1975

Plant Growth and Water Transfer Interactive Process Under Desert Conditions

D. D. Evans

T. W. Sammis

1974 PROGRESS REPORT

PLANT GROWTH AND WATER TRANSFER INTERACTIVE PROCESSES UNDER DESERT CONDITIONS

D. D. Evans (Project Leader) and T. W. Sammis
University of Arizona

US/IBP DESERT BIOME
RESEARCH MEMORANDUM 75-41

in

REPORTS OF 1974 PROGRESS
Volume 3: Process Studies
Abiotic Section, pp. 17-26

1974 Proposal No. 2.3.5.3

Printed 1975

Citation format: Author(s). 1975. Title.
US/IBP Desert Biome Res. Memo. 75-41
Utah State Univ., Logan. 10 pp

Ecology Center, Utah State University, Logan, Utah 84322

ABSTRACT

Moisture transfer into and out of the root zone by abiotic processes is responsible for a significant portion of the observed soil moisture content variations adjacent to desert plants. In this study, the relative magnitudes of these processes were investigated. Data were collected on variations in moisture content and soil moisture potential within vegetated and nonvegetated desert study plots. Soil moisture extraction patterns were determined for the rooting habits of *Larrea tridentata* (creosotebush). Throughfall measurements were collected for *Larrea tridentata* and *Ambrosia deltoidea* (bursage) and the associated variance related to soil moisture variation. Data were collected on plant leaf potentials for both the yearly and daily cycles, using pressure bomb techniques. The observed variations were related to the plant water use and to changes in the resistance to water flow through the plant.

INTRODUCTION

This study is a continuation of a 1972 investigation reported on by Qashu et al. (1973). Precipitation is normally the only water supply for desert plants and they respond to changes in yearly amounts and distribution of the precipitation. The present investigation considers the relative magnitude of the processes controlling soil water distribution and their effects upon water uptake and response by desert plants.

Investigations in the past have not been oriented toward natural ecosystems, but controlled environments. Data (and understanding of processes) from such studies cannot be transferred to natural ecosystems without caution. The adaptive nature of the desert vegetation with its limited water supply requires in situ research oriented toward basic data collection and the understanding of basic processes. The intent of this report is to provide information and insight on these processes concerned with water (use, movement, and space and time distribution).

OBJECTIVES

The generalized goals of this study were to analyze interception, soil moisture recharge, evaporation and transpiration processes for desert plant species. Specifically, the objectives were to:

1. Measure soil moisture variation resulting from precipitation and evapotranspiration by desert shrub species.
2. Compare energy and water balance approaches in estimating evaporation and transpiration rates.

The second objective was dependent on the completion of a lysimeter being constructed at Silverbell. The completion date was December 1974, so the data collected to fulfill the second objective will be reported in the 1975 report. A third objective was added:

3. To follow changes in the hourly water potential of *Larrea tridentata* at different soil moisture contents.

METHODS

Plot Description

The study was conducted at two field locations at the Silverbell Validation Site. Plot 1 was located on a Tubac gravelly-sandy loam soil, and the location of the neutron access tubes and psychrometers installed in that plot are presented in Figure 1. A diagram of the sample location in relationship to the plant crown cover was presented by Qashu et al. (1973). Plot 2 was located on Tres Hermanos fine gravelly-sandy loam soil with the location of the psychrometers presented in Figure 2. In this plot the psychrometers were located under two adjacent creosotebush plants one foot apart, and within the center crown of the bursage plant.

Miniature rain gauges were installed in Plot 1 in the open and under the creosotebush (*Larrea tridentata*) and bursage

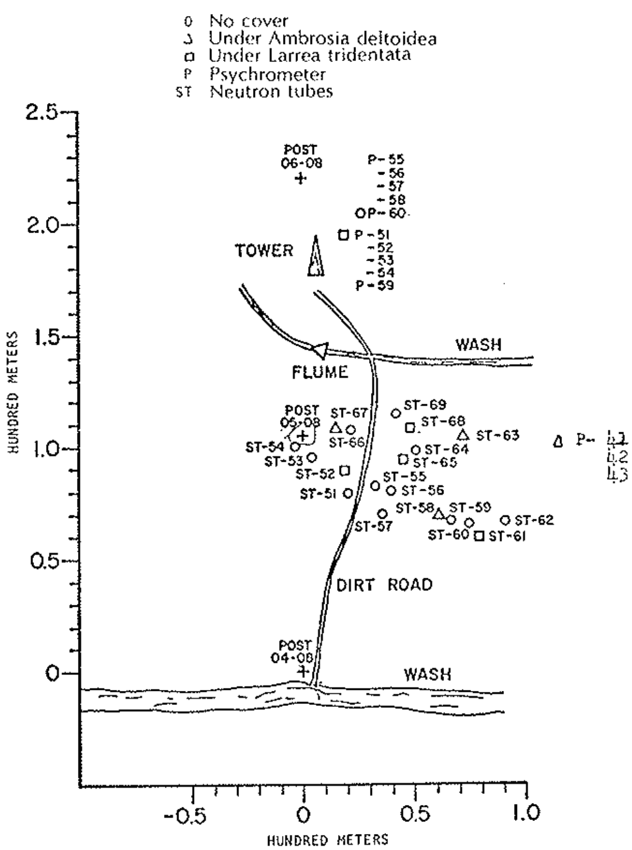

Figure 1. Diagram of Plot 1: approximate location of measurements taken near center of Silverbell Validation Site.

(*Ambrosia deltoidea*) vegetation. Their locations are referenced to the location of the nearest neutron access tubes.

Water Potential Measurements

Measurements of soil water potential during the 1974 study were obtained using soil psychrometers and a psychrometric microvoltmeter manufactured by Wescor, Inc. The instruments have a range from -0.5 to -50 bars with an approximate accuracy of 0.5 bars. Potential measurements above -0.5 bars and below -50 bars are difficult to read and sometimes give similar responses on the meter. A more detailed description of the limitations and response of the psychrometer is discussed by Qashu et al. (1972) and Wheeler (1972). The data are assigned DSCODE A3UQH13.

