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Soil Factors Influencing Water Uptake by Plants Under Desert Conditions

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ABSTRACT

Space-time variabilities of rainfall in desert areas are further complicated by soil differences and the spatial distribution of vegetative cover. This mosaic pattern is reflected in infiltration and soil water storage from a rainfall event and the disposition of the water. The first year activities included installation of sensors and measurements of soil water content and total psychrometric potential under a limited number of conditions. These first year data are of limited utility but are used in developing a more complete design for the 1974-75 activities. The results are consistent with data from the Santa Rita Site for psychrometric potential between -0.2 to-50.0 bars in the bare plots and for areas with vegetative cover. Leaf potential readings show similar trends to soil potential.

INTRODUCTION

This study is a continuation of the 1971 and 1972 investigations and is the first report of work at the Silverbell Validation Site. The report must be viewed as a preliminary contribution because of change in location from Santa Rita to Silverbell. Information from 1973 investigations are used in improving the experimental designs and the data acquisition program for 1974. The need for more intensive instrumentation continues to be a major factor for limiting the utility of results in predictive models of soil-plant-atmosphere system behavior.

OBJECTIVES

1. To measure spatial and temporal variations of water content, water potential and temperature within the root system of two major plant species and in open area.
2. To determine soil moisture extraction patterns in open areas and under selected plants.

METHODS

Plot Description

The studies are conducted at a field location at the Silverbell Validation Site. Predominant plant species in the area include *Larrea divaricata* and *Franseria deltoidea.* Tubac gravelly sandy loam is the major soil at plot locations. The slope is 1-3% with good drainage. A sketch showing locations of plots is presented in Figure 1. Soil water potential measurements were taken in an open area and under a *L. divaricata* (see Figure 1). Aluminum tubes 2 inches in diameter were installed using a power auger. The tubes are used for neutron measurements of soil water content. A location map of sensors and neutron tubes is shown in Figure 1. Exact locations near individual plants are shown in Figure 2. Statistical summary of locations and depths of equipment shown in Figure 1 is presented in Table 1.

Methods of installation and calibration of psychrometers are as described by Qashu et al. (1973).

RESULTS

Data are submitted regularly to the Desert Biome Central Data Bank for: (1) measurements of soil moisture potential and soil temperature; (2) leaf potential; (3) precipitation.

A summary of soil water potential and temperature is presented in Table 2. Precipitation data are presented in Table 3. Cumulative soil moisture content at the through sites are presented in Figure 3. Table 4 is a summary of soil water content. Leaf water potentials for selected irregular time periods are presented in Table 5.

DISCUSSION

The period covered by the report represents a relatively dry season with a total preciitation of 21.23 cm which is

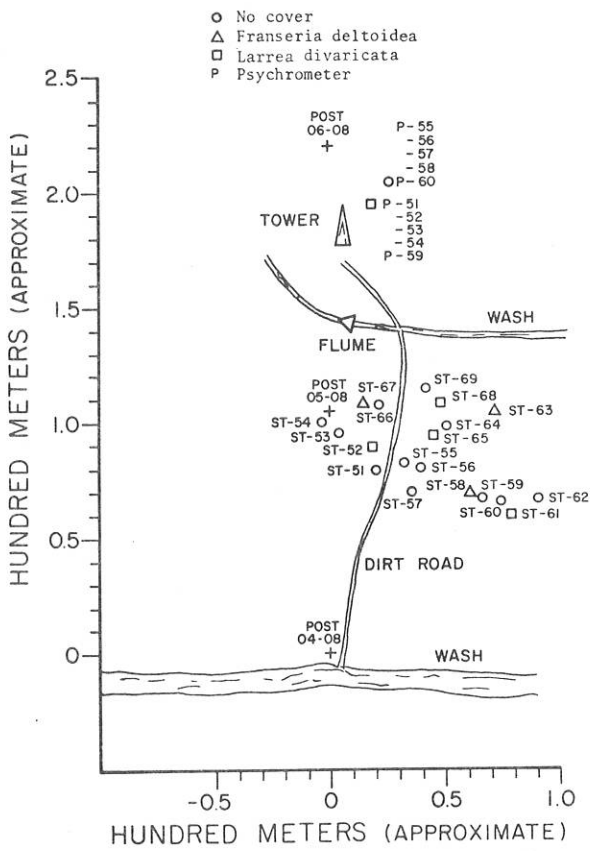

Figure 1. Map showing appropriate locations of neutron tubes and psychrometer stacks.

