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Tucson Basin Validation Site

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1973 PROGRESS REPORT

TUCSON BASIN VALIDATION SITE

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ABSTRACT

During 1973 major emphasis was on the work started on the Silverbell bajada site in 1972. Several new studies on winter annuals, root distribution, invertebrates, reptiles, and soil moisture were started. Studies on winter annuals were completed.

This past year the amount of rainfall was 21.3 cm, about one-half of the mean annual precipitation. More than 60% (14.4 cm) of the total annual rainfall was in the months of February and March. The rest of the year was very dry.

Work on soil moisture included installations of sensors and measurements of soil water content and total psychometric potential under a limited number of conditions. The data from 1973 are of limited utility but are being used to develop a more complete design for the 1974-1975 activities. The results, however, are consistent with data from the Santa Rita site for psychometric 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.

Leaf production was estimated on *Olneya tesota*, *Acacia constricta* and *Ambrosia deltoidea*. There is a significant decrease in leaf production on *Acacia* and *Ambrosia* (57.3% and 59.8%, respectively). The decreases are due to a very dry summer during 1973. Inflorescence and fruit production were estimated on *Acacia*, *Cercidium microphyllum* and *Larrea divaricata*. *Olneya* did not flower during 1973.

The composition of the winter annuals on the Silverbell site is complex and varied. Forty-six annuals have been identified. The number of winter annual species varies greatly from one plot to another. Plot 82 had the highest number of winter annual species. Biomass production (kg/ha) for different winter annuals is also variable. *Lotus* species (*Lotus humistratus*, *Lotus tomentellus* and *Lotus* sp.) have the highest biomass production (328.4 kg/ha in the open and 20.6 kg/ha under the shrubs). Biomass production for winter annuals did not differ significantly in the open and under shrubs, with the highest biomass production under *Olneya*. The differences in the biomass production of winter annuals under different shrubs (*Larrea*, *Olneya*, *Cercidium*, and *Acacia*) are not significant.

Litter production in eight randomly selected plots varied from 410 kg/ha to 8,825 kg/ha. Analysis of variance of the data showed no significant differences.

The concentration of fibrous roots under all cover types was greatest at 20 to 30 cm and gradually decreased to near zero at 85 to 100 cm. Measurements of root density were made under *Ambrosia*, *Cercidium* and *Olneya*.

The results of work on invertebrates and reptiles were considered inconclusive. More data are being collected on these fauna and results will be reported later.

During 1973 the avian biomass on the Silverbell site varied from a January low of 6.6 kg/20 ha to a June high of 15.4 kg/20 ha. It decreased to an October low of 5.8 kg/20 ha. Several species showed increases in the number of pairs breeding on the plot, notably verdins, rufous-winged sparrows, brown towhees, and gila woodpeckers. Cactus wrens and curve-billed thrashers, on the other hand, showed decreases in numbers of breeeding pairs. Net productivity in terms of biomass of young produced showed a three-fold increase over 1972.

The biomass of nocturnal rodents increased dramatically during the summer of 1973. The increase is primarily due to the increases in *Perognathus amplus* and *Perognathus penicillatus*. The biomass of small mammals at the Silverbell site was about one-half of the biomass at Santa Rita sites.

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Plants	J. Thames E. Arvizo T. Verma	Reptiles	E. Arvizo

INTRODUCTION

During 1973 most of the research activities were on the Silverbell site (Sec. 21, R9E, T11S). A remote-controlled meteorological station and a small watershed which was instrumented during 1972 remained in operation throughout the year. During this past year several new studies on biomass production, root distribution, reptiles, and small mammals were started.

Rainfall during 1973 was very low, resulting in an extremely dry year. Total rainfall during the year was 21.2 cm, about one-half of the mean annual precipitation in the area.

Soil moisture data must be viewed as a preliminary contribution because of change in location from Santa Rita to Silverbell. This information is being used to improve the experimental designs and the data acquisition program for 1974. The measurements of soil moisture potential, soil temperature, leaf potential, and precipitation are being continued on the Silverbell site.

Biomass production inventories of *Ambrosia*, *Larrea*, *Cercidium*, *Olneya*, and *Acacia* were continued during this past year. There was a decrease in *Acacia* leaf production, probably because of lower amounts of rainfall during the summer. The increase in leaf production in *Olneya* is because of it's evergreen nature. Samples were also taken to estimate the production of flowers and fruits on these trees. The data on terminal growth are being analyzed and will be reported at a later date.

Inventories of composition, distribution and biomass of winter annuals have been completed. Biomass production of winter annuals, in the open and under each of the four shrubs, *Larrea*, *Olneya*, *Cercidium*, and *Acacia*, was analyzed; the highest biomass production occurred under *Olneya*.

Litter production measurements were completed on eight plots established during 1972. Litter production in Plot D was unusually high because of a large number of joints dropped from a nearby cholla. For better representative estimates of litter production an increase in the sample size would be desirable.

Efforts were made this past year to obtain estimates of distribution, density and biomass of below-ground parts. Various probability functions have been used to describe these characteristics for *Ambrosia*, *Cercidium* and *Olneya*. Data are presently being collected in a pure *Larrea* stand to determine if an adequate stochastic model can be developed either to: (1) use joint probability functions, one to describe the vertical distribution and another to describe horizontal distribution, and rotate the resulting functions about the plant of interest; or (2) use the gamma function to describe the two-dimensional root system, but use the λ and r parameters as functions of the factors that determine the variation in root density with distance from the plant.

Invertebrates are being studied by two methods, D-Vac and can-trapping. The data are insufficient for any conclusive results. Monthly samples for 1974 are underway and the results will be reported later.

Reptilian studies at the Silverbell site were not initiated until October, 1973; consequently, definitive conclusions are not possible. More extensive studies will be conducted during 1974.

Avian biomass studies started at the Silverbell site during 1972 on a 20-ha plot were continued through 1973. During 1973 there was a significant increase in avian biomass over 1972.

Small mammal live-sampling traps were operated two times per night (midnight and daybreak) for three nights. The biomass of nocturnal rodents increased during the summer of 1973.

OBJECTIVES

The objectives of the validation measurements are four-fold:

1. To conduct an initial inventory (standing crop measurements) of energy, nitrogen, phosphorus, carbon, and water in as many as possible of the biotic (species) and abiotic components of the site.
2. To make periodic assessments of the state of the major biotic and abiotic components of the system.
3. To make periodic measurements of the physical factors and inputs in the site.
4. To develop equipment and facilities to accomplish the above.

DATA COLLECTION DESIGN

FINDINGS

A. ABIOTIC

B. PLANTS

C. INVERTEBRATES

D. VERTEBRATES

A. ABIOTIC

A.1. Air Temperature

Air temperature was measured at three heights above ground: 40 cm, 2 m and 8 m. Weekly summaries of bi-hourly recordings at these heights are presented in Table 1. In many cases irregularities in data recording meant that a full set of seven days was not available at the time these summaries were made. The actual number of days contributing to a weekly summary is listed in the table.

At each height the summarized data are presented as minima, maxima and the mean. The lowest temperature

Table 1. Air temperature*

Temp. at 40 cm Min.	Max.	Mean	No. days*	Temp. at 2 m Min.	Max.	Mean	No. days*	Temp. at 8 m Min.	Max.	Mean	No. days*
-4.4	18.4	9.03	4	-2.5	16.2	8.85	4	1.1	14.7	8.93	4
3.1	4.1	3.8	1	3.8	4.6	4.50	1	4.3	5.2	4.9	1
-4.6	23.8	9.05	4	-2.5	21.9	9.25	4	0.7	21.2	9.9	4
-7.7	23.0	5.63	7	-6.6	21.0	6.19	7	-5.0	21.5	7.07	7
-5.5	25.2	9.84	7	-3.3	22.9	10.79	7	1.8	21.6	11.50	7
0.0	24.9	11.86	7	2.3	22.7	12.01	7	4.4	22.1	12.66	7
0.6	18.7	10.18	6	1.6	22.6	10.35	6	3.1	21.1	10.37	6
0.5	23.1	10.77	6	1.4	20.7	11.27	6	4.1	20.0	11.58	6
2.2	27.1	13.27	7	3.5	24.9	13.47	7	5.2	24.9	14.39	7
0.6	20.9	10.17	7	1.4	20.7	10.17	7	2.4	20.1	10.24	7
-0.7	23.3	10.37	6	0.7	22.4	10.53	6	6.0	26.8	15.65	6
0.1	25.5	12.26	7	1.1	24.2	12.60	7	2.5	24.5	13.63	7
0.3	27.8	12.79	7	0.2	27.0	12.70	7	3.6	26.7	12.64	7
-	-	-		-	-	-		-	-	-	
-	-	-		-	-	-		-	-	-	
-	-	-		-	-	-		-	-	-	
-	-	-		-	-	-		-	-	-	
-	-	-		-	-	-		7.6	24.5	16.86	3
10.5	39.3	23.67	3	12.9	36.7	24.23	4	15.2	35.3	25.03	3
12.5	41.7	29.04	5	13.7	38.7	27.98	5	17.5	37.2	28.20	5
12.3	39.5	27.41	7	12.6	36.0	26.76	7	14.2	34.9	26.77	7
12.7	44.2	28.33	7	14.5	38.6	27.64	7	17.1	39.5	27.86	7
11.8	46.8	29.81	7	13.6	43.3	29.40	7	17.0	42.2	30.31	7
10.1	44.6	26.89	7	12.2	41.4	26.49	7	14.5	39.5	26.61	7
11.7	44.8	30.36	7	13.6	42.1	30.20	7	17.1	41.7	30.73	7
19.2	47.8	35.57	7	12.2	45.1	34.90	7	23.1	43.8	35.09	7
25.2	48.1	38.05	6	25.8	44.6	36.73	6	26.0	43.5	36.27	6
23.3	44.7	33.26	5	23.5	41.5	32.12	5	24.0	40.7	31.64	5
19.0	42.5	30.48	6	19.3	40.1	29.63	6	19.5	39.5	29.52	6
15.3	45.4	32.76	7	16.4	42.3	32.31	7	19.8	41.6	32.46	7
21.8	44.8	32.44	7	22.1	41.6	31.14	7	22.2	40.9	30.67	7
19.3	44.7	32.63	7	20.3	41.0	31.71	7	23.0	39.6	31.59	7
20.9	45.3	33.30	7	20.7	42.3	32.29	7	23.6	41.0	32.41	7
19.1	46.0	32.16	7	20.3	42.4	31.44	7	21.6	41.0	31.47	7
17.4	42.5	31.57	7	19.0	39.4	30.71	7	20.7	38.5	30.66	7
13.1	44.9	31.19	7	14.9	42.3	30.91	7	18.4	41.0	31.47	7
2.4	40.9	28.96	7	13.6	38.0	28.61	7	16.0	36.8	29.17	7
4.0	43.6	29.36	7	15.0	39.9	29.11	7	16.9	41.5	29.61	7
8.9	43.3	24.96	7	10.9	36.0	24.75	7	13.1	34.8	25.33	7
9.2	43.2	26.60	7	11.0	37.1	26.24	7	14.2	40.0	26.81	7
2.6	27.0	19.23	7	4.0	34.1	19.36	7	6.4	32.8	20.19	7
8.4	38.9	24.27	7	10.1	36.7	25.01	7	12.5	35.3	26.30	7
6.7	36.7	20.19	7	8.2	34.6	20.90	7	9.7	36.8	22.36	7
1.9	34.4	17.89	7	4.2	32.0	18.56	7	6.1	31.4	19.70	7
2.2	34.6	17.37	7	0.8	30.6	17.94	7	6.9	31.2	19.43	7
-1.4	31.9	16.08	6	1.5	29.8	17.28	6	6.2	29.0	18.17	6
-1.5	26.5	9.07	7	0.0	24.8	9.47	7	0.7	23.9	9.91	7
-2.4	20.6	9.66	7	-1.5	28.0	10.74	7	0.2	27.7	11.73	7
-4.4	24.4	8.39	7	-3.5	22.5	9.3	7	-0.9	22.1	10.69	7
-1.4	28.9	10.74	7	1.0	27.1	12.09	7	0.0	26.0	13.83	7
-2.6	27.0	9.97	6	0.2	25.1	11.08	6	3.6	24.1	12.53	6
-4.2	22.9	7.31	7	-4.2	21.1	8.29	7	-1.2	20.6	9.76	7
-1.2	21.7	9.25	2	1.6	20.0	9.85	2	3.2	19.3	11.40	2

Table 2. Relative humidity*

1972 Week of the Year	Period	Relative Humidity at 40 cm Min.	Max.	Mean	No. days*	Relative Humidity at 8 m Min.	Max.	Mean	No. days*
1	Jan 1-6	25.0	95.0	66.47	3	27.0	95.0	61.45	2
2	7-13	-	-	-		-	-	-	
3	14-20	12.0	94.0	46.55	4	11.0	71.0	38.73	4
4	21-27	10.0	86.0	40.06	7	9.0	80.0	35.30	7
5	28-3	9.0	93.0	41.01	7	8.0	95.0	31.86	7
6	Feb 4-10	17.0	95.0	59.72	6	13.0	95.0	56.60	6
7	11-17	33.0	95.0	74.68	4	33.0	94.0	67.63	3
8	18-24	22.0	95.0	64.48	5	17.0	95.0	58.52	5
9	25-3	20.0	95.0	58.50	7	18.0	95.0	52.24	7
10	Mar 4-10	20.0	95.0	63.44	7	16.0	85.0	61.27	7
11	11-17	28.0	95.0	73.00	2	24.0	95.0	71.70	2
12	18-24	19.0	95.0	90.68	4	6.0	95.0	69.55	4
13	25-31	8.0	95.0	90.47	7	7.0	95.0	76.14	7
14	Apr 1-7	-	-	-		-	-	-	
15	8-14	-	-	-		-	-	-	
16	15-21	-	-	-		-	-	-	
17	22-28	-	-	-		-	-	-	
18	29-5	81.0	95.0	93.95	4	10.0	95.0	44.93	4
19	May 6-12	-	-	-		7.0	35.0	15.27	3
20	13-19	-	-	-		7.0	45.0	16.40	5
21	20-26	8.0	95.0	29.85	2	7.0	28.0	13.33	7
22	27-2	7.0	83.0	23.79	7	7.0	69.0	20.07	7
23	Jun 3-9	6.0	71.0	15.64	7	7.0	52.0	12.70	7
24	10-16	6.0	95.0	24.09	7	7.0	95.0	27.84	7
25	17-23	6.0	56.0	13.62	7	7.0	95.0	11.44	7
26	24-30	6.0	57.0	16.59	7	7.0	95.0	14.30	7
27	Jul 1-7	6.0	50.0	16.71	7	7.0	43.0	17.27	6
28	8-14	8.0	76.0	34.02	5	7.0	72.0	33.50	5
29	15-21	9.0	95.0	37.82	6	8.0	94.0	38.18	6
30	22-28	6.0	71.0	20.06	7	7.0	62.0	17.84	7
31	29-4	7.0	95.0	36.10	7	7.0	94.0	34.36	7
32	Aug 5-11	7.0	74.0	26.33	7	7.0	95.0	23.89	7
33	12-18	6.0	97.0	29.20	7	7.0	95.0	26.11	7
34	19-25	6.0	95.0	27.09	7	7.0	89.0	26.20	7
35	26-1	6.0	67.0	19.41	7	7.0	56.0	15.59	7
36	Sep 2-8	6.0	95.0	13.16	7	7.0	24.0	10.14	7
37	9-15	7.0	95.0	20.70	7	7.0	58.0	15.39	7
38	16-22	7.0	95.0	20.93	7	7.0	53.0	14.60	7
39	23-29	7.0	95.0	19.64	7	7.0	95.0	13.01	7
40	30-6	7.0	95.0	16.87	7	7.0	95.0	12.19	7
41	Oct 7-13	7.0	95.0	27.24	7	8.0	54.0	14.83	7
42	14-20	7.0	95.0	14.33	7	7.0	27.0	10.41	7
43	21-27	7.0	95.0	23.84	7	8.0	27.0	13.43	7
44	28-3	7.0	95.0	28.27	7	8.0	24.0	11.36	7
45	Nov 4-10	7.0	95.0	35.84	7	7.0	70.0	16.26	7
46	11-17	7.0	95.0	35.87	6	8.0	31.0	10.58	6
47	18-24	8.0	95.0	65.77	7	7.0	95.0	42.61	7
48	25-1	8.0	95.0	68.11	7	8.0	95.0	31.71	7
49	Dec 2-8	8.0	95.0	55.27	7	10.0	95.0	20.21	7
50	9-15	8.0	95.0	59.50	7	9.0	95.0	18.87	7
51	16-22	8.0	95.0	52.05	6	9.0	41.0	15.83	6
52	23-29	9.0	95.0	54.16	7	9.0	52.0	19.41	7
	30-31	10.0	95.0	56.25	2	11.0	65.0	27.20	2

* REMARKS

1 one day data in a week
2 two day data in a week
3 three day data in a week
4 four day data in a week
5 five day data in a week
6 six day data in a week
7 seven day data in a week

Min = The minimum of the seven daily minimum values
Max = The maximum of the seven daily maximum values
Mean = The mean of the seven daily average values

recorded was at 40 cm, - 7.7 C in the fourth week of January: in that same week, minimas occurred for the 2 and 8 m heights of -6.6 and - 5 C, respectively. The highest temperature recorded at the station was 48.1 C at 40 cm in the first week of July: the yearly maxima for 2 m and 8 m occurred a week earlier at 45.1 and 43.8 C, respectively. The coldest week of the year was the second week in January during which the mean was 3.8, 4.5 and 4.9 for the ascending heights, respectively. The warmest week of the year was the first week in July when the corresponding temperatures were 38.5, 36.73 and 36.27 C.

