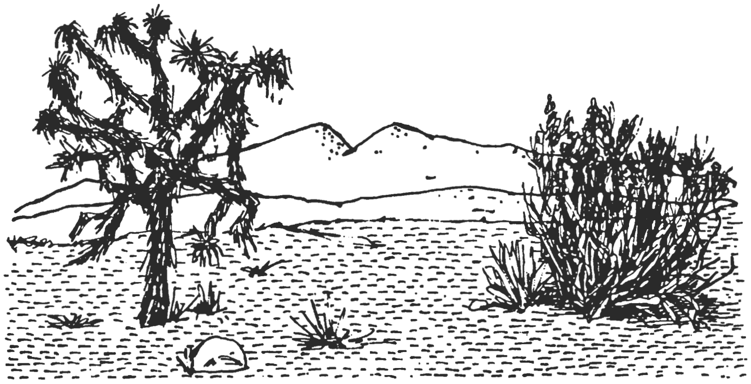

Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 13 August 1977

COOPER'S DESERT THORN

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]

Lycium cooperi Gray.

Family: Solanaceae

Peach thorn, Cooper Lycium, Cooper Desert Thorn, wolfberry.

Photos: Top left to right-fruit and seed, small seedling; Lower left to right-seedling, mature stem with flowers, mature shrub one meter tall).

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management. Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

The following description is adapted from Munz (1974) and McMinn (1939).

Habit: Stout, densely branched, spiny shrub, 1-2 m high with rigid, thick branches, densely pubescent when young; spines short, about 2 mm long; bark of trunk and larger branches smooth and dark brown.

Seedling: cotyledons linear, curved and tapering; first true leaves obovate; alternate; densely hairy.

Leaves: spatulate, 1-3 cm long, 4-10 mm broad; bunched, 3-10 leaves per bunch, very short-petiolate; branches sometimes covered by dense clusters of leaves interspersed with flowers.

Flowers: greenish-white with lavender veins, numerous, 1 to 3 in bunches; corolla 5-8 mm long, funnel-shaped, often hairy, usually persistent after withering; stamens and style subequal to the corolla; calyx bowl-shaped to oblong or bell-shaped, 8-15 mm long, usually glandular-hairy, the hairs falling away with age, the lobes triangular to lanceolate, about half as long as the tube; flowering March to April.

Fruit: yellow-green, hardened, pear-shaped, 5-9 mm long; the lower portion usually several-seeded, the upper portion usually 2-seeded.

Found on the alluvial plains and foothill slopes from the Creosote Bush Scrub to the Pinyon-Juniper Woodland below 6,000 ft elevation (Munz, 1974), Lycium cooperi occurs in California's Colorado and Mojave Deserts, the upper San Joaquin Valley, in Kern County, in Nevada from Mineral and Esmerelda Counties southward, in southwestern Utah, and in Arizona in the Mojave Desert in Yuma and Mojave Counties (Benson and Darrow, 1954).

We collected dry berries along and to the north of State HW 58, 13 km (8 miles) NW of Mojave going toward Bakersfield, in a Joshua Tree Woodland (elev. approx. 1,000 m (3,400 ft) on August 18, 1973. Hand-picking was not practical because the shrub is extremely thorny. The berries were knocked from the shrubs onto a tarpaulin spread on the ground below as well as collected from the ground around the bushes, with the latter method producing a larger yield, of equal germinability (19%) (Kay, 1975).

The pulp of the berries was very sticky, making the seeds difficult to remove. After cleaning in a fanning mill (No. 30 top screen, No. 1/12 bottom screen), the berries were dried at 32 C, run through a belt harvester for shelling, and then redried and recleaned in the fanning mill (No. 7 top screen, No. 1/16 bottom screen) to produce an average pure seed count of 468,000/kg (212,500/lb), 87% undamaged seed, and a 45% purity. Humidity and the amount of pulp left on the seeds can affect the seed weight considerably.

For extraction on a larger scale Rudolf (1974) suggested that berries be fermented, mashed in water, and then run through a hammer mill equipped with screens of suitable sizes.

A depth of planting study in washed plaster sand showed emergence was poor and sporadic. Temperatures were lower than the option 15-20 C (Kay, 1975). Only a few seedlings emerged from 1-cm over a 2-month period, and none from 2 or 4 cm (Kay 1975). Covering with less than 1-cm may be desirable.

In a seed storage experiment the seeds were treated with Phostox to prevent insect damage and dried for six days at 35 C. The seeds were divided up and sealed in sixty one-gallon jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C and the remainder at -15 C. A fourth treatment consisted of bagging a portion of the seed and storing in a seed warehouse in Davis, California. The experiment was designed to provide yearly tests of germinability over a twenty year period. The results of tests to date are presented in table 1.

Table 1. Germination of seeds of *Lycium cooperi* under several storage conditions over time.

	Months after initiation of storage				
	0	13	18	30	42
Warehouse	19	24	20	9	12
Room temp. (sealed)*		27	18	8	16
4 C (sealed)*		31	18	8	16
-15 C (sealed)*		26	13	7	16

* Sealed at a seed moisture content of 5.5%

No significant difference in germination between storage conditions has been observed. The initial increase in germination may indicate that afterripening occurs. The further decrease in germination at 30 months followed by a slight increase at 42 months is difficult to explain. The germination of seeds mixed with activated charcoal at 42 months did not differ from the control (lacking charcoal). Germination is most rapid in the second week, but is spread over the 30 day period (20 C in rolled towels). Optimum germination temperature is 15-20 C (Table 2).

Table 2. Effect of constant temperatures on germination of *Lycium cooperi*.

Temperature C	2	5	10	15	20	25	30	40
Germination %	0	0	2	7	8	5	4	0

*Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

References

Benson, L. and R. A. Darrow. 1954. The trees and shrubs of the southwestern deserts. 2nd ed. Univ. New Mexico Press, Albuquerque. 437 pp.

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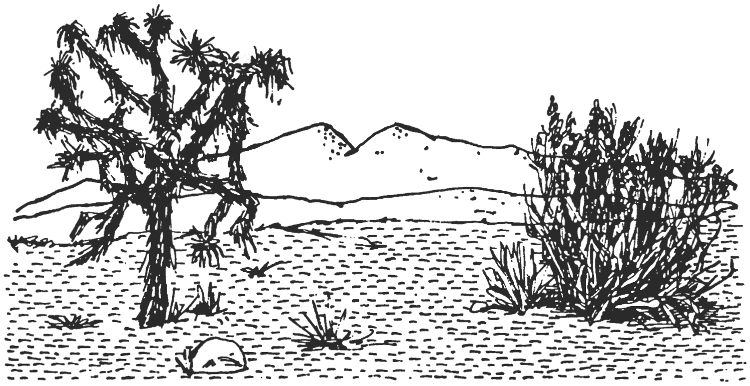
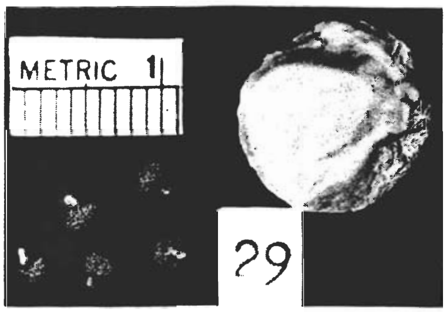


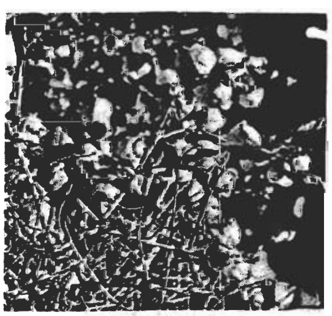
Mojave Revegetation Notes

UC DAVIS   AGRONOMY & RANGE SCIENCE

No. 14   BLADDER SAGE   February 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



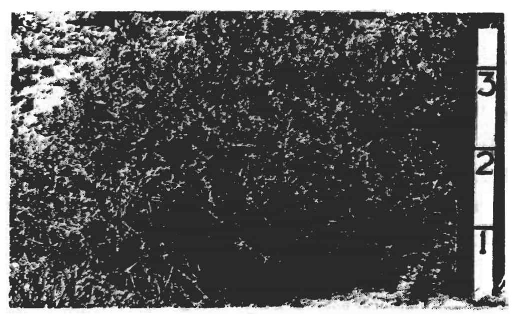


Top-bottom: Seeds and bladder, seedling with cotyledons, stems with leaves and bladders.

Salazaria mexicana Torr.

Bladder sage, Paper-bag bush

Family: Labiatae



Mature shrub-one meter high.

1/ Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports on work supported by the Bureau of Land Management--Contract No. 53500-CT4-2(N), Document Obligation No. 6809.

The following description is adapted from Munns (1974) and McMinn (1939).

Habit: Low dense shrubs to 1 m high; spinescent, with intricate branches.

Leaves: Small, green, lacking or with sparse hairs; oblong or elliptical, 1-1.5 cm long, short-petioled; present at axils or nodes, generally sparse on stem.

Flowers: In the axils of upper (bractlike) leaves, variable in form; racemes 5-10 cm long; calyx lips entire, rounded, 6-8 mm long, usually purple; corollas 16-20 mm long, the tube white, the lower lip bluish-violet, lateral lobes joined to form a hood which includes stamens and style; 4 paired stamens; flowering March-June.

Fruit: Roughened olive-brown nutlets; the mature calyces papery, globose, inflated, as much as 2 cm in diameter, pearly or rose-colored.

Salazaria mexicana, whose name derives from that of Don Jose Salazar, a member of the US and Mexican Survey commission (McMinn, 1951) is an attractive plant, where it escapes damage from browsing animals such as rabbits (Stark, 1966). The bladder sage (or paper-bag bush) can be found growing in desert washes and on foothill slopes between 300 to 1000 m (1000-3500 ft) elevation (Benson and Darrow, 1954). The wide mesas of the Lower Sonoran Zone (Coville, 1893) are the chief habitat of the shrub, and its range extends throughout the deserts from Inyo County to Riverside County, to Utah, Texas, and northern Mexico, in common association with plants of the Creosote Bush Scrub and Joshua Tree Woodland communities (Munz, 1974).

Dry bladders were collected June 24, 1973, in a Joshua Tree Woodland north of State Hwy. 178 about 7.2 kg (4.5 miles) west of the Freeman Junction of State Hwy. 14 and Hwy. 178, 68.8 kg (43 miles) north of Mojave (Kay, 1975). As throughout the western Mojave Desert, where seed of various shrubs was collected, Salazaria was scarce and the bladder yield was poor. Bladder fill was 39%, with several containing 2 or 3 seeds such that 100 bladders averaged 64 seeds. Because of the limited bladder supply, no continuing effort was made to remove the seeds from the bladders, though a limited trial indicated that a belt harvester was not effective. Pure bladders averaged 62,000/kg (28,000/lb) and pure seeds averaged 211,000/kg (96,000/lb). The bladders are easily windblown, and vacuum-harvesting would probably be efficient in the field.

Seed germinability was tested within 30 days of collection by placing the bladders on moist towels at 20 C under dark conditions for 28 days. A total of 43% of the bladders had one or more germinable seeds (Kay, 1975). Optimum temperature for germination was 10-20 C (Table 1).

Table 1. Effect of constant temperatures on the germination of Salazaria mexicana.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	0	0	17	24	15	11	2	0

*Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

In November, a depth-of-seeding test was begun. Seed was removed from the bladders and planted in washed plaster sand, kept around 10 C for 8 weeks. Emergence was greatest and most rapid at 1 cm, reduced and delayed at 2 cm, and minimal at 4 cm (Figure 1). Emergence from 1 and 2 cm was respectively 62% and 24% compared to 84% in the laboratory. Emergence from 4 cm is uncommon among the 17 shrubs tested, indicating that Salazaria may be useful for seeding in soils which require deep planting to reach an effective moisture source. According to Stark (1966), the seed germinates readily, and bare-root seedlings survive planting in porous soils.

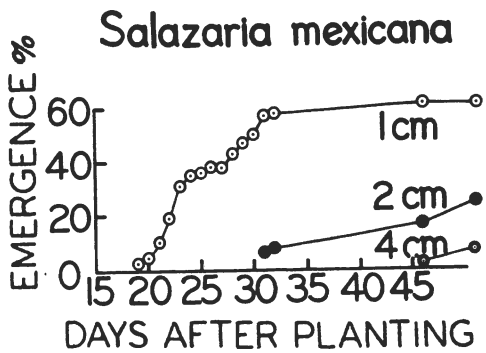


Fig. 1. Effect of depth of planting on percent and time of emergence.

In a seed germination experiment, bladders were treated with Phostox after processing and dried at 35 C for six days. The bladders were divided and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. The experiment was designed to provide germination tests on a yearly basis over a twenty year period. The results to date are presented in Table 2.

Table 2. Germination of seeds of Salazaria mexicana in several storage environments over time. Seeds were removed from bladders before placing on moist blotters.

Storage conditions	Months after initiation of storage 0	13	18	30	43
			---%---		
Warehouse	84	92	66	54	47
Room temperature (sealed)		91	86	68	83
4 C (sealed)		94	88	76	81
-15 C (sealed)		83	88	76	80

Very little loss of germinability as noted at 13 months. At 18 months a significant decrease had occurred in bagged warehouse storage. By 43 months warehouse storage stands out as a much poorer condition than any of the sealed storages. Most germination occurs in the first two weeks at 15 C.

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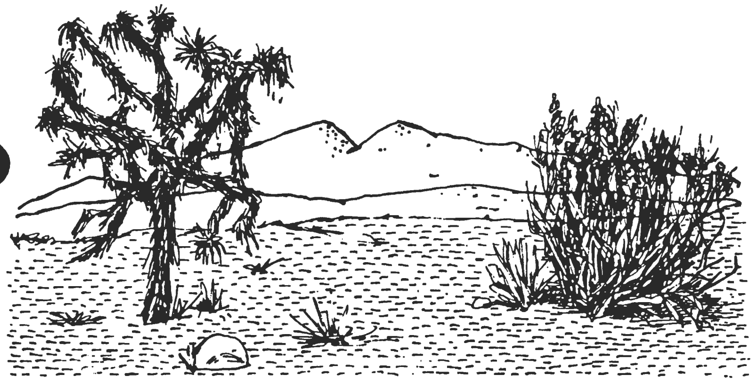
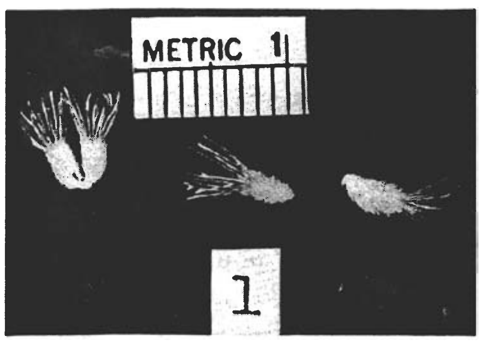


Mojave Revegetation Notes

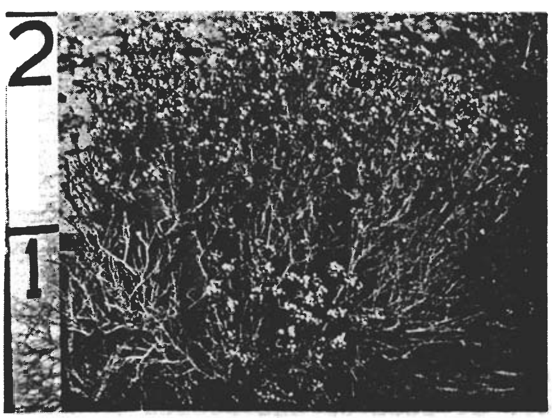
UC DAVIS AGRONOMY & RANGE SCIENCE

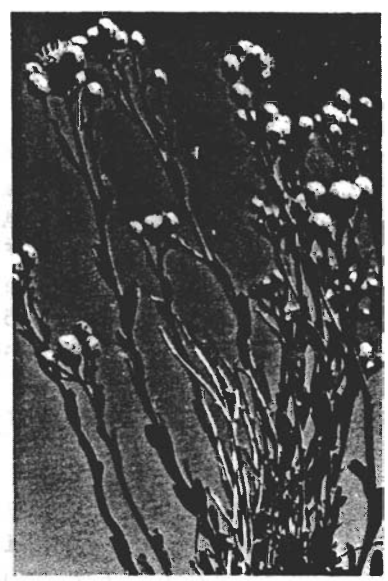
No. 15 | GOLDENHEAD | August 1977

Burgess L. Kay, Catherine M. Ross, and Walter L. Graves[1/]



Acamptopappus sphaerocephalus (Harv. & Gray) Gray var. hirtellus Blake





Photos: Top left, achenes; bottom left, mature shrub (6 dm tall); right, floral buds and flowers.

[1/]Wildlands Seeding Specialist, Research Associate, and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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The following description is adapted from Abrams and Ferris (1960), McMinn (1951) and Munz (1974).

Habit: Low, much branched, rounded shrub, 2-9 dm high; stems gray-white-barked; stems and leaves glabrous or with sparse stiff hairs on leaf margins.

Leaves: Alternate; simple; entire; not petioled, usually yellow, spatulate, 5-20 mm long, 1.5-5 mm broad; sometimes quite small and linear, sometimes large and oblanceolate.

Flowers: Spheroidal heads, about 1 cm in diameter; yellow; solitary or in loose terminal clusters; ray flowers absent; notable character is the fringed margin of the thin membranous involucral bracts, bracts commonly with a greenish subapical spot; flowering April to June.

Fruit: Pappus of flattened bristles, the tips dilated; achenes 3-4 mm long, about 2 mm broad, densely covered with long, stiff, appressed hairs.

"Along with Ambrosia dumosa, Acamptopappus, where locally abundant, may be an important source of food for rodents (Pequegnat, et al., 1949)." The variety hirtellus, named in reference to its minutely hirsute foliage, can be found along the western borders of the Mojave Desert, as far north as Lone Pine, Inyo Co., and in western Nevada (Munz, 1974). A slow-growing shrub of the Lower Sonoran Life Zone, goldenhead is usually confined to the gravelly or sandy mesas and slopes of the Larrea belt, generally below 1,200 m (4,000 ft) elevation (Benson, et al., 1954; McMinn, 1951; Munz, 1974). The shrub is not easily identified until flowering (Coville, 1893).

We tested achenes collected from shrubs of the hirtellus variety growing in the Mojave Desert at an elevation of about 1,280 m (4200 ft.). Though common along the L.A. Aqueduct (Mojave Desert), this shrub was not found in large enough stands for easy seed collection. The fluffy nature of the achenes made hand-cleaning more practical than fanning. In a collection of 1.3 kg made in August, 1973, hand cleaning gave a yield of 1.17 kg of achenes of 64% purity, 13% achene fill, and 11% initial germination. Earlier collection would have been possible at lower elevations, where achenes ripen and are shed earlier in the summer.

Assuming this collection to be representative, achene yields of about 1,038,000 achenes/kg (471,600/lb) can be expected. After the achenes were processed they were treated with Phostox to prevent insect damage and dried for six days at 35 C. The achenes were divided up and sealed in sixty one-gallon glass jars containing silica gel desiccant. Twenty jars were stored at room temperature, twenty at 4 C, and twenty at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse in Davis, California. This experiment was designed to provide germination tests on a yearly basis for twenty years. Tests were discontinued after 30 months due to negligible germination. The results obtained are shown in Table 1.

Table 1. Germination of achenes of Acamptopappus sphaerocephalus under several storage conditions over time.

	Months after initiation of storage			
	0	13	18	30
Storage conditions		---%---		
Warehouse	11	2	2	0
Room Temp. (sealed)*		4	2	1
4 C (sealed)*		6	3	1
-15 C (sealed)*		5	3	1

* Achenes stored at 2.8% moisture.

There was no significant difference between storage conditions.

Optimum temperatures for seed germination are 2-10 C (Table 2). Germination should occur in the winter months.

Table 2. Effect of constant temperature on the germination of Acamptopappus sphaerocephalus.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	2	9	3	0	0	0	0	0

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada.

