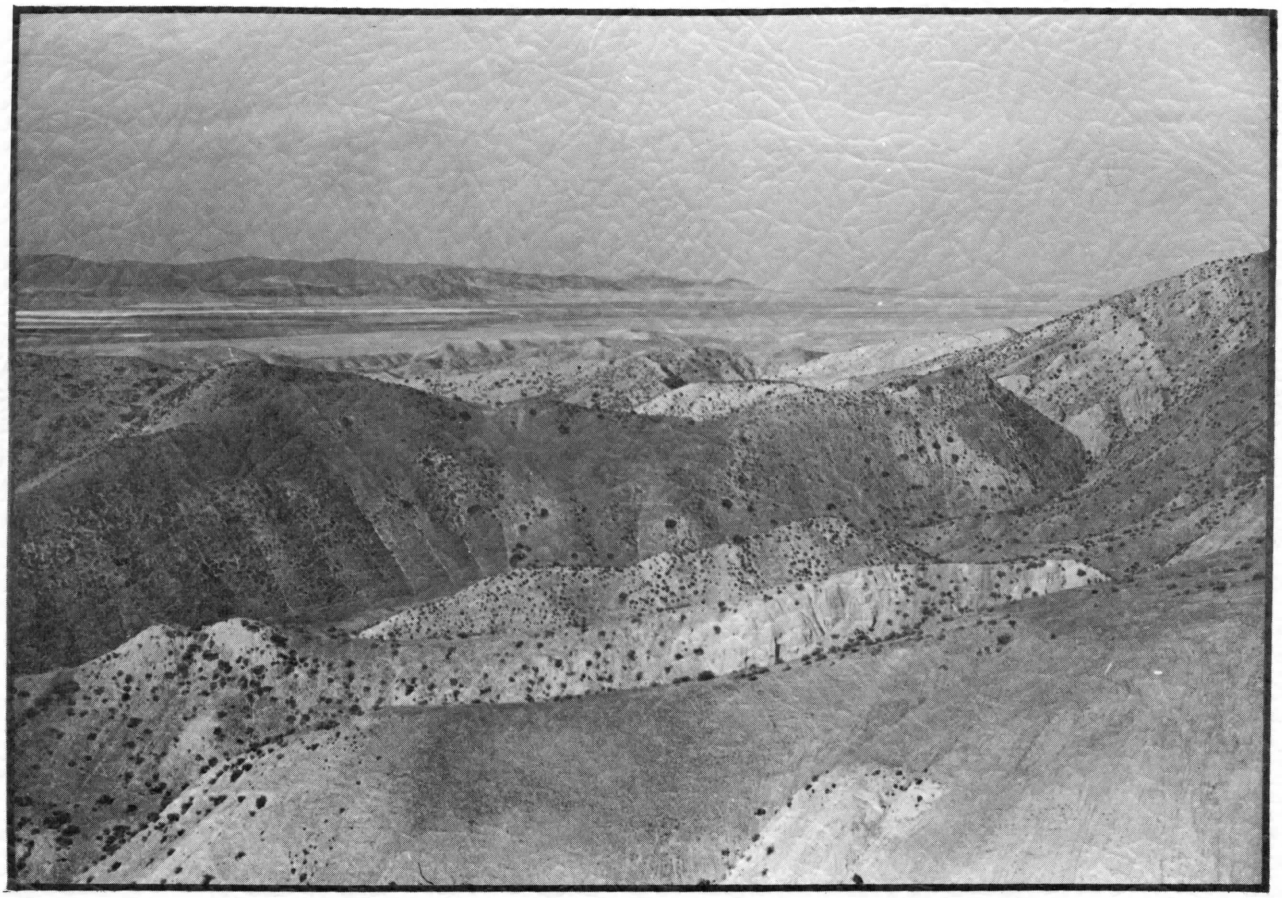
TEMBLOR RANGE RESEARCH

ANNUAL REPORT

1966-1967



UNIVERSITY OF CALIFORNIA

Departments of Agronomy - Davis, Riverside

This research is conducted by the Agronomy Department in accordance with Supplement No. 3 to the Master Memorandum of Understanding between the Bureau of Land Management, Department of the Interior, and The Regents of the University of California. Effective date of Supplement is September 13, 1963.

The work is supported in part by grants from the Counties of Kern and San Luis Obispo emanating from Taylor Grazing Fees.

Again we wish to express our thanks to the Boards of Supervisors of Kern and San Luis Obispo Counties, Farm Advisors James Clawson and Roy Parker, and officials of the Bureau of Land Management. The continued interest and help of Mr. Carl Twissleman is also acknowledged.

Mr. Jerry Chatterton continues to work on the ecology and physiology of allscale for the M.S. degree. Mr. Lance Evans will be working on the asphalt emulsion studies as part of the requirements for the M.S. degree. Cameron Duncan and Philip McGoldrick of Riverside will be assisting Mr. Chatterton and Mr. Evans. Richard E. Owen will be assisting in the projects originating from Davis.

The cooperation of the San Luis Obispo County Office of the Agricultural Commissioner in poisoning the rodents is acknowledged. Without their continuing control efforts it would not be possible to do range seeding research in this area.

Thanks are also due Dr. W. E. Martin of the U.C. Agricultural Extension Service, Davis, for greenhouse fertility studies on Temblor soils.

R. Merton Love, UCD

Burgess L. Kay, UCD

Cyrus M. McKell, UCR

September 1, 1967

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Davis, Riverside
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Introduction

Two new grassland sites were selected for species adaptation and establishment studies. The advice and assistance of the Bureau of Land Management and the Farm Advisors of Kern and San Luis Obispo Counties was sought in selecting these sites and all involved seem satisfied with the locations. It is hoped that information gained from these sites will be applicable to a wide area.

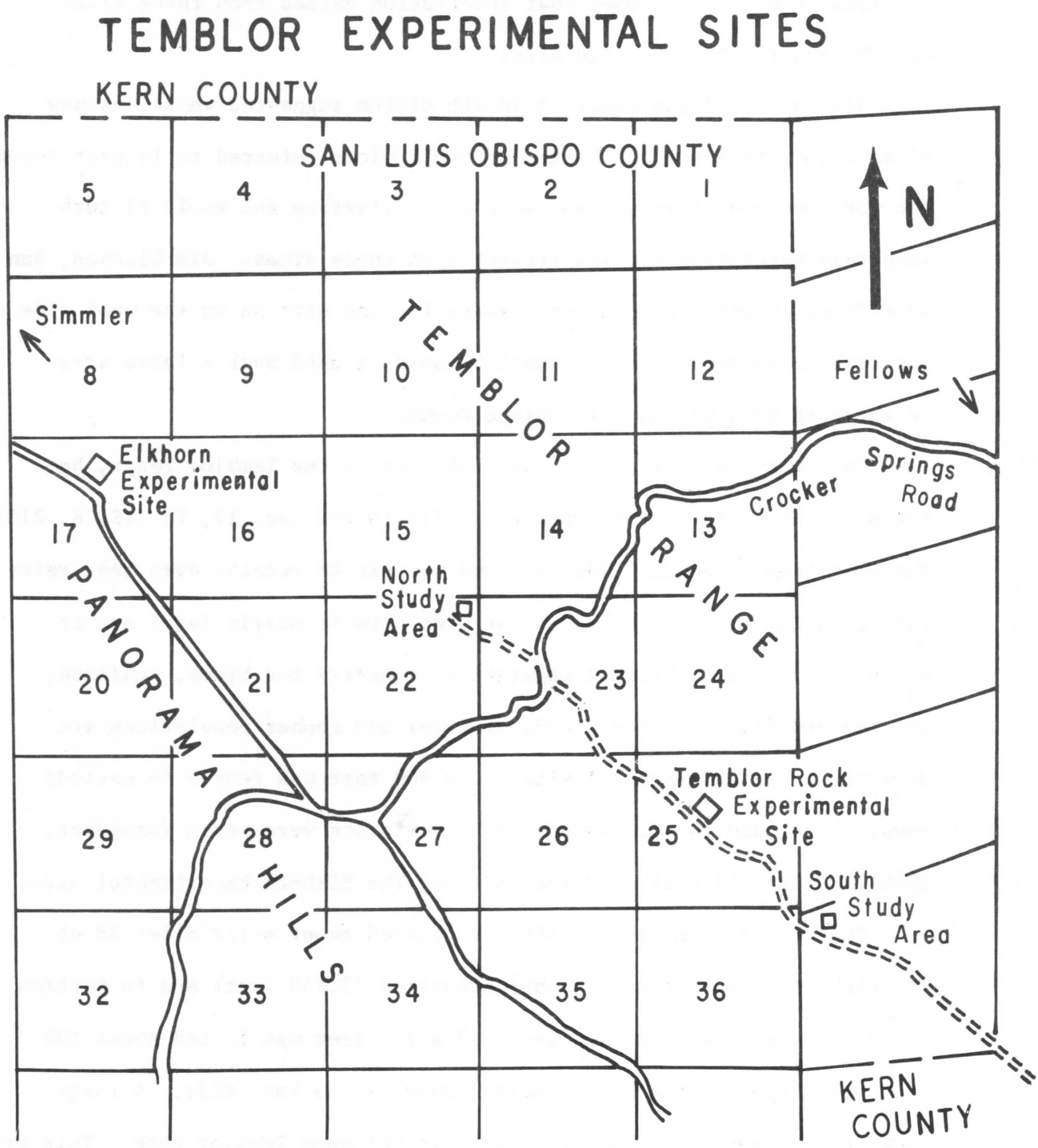
Jim Garner of the Bakersfield BLM office suggested we select new sites rather than use the North and South plots referred to in past reports. The work proposed involves spraying or cultivating and would disturb long term vegetation studies presently on these areas. Jim Clawson, San Luis Obispo County Farm Advisor, suggested one site be on the west side of the Temblor Range as the information could be used over a large area in the east part of San Luis Obispo County.

