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Jornada Validation Site Report

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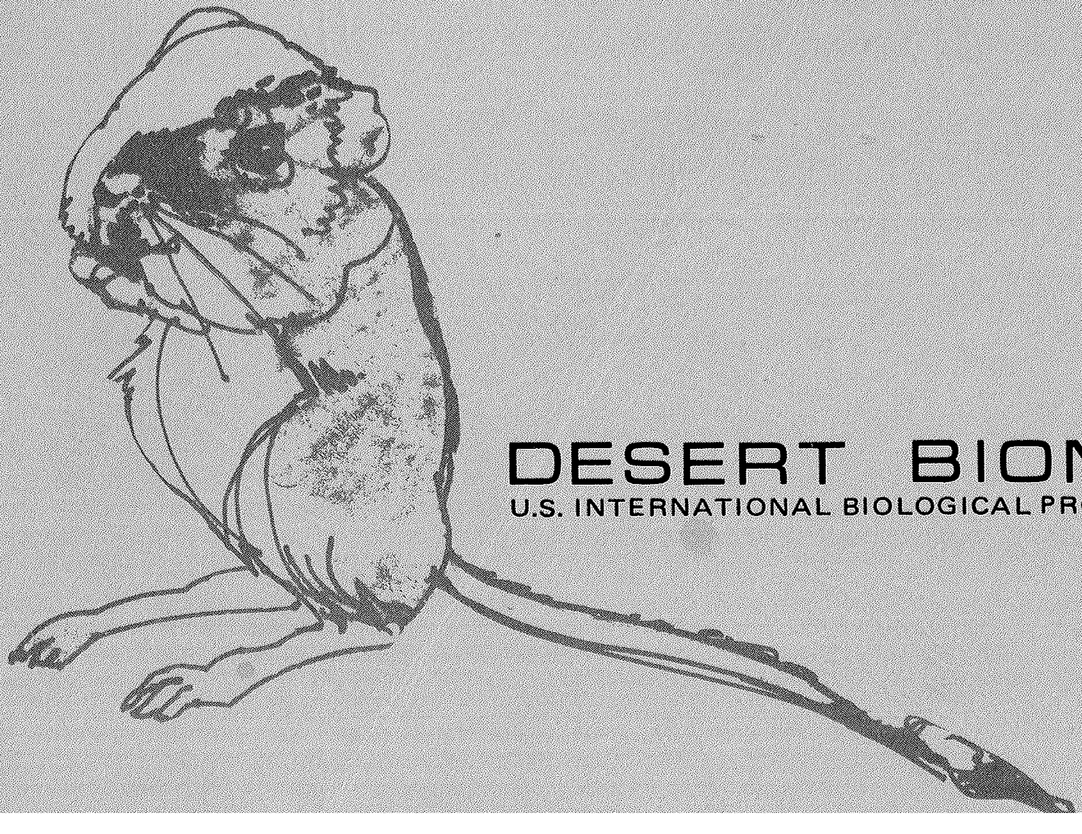
Coordinator: Walter G. Whitford



DESERT BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1972 PROGRESS REPORT

JORNADA VALIDATION SITE REPORT

Coordinator: Walter G. Whitford

New Mexico State University
Las Cruces, N. M.

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ABSTRACT

The Jornada Validation Site studies initiated in 1970 continued in 1972 on the bajada and playa portions of a small watershed in the Chihuahuan Desert. Studies of state variables continue to provide the data necessary for analyzing the dynamics of this desert watershed ecosystem. The following paragraphs compare the alluvial fan site (bajada) with the playa site and relate to the salient findings of the major investigations:

Abiotic. Instrumentation to monitor air temperatures in a standard weather bureau shelter was established on the playa bottom in March, 1970 and on the bajada study site in May, 1971. The warmest month for both areas is July with a mean of about 80 F for the playa and 84 F for the bajada. The coldest month is January with means of about 40 F and 46 F, respectively. It appears that the playa site has greater extremes than the general climate of the area. When compared to the playa, the bajada site is generally 3-6 F warmer on the average in winter months, perhaps reflecting its upland position relative to cold air drainage.