A.2. Relative Humidity

Relative humidity was recorded at two heights at the Silverbell meteorological station in 1973. At 95% relative humidity the recording apparatus was at the limits of its accuracy and so values of higher humidity are presented as 95. Weekly summaries of minima, maxima and means are presented in Table 2. In several cases, less than seven days contributed to the summary data as indicated in the table. There are significant differences between the record for 40 cm and the record for 8 m, although the trends are the same. Humidity at 40 cm was higher than at 8 m in almost every case. The weekly maximum humidity was over 85% at 40 cm for all months except June, July and August. Weekly means fell below 30% during the months of May through October at 40 cm, and the months of May through December at 8 m. The highest mean was 93.95% in the first week of May at 40 cm and 76.14% at 8 m for the last week in March. For the intervening four weeks no data are

Table 3. Precipitation

Date of Event	Inches Precipitation
Feb. 7	0.43
Feb. 12	0.25
Feb. 13	0.30
Feb. 16	0.18
Feb. 17	0.08
Feb. 20	0.07
Feb. 21	0.82
Feb. 22	0.21
Mar. 9	0.09
Mar. 12	0.44
Mar. 13	1.25
Mar. 14	0.62
Mar. 17	0.35
Mar. 23	0.70
Mar. 26-30	No data
May 5	0.37
June 12	0.10
June 13	0.40
July 16	0.63
Aug. 3	0.10
Aug. 10	0.25
Aug. 20	0.05
Nov. 19	0.43
Nov. 20	0.61
Year Total	8.73

Table 4. Soil moisture potential and soil temperature at selected depths

	VEGETATED PLOT									NON-VEGETATED PLOT								
Date	5*		10		20		40		Ave.	5		10		20		40		Ave.
(1973)	T**	ψ***	T	ψ	T	ψ	T	ψ	Temp.	T	ψ	T	ψ	T	ψ	T	ψ	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.

available so it is conceivable that higher humidities particularly at 8 m were experienced on the site.

A.3. Precipitation

A total of 8.73 inches of precipitation were recorded on the site for 1973. Of this, 5.79 inches fell in the months of February and March, with the summer precipitation falling below normal. Amounts of rainfall and the dates of occurrence are presented in Table 3.

A.4. Soil Moisture

Soil moisture measurements at Silverbell Validation Site were started in February, 1973. A neutron moisture meter was used to measure the moisture contents down to 36 inches in an open area and under *Larrea*. Data collected in 1973 (Tables 4 and 5) are used in improving the experimental designs and the data acquisition program for 1974. The objectives were to measure spatial and temporal variations of water contents in the soil and to evaluate the effects of canopy characteristics on soil moisture extraction under selected plants.

Table 5. Moisture content, accumulative to 36-inch depth

Date (1973)	No Cover				LARDIV *				AMBDEL **			
	# of Tubes	$\bar{\theta}$	s	$\Delta\theta$	# of Tubes	$\bar{\theta}$	s	$\Delta\theta$	# of Tubes	$\bar{\theta}$	s	$\Delta\theta$
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

**Ambrosia deltoidea

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

B. PLANTS

B.1. Perennials

Leaf Production

Ironwood (*Olneya tesota*) and whitethorn *Acacia* (*Acacia constricta*), were selected on untreated sites. Five trees of both species were used. Two branches from each tree were clipped at 2.5 cm and 1.25 cm stem diameters, respectively. All leaves from the branches were hand picked, dried at 80 C for 48 hr and then weighed. Stems were air dried for two weeks and weighed. Data are given in Table 1. Average weights were calculated from two branches for each tree. Statistical analyses for ungrouped and grouped data are shown in Tables 2 and 3.

From the grouped data, leaf-weight ratios were calculated. For ironwood, comparison was made with last year's ratio to determine new growth. It was assumed that $BW_{73} = BW_{72}$:

$$\frac{LW_{73}}{BW_{73}} - \frac{LW_{72}}{BW_{72}} = \frac{LG_{73}}{BW_{73}} \qquad (1)$$

For whitethorn *Acacia*, leaf-branch weight ratio represents growth for the 1973 season. This equivalence allows us to determine new growth for *Acacia*.

The leaf-growth to branch-weight ratios, shown in Table 4, are to be used in equation 2 to determine growth for the year on the total site:

$$\frac{\text{Trees}}{\text{ha}} \times \frac{\text{Bw}}{\text{Tree}} \times \frac{\text{Leaf growth or weight}}{\text{Branch weight}} = \frac{\text{Leaf growth}}{\text{ha}} \qquad (2)$$

Confidence bands for the two years and two species do not overlap. This indicates a significant decrease in *Acacia* leaf production. Decrease in *Acacia* leaves is consistent with the unusually dry summer of 1973. *Olneya* added a significant number of new leaves. Additional leaf weight on *Olneya* is expected due to the evergreen nature of this plant.

Ambrosia deltoidea leaves and branches were collected after new leaf production ceased in July, 1973. *Ambrosia* also exhibited a significant decrease in leaf production.

The decrease in leaf production for the two deciduous species is similar (*Acacia*, 57.3%; *Ambrosia*, 59. 8%).

Table 1. Leaf weight vs branch weight for two desert species

		Acacia				*Olneya*			
Tree	Branch	Stem gm	Ave	Leaf gm	Ave	Stem gm	Ave	Leaf gm	Ave
1	1	206	183	2.21	2.135	679	649.5	87.48	84.495
	2	160		2.15		620		81.51	
2	3	187	142	4.26	2.53	579	508.5	76.26	80.805
	4	97		.80		438		85.35	
3	5	184	174	1.95	4.84	528	499	129.67	101.60
	6	164		7.73		470		73.53	
4	7	177	142	9.47	6.83	466	548	28.48	42.87
	8	107		4.19		630		57.26	
5	9	205	171.5	5.25	5.405	1025	888	85.11	96.73
	10	138		5.56		751		108.35	

Table 2. Statistical analysis for ungrouped stem-leaf weight data

	N	$\bar{X}$ gm	s^2	s gm
Acacia Stem[1]	10	162	1438.94	37.93
Leaf[2]	10	4.35	7.57	2.75
Iron wood Stem[3]	10	618	30,573.44	174.85
Leaf[4]	10	81	732.69	27.07

1] 95% CL = 162 ± 27.13
2] 95% CL = 4.35 ± 1.97
3] 95% CL = 618 ± 125.07
4] 95% CL = 81.30 ± 19.36

Table 3. Statistical analysis for grouped branch-leaf weight data

	N	$\bar{X}$ gm	s^2	s gm
Acacia Stem[1]	5	162.50	368.50	19.20
Leaf[2]	5	4.35	3.93	1.98
Olneya Stem[3]	5	618.60	26,235.37	161.97
Leaf[4]	5	81.30	534.37	23.12

1] 95% CL = 162.50 ± 23.84
2] 95% CL = 4.35 ± 2.46
3] 95% CL = 618.60 ± 201.08
4] 95% CL = 23.12 ± 10.34

Table 4. Leaf weight/branch weight analysis

Species	N	Leaf Wt/ Branch Wt.	s^2	s
Acacia[1]	5	.0286	.0002	.0143
Olneya[2]	5	.1359	.0023	.0480
Ambrosia[3]	7	.2570	.0024	.0487

1] 95% CL = .0286 ± .0178
2] 95% CL = .1359 ± .0596
3] 95% CL = .2570 ± .0450

Inflorescence

Samples of inflorescences of *Acacia constricta*, *Ambrosia deltoidea*, *Cercidium microphyllum*, and *Larrea divaricata* were collected when blooming was judged to be at maximum. Collections were completed during June and July, 1973. *Ambrosia* and *Larrea* were chosen on upland sites while *Acacia* and *Cercidium* were selected along washed sites.

Field sampling consisted of clipping branches of certain sizes from plants in conspicuous bloom, stripping inflorescences and determining the oven-dry weight of the branches and inflorescences. The inflorescences branch analysis is shown in Table 5.

Table 5. Analysis of inflorescence data

Species	Sample Size	Infl. Wt. / Branch Wt.	S^2	S
Acacia[1]	25	.0476	.0004	.0196
Ambrosia[2]	7	.0191	.0001	.0121
Cercidium[3]	24	.0137	.0003	.0159
Larrea[4]	8	.0053	.000009	.0029

1] 95% CL = .0476 ± .0081 3] 95% CL = .0317 ± .0067
2] 95% CL = .0191 ± .0181 4] 95% CL = .0053 ± .0024

In 1973 the inflorescence ratio for *Acacia* almost doubled as compared to that of 1972. *Cercidium* and *Larrea* flower production declined significantly in 1973 (26.6% and 6.6% of last year, respectively).

Fruit Production

Samples of mature fruits of *Acacia*, *Ambrosia*, *Cercidium*, and *Larrea* were collected in the same manner as the inflorescences. The fruit weight-branch weight analyses are summarized in Table 6.

Fruit production on *Acacia* and *Cercidium* increased two and one-half and three times, respectively, as compared to that of 1972. *Larrea* produced only about one-half as much fruit as in 1972.

Table 6. Analysis of fruit data

Species	Sample Size	Fruit Wt. / Branch Wt.	S^2	S
Acacia[1]	25	.0240	.0004	.0196
Ambrosia[2]	7	.0627	.0006	.0252
Cercidium[3]	25	.0544	.0027	.0521
Larrea[4]	21	.0303	.0003	.0167

1] 95% CL = .0240 ± .0071 3] 95% CL = .0544 ± .0214
2] 95% CL = .0627 ± .0227 4] 95% CL = .0303 ± .0079

B.2. Annuals

One hundred, 0.5 m^2 plots were sampled during the winter months of 1973. Biomass and densities of individual annual species were measured in the open and under shrubs. Sixty of these randomly selected plots were in the open and 40 under shrubs. Ten plots were sampled under each of four shrubs: *Larrea*, *Olneya*, *Cercidium*, and *Acacia*. All annual plants (including forbs) were removed from plots, identified and separated into species, oven-dried and then weighed.

Forty-six annuals (Table 7) have been identified. In the case of certain plants, though different species were identified it was difficult to separate them and therefore

Table 7. Winter annuals

ANNUALS	Symbols Used for Data Analysis
Aristida adscensionis	ARIADS
Astragalus sp.	ASTSP
Astragalus didymocarpus	ASTSP
Astragalus nuttallianus	ASTSP
Chaenactis carphoclinia	CHACAR
Chaenactis sp.	CHACAR
Chorizanthe sp.	CHOSP
Cryptantha angustifolia	CRYANG
Cryptantha pterocarya	CRYPTE
Cryptantha sp.	CRYPTE
Daucus pusilus	DAUPUS
Descurainia pinnata	DESPIN
Draba cuneifolia	DRACUN
Eriostrum sp.	ERISP
Eriogonum sp.	ERITHO
Eriogonum thomasii	ERITHO
Eriophyllum lanosum	ERILAN
Erodium texanum	EROTEX
Eucrypta sp.	EUCSP
Festuca octoflora	FESOCT
Filago sp.	FILSP
Geraea canescens	GERCAN
Lappula redowskii	LAPRED
Lepidium sp.	LEPSP
Lesquerella gordoni	LESGOR
Lesquerella sp.	LESGOR
Linanthus bigelovii	LINBIG
Lotus sp.	LOTSP
Lotus humistratus	LOTSP
Lotus tomentellus	LOTSP
Lupinus sparsiflorus	LUPSPA
Monoptilon bellioides	MONBEL
Nama hispidum	NAMHIS
Nemacladus glanduliferus	NEMGLA
Oenothera chamaenerioides	OENCHA
Oligomeris linifolia	OLILIN
Pectocarya heterocarpa	PECHET
Pectocarya sp.	PECHET
Plantago insularis	PLAINS
Plantago sp.	PLASP
Schismus arabicus	SCHARA
Schismus sp.	SCHARA
Silene antirrhina	SILANT
Thelypodium	THESP
Tillaea erecta	TILERE
Unidentified	UNK

their generic names have been used for biomass analysis.