Figure 2. Exact locations of neutron tubes and psychrometers relative to cover (scale 1:300).

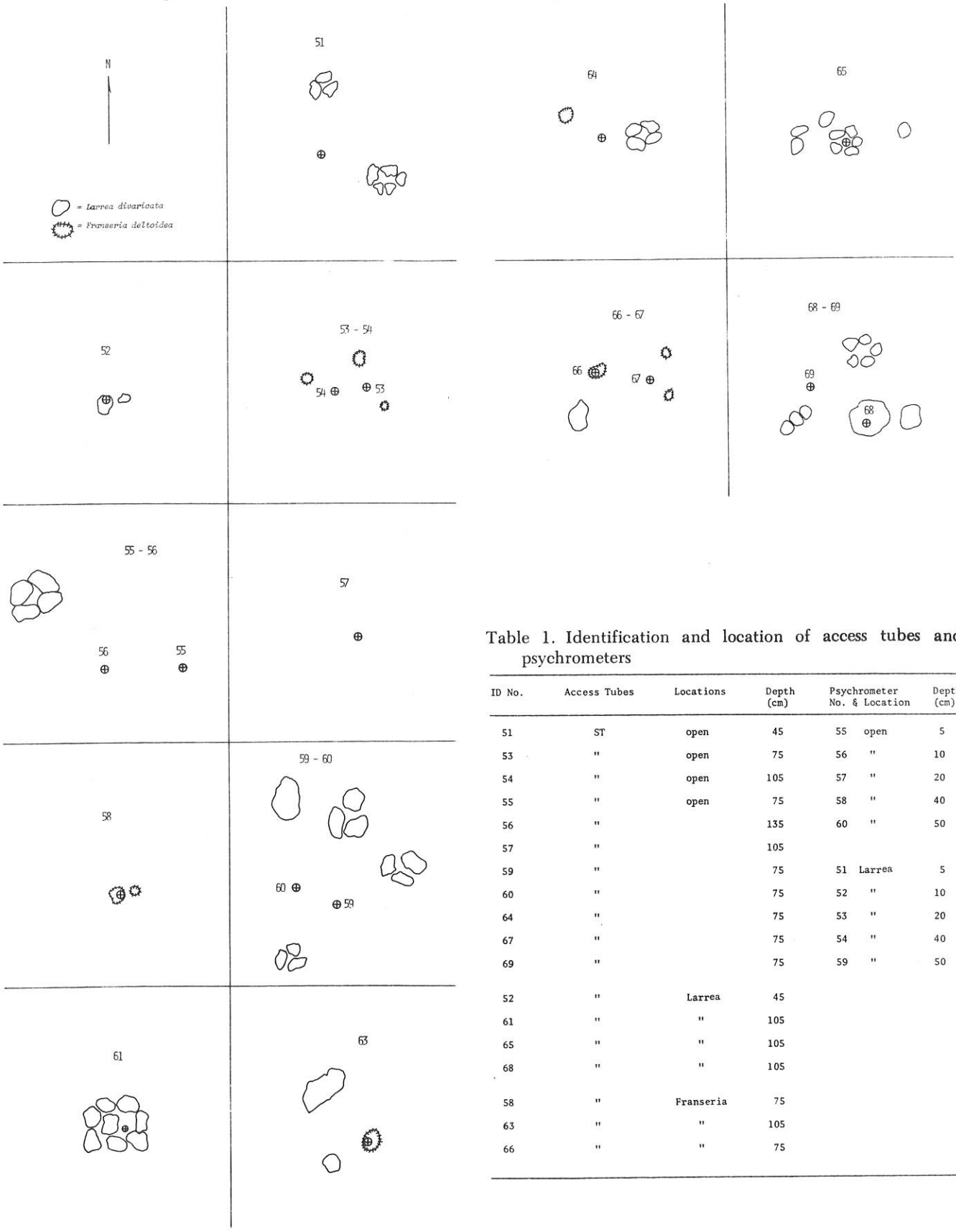

Table 1. Identification and location of access tubes and psychrometers

ID No.	Access Tubes	Locations	Depth (cm)	Psychrometer No. & Location	Depth (cm)
51	ST	open	45	55 open	5
53	"	open	75	56 "	10
54	"	open	105	57 "	20
55	"	open	75	58 "	40
56	"		135	60 "	50
57	"		105		
59	"		75	51 Larrea	5
60	"		75	52 "	10
64	"		75	53 "	20
67	"		75	54 "	40
69	"		75	59 "	50
52	"	Larrea	45		
61	"	"	105		
65	"	"	105		
68	"	"	105		
58	"	Franseria	75		
63	"	"	105		
66	"	"	75		

Table 2. Soil moisture potential and soil temperature at selected depths

Date (1973)	VEGETATED PLOT 5* T**	5* ψ***	10 T	10 ψ	20 T	20 ψ	40 T	40 ψ	Ave. Temp.	NON-VEGETATED PLOT 5 T	5 ψ	10 T	10 ψ	20 T	20 ψ	40 T	40 ψ	Ave. Temp.
Apr 4	21.8	1.1	15.2	.8	14.2	.4	14.2	.2	16.35	29.9	.5	24.6	2.0	19.5	1.4	17.0	.2	22.75
Apr 12	16.2	8.6	16.2	4.7	17.7	1.4	18.5	1.0	17.15	22.8	5.1	19.5	1.2	19.5	2.0	21.0	.2	20.70
Apr 18	25.8	29.2	21.5	12.7	20.0	8.0	20.0	6.8	21.82	32.4	55.9	27.3	6.7	22.8	4.2	21.8	3.9	26.08
Apr 26	39.5	52.0	30.9	25.9	25.3	18.9	22.8	15.1	29.62	40.3	36.8	36.7	24.7	30.4	14.0	24.3	11.6	32.85
May 2	41.5	50.7	29.4	53.4	22.8	25.0	22.0	22.4	28.92	43.3	49.5	37.0	58.5	28.4	21.2	24.3	16.8	33.25
May 8	38.5	6.0	30.4	26.3	25.6	28.0	24.3	26.2	29.70	45.3	3.7	39.2	3.7	30.4	12.7	26.3	16.2	35.30