One site was selected on the west side of the Temblor range, between the Temblors and the Panorama Hills (N 1/2 Sec. 17, T. 31S, R. 21E). The elevation is about 2,500 feet and appears to receive even less rainfall than the top of the hill. The plot site is nearly level and is shrub free. The herbaceous vegetation is mostly red brome, schismus, and redstem filaree. The ground squirrel and gopher populations are very high. An experimental site 400 x 400 feet was fenced to exclude cows, sheep, and rabbits before any experiments were begun (November, 1966). This site will be referred to as The Elkhorn Experimental Site.

The second experimental site is located about 4-1/2 miles SE of the Elkhorn Site, but at a higher elevation (3,150 feet) and in Section 25 of the same township. An area 230 x 290 feet was fenced about 100 feet below the crest of the Temblor Range on the East side. A large rock in the center of this site gives it the name Temblor Rock. This site

is about 1 mile NW of the South Temblor Plot referred to in past reports. The vegetation is mostly red brome and redstem filaree, with no shrubs. Gophers are a problem.

A fertilizer study on malpais bluegrass was initiated at the North Temblor site, and the saltbush (Atriplex sp.*) study was continued at the site north of McKittrick.



*Consult appendix 1 for a list of common and scientific plant names used in this report.

I WEATHER CONDITIONS

Table No. 1 gives the 1966-67 data for precipitation in the North Exclosure, Elkhorn, and Temblor Rock sites. Early rains, one in late September, the other in early November, produced false germinations. A portion of the seed present germinated and the plants lived a few weeks and died. The true opening occurred from rains in early December. Plant growth continued into late April. Resident plants were mature by mid-May.

Winter temperatures were not measured, but were generally agreed to be below normal.

As a basis for considering results of the field work on the Temblor Range the Elkhorn plains and the area north of McKittrick a graph of rainfall received at Maricopa is included (Figure 1).

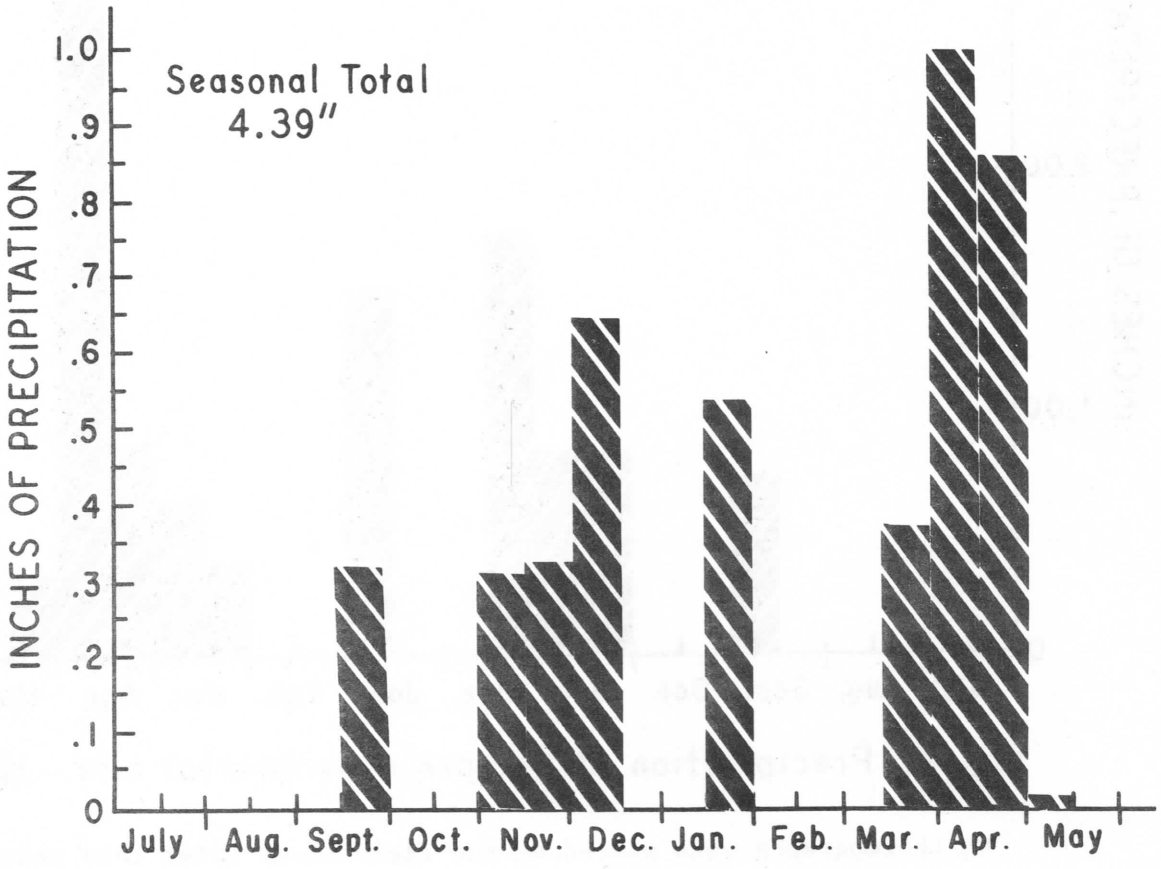


Fig. 1. Precipitation at Maricopa Station - 1966-67

The major portion of precipitation was received in early December and again in April. The season total of 4.39 is lower than the long term average of 5.86 inches for the general area. Cold weather during the wet period tended to keep plant growth to a low level during the winter months, but the above normal April rainfall increased plant growth. A similar graph of rainfall at the Elkhorn experimental site is included for comparison (Figure 2).