Distribution of biomass for annuals is given in Tables 8 and 9. Plots 24, 70, 90, and 96 had no winter annuals. The number of winter annual species varies greatly from one plot to another and no definite trend was apparent in their distribution in the sampled plots. Plot 82 showed the highest

Table 8. Biomass data by plots

Plot No.	No. of Annuals	Annuals Tot. Weight gms.	Av. Weight gms.	Variance	Stnd. Dev.
1	13	43.3	3.33	6.8	2.61
2	6	51.9	8.65	159.0	12.61
3	6	15.2	2.53	9.0	3.00
4	9	21.3	2.37	12.2	3.50
5	5	18.4	3.68	20.4	4.51
6	10	15.8	1.58	4.1	2.03
7	9	26.3	2.92	31.7	5.63
8	6	12.0	2.00	13.4	3.66
9	4	43.4	10.85	117.0	10.82
10	5	37.1	7.42	103.6	10.18
11	3	9.6	3.20	11.1	3.33
12	7	16.2	2.31	8.1	2.85
13	9	24.8	2.76	14.0	3.75
14	5	53.8	10.76	521.3	22.83
15	16	75.5	4.72	80.6	8.97
16	10	41.5	4.15	70.7	8.41
17	6	21.4	3.57	34.2	5.85
18	9	42.5	4.72	54.2	7.36
19	3	9.5	3.17	19.1	4.37
20	8	32.1	4.01	30.7	5.54
21	9	84.7	9.41	222.3	14.91
22	6	43.5	7.25	18.2	4.27
23	11	50.9	4.63	17.2	4.15
25	7	21.3	3.04	20.4	4.52
26	9	67.1	7.46	88.8	9.43
27	12	40.2	3.35	13.5	3.67
28	11	36.1	3.28	18.5	4.30
29	7	15.7	2.24	13.3	3.65
30	10	53.9	5.39	84.5	9.19
31	7	38.3	5.47	61.4	7.84
32	6	32.2	5.37	92.9	9.64
33	8	28.9	3.61	58.7	7.66
34	6	45.7	7.62	95.8	9.79
35	11	46.9	4.26	17.4	4.17
36	3	5.3	1.77	1.9	1.39
37	10	32.5	3.25	82.0	9.06
38	11	18.2	1.66	2.9	1.71
39	7	8.3	1.19	1.1	1.06
40	7	18.7	2.68	28.3	5.32
41	7	6.1	.87	.6	.76
42	7	12.3	1.76	6.8	2.60
43	8	19.2	2.40	3.9	1.97
44	10	29.2	2.92	1.32	3.63
45	8	25.6	3.20	1.23	3.51
46	7	70.3	10.04	80.7	8.99
47	7	39.6	5.66	34.5	5.87
48	8	72.5	9.06	258.4	16.08
49	6	21.1	3.52	21.2	4.60
50	10	23.7	2.37	9.5	3.08
51	12	95.4	7.95	137.4	11.72
52	9	85.7	9.52	202.8	14.24
53	7	109.0	15.57	257.7	16.05
54	9	84.0	9.33	165.0	12.85
55	9	76.2	8.47	205.0	14.32
56	8	30.6	3.83	23.0	4.80
57	8	48.6	6.08	49.8	7.05
58	9	81.5	9.06	201.9	14.21
59	6	83.1	13.85	316.7	17.80
60	9	71.5	7.94	132.4	11.51
61	9	111.6	12.40	277.7	16.66
62	12	80.3	6.69	153.7	12.40
63	7	76.9	10.99	115.7	10.76
64	10	31.4	3.14	15.6	3.95
65	9	50.0	5.56	76.6	8.75
66	10	24.6	2.46	7.2	2.68
67	7	64.1	9.16	78.8	8.88

Table 8. continued

Plot No.	No. of Annuals	Annuals Tot. Weight gms.	Av. Weight gms.	Variance	Stnd. Dev.
68	13	89.2	6.86	72.5	8.52
69	7	44.0	6.29	16.7	4.09
71	13	75.7	5.82	109.4	10.46
72	6	68.5	11.42	111.7	10.57
73	9	51.5	5.72	76.7	8.76
74	12	43.0	3.58	18.4	4.29
75	6	123.7	20.62	1879.4	43.35
76	6	70.4	11.73	293.0	17.12
77	9	37.4	4.16	54.5	7.38
78	12	126.5	10.54	284.9	16.88
79	6	44.5	7.42	68.6	8.28
80	6	23.4	3.90	14.4	3.79
81	19	85.1	4.48	34.7	5.89
82	1	.5	.50	0000	0000
83	13	57.1	4.39	18.0	4.24
84	11	63.8	5.80	63.0	7.94
85	9	51.8	5.76	142.3	11.93
86	12	48.9	4.08	14.9	3.85
87	5	4.9	.98	.2	.44
88	9	23.4	2.60	8.2	2.87
89	10	43.6	4.36	35.6	5.97
91	8	15.1	1.89	1.8	1.35
92	9	34.2	3.80	15.6	3.95
93	8	64.6	8.08	303.3	17.41
94	5	32.9	6.58	71.7	8.47
95	10	13.0	1.30	1.4	1.19
97	8	12.2	1.51	2.0	1.42
98	7	23.1	3.30	12.1	3.48
99	10	28.4	2.84	9.4	3.07
100	6	26.0	4.33	2.7	5.20

Table 9. Biomass data by species

Specie	Tot. Weight (100 Plots) gms.	Av. Weight gms.	Variance	Stnd. Dev.
ARIADS	.9	.01	.0	.07
ASTSP	150.7	1.51	14.4	3.80
CHACAR	321.2	3.21	46.4	6.81
CHOSP	2.8	.03	.0	.15
CRYANG	37.0	.37	2.4	1.56
CRYPTE	58.6	.59	6.4	2.54
DAUPUS	25.8	.26	1.7	1.31
DESPIN	20.4	.20	1.3	1.14
DRACUN	48.3	.48	3.2	1.78
ERILAN	268.3	2.68	9.3	3.06
ERISP	27.5	.28	.7	.83
ERITHO	.1	.00	.0	.01
EROTEX	96.8	.97	8.0	2.83
EUC	2.7	.03	.0	.18
FESOCT	43.5	.44	2.5	1.59
FILSP	217.0	2.17	17.6	4.20
GERCAN	3.0	.03	.0	.18
LAPRED	4.4	.04	.2	.44
LEPSP	52.6	.53	1.7	1.31
LUPSPA	15.3	.15	1.7	1.29
LESGOR	56.8	.57	8.8	2.97
LINBIG	1.4	.01	.0	.14
LOTSP	1026.5	10.27	191.0	13.82
MONBEL	21.7	.22	.4	.65
NAMSP	9.6	.10	.8	.91
NEMGLA	49.2	.49	1.3	1.15
OENCHA	.2	.00	.0	.02
OLILIN	17.4	.17	3.0	1.74
PECHET	301.5	3.02	39.4	6.28
PHASP	15.4	.15	1.7	1.31
PLAINS	445.4	4.45	81.7	9.04
SCHARA	330.9	3.31	55.5	7.45
SILANT	13.2	.13	.5	.73
THESP	161.6	1.62	50.5	7.11
TILERE	8.4	.08	.5	.72
UNK	394.3	3.94	173.9	13.19

Table 10. Winter annuals biomass production (kg/ha)

Annuals	Open	*Larrea*	*Olneya*	*Cercidium*	*Acacia*	Average
	Shrub Cover					
ARIADS	.4	0	0	0	0	0
ASTSP	49.8	1.6	0	1.2	0	.8
CHACAR	33.0	134.4	237.0	37.6	15.2	106.0
CHOSP	1.2	0	0	0	2.0	.4
CRYANG	3.6	2.0	1.2	6.0	42.6	13.0
CRYPTE	0	6.8	78.0	31.4	.8	29.2
DAUPUS	15.6	1.2	0	30.6	10.4	10.6
DESPIN	.2	0	23.8	16.0	0	10.C
DRACUN	7.2	1.0	10.6	31.0	10.6	13.2
ERILAN	61.2	106.6	15.6	24.2	22.6	42.2
ERISP	3.0	6.0	15.4	7.6	7.8	9.2
ERITHO	0	0	0	0	0	0
EROTEX	29.8	3.2	3.4	8.2	.4	3.8
EUC	0	.2	0	1.8	3.2	1.2
FESOCT	5.2	29.6	21.0	3.6	0	13.6
FILSP	31.8	63.8	32.4	85.0	64.6	61.4
GERCAN	1.0	0	0	0	0	0
LAPRED	0	8.8	0	0	0	2.2
LEPSP	2.8	22.2	26.0	17.4	22.6	22.0
LUPSPA	5.2	0	0	0	0	0
LESGOR	2.4	32.2	63.4	3.4	0	24.8
LINBIG	0	0	2.8	0	0	.8
LOTSP	328.4	34.4	7.4	.6	42.2	20.6
MONBEL	6.8	1.0	0	0	1.8	.8
NAMSP	3.2	0	0	0	0	0
NEMGLA	13.6	1.2	0	0	15.4	4.2
OENCHA	0	0	0	0	0	0
OLILIN	5.8	0	0	0	0	0
PECHET	23.4	303.6	90.2	54.4	14.4	115.6
PHASP	.2	0	0	26.0	0	6.4
PLAINS	107.6	172.2	15.8	14.4	43.4	61.4
SCHARA	58.6	54.6	132.4	79.6	41.8	77.2
SILANT	.6	0	5.6	16.6	2.4	6.2
THESP	.8	69.4	196.4	52.0	0	79.4
TILERE	.2	1.2	0	14.2	0	3.8
UNK	6.6	87.0	330.8	195.4	136.6	187.4

t = .29 for Annual Production in the open versus under shrub cover (Average)

Table 11. Analysis of variance for annual production in the open and under *Larrea*, *Olneya*, *Cercidium* and *Acacia*

GRAND TOTAL = 4521.6   NO. OBS. = 180   MEAN = 25.12

SOURCE	SS	DF	MS
TREATMENTS	11519.4	4	2879.85
ERROR	522769.0	175	2987.25
TOTAL	534288.0	179	

F = .964047 ON 4 and 175 DEGREES OF FREEDOM.

Table 12. Analysis of variance for annual production under *Larrea*, *Olneya*, *Cercidium* and *Acacia*

GRAND TOTAL = 3712.4   NO. OBS. = 144   MEAN = 25.7806

SOURCE	SS	DF	MS
TREATMENTS	11519.5	4	2879.85
ERROR	522769.0	175	2987.25
TOTAL	534288.0	179	

F = 1.2828 ON 3 and 140 DEGREES OF FREEDOM.

number of winter annuals. The biomass production of different winter annuals is also variable; *Lotus* spp. showed the highest biomass production.

Biomass production (kg/ha) did not differ significantly in the open and under shrubs (Table 10), but slightly higher values were observed under shrubs. The highest biomass production was under *Olneya* and the lowest under *Acacia*. Table 11 shows the analysis of variance on biomass production in the open and under four different shrubs. The differences are not statistically significant. The variation in biomass production of winter annuals under four different shrubs (Table 12) is not statistically significant. Since the data is only for one year, it is difficult and premature to relate the biomass production to the canopy characteristics of the area. The biomass production in the open and under different shrubs should be studied over a longer period. Microclimatic changes caused by the canopy characteristics of the area should be related to certain common winter annuals in the area.

B.3. Litter Production

Eight 0.5 m^2 plots established in 1972 were used for litter measurements. Large pieces of litter were hand picked from the plots. Samples were then hand picked, separating larger pieces of litter into woody, non-woody and stems. Soils and gravels were separated by flotation. The organic remainder was oven-dried and hand-sorted into fecal, stems and non-woody, then weighed (Table 13).

The greater amount of total litter produced in one year compared to the initial sample may seem large. This may be due to the unusual weather of the preceding and present growing seasons. The very wet winter growing season of 1972-73 increased the production of desert annuals. This, in part, explains the increase in non-woody and stem separates. Compounding the excellent growing season for annuals in 1972 was the ensuing dry summer of 1973 which decreased the pressure of animals feeding on mature herbage.

Production of woody litter is much less susceptible to the variation in climate. This is shown by the sharp reduction in woody litter produced on the plots. Relatively rapid disintegration (2-3 years) of the bulk of woody litter is indicated by the fact that one year's production was one-half that of the initial sample.

Variability of the samples for one year's production are concordantly larger for all separates. This is not unexpected as the forces acting upon the litter production and degradation would tend to average out with time. The raw data is converted to kg/ha and analyzed for the total site in Table 13. The conversion factor is 1 g/plot = 20.2 kg/ha.

Table 14 shows the analysis of variance for litter production from all eight plots. The calculated F value indicates the plot differences are not significant at the 95% level. It was believed that the large sample from Plot D might have increased the variance exclusively.

Table 15 is an analysis of litter excluding Plot D. Plot D gained about three times the non-woody litter than the next largest non-woody separate because of a large number of joints dropped by a nearby cholla. When the statistics were developed omitting this plot, the variance was reduced considerably (Table 15). However, as shown in Table 16, differences were still non-significant.

It would be desirable to increase the sample size. Data from this year's sampling indicate 557 samples would be needed to obtain estimates within ±10% of the true mean and to that 22 samples would be necessary for estimates within 50% of the mean.

Table 13. Litter weight distribution (kg/ha)

Plot	Feces	Stems	Woody	Non-Woody	Total
A	6.12	36.72	128.52	277.44	448.80
B	16.32	130.56	2721.36	1105.68	3973.92
C	18.36	79.56	338.64	652.80	1089.36
D	48.96	707.88	1124.04	6944.16	8825.04
E	4.08	173.40	89.76	544.68	811.92
F	36.72	499.80	3543.48	1521.84	5601.84
G	16.32	367.20	318.24	2250.12	2951.88
H	46.92	32.64	140.76	189.72	410.04
Total (n=8)	193.80	2027.76	8404.80	13,486.44	24,112.78
$\bar{X}$	24.22	253.47	1050.60	1,685.81	3,014.10
S^2	310.90	61,087.30	1,807,967.50	4,989,029.90	9,043,523.90
S	17.63	247.16	1,344.61	2,233.61	3,007.25
95% CI	14.52	206.66	1,124.30	1,867.64	2,514.52

Table 14. Analysis of variance for litter production (no. of plots = 8)

Grand Total = 24112.8 No. Obs. = 32 Mean = 753.525

Source	SS	DF	MS
Treatments	1.59×10^8	7	2.20×10^7
Error	4.61×10^8	24	1.92×10^7
Total	6.19×10^8	31	

F = 1.146 On 7 and 24 Degrees of Freedom

Table 15. Statistics for litter data (total site) omitting plot D (kg/ha)

Separate		N	$\bar{X}$	S^2	S
Feces	1]	7	20.69	246.13	15.69
Stems	2]	7	188.55	31,937.32	178.71
Woody	3]	7	1040.11	2,108,267.97	1451.99
Non-Woody	4]	7	934.61	553,811.37	744.19
Total	5]	7	2183.97	4,118,963.42	2029.52

1] 95% CL = 20.69 ± 14.03

2] 95% CL = 188.55 ± 159.75

3] 95% CL = 1040.11 ± 1297.91

4] 95% CL = 934.61 ± 665.22

5] 95% CL = 2183.97 ± 1814.16

Table 16. Analysis of variance for litter production (no. of plots = 7)

Grand Total = 15287.8 No. Obs. = 28 Mean = 545.991

Source	SS	DF	MS
Treatments	6.18×10^7	6	1.03×10^7
Error	1.56×10^8	21	7.42×10^5
Total	2.18×10^8	27	

F = 1.38803 On 6 and 21 Degrees of Freedom

B.4. Root Study

Field Methods

Efforts were made in 1973 to obtain estimates of below-ground plant parts. The approach used involved excavation and volumetric measurements of root biomass by point-frame sampling to estimate root density. Separating roots by species was not possible on the Silverbell site. Thus, it was assumed that each of the major perennial species was a center of root concentration that decreased with distance from the plant. This was visualized in three dimensions as a landscape of peaked hills rising from sloping valleys. This concept was used to develop a model describing the total root biomass.

Volumetric Sampling

Because of the rockiness of the soils on the Silverbell site, core sampling was impractical. Instead, holes of about one square foot in surface area and one foot deep were dug with a spade. The soil material, including roots, was removed for working and weighing. The volume of material removed was determined by lining the hole with plastic and filling with measured quantities of water. Samples were taken in the open and under the crowns (half the crown radius) of *Olneya*, *Cercidium*, and *Ambrosia*. A special apparatus was constructed to wash the roots from the soil (Figure 3). Data are recorded on DSCODE A3UTC37.

Point Frame

A point frame consisting of 50 movable pins at 1 cm intervals was used to determine root density. Counts were made at 5 cm increments from the surface to the bottom of a trench dug with a backhoe. Roots intercepted by the pins were counted on the exposed face of the soil profile (Figure 1). Data are reported on A3UTC36.