Soil Moisture Content

Soil moisture measurements were made using a neutron probe manufactured by Troxler Electronic Laboratories, Inc. The calibration curve provided with the instrument was used for interpreting the recorded values. The neutron counts were recorded by a scaler for a time duration of one minute (A3UQH17).

Leaf Potential

A pressure bomb technique, as described by Scholander et al. (1965), was used to obtain measurements of plant leaf potential. The potential is taken as equivalent to the pressure required to force vascular sap back to the surface of a cut stem end. A measurement error of $\pm$ 0.5 bars is considered applicable. The potential measured is considered the matric potential in the leaf cells (A3UQH15).

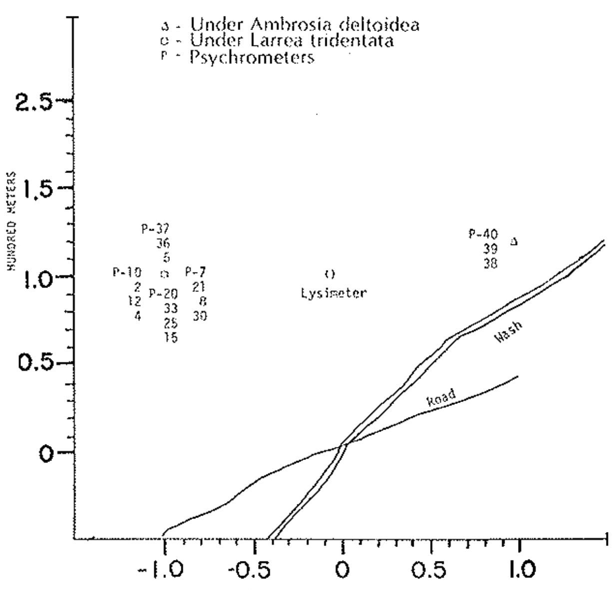

Figure 2. Diagram of Plot 2: approximate location of measurements taken in northeast corner of Silverbell Validation Site.

RESULTS AND DISCUSSION

Soil Moisture

Accumulative soil moisture to 90 cm is presented in Table 1. At the 0.975 level of significance there is no difference between the total soil moisture in the bare soil vs. the moisture under the creosotebush and bursage plants. However, there is a larger variation of total soil moisture distributed spatially, as expressed by the standard deviation, for the moisture under the creosotebush plants vs. the moisture under the bursage plants and in the open area. The summer rainfall tends to increase the spatial variability with the coefficient of variation for accumulative soil moisture being similar to the coefficient of variation for the rainfall input (see "Throughfall Measurements" section).

The extraction pattern of moisture for the vegetative and nonvegetative areas are presented in Table 2. Water loss from the bare soil comes mainly from the top 30 cm with a greater percentage coming from the deeper depths as the profile dries out. The creosotebush plant extraction pattern indicates that the 30-cm and 90-cm depths have the greatest root activity with a decrease of extraction of water from the 60-cm depth until the summer rainfall replenishes the water in the root zone. Bursage plants draw most of their water from the top 60 cm, predominantly from the top 30 cm of the soil profile.

Soil Moisture Potential

Psychrometer potential measurements for Plots 1 and 2 are presented in Tables 3 and 4. Plot 2 had four psychrometers placed at each depth around two adjacent creosote plants. The reported mean values and standard deviations in Table 4 show a large variation in soil moisture potentials. This is especially true at deeper depths after a rainfall event and is due to the space differential rate of advance of the wetting front. Psychrometer measurements are considered a point measurement and in order to improve the confidence limits on the mean value a larger number of psychrometer readings should be taken.

Visual observation of the vegetation indicated a lusher vegetative cover at Plot 2 compared to Plot 1, both in the amount of grass cover and the amount of creosotebush and bursage cover. This can be attributed to soil characteristics. The soil profile at Plot 2 was observed to be deeper. The final infiltration rate measured by a rainfall simulator (conducted and reported under a separate report) for Plot 2 was twice that for Plot 1. The moisture potential at Plot 2 goes from a very high potential to a low potential within 15 days, indicating a very steep moisture release curve. A field moisture release curve can be derived using the soil moisture potential data in Table 4 and soil moisture data collected by Cable (1975) and reported in a separate research report. Both data sets were collected at the same location.

Soil Temperature

Soil temperature measurements were taken at the same time as soil water potential measurements. The data presented in Tables 5 and 6 show, as expected, that the

Table 1. Soil moisture content and variability in bare soil under creosotebush (*Larrea tridentata*) and under bursage (*Ambrosia deltoidea*)