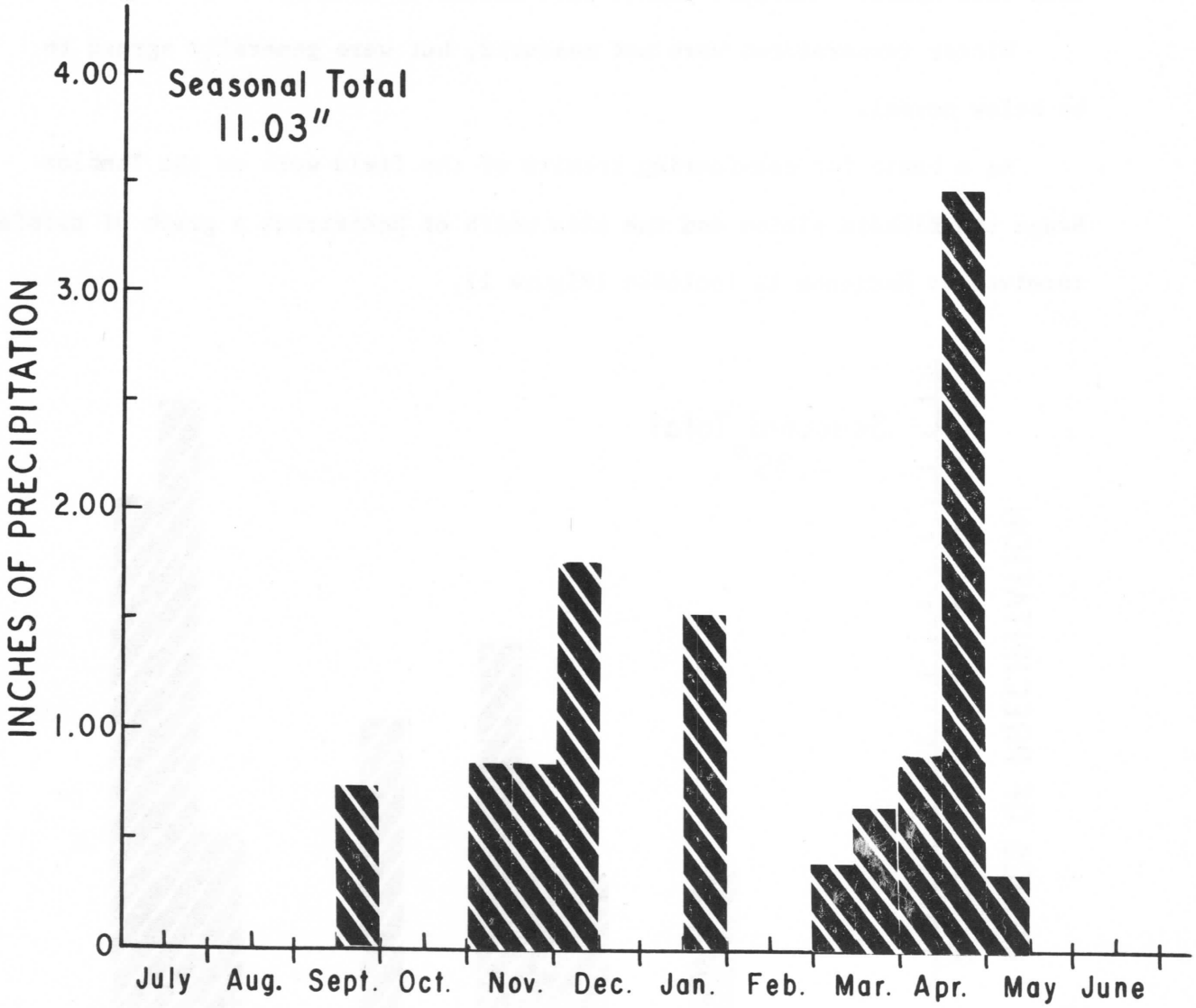


Fig. 2. Precipitation at Elkhorn experimental site - 1966-67

No thermographs were placed at the field study sites this year because of difficulties of making weekly maintenance trips. As more intensive seedling establishment work warrants in 1967-68 they will again be placed

in the field.

Average readings of gypsum blocks placed in the soil in 1965 at the North exclosure indicated that below 12" in the soil no degree of moisture in the plant growth range remained on May 6, 1967. Readings on that day were 4.3, 26.9 and 46 bars of section at 12, 24 and 36 inches depth, respectively. Implications of this are clear for perennial grasses such as Malpais bluegrass which must exist only on soil moisture in the upper levels of the soil and go into dormancy during the hot dry summer.

Table No. 1

Precipitation, Temblor Range, 1966-1967, November 2 - May 17

Date gauge read	North Exclosure	Temblor Rock	Elkhorn
1966			
Oct. 5	0.70	0.70*	0.70*
Dec. 13	4.50	3.66	3.45
1967			
Jan. 25	1.20	1.25	1.02
Mar. 4	0.45	0.45	0.50
17	0.65	0.55	0.65
Apr. 3	0.85	1.31	0.90
27	3.55	3.19	3.49
May 3	0.20*	0.20	0.15
17	0.13*	0.13	0.17
Total Oct. 5 - May 17	12.23	11.44	11.03

* Estimated from other gauge.

II ATRIPLEX STUDY

During the 1966-67 season considerable progress was made in the saltbush study north of McKittrick. Agreement for use of the study site was obtained from the Bank of California, Trustee for the Martha Lundin Trust and from Union Oil Company, holder of an exploratory drilling lease. Permission and enthusiastic participation from Mr. Carl Twisselman, lessee for surface grazing, has been most important.

Preparation for three general land and vegetation treatments is nearly complete, except for fencing. Carl Twisselman provided for the disking (Fig. 3) and the shrub topping treatments (Fig. 4). The other treatment was an untouched area to serve as a comparison.

Studies initiated by Mr. Jerry Chatterton, a graduate student, included an analysis of soil characteristics, soil salt content, soil moisture depletion and plant observations. He also has initiated seed germination and salt tolerance studies of atriplex in the greenhouse at UC Riverside.

A. Soil Characteristics

Results of the soil analysis on samples taken from 0 to 48 inches depth under saltbush and in the open spaces between plants indicate some very large differences (Tables 2 and 3). For example, calcium, magnesium, and sodium are in higher concentration under saltbush shrubs than in the open spaces. The difference between the two locations continues to exist even at a depth of 4 feet. Other elements such as phosphorus boron and potassium are higher under the saltbush cover but at 48 inches there is no difference between the concentration of these two elements in sites under shrubs and open spaces.

B. Soil Moisture

Soil moisture patterns were studied in the saltbush area during the year and reveal the extent of aridity that prevails in the area. Two types

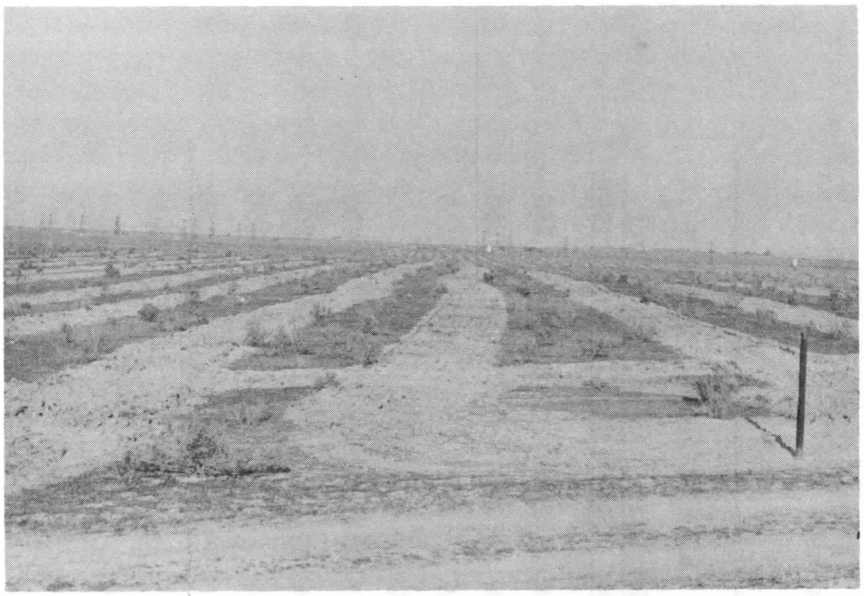


Fig. 3. Field of atriplex disked in strips.