Excavation

Three specimens each of *Olneya* and *Cercidium* were excavated with a backhoe. Trenches were dug to bedrock (about 1 m) on four sides of each plant, the plant was excavated and large roots were weighed (Figure 2). Height and crown diameter of the plant were measured. The above-ground parts as well as the understory, principally *Ambrosia*, were weighed (A3UTC38).

Several lateral roots were excavated on specimens of

Figure 1. Estimating root concentrations with point frame

Figure 2. Excavation of *Olneya*, counting roots and determining volume of root biomass sample.

Olneya and *Cercidium*. Interestingly, a single, and the only significant lateral root of one *Cercidium* plant, extended about 15 m from the tree before disappearing. The root was about 3.1 cm in diameter and followed a tortuous path 10 to 20 cm below the soil surface. The root weighed 4.4 kg and had a total length of 21 m (see Table 17).

Root Density Analysis

The rationale of the analysis was to use the point frame data to distribute the root biomass as determined from the hole samples throughout the soil profile. A basic assumption in performing the analysis is that root weight is a linear function of root density.

The data from the open, *Ambrosia*, *Cercidium* and *Olneya*, were included in the analysis. Roots greater than 1 cm in diameter were excluded. These roots were infrequent in both the point frame and hole samples and would have been a source of great variability. It was also believed that the fibrous roots would be of greater interest.

Root Concentrations

The concentration of fibrous roots with depth under all cover types was greatest at 20 to 30 cm and gradually decreased to near zero at 85 to 100 cm. There were no roots (except directly under the plants) a few centimeters just beneath the surface. This is considerably different from experiences in humid areas where root density normally is greatest near the surface and decreases, often exponentially, with depth.

Presumably, the upper 10 to 15 cm of soil on the Silverbell site act as a moisture barrier. This apparent phenomenon, which in a sense is a drought evasion mechanism, should be given further study, particularly as related to soil moisture movement near the surface.

In order to extrapolate the hole sample data it was necessary to develop a functional relationship of the distribution of root density with soil depth. Density distribution as indicated by the point frame samples was highly skewed as should be expected from casual field observations. It was thought the distribution might be approximated by a log normal relationship.

A χ^2 goodness of fit test for normality was made for the normalized root count data collected in the open areas and under the crowns of *Ambrosia*. In order to make the test, the standard normal variate (log depth in this case) was partitioned into five equal probability classes as given in Table 18. Results indicated the log normal distribution was inadequate to describe root density as a function of depth. However, the data were highly variable and insufficient in some of the probability classes to provide an adequate test. For example, see the -.841 to -2.53 interval for the open site and the -.253 to .841 interval for *Ambrosia*. There is also the possibility of a bimodal distribution, but a great many more samples would be necessary to show this.

Table 17. Lateral root excavation data

Species	(meters) Crown	(kilogram) Tree Wt.	(kilogram) Root Wt.	(meters) Lateral Root Length	(kilograms) Lateral Root Weight
Cercidium I	3.76	98.16	----	20.65	5.76
Cercidium II	3.29	45.47	12.84	21.34	4.43
Olneya	3.45	85.55	33.64	14.40+	5.21

Figure 3. Washing of the roots from soil.

The more rigid Kolmogorov-Smirnov test was applied to the data from all sites (Tables 19 through 22). Maximum deviation of observed from theoretical exceeded the 5% confidence level for all cover types for 40% of the data points. Deviations were consistently high at the tails of the distributions at the lower depths.

Because of the high deviations encountered with the log-normal distribution and the similarity of the observed root concentration to a gamma probability density function, the gamma distribution function was tried. It can be written as:

$$f(x) = \frac{\lambda}{(r-1)!} (\lambda x)^{r-1} e^{-\lambda x} \text{ for } x \geqslant 0$$

Where x is the gamma function and the parameters λ and r are estimated by the mean and variance of the observed data. For results of the analyses see Tables 19 to 22. The Kolmogorov-Smirnov test implies that this distribution should also be rejected at the .05 level. However, the actual fit to the data was close and for some of the cover types just missed being significant (see Figures 4 through 7). In general, the maximum differences between observed and theoretical were less than those for the log normal. Deviations exceeded allowable limits for 25% of the data points.

Other probability distribution density functions might have fit the data equally well as did the gamma distribution. However, because of the variability encountered at a few depths, rigid tests would likely produce similar results. The gamma distribution function was assumed adequate at this

Table 18. Calculation of the X^2 goodness of fit test for log normality

EQUI-PROBABILITY INTERVALS CLASS	DEPTH	O	E	O - E	X^2
		OPEN SITE			
- ∞ to .84	5 - 20	100	113	13	1.496
-.841 to -.253	25	65	113	48	20.389
-.253 to .253	30 - 35	137	113	24	5.097
.253 to .841	40 - 45	131	113	18	2.867
.841 to ∞	45 - 70	133	113	20	3.539
				Total	35.21
		AMBROSIA			
- ∞ to .84	5 - 20	160	122	38	11.8
-.841 to -.253	25 - 30	116	122	6	.29
-.253 to .253	35	64	122	58	27.57
.253 to .841	40 - 50	148	122	26	5.54
.841 to ∞	55 - 70	124	122	2	.03
				Total	45.23

Table 19. Frequency distributions of root density with depth and Kolmogorov-Smirnov test -- open

DEPTH NO.	CM.	LOG	FREQUENCY NO. /300 COUNTS	CUMULATIVE FREQ.	FRACTION	NORMALIZED DEPTH - Z	LOG - NORMAL DISTRIBUTION S(x)	S(x) - F(x)	GAMMA DISTRIBUTION S(x)	S(x)- F(x)
1	5	.6990	6	6	.011	-4.0968	.001	.010	.0004	.010
2	10	1.0000	12	18	.032	-2.5913	.005	.027	.011	.021
3	15	1.1761	36	54	.095	-1.7105	.044	.051	.056	.039
4	20	1.3010	46	100	.177	-1.0853	.140	.037	.152	.025
5	25	1.3979	65	165	.291	- .6012	.274	.017	.290	.001
6	30	1.4771	74	239	.422	- .2051	.421	.001	.446	.024
7	35	1.5441	63	302	.534	.1300	.552	.018	.595	.061
8	40	1.6021	73	375	.662	.4201	.663	.001	.720	.058
9	45	1.6532	58	433	.765	.6757	.752	.013	.817	.052
10	50	1.6990	62	495	.874	.9048	.816	.058	.8850	.011
11	55	1.7464	42	537	.949	1.1118	.866	.083	.931	.018
12	60	1.7782	21	558	.986	1.3009	.903	.083	.960	.026
13	65	1.8129	5	563	.995	1.4745	.929	.076	.978	.017
14	70	1.8451	3	566	1.000	1.6355	.949	.051	.989	.012

LOG NORMAL: $\bar{X} = 1.5181$, $\sigma = .19937$

GAMMA: $\bar{X} = 7.20$, $\sigma^2 = 7.3984$

$r = 7.0069$

$\lambda = .97318$

$\Gamma = 728.0973$

5% LEVEL OF SIGNIFICANCE FOR MAX $|S(x)-F(x)|$ = .037

Table 20. Frequency of root density with depth and Kolmogorov-Smirnov test -- *Ambrosia*

	DEPTH		FREQUENCY	CUMULATIVE		NORMALIZED DEPTH - Z	LOG - NORMAL DISTRIBUTION		GAMMA DISTRIBUTION	
NO.	CM.	LOG	NO. /300 COUNTS	FREQ.	FRACTION		S(x)	S(x) - F(x)	S(x)	S(x) - F(x)
1	5	.6990	7	7	.011	-3.4465	001	.010	.000	.011
2	10	1.0000	18	25	.041	-2.1648	015	.023	.004	.037
3	15	1.1761	63	88	.144	-1.4149	079	.065	.106	.038
4	20	1.3010	72	160	.261	- .8819	189	.072	.210	.051
5	25	1.3979	55	215	.351	- .4705	319	.032	.335	.016
6	30	1.4771	61	276	.451	- .1333	448	.003	.463	.012
7	35	1.5441	64	340	.556	.1520	560	.004	.582	.026
8	40	1.6021	55	395	.645	.3989	655	.010	.684	.039
9	45	1.6532	47	442	.722	.6166	732	.010	.768	.046
10	50	1.6990	46	488	.797	.8116	791	.006	.834	.037
11	55	1.7404	33	521	.851	.9879	840	.011	.883	.032
12	60	1.7782	19	540	.882	1.1488	875	.007	.919	.037
13	65	1.8129	42	582	.951	1.2966	903	.048	.945	.006
14	70	1.8451	30	612	1.000	1.4337	924	.076	.963	.037

LOG NORMAL: X = 1.5084, σ = .234848

GAMMA: X = 7.3349, σ^2 = 11.8040

α = 4.5578

β = .62139

Γ = 12.6117

5% LEVEL OF SIGNIFICANCE FOR MAX $|S(x) - F(x)|$ = .035

Table 21. Frequency distributions of root density with depth and Kolmogorov-Smirnov test -- *Olneya*

	DEPTH		FREQUENCY	CUMULATIVE		NORMALIZED DEPTH - Z	LOG - NORMAL DISTRIBUTION		GAMMA DISTRIBUTION	
NO.	CM.	LOG	NO. /300 COUNTS	FREQ.	FRACTION		S(x)	S(x) - F(x)	S(x)	S(x) - F(x)
1	5	.6990	26	26	.039	-2.6290	.004	.035	.002	.037
2	10	1.0000	57	83	.123	-1.5304	.063	.060	.009	.003
3	15	1.1761	92	175	.260	- .8876	.187	.073	.214	.046
4	20	1.3010	69	244	.362	- .4318	.334	.028	.348	.014
5	25	1.3979	77	321	.477	- .0781	.468	.009	.482	.005
6	30	1.4771	68	389	.578	.2109	.583	.005	.602	.024
7	35	1.5441	56	445	.661	.4555	.677	.016	.703	.042
8	40	1.6021	63	508	.755	.6672	.748	.007	.783	.028
9	45	1.6532	39	547	.813	.8337	.797	.016	.845	.032
10	50	1.6990	32	579	.860	1.0209	.846	.014	.891	.031
11	55	1.7404	32	611	.908	1.1720	.879	.029	.925	.017
12	60	1.7782	25	636	.945	1.3099	.905	.040	.949	.004
13	65	1.8129	22	658	.978	1.4366	.925	.053	.965	.013
14	70	1.8451	15	673	1.000	1.3541	.939	.061	.977	.023

LOG NORMAL: $\bar{X}$ = 1.41928, σ = .273976

GAMMA: $\bar{X}$ = 6.2407, σ^2 = 11.3286

α = 3.4379

β = .5509

Γ = 3.1051

5% LEVEL OF SIGNIFICANCE FOR MAX $|S(x) - F(x)|$ = .034

Table 22. Frequency distributions of root density with depth and Kolmogorov-Smirnov test -- *Cercidium*

DEPTH NO.	CM.	LOG	FREQUENCY NO. /300 COUNTS	CUMULATIVE FREQ.	FRACTION	NORMALIZED DEPTH - Z	LOG - NORMAL DISTRIBUTION S(x)	S(x) - F(x)	GAMMA DISTRIBUTION S(x)	S(x) - F(x)
1	5	.6990	21	21	.034	-2.5980	005	.029	.002	.032
2	10	1.0000	71	92	.152	-1.5203	064	.088	.009	.143
3	15	1.1761	58	150	.247	- .8898	187	.060	.202	.045
4	20	1.3010	63	213	.351	- .4427	330	.021	.330	.021
5	25	1.3979	64	277	.456	- .0959	460	-.004	.458	.002
6	30	1.4771	56	333	.548	.1869	575	-.027	.575	.027
7	35	1.5441	66	399	.657	.4279	666	-.009	.673	.016
8	40	1.6021	42	441	.726	.6355	739	-.013	.754	.028
9	45	1.6532	48	489	.806	.8185	794	.012	.815	.009
10	50	1.6990	29	518	.853	.9825	836	.017	.862	.009
11	55	1.7404	29	547	.901	1.1307	871	.030	.896	.005
12	60	1.7882	25	572	.942	1.2661	898	.044	.921	.021
13	65	1.8129	19	591	.974	1.3903	918	.056	.938	.036
14	70	1.8451	16	607	1.000	1.5059	933	.067	.950	.050

LOG NORMAL $\bar{X} = 1.4246$ $\sigma = .27929$

GAMMA $\bar{X} = 6.3509$ $\sigma^2 = 11.7724$

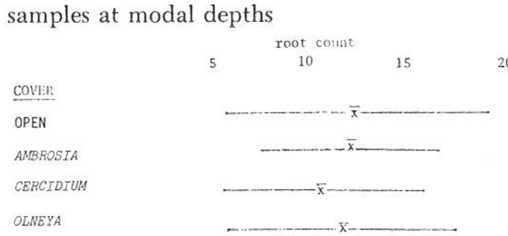
$\alpha = 3.4261$ $\beta = .53947$ $\Gamma = 3.14296$

5% LEVEL OF SIGNIFICANCE FOR MAX $|S(x) - F(x)| = .036$

Table 23. Point frame samples at modal depth of root concentration

	OPEN	*AMBROSIA*	*CERCIDIUM*	*OLNEYA*
	Roots encountered per 50 points			
	10	5	18	13
	17	11	8	16
	7	12	7	4
	20	12	6	6
	5	16	10	16
	15	16	14	14
σ^2	35	16	21	27
$\bar{X}$	12.3	12.0	10.5	11.5
Mode	30	25	20	20

Table 24. Confidence limits for point frame samples at modal depths



time. It will be further tested with additional data to be collected in 1974.

Based on the analyses of the limited point frame sampling, a great many more samples would be required to precisely describe the change in root concentration with depth. Root counts for the six point-frame measurements made at the modal depth for the four cover types are given in Table 23. Five percent confidence limits indicate there were no differences in root concentrations at the modal depth (Table 24). Estimates of the number of the samples required at several levels of precision are plotted in Figure 4 for the open and *Ambrosia* covers, which had the highest and lowest variances, respectively. At the modal depth of root concentration, 5% confidence limits given in Table 24 indicate no significant differences between cover types. The sampling precision of the point frame counts for all depths are shown in Figure 8. The data are for the open and *Ambrosia* which had the highest and lowest variance, respectively.

Root Biomass

Oven-dry weights of roots extracted from the hole samples were distributed throughout the soil profile using the probabilities determined from the point frame sampling. Surface area of the sample holes was determined by dividing the volume of soil removed by the depth of the hole.

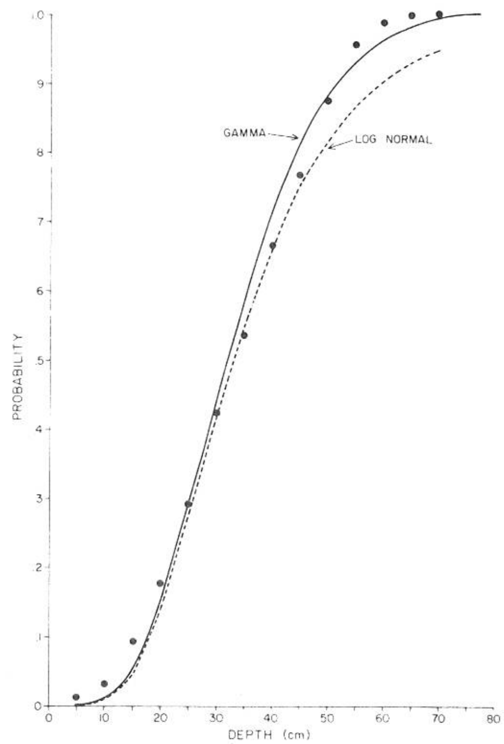


Figure 4. Root frequencies probability - open.