	No Cover				Larrea tridentata				Ambrosia deltoidea			
Date	$\overline{\theta}_T$* moisture	S**	No. of tubes	Δθ***	$\overline{\theta}_T$ moisture	S	No. of tubes	Δθ	$\overline{\theta}_T$ moisture to 90 cm	S	No. of tubes	Δθ
1-7-74	6.69	.85	10	--	6.99	2.36	3	--	6.72	.08	3	--
1-23-74	6.85	.78	10	.16	7.22	2.29	3	.23	6.93	.02	3	.21
2-6-74	6.68	.69	10	- .17	6.95	2.25	3	- .27	6.80	.11	3	- .13
2-20-74	6.49	.60	10	- .19	6.69	2.19	3	- .26	6.60	.12	3	- .19
3-11-74	6.77	.56	10	.28	6.98	2.25	3	.29	6.84	.08	3	.23
3-20-74	6.82	.53	10	.05	7.02	2.25	3	.04	6.85	.06	3	.01
4-3-74	6.67	.51	10	- .16	6.81	2.03	3	.21	6.71	.11	3	- .14
4-17-74	6.46	.50	10	- .21	6.57	1.96	3	.23	6.59	.05	3	- .11
4-29-74	6.18	.52	10	- .28	6.43	1.92	3	- .14	6.38	.04	3	- .21
5-14-74	6.00	.47	10	- .18	6.31	1.94	3	- .12	6.23	.04	3	- .15
5-29-74	5.89	.46	10	- .11	6.21	1.93	3	- .10	6.16	.03	3	- .07
6-12-74	5.75	.43	10	- .15	6.17	1.95	3	- .04	6.05	.06	3	- .11
6-26-74	5.55	.38	10	- .20	5.95	1.96	3	- .21	5.82	.12	3	- .22
7-10-74	7.00	2.38	10	1.45	7.08	2.51	3	1.13	6.59	.25	3	1.77
7-24-74	8.91	2.01	10	1.91	9.04	2.55	3	1.96	9.48	.24	3	2.89
8-23-74	7.79	1.33	10	-1.12	7.81	2.25	3	-1.23	7.88	.12	3	-1.60
9-14-74	5.71	1.53	10	-2.08	6.20	1.92	3	-1.62	6.09	.13	3	-1.80
10-7-74	6.08	1.17	10	.37	6.27	2.17	3	.07	6.32	.06	3	.23
11-21-74	6.31	.86	10	.23	6.56	2.15	3	.29	6.39	.08	3	.07

*$\overline{\theta}_T$ = mean total soil moisture, to 90 cm, in cm.
** S = standard deviation.
***Δθ = change in total moisture content from the previous time period, in cm.

Table 2. Soil moisture extraction pattern for bare soil, creosotebush (*Larrea tridentata*) and bursage (*Ambrosia deltoidea*)

	No Cover				Larrea tridentata				Ambrosia deltoidea			
		% extraction at 3 depths (cm)				% extraction at 3 depths (cm)				% extraction at 3 depths (cm)		
Date	Δθ*	0-30	30-60	60-90	Δθ	0-30	30-60	60-90	Δθ	0-30	30-60	60-90
1-7-74												
1-23-74	.16	84.66	3.07	18.40	.23	57.14	10.71	32.14	.21	66.67	9.52	23.81
2-6-74	- .17	117.03	-12.38	- 4.64	- .27	114.81	- 14.81	0.00	- .13	125.00	- 25.00	0.00
2-20-74	- .19	80.88	7.35	11.76	- .26	74.58	10.17	15.25	- .19	80.95	14.29	4.76
3-11-74	.28	72.38	12.75	14.87	.29	58.06	19.35	22.58	.23	48.00	28.00	24.00
3-20-74	.05	140.24	-21.95	-18.29	.04	200.00	- 25.00	- 75.00	- .01	-400.00	200.00	300.00
4-3-74	- .16	215.60	-54.32	-61.28	- .21	123.00	- 19.00	- 4.00	- .14	128.57	- 14.29	- 14.29
4-17-74	- .21	74.03	2.16	23.81	- .23	74.00	2.10	23.80	- .11	100.00	- 0.00	- 0.00
4-29-74	- .28	63.54	19.03	17.42	- .14	50.00	16.67	33.33	- .21	60.38	22.64	16.98
5-14-74	- .18	95.36	2.17	2.48	- .12	127.27	0.00	- 27.27	- .15	59.46	24.32	16.22
5-29-74	- .11	140.22	-13.04	-27.17	- .10	75.00	25.00	0.00	- .07	114.29	- 14.29	0.00
6-12-74	- .15	82.76	31.03	-13.79	- .04	869.07	-434.53	-434.53	- .11	76.92	46.15	- 23.08
6-26-74	- .20	58.06	22.07	19.86	- .21	40.70	25.93	33.33	- .22	60.87	13.04	26.09
7-10-74	1.45	57.69	18.05	24.27	1.13	97.35	2.65	0.00	1.77	100.00	0.00	0.00
7-21-74	1.91	86.45	15.50	- 1.95	1.96	69.41	28.28	2.31	2.89	69.37	28.87	1.76
8-23-74	-1.12	142.51	-10.63	-31.88	-1.23	128.10	5.79	- 33.88	-1.60	105.73	14.65	- 20.38
9-14-74	-2.08	34.70	37.19	28.11	-1.62	29.56	33.33	37.11	-1.80	37.85	36.16	- 1.80
10-7-74	.37	115.57	4.10	-19.67	.07	285.71	- 42.86	-142.86	.23	134.78	- 8.70	.23
11-21-74	.23	- 59.63	83.94	75.69	.29	36.36	36.36	27.27	.07	30.00	10.00	60.00

*Δθ = change in total moisture content from the previous time period, in cm.