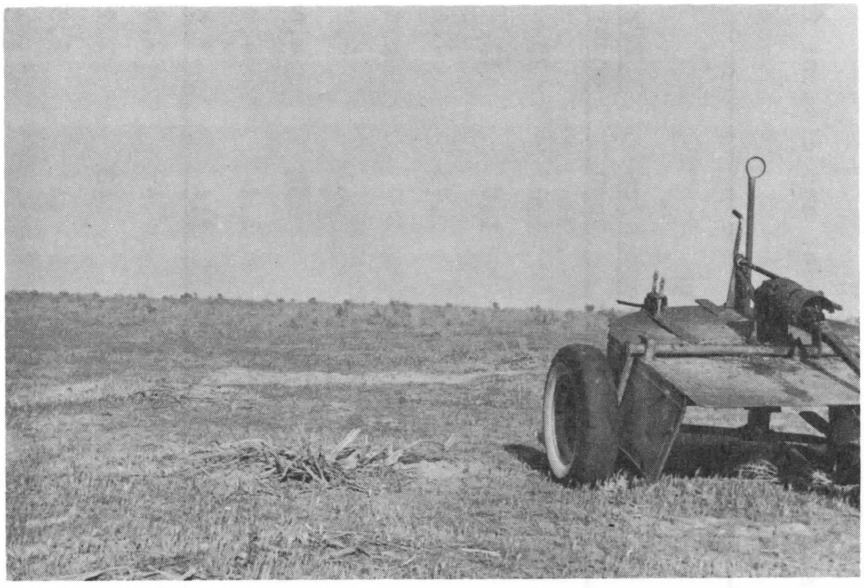


Fig. 4. Atriplex plant after being chopped with cotton chopper at right.

Table No. 2.

Analysis of soils taken from under and distant from atriplex plants.

Date	Depth	EC_c millimphos/cm		P PPM Soil		K PPM Soil		Total N PPM Soil	
		under	open	under	open	under	open	under	open
Dec. 3, 1966	0-2"	3.1	1.0	27	11	798	284	1050	750
	2-4"	2.0	1.0	12	6.0	898	260	600	350
	4-6"	1.6	.73	7.6	7.6	546	228	350	250
	6-8"	1.4		6.8		210		350	
	12"	6.1	.61	6.0	7.6	127	109	300	200
	24"	3.7	.58	4.6	5.0	86	97	200	200
	36"	3.9	1.1	4.0	3.6	184	74	200	150
	48"	6.9	2.4	7.6	7.0	90	71	300	150
Mar. 4, 1967	0-2"	1.1	.49	7.6	6.4	998	248	650	500
	2-4"	.89	.40	2.2	3.2	700	160	350	300
	4-6"	.86	.41	2.8	3.0	308	143	300	250
	6-8"	.94	.36	2.0	2.2	94	109	250	250
	12"	1.7	.42	2.0	2.0	57	73	250	250
	24"	.62	.46	3.2	2.4	53	54	200	200
	36"	.44	.41	2.0	2.2	51	59	100	150
	48"	.50	.50	1.6	2.8	58	49	100	150

Table No. 3.

Analysis of soils taken from under and distant from atriplex plants.

Date	Depth	Ca me/l		Mg me/l		Na me/l		Cl me/l		B me/l	
		under	open	under	open	under	open	under	open	under	open
Dec. 3, 1967	0-2"	12.0	9.0	4.3	1.2	12.8	1.8	7.8	0.3	1.2	.90
	2-4"	8.4	8.4	.5	1.4	10.1	2.6	7.6	2.2	.90	.40
	4-6"	6.4	5.0	1.4	2.8	8.7	2.7	6.6	1.2	.75	.50
	6-8"	6.4		1.9		9.2		4.6		.55	
	12"	34.2	5.8	2.6	.8	27.4	1.8	36.1	1.0	.35	.35
	24"	24.0	3.2	1.0	.3	11.5	4.0	17.8	1.1	.35	.35
	36"	17.9	1.6	1.9	.1	17.6	9.4	22.8	2.7	.25	.60
	48"	43.2	4.5	1.6	.4	44.4	18.3	21.2	8.7	2.1	1.5
Mar. 4, 1967	0-2"	2.4	2.8	1.6	2.0	7.3	.9	1.4	.8	1.2	.30
	2-4"	2.2	3.8	.3	.7	7.6	1.1	1.4	.9	.85	.30
	4-6"	2.6	2.9	.2	1.3	8.7	1.3	1.5	.9	.80	.30
	6-8"	2.6	3.0	.2	.7	8.5	1.3	2.3	.8	.55	.55
	12"	7.6	3.3	.9	.9	8.7	1.3	11.1	1.2	.60	.55
	24"	3.3	3.4	.7	.3	2.8	1.5	2.4	1.7	.65	.60
	36"	1.8	2.5	2.7	.7	2.4	1.8	.8	.7	.70	.50
	48"	1.8	1.6	.4	1.1	3.6	3.9	1.0	.9	.75	.70

of moisture measurements were made (Tables 4 and 5). On a percent basis there appears to be more moisture under shrubs than in the open spaces. At 3 feet and below there was no appreciable change in moisture during the first 6 months of 1967. Only in the surface foot of soil was any moisture available for plant use. After March even this part of the soil profile appears to be devoid of moisture for plant growth.

Measurements of soil moisture in the next year will compare the treated areas and untreated areas with respect to moisture availability.

C. Atriplex Growth Under High Levels of Salinity

A preliminary survey in the greenhouse compared growth of young plants of atriplex at levels of sodium chloride in Hoagland's Solution ranging from 0 to 15,000 parts per million. No visible differences in rate of growth or plant habit were obtained. Further study of this problem will be developed to determine how atriplex is adapted ecologically and physiologically to growth in high salt content soils.

III SPECIES ADAPTATION

A. Old trials.

Examination of the trials seeded at the North and South exclosures in 1964-65 and 1965-66 shows mostly severe rodent activity. Very little will be learned from seeding trials if rodents are not kept in check. The entire area has the appearance of having been plowed. Previous reports indicate that viable seed was set by some of the species tested, but the seed was apparently eaten by the rodents.

One perennial grass species, erect brome introduced from Turkey, has survived at both locations. Why this one of the several perennial grasses seeded was able to survive the rodent activity is not known. However the fact that a seeded perennial is surviving is a milestone in the testing

Table No. 4.

Moisture (% by volume) measured under and distant from atriplex plants by a neutron moisture probe.

Date	Depth 1 ft.		3 ft.		5 ft.		7-1/2 ft.		10 ft.	
	under	distant	under	distant	under	distant	under	distant	under	distant
Dec. 30, 1966	18.5	15.0	15.2	12.3	11.0	12.5	10.4	10.8	11.9	8.1
Jan. 29, 1967	18.0	15.3	15.5	13.0	10.8	12.4	10.3	10.8	11.6	8.1
Mar. 4, 1967	14.3	12.1	14.8	13.1	10.8	12.5	9.9	10.8	11.6	7.9
Apr. 3, 1967	13.4	10.7	15.0	13.4	11.0	12.6	10.0	10.8	11.7	7.8
May 6, 1967	13.4	11.6	14.8	13.0	10.8	12.2	9.7	10.9	11.6	7.8
June 2, 1967	12.4	10.5	14.7	13.7	10.6	12.3	9.8	10.6	11.7	7.8

Table No. 5.

Moisture (bars suction) measured under and distant from atriplex plants by resistance blocks.