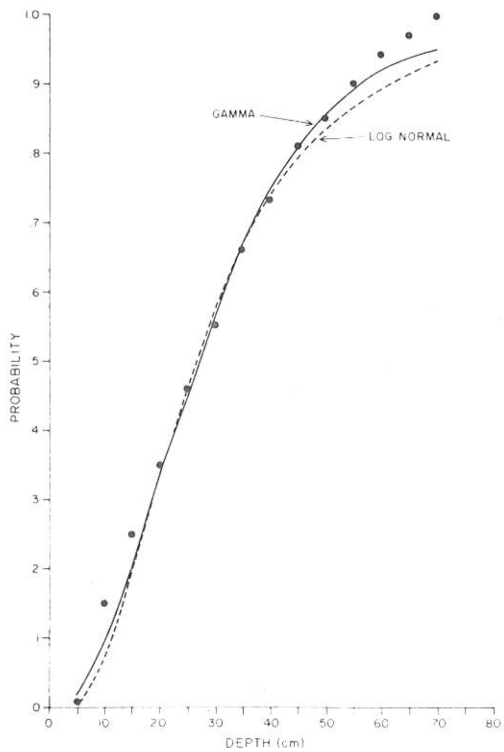


Figure 6. Root frequency probability - *Cercidium*.

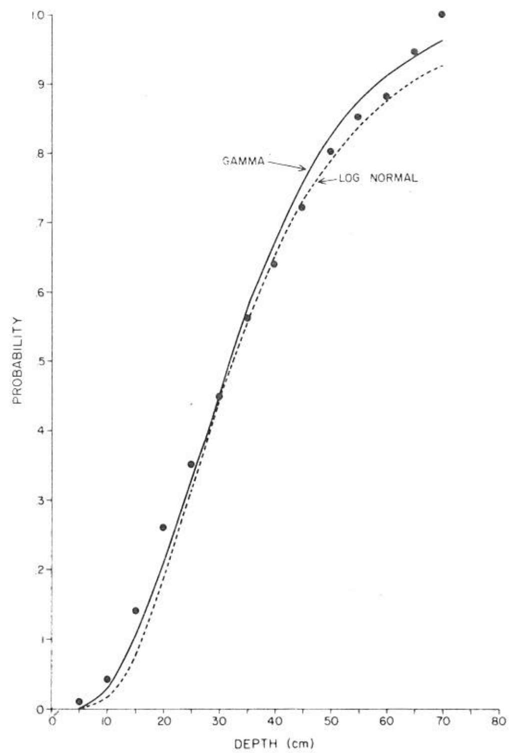


Figure 5. Root frequency probability - *Ambrosia*.

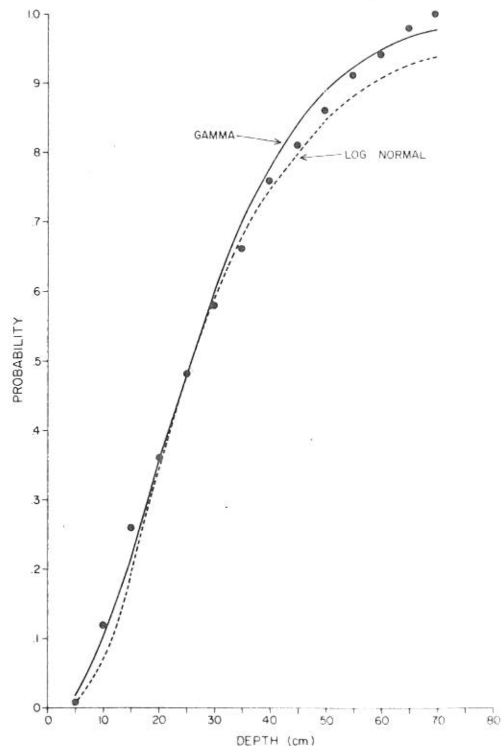


Figure 7. Root frequency probability - *Olneya*.

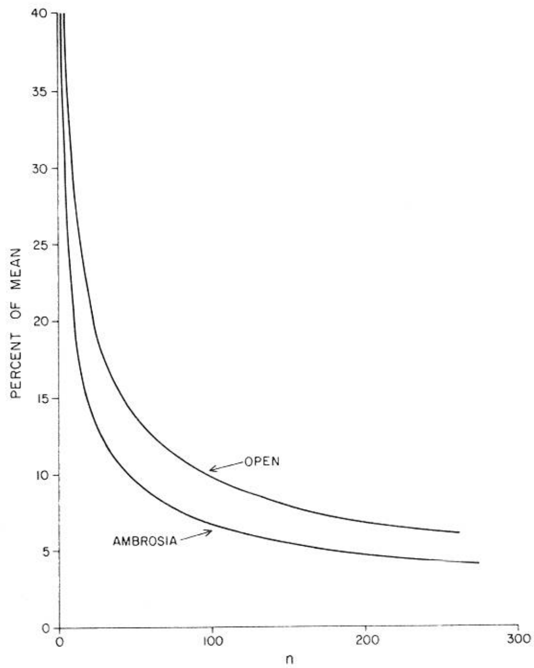


Figure 8. Point frame sampling precision.

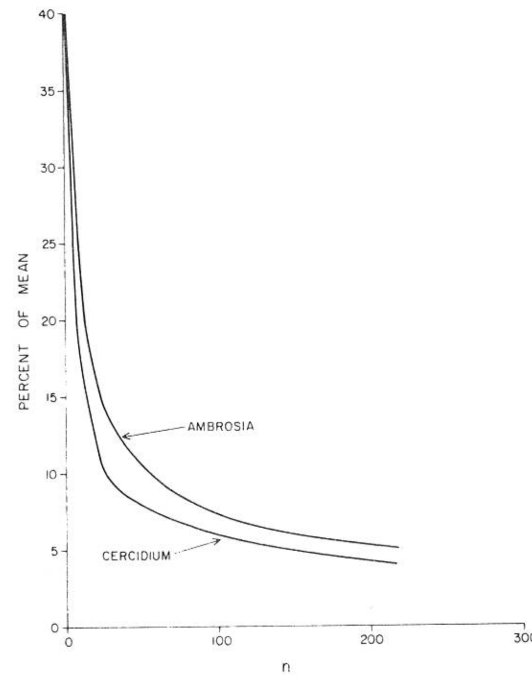


Figure 9. Root weight sampling precision.

Table 25. Root weight sample data and computed total biomass in soil profile

SAMPLE no.	DEPTH cm.	VOL. cc.	SAMPLE WT. gm.	SURFACE AREA cm^2	PROBABILITY	BIOMASS Kg/Ha
1	21	30,000	83.50	1428.5714	.2353	24,841.
2	20	27,300	66.25	1365.0000	.[illegible]104	23,068.
3	33	51,750	74.75	1568.1818	.5340	8,926.
4	28	39,500	145.80	1410.7143	.4116	25,110.
5	27	43,700	93.5	1618.5185	3860	14,966.
				CERCIDIUM		
1	26.5	48,100	225.00	1815.0943	.4935	25,118.
2	30.0	41,500	230.90	1383.3333	.575[illegible]	29,022.
3	27.5	48,000	156.18	1745.4545	.5169	17,312.
4	27.0	53,500	224.70	1981.4815	.5052	22,446.
5	28.5	43,000	113.67	1508.7719	.5402	13,948
6	29.0	50,000	126.45	1724.1379	.5518	13,291.
				OLNEYA		
1	37.0	35,000	153.30	945.9459	.7351	22,045.
2	37.0	45,000	367.00	1216.2162	.7351	41,048.
3	29.0	27,500	92.30	948.2758	.5782	16,834.
4	28.5	21,600	91.40	757.8947	.5662	21,299.
5	25.0	23,500	303.20	940.0000	.4822	66,892
6	27.0	28,500	185.52	1055.5556	.5302	33,149.
				OPEN		
1	27.0	30,000	46.20	1111.1111	.3522	11,805
2	30.0	46,000	59.20	1533.3333	.4459	8,659.
3	30.0	45,000	58.40	1500.0000	.4459	8,732.
4	29.5	48,500	47.15	1644.0678	.4303	66,652
5	27.5	44,500	27.32	1618.1818	.3678	45,[illegible]

It was believed this gave a better estimate of surface area than direct measurement, since the holes tended to sluff in somewhat around the edge and, because of rocks, it was not possible to dig a perfectly square hole. Weight of roots in the profile were calculated from the probability of their concentrations at the depth sampled. The analyses are given in Table 25.

Analysis of the total biomass data indicated a high variability, as should be expected. *Cercidium* had the highest variance and the open site had the lowest of the four cover types. The number of samples required for a range of precision are shown in Figure 8 for the point frame and Figure 9 for root weight.

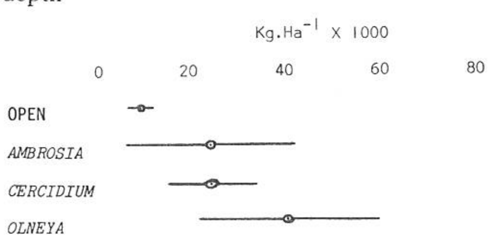
The mean total biomass was distributed throughout the soil profile according to the calculated distribution probabilities (Table 26). The probability distribution of root biomass for the four cover types is shown in Figure 10.

The total biomass (integral of the curves in Figure 10) is compared for the four cover types in Table 27. Although there is quite a spread in the distributions, little can be

Table 26. Cumulative root biomass distribution with soil depth

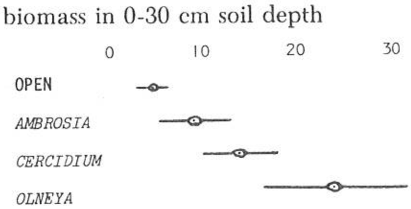
	OPEN		*AMBROSIA*		*CERCIDIUM*		*OLNEYA*	
DEPTH	PROB.	BIOMASS	PROB.	BIOMASS	PROB.	BIOMASS	PROB.	BIOMASS
5	.004	2.9972	.0049	94.9718	.0224	483.1456	.0239	801.7136
10	.0109	81.6737	.0357	691.9374	.0926	1,997.2894	.0986	3307.4877
15	.0558	418.1094	.1057	2,048.6774	.2020	4,356.9380	.2142	7185.2319
20	.1516	1135.9388	.2104	4,077.9728	.3301	7,119.9269	.3487	11696.9672
25	.2898	2171.4714	.3348	6,489.0936	.4586	9,891.5434	.4822	16175.1579
30	.4459	3341.1287	.4627	8,968.0514	.5751	12,404.3319	.6022	20200.4979
35	.5948	4456.8364	.5816	11,272.5712	.6739	14,535.3491	.7030	23581.7835
40	.7203	5397.2079	.6842	13,261.1644	.7535	16,252.2415	.7834	26278.7613
45	.8166	6118.7838	.7681	14,887.3142	.8153	17,585.2057	.8452	28351.8114
50	.8850	6631.3050	.8337	16,158.7734	.8618	18,588.1642	.8912	29894.8584
55	.9309	6975.2337	.8831	17,116.2442	.8960	19,325.8240	.9247	31018.5992
60	.9601	7194.0293	.9193	17,817,8726	.9206	19,856.4214	.9485	31816.9583
65	.9780	7328.1540	.9451	18,317.9282	.9380	20,231.7220	.9653	32380.5059
70	.9885	7406.8305	.9632	18,668.7424	.9502	20,494.8638	.9768	32766.2676
75	.9946	7452.5378	.9756	18,909.0792	.9586	20,676.0434	.9847	33031.2692
80	.9979	7477.2647	.9840	19,071.8880	.9643	20,798.9867	.9900	33209.0550
85	.9997	7490.7521	.9896	19,180.4272	.9681	20,880.9489	.9935	33326.4608
90	1.0007	7498.2451	.9933	19,252.1406	.9707	20,937.0283	.9959	33406.9676
95	1.0012	7501.9916	.9957	19,298.6574	.9724	20,973.6956	.9974	33457.2843
100	1.0014	7503.4902	.9972	19.327.7304	.9736	20,999.5784	.9984	33490.8288

Table 27. Confidence limits for total root biomass in 0-100 cm soil depth



	$\bar{X}$	S^2
OPEN	7493	8,051,008
AMBROSIA	19382	51,256,640
CERCIDIUM	21569	40,446,463
OLNEYA	33545	345,989,496

Table 28. Confidence limits for root biomass in 0-30 cm soil depth



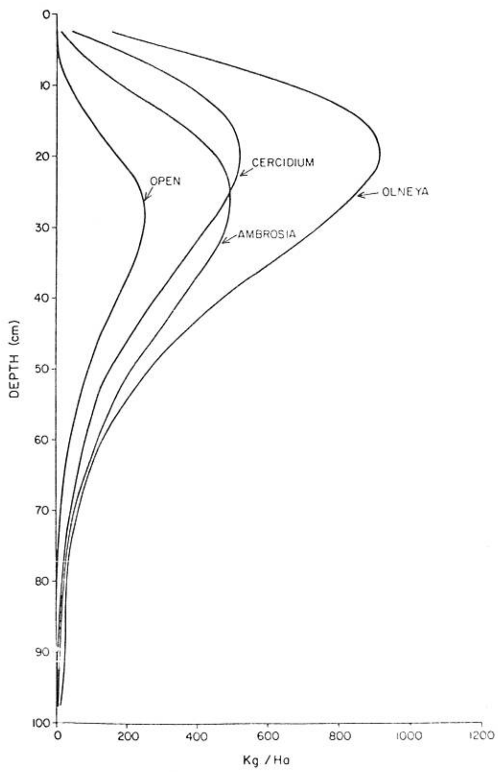


Figure 10. Root biomass distribution.

Table 29. Root probability distribution with distance from plant center - *Olneya*

	Distance from plant center (meters)					
Depth	.25	.50	.75	1.00	1.25	1.50
.05	.0022525	.0016275	.0013949	.0012400	.0011216	.0010249
.10	.0070356	.0050834	.0043569	.0038730	.0035031	.0032011
.15	.0108980	.0078741	.0067487	.0059992	.0054262	.0049584
.20	.0126674	.0091525	.0078444	.0069732	.0063072	.0057634
.25	.0125805	.0090897	.0077906	.0069254	.0062640	.0057239
.30	.0113106	.0081722	.0070042	.0062264	.0056317	.0051461
.35	.0094940	.0068597	.0058793	.0052264	.0047272	.0043196
.40	.0075785	.0054757	.0046931	.0041719	.0037734	.0034481
.45	.0058216	.0042063	.0036051	.0032047	.0028987	.0026487
.50	.0043386	.0031348	.0026867	.0023884	.0021602	.0019740
.55	.0031551	.0022797	.0019538	.0017369	.0015710	.0014355
.60	.0022485	.0016246	.0013924	.0012378	.0011196	.0010230
.65	.0015754	.0011383	.0009756	.0008673	.0007844	.0007168
.70	.0010880	.0007861	.0006737	.0005989	.0005417	.0004950
.75	.0007420	.0005361	.0004595	.0004085	.0003695	.0003376
.80	.0005006	.0003617	.0003100	.0002756	.0002493	.0002278
.85	.0003345	.0002417	.0002072	.0001842	.0001666	.0001522
.90	.0002217	.0001602	.0001373	.0001220	.0001104	.0001009
.95	.0001458	.0001053	.0000903	.0000803	.0000726	.0000663
1.00	.0000952	.0000688	.0000590	.0000524	.0000474	.0000433

	1.75	2.00	2.25	2.50	2.75	3.00
.05	.0009428	.0008716	.0008086	.0007522	.0007014	.0006551
.10	.0029449	.0027222	.0025255	.0023495	.0021906	.0020462
.15	.0045615	.0042167	.0039119	.0036393	.0033932	.0031696
.20	.0053022	.0049013	.0045470	.0042302	.0039442	.0036842
.25	.0052658	.0048677	.0045158	.0042012	.0039171	.0036589
.30	.0047343	.0043763	.0040600	.0037771	.0035317	.0032896
.35	.0039739	.0036735	.0034080	.0031705	.0029561	.0027613
.40	.0031721	.0029323	.0027204	.0025308	.0023597	.0022042
.45	.0024367	.0022525	.0020897	.0019441	.0018126	.0016932
.50	.0018160	.0016787	.0015574	.0014488	.0013509	.0012619
.55	.0013206	.0012208	.0011326	.0010536	.0009824	.0009176
.60	.0009412	.0008700	.0008071	.0007509	.0007001	.0006540
.65	.0006594	.0006096	.0005655	.0005261	.0004905	.0004582
.70	.0004554	.0004210	.0003905	.0003633	.0003388	.0003164
.75	.0003106	.0002871	.0002664	.0002478	.0002310	.0002158
.80	.0002095	.0001937	.0001797	.0001672	.0001559	.0001456
.85	.0001400	.0001294	.0001201	.0001117	.0001042	.0000973
.90	.0000928	.0000858	.0000796	.0000740	.0000690	.0000645
.95	.0000610	.0000564	.0000523	.0000487	.0000454	.0000424
1.00	.0000399	.0000368	.0000342	.0000318	.0000297	.0000277

inferred from their differences except that the open site has a significantly lower root biomass than does *Cercidium* and *Olneya* but does not vary from that of *Ambrosia.* Comparison of the root biomass measured by the hole sampling gave similar results, but the variability was considerably less (Table 28).