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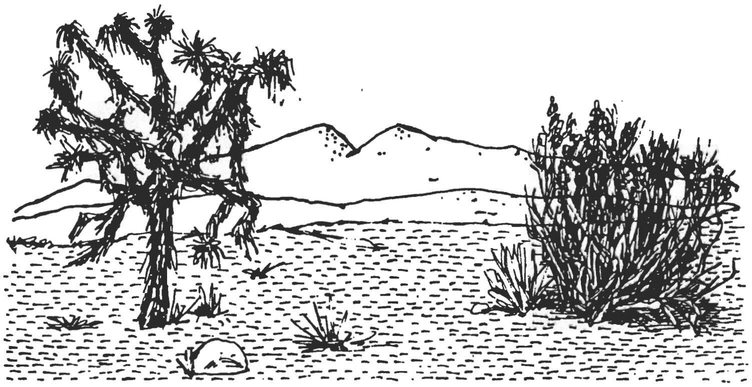


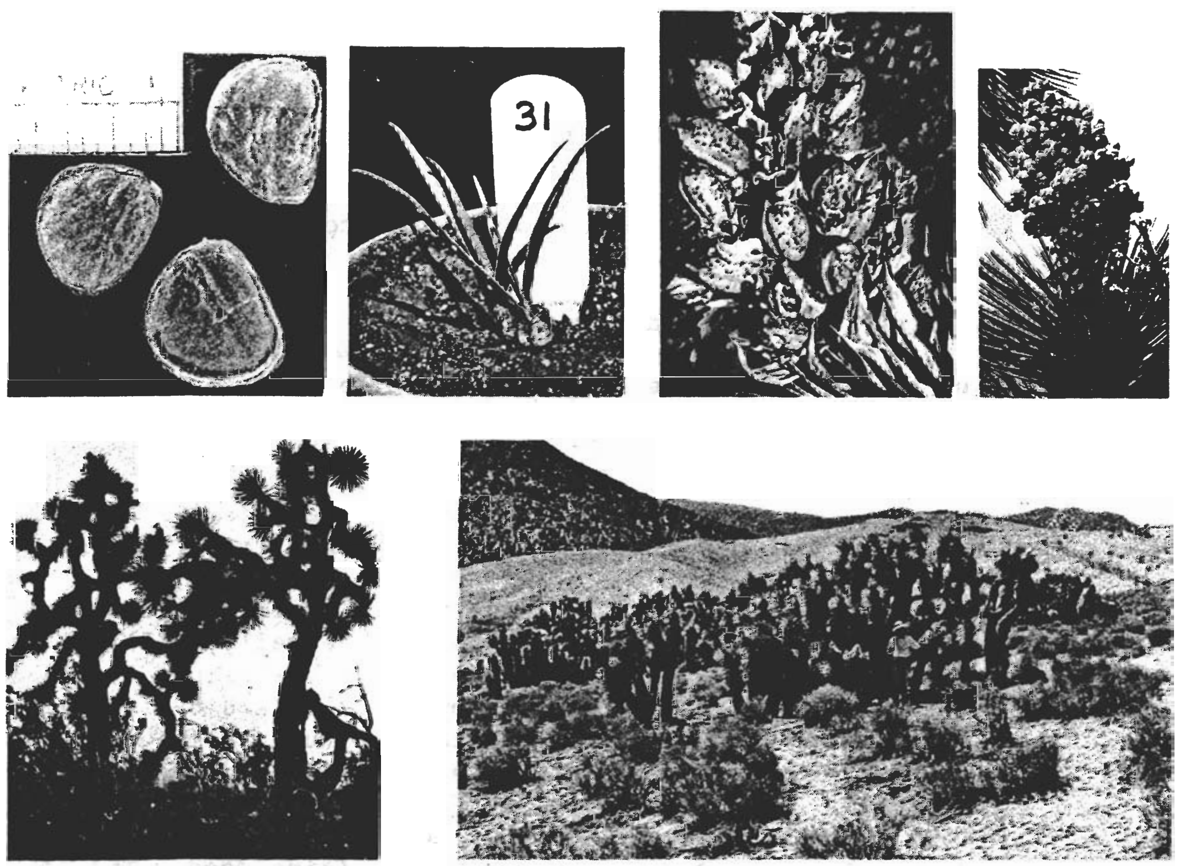
Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 16 August 1977

Joshua-Tree
Yucca brevifolia var. herbertii (J. M. Webber) Munz

Burgess L. Kay, Charles R. Brown, and Walter L. Graves[1/]



Photos: Upper left-seeds; Upper middle-seedling; Upper right-fruits; Lower left-var. brevifolia; Lower right-var. herbertii (thicket of trunks).

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Dr. Brown is currently Post-doctoral Fellow, International Potato Center, Lima, Peru. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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Yucca brevifolia Engelm. var. herbertii (J. M. Webber) Munz
Joshua tree, Yucca-cactus, Tree-Yucca, Yucca palm

Family: Agavaceae

The following description is taken from Munz (1974), McMinn (1951), and Benson and Darrow (1954).

Seedling: Numerous grass-like leaves usually narrow, succulent, limp, chalky, blue-green.

Habit: Small tree, 1-5 m. tall, arising from scaly underground rootstocks, forming clumps up to 10 m in diameter. Stem stout, checked into small squarish plates.

Leaves: Leaf bases whitish, 4-5 cm wide, 2-3.5 dm long, rigid, toothed, with fibers at margin, apical spine 7-12 mm long. Leaf clusters near ends of branches 3-15 dm. long.

Inflorescence: Not stalked, very dense panicle of racemes.

Flowers: Spherical, sepals and petals thick and fleshy, greenish, 2-3 cm long, 8-10 mm broad; stamens 1-1.5 cm long, pistil 2.5-3 cm long.

Fruit: Ellipsoidal, 6-9 cm long, 4-5.5 cm in diameter, dry and spongy at maturity, not splitting open.

Seeds: Thin, smooth, 7-10 mm long, dark in color.

The Joshua tree grows in the Lower Sonoran Life Zone in the Mojave Desert west to Antelope Valley and to Upper Piru Creek along the highway to Gorman to Castaic, Los Angeles County, and north to eastern Kern and Inyo Counties. It extends eastward to Nevada and Arizona (McMinn, 1951). The variety herbertii is limited to the western end of the Mojave Desert, Los Angeles County to Monolith and Walker Pass, Kern County (Munz, 1974).

The Joshua tree is found only where the rainfall amounts to 200 to 250 mm per year between 600 and 1,800 m elevation (Maxwell, 1971). That it was distributed at lower elevations in earlier times has been inferred from evidence that Yucca brevifolia leaves and flowers comprised 80% of the diet of the giant ground sloth, an extinct inhabitant of lower elevations (Webber, 1953). It generally flowers from March to early April, and seeds ripen in July and early August. Pollination seldom occurs without the aid of the female yucca moth, Pronuba yuccasella. This moth gathers pollen and places it on the stigmatic tube while simultaneously depositing eggs. The larvae feed exclusively on the maturing seeds, but usually consume only a small percent (Alexander and Pond, 1974). It is likely that Yucca spp. in general are outcrossed. Czaja (1947) found a higher proportion of viable seeds on outcrossed plants than on self-pollinated plants.

In the areas where the Joshua tree is a dominant species it often contributes the only canopy to the area. At 1,750 m elevation in the Mojave, Zembal (1974) determined that there was an average of 112 trees per hectare ranging from 0.6 to 6 m in height. This provided nesting space for nine species of birds. The largest Joshua tree ever recorded was 24 m tall, 3 m in girth at the base, and estimated to be a thousand years old (Webber, 1953).

Vasek (1973) reported that an individual Joshua tree at 2100 m elevation averaged 10 cm growth per year, bearing its first inflorescence at 11 years of age. Leaves apparently functioned for as long as 12 years. McCleary and Wagner (1973) found that Joshua tree seedlings attain about 50% more growth under short-day (10 hr light, 14 hr dark) conditions than long-day (16 hr light, 8 hr dark). The sometimes bizarre branching patterns displayed by Joshua trees are attributeable to the activity of Yucca-boring beetles. The tree walls off injured areas with a silica-type substance which forces the new branch to take off in a new direction (Maxwell, 1971).

Members of the genus _Yucca_ have been utilized in a number of ways. Native Americans split the fruits of nondehiscent Yuccas (_Y. brevifolia_, for example) and scraped out the seeds and fibers. Sometimes the fruits were boiled or roasted before being opened. The fleshy pulp in the fruit casing was used as a pie-filling, dried in strips, or was molded into cakes and dried (Harrington, 1972). In addition, the large black seeds were roasted and either eaten whole or ground into a meal (Yanovsky, 1936). Fibers in the leaves were used to make sandals, leggings, mats, cord, rope, and baskets, and the roots supplied a good substitute for soap (Harrington, 1972).

At one time the Joshua tree was used in the manufacture of paper pulp by a company operating out of San Francisco. That enterprise had ceased by 1886--luckily for the present-day Joshua tree enthusiasts--but not before a few editions of the London _Daily Telegraph_ were printed on "Yucca paper." Also, the wood was very popular for use as surgeon's splints owing to its sturdiness, lightness, and porosity (McKelvey, 1938).

The Germans developed a strong interest in the 1930's in cultivating _Yucca_ spp. for fibers (Corell, 1932; Camin, 1930). Previous to that, a number of soaking (retting) processes had been patented in the United States, France, and Great Britain.

Botkin and Shires (1944) investigated the tensile strength of leaf fibers of _Yucca glauca_ and _Y. elata_ and found them to be equal in strength to the usual commercial fibers, American hemp, palma istle, and African sisal. The leaf fibers of _Y. baccata_ and _Y. torreyi_ (rigid-leaf types) were found to be one-third stronger than the other species, and about equal to manila. Botkin and co-workers (1943) determined that stands of _Y. glauca_ could probably give an average yield of air-dry yucca leaves of 1,445 kg/ha, and stands of _Y. elata_ would yield 592 kg/ha. Fiber content averaged 42% of air-dry weight. After surveying the extent of distribution of these two species they estimated that 32 million kg of fiber from _Y. glauca_ and 7.3 million kg of fiber from _Y. elata_ could be obtained from New Mexico alone. They noted that 36.4 million kg of fiber were processed from _Y. glauca_ during the first World War.

Earlier, several researchers pointed to the value of several species of _Yucca_ as emergency stock feed during times of drought. Jones and Conner (1918) recommended chopping and shredding of the stems and leaves of _Y. elata_, _Y. macrocarpa_, _Y. baccata_, and _Y. glauca_. This roughage, which is low in crude protein and high in fiber, when mixed with cottonseed meal, can actually improve the condition of cattle. Wooton (1918) rated the yucca alone as equivalent to range grass hay. He recommended 9 to 18 kg of choppings combined with 0.5 to 1.0 kg of cottonseed cake as a daily ration for mature stock. He noted that a harvested stand of Y. glauca would renew itself in 3 to 4 years, whereas Y. elata would require 10 to 15 years. Forsling (1919) warned that hungry cattle could incur ill effects by over-consumption of chopped yucca leaves, resulting in bloat and choking.

The genus was seriously considered for papermaking again during World War II, to the extent that a processing plant was built in Kingman, Arizona. Various chemical retting processes had been perfected by that time (Cruse, 1949). Martinez (1959) noted the presence of the steroid sarsasapogenina, a possible precursor to cortisone, in the leaves of Y. brevifolia.

Primarily because of the deterioration of its habitat, and the prospect that private enterprise might find some further use for it, the Joshua Tree National Monument, consisting of 101,443 hectares, was established in 1936 (Anonymous, 1974).

Webber (1953) found that Y. brevifolia and Y. whipplei are the only two species which reproduce by seeds to any extent. Successful reproduction through germinating seed is unusual in the lower valleys and mesas of the desert, where the annual precipitation is meager. At higher elevations, rainfall is much greater and Joshua tree seedlings are plentiful. In addition, the Joshua tree produces rhizomes bearing scalelike leaves without nodes or internodes. Extensive sprouting from rhizomes, a characteristic of var. herbertii, may result in a clump of 30 to 40 trunklike stems covering an area 10 m in diameter. The Navaho yucca-borer, a butterfly, lays its eggs on young plants that spring from runners. The larvae bore into the runners, where they feed and pupate. By some uncanny means the female can distinguish seedlings that have arisen from seeds, which have no rhizomatous feeding ground, and lays eggs only on seedlings derived from runners.

A collection of Yucca brevifolia var. herbertii was made in July of 1974 by Carl Rice of the Bureau of Land Management. This site was located at the bottom of Dove Springs Canyon, in the Western Mojave Desert, on gravelly alluvium in a Creosote Bush Scrub Zone about 45 km (28 miles) NNE of Mojave or 10 km (6 miles) WNW of the L.A. Aqueduct at 1,370 m (4,050 ft.) elevation. The fruit collected from this site was assumed to be from the 1973 seed crop since it was too early for the 1974 fruit production to be ripe. The dry capsules yielded 45% seeds of 94% purity following belt harvesting and one pass through a fanning mill equipped with a No. 26 top screen and a No. 14 bottom screen. This processing removed the spongy fruit parts and seed that was damaged or aborted by Pronuba moth larvae. The undamaged filled seed count was 87%. The pure seed count was 11,500/kg (5,257/lb). The 85% germination gave a count of 9,200 "viable" seeds/kg (4,200/lb). An initial germination test in August, 1974, performed at 20 C in darkness, gave 85% corrected to 98% on a filled-seed basis (Kay, 1975).

A long-term seed-storage experiment was initiated with this collection. Nine sets of 200 seeds were individually sealed in laminated plastic aluminum foil packets and placed in 3 storage conditions: room temperature, 4 C, and -15 C. A fourth environment consisted of placing the seed in bags and storing in a seed warehouse where it would experience normal fluctuating temperature and moisture of a "typical" warehouse condition. The results of the germination tests to date are presented in Table 1.

It is apparent that Joshua tree seeds have retained their initial viability after 35 months, under all storage conditions. They germinate rapidly, with almost complete germination in the first seven days.

Table 1. Germination of seed of *Yucca brevifolia* var. *herbertii* stored in several environments for various periods.

	Months after storage linitiated				
	0 (Aug., 1974)	6	11	23	35
			---%---		
Warehouse	85	90	84	86	84
Room temp. (sealed)*	--	92	90	92	88
4 C (sealed)*	--	93	92	88	88
-15 C (sealed)*	--	94	88	89	88

* These seed lots had a moisture content of 3.9% when sealed.

Mayer and Poljakoff-Mayber (1963) state that *Y. brevifolia* seeds will germinate only shortly after ripening. That is in disagreement with the results in Table 1.

McCleary and Wagner (1973) found that storage in airtight sealed jars at room temperature resulted in 98% and 72% germination after 6 and 18 months of storage. They also found that germination is maximum at 20 and 25 C, and inhibited at 10 and 15 C. Went (1948) commented that scarification and/or leaching were unnecessary to induce germination. Seed would germinate any time of the year after rain. Soil storage of shed seeds is unlikely because of intense rodent and insect predation. The food-storage tissue in the *Yucca* seed is the perisperm, a derivative of maternal tissue (Arnott, 1961).

Webber (1953) reported that transplantation of seedlings at 3 years and 5 years was quite successful. Mortality was negligible and the plants suffered only dieback of their outer leaves (due to damage of the rhizomes).

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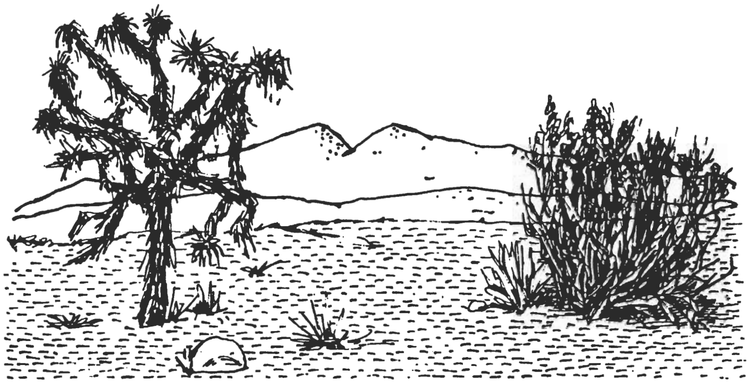


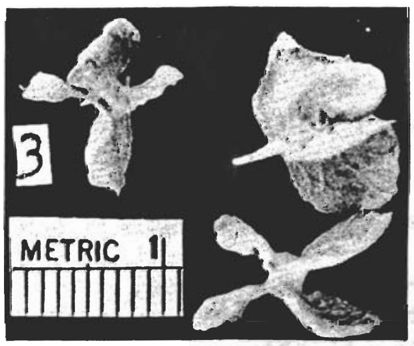
Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 17 Fourwing Saltbush December 1977

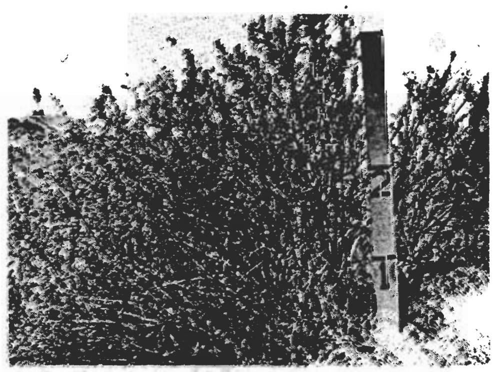
Burgess L. Kay, Charles R. Brown, and Walter L. Graves[1/]

<u>Atriplex</u> <u>canescens</u>
(Pursh.) Nutt.



Family: Chenopodiaceae

Fourwing saltbush, wing-scale, Chamiza, Chamizo, Chamise, Boxbrush, White greasewood, Salt sage, Scalebush, Shadscale, Wafer sage.



Photos: Upper left-utricles; Lower left-fruit-laden stems; Upper right-seedling; Lower right-mature shrub (1 m tall).

[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Dr. Brown is currently Post-doctoral Fellow, International Potato Center, Lima, Peru. Mr. Graves is now Farm Advisor, U.C. Cooperative Extension, San Diego, California.

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Introduction

Fourwing saltbush is an important shrub of many uses. This paper attempts to report briefly the results of our studies with seed from the Western Mojave Desert as well as a review of the extensive literature.

> **Important Points for Fourwing Saltbush Establishment**
>
> 1. Collect quality seed as close as possible to seeding site.
> 2. Seed in the fall or winter.
> 3. Cover seed with no more than one-cm of soil. Removing the wings from the seed will make seeding easier and speed germination.
> 4. Protect the new seeding from grazing by ruminants and rodents.

Description

The following description is derived from Munz (1974) and McMinn (1951).

Habit: Much-branched erect shrub, 4-20 dm. high, with small gray scales; branches round and ascending.

Seedling: Opposite, scaly, linear-lanceolate leaves, whitish green.

Leaves: Alternate, evergreen, numerous, linear, 1-veined from base, elliptical or spatula-shaped, rounded at apex, narrowed at base, covered by dense gray scales on both surfaces, directly attached to stem, 1.5-5 cm long, 2-8 mm wide. Herbarium specimens show plants, some with very small leaves (1-2 cm long) and some with large (5 cm long) leaves. Leaves can be linear.

Flowers: Predominantly dioecious, i.e., male and female flowers borne on separate plants; male flowers in clusters in dense spikes forming long terminal panicles; female flowers in dense leafy spike-like panicles.

Fruits: Fruiting bracts directly attached, forming four projecting fringed wings united in a thick hard body over seed; 6-15 mm long and 4-8 mm wide.

Distribution

Atriplex canescens is the most widely distributed species of the Atriplex genus in North America. It ranges from Eastern Oregon to North Dakota, southward to Mexico and eastward to Texas, occupying areas in California, Nevada, Utah, Arizona, Oklahoma, Kansas, Colorado, Wyoming, Montana, and Idaho (Benson and Darrow, 1954; Hastings et al., 1972). It is common on dry slopes, flats, and washes below 2100 m (7000 ft.) in Alkali Sink, Creosote Bush Scrub, and Pinyon-Juniper Woodland. Occurring in both the Colorado and Mojave deserts, it can be found extending to the coastal strand in San Diego County in California.

Historical Uses

Atriplex canescens and other saltbushes have been the subject of extensive research in the last hundred years. Shinn and Jaffa (1899) reported the results of an eighteen-year study of a number of Australian Atriplex species which were introduced into California because of their adaptation to arid saline environments. The authors extolled the virtue of Atriplex semibaccata and calculated that a five-ton forage crop per acre would extract about two percent of the salts in the upper foot of soil per annum. In a later publication, Shinn (1902) presented testimony of several cattlemen who were so impressed by A. semibaccata that they were actively establishing it on both their good and bad soils. In feeding experiments, Foster et al. (1921) concluded that A. canescens could serve as an emergency feed for cattle although it would ideally be supplemented by a cereal grain. Brown (1933) emphasized its debilitating effects on the digestive system as the sole food source. Goodin and McKell (1971) have estimated non-irrigated cultivated forage yield to attain 9,189 kg/ha. Dayton (1931) ranks fourwing saltbush is among the best of desert browse. Furbush (1962) rates fourwing as good to very good for cattle and good for sheep and deer. Sampson and Jespersen (1963) rated this species as a good to fair browse for sheep, goats, and deer, and fair to poor for cattle and horses. Cook et al. (1959) studied the variation of nutritional components and found, among other things, that total protein decreases with maturation whereas energy value increases. Cordova and Wallace (1975) ranked fourwing saltbush rather high among several shrubs studied, pointing out that digestibility also decreases as stems and leaves mature. NAS (1971) reports crude protein to vary from 14.1 to 19.4 and digestable protein to vary from 67 to 75%. TDN is somewhat low varying from 39 to 42%. Where selenium is unusually abundant in the soil, fourwing has been found to accumulate it at potentially toxic levels (Davis, 1972). Livestock losses have occurred where there is little or nothing else to eat (Blauer et al., 1976).

Aside from being considered only a marginal agricultural crop by some workers (Everson, 1974), A. canescens has received attention as an excellent cover for wildlife (Calif. Dept. Fish and Game, 1968). It is also recommended for use in reclaiming disturbed land areas (e.g., mine spoils) and rehabilitating depauperate, infertile, saline soils and arid zones (Nord, 1977; Aldon and Springfield, 1973; Moghaddam and McKell, 1975).