Table 3. Soil moisture potential (-bars) at selected depths in Plot 1

	No Cover					Larrea tridentata					Ambrosia deltoidea		
Date	5 cm	10 cm	20 cm	40 cm	60 cm	5 cm	10 cm	20 cm	40 cm	60 cm	15 cm	30 cm	60 cm
1-7-74	.4	.2	8.6	50.0	50.0	.7	3.8	12.5	.9	.4			
1-23-74	2.0	1.1	2.4	.9	.8	1.5	1.3	2.0	.2	.2			
2-6-74	16.3	3.1	6.9	1.1	1.0	4.8	2.5	4.9	1.1	.2			
2-20-74	34.0	7.3	14.1	30.7	2.1	17.7	8.3	9.6	1.1	1.1			
3-11-74	15.0	50.0	14.1	31.6	5.4	12.0	8.3	24.1	8.0	.2			
3-20-74	1.0	.2	2.9	28.6	15.5	.2	6.4	17.8	.2	.2			
4-3-74	50.0	9.4	2.8	27.6	20.8	1.0	17.8	23.3	1.9	.2			
4-17-74	50.0	50.0	3.6	43.8	38.2	1.5	2.5	35.9	4.6	1.8			
4-29-74	50.0	50.0	50.0	45.2	50.0	50.0	50.0	50.0	45.4	50.0			
5-14-74	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			
5-29-74	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			
6-12-74	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			
6-26-74	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0	50.0			
7-10-74	4.0	3.3	.7	.2	17.2	.8	3.1	50.0	50.0	50.0	.2	50.0	50.0
7-24-74	1.9	2.0	1.6	.3	.2	.2	1.6	.2	.2	.2	5.4	.2	2.5
8-6-74	4.1	4.2	1.1	11.0	3.0	4.4	1.5	1.6	10.1	1.6	14.7	3.3	2.7
8-20-74	12.1	7.1	.2	28.2	24.7	4.4	16.0	27.9	28.3	--	28.7	22.8	9.9
9-14-74	.2	.9	1.1	.2	.2	.2	.2	.2	.2	.2	.2	39.2	48.2
11-28-74	50.0	22.1	1.2	.1	13.5	35.4	19.1	26.0	42.5	.5	--	--	--

Table 4. Soil moisture potential (-bars) at selected depths in Plot 2

	Larrea tridentata								Ambrosia deltoidea		
	15 cm		30 cm		60 cm		90 cm		15 cm	30 cm	55 cm
Date	$\bar{\psi}$*	S**	$\bar{\psi}$	S	$\bar{\psi}$	S	$\bar{\psi}$	S	$\bar{\psi}$	$\bar{\psi}$	$\bar{\psi}$
3-11-74	.8	1.3	15.5	18.6	1.2	1.8	1.6	1.2			
3-20-74	1.0	1.0	4.0	3.6	.9	.9	2.4	1.6			
4-3-74	2.6	2.4	2.5	3.4	.8	.8	1.4	.6			
4-17-74	.9	1.4	.2	0.0	.8	.6	.6	.5			
4-29-74	.7	1.0	.2	0.0	.5	.5	.5	.5			
5-14-74	.4	.4	.2	0.0	1.1	1.0	2.6	1.6			
5-29-74	1.0	1.0	26.8	32.8	25.2	28.6	33.4	28.8			
6-12-74	50.0	0.0	50.0	0.0	50.0	0.0	50.0	0.0			
6-26-74	50.0	0.0	50.0	0.0	50.0	0.0	50.0	0.0	50.0	50.0	50.0
7-10-74	3.0	2.4	10.8	5.6	.8	.7	.9	1.0	35.2	34.7	32.2
7-24-74	1.4	1.7	2.2	1.8	2.2	2.6	.2	0.0	30.6	30.4	31.6
8-6-74	5.1	8.5	1.8	1.4	.2	0.0	1.4	1.6	38.0	38.0	--
8-20-74	46.2	7.3	49.9	.5	46.3	6.6	49.1	1.6	35.4	35.2	32.9
9-14-74	.2	0.0	.2	0.0	.2	0.0	16.8	28.8	30.4	34.2	31.6
11-28-74	31.7	1.9	38.2	5.8	30.3	17.8	20.7	26.6	44.3	24.2	26.4

*$\bar{\psi}$ = mean soil moisture potential.
**S = standard deviation.

temperature gradient from the 20-cm depth to the surface is larger within the bare soil than beneath either the creosotebush or bursage plants. Because thermal conductivity and heat capacity are a function of the moisture content of the soil, there is a larger variation in the soil temperatures beneath the creosotebush plant for depth and times of the year when the soil moisture variation is the greatest.

Thermally induced moisture movement can be estimated by the following equation (Wheeler 1972):

$$q_{vap} = h \cdot a \cdot n \; \nabla T \, (1.94 \times 10^{-7}) \text{ g cm}^{-2} \text{ sec}^{-1} \quad (1)$$

where h is relative humidity, a is volumetric air content of soil, n is a correction factor, and T is temperature. For values of the parameters in the above equation selected by Wheeler (1972), q_{vap} was essentially constant in the range of matric potential from -1 to -40 bars at a value of 2.2×10^{-5} g cm^2 day^{-1} °C m^{-1}. Reviewing the values used by Wheeler for a, h and n, it appears that the above q_{vap} value can be used to estimate thermally induced moisture movement for the soils at Silverbell.

Table 5. Soil temperature (° C) at selected depths in Plot 1

Date	No Cover					Larrea tridentata					Ambrosia deltoidea		
	5 cm	10 cm	20 cm	40 cm	60 cm	5 cm	10 cm	20 cm	40 cm	60 cm	15 cm	30 cm	60 cm
1-7-74	10.1	12.2	8.9	12.4	13.7	9.6	8.9	9.4	11.6	14.2			
1-23-74	19.0	14.7	10.9	14.2	16.0	9.1	7.6	7.8	11.6	14.2			
2-6-74	22.8	17.2	13.2	14.9	16.0	11.1	9.4	9.6	12.4	15.2			
2-20-74	23.8	18.2	16.0	15.7	16.5	15.2	11.9	11.4	12.7	14.4			
3-11-74	18.2	16.2	12.2	14.2	15.7	13.2	10.6	11.1	13.7	15.7			
3-20-74	18.7	16.7	21.3	21.3	18.7	16.2	16.5	18.0	20.0	19.0			
4-3-74	29.4	23.8	23.5	23.3	21.0	19.0	18.0	19.7	21.3	20.8			
4-17-74	48.9	36.0	26.1	25.8	28.9	38.2	29.4	25.3	25.3	24.6			
4-29-74	32.7	25.6	25.8	26.3	25.3	25.3	23.8	25.3	26.1	25.3			
5-14-74	36.0	29.9	29.4	31.1	30.1	29.6	27.8	30.6	30.4	28.1			
5-24-74	45.6	35.7	30.1	32.7	32.4	34.7	30.6	32.7	32.9	29.7			
6-12-74	44.3	35.4	31.6	33.4	33.7	33.7	33.4	34.2	33.7	30.6			
6-26-74	47.8	40.8	35.7	38.0	40.0	40.5	38.5	40.0	38.5	35.7	39.0	40.0	38.5
7-10-74	33.4	31.1	34.9	35.4	32.7	30.1	--	32.7	35.2	34.2	32.9	34.2	--
7-24-74	48.6	46.1	32.9	32.9	38.0	40.5	32.9	31.1	32.9	31.6	36.7	32.9	--
8-6-74	45.6	43.0	27.8	25.3	38.0	40.5	38.0	32.9	30.4	30.4	32.9	30.4	--
8-20-74	46.8	43.0	21.5	28.1	36.7	40.5	34.2	40.5	31.6	--	35.4	32.9	--
9-14-74	45.6	38.0	34.2	32.9	28.4	36.7	27.8	30.4	33.4	32.9	30.4	32.9	--
11-28-74	20.5	20.3	25.3	--	15.2	15.2	12.7	16.2	14.7	18.2	--	--	--