Future Plans

From the analysis of the limited sample data, it seems possible to describe the root biomass of a desert system using a probabilistic approach. The single one-dimensional model presented appeared to be validated by the field data. It should be expanded to three dimensions. One approach is to use joint probability functions, one to describe the vertical distribution, and another to describe the horizontal distribution and rotate the resulting functions about the plants of interest.

This approach was tried for a single plant for two dimensions with the data available. The gamma function was used to describe the vertical distribution of roots and a J-distribution function was assumed to describe the horizontal distribution from the plant center. The results are given in Table 29. Each number represents the proportions of the total biomass of the plant at various depths and distances from the plant. These functions must still be validated.

Another approach is to use the gamma function to describe the two-dimensional root system, but use the λ and r parameters as functions of the factors that determine how root density varied with distance from the plant.

Boundary conditions, determined by the spacing and types of plants, complicate a three-dimensional model. However, with adequate data the problem may not be difficult. Data are presently being collected in a pure *Larrea* stand to determine if an adequate stochastic model can be developed with either of the above approaches.

C. INVERTEBRATES

Invertebrates were sampled using two methods: the D-Vac method (A3UTC40) and the can-trapping method (A3UTC39). D-Vac was used on some shrubs while can-trapping collected surface invertebrates.

C.1. D-Vac Method

Invertebrates residing on plants were collected using a D-Vac vacuum insect sampling machine model 1-A. A clear plastic tent 4' x 4' x 4' was quickly placed over an individual plant. Ports on the vertical sides provided access for a 3' flex hose 10' long which was fastened to the large hose from the D-Vac machine. The plant and the inside surface of the tent were vacuumed for 8 minutes. Samples containing invertebrates and plant debris were chloroformed, then sorted under a hand lens.

Acacia constricta, *Ambrosia deltoidea* and *Larrea divaricata* were vacuumed in September and October of 1973. Two samples were collected for each species followed by an examination of the entire plant to determine the effectiveness of the vacuuming. Following this, a 24-hr period was selected in early October and samples were taken every 4 hr starting at 6:00 p.m. Two plants each of *Ambrosia*, *Acacia* and *Larrea* were vacuumed during each sample period. Plants were chosen for similarity in size and location and vacuumed only once.

Results of the complete examination showed no residual invertebrates. However, vacuum samples were found to contain an average of one insect per plant. The 24-hr samples had an average of .8 invertebrates per plant. These results were considered inconclusive. Monthly samples for 1974 are underway and results will be reported later.

C.2. Can-Trapping Method

Fifteen four-gallon cans 25 cm in diameter were buried flush with the surface at randomly located points on each of two 100 m^2 sites. Wooden covers supported 2-3 cm above the cans by rocks provided attractive sheltered areas. Once trapped, large crawling invertebrates could not escape. Traps were monitored for four weeks in October and early November of 1973.

Trapped invertebrates were removed from the cans and released away from the sites in order to reduce the possibility of trapping an individual twice. The success of this technique was indicated by the diminishing returns of capture. Four weeks was considered enough time to trap most of the crawling invertebrates.

Data for the two 100 m^2 plots are shown in Table 1.

Table 1. Invertebrate can trapping totals

	Site 1	Site 2
Order Araneida		
Genus *Lycosidae*	1	0
Order Scorpioneda		
Genus *Centruroides*	1	3
Genus *Hadrurus*	5	1
Family Tenebrionidae		
Genus *Eliades*	51	121
Order Solpugida	0	3
Family Gryllidae	1	0

D. VERTEBRATES

D.1. Reptiles

Introduction

Reptilian studies at the Silverbell Validation Site were not initiated until October, 1973; consequently definitive conclusions are not possible. Preliminary research in 1970 by Lowe (Thames et al., 1971) listed 39 reptiles and amphibians. The current study noted 11 reptiles including eight lizards and three snakes. The lizards seen were banded gecko (*Coleonyx variegatus*), zebra-tailed (*Callisaurus draconoides*), leopard (*Crotaphytus wislizenii*), desert spiny (*Sceloporus magister*), regal horned (*Phrynosoma solare*), and the western whiptail (*Cnemidophorus tigris*). Snakes seen were the coachwhip (*Masticophis flagellum*), western shovel-nosed (*Chionactis occipitalis*), and western diamondback rattlesnake (*Crotalus atrox*).

Materials and Methods

Two 100 m^2 grids with 10 m reference stakes were constructed on October 2-4, 1973. They were placed at the western and eastern perimeters of the 259-ha validation site. Fifteen 4-gallon can-traps were placed at random in each study site. Noosing combined with can-trap captures were the primary means used to obtain individuals for recapture marking. A 16 x 16 inch plywood cover supported by one-inch blocks was placed over each trap. The two areas were walked twice daily, mornings and evenings, a total of 15 days between October 6 and November 5. The observer made runs in line with each 10 m stake row. A lizard was assigned to the nearest stake or midway between two reference stakes.

Lizards captured were sexed, weighed, measured, and toe clipped. Numbers were painted on the lizards' backs to enable the gaining of density data from a distance.

Results and Future Study Plans

A total of 121 lizards were either captured or sighted during the study interval. *Callisaurus draconoides* was the most commonly seen lizard with a 65% of total lizard sightings. *Cnemidophorus tigris* and *Uta stansburiana* constituted 17% and 7% of the observations, respectively. The remaining 11% of the observations was distributed among various species: *Sceloporus magister*, *Crotaphytus wislizenii*, *Phrynosoma solare*, and *Urosaurus graciosus*. Using the criteria that a lizard repeatedly seen within 20 m of the same reference point was a resident of the immediate area, 78 individuals were designated as permanent inhabitants of the two study areas. The eastern study area contained seven *Cnemidophorus tigris*, 16 *Callisaurus draconoides*, four *Uta stansburiana*, one *Sceloporus magister*, and one *Crotaphytus wislizenii* for a total of 29. The western study areas had nearly twice the number of inhabitants as the eastern site with 49 residents designated. On the eastern area 55% of the residents were *Callisaurus draconoides* while 24% were *Cnemidophorus tigris*. On the western area *Callisaurus draconoides* accounted for 57% of all lizard species marked and *Cnemidophorus tigris*, 18%. No explanation can be offered for the discrepancy in total resident individuals of the two sites. Of course, small sample number is a factor.

Tentative plans for improving the research project for 1974 include placement of five more can-traps in each site and extending the study period from March through August. More observers for each run would be helpful. With larger samples and more data, biomass inferences can then be attempted.

D.2. Birds

Total avian biomass on the Silverbell site was determined monthly by line transect and direct mapping methods as in previous years. Results are summarized in Tables 1, 2 and 3. The change in biomass from 1972 to 1973 is indicated in Table 4, expressed as a proportional change of the 1972 biomass.

All biomass figures represent actual weights and not "dry" weight.

Results

The 1973 avian biomass on the 20-ha Silverbell plot increased from a January low of 6.6 kg/20 ha to a June high of 15.4 kg/20 ha, then decreased to an October low of 5.8 kg/20 ha. The major differences between 1973 and 1972 were: (1) lower winter and spring, and higher summer figures and (2) a maximum biomass of 15.4 kg/20 ha in June of 1973 compared to a maximum biomass of 11.2 kg/20 ha in July of 1972.

In general, the higher biomass figures for 1973 were the result of an increased number of young produced and an increased number of individuals and species breeding. Mockingbirds and roadrunners bred for the first time on the plot in 1973, while Harris' hawks and Scott orioles were generally absent. Several species showed increases in the number of pairs breeding on the plot, notably verdins, rufous-winged sparrows, brown towhees, and gila woodpeckers. Cactus wrens and curve-billed thrashers, on the other hand, showed decreases in numbers of breeding pairs. Net productivity, in terms of biomass of young produced, showed a three-fold increase over 1972.

Table 1. Number of individuals regularly occurring each month on the 20-ha Silverbell plot (A3URJ12, A3URJ14). Upper column, 1971-1972; lower column, 1972-1973

SPECIES	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Green-tailed Towhee	0	0	0	0	0	1	1	0	0	0	0	0
	0	0	0	1	1	2	2	0	0	0	0	0
Rufous-sided Towhee	0	1	1	1	1	0	0	0	0	0	0	0
	1	0	0	0	0	0	0	0	0	0	0	0
Brown Towhee	4	4	4	4	4	4	4	4	4	5	5	4
	4	4	4	5	5	5	5	5	10	8	6	5
Rufous-winged Sparrow	2	2	2	2	2	2	2	2	2	4	4	2
	2	2	2	4	4	4	7	6	6	6	6	4
Black-throated Sparrow	10	10	10	4	4	4	7	7	7	16	16	10
	10	10	10	10	10	7	7	12	12	10	10	10
Brewer Sparrow	10	75	75	75	75	50	15	0	0	0	0	5
	6	70	100	100	100	75	0	0	0	0	0	0
White-crowned Sparrow	1	2	2	6	6	2	0	0	0	0	0	0
	1	2	5	10	25	0	0	0	0	0	0	0
Cactus Wren	14	14	14	14	14	19	19	19	19	14	14	14
	14	14	12	10	10	10	18	22	18	14	10	10
Mockingbird	5	5	5	5	5	2	0	0	1	0	0	5
	5	1	1	1	2	2	6	6	2	2	1	1
Curve-billed Thrasher	10	10	10	10	10	12	12	12	15	14	14	10
	10	10	10	8	8	8	16	12	8	8	8	8
Western Bluebird	0	0	4	4	4	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
Black-tailed Gnatcatcher	10	10	10	10	10	14	14	10	10	10	10	10
	10	10	10	9	9	12	9	9	10	10	10	10
Ruby-crowned Kinglet	4	4	4	3	3	1	0	0	0	0	0	1
	2	2	1	1	0	0	0	0	0	0	0	1
Phainopepla	9	9	9	9	1	0	0	0	0	0	3	9
	8	5	5	5	+	0	0	0	0	0	0	3
Loggerhead Shrike	1	1	1	1	1	0	0	0	0	0	0	1
	1	1	0	0	0	0	0	1	1	0	0	0
Starling	3	3	3	3	3	2	2	0	1	1	1	3
	3	2	2	2	2	2	2	2	1	1	1	1
Gray Vireo	0	0	0	0	0	1	0	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0
Orange-crowned Warbler	0	0	0	0	0	0	1	0	0	0	0	0
	0	0	0	0	0	0	1	0	0	0	0	0
Lucy Warbler	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	1	0	0	0	0	0
Virginia Warbler	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	1	0	0	0	0	0
Audubon Warbler	0	1	1	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
MacGillivray Warbler	0	0	0	0	0	0	0	0	0	0	1	0
	0	0	0	0	0	1	0	0	0	0	0	0
Wilson Warbler	0	0	0	0	0	0	2	0	0	0	0	0
	0	0	0	0	0	2	1	0	0	0	0	0
Hooded Oriole	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	2	1	0	0	0	0
Scott Oriole	0	0	0	0	0	2	2	2	4	4	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
Bullock Oriole	0	0	0	0	0	0	3	0	0	0	0	0
	0	0	0	0	0	0	2	0	0	0	0	0
Brown-headed Cowbird	0	0	0	0	1	6	6	6	6	6	0	0
	0	0	0	0	0	0	6	6	6	3	0	0
Pyrrhuloxia	4	4	4	4	4	4	5	5	7	7	5	5
	4	4	4	4	4	4	4	4	7	7	4	4
House Finch	1	1	1	3	3	3	1	1	1	1	1	1
	1	1	2	3	3	13	13	2	2	1	1	1

Table 1, continued

SPECIES	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Harris' Hawk	1	0	0	1	1	1	1	1	1	1	1	1
	+	0	0	+	+	+	+	+	+	+	+	+
Sparrow Hawk	0	0	0	0	0	0	0	0	1	1	1	1
	+	0	0	0	0	1	1	1	0	0	0	0
Gambel Quail	11	11	11	11	11	4	4	7	11	11	11	11
	11	11	11	10	7	7	25	34	25	16	12	12
White-winged Dove	0	0	0	0	0	6	6	6	8	8	0	0
	0	0	0	0	0	1	8	5	6	4	0	0
Mourning Dove	1	1	1	11	8	8	8	8	8	1	1	1
	1	1	1	1	4	12	14	16	14	16	6	1
Roadrunner	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	1	1	2	2	2	8	8	2
Screech Owl	+	+	+	+	+	+	+	+	+	+	+	+
	1	1	1	1	1	1	1	1	1	1	1	1
Elf Owl	0	0	0	0	4	4	4	6	8	8	0	0
	0	0	0	4	4	4	4	6	8	8	0	0
Lesser Nighthawk	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0
Poorwill	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	2	2	2	0	0	0	0
Costa Hummingbird	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	1	1	1	1	0	0	0
Gilded Flicker	5	5	5	5	5	5	8	10	7	5	5	5
	5	5	5	5	5	5	5	10	10	5	5	5
Red-shafted Flicker	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	1	0	0	0	0	0	0	0	0
Gila Woodpecker	6	6	6	6	6	6	6	9	9	9	11	6
	6	6	7	7	7	7	7	7	15	15	7	7
Ladder-backed Woodpecker	2	2	2	2	2	2	2	2	3	3	2	2
	2	2	2	2	2	2	2	2	2	2	2	2
Wied Crested Flycatcher	0	0	0	0	4	4	4	4	8	8	0	0
	0	0	0	0	0	0	4	11	11	2	0	0
Ash-throated Flycatcher	0	0	0	1	5	3	3	3	3	3	0	0
	0	0	0	0	2	4	7	7	4	2	0	0
Empidonax flycatcher	0	1	1	1	0	0	1	0	0	0	0	0
	0	0	0	0	0	1	0	0	0	0	0	0
Purple Martin	0	0	0	0	0	2	2	2	5	5	5	2
	0	0	0	0	0	0	2	2	2	5	5	0
Violet-green Swallow	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	1	0	0	0	0	0	0	0
Verdin	8	8	8	8	8	12	18	14	13	13	8	8
	8	8	8	10	13	13	21	29	23	13	12	12
House Wren	1	1	1	0	0	0	0	0	0	0	0	0
	1	1	0	0	0	0	0	0	0	0	0	0