May 16	30.4	50.0	31.1	31.8	30.6	34.6	28.1	31.6	30.05	31.1	17.6	34.2	17.6	34.4	16.7	29.1	19.0	32.20
Sep 8	36.7	50.0	34.2	50.0	35.4	50.0	35.4	50.0	35.42	48.1	50.0	39.2	50.0	36.7	50.0	36.7	50.0	40.18
Sep 15	28.1	50.0	29.4	50.0	32.7	50.0	33.4	50.0	30.90	30.9	50.0	30.4	50.0	33.9	50.0	34.7	50.0	32.48
Sep 22	25.6	50.0	27.3	50.0	30.9	50.0	32.9	50.0	29.18	30.9	50.0	29.6	50.0	33.7	50.0	34.7	50.0	32.22
Sep 29	23.5	50.0	23.8	50.0	27.3	50.0	29.4	50.0	26.00	21.5	50.0	22.8	50.0	30.9	50.0	31.6	50.0	26.70
Oct 6	20.8	50.0	24.8	50.0	27.3	50.0	28.4	50.0	25.32	27.3	50.0	25.3	50.0	29.9	50.0	30.6	50.0	28.28
Oct 13	13.7	50.0	18.5	50.0	22.5	50.0	25.3	50.0	20.00	14.2	50.0	16.2	50.0	28.1	50.0	26.1	50.0	21.15
Oct 20	17.5	50.0	21.8	50.0	25.3	50.0	26.6	50.0	22.80	18.2	50.0	20.5	50.0	28.6	50.0	27.8	50.0	23.78
Oct 27	15.2	50.0	18.7	50.0	22.5	50.0	25.3	50.0	20.42	16.2	50.0	17.5	50.0	27.6	50.0	26.3	50.0	21.90
Nov 3	13.9	50.0	17.7	50.0	20.8	50.0	23.0	50.0	18.85	13.4	50.0	15.7	50.0	26.3	50.0	24.3	50.0	19.92
Nov 10	11.6	50.0	14.9	50.0	18.0	50.0	20.5	50.0	16.25	--	--	--	--	--	--	--	--	--
Nov 20	7.8	.20	8.9	50.0	13.2	50.0	18.7	50.0	12.15	--	--	--	--	11.6	50.0	19.5	50.0	15.55
Nov 27	1.0	.20	3.0	.20	6.1	50.0	12.7	50.0	5.70	--	--	--	--	4.6	50.0	11.9	50.0	8.25
Nov 29	8.6	.20	6.8	.20	8.4	50.0	13.7	50.0	9.38	11.9	.20	9.9	4.97	9.4	.20	14.7	50.0	11.48