Physiological Features

Fourwing saltbush is able to survive circumstances of deeply located surface water. Its value as a forage on the range is often due to the presence of succulent shoots and foliage during the late summer and fall, when annuals have gone to seed and many other perennials have shed leaves. Development in the seedling stage is characterized by extensive root penetration. Wallace et al. (1974) found that the roots compose 40 percent of the total biomass of adult plants. The roots and leaves were found to be the main repository of sodium, potassium, and calcium ions. Wallace et al. (1973) concluded that fourwing is somewhat resistant to the absorption of sodium while being tolerant to high concentrations in the soil, in contrast to A. hymenelytra and A. confertifolia, which deposited more sodium in the leaves. Fourwing was found to respond to sodium with increased yields, which is possibly an expression of a sodium requirement. Wallace and Kleinkopf (1974) found a high correlation between shoot water potential and build-up of potassium and sodium in the shoots.

Mycorrhizal associations appear to be important to the optimum growth of *A. canescens*. Williams et al. (1974) found that plants inoculated with the Phycomycete *Endogone mosseae* produced significantly higher dry-weights than uninoculated controls. Williams and Aldon (1976) observed ovoid vesicles within plant roots containing fungal hyphae and chlamydospores. They identified the fungal genus as *Glomus*. Aldon (1975) found that inoculation of seedlings with *Glomus mosseae* improved transplanting success and that growth of plants was significantly better in soil infested with *G. mosseae* than in an uninoculated control soil.

Variation

Over its entire range *A. canescens* displays a variety of plant habits. McMinn (1951) lists four varieties distinguished by leaf dimensions and wing margin dentation. Munz (1974) limited recognition of infraspecific divisions to two subspecies. Stutz (1974), however, attributed four subspecies with completely different names to *A. canescens*. Blauer et al. (1976) suggested that many subspecies have been proposed unjustifiably and may be better thought of as ecotypes. Stavast et al. (1974) studied populations that are probably hybrid swarms between *A. canescens* and *A. cuneata*. They suggested that the variability contained therein might be utilized for selection of particularly favorable combinations of agronomic traits. Van Epps (1975) noted that winter hardiness of accessions varies with its point of origin. He suggested that seed for reseeding should be obtained from the immediate vicinity or from a location that is colder than the anticipated planting site. A planting study performed by J.A. Young* (personal comm., 1977) supports this contention. Plantings derived from seed collected from 900 m (3000 ft), 1200 m (4000 ft.), and 1800 m (6000 ft) were subjected to freezing conditions near Reno, Nevada. No plants survived from the collection at 900 m, 6% survived from 1200 m collection, and all plants survived from the 1800 m collection.

An isolated population of *A. canescens* consisting of unusually large fast-growing individuals was recently discovered in Utah. The chromosome number of these plants, 2n = 18, is half that of normal *canescens* (Livingston and Stutz, 1974). Further study has led to the conclusion that "gigas" *canescens* is diploid and that normal *canescens* is an autotetraploid. "Gigas" *canescens* differs from the widespread autotetraploid in exhibiting more rapid twig elongation, greater shoot tenderness, and higher seed germination and production. Found in a sand-dune habitat, its extraordinarily long branches are thought to be an adaptation to shifting topography (Stutz and Livingston, 1973; Stutz et al., 1975).

Seed Production

The possibility of growing fourwing saltbush for seed production has been investigated by several workers. Stroh and Thornburg (1969) recommended cutting plants down to a 5 cm stubble. That would leave prostrate shoots which send up vertical seed-bearing lateral branches. The main problem is the retention of moisture by stems and leaves, making it difficult to separate utricles from trash. A potential yield of 4,032 kg/ha was obtained in hand-harvested material. Springfield (1967) has noted that particular sites of fourwing have a higher utricle fill than others. He

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* Range Scientist, ARS/USDA, Univ. Nevada, Renewble Resources Ctr., Reno, NV, 89502.

suggested that seed-fill be a primary criterion in selecting materials for seed production. Fourwing is predominantly dioecious. MacArthur (1977) has reported a presence of 10% monoecious individuals in Utah. This may differ from region to region as it has not been noted in A. canescens in the Mojave Desert. In the absence of determination of sex before planting it would be necessary to overplant and then thin to the desired proportion of pistillate and staminate plants. Vegetative propagation using stock of predetermined sex could eliminate this, but its practicality remains to be determined. Hedge-pruning of 4-year-old plants delays seed production for one-year. Thus, combine-harvest would entail one seed crop every two years (Van Epps, 1974). Other factors to be considered in seed production include proper spacing of plants in order to avoid moisture stress, selection of cold-tolerant ecotypes, and selection of climate of production area so that snow would not impede harvest operations.

Seed Collection

Until large quantities of seed are available through seed production projects, it will be necessary to collect seed from wild stands. It flowers from June to August, with fruit ripening from November to January. In general, the utricles of this species tend to stay on the bush for several weeks to several months after maturity and drying, thus allowing some flexibility in harvest timing. We found that hand-stripping the utricles into hoppers is an easy and efficient operation. Plummer et al. (1966) were able to collect twice as much seed by hand as with a vacuum harvester. We made two Mojave collections at different elevations on December 15, 1973. The collection, made at 900 m (3000 ft) elevation, was dried for 3 days at 38 C. One cleaning pass was made through a fanning mill equipped with a No. 2 top screen and a No. 8 bottom screen, yielding 12.5 kg of dry utricles with a purity of 90%, and thus a net utricle yield of 78%. Pure utricle count was 37,000/kg (16,850/ lb) with a fill of 57%. The 3% germination thus gave a yield of 1,590 "viable" utricles/kg (723/lb). The second collection was made on the same day at 1200 m (4,000 ft) elevation. This collection was dry at harvest and required no cleaning. The pure utricle count was 44,000/ kg (20,000 lb) with a fill of 65%. The 23% germination gave 10,000 "viable" utricles/kg (4,560/lb) (Kay, 1975). Plummer et al. (1968) found seeds of Great Basin ecotypes to vary from 55,000 to 330,000/kg (25,000 to 150,000/lb). Springfield (1970a) suggests fill percentages of less than 40% should be considered substandard.

Germination Requirements

Optimum conditions for germination have received considerable attention from a number of workers. A general agreement exists that the depth of planting should not exceed one centimeter (one-half inch) (Springfield and Bell, 1967; Nord et al., 1971; Williams et al., 1974). Seeds germinate best at temperatures ranging from 13 to 24 C (Springfield, 1969, 1970b). Kay (1975) found that germination of seed collected near Mojave occurred equally well from 2-40 C (Table 1).

Table 1. Effect of constant temperatures on the germination of *Atriplex canescens*.*

Temperature C	2	5	10	15	20	25	30	40
Germination %	19	15	17	20	13	8	14	16

* Courtesy of Dr. James A. Young. ARS-USDA, Reno, Nevada

)70a) reported that the removal of the wings (bracts) .cle) is a common practice to achieve ease of handling :ills are employed), reduction of bulk, and easier depths with soil. Although Springfield found no . final germination between winged and de-winged fruits :ds) de-winged seeds germinated more quickly until the

Establishment

; have shown that transplantation of seedlings is the ing stands if the seedlings are at the proper height lemati, 1977; Cable, 1972). Soil moisture at trans- :ant. One study obtained 80 percent survival when soil .d not exceed -2 atmospheres (Aldon, 1972). Reproduc- 'outing from the roots has been observed in New Mexico, :hat under certain conditions where seedling establish- 'ecarious, sprouting may be a highly effective means of Woodmansee and Potter, 1970). Wiesner and Johnson :d a method of rooting cuttings which is 93 percent :riments with fourwing saltbush in the western Mojave .ted in better establishment than transplantation.

of establishing fourwing saltbush, according to Graves 'ect seeding in early winter without irrigation, but .nst browsing during the initial two to three years 'lummer et al. (1966) reported good stands from spot ι rate of 5.6 kg/ha. Springfield (1970a) recommends ; to 9.0 kg/ha for de-winged seed or 9 to 17 kg/ha for ;field (1963) found that seedbed preparation is necessary ls in western New Mexico.

:ans and times of planting have been attempted with :o Plummer et al. (1966). The particular time chosen 'egion. Seed broadcast onto snow and subsequently :lt gave good early stands in Utah. Aerial seedings of with grasses and legumes has resulted in good stands n woodland in the Colorado River Basin.

.n dense cheatgrass has been accomplished by use of a :r (Giunta et al., 1975). The palatability of fourwing since the primary cause of stand failure during the often foraging (by birds, rodents, and rabbits) on seeds of plants. Wilson (1928) observed extreme nts due to the eating of crown areas of the stem and by rabbits. Furbush (1962) indicates that fourwing m overuse and is easily broken down by livestock. .shment area also would prove formidable opponents of :r heavy predation, establishment would be impossible :encing. Plummer et al. (1966) suggested a poisoning nice and other rodents from completely consuming very

)f A. canescens is adversely affected by a high day-time found to reach 53 C at the soil level on barren ground :ss extreme temperature (39 C) created by partial

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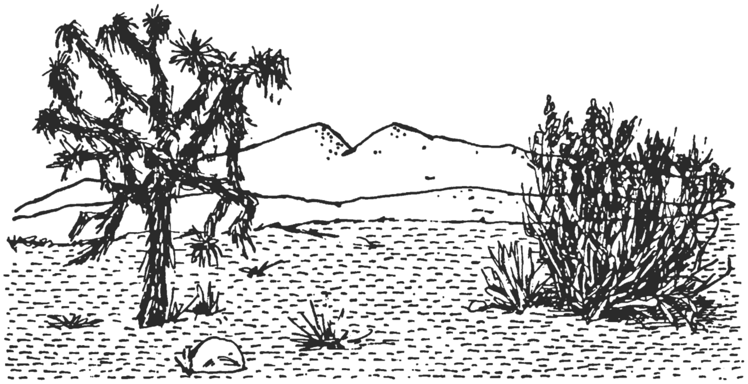


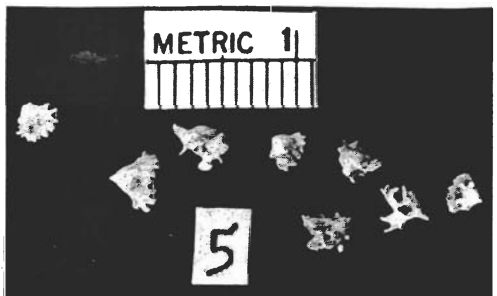
Mojave Revegetation Notes

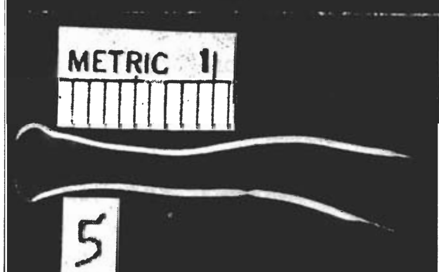
UC DAVIS AGRONOMY & RANGE SCIENCE

No. 18 November, 1977

Desert Saltbush

Burgess L. Kay, Charles R. Brown, and Walter L. Graves[1/]



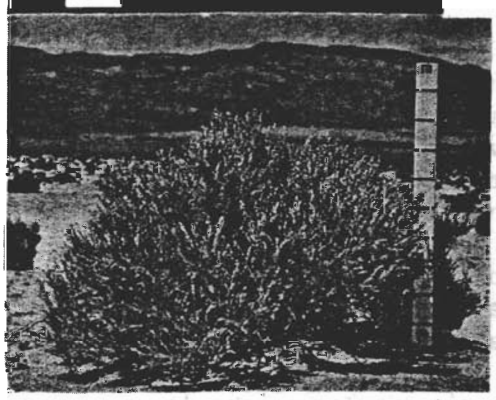


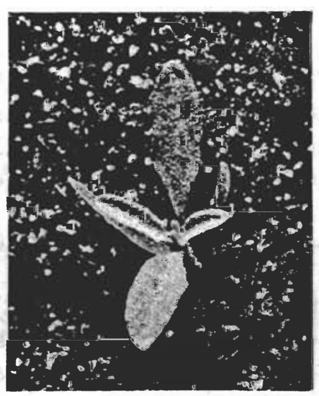
Atriplex polycarpa (Torr.) Wats. [Obione p. Torr.]

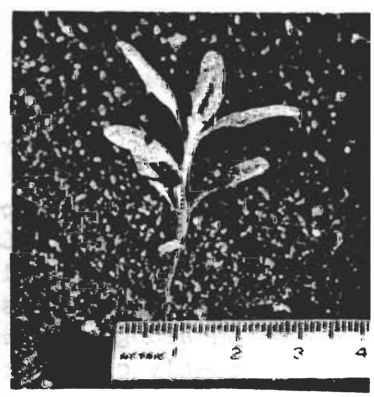
Family: Chenopodiaceae

Desert saltbush, Cattle spinach, Allscale.

Photos: Left top to bottom, utricles, cotyledons and hypocotyl, mature shrub (8 dm); right seedlings (1 cm and 4 cm)







[1/] Wildlands Seeding Specialist, Research Associate, and Graduate Student. Dr. Brown is currently Post-doctoral Fellow, International Potato Center, Lima, Peru. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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The following description is extracted from McMinn (1951), Munz (1974), Sampson and Jespersen (1963), and Foiles (1974).

Habit: Low, rounded, erect, intricately branched shrub 1-2 m tall, with gray or yellowish-brown branches, the bark shed in long strips.

Leaves: Alternate, crowded on young twigs, oblong to spatula-shaped, 3-20 mm long, coated with small scales on both sides of leaf. One-veined from the base.

Flowers: Male and female flowers are borne on separate plants; the male in leaf axiles or on terminal spike; the female crowded along the numerous divergent branches in diffuse flower clusters. Flowers tan to greenish in color.

Fruit: Fruiting bracts, 2-4 mm long, shallowly to deeply lobed, deeply or shallowly toothed, the face warty or (rarely) smooth.

Seed: Pale brown, 1-1.5 mm. long.

Found on alkaline plains and occasionally rocky or gravelly slopes in desert or grassland, Atriplex polycarpa is limited to between 120 m (400 ft) to 900 m (3000 ft) elevation in alkali sinks in communities with creosote bush scrub, shadscale scrub, and sagebrush scrub. It is found in scattered localities in the San Joaquin Valley and Mojave and Colorado Deserts in California, southern Nevada, southwestern Utah and Arizona, Baja California, and northwestern California (Munz, 1974; Benson and Darrow, 1954). It is less extensive than A. canescens in geographic distribution (Hastings et al., 1972), and less cold tolerant and more drought-hardy (Nord, 1977). It is reported to flower from May to August, with fruit ripening from October to December and seed dispersal occurring from November to May (Foiles, 1974).

A. polycarpa has long been noted for its excellent forage qualities (Bidwell and Wooton, 1925). It is rated "good for deer; good to fair for cattle, sheep and goats; and fair for horses" (Sampson and Jespersen, 1963). It is known to grow well on rangelands with soil pH varying from 6 to 8 (Nord, 1977). It is often found in association with highly unpalatable species and may be the only shrub in areas that are too arid or saline for other species to grow (Chatterton et al., 1971b). Its greatest forage value is in the fall, when grassland species make a minimal nutritional countribution to the range. Its nutritional value in crude protein, total digestible nutrients, and fats is comparable to that of alfalfa, and late in the year it is a good source of calcium, phosphorus, and carotenoids (Chatterton, 1970). Goodin and McKell (1970) have estimated maximum forage yields under cultivation to be 12,822 kg/ha and suggest that cultivation as a forage crop has considerable potential in marginal lands subject to prolonged drought on excessive salinity. Phosphorus content in the soil is significantly correlated with yield of aerial plant parts (Lailhacar-Kind, 1976). Although extremely tolerant of salt in the environment, its germination has been found to be reduced with higher salt concentrations (Chatterton and McKell, 1969). Large quantities of salt are accumulated in the shoots. Salinity tolerance may be due to an accumulation of salt in the trichomes on the leaf surface from adjacent mesophyll cells, reducing salinity stress of photosynthetically active tissue (Chatterton, 1970). Adult plants have been tested and found to withstand shoot water-potential deficits of -69 bars (Sankary and Barbour, 1972). It does not accumulate nitrate even in high-nitrate environments (Chatterton et al., 1971a). A. polycarpa flourishes on soils unsuitable for most other species, and is usually absent from less saline soils due to competition from more aggressive species (Lailhacar-Kind, 1976).

Desert saltbush has been proposed as the best species to establish in pure stands as a quail habitat (Glading et al., 1945). A congener, A. lentiformis, is in fact called "quailbush". MacMillan (1960) found that a planting rate of 45 kg/ha was adequate to establish a thick stand of saltbush. It establishes easily if adequate moisture is present in the soil, and further care involves only protection from sheep and cattle. A satisfactory management system would allow only limited use during the summer and fall months. The species has been virtually eradicated by overgrazing in many of its original localities (Sampson and Jespersen, 1963). Graves et al. (1976) found transplants to be more successful than spot seeding under western Mojave Desert conditions.

A saponin content of 1.2% of dry weight has been found in the foliage of Atriplex polycarpa. Extracts from increasing quantities of foliage have been found to be increasingly inhibitory to germination of its own seed and that of several other species but will enhance germination of seed of California ephedra (Askham and Cornelius 1971). It is unlikely that the bracteoles of the utriculate fruiting body contain saponin (Sankary and Barbour 1972). Even so, the leaching of seeds has been found to increase germination (Cornelius and Hylton, 1969).

Temperature requirements for germination are not likely to be limiting because it germinates over a wide range of temperatures from 2 to 25 C (Table 1). Others suggest the optimum temperature range is 9-15 C (Sankary and Barbour (1962), Cornelius and Hylton (1969)).

Table 1. Effect of constant temperatures on the germination of Atriplex polycarpa collected near Mojave (see seed storage exp.).*

Temperature C	2	5	10	15	20	25	30	40
Germination %	23	27	24	20	22	14	5	0

*Courtesy of Dr. James A. Young, ARS-USDA, Reno, Nevada.

Graves and co-workers (1975) investigated the effects of a number of seed treatments on the germination of A. polycarpa. The results of some of the treatments are graphed in Figure 1.

Activated carbon was the best treatment for speeding initiation of germination. It also resulted in a significantly higher 7-day and 14-day germination. Stratification in moist sand at 2 C for thirty days, heating at 60 C for four hours, and exposure to 100 ppm ethylene for twenty-four hours increased 7-day germination but were not significantly different from the control at 14 days. In addition, scarification, soaking in 6% sodium hypochlorite solution for 24 hours, and soaking in 6% hydrogen peroxide solution for 10 minutes significantly decreased germination at 14 days.

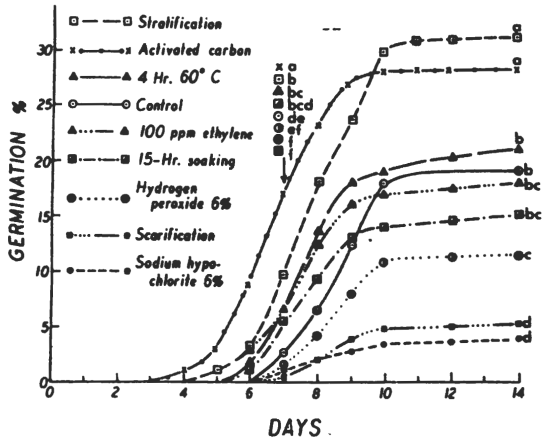

Figure 1. Germination of A. polycarpa after seed treatments.

Nord et al. (1971) reported best emergence in late spring from a planting depth of 1.25 cm versus 2.5 cm. Williams et al. (1974) obtained no germination of A. polycarpa in washed plaster sand at either 1 or 2 cm. We obtained 13% germination in the same type of medium from a 1-cm depth, using a different seed source, described below. The daily progression of this emergence is shown in Figure 2 (Kay, 1975). Covering the seed with as little soil as possible (2-3 mm) would probably improve emergence.

Figure 2. Emergence of Atriplex polycarpa in washed plaster sand from depths of 1 and 2 cm.

Chatterton and McKell (1969b) reported higher seed quality and germination from a November 2 collection than from one made on December 3 in 1966. They suggested percentage of seed fill was highest and germination most rapid in seed which matured early. Seeds left to ripen on the plants often germinate while still on the plant.

Utricle size has been found to be significantly related to germination (Fig. 3). Both size categories greater than 1.7 mm (1/15 inch) gave significantly better 14-day germination than unsorted control utricles. The two size categories of less than 1.7 mm gave lower germination than the control. Sizes less than 1.7 mm. represent 33% of this seed lot, but only 15% of the germinating potential (Kay 1974). Separating utricles on the basis of size before seeding may improve seeding success.

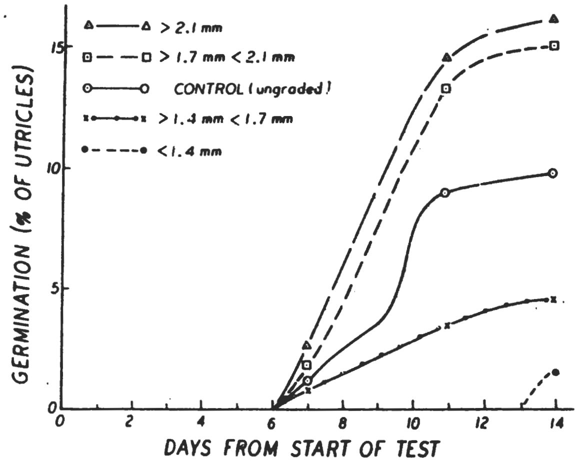

Figure 3. Average germination rate of A. polycarpa utricles from four size gradations.