Date	Depth 1 ft.		3 ft.		5 ft.		7-1/2 ft.		10 ft.	
	under	distant	under	distant	under	distant	under	distant	under	distant
Dec. 19, 1966	4.4	5.0	52.2	52.2	51.5	49.0	47.5	46.0	48.0	51.1
Dec. 30, 1966	4.4	5.6	50.8	52.0	50.8	46.2	47.0	49.0	43.6	47.0
Jan. 29, 1967	7.3	8.4	50.8	53.5	50.8	52.0	43.0	49.5	47.0	49.5
Mar. 4, 1967	27.6	18.8	50.8	52.0	49.5	50.0	46.0	45.0	41.2	47.0
Apr. 3, 1967	33.6	33.3	53.4	53.8	50.3	51.4	45.6	48.0	41.8	47.6
May 6, 1967	36.8	27.2	54.5	53.0	52.0	50.8	45.0	46.0	40.5	47.0
June 2, 1967	35.6	33.6	48.9	51.8	50.2	48.5	43.2	45.0	37.8	45.6

program. The fact that the area will support perennial grasses is borne out by the presence of the three resident bunchgrasses-malpais bluegrass, nodding stipa and beardless wild rye.

B. Current trials.

A species adaptation trial was established at each of the new experimental sites. The trials consist of 29 legumes (mostly annuals) and four perennial grasses. Three of the perennial grasses produced some flowers the first season at both sites. This is an encouraging expression of vigor. These three grasses were hardinggrass, Davis slender wheatgrass, and kangaroo valley ryegrass. Palestine orchardgrass made excellent seedlings, but no flowers.

Of the legumes seeded, the following looked the most promising: Clare subclover, bur clover, 173 barrel medic, and Hykon rose clover. In addition Yamina cup clover looked good at the Elkhorn site. All species were slightly later at the Temblor Rock site. A complete list of species tested and establishment, production, and seeding data appear in Table No. 6.

When studying the data in Table No. 6 it is important to remember that this was a relatively long growing season. Many of the species which successfully produced seed this year would not be expected to do so every year at this site. Many species which showed the greatest vigor on May 17 will probably not have a place on the Temblor as the growing season will commonly be terminated before this date.

Rodent control will be maintained if possible in order that survival over the next few years can be measured. Also the most promising species will be sown in future trials.

The following details of planting and weather conditions have an important bearing on the outstanding seeding results:

Table No. 6

Plant introductions in 1966-67 species adaptation trials at Elkhorn and Temblor Rock.

	ELKHORN			TEMBLOR ROCK		
	Vigor*		Maturity stage	Vigor*		Maturity stage
	April 3	May 17	June 2	April 3	May 17	June 2
SUBCLOVER VARIETIES (*Trifolium subterraneum* L.)						
Tallarook	2.7	4.7	seed ripe	2.3	1.7	no seed
Mt. Barker	2.7	3.3	no seed	2.3	1.3	no seed
Bacchus Marsh	3.3	4.3	shriveled seed	2.7	1.0	no seed
Woogenellup	3.7	5.0	seed ripe	3.7	2.7	early ripe
Clare	4.7	5.0	shriveled seed	4.3	3.0	seed ripe
Yarloop	4.0	4.3	seed ripe	3.7	2.3	seed ripe
Dwalganup	2.7	1.7	seed ripe	3.0	1.3	seed ripe
Geraldton	3.3	1.3	seed ripe	2.3	1.0	seed shriveled
Dinninup	3.3	3.7	seed ripe	3.0	1.3	seed ripe
ROSE CLOVER VARIETIES (*Trifolium hirtum* All.)						
Wilton (Calif. Cert.)	2.3	3.3	plant and seeds green	2.0	2.2	late bloom
P.I. 170821	2.7	4.7	plant and seeds green	1.7	1.7	late bloom
Kondinin	4.0	5.0	seed ripe	3.7	2.7	head green
Cyprus	3.7	4.7	seed ripe	3.3	2.8	50% heads green
Hykon	5.0	4.3	seed ripe	4.0	3.3	50% heads green
Troodos Th 59 g	3.7	3.7	seed ripe	2.0	2.0	seed ripe
Sirint	3.3	3.3	seed green	3.0	2.0	seed ripe
Th 52	3.0	5.0	plants and heads green	3.0	4.0	plant and heads green
S-6	3.3	5.0	heads green	2.7	4.7	plant and heads green

(continued)

Table No. 6 (cont'd)

	ELKHORN			TEMBLOR ROCK		
	Vigor*		Maturity stage	Vigor*		Maturity stage
	April 3	May 17	June 2	April 3	May 17	June 2
MEDICS (Medicago spp.)						
Bur clover (M. hispida Gaertn.)	5.0	4.7	seed ripe	4.0	4.3	seed ripe
Black medic (M. lupulina L.)	2.0	3.3	plant green-no seed	2.0	2.3	no seed
173 barrel medic (M. tribuloides Desr.)	5.0	4.7	seed early ripe	3.7	5.0	seed green
Cyprus barrel medic (M. tribuloides Desr.)	4.7	4.0	seed ripe	3.3	2.7	seed green
MISCELLANEOUS LEGUMES						
Dixie crimson clover (T. incarnatum L.)	3.3	3.0	no seed	2.7	1.0	no seed
Purple clover (T. purpureum Loisel.)	4.7	4.3	seed early ripe	3.7	1.0	late bloom
Beenong cup clover (T. cherleri L.)	2.3	1.0	green seed	2.0	1.0	green seed
Yamina cup clover (T. cherleri L.)	3.3	4.0	seeded	2.7	2.0	seeded
Hairy canary clover (Dorycnium hirsutum (L.) Ser.)	1.0	1-	no seed	1.0	1-	no seed
Lana woollypod vetch (Vicia dasycarpa Ten.)	5.0	5.0	green seed	5.0	5.0	some seed
Auburn woollypod vetch (Vicia dasycarpa Ten.)	5.0	5.0	green seed	5.0	5.0	no seed
ANNUAL GRASSES						
Gaudin ryegrass (Lolium gaudini Parl.)		4.7	seed ripe		5.0	seed ripe

(continued)

Table No. 6 (cont'd)

	ELKHORN			TEMBLOR ROCK		
	Vigor*		Maturity stage	Vigor*		Maturity stage
	April 3	May 17	June 2	April 3	May 17	June 2
PERENNIAL GRASSES						
Hardinggrass (*Phalaris tuberosa* var *stenoptera* (Hack.))			one plant headed-others vegetative			few plants headed
Palestine orchardgrass (*Dactylis glomerata* L.)			green-vegetative			green-vegetative
Davis slender wheatgrass (*Agropyron trachycaulum* (Link.) Malte var. *major*			anthesis			few plants headed
Kangaroo Valley ryegrass (*Lolium perenne* L.)			late anthesis			anthesis

* Vigor was rated on a 1-5 basis, 1 being poor and 5 excellent. Data are means of three replications.

1. Weed control - the site was sprayed with paraquat at 0.5 lb/acre on the evening of December 14, 1967. The resident vegetation was 1-2 inches high. Additional weed control was achieved by the furrows.

2. Site preparation - furrows 6 inches wide and 3-1/2 inches deep were dug 6 feet apart on December 15, 1967.

3. Soil moisture - 3.45 inches of rain had fallen prior to planting at the Elkhorn and 3.66 inches at the Temblor Rock.

4. Inoculation - legumes were pellet inoculated with extremely high rates of appropriate bacteria on November 15 in anticipation of planting on November 16. However, soil conditions proved too dry and the pelleted seed was stored under refrigerated conditions until immediately before planting. Then the pellets were dusted with fresh bacteria-peat culture immediately before planting into moist soil. Only one furrow was opened at a time and was seeded by hand and covered immediately in an effort to keep the peat and soil from drying out.

5. Seeding - eight grams of seed were planted in 4 feet of row and covered immediately to a depth of about 3/4 inch. A dam was placed in the furrow every four feet to keep the water and seed from moving from plot to plot.

6. Fertilizer - one pound of single super phosphate was added to each 48 feet of row. At this stage we didn't know what the nutrient status of these soils was and P and S were added as insurance. Actually the fertilizer would probably not be necessary at either site.