Table 6. Soil temperature (° C) at selected depths in Plot 2

Date	Larrea tridentata								Ambrosia deltoidea		
	15 cm		30 cm		60 cm		90 cm		15 cm	30 cm	55 cm
	T̄*	S**	T̄	S	T̄	S	T̄	S	T̄	T̄	T̄
3-11-74	9.2	1.1	9.3	1.4	12.7	---	15.2	.7			
3-20-74	19.4	.7	20.2	.9	21.2	.7	20.6	.4			
4-3-74	20.1	1.1	21.6	.4	21.7	.2	21.3	.2			
4-17-74	24.0	2.7	24.8	.7	24.9	1.9	22.4	.8			
4-29-74	25.0	2.1	26.6	1.8	25.3	2.5	22.9	1.2			
5-14-74	28.0	.7	27.4	.2	26.2	1.6	25.1	.3			
6-12-74	38.1	1.7	36.8	1.1	35.2	.2	33.3	.1			
6-26-74	39.6	1.1	39.5	1.4	37.5	0.0	35.1	.3	40.3	38.2	40.5
7-10-74	33.2	1.2	34.8	.6	36.7	0.0	35.6	.2	35.2	34.7	32.2
7-24-74	34.4	1.6	32.3	1.3	32.6	.8	31.9	1.1	30.6	30.4	31.6
8-6-74	38.6	4.3	32.4	3.2	33.7	1.4	34.6	1.4	38.0	38.0	--
8-20-74	35.8	1.6	34.6	1.4	34.8	1.2	35.0	.7	35.4	34.2	32.9
9-14-74	30.0	1.6	31.8	1.6	34.2	1.2	32.7	2.7	--	34.2	31.6
11-28-74	16.2	2.2	15.6	.8	18.5	.8	20.4	.1	15.2	13.2	11.4

*T̄ = mean temperature.
**S = standard deviation.

Average temperature gradients during the summer months, and estimated moisture fluxes for the bare soil and vegetative cover are presented in Table 7. Also presented in Table 7 is the moisture flux determined for an average 10-bar per meter gradient at a soil suction of 1 bar and 50 bars. The assumed conductivity values for the calculation were from the 1972 report by Mehuys et al. (1974) on the soils at the Silverbell Validation Site. As can be seen from the table, thermally induced moisture movement becomes important only under dry conditions and then both in the bare soil and under the vegetative cover.

Throughfall Measurements

Miniature rain gauges were installed in the open and under the vegetative cover to evaluate throughfall. The rain gauges were made from 5-cm diameter aluminum tubing, 6 inches long, that were installed with the tops at 1.5-cm above-ground level. Evaporation from the rain gauges invalidated the results unless measurements were read promptly after a rainfall event. Measurements presented in Table 8 show that 65% of the rainfall occurred as throughfall under the creosotebush plant and only 15 to 27% occurred as throughfall under the bursage plant. The

Table 7. Comparison of moisture fluxes produced by potential and thermal gradients

Average Temperature Gradient (°C/m)	Cover Type	Moisture Flux Thermally Induced (gm cm^{-2} day^{-1})	Moisture Flux under a Gradient of 10 Bars per Meter (gm cm^{-2} day^{-1})
5-10	Larrea tridentata	$1.2 - 2.2 \times 10^{-3}$	2×10^{-2} at 1 bar suction
3-8	Ambrosia deltoidea	$.6 - 1.8 \times 10^{-3}$	2×10^{-5} at 50 bars suction
10-20	No cover	$2.2 - 4.4 \times 10^{-3}$	

Table 8. Throughfall as measured by miniature rain gauges

Cover Type	Nearest Neutron Tube*		Rainfall (mm) 10-8-74		Rainfall (mm) 10-27-74
No cover	60		9.3		16.0
	64		9.1		14.8
	69		--		18.2
	67		6.1		15.5
	63		--		16.3
	55		9.1		16.3
	52		10.8		16.3
		Avg. =	8.8	Avg. =	16.2
		SD** =	1.71	SD =	1.04
		CV*** =	19%	CV =	6%
Ambrosia deltoidea	58		1.7		1.9
	63		2.9		4.4
	66		2.7		1.0
		Avg. =	2.43	Avg. =	2.43
		SD =	.64	SD =	1.76
		CV =	26%	CV =	72%
Larrea tridentata	61		9.1		12.3
	65	3.0	3.0		12.8
	68		5.9		8.6
	52		5.4		9.3
		Avg. =	5.85	Avg. =	10.75
		SD =	2.51	SD =	2.11
		CV =	42%	CV =	19%

*See Figure 1.
**SD = standard deviation.
***CV = coefficient of variation.

coefficient of variation is larger for throughfall under both the creosotebush and bursage plants compared to the rainfall in the open. Part of the large variation for the throughfall measurements can be attributed to the small sample size. However, using the Student *T* test and comparing the mean throughfall for both plant types to the rainfall in the open, the mean values are significantly different at the 0.975% level.