We collected a 3.9 kg utricle sample of A. polycarpa in December 1973. They were dried at 38 C for three days, after which they were cleaned in a fanning mill equipped with a No. 11 top screen and a No. 6 x 34 bottom screen. A utricle yield of 3.4 kg with 38% purity gave a clean utricle yield of 32%. The pure utricle count was 1,210,000/kg (550,000/lb) with a fill of 60%. The 23% germination gave a count of 106,000 "viable" utricles kg (48,000/lb) (Kay 1975).

A long-term seed-storage study was initiated in December of 1973. The seed collection was treated with Phostox to protect against insect damage and dried for 6 days at 35 C. Seedlots were placed in 60 hermetically sealed one-gallon glass jars containing 90 grams of silica gel. Twenty jars have been stored at room temperature, twenty at 4 C, and twenty at -15 C. Storage in bags in a seed warehouse comprised the fourth treatment. One jar from each treatment will be opened each year to test for germination. The results to date are presented in Table 2.

Table 2. Germination of seeds of A. polycarpa, stored under several conditions, at several times since initiation of the study.

	Months after initiation of storage				
	0	13	18	33	45
Storage conditions			----%----		
Warehouse	23	23	30	23	19
Room temp. (sealed)*		26	28	26	23
4 C (sealed)*		30	27	25	27
-15 C (sealed)*		26	21	24	22

* Stored with a moisture content of 4.4%.

It is apparent from these results that the four storage conditions have been equivalent in their preservation of germinability through 33 months of storage. At 45 months, however, warehouse storage has resulted in a germination that is significantly lower than from the 4 C, sealed treatment. Another seed lot (Williams et al. 1974) was stored at 10 C in unsealed containers for 75 months. Germination declined to zero from the 13% when stored (68% filled, 38% live embryos indicated by tetrazolium test).

Utilizing seed from a different site, Nord (1975, personal comm.) reported 69% germination of seed stored at freezing temperatures in both sealed and unsealed containers. Refrigerated storage in unsealed storage resulted in complete loss of viability, where 51% germination was retained in sealed containers. These tests were performed nine months after initiation of storage.

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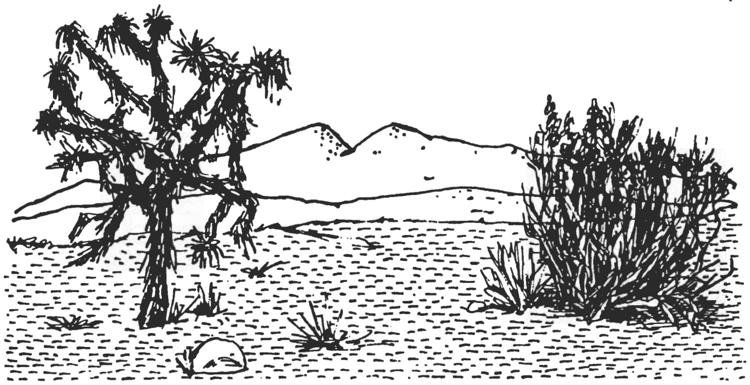


Mojave Revegetation Notes

U C DAVIS AGRONOMY & RANGE SCIENCE

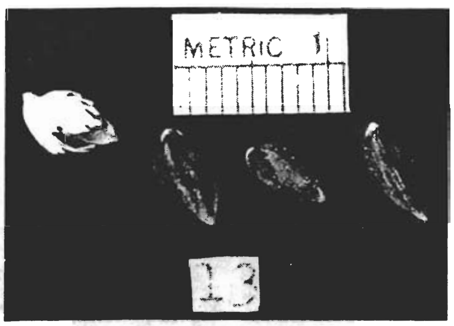
No. 19 GRAY EPHEDRA AND GREEN EPHEDRA August, 1977

Burgess L. Kay, Catherine M. Ross, Walter L. Graves, and Charles R. Brown[1/]

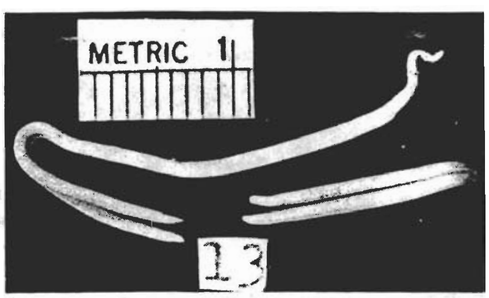
Ephedra nevadensis
Gray ephedra, Nevada ephedra
Joint fir

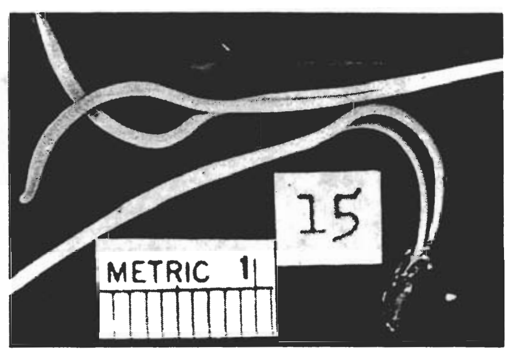
Family: Ephedraceae

Ephedra viridis
Green ephedra, Mormon tea



Seeds





Newly germinated seedlings

[1/] Wildlands Seeding Specialist, Research Associate, Graduate Student, and Research Associate. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California. Dr. Brown is currently Post-doctoral Fellow, International Potato Center, Lima, Peru.

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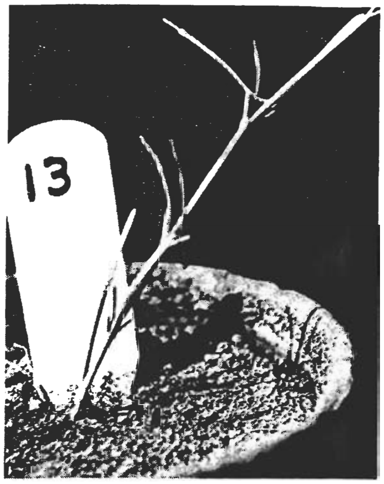
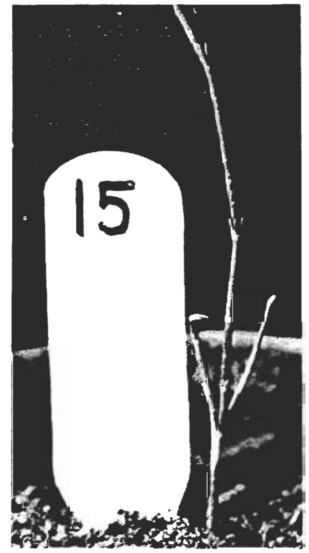
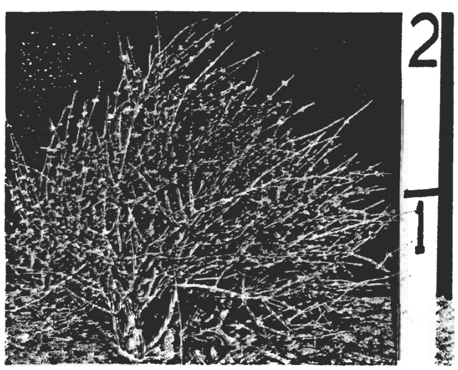
Ephedra nevadensis



Ephedra viridis



Seedling



Mature Shrubs

The following description, adapted from Munz (1974) and Sampson and Jespersen (1963), applies to both species.

Habit: Erect, twiggy, 5-15 dm. high; numerous jointed, grooved branches, brittle, smooth, not spiny.

Seedling: Single jointed stems with pairs of scale-like leaves opposite at each joint.

Flowers: Male and female flowers on separate plants (dioecious); male cones nearly spherical, 3-4 mm in diameter, solitary or several in a cluster; female cones roundish, 5-11 mm in diameter, on short stalk.

Leaves: scale-like, in pairs, opposite 1.5 to 6 mm long.

Fruit: female cones rounded; seeds usually in pairs, with flat faces.

Distinguishing features: Leaf-bases of E. viridis are brown; seeds finely grooved longitudinally (requires magnification), branchlets green, 1-1.5 mm in diam., numerous, tending to be erect and parallel. Leaf bases of E. nevadensis are gray; seeds smooth; branchlets gray-green, covered with white powder, 2 mm in diameter and divergent. Seedlings can be distinguished easily by the bright-green epigeal (cotyledons aboveground) form of E. viridis and the blue-green hypogeal (cotyledons below-ground) growth of E. nevadensis.

These two species of Ephedra are common in the Upper Sonoran Life Zone in upper elevations of the Larrea belt, Joshua Tree Woodland, and Pinyon Juniper community. E. viridis is usually found at higher elevations ranging from 900-2100 m (3000-7000 ft.), while E. nevadensis is found mostly below 1400 m (4600 ft) (McMinn, 1951). Both species are found on the Mojave and Colorado Deserts, extending north to the Owens Valley and eastward into Utah and Arizona. E. viridis is found from Lassen and Inyo counties in California, to western Colorado.

Gray ephedra is valued as browse for domestic stock and deer on the winter range, and utilization of stems by cattle in some areas is as much as 50%. Green ephedra, less palatable, is browsed only lightly on summer and fall range where more succulent and palatable forage is abundant (Sampson and Jespersen, 1963). Leach et al. (1957) found that green ephedra constituted 9% of the plant cover of a southern Inyo County male deer winter range, and was browsed heavily in January and February. Younger brush-like stems were preferred, with about 4% utilization. High contents of calcium, magnesium, and phosphorus have been measured in fresh mature aerial parts of gray ephedra (National Academy of Sciences, 1971).

Clark et al. (1927) investigated the physiological activity of gray ephedra whose ephedrine-like action was later shown to be due to the presence of simple colloids rather than ephedrine-related substances (Read et al., 1927). The drug ephedrine is obtained from a Chinese herbaceous species named E. sinica (Sampson and Jespersen, 1963). The dried stems of green ephedra are available in health-food stores under names such as "squaw-tea" or "Mormon tea". Native Americans made meal, flour, and a type of coffee from the large, nutlike seeds (Bay, 1976).

Many aspects of the biology of Ephedra remain unexplored, but two studies have reported on different facets of its natural history. In an attempt to measure the biomass of roots using aboveground plant parts, Wallace and co-workers (1974) sampled eleven plants of gray ephedra in the Rock Valley Area of the Nevada Test Site of the Mojave Desert and obtained mean stem and root weights of 102 and 73 grams. In a study of sex proportions in green ephedra, Freeman et al. (1976) found that male plants predominated on steep slopes while females outnumbered males four to one on bottomlands. They concluded that male and female plants have different survival rates in different habitats, serving as a means of reducing intraspecific competition by reducing habitat sharing by members of the opposite sex.

Seed of green ephedra was obtained from J. A. Young, Reno, Nevada, from collections made in the summer of 1973 in the Dog Skin Mountain Range of Washoe County, Nevada. We obtained a seed sample of gray ephedra composed of a mixture two small harvests made on June 23, 1973. One collection was made north of State Hwy. 178, 7 km (4.5 mi) west of the Freeman Junction of State Hwy. 14 and Hwy. 178, 69 km (43 mi) north of Mojave, at 1200 m (4,000 ft). The second collection site was off State Hwy. 14 to the west on Dove Springs Road leading to the L.A. Aqueduct Station about 56 km (35 miles) NNE of Mojave at 975 m (3,200 ft). Insect damage to the seed was a problem with gray ephedra. Collected seed was cleaned with ease to a high purity with a fanning mill equipped with a No. 12 top screen and a No. 1/12 bottom screen (Kay, 1975a). Table 1 gives pure seed counts, percent purity, percent fill, and date of maturity for the two species.

Table 1. Seed characteristics of Ephedra viridis and E. nevadensis.

Species	Pure Seed Numbers kg	lb	% purity	% fill	Maturity date
E. viridis	55,400	25,200	97	94	May-July
E. nevadensis	41,300	18,763	99	99	May-July

Young et al. (1977) reported that green ephedra seeds germinated best under alternating temperatures of cold night (2 - 5 C, 16 hours) and moderate day (15 - 30 C, 2 hours). Constant high temperatures of 20 and 25 C reduced germination. Figure 1 shows that green ephedra germinates successfully over a range of 10 to 20 C, with highest germination at 15 C.

In contrast, germination of gray ephedra seed was optimum when the temperature alternated between 20 C (16 hours) and 25 C (2 hours). As seen in Figure 1, gray ephedra germinates well in the range of 10 and 20 C, but is highest at 20 C.

It is worth noting from these graphs that gray ephedra has a more rapid initial germination than green ephedra. In addition, exposure to constant high temperature (20 C) harms germination of gray ephedra less than that of green ephedra (Young et al., 1977).

Depth-of-planting studies with our collection of gray ephedra resulted in the emergence of 30% (42% on a viable-seed basis, with insect damaged seed removed) from a depth of 1 cm over a 10-day period with temperature

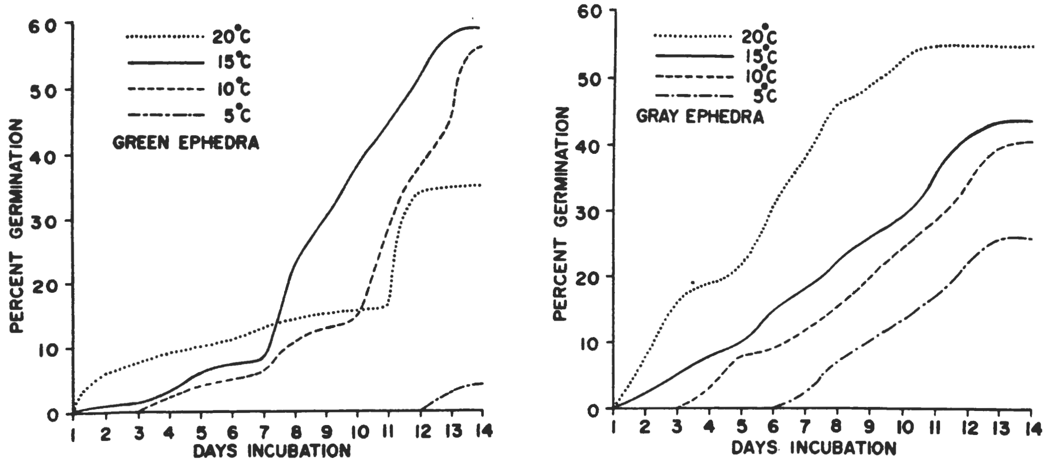


Figure 1. Rate of germination for 2 weeks of gray and green ephedra seeds at constant temperatures from 5 through 20 C. Seeds tested three months after harvest.

averaging about 10 C. Total emergence was similar at 2 cm, though slightly delayed. Roughly 13% (18% viable seed) emergence, delayed further, was recorded for 4 cm (Kay, 1975). The above data are summarized in Figure 2. Tests made on a different seed source resulted in 95% and 62% emergence from 1 cm and 2 cm, respectively (Williams et al., 1974*).

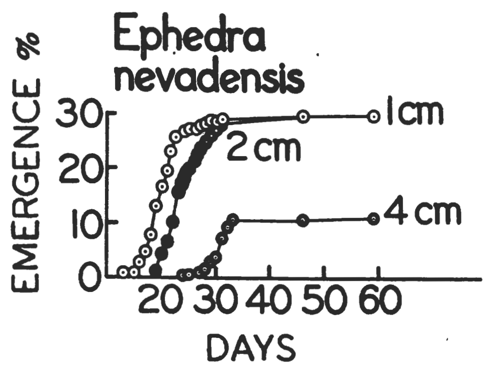


Figure 2. Effect of depth of planting on seedling emergence of *E. nevadensis* (Gray ephedra).

Several seed treatments were carried out to see whether the germination rate could be improved. Exposure of gray ephedra seeds to a 4-hour pre-imbibition treatment of flowing air of 80 C depressed germination significantly seven days after planting, although no difference remained at fourteen days (see figure 3). Stratification in moist sand and moist activated carbon at 2 C resulted in 76% and 71% radicle emergence, respectively, after 30 days of treatment (Graves et al., 1975).

*The seed in this study, initially identified by the commercial collector as *E. viridis*, has subsequently been determined to be *E. nevadensis*.

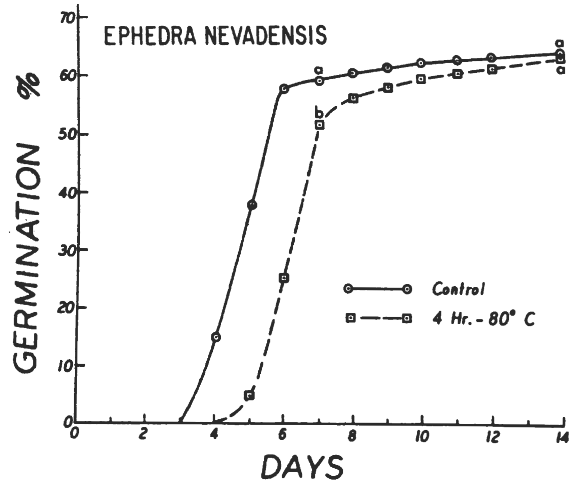


Figure 3. Effect of preimbibtion heat treatment on germination of E. nevadensis.

A seedlot of both species was placed in storage under seed warehouse conditions and sealed at room temperature, 4 C, and -15 C. Table 2 shows germination percentages resulting from these storage conditions. Although the germination was initially lower in green ephedra than in gray ephedra, subsequent tests have shown that the reverse is true. Germinability is much higher in green ephedra than in gray ephedra except when green ephedra is stored sealed at room temperature. The germinability of gray ephedra showed a marked decline at the 13 month test and has maintained this lower level consistently up to the most recent test. These tests suggest that seed of green ephedra may increase its germination due to an after-ripening effect. Although storage at -15 C maintains the best germinabilty, both warehouse condiditions and sealed storage at 4 C result in a good retention of germinability for green ephedra. Gray ephedra germination is complete in 14 days, while green ephedra germinates throughout the 30 day test (15 C).

Table 2. Germination of grey ephedra and green ephedra under four storage conditions.

Species and Storage Conditions	Germination percentage Months after collection 6	13	17	29	42
Gray ephedra			---%---		
Warehouse	68	25	28	34	28
Room temp*		32	30	24	23
4 C*		26	32	29	32
-15 C*		36	32	29	29
Green ephedra			---%---		
Warehouse	38	65	66	62	72
Room temp*		42	84	48	13
4 C*		35	84	74	69
-15 C*		35	82	71	81

* Seeds were dried to 4.6% moisture and sealed in glass containers.

The results of germination tests after storage reported by Young et al. (1977) are essentially in agreement with this difference, with green ephedra showing less reduction of germination than gray ephedra after storage in paper bags at room temperature. Gray ephedra was reported by those workers to tolerate greater osmotic potentials (higher salinity) in the germination medium than green ephedra. That suggests that gray ephedra may be better adapted to more saline habitats than green ephedra (Young et al., 1977).

Bay (1976) has recommended green ephedra for landscaping roadsides, mine dumps, and recreation sites because of its drought-tolerance and attractive bright-green color. He states that it can survive range fires and spreads by roots.

Plummer et al. (1968) recommended both gray and green ephedras for reseeding in the big-game rane in Utah since both have been consistent in establishment and persistence from direct seeding.

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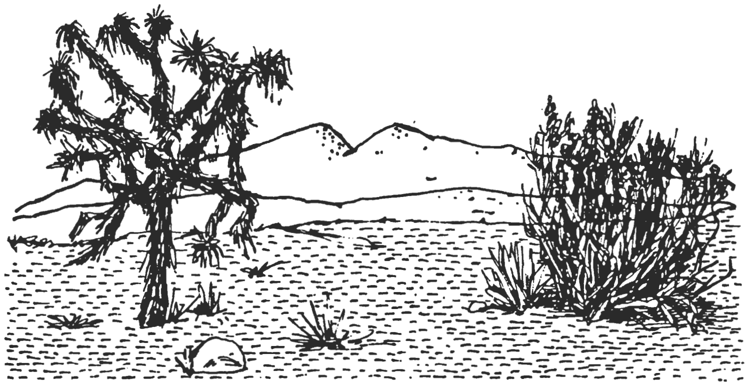
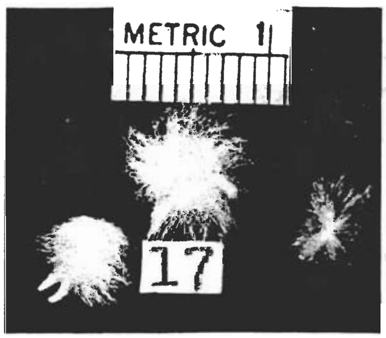


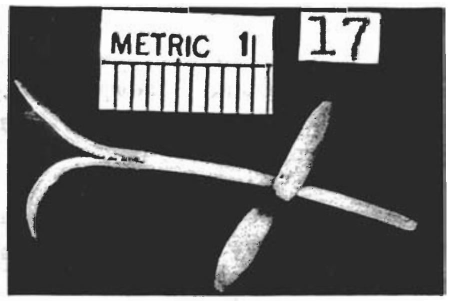
Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

No. 20 Winterfat November 1977

Burgess L. Kay, Charles R. Brown, and Walter L. Graves[1/]





Ceratoides lanata (Pursh.) J. T. Howell, formerly Eurotia lanata (Pursh.) Moq. (Howell, 1971).