*In centimeters.
**Temperature, in °C.
***Moisture potential, in -bars.

NOTE: If ψ is -50, the moisture potential is equal to or greater than -50 bar.

Table 3. Precipitation, Silverbell site (1973), in inches

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	--	--	--	--	--	--	--	--	--	--	--	--
2	--	--	--	--	--	--	--	-	--	--	--	--
3	--	--	--	--	--	--	--	.10	--	--	--	--
4	--	--	--	--	--	--	--	--	--	--	--	--
5	--	--	--	--	.37	--	--	--	--	--	--	--
6	--	--	--	--	--	--	--	--	--	--	--	--
7	--	.43	.62	--	--	--	--	↑	--	--	--	--
8	--	--	--	--	--	--	--	↑	--	--	--	--
9	--	--	1.25	--	--	--	--	↑	--	--	--	--
10	--	--	--	--	--	--	--	↑	--	--	--	--
11	--	--	--	--	--	--	--	↑	--	--	--	--
12	--	.13	.44	--	--	.10	--	.25	--	--	--	--
13	--	.15	.09	--	--	.40	--	↓	--	--	--	--
14	--	--	.35	--	--	--	--	↓	--	--	--	--
15	--	--	--	--	--	--	--	↓	--	--	--	--
16	--	.18	--	--	--	--	.63	↓	--	--	--	--
17	--	--	--	--	--	--	--	↓	--	--	--	--
18	--	--	--	--	--	--	--	↓	--	--	--	--
19	--	--	--	--	--	--	--	↑	--	--	.47	--
20	--	.025	↑	--	--	--	--	.05	--	--	.62	--
21	--	.805	↑	--	--	--	--	↓	--	--	--	--
22	--	.20	↑	--	--	--	--	↓	--	--	--	--
23	--	--	↑	--	--	--	--	--	--	--	--	--
24	--	--	↑	--	--	--	--	--	--	--	--	--
25	--	--	↑	--	--	--	--	--	--	--	--	--
26	--	--	.70	--	--	--	--	--	--	--	--	--
27	--	--	↓	--	--	--	--	--	--	--	--	--
28	--	--	↓	--	--	--	--	--	--	--	--	--
29	--	--	↓	--	--	--	--	--	--	--	--	--
30	--	--	↓	--	--	--	--	--	--	--	--	--
31	--	--	--	--	--	--	--	--	--	--	--	--
Total	0	1.920	3.45	0	.37	.50	.63	.40	0	0	1.09	0

Seasonal Total = 8.36 inches

← →: No exact, date, occurred sometime between arrows.