Table 2. Biomass (grams per 20 ha) of birds on the 20-ha Silverbell plot (A3URJ12, A3URJ14). Upper column, 1971-1972; lower column, 1972-1973. Only those species which had densities of one bird per 20 ha or greater are included

SPECIES	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Harris' Hawk	1563	0	0	1563	1563	1563	1563	1563	1563	1563	1563	1563
	0	0	0	0	0	0	0	0	0	0	0	0
Sparrow Hawk	0	0	0	0	0	0	0	0	97	97	97	97
	0	0	0	0	0	97	97	97	0	0	0	0
Gambel Quail	1866	1866	1866	1866	1866	678	678	1187	1866	1866	1866	1866
	1866	1866	1866	1696	1187	1187	4240	5766	4240	2714	2035	2035
White-winged Dove	0	0	0	0	0	875	875	875	1167	1167	0	0
	0	0	0	0	0	146	1167	730	875	584	0	0
Mourning Dove	131	131	131	1444	1050	1050	1050	1050	1050	131	131	131
	131	131	131	131	525	1576	1838	2101	1838	2101	788	131
Roadrunner	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	240	240	240	479	479	479	1917	1917	479
Screech Owl	0	0	0	0	0	0	0	0	0	0	0	0
	115	115	115	115	115	115	115	115	115	115	115	115
Elf Owl	0	0	0	0	80	80	80	120	160	160	0	0
	0	0	0	80	80	80	80	120	160	160	0	0
Lesser Nighthawk	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	35	0	0	0	0	0	0
Poorwill	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	94	94	94	0	0	0	0
Costa Hummingbird	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	3	3	3	3	0	0	0
Gilded Flicker	520	520	520	520	520	520	832	1040	728	520	520	520
	520	520	520	520	520	520	520	1040	1040	520	520	520
Red-shafted Flicker	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	136	0	0	0	0	0	0	0	0
Gila Woodpecker	420	420	420	420	420	420	420	630	630	630	770	420
	420	420	490	490	490	490	490	490	1050	1050	490	490
Ladder-backed Woodpecker	61	61	61	61	61	61	61	61	92	92	61	61
	61	61	61	61	61	61	61	61	61	61	61	61
Wied Crested Flycatcher	0	0	0	0	184	184	184	184	368	368	0	0
	0	0	0	0	0	0	184	506	506	92	0	0
Ash-throated Flycatcher	0	0	0	28	140	84	84	84	84	84	0	0
	0	0	0	0	56	112	196	196	112	56	0	0
Empidonax Flycatcher	0	12	12	12	0	0	12	0	0	0	0	0
	0	0	0	0	0	12	0	0	0	0	0	0
Purple Martin	0	0	0	0	0	98	98	98	246	246	246	98
	0	0	0	0	0	0	98	98	98	246	246	0
Violet-green Swallow	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	16	0	0	0	0	0	0	0
Verdin	59	59	59	59	59	89	133	104	96	96	59	59
	59	59	59	74	96	96	155	218	170	96	89	89
House Wren	10	10	10	0	0	0	0	0	0	0	0	0
	10	10	0	0	0	0	0	0	0	0	0	0
Cactus Wren	536	536	536	536	536	728	728	728	728	536	536	536
	536	536	460	383	383	383	689	843	689	536	383	383
Mockingbird	249	249	249	249	249	99	0	0	50	0	0	249
	249	50	50	50	99	99	298	298	99	99	50	50
Curve-billed Thrasher	820	820	820	820	820	984	984	984	1230	1148	1148	820
	820	820	820	656	656	656	1312	984	656	656	656	656
Western Bluebird	0	0	92	92	92	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
Black-tailed Gnatcatcher	55	55	55	55	55	77	77	55	55	55	55	55
	55	55	55	50	50	66	50	50	55	55	55	55
Ruby-crowned Kinglet	24	24	24	18	18	6	0	0	0	0	0	6
	12	12	6	6	0	0	0	0	0	0	0	6

Table 2, continued

SPECIES	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT
Phainopepla	234	234	234	234	26	0	0	0	0	0	0	234
	208	130	130	130	0	0	0	0	0	0	0	78
Loggerhead Shrike	47	47	47	47	47	0	0	0	0	0	0	47
	47	47	0	0	0	0	0	47	47	0	0	0
Starling	213	213	213	213	213	142	142	0	71	71	71	213
	213	142	142	142	142	142	142	142	71	71	71	71
Gray Vireo	0	0	0	0	0	10	0	0	0	0	0	0
	0	0	0	0	0	10	0	0	0	0	0	0
Orange-crowned Warbler	0	0	0	0	0	0	9	0	0	0	0	0
	0	0	0	0	0	0	9	0	0	0	0	0
Lucy Warbler	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	11	6	0	0	0	0	0
Virginia Warbler	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	8	0	0	0	0	0
Audubon Warbler	0	12	12	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	10	0	0	0	0	0	0
MacGillivray Warbler	0	0	0	0	0	0	0	0	0	0	10	0
	0	0	0	0	0	10	0	0	0	0	0	0
Wilson Warbler	0	0	0	0	0	0	14	0	0	0	0	0
	0	0	0	0	0	14	7	0	0	0	0	0
Hooded Oriole	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	47	47	24	0	0	0	0
Scott Oriole	0	0	0	0	0	77	77	77	154	154	0	0
	0	0	0	0	0	0	0	0	0	0	0	0
Bullock Oriole	0	0	0	0	0	0	99	0	0	0	0	0
	0	0	0	0	0	0	66	0	0	0	0	0
Brown-headed Cowbird	0	0	0	0	40	233	233	233	233	233	0	0
	0	0	0	0	0	0	233	233	233	117	0	0
Pyrrhuloxia	142	142	142	142	142	142	178	178	249	249	178	178
	142	142	142	142	142	142	142	142	249	249	142	142
House Finch	19	19	19	57	57	57	19	19	19	19	19	19
	19	19	38	57	57	247	247	38	38	19	19	19
Green-tailed Towhee	0	0	0	0	0	28	28	0	0	0	0	0
	0	0	0	28	28	57	57	0	0	0	0	0
Rufous-sided Towhee	0	42	42	42	42	0	0	0	0	0	0	0
	42	0	0	0	0	0	0	0	0	0	0	0
Brown Towhee	180	180	180	180	180	180	180	180	180	225	225	180
	180	180	180	225	225	225	225	225	450	360	270	225
Rufous-winged Sparrow	31	31	31	31	31	31	31	31	31	61	61	61
	31	31	31	61	61	61	107	92	92	92	92	61
Black-throated Sparrow	131	131	131	52	52	52	92	92	92	210	210	131
	131	131	131	131	131	92	92	157	157	131	131	131
Brewer Sparrow	100	750	750	750	750	500	150	0	0	0	0	50
	60	700	1000	1000	1000	750	0	0	0	0	0	0
White-crowned Sparrow	26	52	52	156	156	52	0	0	0	0	0	0
	26	52	130	260	650	0	0	0	0	0	0	0

Table 3. Estimated wet-weight biomass of birds on the 20-ha *Carnegia-Cercidium* plot, 1971-1973. Kilograms per 20 ha

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1971	-	-	-	-	-	-	-	-	-	-	7.4	6.6
1972	6.7	9.6	9.4	9.1	9.0	9.6	11.2	10.0	7.8	7.6	6.0	6.2
1973	6.6	6.9	7.0	8.0	13.6	15.4	13.7	12.2	8.1	5.8	-	-

Table 4. Change in estimated wet-weight biomass of birds on the 20-ha *Carnegia-Cercidium* plot, 1972-1973, expressed as proportional change of 1972 biomass. Based on grams per 20 ha

JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
-.02	-.29	-.25	-.12	+.50	+.62	+.22	+.22	+.04	-.24	?	?

D.3. Small Mammals

Introduction

As indicated last year, several methods of approximating the population of small mammals in an area have been proposed. For a variety of reasons, most have only limited application in an area such as the IBP Desert Biome Validation Site, where, ideally, the ecosystem should not be disturbed.

The following system was proposed last year as a compromise that should produce realistic estimates with minimal disturbance to a validation site. It is basically a modification of Calhoun (1959).

Live traps are set at 32 stations arranged equidistantly in two rows, baited and run two times per night (midnight and daybreak) for three nights. Each animal caught is examined, weighed, toe clipped, and released; the time and station of capture as well as sex and weight, are recorded. The resulting data are converted into an estimate of biomass per unit area by using information derived from mark-release studies of adjacent populations as to the radius of the average home range size of the various components of the population.

The conversion of the trapping data from the transit lines into biomass per hectare consists of calculating, for each species, the effective sample area for each species, then computing the total biomass (number caught x average weight). The result is converted into grams per hectare for each species and finally, values for each species are totaled.

Parallel lines of live traps as indicated above were set and operated at six sites as follows:

1. Section 14, T18S, R14E, Santa Rita Experimental Range, Pima County, Arizona. This is the original "undisturbed" Tucson Basin Validation Site: The traps were operated for four periods as follows: **June, 1971** (= midnight June 1, sunup and midnight June 2, sunup and midnight June 3, and sunup June 4); **November, 1971** (= midnight November 11, sunup and midnight November 12, and sunup and midnight November 13); **May, 1972** (= midnight May 25, sunup and midnight May 26, sunup and midnight May 27, and sunup May 28); and **September, 1972** (= midnight September 29, sunup and midnight September 30, sunup and midnight October 1, and sunup October 2). Stations were situated at intervals of 20 m and three traps were at each station (A3UCE09).
2. Section 11, T18S, R14E, Santa Rita Experimental Range, Pima County, Arizona. This is the original "manipulated" Tucson Basin Validation Site where all the cacti and woody vegetation were destroyed by "chaining" (A3UCE10). The traps were operated as indicated in A3UCE09.
3. Section 21, T11S, R9E, Silverbell bajada site, Pima County, Arizona. This is the "destructive sampling permitted" area of the unmanipulated ("control" or "undisturbed") portion of the validation site. Live traps were operated for two periods as follows: **June, 1972** (= midnight June 5, sunup and midnight June 6, sunup and midnight June 7, and sunup June 8) and **October, 1972** (= midnight October 6, sunup

Table 5. Values used as constants in computing the grams per hectare values in Tables 6-9

Species	Abbreviation	r Value x Home Range (Meters)	x Weight (Grams)	Santa Rita Computed Sample Area (Hectares)	Silverbell Computed Sample Area (Hectares)
Dipodomys merriami	DIMPER	20.3	39.5	2.03	1.44
Perognathus amplus	PERAMP	16.6	11.0	1.75	1.22
Perognathus penicillatus	PERPEN	14.8	19.6	1.62	1.12
Perognathus baileyi	PERBAI	16.7	34.0	1.76	1.23
Perognathus flavus	PERFLA	17.5	6.0	1.82	1.27
Reithrodontomys fulvescens	REIFUL	13.1 (?)	14.0	1.49	1.02
Onychomys torridus	ONYTOR	26.1	26.5	2.48	1.81
Neotoma albigula	NEOALB	15.3	187.0	1.65	1.15
Sigmodon arizonae	SIGARI	15.1 (?)	50.0	1.64 (?)	1.14 (?)
Mus musculus	MUSMUS	15.3 (?)	12.0	1.65 (?)	1.15 (?)

The r values listed above are preliminary and are subject to revision as additional data becomes available from live trap grids still being operated.

and midnight October 7, sunup and midnight October 8, and sunup October 9). Stations were situated at 15 m intervals with two traps per station (A3UCE12).

4. Section 21, T11S, R9E, Silverbell bajada site, Pima County, Arizona. This is the "destructive sampling permitted" area of the "manipulated" portion of the validation site where the vehicles had criss-crossed the area (A3UCE13). Live traps were operated as indicated in A3UCE12.
5. Section 21, T11S, R9E, Silverbell bajada site, Pima County, Arizona. This is the "validation" area of the "unmanipulated" portion of the site (A3UCE14). Live traps were operated as indicated in A3UCE12.
6. Section 21, T11S, R9E, Silverbell bajada site, Pima County, Arizona. This is the "validation" area of the "manipulated" portion of the site (A3UCE15).

Results are tabulated in Tables 6-11 and constants used in computing these values are given in Table 5. Figures 1-3 are pictorial representations of the results. Several facts are evident:

1. The biomass of nocturnal rodents increased dramatically during the summer of 1973. The increase may be the result of the increased rainfall in the past winter and spring that resulted in the production of many more seeds by spring flowering annuals.
2. The biomass increase is primarily the result of increases in *Perognathus amplus* and *Perognathus penicillatus*.
3. The feral house mice, *Mus musculus*, which were present in the fall of 1972 were missing from all 1973 samples. Other studies indicate that this is a widespread situation.

Table 6. Nocturnal rodent biomass for Santa Rita control area, A3UCE09 (see text). N = average number of individuals per hectare. G/h = average grams per hectare. Abbreviations are given in Table 5.

	June 71		Nov. 71		May 72		Sept. 72		May 73	
	N	G/h	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	10.2	403	11.2	441	8.7	345	5.3	211	3.9	156
PERAMP	5.8	58	0	0	4.7	51	2.3	26	1.1	13
PERPEN	1.3	25	1.9	37	1.9	37	4.4	86	1.9	36
PERBAI	4.1	140	1.8	60	1.8	60	3.6	120	1.1	39
PERFLA	0	0	0	0	0	0	0	0	.0	0
REIFUL	0	0	.7	10	0	0	.7	10	0	0
ONYTOR	0	0	2.8	74	.8	21	.8	21	0.4	11
SIGARI	0	0	0	0	0	0	0	0	0	0
MUSMUS	0	0	0	0	0	0	.6	8	0	0
Subtotals	21.4	626	18.4	622	17.9	514	17.7	482	8.4	255
NEOALB	.6	117	1.2	234	.6	117	.6	117	.6	117
Totals	22.0	743	19.6	856	185	631	18.3	599	9	372

4. The biomass at the Santa Rita sites (A3UCE09 and CE10) is approximately twice that at the Silverbell sites (A3UCE12, CE13, CE14, CE15).
5. The biomass estimates of *Neotoma albigula* are not valid and probably should be eliminated from comparisons of these data. Basically the two-parallel-line technique does not sample enough area to give a realistic estimate of *Neotoma*. In fact, there are some *Neotoma* on each of the sites, with the densest population (as shown by the data) on the Santa Rita "control" (A3UCE09).
6. There appears to be significantly more biomass on the manipulated areas (A3UCE10, CE13 and CE15). The greater disturbance at the Santa Rita site (A3UCE10, "chaining") resulted in a greater increase

Table 7. Nocturnal rodent biomass for Santa Rita manipulated area, A3UCE10, see Table 5

	June 71		Nov. 71		May 72		Sept. 72		May 73	
	N	G/h	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	18.9	748	18.4	729	17.0	671	10.7	422	8.4	331
PERAMP	2.9	32	0	0	3.5	39	0	0	1.1	13
PERPEN	6.3	123	0	0	1.3	25	6.3	123	1.9	36
PERBAI	.6	20	1.2	40	2.9	50	1.2	40	.6	19
PERFLA	0	0	.5	3	0	0	0	0	0	0
REIFUL	.7	10	0	0	.7	10	0	0	0	0
ONYTOR	4.4	117	2.8	74	2.0	53	.4	11	1.2	32
SIGARI	0	0	0	0	0	0	0	0	0	0
MUSMUS	0	0	0	0	0	0	.6	8	0	0
Subtotals	33.8	1,050	22.9	846	27.4	848	19.2	604	13.2	431
NEOALB	0	0	0	0	0	0	.6	117	0	0
Totals	33.8	1,050	22.9	846	27.4	848	19.8	721	13.2	431