Winterfat, White sage, Winter sage, Feather sage.

Family: Chenopodiaceae

Photos: Upper left - utricles; Upper right - cotyledons and hypocotyl; Lower left - seedling; Lower middle - fruit-laden branches; Lower right - shrub (4.5 dm tall).

[1/]Wildlands Seeding Specialist, Research Associate, and Graduate Student. Dr. Brown is currently Post-doctoral Fellow, International Potato Center, Lima, Peru. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

This paper reports work supported by the Bureau of Land Management Contract No. 53500-CG4-2(N). Document Obligation No. 6809.

The following description is taken from Sampson and Jespersen (1963), Munz (1974), McMinn (1951), and Blauer et al. (1976).

Seedling: Alternate linear leaves attached directly to stem (sessile), sometimes in bunches (fascicled); covered with dense coating of branched and unbranched hairs; green to whitish green in color.

Habit: Erect or spreading shrub 3-8 dm. high, slender branches, spiny with age; whitish when young, rusty-colored with age; branches look cottony when in fruit.

Leaves: Linear to lanceolate; typically in bunches 1.5-5 cm. long, 2-8 mm. wide; margins entire and rolled backward upon the lower side.

Flowers: Unisexual but may be either monoecious or dioecious; flowers form in dense paniculate clusters along the upper portion of the branches. Female (pistillate) flowers are below the male (staminate) flowers on monoecious plants. Male flowers lack bracts and petals, four stamens borne opposite sepals, female flowers lack sepals and petals. Pistils are enclosed by a pair of bracts that are united for more than half their length.

Fruit: A utricle surrounded by 2 persistent bracts 5 mm long, covered by silvery white hairs and beaked above by 2 short horns.

Seed: Pear-shaped nutlet 3 mm long.

Winterfat usually occurs in subalkaline areas on mesas and flats above 6000 m (2000 ft.) elevation in eastern Lassen County, Inyo County, the Mojave Desert region of Kern, Los Angeles, and San Bernardino Counties, and in the eastern foothills of the Inner Coast Range in Kern County. It extends northward to eastern Oregon, Washington, Idaho, and Canada; eastward through the Great Basin and the Rocky Mountain States to New Mexico, western Texas, and Nebraska; and southward to Mexico (McMinn 1951).

In the Great Basin Zone it generally flowers from March to June, and seeds mature from September to October. Flowering is earlier in the Mojave Desert Region with seed maturing as early as June. The seed is dispersed by wind (Springfield, 1974a). Seed germinates in the late winter and early spring. Seedling survival is usually limited to habitats that are sheltered by older plants and litter (Woodmansee and Potter, 1971). It is highly drought-resistant, producing abundant seed even in dry years.

Winterfat is moderately tolerant to conditions of high salt ion content in the soil. It is not found in soils that contain more than 0.05% salt in the upper two feet (Fautin, 1946). As a rule, winterfat stands mark land that is suited for crop poduction (Shantz, 1938). It is often found in areas of extreme summer drought. Redmann (1976) found shoot osmotic pressures as low as -43 bars at the end of the summer season. Winterfat roots occupy the upper foot of soil intensely and take advantage of abundant soil moisture in the spring while maintaining a semi-dormant state during drought periods (Shantz and Piemeisel, 1940). It is possible that investigation of mycorrhizal associations will prove useful in establishment trials. Williams and Aldon (1976) have observed the fungal genus Gigospora in soil surrounding roots of winterfat.

Eaten by domestic livestock and by deer, winterfat, as the name implies, is regarded as a highly superior winter forage. It recovers from moderate browsing with rapid spring and summer growth. Its prolific digestible seed crop is eaten eagerly by livestock (Hilton, 1941) (Dayton 1931). Goats show a preference for winterfat over associated species (Sampson and Jespersen, 1963). Studies in Utah have shown that it is relatively high in nutrients except cellulose and ether extract. Likewise, the digestion coefficients for all constituents except cellulose and ether extract were relatively high. Its energy-yielding values are low, being about 1320 kcal/kg of feed intake, whereas 1460 kcal/kg is considered necessary. Winterfat is a good source of digestible protein and vitamin A but is slightly deficient in phosphorus (Cook et al., 1954). Over a period of five years, sheep were found to utilize 40% of a stand of winterfat composing 12% of the botanical composition in northwestern Utah. This resulted in a diet consisting of 16% winterfat from November 1 to April 1. Cattle were found to utilize 60% of winterfat where it made up 8% of the botanical composition, with the result that it composed 15% of their diet during the period from October 1 to March 15 (Cook and Harris, 1968). NAS (1971) reports crude protein and digestable protein of fresh aerial parts to vary respectively from 21% and 14.9% at the immature stage to 11% and 6.8% at the mature stage. TDN remained fairly consistent at 52 to 55%. Native Americans have been reported to use a decoction of the leaves to stimulate hair growth (Bay, 1976) and treat fever, and a powder made from the roots to treat burns (Kearney and Peebles, 1960).

Furbush (1962) indicates that winterfat will not withstand overgrazing, so good mmanagement practices are required to maintain the plant on heavily stocked ranges. The overall rating of winterfat is good to excellent for cattle, sheep and deer. Trlica and Cook (1971) rated winterfat as having a poor capacity for regrowth after defoliation. The effects of defoliation are more pronounced with shorter times between normal quiescence and defoliation. The winterfat plant is best able to recover and build up carbohydrate reserves if defoliation occurs during early growth or during quiscence in the previous year. The intolerance of winterfat to heavy grazing is well-known, and Fautin (1946) and Dayton (1931) surmise that it was more abundant before the advent of the white man on the North American continent. Areas where it has been reduced by grazing in western Utah have been invaded by little rabbitbrush (Chrysothamnus stenophyllus). Eckert (1954) found that halogeton invaded areas where winterfat abundance was reduced in Nevada. He blamed its decline on overgrazing by livestock, rabbits, and buprestid beetles. Strickler (1956) found a significant relationship between the number of big headed grub (Aemaeodera sp.) tunnels and the mortality of winterfat. Currie (1966) also found that rabbits, where abundant, account for considerable consumption of winterfat. Shantz and Piemeisel (1940) comment that Russian thistle has moved into areas in the Escalante Valley of Utah where winterfat has been overgrazed.

Hodgkinson (1975) found that clipping heights of 7, 5, and 3 inches (corresponding to 30, 50, and 80% utilization) produced 781, 1132, and 2848 kg/ha air-dry browse average annual yield over a three-year period. Kinsinger and Stickler (1961) found that the product of percent ground cover and increase in height is the most reliable predictor of yield. Goodman (1973) reported that the biomass of pure stands of winterfat exceeds the sum of biomasses of Atriplex confertifolia and winterfat growing in a mixed stand. This is an instance where the monospecific community is more productive than the mixed.

The below-ground biomass of winterfat has been shown to be 25 times the aboveground biomass (Caldwell and Camp, 1974). Carbon-14-labeling studies have shown that root growth and extension is initiated a few days before active shoot growth in the spring and extends several months after the termination of shoot growth and reproductive development (Caldwell and Fernandez, 1975). Root activity clearly progresses from the upper soil layers to greater depths of the soil profile as the season proceeds and soil moisture is depleted (Fernandez and Caldwell, 1975). Several studies comparing Atriplex confertifolia and winterfat have shown that the transpiration rates and root extension rates of the former remain higher later into the summer (Moore et al., 1972), resulting in a greater annual carbon fixation and standing aboveground biomass (Caldwell, 1974).

Blauer and co-workers (1976) have noted different ecotypes showing a wide range of variation in stature, seed production, seed size, seedling germination and vigor, pubescence on fruit and seed, and tolerance to varying pH in soils. A geographic variant, variety subspinosa, occurs throughout the range in Arizona and is the only form in the southern counties there. This form has woodier stems, more spreading branches, and hairs with few or no elongate rays (Kearney and Peebles, 1960). A small number of viable seeds have been produced by pollinating pistillate fourwing saltbush flowers with winterfat pollen. None of the seedlings survived (Blauer et al., 1976). Workman and West (1969) found differences among populations of winterfat for germination under saline conditions and survival of transplantation. In studies of nursery-grown plants derived from six locations in Wyoming, Riedl et al. (1958) noted considerable variation in seedling vigor within and between lines.

We collected a very trashy utricle sample of 2.6 kg from the ground on August 17, 1973, along the base of a dry-gully embankment between L. A. Aqueduct Station 4540 and State HW 14 about 16 km (10 mi) north of Mojave at 880 m (2900 ft) elevation. Rock and soil were removed by screening through a No. 18 hand sieve, yielding 0.72 kg of utricles. The hand-cleaned utricles had a purity of 38%, a clean weight of 143,000 utricles/kg (65,000/lb), and a fill of 67%. A final count of 24,000 "viable" utricles/kg (10,900/lb) can be calculated when the initial germination of 44% is taken into account. It was noted that a collection of utricles from plants in this area in June gave a germination of 33%. This indicates that full ripening of the seed is essential for maximum seed quality. Winterfat utricles are mature three months earlier in this zone than in the Great Basin Zone. A jeep-mounted vacuum harvester could be used to advantage for either ground or plant collections of the light, cottony utricles. The number of fruits/lb was reported by Stevens et al. (1977) to vary from 55,125 to 275,625/kg (25,000 to 125,000/lb).

Several techniques were tried to separate seeds from utricle materials. Hand-rubbing on a corrugated rubber belt attached to a wooden box yielded seed with 43% germination. Processing through a hammermill run at a slow speed (1700 RPM) with a 6 mm (1/4-inch) screen yielded shelled seeds with an average germination of 60%. Hammermilling resulted in 20% abnormal germination due to damage to the radicle or cotyledon of the embryo. The hand-shelled seeds resulted in only 2% abnormal germination. We explain the differences in germination between the procedures by noting that hammermilling left a large percentage of the smaller seeds of probable low viability. Thus, hammermilling tended to accumulate larger seeds while hand-shelling made no discrimination for size. The hand-shelled pure seed count was 356,000/kg (161,783/lb). Since hand-shelling is so time consuming and expensive and hammermilling so damaging to the seed we advise restraint in threshing utricles unless a definite advantage in the field-planting of shelled seed can be demonstrated. Plummer (1968) found establishment is usually better from planted utricles than from extracted seed.

We performed a depth-of-planting study at depths of 1, 2, and 4 cm in an 8-cm bed of washed plaster sand. The results are presented in Figure 1. No emergence was observed at the 4-cm depth. At a 1-cm depth the rapid initial emergence attained 60% of total emergence over a three-day period. The 2-cm depth gave a slower and lesser total emergence, only 10% of the 1-cm depth (Kay, 1975). Shallow seeding is indicated by Plummer (1968) as he notes that winterfat seed sown from an airplane in mixtures with grasses in the late fall and winter, winterfat becomes established better than many other shrubs. Springfield (1971) found that winterfat seeds planted at 1.6 mm, 3.1 mm, and 6.2 mm emerged best from 1.6 mm when soil moisture is nearer field capacity than saturation. Springfield (1970) found seedling emergence and survival were highest from surface planting of seeds and shallow planting of fruit (utricles).

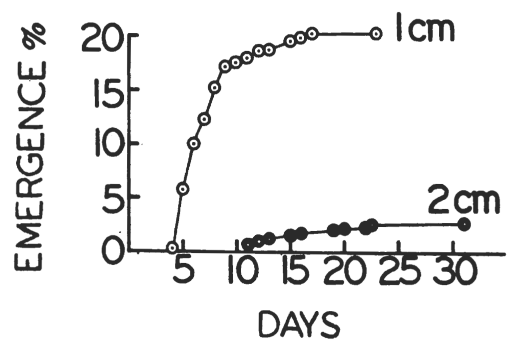


Figure 1. Effect of depth of planting on emergence of Ceratoides lanata.

After processing in 1973, part of the collection of winterfat seeds was treated with Phostox to protect against insect damage and dried at 35 C for six days. Table 1 shows the results to date of germination tests. The four storage conditions consisted of: 1) sack-storage in warehouse conditions; and storage in sealed one-gallon jars containing desiccant in 2) normal fluctating room temperature, 3) cold storage (4 C), and 4) freezing (-15 C). Twenty jars per treatment allow for the opening of one jar from each treatment each year for a total of twenty germination tests.

It appears from results in Table 1 that sealing in the presence of a desiccant preserves germination equally well during 43 months of storage, regardless of temperature. Germination is negligible under warehouse conditions (Kay, 1975). In the 43 month test, most germination occurred in the first 7 days at 10 C.

Springfield (1968b, 1974b) likewise found good storage of winterfat seeds in sealed containers under refrigeration, preferably below freezing, maintained seed viability. In contrast, he obtained 93 to 99% viability after three years. Unsealed conditions were quite inferior. He did not recommend storage under any circumstances at room temperature for periods exceeding one year (Springfield, 1973). He also noted that germination decreased after two years, although not drastically, and that the year the seed was collected influenced its retention of viability (Springfield, 1968a).

Table 1. Germination of Ceratoides lanata seed under several storage conditions over time.

	Months after harvest				
	0	6	18	30	43
			----%----		
Warehouse	22	0	0	0	1
Room temp. (sealed)	--	18	22	17	20
40 C (sealed)	--	21	31	18	23
-15 C (sealed)	--	17	28	20	21

We found that there were no significant differences in germination of winterfat at harvest time at temperatures ranging from 2 to 30 C (Table 2). Springfield (1972) found germination of collections ranging from one to four years in age to be optimum between 10 and 27 C and best at 15 C. Those seeds had been stored at 3 to 6 C in paper bags from the date of collection until germination.

Table 2. Effect of constant temperatures on the germination of Ceratoides lanata.*

Temperature	2	5	10	15	20	25	30	40
Germination	14	15	21	16	15	15	10	0

*Courtesy of Dr. James A. Young. ARS-USDA.

Several studies have shown a pronounced interaction between seed source and germination under saline circumstances (Clark and West, 1971; Moyer and Lang, 1976). In addition, this interaction has been found to be influenced by temperature, with cool temperature tending to ameliorate the effects of salinity (Springfield, 1968a). Workman and West (1967) found that a collection from a relatively saline site was more salt-tolerant than other collections, having little reduction of germination at 0.5% NaCl solution. As noted previously, it is likely that the considerable variability to be found over winterfat's vast geographic distribution will be useful in developing materials suitable for many different environments.

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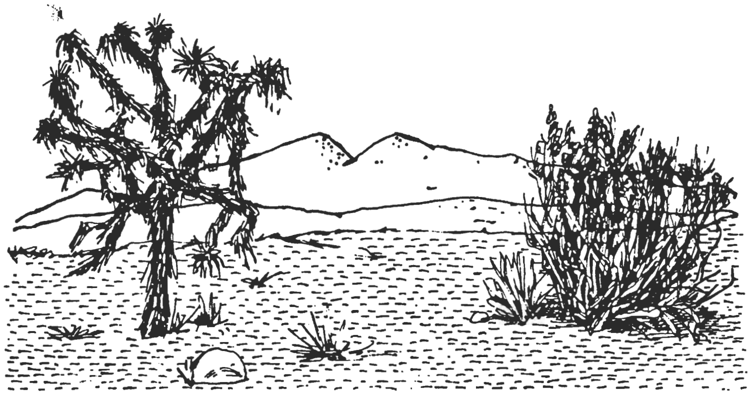
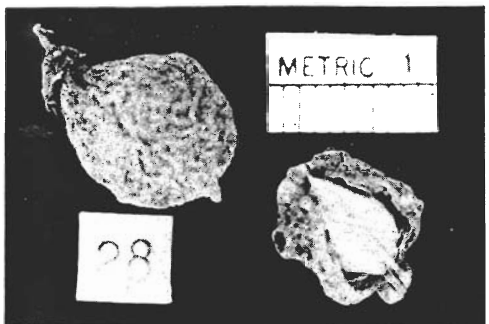


Mojave Revegetation Notes

UC DAVIS AGRONOMY & RANGE SCIENCE

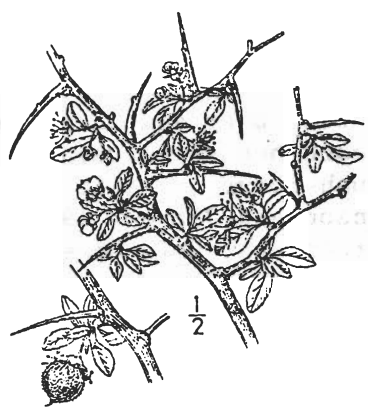
No. 21 DESERT PEACH November 1977

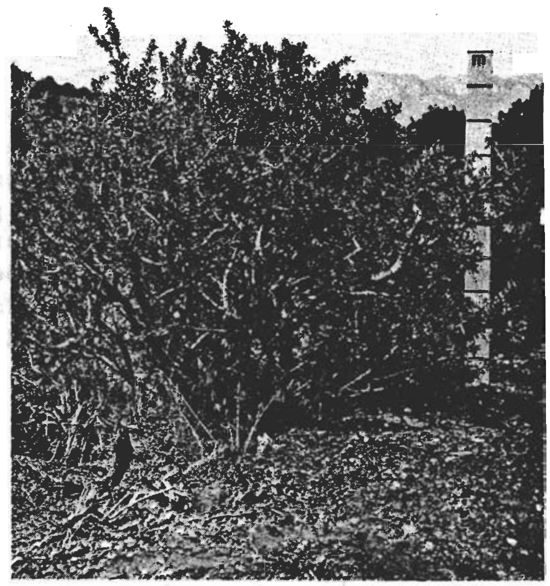
Burgess L. Kay, James A. Young, Catherine M. Ross, and Walter L. Graves[1/]



Prunus andersonii Gray. Desert peach, Nevada wild almond, Anderson peachbrush.

Photos: top, drupe and exposed seed (pit); bottom left, seedling; center, branches[2/]; right, mature shrub.





[1/]Wildlands Seeding Specialist UC; Range Scientist ARS-USDA, Reno, Nevada; Research Associate; and Graduate Student. Ms. Ross is currently Range Conservationist, Bureau of Land Management, Miles City, Montana. Mr. Graves is now Farm Advisor, UC Cooperative Extension, San Diego, California.

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Descriptions adapted from Jepson (1925), McMinn (1939) and Munz (1974).

Habit: Spreading, diffusely branching, deciduous shrub, 1 to 2 m high; short rigid branchlets ending in very thorny spines. Bark is smooth, except in very old specimens, and dull gray in color.

Leaves: Simple, alternate, in a bundle (fascicled) on short thorny lateral branchlets; oblong to oblanceolate, minutely serrulate, narrowed to a short petiolar base. The larger leaves are 15 to 20 mm long, 4 to 7 mm broad, and dark green (bluish) with red or brown veins.

Flowers: Usually solitary, occasionally clustered; red to pink, perfect, 12 to 22 mm in diameter; floral tubed sepals reddish; narrowly egg-shaped, stalked, 7 to 10 mm long, with dark-brown hairs; flowering March to June.

Fruit: Roundish to elliptical stone fruit, about 12 mm long, brownish, covered with short woolly, matted hairs, with a thin pulp and a somewhat toughened stone; embryo within, almondlike but small and round.

Desert peach is one of the few spring-blooming shrubs of the trans-Sierra Nevada and Great Basin with showy-color flowers. This provides a pleasing contrast to the landscapes of the Great Basin, dominated by gray sagebrush. The shrubs range extends from Kern and Inyo counties north along the eastern slope of the Sierra Nevada to Modoc and Lassen counties. At the sourthernmost edge of its range, desert peach is found in the Southfork Valley below Walker Pass, and as far west as Onyx (Benson and Darrow 1954). Coville (1893) observed a few specimens of desert peach growing along the interface between the Upper and Lower Sonoran life zones in the Death Valley area. Desert peach occurs between 1,100 and 2,300 m in the Joshua Tree Woodland and Sagebrush Scrub, up into the Pinyon/Juniper Woodland and Yellow Pine Forest (Benson and Darrow, 1954; Munz, 1974). Asa Gray named the species for Dr. Anderson, an early Comstock and Carson City (Nevada) physician who was an avid plant collector. Desert peach probably reaches its greatest abundance on the alluvial fans of the Sierra Nevada north and south of Carson City.

Throughout its range, desert peach reaches its greatest development on soils derived from decomposing granite (Young et al., 1977a). This shrub has a definite affinity for these soils. The shrub occurs as large clones, with the aboveground portions of the plants connected by underground stems. Large lignetubers form where the stems emerge. An individual clone may cover several acres, although several clones usually occur sympatrically in a given area.

The clones vary greatly in the showiness, color, and abundance of flowers. Clones growing side by side may differ in flowering date by as much as a month.