Table 4. Moisture content, accumulative to 36-inch depth

Date (1973)	No Cover # of Tubes	No Cover $\bar{\theta}$	No Cover s	No Cover Δθ	Lartri* # of Tubes	Lartri* $\bar{\theta}$	Lartri* s	Lartri* Δθ	Fradel** # of Tubes	Fradel** $\bar{\theta}$	Fradel** s	Fradel** Δθ
Feb 27	9	5.34	.44	.00	3	4.65	1.29	.00	3	5.48	.10	.00
Mar 20	8	5.78	.38	.45	3	5.71	1.69	1.06	3	5.79	.12	.32
Mar 30	4	5.17	.30	-.61	3	5.24	1.60	-.48	1	5.30	.00	-.49
Apr 12	8	4.67	.37	-.51	3	4.47	1.69	-.76	3	4.81	.07	-.49
Apr 26	5	3.65	.47	-1.02	3	3.67	1.32	-.80	2	3.99	.04	-.82
May 2	8	3.50	.33	-.15	3	3.46	1.23	-.21	3	3.81	.10	-.18
May 16	8	3.26	.21	-.24	3	3.16	1.16	-.30	3	3.36	.09	-.45
Jun 7	10	2.80	.18	-.46	4	2.68	.81	-.49	3	2.92	.07	-.44
Jun 15	10	2.78	.16	-.02	4	2.71	.85	.04	3	2.94	.04	.02
Jun 29	11	2.66	.18	-.12	4	2.56	.78	-.15	3	2.75	.01	-.19
Sep 15	10	2.21	.11	-.45	3	2.37	.80	-.20	3	2.42	.06	-.33
Sep 22	10	2.17	.13	-.04	3	2.30	.83	-.07	3	2.36	.10	-.05
Sep 29	10	2.15	.13	-.02	3	2.28	.79	-.02	3	2.37	.11	.00
Oct 6	10	2.13	.14	-.02	3	2.30	.74	.02	3	2.35	.05	-.02
Oct 13	10	2.13	.13	.00	3	2.30	.74	.00	3	2.33	.03	-.02
Oct 20	10	2.13	.13	-.01	3	2.29	.74	-.02	3	2.34	.02	.00
Oct 27	10	2.17	.12	.04	3	2.29	.74	.00	3	2.33	.01	.01
Nov 3	10	2.12	.13	-.05	3	2.30	.75	.00	3	2.32	.04	-.02
Nov 10	10	2.12	.11	.00	3	2.27	.75	-.03	3	2.34	.05	.02
Nov 20	10	2.34	.29	.22	3	2.57	.83	.30	3	2.48	.02	.14
Nov 29	10	2.98	.78	.64	3	3.15	.93	.58	3	2.86	.12	.38

*Larrea divaricata
**Franseria deltoida

NOTE: $\bar{\theta}$ and Δθ are in inches.