7. Rodents were controlled throughout the growing season by poisoning. The San Luis Obispo County Agricultural Commissioner has been of great assistance in poisoning the two new experimental areas.

IV SOIL FERTILITY

A. Greenhouse pot study of soil from Elkhorn and Temblor Rock sites.

Soils were collected from each of the two new experimental sites. Dr. W. E. Martin of the U. C. Agricultural Extension Service, Davis, conducted a greenhouse study using clare subclover as an indicator plant. Zinc was shown to be deficient on both soils. However, Dr. Martin doubts that zinc would be a major problem in the field.

Both soils are slightly deficient in phosphorus, but again not enough to be a major problem. Sulfur is quite deficient at the Temblor Rock site, but not at Elkhorn. For full results of pot tests see Table No. 7. The difficulty in wetting the soil experienced in earlier tests was not noticed in these soils.

A fertilizer test in the field is planned for both sites in the 1967-68 season. Plant responses to zinc and sulfur will be measured after planting a mixture of annual clovers for use as indicator plants.

B. Field trial on malpais bluegrass.

On many occasions it has been observed that the perennial bluegrass (Poa scabrella) in the 10 acre exclosures are green after the annual plants mature. On the Temblor Range in general and on the north slopes in particular the growth of the bluegrass appears to be an important component of the vegetation. Because of the obvious adaptation of this species for the difficult environment of the Temblor Range, we decided to study this species. Our studies this year on bluegrass deal with its growth habit, response to temperature, and production under levels of fertilization.

a. Growth habit.

Plants of bluegrass remain dormant during the long dry summer and in the fall green-up only a little earlier than the annual grasses and filaree. Under protection from grazing the size of each plant is larger

Table No. 7

Response of clare subclover to fertilizers in the greenhouse on two Temblor Range soils.

Treatment	Relative yield - percent Elkhorn	Temblor Rock
Check	70.0**	51.2**
Full fertilizer @ P_{67}*	100.0	100.0
Full minus P	69.1**	73.4**
" " K	90.3	92.0
" " S	69.5**	39.6**
" " Mo	97.8	98.3
" " Zn	70.7**	72.8**
Full plus N	--	126.9**
" " B	94.5	89.4
" " Ca	102.0	98.4
Soil analysis P (ppm)	12.6	12.6
Zn (ppm)	0.55	0.20
pH	7.65	7.40

* Full includes P, K, S, Mo, and Zn, but no nitrogen. N is supplied by bacteria on the clover roots.

** Statistically significant difference at the .05 level as compared to full fertilizer @ P_{67}.

than where unprotected. From soil moisture studies it appears that bluegrass plants depend on moisture mainly in the surface foot or more of soil and do not obtain moisture from deeper soil levels.

b. Bluegrass fertilizer study in the field.

On November 1, 1966 4 rates of fertilizer were applied to plots in the north exclosure on Temblor Range. The rates of fertilizer were (1) 100# N + 44# P/acre, (2) 66# N + 28# P/acre, (3) 33# N + 14# P/acre and (4) no fertilizer. Each plot measured 10 x 20 feet.

On December 3, 1966 granular Eptam was applied by hand to 1/2 of each of the fertilizer plots at the rate of 8 lbs/acre. On March 7, 1967 the same 1/2 was sprayed with 2,4-D amine at 1.0 lb/acre in an effort to control filaree.

On June 3, 1967 2 sq. ft. were harvested from each plot (1 sq. ft. in the Eptam-2,4-D applied area and 1 sq. ft. in the no Eptam-2,4-D area) and the dry weight recorded. No attempt was made to separate the bluegrass from the other material because on May 6, 1967 it was observed that sheep had entered the enclosure and selectively grazed the bluegrass in the fertilizer plots. Because of the grazing, not one bluegrass clump had gone to head.

Results

The high rate of fertilizer increased total forage yield by 4 times (Table 8) and in all cases the yield was decreased by Eptam. There was no observed increase in the growth of the bunches of bluegrass with Eptam, even though it was expected that the reduction in annual grass competition would encourage growth of the bluegrass. Grazing by the sheep prevented any observation of the response of the bluegrass.

The yield of forage on untreated plots was about the same as the forage yield measured on untreated range on plots of the Elkhorn plains.

Table No. 8

Yields in lbs/acre from fertilizer treatments on top of Temblor.

Treatments	Control	33# N/acre + 14# P/acre	66# N/acre + 28# P/acre	100# N/acre + 48# P/acre
No Eptam	623.4	1131.6	1678.2	2589.3
8# Eptam/acre	431.6	671.3	1227.5	2129.0

c. Temperature and fertility studies in the greenhouse.

Malpais bluegrass from the Temblor Range was transplanted into greenhouse pots containing one kilogram of Temblor soil mixed with 200 grams of vermiculite to facilitate drainage and aeration. The bluegrass was grown for two weeks in the greenhouse without any fertilization. Then each pot was clipped to about 1-1/2 inches above the crown and half of the fertilizer was applied. Two weeks later the remaining half of the following fertilizer rates were applied: 0, 50 N, 100 N, 44 P, 44 P + 100 N, 44 P + 100 N + 20 S, 100 N + 20 S and 20 S. Clippings were taken every two weeks for yield and further analysis. Half of the pots were grown in the greenhouse under temperatures ranging from 65° to 80°F. The other half were grown in a growth chamber with day temperature constant at 55°F and nights 45°F.

The Malpais bluegrass showed increased growth with increased rates of nitrogen and phosphorus fertilization but showed depressed growth with sulfur treatments (Table 9). The response to nitrogen and phosphorus was greater at the 45-55° temperature range than at the 65-80°F range. At the lower temperature range (similar to actual spring temperatures on the Temblor Range), the application of 100 lbs/acre of N doubled the yield while at the

Table No. 9

Yields of Malpais bluegrass from fertilizer treatments in the greenhouse.

Fertilizer treatments (lbs/A)	Yields			
	Greenhouse (65°-80°)		Growth Chamber (45°-55°)	
	gms/pot	lbs/A	gms/pot	lbs/A
Control	.898	431	.873	419
50 N	.980	470	1.520	730
100 N	.997	479	1.790	859
44 P	1.201	576	1.006	483
44 P + 100 N	1.416	680	2.446	1174
44 P + 100 N + 20 S	1.292	620	2.338	1122
100 N + 20 S	.873	419	1.782	855
20 S	.618	297	.612	294

higher temperatures there was only a slight increase. The highest yields were obtained from the application of 100 lbs/acre N + 44 lbs/acre P. In all cases the addition of sulfur to any nitrogen and/or phosphorus treatment reduced the yield slightly. Sulfur treatment alone yielded least of all. These results suggest that fertilization with nitrogen and phosphorus would stimulate the growth of Malpais bluegrass on the Temblor. Results are similar to those obtained with soft chess in the previous year. Sulfur is not required for the particular soil found on the summit of the Temblor Range, while 2 miles SE a response was obtained at the Temblor Rock Experimental Site.

V SEEDING TECHIQUES

An experiment was established at the Elkhorn site to compare various weed control techniques, dates of planting, and planting methods (furrow vs direct drilling) on the establishment of four forage species (Hykon rose

clover, bur clover, Davis slender wheatgrass, and hardinggrass).

Weed control techniques being tested are soil active herbicides (atrazine applied at 2 rates in December 1966), contact herbicide as a fallow treatment (paraquat applied on March 1, and again on April 26, 1967), cultivation in the spring as a fallow treatment (rototilled on March 1, and again on April 26, 1967), cultivated in the fall after the opening rain, sprayed with paraquat in the fall after the opening rain, and no weed control.

Seeding techniques will compare shallow drilling with deep furrow drilling - both before the opening rain and again about 2 weeks after the opening rain - in each of the weed control treatments listed above.

Under the dry conditions that prevail in this area it will probably be necessary to have some fallow moisture present to consistently enjoy planting success, particularly of perennial grasses. Equally important is the suppression of the resident vegetation during this critical establishment period.