Analysis of annual rings in stems of desert peach in large clones reveals few stems more than 8 years old. Stems continually emerge and die within the spiny thickets. Mathias et al. (1968) considered desert peach to have good drought tolerance and to be adapted for ornamental use in middle-elevation areas of California's desert zone from 1,000 to 1,500 m. Plummer (1977) notes that desert peach is widely adapted to northern and southern desert regions. He considers the species easy to establish from seeds, spreading aggressively by underground stems. In areas of the trans-Sierra where desert peach occurs natively, its aggressive competitiveness may be a problem for gardeners.

Desert peach leaves are summer-deciduous, dropping as soon as soil moisture is depleted. Billings and Morris (1951) reported the desert peach leaves reflected 70% of the incident infrared light, making them well adapted to the high desert environment.

Being a spring bloomer, desert peach flowers and fruits are often caught by late spring frosts. As a result fruit production varies greatly between years. The great variability among clones in flowering date tends to compensate for the danger of spring frost. Although one clone may freeze, some fruit can be set on later-flowering clones. The fruits are attractive to many small animals (Stark, 1966).

Two types of fruit are produced by desert peach. On years with above-average soil moisture extending into early summer, fleshy fruits are produced. These resemble a small apricot with a reddish blush on the fruit. When ripe, these fleshy fruits split and the pits can be removed. The pits require stratification before they will germinate, but they are generally highly viable.

Normally the most abundant fruit produced is mummified, with the flesh dried on the pit. The mummified fruits are much more difficult to germinate, and the mummified flesh provides a good substrate for microorganism growth during stratification.

A good method of collection is to bend the spiny branches over the lip of a garbage can and strip the fruits with gloved hands (Young et al., 1977b). The collected material should be rough screened to remove leaves and twigs. Leaves will cause collected fruits to mold if stored en masse. Any fruits that split should have the fleshy portion of the fruit removed.

The fleshy portion of the fruit is generally infested with insect larvae. Insect damage is usually confined to the flesh, leaving the embryo undamaged. Collectors of the fruits for preparation of jams or jellies should be aware of the abundance of insect larvae.

Mature desert peach fruits or pits have very low germination unless treated. Best results have been obtained with cool-moist stratification. This stratification is accomplished by placing the fruits in a plastic bag with a moisture-holding substrate. We have compared sand, activated charcoal, and vermiculite. The substrate should be moist, during the entire stratification period, though not saturated.

The reason for using activated charcoal as a substrate is to absorb soluble germination inhibitors during the stratification period. Pea-sized charcoal granules are preferred to finely ground charcoal. The fruits to be stratified can be rolled in cheesecloth to facilitate their later removal from the substrate.

Germination of flesh-free pits in activated charcoal was optimum with stratification for 4 weeks at 2 C (Table 1). Using mummified fruits collected in the Dog Skin Mountain Range of Washoe County, Nevada in June 1974 we compared sand, activated charcoal, and vermiculite as substrates at 2 C (Table 2). Microorganism growth in the residue of mummified fruit makes these fruits difficult to germinate in petri dishes. We evaluated the stratification treatments by placing the stratified fruits in flats of sterilized soil in the greenhouse and observing emergence. With this method activated charcoal and vermiculite were roughly equal in enhancing germination. Stratification periods longer than 6 weeks gave greatest enhancement of germination.

Seeds of desert peach produced in different years apparently have variable stratification requirements. The propagator should observe the seeds during stratification to pick the optimum time for transplanting to growing containers. From results of Plummer (1977), fall seedling followed by natural stratification should be used for direct-seeding.

Table 1. Germination in petri dishes of flesh-free desert peach pits after stratification in activated charcoal for 0 through 6 weeks at 0, 2, 5, or 10 C.

Stratification duration weeks	Percent germination — Stratification temperature C			
	0	2	5	10
0	2	2	2	2
2	3	22	28	3
4	4	44	24	6
6	8	26	16	2

Table 2. Emergence of desert peach seedlings from soil in the greenhouse after stratification for 0 to 10 weeks in sand, activated charcoal, or vermiculite at 2 C. The mummied fruits were collected in 1974.

Stratification duration	Percent emergence in greenhouse — Stratification material		
weeks	Sand	Activated charcoal	Vermiculite
0	3	3	3
2	2	3	3
4	8	6	6
6	9	14	23
8	12	24	32
10	10	31	39

For a seed storage experiment, seed was collected in the Dog Skin Mountain Range of Washoe County, Nevada, during the summer of 1973. The sample was a mixture of dried drupes and clean pits (3,500/kg). After the seed was processed, it was treated with Phostox[3/] to prevent further insect damage and dried at 35 C for six days. It was divided and sealed in 60 one-gallon glass jars containing silica-gel desiccant. Twenty jars were stored at room temperature, 20 at 4 C, and 20 at -15 C. A fourth treatment consisted of bagging and storing in a seed warehouse at Davis, California. This experiment was designed to provide germination tests on a yearly basis for 20 years.

Table 3. Percent germination of seed of Prunus andersonii stored under different conditions over time.

Storage conditions	Months after initiation of storage			
	13	18	30	43
Warehouse	1	7	0	0
Room temp. (sealed)	2	0	3	0
4 C (sealed)	1	3	3	3
-15 C (sealed)	0	7	0	3

Germination tests were performed at 13, 18, 30, and 43 months. Resulting germination was very low, ranging from 0 to 7% (Table 3). A sample which had been in the warehouse storage 43 months was stratified in 10 x 50-mesh activated carbon for 10 days at 2 C. Germination was still only 3% compared with none without carbon stratification. The samples show excessive insect activity, though resulting damage is confined to the outer seed parts. Removing the embryos after 43 months of storage showed a fill of 74% damage-free embryos, 10% shriveled, and 16% empty. The undamaged seeds were tested with tetrazolium dye and all appear to be viable, so it appears that some dormancy requirement has not been met.

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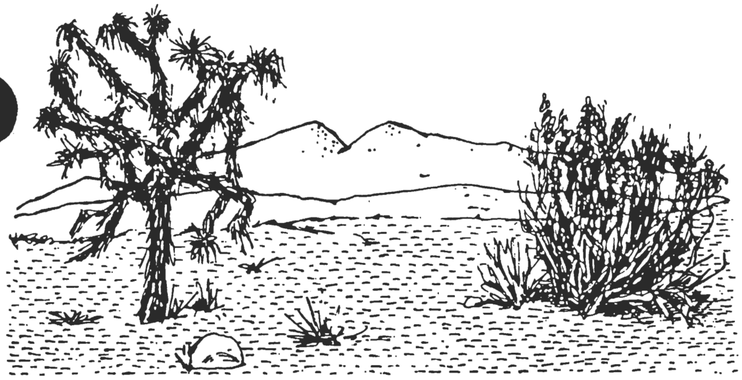


Mojave Revegetation Notes

U C DAVIS AGRONOMY & RANGE SCIENCE

No. 22 October 1979

Summary of Revegetation Attempts on the Second Los Angeles Aqueduct

Burgess L. Kay[1/]

Abstract

A 200-ft right-of-way cleared 2 to 4 years earlier was drill-seeded with seven native shrub species at six sites. Samples in the eighth growing season after planting show that stands of Ambrosia and Larrea were sometimes, though not always, superior with planting than with natural (volunteer) establishment. Atriplex polycarpa, Ephedra, Hymenoclea, and Lepidospartum did not respond to seeding. Atriplex canescens became established at two sites but appears susceptible to grazing damage. Chrysothamnus nauseosus (not seeded) is the most prolific revegetating species. Most of the aqueduct is still a highly visible scar and will remain so for many more years.

Figure 1. Shrub seeds were planted one-half inch deep with a rangeland drill. Note rough seedbed that resulted from ripping to relive compaction.

[1/]Wildland Seeding Specialist, Department of Agronomy and Range Science, University of California, Davis.

Introduction

The second LA aqueduct from Haiwee Reservoir to Fairmont Reservoir (124 miles) was constructed in the period 1968-1970. A right-of-way 200 ft wide (sometimes more) was stripped of all vegetation. A study team headed by Stewart Porter, BLM, Sacramento, described the impact of the aqueduct construction and suggested corrective measures in July 1970 (Porter 1970). This investigative team suggested that all disturbed areas be ripped 10 inches deep on 24 inch centers to relieve compaction. Most disturbed areas were thus ripped in 1971-72. Transplanting of native shrubs was suggested but never tried. Drill-seeding of existing and introduced species on 20 acres was also suggested for the fall of 1970.

Methods

The first obstacle to such an ambitious seeding was the lack of available desert shrub seed. The summer of 1970 was a poor seed-crop year for many shrubs. The first seed actually collected was in December 1970; most of the seed was collected in the spring and fall of 1971. The seed was gathered by a commercial seed collector. Table 1 summarizes the species used, collection date, location, quality of seed, and seeding rate.

Seeding was begun in Feburary 1972 on six experimental sites, each 5 to 36 acres, along the aqueduct, for a total of 100 acres (Table 2). The seed was mixed in Mojave by personnel of the City of Los Angeles Water and Power Department. A plaster mixer was used to blend the seven desert species with a volume of rice hulls sufficient to facilitate delivery by the flutes in a rangeland drill. All seeding (drilling) was on a ripped seedbed with the seed planted one-half inch deep in 12-inch rows (Fig. 1). City of Los Angeles crews performed the seeding operation, which was supervised by Lavern Walgren of the BLM Bakersfield office. Cages (60 x 60 in. buried 9 in. deep) made of hardware cloth were placed on each drilled area by Carl Rice, BLM, Sacramento, to determine the effect of animals and birds on the establishment of shrub seedlings.

None of the drilled seedings was ever irrigated. However, one-half of each of the 60 x 60" cages was watered (2 gal about once a week for 6 months) following planting. There was no significant rainfall in the 9 months after seeding. The first rain sufficient to effect germination was in December of 1972. The following growing season, 1972-73, was a year of relatively normal rainfall.

Sampling of the success of planting was in May of 1979, in the eighth growing season after planting. Each of the six drilled areas plus adjacent undrilled areas were sampled. Plant numbers and height of both seeded and unseeded shrub species were measured in six-foot-wide transects. A total of 24,300 ft^2 of seeded area and 26,092 ft^2 unseeded area were measured. Locating a representative unseeded area was a problem. Used generally was an area on one or sometimes both ends of the seeding, although those may not be comparable to the site seeded because of the extreme variability in site and plant communities.

Another study using the same seed lots as the drilling experiment and located at Cameron Wash and Robber's Roost was conducted one year after the drilling. Walter Graves, a University of California at Davis graduate student, investigated transplanting vs. direct seeding (Graves et al. 1978).

Table 1. Shrub species, collection date, location, quality, and seeding rate of seed used in drilling experiments.

Species	Date	Collection location	Percent germ.	Seeds per foot*	lbs/ acre[a/]
Ambrosia dumosa	5/71	12 mi SE Lancaster	26	6.3	2
Atriplex canescens	12/70	Victorville	23	0.2	1/4
Atriplex polycarpa	12/70	Carissa Plains	38	3.1	1/4
Ephedra nevadensis[b/]	7/71	Lancaster	60	?	?
Hymenoclea salsola	5/71	Lancaster-Mojave	70	0.3	1/4
Larrea tridentata	8/71	Little Lake-Mojave	60	11.2	6
Lepidospartum squamatum	10/71	Victorville	>47	1.8	1/8

a/ Total seed rate was 8.9 lb/acre with 17 lb rice hulls.

b/ Ephedra was not included in the mix, but was seeded separately through the small seed box.

RESULTS

Planting increased the numbers of some species on a few sites although rarely creating an undisturbed aspect. Larrea stands may have benefited from seeding on four sites, and Ambrosia on three sites (Table 2). The relatively greater success of these two species may be because of the higher seeding rates used (Table 1). Ephedra, Hymenoclea, and Lepidospartum do not appear to have been increased by drilling on any site. Atriplex polycarpa survived at only one site and was probably the result of natural seeding since it is very numerous on the unseeded area at this site. The seed used had been collected in San Luis Obispo County and may have been poorly adapted to the new site or relatively more palatable in the new location.

Atriplex canescens may have been the victim of grazing pressure. A. canescens is present only on the Robber's Roost and Freeman Plain sites and shows heavy grazing pressure (Figure 10). A fenced enclosure protecting the study by Walter Graves at Robber's Roost shows close hedging by cows (Fig. 11). Graves study also showed A. canescens to be relatively easy to establish by direct seeding if protected from grazing animals. Volunteer establishment of Chrysothamnus nauseosus ssp. hololeucus was outstanding at many sites and present at all but one site. This species should be included in any future seeding attempts.

The total number of plants/acre (seeded and unseeded species) was not increased by drilling but was actually less because of the large numbers of Chrysothamnus plants in unseeded sites at Cameron Wash and Red Hill. The average of all sites was 3,526 shrubs of all species on the unseeded areas and 2,428 on the seeded areas.

Plant heights varied considerably from site to site and within a site, but had no consistent trend between drilled and undrilled sites (Table 3).

Table 2. Number of shrubs/acre before disturbance (sampled by Carl Rice, Nov. 1971, on adjacent areas) compared with natural revegetation (unseeded) and seeded areas in May 1979.

	Cameron Wash			Robber's Roost (South Freeman)			Freeman Plain (Hwy. 178)		
	Undis-turbed	Un-seeded	Seeded	Undis-turbed	Un-seeded	Seeded	Undis-turbed	Un-seeded	Seeded
1) Seeded species									
<u>Ambrosia</u> <u>dumosa</u> (bursage)	981	197	962	3161	245	208	3488	33	251
<u>Atriplex</u> <u>canescens</u> (4-wing salbush)				--	--	122	--	--	36
<u>Atriplex</u> <u>polycarpa</u> (desert saltbush)							109	1815	2599
<u>Ephedra</u> <u>nevadensis</u> (gray ephedra)	--	5	--						
<u>Hymenoclea</u> <u>salsola</u> var. <u>salsola</u> (white burrowbush)	--	111	76	--	8	6	--	33	18
<u>Larrea</u> <u>tridentata</u> (creosote bush)	1090	207	313	109	--	--	545	16	520
<u>Lepidospartum</u> <u>squamatum</u> (scale brome)	--	5	--				--	33	--
2) Unseeded species									
<u>Acamptopappus</u> <u>sphaerocephalus</u> var <u>hirtellus</u> (goldenhead)				--	--	31			
<u>Ceratoides</u> <u>lanata</u> (winterfat)				218	--	--			
<u>Chrysothamnus</u> <u>nauseosus</u> spp. <u>hololeucus</u> (rubber rabbitbrush)	--	2286	292	--	8	12	--	98	18
Other unseeded shrub species	759	181	227	1635	--	49	1629	16	--
Total shrubs/acre	2830	2992	1870	4905	261	348	5771	2044	3442

Table 2 (continued):

	Nine-Mile Canyon			Red Hill (711)			Red Hill (553)		
	Undis-turbed	Un-seeded	Seeded	Undis-turbed	Un-seeded	Seeded	Undis-turbed	Un-seeded	Seeded
1) Seed species									
Ambrosia dumosa (bursage)	2831	227	208	2180	4453	1549	2180	184	899
Atriplex canescens (4-wing saltbush)									
Atriplex polycarpa (desert saltbush)									
Ephedra nevadensis (gray ephedra)				218	--	--	218	46	23
Hymenoclea salsola var. salsola (white burrowbush)	--	--	16	109	4646	3969	109	691	392
Larrea tridentata (creosote bush)	436	18	--	--	--	97	--	--	46
Lepidospartum squamatum (scale broom)	--	6	--	--	--	--	--	--	--
2) Unseeded species									
Chrysothamnus nauseosus spp. hololeucus (rubber rabbitbrush)	--	6	5	--	10,648	6679			
Other unseeded shrub sp.	109	--	--	2259	--	--	545	--	--
Total shrubs/acre	3376	257	229	4984	19,747	12,294	4984	921	1360

Table 3. Average height (inches) of shrubs on May 15-17, 1979, on unseeded (A) and seeded sites (B).

	Cameron Wash		Robber's Roost		Freeman Plain (Hwy 178)		Nine-Mile Canyon		Red Hill 711		Red Hill 533		Average	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
Ambrosia	7	8	11	14	10	11	14	15	4	7	10	10	9	11
Atriplex canescens			--	19									--	12
A. polycarpa					18	15							18	15
Ephedra	12										8	6	10	6
Hymenoclea	13	19	--	24	16	18	--	17	7	9	14	14	13	17
Larrea	12	28	37	18	12	6	43	--	--	32	--	10	26	20
Lepidospartum							12	--					12	--
Chrysothamnus	5		34	20	19	30	10	10	4	3			14	16
Eriogonum	7	12			18	--							13	12
Tetrademia		5											--	5
Acamptopappus			13	11									13	11

Following are site-by-site descriptions and photographs of the areas. Also, a number of Carl Rice's old photos of the aqueduct were repeated to show vegetative changes in the ensuing nine years.

Cameron Wash

The original aspect was Larrea and Ambrosia (Rice 1971). The seeded plots have numbers of Ambrosia comparable to numbers in the undisturbed area, but less than one-third the original number of Larrea (Table 2). The Larrea are not evenly distributed on the site, and do not create a significant Larrea aspect overall. However, the south end appears quite satisfactory and is apparently the result of drilling (Fig. 2). Protection apparently benefited Atriplex canescens (Fig. 3).

The dominant species in both seeded and unseeded areas is Chrysothamnus nauseosus. Heights range from 2 to 57 inches, representing several periods of establishment and probably a second generation. Chrysothamnus was not found in the undisturbed sample by Rice. Two other species shown to be present by Rice have returned in lesser numbers. Eriogonum fasciculatum was 650/acre and is now 174. Haplopappus linerifolius var. interior was 109/acre and is now 22.

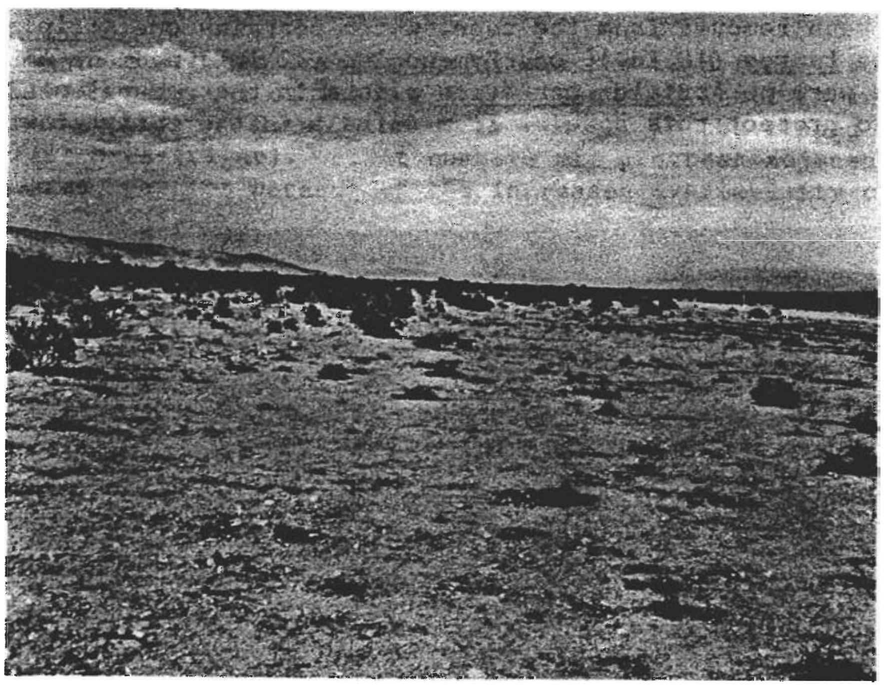


Fig. 2. The best success at returning an area to the original aspect is the drilled area (background) at the south end of the Cameron Wash seeding (4816). Foreground was not drilled. Natural establishment was better on the ripped area, left (closest to seed source), than the unripped, right.

*Numbers in photo captions refer to white papers or flush markers posted on the aqueduct.

Figure 3. Seeded area at Cameron Wash. Most abundant is *Ambrosia*, with significant numbers of *Larrea*, *Hymenoclea*, *Chrysothamnus*, and *Eriogonum*. The top has been removed from the cage, which contains one *Atriplex canescens* (66 in.), one *Larrea* (18 in.), one *Hymenoclea* (12 in.) and one *Ambrosia* (8 in.). There were no *Atriplex canescens* plants in the general seeding, indicating a need to protect this species from animals in the early growth stages.