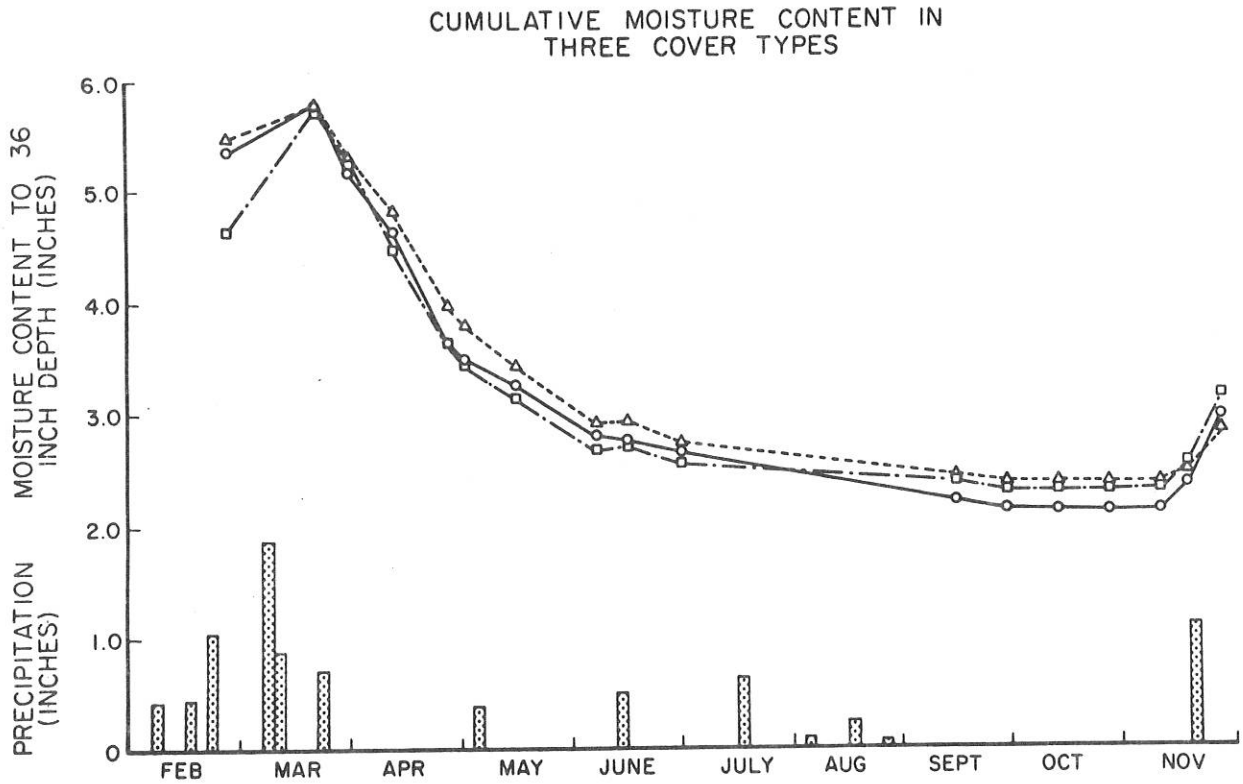

Figure 3. Cumulative soil water content in the through sites, *Franseria deltoidea* (△), *Larrea divaricata* (□), and in the open (O).

Table 5. Leaf potential, measured with pressure bomb, Silverbell site (1973)

Date	Average Potential of Samples						Plant
	Time	Atm	Time	Atm	Time	Atm	
Apr 4	1230	26.93	1310	23.67	1330	24.95	*Lartri
May 2	1345	34.88	1412	32.99			Lartri
May 8	1530	25.40					Lartri
May 16	2325	41.33					Lartri
Jun 15	1325	52.04					Lartri
Jun 29	1315	53.17					Lartri
Jul 10	0950	63.61					Lartri
Apr 4	1400	17.86					**Fradel

*Larrea divaricata
**Franseria deltoida

about one-half of mean annual precipitation in the area. It is of interest to note that rainfall responses were not detected at the 20 cm depth under *Larrea* but were detected at the 20 cm depth nine days after the storm in the area without vegetative cover. No attempt was made to calculate transfer rates and coefficients, but with additional instrumentation and better coordination of data collection we should be able to obtain reliable information about magnitudes of transfer coefficients. The 1974 project will include more frequent measurements during rapid changes incurred by rainfall. The limited observations on leaf potential reflect effect of rain on May 5 but frequency of observations does not allow definite conclusions with numerical support. The 1974 study will include measurements of sap and leaf potential which will be coordinated with soil water content and soil water potential measurements.

LITERATURE CITED

Qashu, H. K., D. D. Evans, M. L. Wheeler, and T. Sammis. 1973. Water uptake by plants under desert conditions. US/IBP Desert Biome Res. Memo. RM 73-42.