Soil moisture is being measured at 12 inches, 24 inches, and 36 inches in all four replications of each of the weed control treatments listed above. It appears a soil active herbicide may be necessary to produce any fallow effect. Both cultivation and spring paraquat applications fallowed considerable moisture, but a crop of summer weeds (turkey mullein and annual spurge) threatens to use up this moisture. If either of these treatments is to be a true fallow it will be necessary to control these summer weeds.

VI PETROLEUM MULCH AS AN AID IN SEEDLING ESTABLISHMENT

The technique of spraying paraquat adjacent to seeded rows of range species to control competition has been shown to be effective in areas of California. One of the requirements for this technique is that it must come after the first rainy period and weed seedlings are established. Moist

soil for growth of the seeded species is also an advantage for success of the planting. However, in many locations temperatures are often unfavorable for seedling growth by the time favorable soil moisture exists. A preliminary trial was established in the fall of 1966 to utilize a petroleum mulch product to test its usefulness for increasing soil surface temperatures and for reducing weed competition.

Five species were drill seeded (one species per row) at a depth of 1/2 to 1 inch, in 22 inch row spacing, on December 15, 1966. Species seeded included 173 Barrel Medic, Davis slender wheatgrass, Kangaroo Valley ryegrass, Kondinin rose clover, and Mt. Barker subclover. Single super phosphate at a rate of 500 lbs/acre (44 lb of actual P) was placed 2-3 inches beneath the seed. On the evening before seeding the area to be planted was sprayed with paraquat at 0.5 lbs/acre. On December 19, 1966 a 6-inch band of petroleum emulsion was sprayed in 10-feet strips on seeded rows.

Height observations were made during the winter and on May 6 and on May 17, 1967 a meter of each row in the untreated, paraquat sprayed, and the paraquat plus emulsion treated areas were harvested and weighed.

Results from the paraquat-emulsion seedling establishment plots were very good. In February the height of plants in the petroleum mulch treated areas were about twice as tall as plants in the paraquat plots. This size difference increased through the balance of the growing season (Fig. 5a and b). Soil temperature just under the surface of the emulsion-treated areas averaged 10 to 15 degrees higher than the paraquat-treated areas. Some difficulty was found in obtaining good temperature data, however, and this will be carefully watched in the study planned for fall 1967.

Plant yields were about 4 times as large in the paraquat + emulsion as in the check plots (Table 10). The differences between yields from paraquat plus emulsion and paraquat only plots varied from no difference

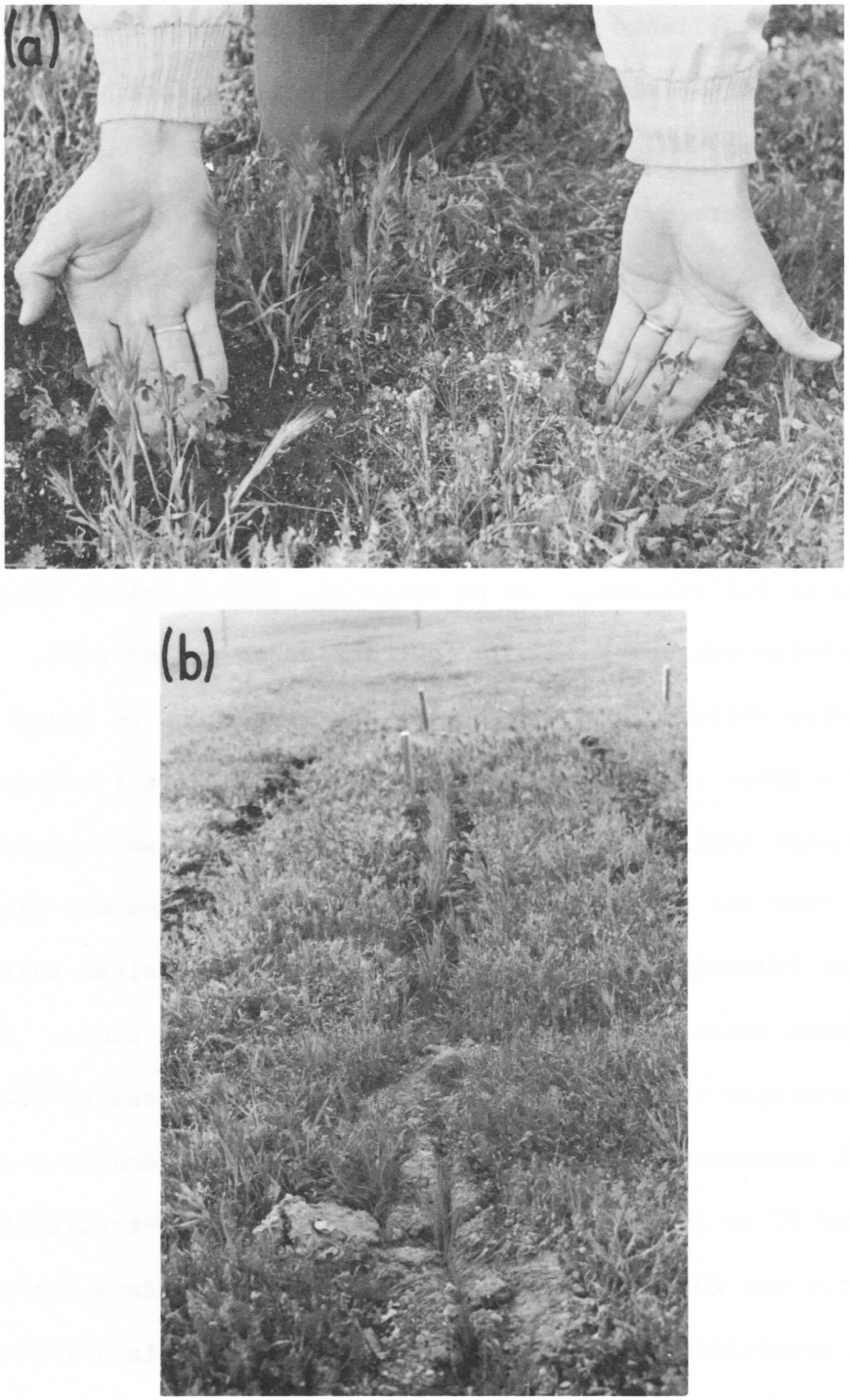


Fig. 5. (a) The size of plants increased in the asphalt emulsion area. The emulsion is seen at left. (b) Note the increased size and number of grass plants where the emulsion starts.

in barrel medic plantings to a near 4-fold difference for the Kangaroo Valley ryegrass.

Table No. 10.

Yields from seedling establishment with paraquat and asphalt emulsion showing actual yields and corrected for lbs/acre based on 1 ft. spacing.

Species	Units	Check	Paraquat	Emulsion + Paraquat
173 Barrel Medic	gm/m	2.9	10.1	8.8
	lbs/acre	84.8	295.4	257.4
Davis slender wheatgrass	gm/m	1.0	1.6	4.0
	lbs/acre	29.2	46.8	117.0
Kangaroo Valley ryegrass	gm/m	.3	1.1	4.5
	lbs/acre	8.8	32.2	131.6
Kondinin rose clover	gm/m	1.6	3.4	6.0
	lbs/acre	46.8	99.4	175.5
Mt. Barker subclover	gm/m	not	1.9	3.8
	lbs/acre	planted	55.6	111.2

Conversion Factor: 1 g/m = 29.25 lbs/acre

VII MISCELLANEOUS EXPERIMENTS

A. Control of plant numbers.

Paraquat was applied to the existing vegetation (red brome, schismus, and redstem filaree) on December 14, 1967. Rates of 0, 1/4, and 1/2 lb/acre were tested. Observations on January 26, 1967 indicated the vegetative cover at Elkhorn was reduced 40% at the 1/4 lb/acre rate and 99% at the 1/2 lb/acre rate, while weed control was nearly 100% at both rates at the Temblor Rock. Subsequent germination restored plant numbers to a very adequate population in all treatments. Weed control would be rated a failure.