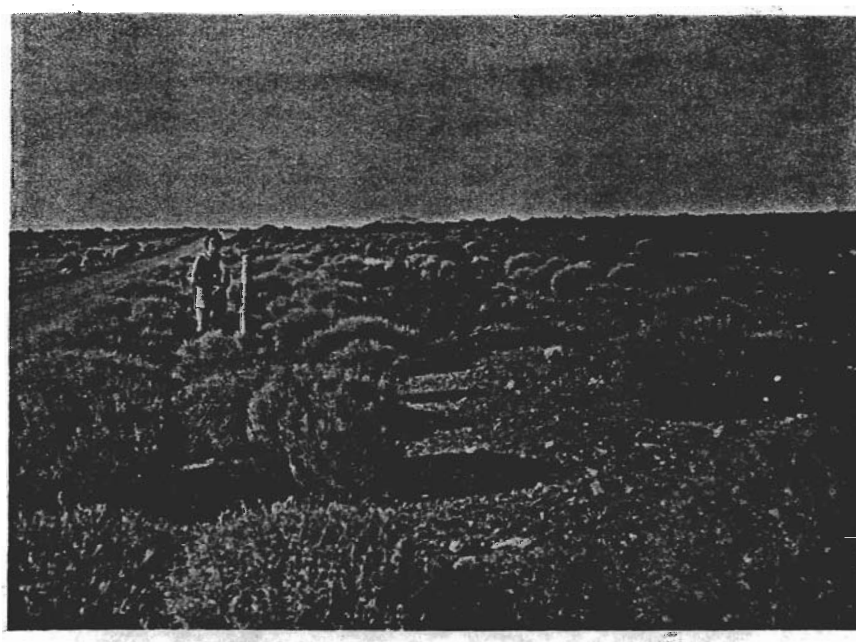


Figure 4. Looking south at an unseeded area north of the Cameron Wash seeding (4727). Note excellent stand of *Chrysothamnus*, with the best growth next to the road (on top of the pipe trench) even though this portion was not ripped. *Larrea* plants are established in significant numbers on the right. They are as tall as 48 inches, but average only 12 inches. The tallest are crown sprouts rather than seedlings.

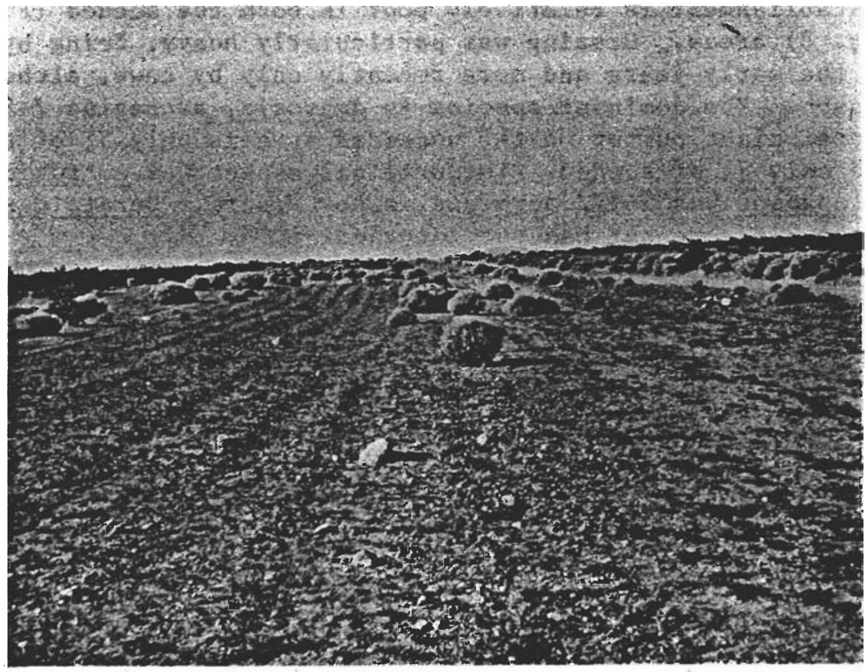


Figure 5. Photo taken immediately across the road from figure 4 shows Chrysothamnus is the dominant species, although fewer in numbers than in the other photo. Establishment is similar in the ripped portion (left) and flat area (right). Plant numbers are greatest adjacent to the undisturbed area, perhaps because of the increased availability of seed.

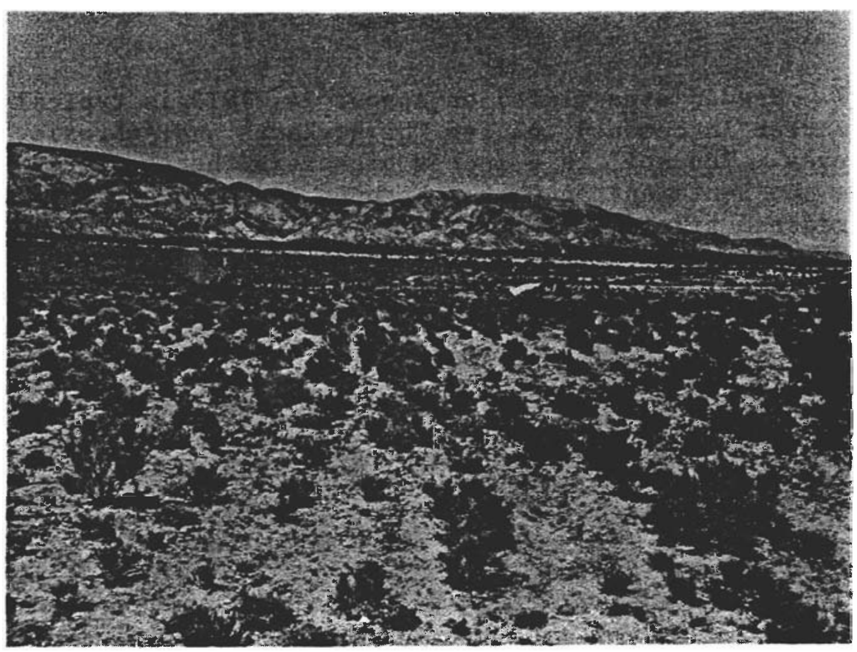


Figure 6. This excellent shrub cover established itself naturally about two miles north of the Cameron Wash drilling. The domimant species is Lepidospartum squamatum. Also present are Ambrosia, Lepidium fremontii, and Encelia. There are no Larrea plants, which means that the area will continue to appear different from the undisturbed area despite the excellent shrub cover.

Robbers' Roost

Shrub establishment is relatively poor in both the seeded (Fig. 7) and unseeded (Fig. 8) areas. Grazing was particularly heavy, being by both cows and sheep in the early years and more recently only by cows, although for a prolonged season. The dominant species is Ambrosia, averaging 7-8 inches tall. The total plant number on the unseeded area is only 5% of the undisturbed sample and only 7% if seeded. The original aspect was Ambrosia-Haplopappus-Larrea. Haplopappus was 1417/ acre and is now 9/acre. Ceratoides lanata (winterfat) was 218/acre but has not returned.

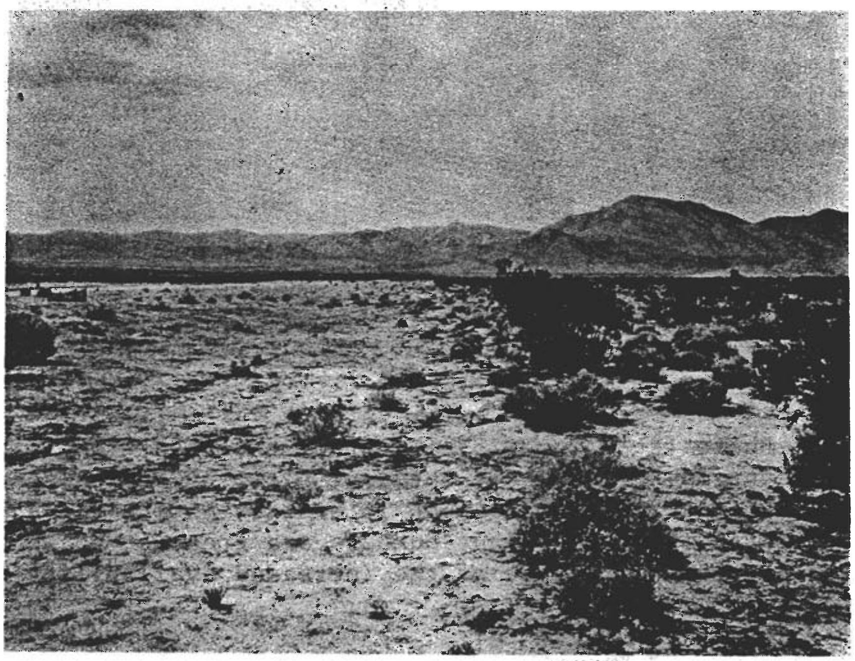


Figure 7. Seeded area (left) on August 24, 1979 is typical of seeding (2526 flush marker in cement). A few Chrysothamus and Ambrosia, and, on the far left, Larrea. The soil is 6 inches higher in the cage (far left) than in adjacent area and contains one Chrysothamnus. Annuals are mostly Erodium cicutarium (redstem filaree).

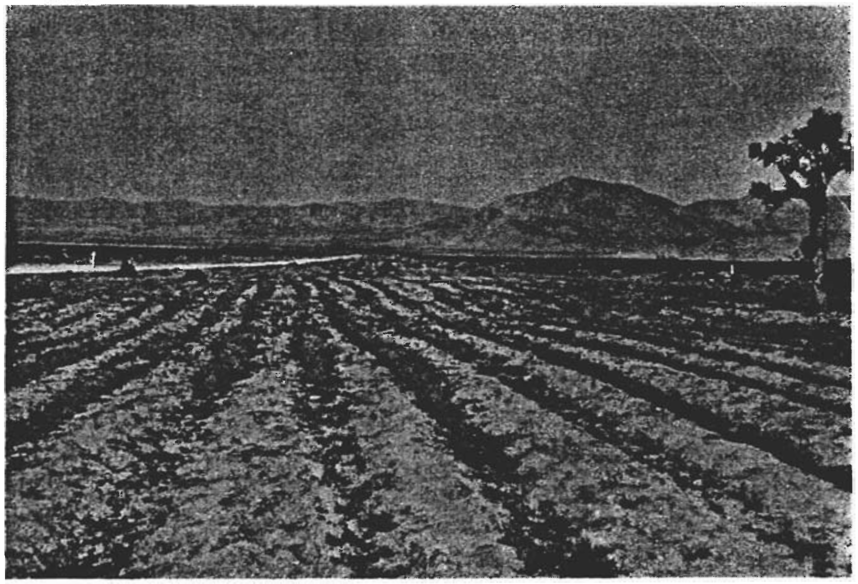


Figure 8. Unseeded area between the fenced experiment and seeded area on May 16, 1979. Very heavily grazed. Photo is 200 yds south of fenced plot, looking south (2509).

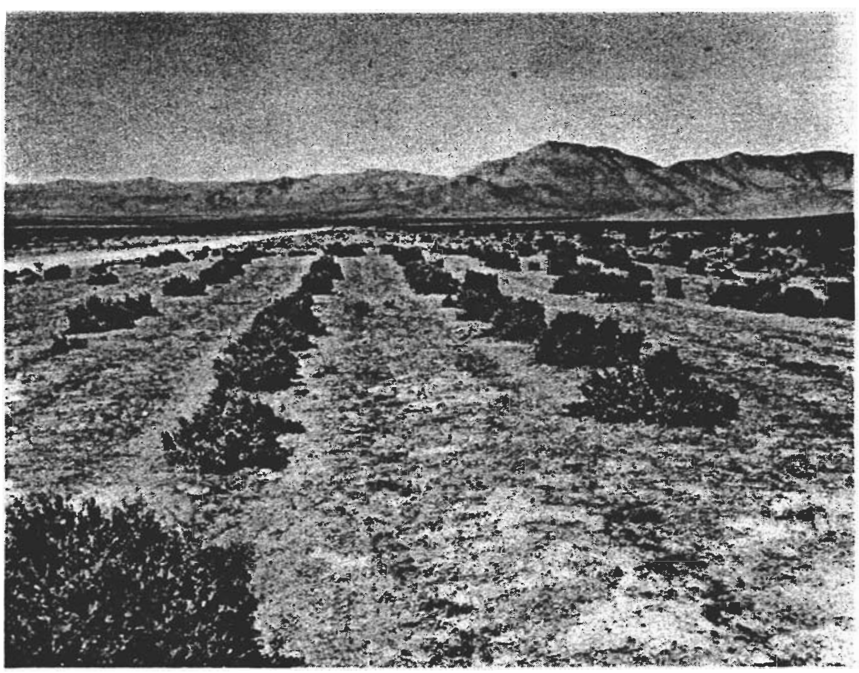


Figure 9. An obvious success of drill-seeding is this limited stand of Atriplex canescens. Rows coincide with every third rip mark and do not extend the full length of the planting. No explanation is obvious for this distribution. The average height of these heavily grazed plants is 19 inches. (2513 looking south).

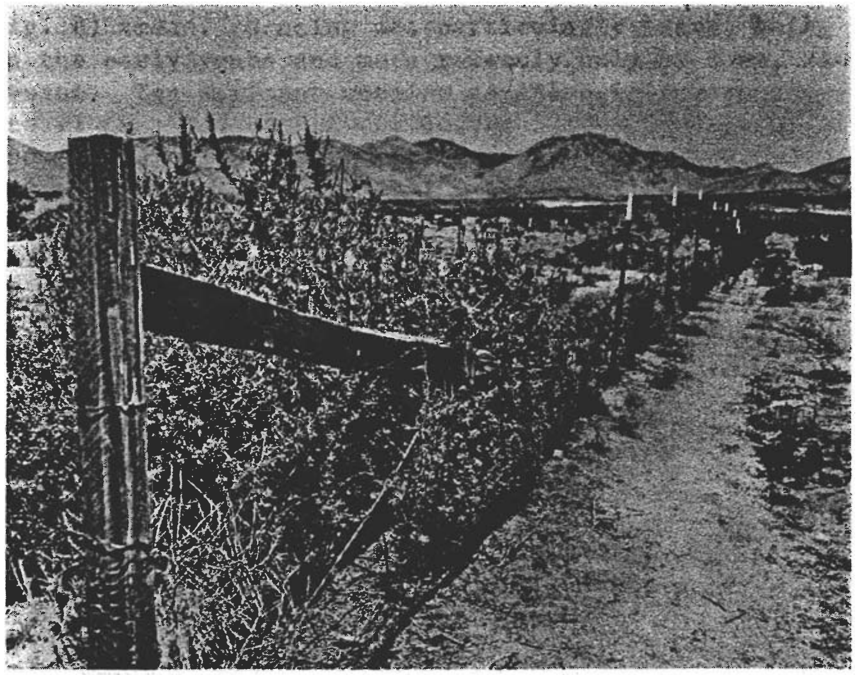


Figure 10. <u>Atriplex</u> <u>canescens</u> plant in corner of Walter Graves experiment is one year younger than those in Fig. 7 but three times as high. Note close hedging along fence. Brace post was cut off by shotgun pellets.

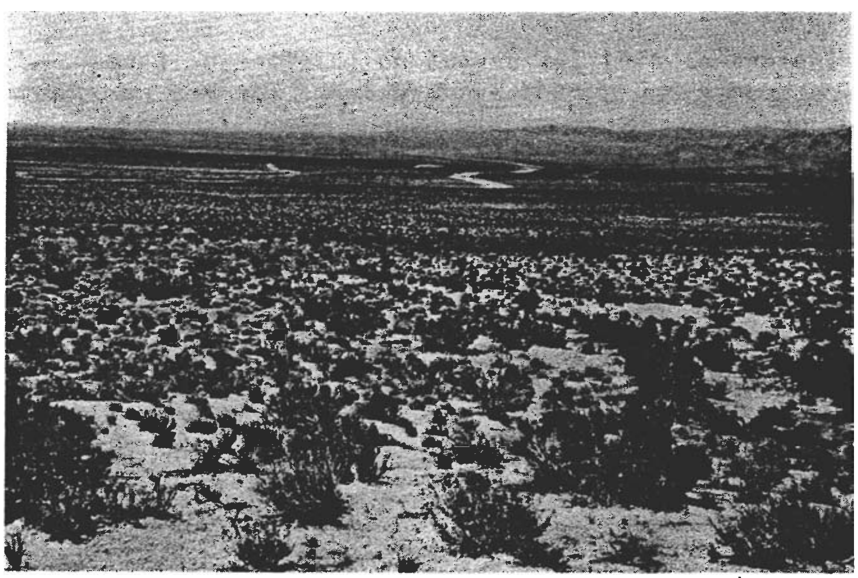


Figure 11. Overview of new aqueduct right, and old aqueduct left (built in 1913), from road near Robber's Roost. Both aqueducts and associated roads are still highly visible scars. Photos 10 and 11 are August 24, 1979.

Freeman Plain (Hwy. 178)

Seeded and unseeded areas have excellent stands of Atriplex polycarpa (Fig. 12) with a good mixture of Ambrosia, Hymenoclea, and Chrysothamnus. Larrea is very scarce in the unseeded area (16 plants/acre) but very adequate in the seeded area (520 plants/acre). However, the plants are only 4-6" tall and may or may not be the result of seeding. The original aspect was Ambrosia-Haplopappus-Larrea. Neither Haplopappus (originally 1520/acre) nor Grayia spinosa (spiny hopsage) (109/acre) has reestablished.

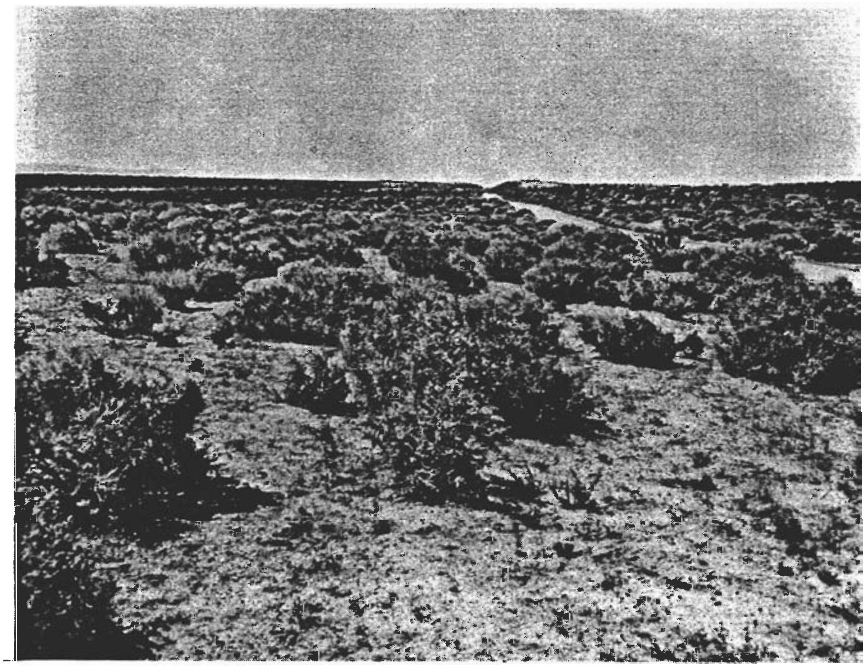


Figure 12. Freeman Plain, south of Hwy 178, looking south from 2288. Shows excellent stand of Atriplex polycarpa typical of seeded and unseeded areas. May 16, 1979.

Nine Mile Canyon

Very poor shrub establishment in both seeded and unseeded areas. Dominant species is *Ambrosia*, about 14 inches high (range 8-24 inches). There are a few *Larrea* in the unseeded area only. The original aspect was *Ambrosia*-*Larrea*. Total plant numbers are about 7% of the undisturbed area.

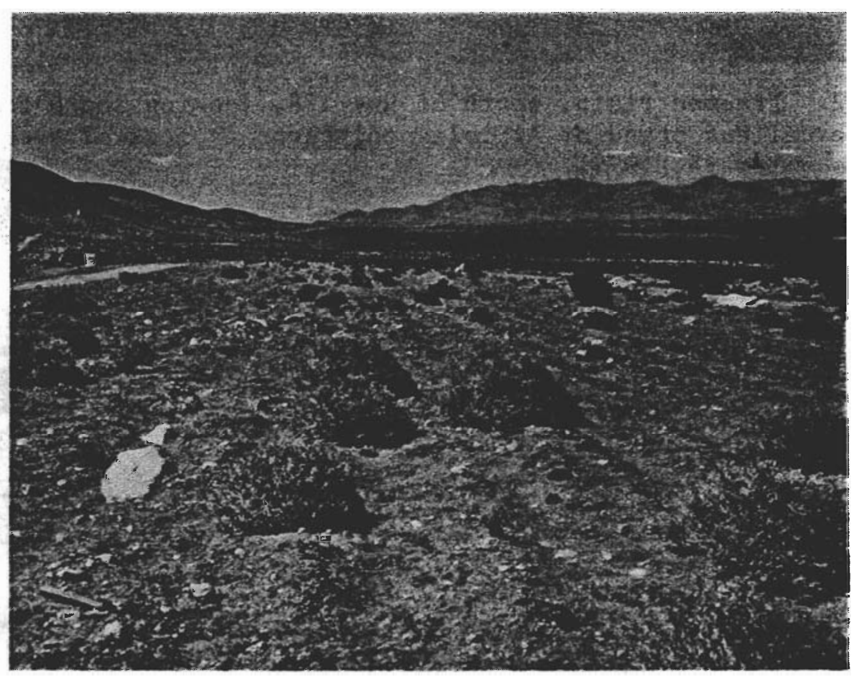


Figure 13. Seeded area (top photo) and unseeded area (lower photo) look similar. Few large plants in foreground are *Atriplex polycarpa*. Area is still relatively bare eight years after planting. Photo at 1273 on May 16, 1979.