Leaf Water Potential

In order to maintain the water potential gradient from the soil to the plant leaf surface, the leaf potential in any plant decreases as the soil water potential decreases. Hypothetical interrelationships between plant potentials and soil potentials are illustrated schematically in Figure 3 (Slatyer 1967). This illustration is representative of commercial crops which have a wilting point around -15 bars. For the creosotebush and bursage plants, the soil water

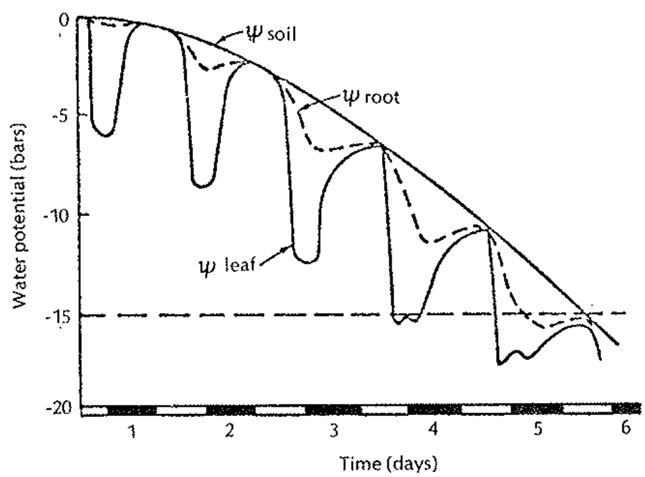

Figure 3. Hypothetical changes in leaf, root and soil water potential during a depletion cycle for an irrigated plant. -- After Slatyer 1967.

potential has to decrease below -70 bars before moisture extraction from that soil moisture zone is reduced to nonmeasurable rates.

Table 9 lists leaf water potential as measured by the pressure bomb method. Potential values do not include osmotic potential. Broyer (1951) reported for irrigated crops that the xylem sap has an osmotic potential of less than -2 bars. During stress conditions in the desert, the osmotic potential may be slightly larger than this amount.

Plant leaf water potentials (Figs. 4-6 and Table 9) of the creosotebush and bursage plants showed a diurnal variation similar to Figure 3. From April to June, the leaf potential declined in response to changes in soil moisture potential. By June 13, 1974, the leaf water potential had decreased to -70 bars. An interesting, and so far unexplainable, occurrence is shown on the 24-hr plot of the creosotebush plant's leaf water potential on June 13, 1974 (Fig. 4a). The minimum leaf potential occurred at 6:00 a.m. and increased toward noon, reaching a maximum at 6:00 p.m. The response of the plant under the dry soil conditions occurring on that date is

Table 9. Plant leaf potential for *Larrea tridentata* and *Ambrosia deltoidea*

	Larrea tridentata									Ambrosia deltoidea					
	Morning			Mid-Afternoon			Late-Afternoon			Morning			Mid-Afternoon		
Date	Time	-Bars	S**	Time	-Bars	S	Time	-Bars	S	Time	-Bars	S	Time	-Bars	S
2-6-74	1136	35.48	.20	1437	35.37	0.00	--	---	--	1152	30.15	2.46	1446	30.04	2.57
2-20-74	--	---	--	1213	53.96	2.08	--	---	--	--	---	---	1240	32.31	3.68
	--	---	--	1530	52.83	1.04	--	---	--	--	---	---	1515	36.73	7.85
3-11-74	--	---	--	1230	53.78	4.83	--	---	--	--	---	---	1245	43.54	3.60
	--	---	--	1430	51.92	.39	--	---	--	--	---	---	1445	56.91	1.42
3-20-74	0950	26.98	4.86	1300	31.75	8.20	--	---	--	1010	33.44	1.09	1320	38.32	2.58
4-3-74	1020	48.07	1.42	1254	42.63	1.40	--	---	--	1026	51.24	4.42	1300	43.77	2.75
4-17-74	1135	58.27	3.49	1530	52.60	7.49	--	---	--	1215	75.96	18.73	1500	41.95	2.83
4-29-74	0920	69.20	3.20	1300	75.51	2.45	--	---	--	0950	83.22	2.75	1240	64.63	10.27
5-14-74	0900	65.98	8.84	1258	63.49	2.75	--	---	--	0915	80.95	4.46	1200	82.54	3.14
5-29-74	1000	67.35	.68	1240	61.22	9.00	--	---	--	1000	73.24	1.71	1300	74.38	4.53
6-13-74	1000	68.03	9.00	1400	61.45	14.92	1800	57.37	5.94	--	---	---	--	---	---
7-17-74	1000	46.03	1.71	1400	42.63	1.96	1800	39.23	.79	--	---	---	--	---	---
7-24-74	--	---	--	1300	38.55	1.42	--	---	--	--	---	---	--	---	---
8-8-74	1000	37.19	2.75	1400	34.69	3.60	1800	33.79	.39	--	---	---	--	---	---
8-15-74	1000	42.40	1.71	--	---	---	1800	36.73	2.45	--	---	---	--	---	---
8-20-74	1000	48.07	.79	1400	46.03	6.32	1800	44.22	9.00	--	---	---	--	---	---
10-7-74	--	---	--	1300	34.01	0.00	--	---	--	--	---	---	--	---	---
10-31-74	0900	16.06	.27	1330	23.40	.41	2000	19.23	.16	--	---	---	--	---	---
11-1-74	--	---		1300	21.02	.96	--	---	--	--	---	---	1300	11.88	.34

*Sample size = 3.
**S = standard deviation.