Table 8. Nocturnal rodent biomass for Silverbell unmanipulated area, A3UCE12 (destructive sampling permitted). See Table 5 for abbreviations

	June 72		Oct. 72		May 73		Sept. 73	
	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	7.6	302	4.9	192	2.8	110	4.2	165
PERAMP	11.5	126	2.5	27	0	0	21.3	234
PERPEN	4.5	88	2.7	53	2.7	53	30.3	595
PERBAI	0	0	0	0	0	0	3.2	109
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	0	0	0	0	0	0
MUSMUS	0	0	3.5	42	0	0	0	0
Subtotals	23.6	516	13.6	314	5.5	163	59	1103
NEOALB	0	0	0	0	0	0	0	0
Totals	23.6	516	13.6	314	5.5	163	59	1103

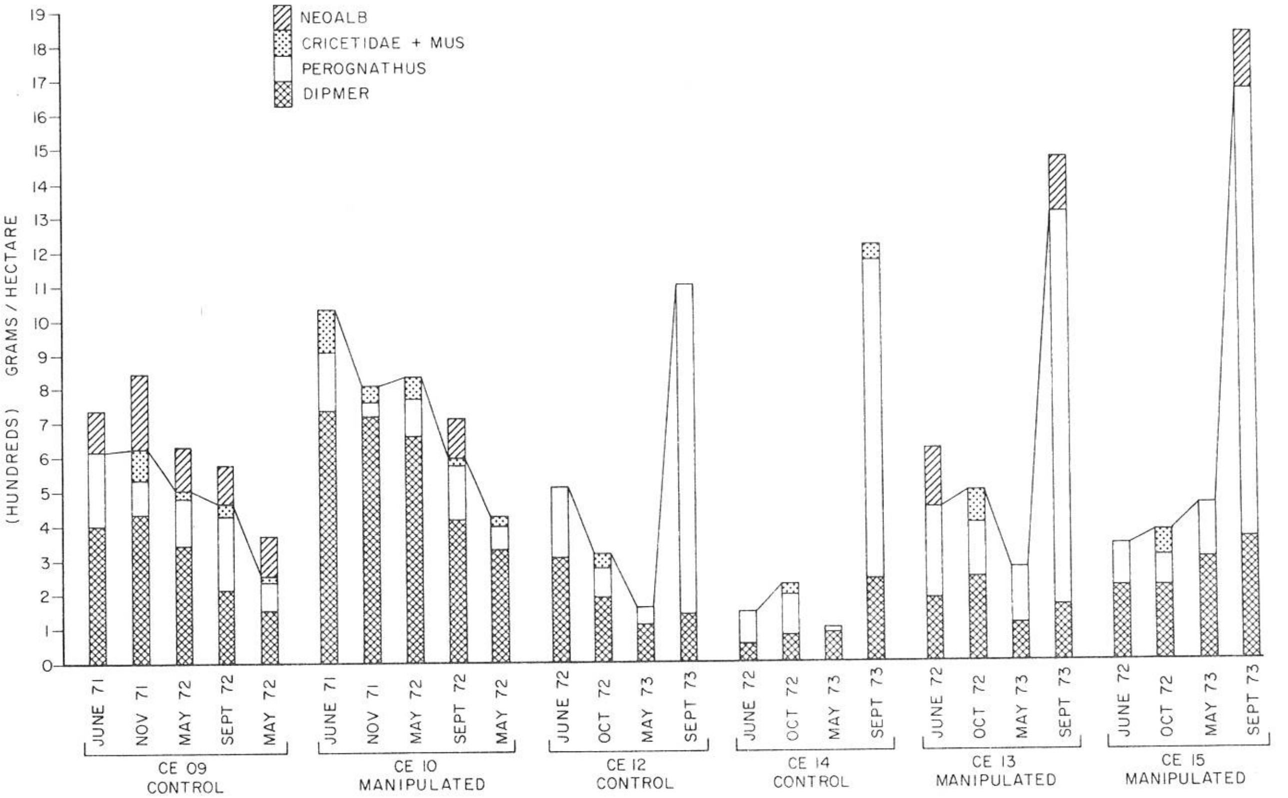


Figure 1. Trapping results indicating species biomass at various sites.

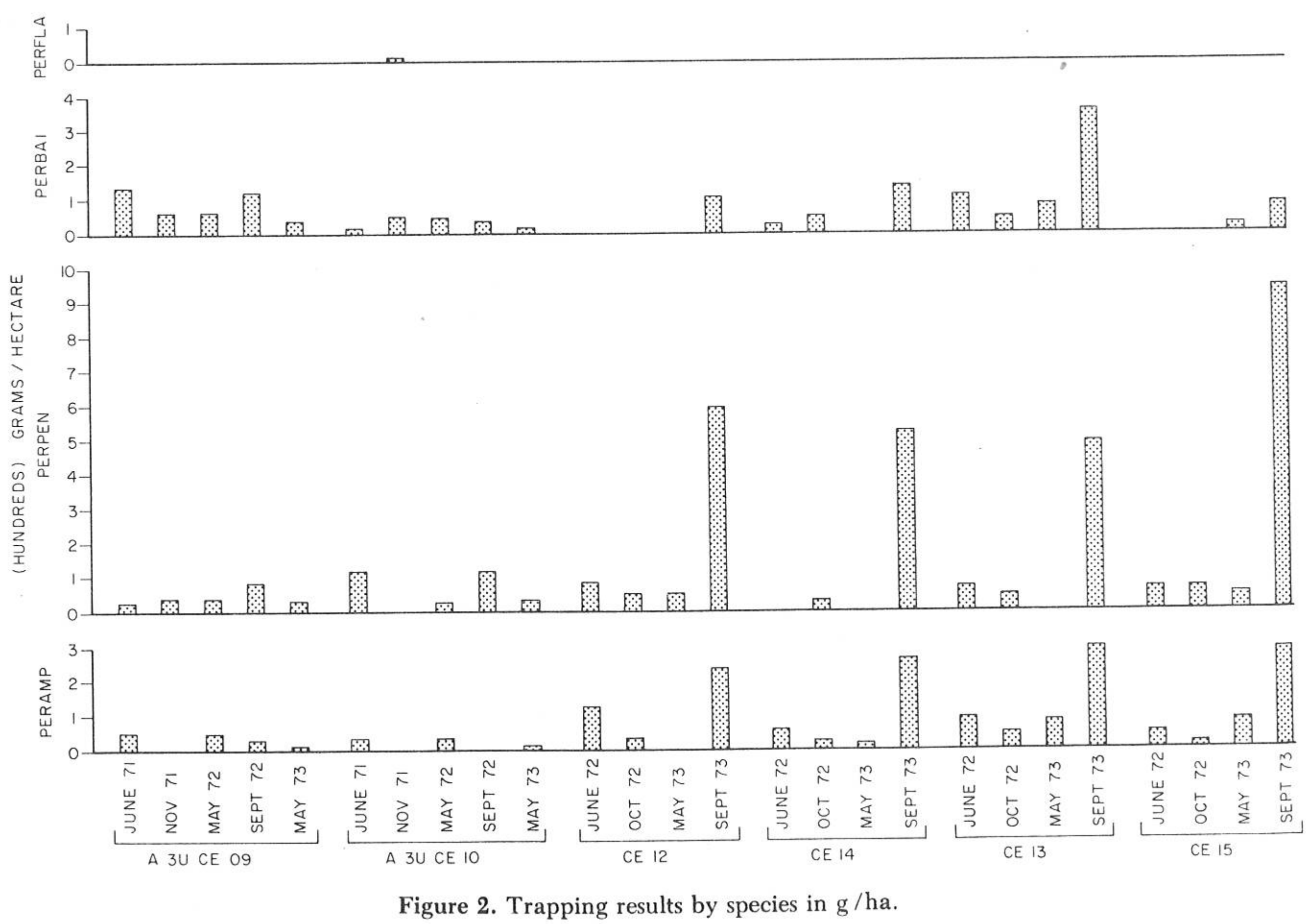


Figure 2. Trapping results by species in g/ha.

Table 9. Nocturnal rodent biomass for Silverbell unmanipulated area, A3UCE14 (validation). See Table 5

	June 72		Oct. 72		May 73		Sept. 73	
	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	1.4	55	2.1	82	2.1	82	6.3	247
PERAMP	5.7	63	2.5	27	1.6	18	23.8	262
PERPEN	0	0	1.8	35	0	0	26.8	525
PERBAI	.8	27	1.6	55	0	0	4.1	138
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	0	0	0	0	.9	44
MUSMUS	0	0	2.6	31	0	0	0	0
Subtotals	7.9	145	10.6	230	3.7	100	61.9	1216
NEOALB	0	0	0	0	0	0	0	0
Totals	7.9	145	10.6	230	3.7	100	61.9	1216

Table 10. Nocturnal rodent biomass for Silverbell manipulated area, A3UCE13 (destructive sampling permitted). See Table 5

	June 72		Oct. 72		May 73		Sept. 73	
	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	4.9	192	6.3	247	2.8	110	4.2	165
PERAMP	9.0	99	4.9	54	7.4	81	27.1	298
PERPEN	3.6	70	2.7	53	0	0	25.0	490
PERBAI	3.3	111	1.6	55	2.4	83	10.6	359
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	0	0	0	0	0	0
MUSMUS	0	0	7.8	94	0	0	0	0
Subtotal	20.8	472	23.3	503	126	274	66.9	1312
NEOALB	.9	163	0	0	0	0	.9	163
Totals	21.7	635	23.3	503	126	274	67.8	1475

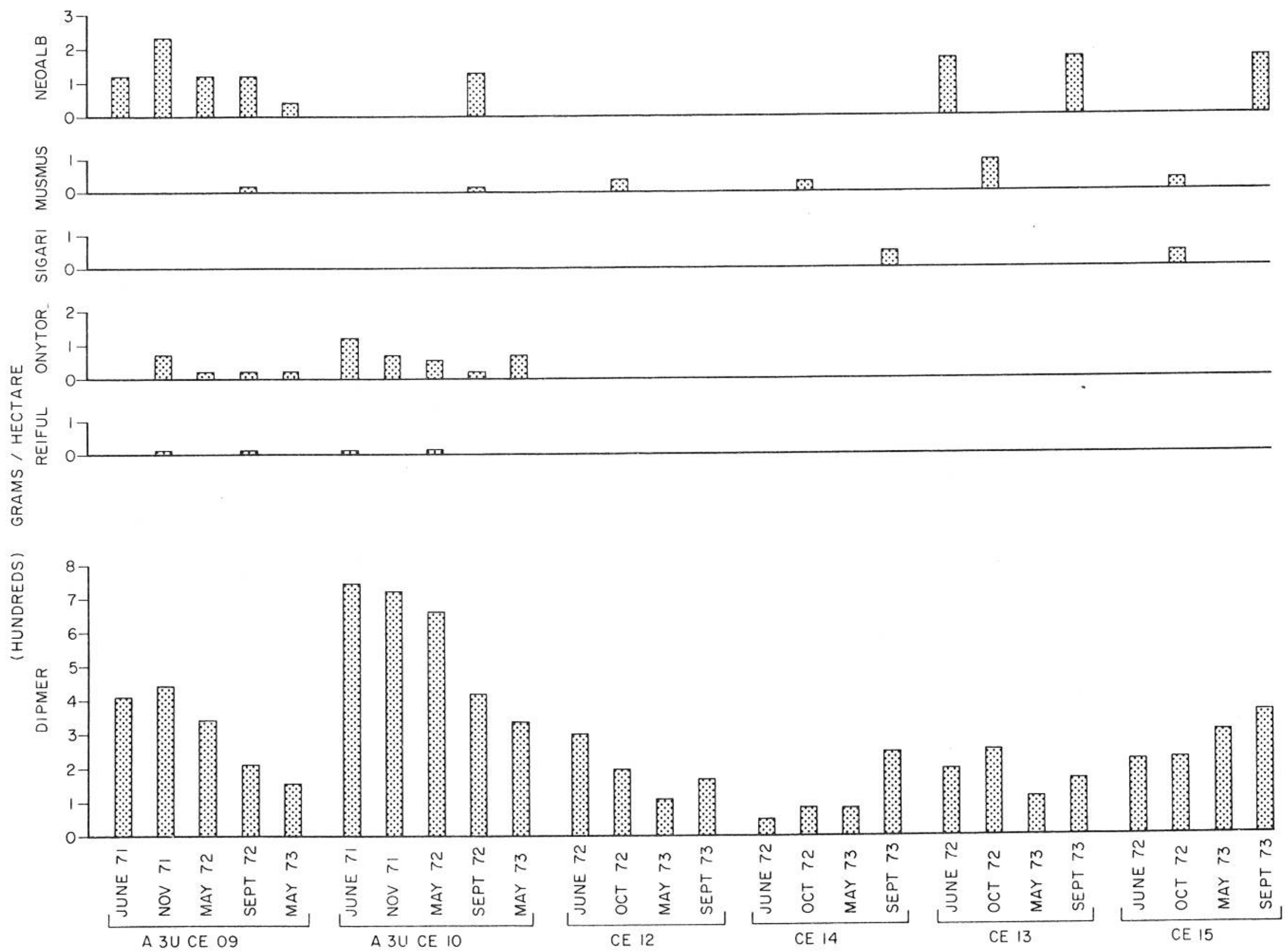


Figure 3. Trapping results by species in g/ha.

Table 11. Nocturnal rodent biomass for Silverbell manipulated area, A3UCE15 (validation). See Table 5

	June 72		Oct. 72		May 73		Sept. 73	
	N	G/h	N	G/h	N	G/h	N	G/h
DIPMER	5.6	219	5.6	219	7.6	302	9.0	357
PERAMP	4.9	54	1.6	18	7.4	81	26.2	289
PERPEN	3.6	70	3.6	70	2.7	53	48.2	945
PERBAI	0	0	0	0	.8	28	2.4	83
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	.9	44	0	0	0	0
MUSMUS	0	0	2.6	31	0	0	0	0
Subtotals	14.1	343	14.3	382	18.5	464	85.8	1675
NEOALB	0	0	0	0	0	0	.9	163
Totals	14.1	343	14.3	382	18.5	464	86.4	1838

than did the manipulation (vehicles) at the Silverbell site. This difference was evident even in the fall of 1973 after the general increase in all areas.

7. The November trapping in 1971 at the Santa Rita sites was so late that *Perognathus* had essentially become inactive. As far as *Perognathus amplus* is concerned, in all samples, only two individuals captured in May or June were recaptured in September, October or November (although at the Santa Rita sites two *P. amplus* marked in May, 1971, were recaptured in June, 1972) and at the Silverbell site six marked in June, 1972 were recovered in May, 1973.
8. The low values for September, 1972 for the Santa Rita sites (A3UCE09 and CE10) are misleading. The actual values should be much higher. Late summer rains in 1972 resulted in large amounts of seeds and other foods being available. Thus the rodents (especially *Dipodomys merriami*) were not susceptible to trapping. This phenomenon has been documented on the two live trap grids being operated bi-monthly or monthly in the same region (CE02 and CE04).
9. At both Santa Rita sites (CE09 and CE10) the June, 1971 densities are greater than the May, 1972 values. This reflects the fact that by June a number of young of the year make up a part of the population. For this reason the "spring" sampling time in 1972 and 1973 was changed to May.

LITERATURE CITED

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