Observations on May 17, 1967 indicated there was a difference in forage production on the three treatments - apparently due to the difference in plant numbers. Species composition did not appear to be different on the three treatments - only the number of plants present. Yields were measured and showed that the lower the population the greater the yield. Forage yields were nearly tripled by the 1/2 lb/acre rate (Table 11).

Table No. 11

Effects of early season paraquat treatments on end of season forage yields.

Paraquat rate lb/acre	Forage yield - lbs/acre Elkhorn	Temblor Rock
0	600	700
1/4	1,040	1,070
1/2	1,760	1,970
L.S.D. .05	520	560
.01	790	920

B. Trial herbicides.

To determine if certain chemicals could be used to select bromegrass from filaree or remove annual plants without damage to the perennial bluegrass several plots were treated. On November 1, 1966 2 and 4 lbs/acre rates of 4 experimental herbicides were applied to 10 x 10 ft. plots in the north enclosure on the Temblor Range. They were supplied by Geigy Chemical Company and designated 13528, 13529, GS17893 and GS18183. The effects of these herbicides were observed on June 3, 1967.

Results:

At the 4 lbs/acre rate, all but 13529 were more than 95% effective

in killing all plants in the plots (Table 12). Four lbs/acre of 13529 left 12% of the plot in filaree and 2 lbs/acre of 13529 left 40% of the plot living in filaree and red brome. The 2 lbs/acre rates of 13528 and GS18183 left a little brome (2% and 5% respectively) and 6 times more filaree (12% and 30%). GS17893 was the most destructive herbicide with only 2 lbs/acre killing 96% of the plot. It appears that lower rates should be used to retain more forage species on plots. Analysis of the plots will be made again in the fall to determine the effect on the perennial bluegrass and germination of annual species.

Table No. 12

Percent filaree and red brome in herbicide plots on Temblor, June 1967.

	Herbicide and Rate							
	13528		13529		GS17893		GS18183	
	2 lbs/A	4 lbs/A	2 lbs/A	4 lbs/A	2 lbs/A	4 lbs/A	2 lbs/A	4 lbs/A
Living Red brome	2%	trace	20%	3%	2%	trace	5%	2%
Living Filaree	12%	trace	20%	12%	2%	0	30%	3%
Plants Total dead	86%	98%	60%	85%	96%	99%	65%	95%

VIII WORK PLAN FOR 1967-1968

All promising lines of research will be continued in addition to emphasizing certain phases of study that may be the thesis research of graduate students. Mr. Jerry Chatterton will continue to study saltbush (Atriplex polycarpa) for his M.S. thesis which should be finished by June 1968. Mr. Lance Evans will start in August 1967 on an M.S. thesis problem dealing with seedling establishment in arid rangeland seedings.

A. Weather conditions.

Measurements of precipitation will be continued. Detailed measurements of soil temperatures will be made in connection with the asphalt emulsion study.

B. Atriplex manipulation study.

This study will be pursued with considerable intensity in 1967-68. Of concern will be plant growth moisture use or conservation and increased productivity as a result of the three treatments. Further observations on Atriplex ecology will be recorded.

C. Species adaptation.

Two extensive species adaptation trials are planned for the fall of 1967. Grasses, legumes, and shrubs are being collected from all available sources. Site preparation for the trials was started early in the spring of 1967 in an effort to control weeds and fallow moisture. Furrow type site preparation was selected because of the extra moisture accumulation.

An area in excess of one acre has been allocated at each of the Elkhorn and Temblor Rock locations. The sites were furrowed in March of 1967 and the weeds controlled during the spring and summer of 1967. The sites were sprayed with paraquat in March and again in April after late rains started another crop of weeds. The areas were sprayed again on July 6 with weed oil to control turkey mullein and annual spurge. Thus no weeds were allowed to set seed during the current growing season and some moisture was fallowed.

Replicated plantings of four 20-foot rows, 24 inches apart will be made in the fall of 1967. Rodent control will be continued throughout the life of the trial - beginning in the fall of 1966.

D. Field fertility trials.

A repeat of the study attempted in 1967 will be set up in 1968. The difficulty of sheep eating the bluegrass will be eliminated by fencing with sheep-proof fence the fertilized area. Plant tissues of bluegrass and annual grasses will be compared for their crude protein content. This may help explain why the sheep showed such a preference for the bluegrass in the previous year's study. Field fertilizer trials will be established at both new experimental sites to measure the effects of zinc and sulfur on the yield of seeded annual legumes.

E. Seeding techniques.

The trial started in 1966-67 will be planted in the fall of 1967. A new trial should be established on an adjacent area as any promising technique will have to be tested for more than one year. The primary emphasis of this work will be in creating soil moisture reserves by chemical fallow practices. Plots thus treated will serve as locations for plant introduction trials. Species that have appeared to be adapted to the Temblor area in previous adaptation trials will be studied in 1967-68. A new technique of studying seed germination over a range of temperatures will be employed to compare introduced species and resident weeds in their optimum temperature requirement. Data thus obtained will be used in interpreting results from field trials where temperature and soil moisture will be subject to moderate control in seedbed and seedling environment modification using paraquat and asphalt emulsion.

APPENDIX 1

Species List: Common and Scientific Names Used in Text

Grasses

Beardless wild rye	Elymus triticoides Buckl.
Bromegrasses	Bromus spp.
Blando brome	B. mollis L.
Erect brome	B. erectus Huds.
Fibrous brome	B. fibrosus Hack.
Red brome	B. rubens L.
Falujagrass	Phalaris tuberosa L. (Faluja)
Hardinggrass	Phalaris tuberosa var. stenoptera (Hack.) Hitch.
Kangaroo valley ryegrass	Lolium perenne L.
Maire fescue	Festuca mairei St. Yves
Malpais bluegrass	Poa scabrella (Thurb.) Benth ex Vasey
Nodding stipa	Stipa cernua Stebbins and Love
Orchardgrass	Dactylis glomerata L.
Palestine orchardgrass	Dactylis glomerata L. (Palestine)
Perlagrass	Phalaris tuberosa var. hirtiglumis Trabut ex Batt. & Trabut.
Ricegrass	Oryzopsis sp.
Indian ricegrass	Oryzopsis hymenoides (R&S) Ricker
Ryegrasses	Lolium spp.
Gaudin ryegrass	L. gaudini Parl.
Wimmera 62	L. rigidum Gaud.
Schismus	Schismus arabicus Nees.
Smilo	Oryzopsis miliacea (L.) Benth. & Hook.
Wheatgrasses	Agropyron spp.
Davis slender wheatgrass	A. trachycaulum (Link.) Malte var. major (Vasey) Fern.
Intermediate wheatgrass	A. intermedium (Host.) Beauv.
Oriental wheatgrass	A. orientale R & S

Legumes

Alfalfa	Medicago sativa L.
Fenugreek	Trigonella fenugraecum L.
Hairy canary clover	Dorycnium hirsutum (L.) Ser.
Rose clover	Trifolium hirtum All.
Sainfoins	Onobrychis spp.
Caucasian sainfoin	O. transcaucasia L.
Trigonella	Trigonella sp.
Arabian trigonella	T. arabica Del.

Others

Annual spurge	Euphorbia ocellata D. & H.
Bluebush	Kochia georgia Diels.
Fescue	Festuca sp.
Annual fescue	F. confusa Piper
Fiddleneck	Amsinckia douglasiana DC
Filaree	Erodium sp.
Redstem filaree	E. cicutarium (L.) L'Her

(continued)

Goldenbush	Haplopappus linearifolius DC
Saltbush	Atriplex sp.
Allscale	A. polycarpa (Torr.) Wats.
Four-winged saltbush	A. canescens (Pursh.) Nutt.
Shrubby Orache	A. halimus L.
Turkey mullein	Eremocarpus setigerus Benth.