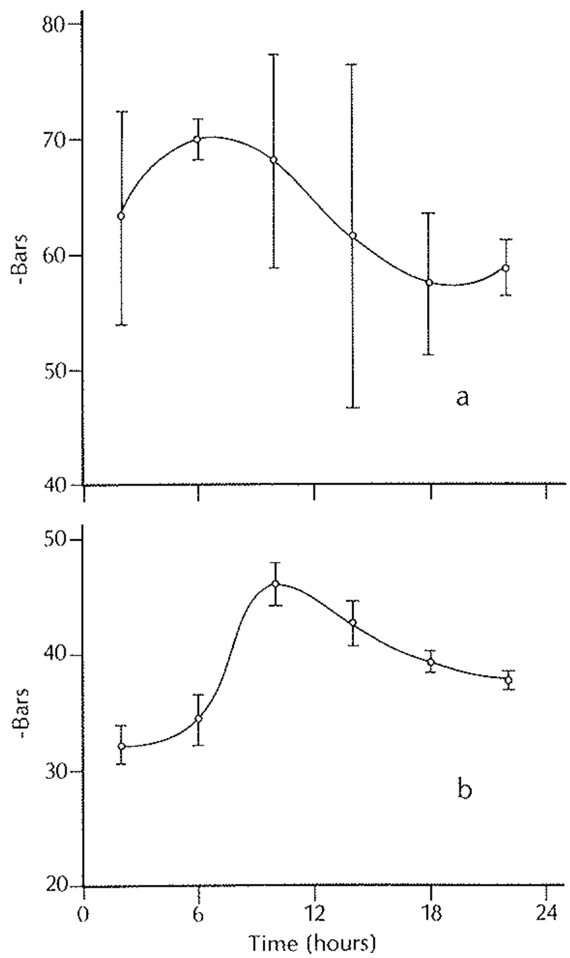

Figure 4. Water plant potential of the creosotebush plant; ⫯ = one standard deviation; a is for June 13, 1974; b is for July 17, 1974.

opposite to the expected response as shown by Figures 4b, 5a, 5b, 6a and 6b. Normally, the largest transpiration rate occurs in the middle of the day when the greatest energy input is available. The plant leaf water potential responds to this increased transpiration demand by increasing the water potential gradient from the soil to the plant leaf, causing the leaf water potential to decrease. Additional measurements of the plant's leaf water potential are needed to further investigate the creosotebush plant's response to soil moisture stress conditions. The lysimeter that was completed at Silverbell will be used to follow the 24-hr transpiration cycle under wet and dry conditions to determine if a change occurs as the soil dries in the normal transpiration cycle, which would explain the reversal in the normal plant leaf water potential cycle. It should be noted that the variance of the sample taken on June 13 is large compared to the other observed readings when the plant was not under water stress.

Rainfall events occurring after June 13 replenished the depleted soil mositure and the creosotebush's leaf water potential increased correspondingly, with the variance of the sample decreasing. In October and November, when the plant is not under soil water stress conditions and the evaporative demand is low, the plant water potential increased to the level observed by Cary and Wright (1971) for field crops of wheat, alfalfa and corn. Cary and Wright report average differences between random samples of plant water potential as 1.2 to 2.3 bars. The average differences for the creosotebush plant under similar water stress conditions were .2 to 2.3 bars.

The variation of the plant leaf water potential under similar conditions for the bursage plant appears to be higher than the variation on the creosotebush plant.

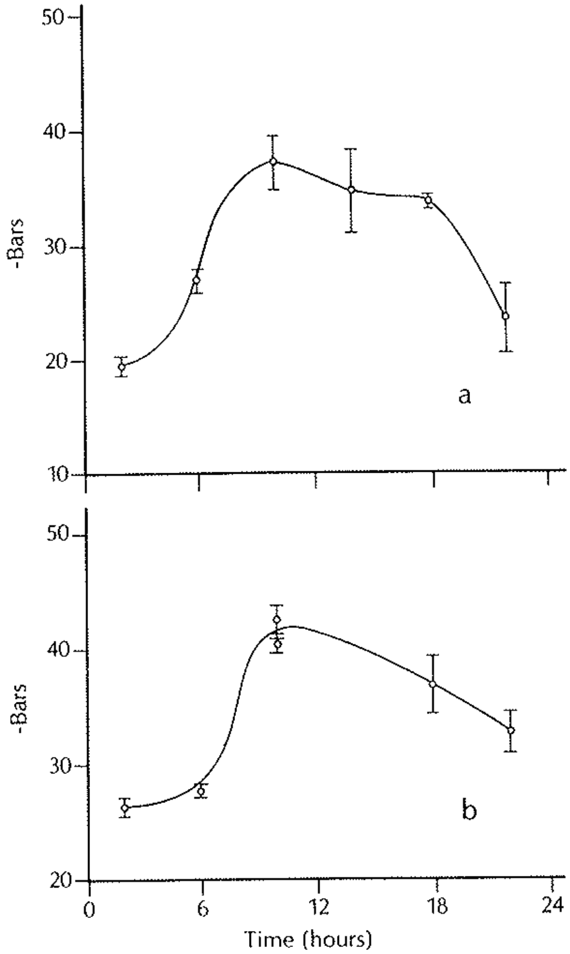

Figure 5. Plant water potential of the creosotebush plant; a is for August 7, 1974; b is for August 15, 1974.