Red Hill

Shrub establishment was fair to good at both sites, with no great difference due to seeding. Ambrosia and Hymenoclea are the dominant species at both sites, plus Chrysothamnus at 711. Total plant numbers at 711 exceed numbers in the undisturbed areas because of the large number of Chrysothamnus seedlings 2-6 inches tall. Eriogonum fasciculatum, originally 1496/acre, was not detected, nor was Ceratoides lanata (218/ acre), Grayia spinosa (218/acre), or Lycium andersonii (desert thorn) (545/acre).

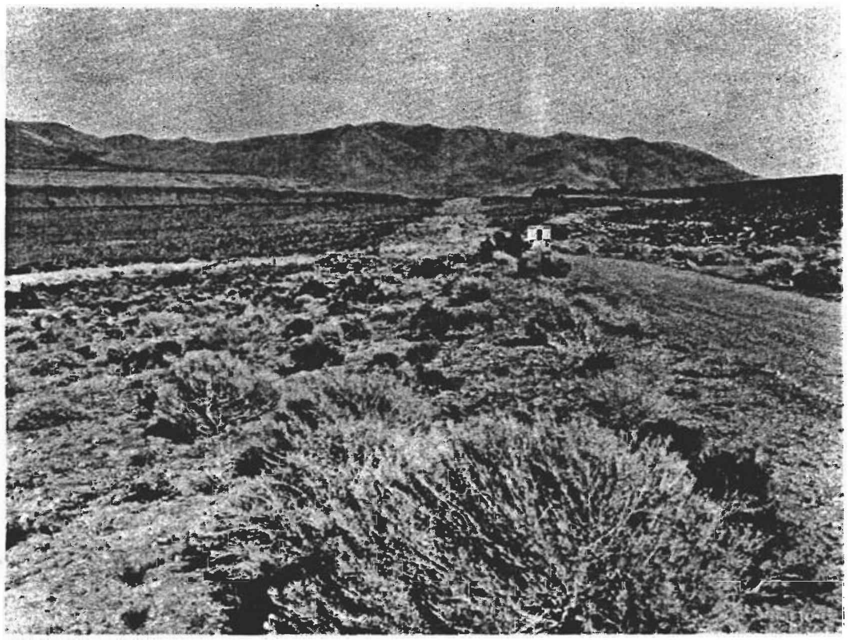


Figure 14. Red hill sites, 711 top and 553 bottom. May 16, 1979.

Figure 15. Looking SW back across the Randsburg cutoff and U.S. 466. Top photo, by Carl Rice, shows aqueduct one year after completion (May 13, 1970). Lower photo, taken August 23, 1979, shows results of natural revegetation and vehicle activity. Dominant vegetation is hedge mustard (Sisymbrium officinale) and Larrea.

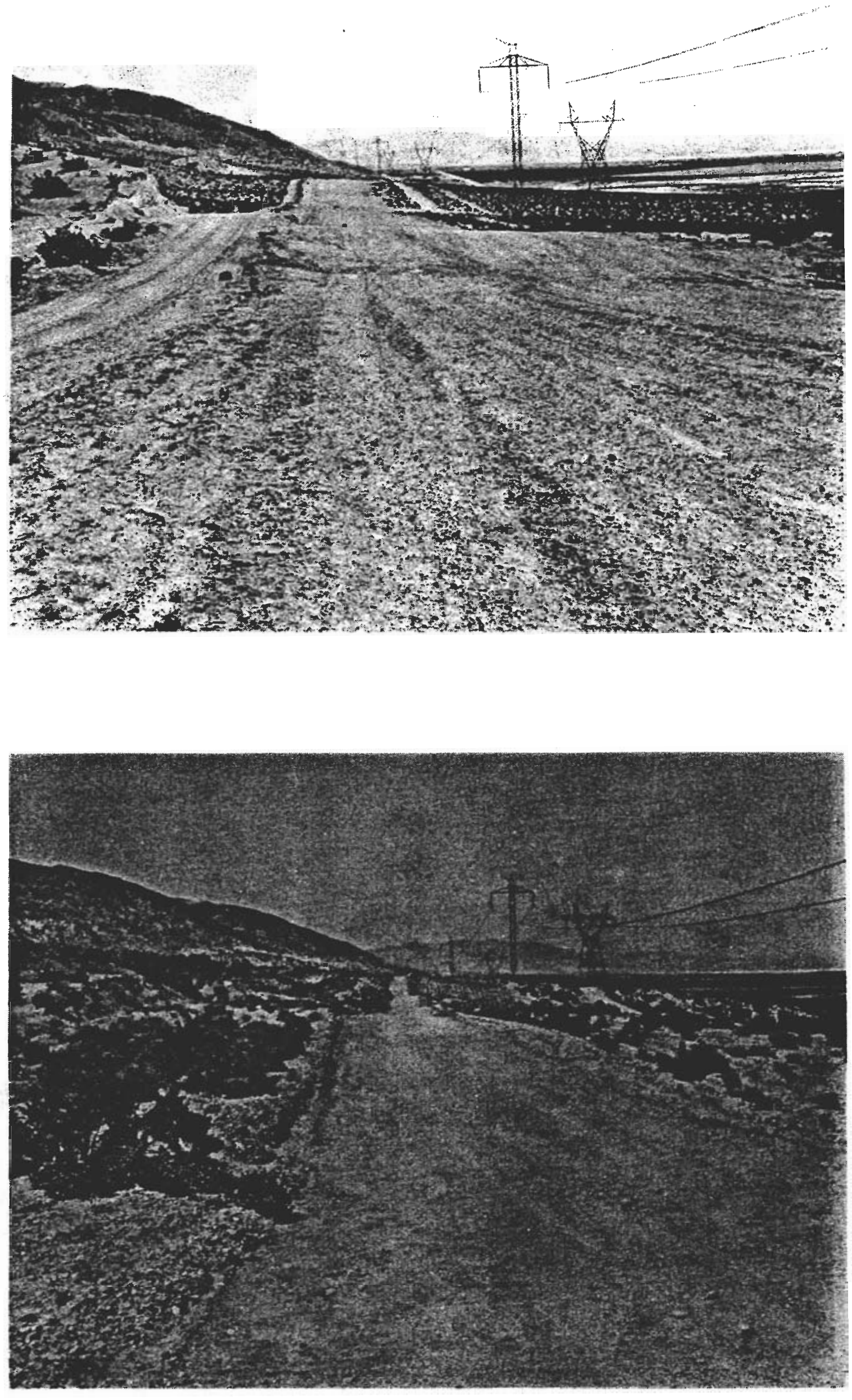
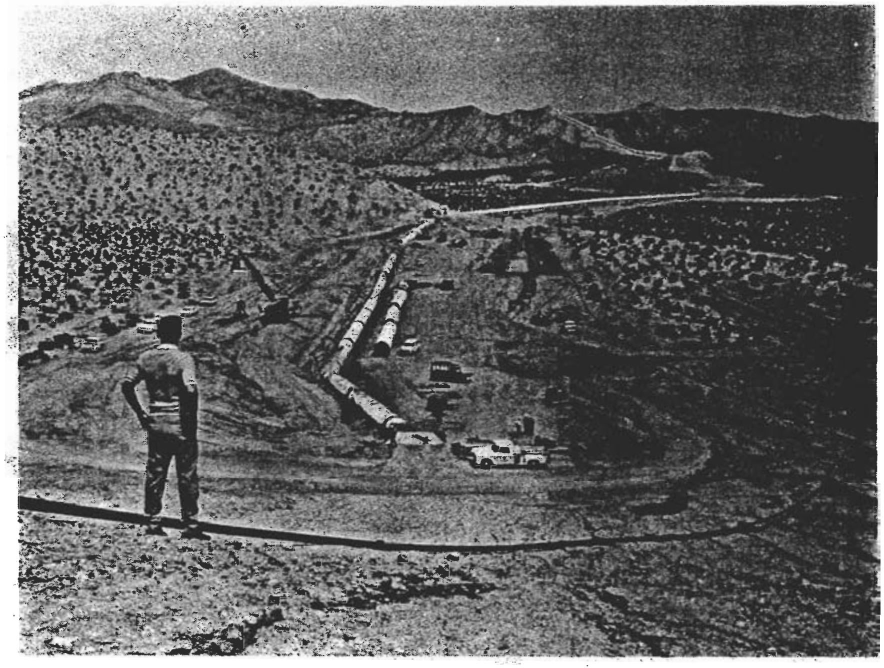


Figure 16. Aqueduct south of Cinco shows fair to good natural revegetation on relatively flat ground. Top photo May 1970, lower photo May 16, 1979. Note that the road, left, has been relocated to center; the old road was ripped, with resulting good natural revegetation.



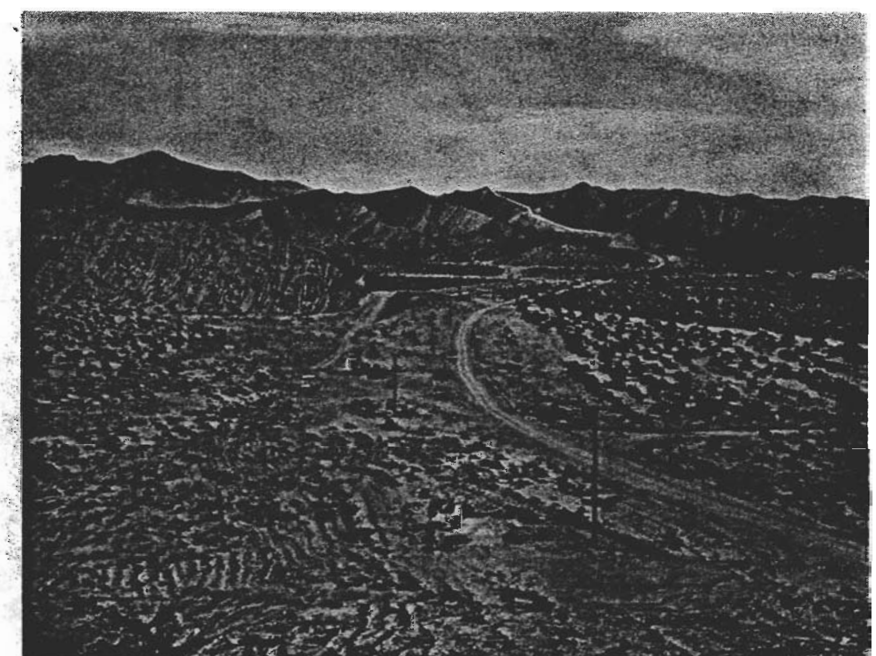


Figure 17. Pipeline construction on May 13, 1970, near Water Canyon 3979 (1 mile west of Jawbone Canyon Store). Width of right-of-way at this point is 336 feet. Bottom photo repeated on August 23, 1979. Note considerable erosion on slope in foreground and intensive motorcycle use in left background. Undisturbed shrubs appear to have grown.

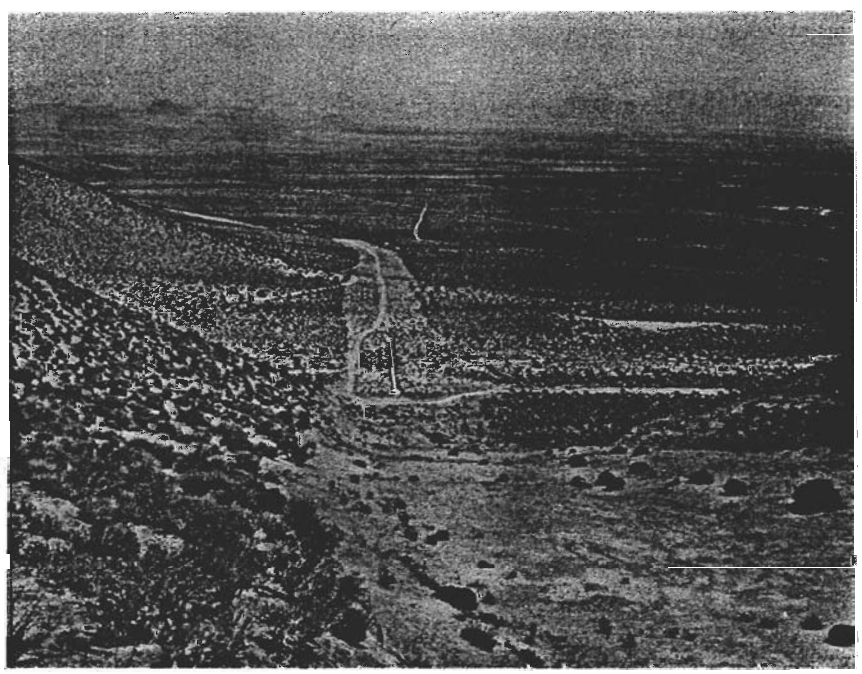


Figure 18. Sandy soil area near Short Canyon (2 miles east of Brady's). Top photo on May 12, 1970. Note in lower photo, taken on May 16, 1979, natural reproduction appears to be good on the flatter areas but poor on the steep slope. Both continue to be very visible disturbances, and steeper slope is eroding.

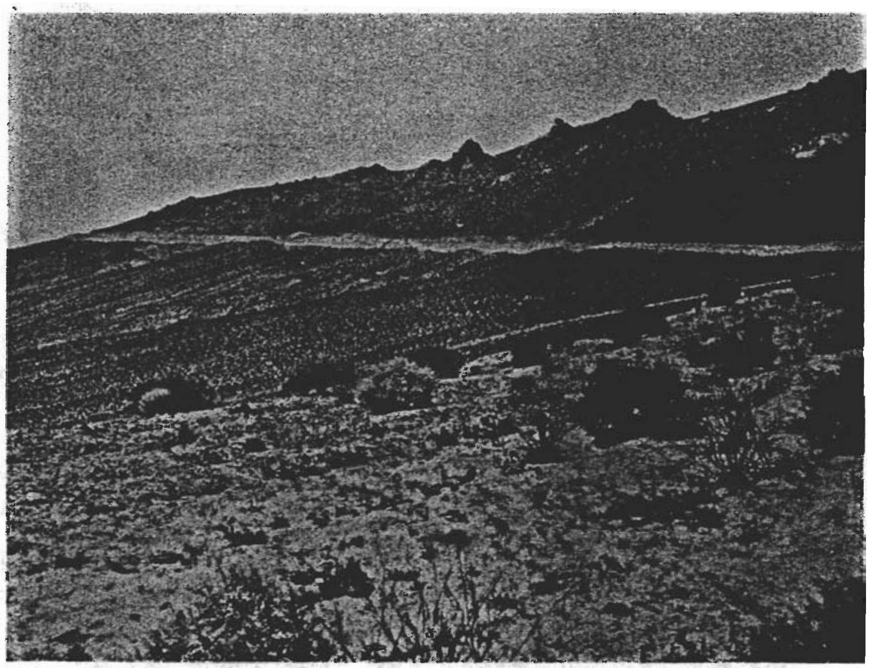
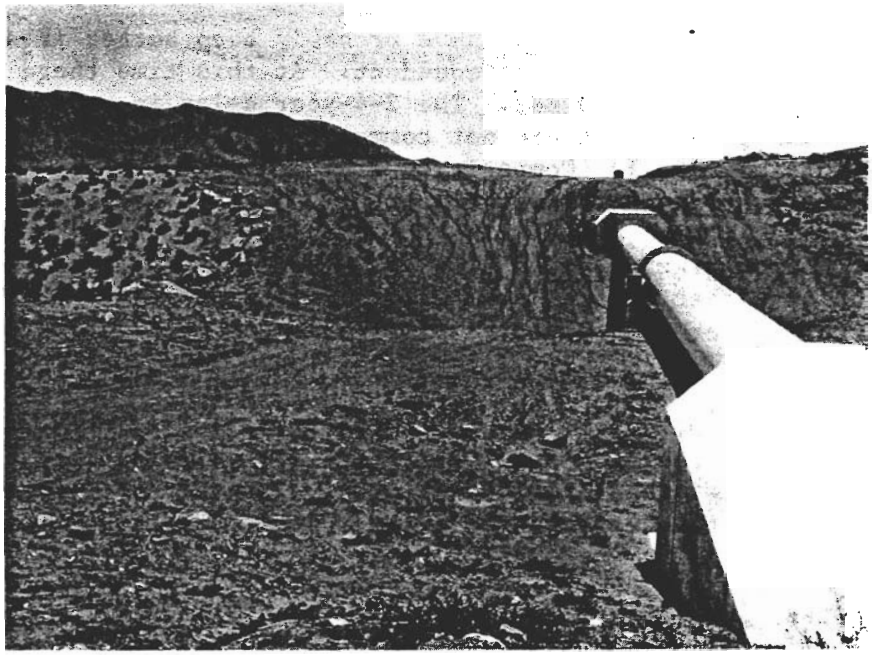


Figure 19. Deep cuts west of Brady's (south of Short Canyon) will remain visible indefinitely. Note vegetation in flat foreground in lower photo (May 16, 1979), compared with Carl Rice photo, top (May 12, 1970). Original vegetation was Ambrosia and Larrea.



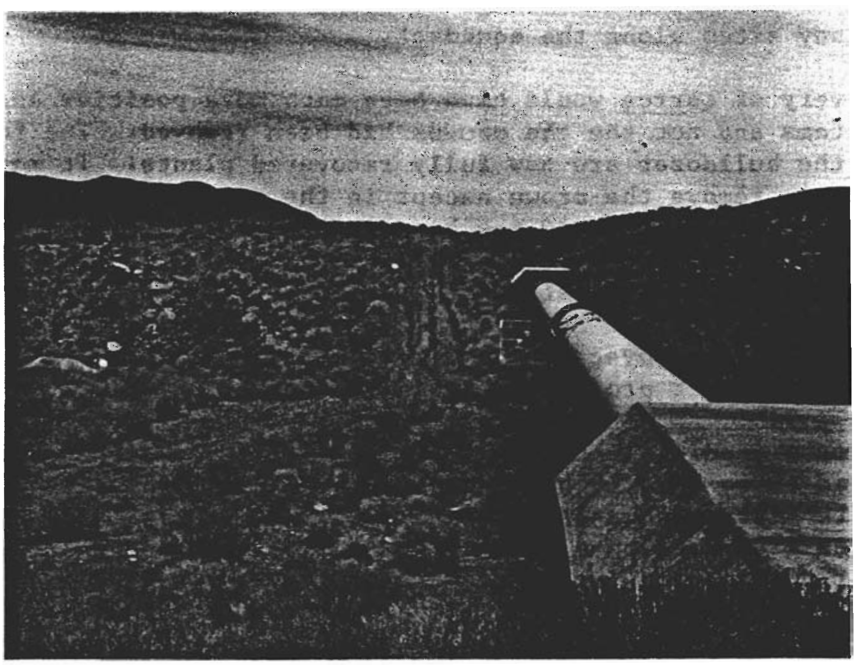


Figure 20. Erosion and revegetation near Little Lake Canyon caretaker's house (772) from May 12, 1970 (upper), to August 24, 1979 (lower). Dominant species is Chrysothamnus nauseosus.

Discussion and Conclusions

The apparent success of planting the two most visually dominant and long-lived species (Larrea and Ambrosia) appears to make the seeding effort successful on at least some of the sites. The results would probably have been much improved if it had rained in the season of planting.

Shrub establishment would also have probably been better if attempted immediately after completion of the aqueduct. At this time there was a relatively low population of weeds. The 2-4-year delay in seeding allowed an invasion of annual plants that are not common in undisturbed sites (Erodium, Amsinkia, Sisymbrium, etc.). Competition from annual plants is one of the most common deterrants to shrub establishment.

Protection from grazing would also have increased chances of establishing shrubs by either natural or artificial seeding methods. Animals seem attracted to this clear and relatively flat site and spend an undue amount of time there.

Seeding success would have been enhanced by including Chrysothamnus nauseosus in the seeding mix. Even though not generally present in large numbers on undisturbed sites, that species is the most capable of establishing on disturbances. Its relatively low palatability may contribute to its success.

The seed used should be gathered from areas as near as possible to the seeding site since the considerable ecotypic differences in seed sources might influence establishment. A possible example is the Atriplex polycarpa seed used in the drilling. It was of acceptable quality, but was gathered from Carissa Plains, San Luis Obispo County. That may be the reason it did not establish in the drilled seedings although the same species is volunteering well on many sites along the aqueduct.

The recovery of Larrea would have been much more positive and rapid if only the stems and not the the crowns had been removed. The few crowns that escaped the bulldozer are now fully recovered plants. It may not have been necessary to remove the crown except in the trench area. Had that been done, much of the aqueduct would now be visually recovered.

There are some excellent stands of shrubs on limited areas of the aqueduct, whether planted or not planted. Many sections, however, are relatively bare, perhaps over half. No attempt was made to determine how much of the aqueduct project is making satisfactory recovery.

Results from seeding in this area of extremely low and erratic rainfall can be expected to be equally poor and erratic even if the best techniques are used. Site disturbances should be avoided, if possible, and, if unavoidable, they should be kept to a minimum size. Seeding should be as early as possible after disturbance, using local seed, covered with soil to a depth 2-3 times the diameter of the seed, and protected from animals and vehicles in order to expect the best degree of success.

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Department of Agronomy and Range Science
University of California
Davis, California 95616