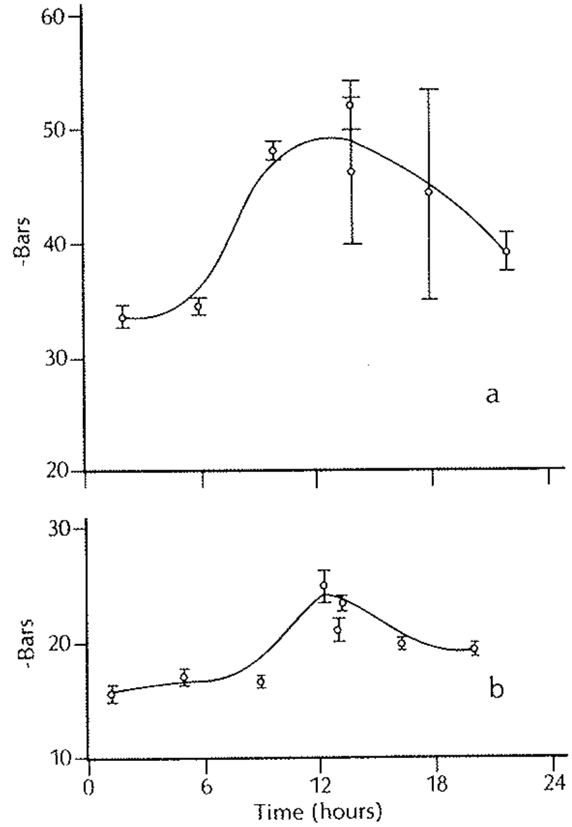

Figure 6. Water plant potential of the creosotebush plant; a is for August 20, 1974; b is for November 1, 1974.

The above discussion is an example of the differences between the response of the desert plants to their environment compared to irrigated crops. The work done in the past on irrigated crops gives a perspective and starting point for research conducted under natural environmental conditions, but, as exemplified and stated earlier, care should be taken in transferring assumptions and research techniques from the controlled water environment of irrigated fields to natural watersheds.

LITERATURE CITED

BROYER, T. C. 1951. Experiments on imbibition and other factors concerned in the water relations of plant tissues. Amer. J. Bot. 38:485-495.

CABLE, D. R. 1975. Seasonal use of soil moisture by *Larrea tridentata* and *Ambrosia deltoidea*. US/IBP Desert Biome Res. Memo. 75-43. Utah State Univ., Logan. 4 pp.

CARY, J. W., and J. L. WRIGHT. 1971. Response of plant water potential to the irrigated environment of southern Idaho. Agron. J. 63(5):691-695.

MEHUYS, G. R., L. H. STOLZY, J. LETEY, JR., and L. V. WEEKS. 1974. Evaluation of critical soil properties needed to predict soil water flow under desert conditions. US/IBP Desert Biome Res. Memo. 74-45. Utah State Univ., Logan 14 pp.

QASHU, H. K., D. D. EVANS, M. L. WHEELER, and R. J. HANKS. 1972. Soil factors influencing water uptake by plants under desert conditions. US/IBP Desert Biome Res. Memo. 72-37. Utah State Univ., Logan. 20 pp.

QASHU, H. K., D. D. EVANS, M. L. WHEELER, and T. W. SAMMIS. 1973. Water uptake by plants under desert conditions. US/IBP Desert Biome Res. Memo. 73-42. Utah State Univ., Logan. 27 pp.

SCHOLANDER, P. F., H. T. HAMMEL, D. BRADSTREET, and E. A. HEMMENSEN. 1965. Sap pressure in vascular plants. Science 148.

SLATYER, R. O. 1967. Plant-water relationships. Univ. of Chicago Press. 272 pp.

WHEELER, M. L. 1972. Application of thermocouple psychrometers to field measurements of soil moisture potential. Ph.D. diss., Dep. of Hydrol. and Water Resour., Univ. of Ariz., Tucson.

APPENDIX

PRECIPITATION, SILVERBELL VALIDATION SITE (1974), IN INCHES (DATA COLLECTED BY JOHN THAMES)

Day	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1	-	-	-	-	-	-	-	-	-	-	-	-
2	.20	-	-	-	-	-	-	.45	-	-	.23	-
3	↑	-	-	-	-	-	-	-	-	-	-	-
4		-	-	-	-	-	-	-	-	-	-	-
5		-	-	-	-	-	-	-	↑	-	-	-
6	.10	-	-	-	-	-	-	-		-	-	-
7		-	-	-	-	-	1.0	.32	.16	-	-	-
8		-	.55	-	-	-	-	-		.04	-	-
9	↓	-	-	-	-	-	-	-	↓	↑	-	-
10	.32	-	-	-	-	-	-	-	-	.05	-	-
11	-	-	-	-	-	-	-	-	-	↓	-	-
12	-	-	-	-	-	-	-	-	-		-	-
13	-	-	-	-	-	-	-	↑	-	↑	-	-
14	-	-	-	-	-	-	-		-	.16	-	-
15	-	-	-	-	-	-	-	.10	-		-	-
16	-	-	-	-	-	-	-		-		-	-
17	-	-	-	-	-	-	-	↓	-	↓	-	-
18	-	-	.10**	-	-	-	.65	.37	-	.12	-	-
19	-	-	-	-	-	-	1.20	-	-	.03	-	-
20	-	-	-	-	-	-	-	-	-	.15	-	-
21	-	-	-	-	-	-	.05	.12	.10	.04	-	-
22	-	-	-	-	-	-	-	-	-	.13	-	-
23	-	-	-	-	-	-	-	-	-	-	-	-
24	-	-	-	-	-	-	-	-	-	-	-	-
25	-	-	-	-	-	-	-	-	.90	↑	-	-
26	-	-	-	-	-	-	.45	-	-	.52	-	-
27	-	-	-	-	-	-	-	-	-	↓	-	-
28	-	-	-	-	-	-	-	-	-	-	-	-
29	-	-	-	-	-	-	-	-	-	-	-	-
30	-	-	-	-	-	-	-	-	-	-	-	-
31	-	-	-	-	-	-	-	-	-	-	-	-
Total	.62	0.0	.65	0.0	0.0	0.0	3.35	1.26	1.16	1.24	.23	0.0

Seasonal Total = 8.51

*← → = no exact date, occurred sometime between arrows.

**Estimated.