Rainfall totals of 1.6 cm and 2.4 cm on the playa during the cool months of November and December, 1971 resulted in a burst of annuals in early spring of 1972, even though the months of February, March, and April were rainless. The late spring, summer and fall months of 1972 were relatively wet, with totals about twice those of 1971 for the same months. Additional rains through the months of October - December kept the playa mostly under water and a big spring bloom of annuals is predicted for 1973. Monthly precipitation totals for some months are considerably higher on the playa than on the bajada. Occasionally, heavy rains will occur on the playa with little or no rain falling on the nearby bajada. One might normally expect higher rainfall on the bajada since it lies at a higher elevation. However, the presence of Mt. Summerford immediately to the west of the bajada site may have a partial rain shadow effect since the winds are often from the west during the summer rainy season. Other abiotic parameters being monitored include solar radiation, relative humidity, wind, soil temperature and soil moisture.

Plant productivity. Greatest total density of annual grasses on the playa occurred in August, 1972, with greatest summed total and reproductive biomass occurring in October, 1972. Highest total densities of annual forbs were recorded in August, 1972 with greatest summed total and reproductive biomass occurring in the same month. In contrast, greatest total density and greatest summed total biomass of annual grasses for the bajada occurred in April, 1972 (none of the annual grasses sampled on the bajada site exhibited reproductive structures at sampling times). Annual forbs exhibited two peaks of high density (April and October, 1972) with maximum summed total and reproductive structure biomass occurring at two times corresponding with maximum density. These biomass estimates reflected spring and fall groups of annual forbs which are not as apparent on the playa.

The small perennial vegetation was sampled concomitantly with the annual vegetation. Data show that the greatest total density of perennial grasses on the playa fringe occurred in August, 1972. Greatest summed total and reproductive biomass for this group occurred in October, 1972. Greatest total densities of perennial forbs occurred in October, 1972 whereas the sub-shrubs greatest total density was in June, 1972. Biomass estimates revealed both of these plant categories to have had the greatest summed total and reproductive biomass in October, 1972. Measurements were also taken in the playa edge and playa bottom proper.

Greatest total density and greatest summed total biomass of perennial grasses on the bajada occurred in April, 1972. Maximum reproductive biomass occurred in the fall. Perennial forb maximum total density and maximum summed total biomass occurred in October, 1972 with highest reproductive biomass in April and June, 1972.

Large perennial vegetation on the playa was studied using forty 5 m x 100 m belt transects randomly positioned around the playa fringe. Biomass components were estimated using size characteristics for each species. Off-site destructive sampling was used to obtain regression equations relating biomass to canopy ground cover and canopy volume. Growth patterns, reproductive patterns and biomass estimates were studied for *Yucca elata, Xanthocephalum sarothrae, Ephedra trifurca,* and *Prosopis glandulosa* var. *torreyana.*

Large perennials on the bajada were also monitored for biomass changes through time using forty 5 m x 100 m belt transects. Biomass components were estimated using the size dimensions of the individuals of each species. Again, off-site destructive sampling was used to obtain regression equations relating biomass of component parts of each species to the canopy cover and canopy volume. Estimation equations were developed for *Larrea divaricata, Flourensia cernua, Parthenium incanum, Zinnia pumila, Fallugia paradoxa,* and, *Yucca baccata.*

Invertebrates. Relative abundance, family composition, and diversity of arthropods on playa shrubs were studied. The shift from membracids to psyllids reflects either temperature extremes or phenology of the host plant or both. The high density of spiders (Aranea) in July and the marked shift in species composition are related to reduction in total numbers and biomass of herbivores. During this month the number and biomass of predators exceeded that of herbivores.

The bajada shrubs exhibited shifts in the arthropod fauna through the season similar to the population shifts on playa shrubs. The numbers and biomass of plant feeders such as issids, fulgorids, lygaeids, psyllids, membracids, etc., appear to be a direct function of primary production. The particular group that predominates at any one period is probably a function of season and/or phenology of the host plant. These insects are relatively independent of the climatic extremes associated with drought but are apparently most active on plants in active growth phases when exudate production is highest. The relationship between water status of the plant and insect biomass supported is evident when a comparison between shrubs on the bajada upland are compared with the insect biomass on shrubs lining the arroyo. Although the density and biomass of these shrubs is low in comparison to the upland shrubs, the biomass support is considerably greater and these plants contribute a significant portion of the total insect production for the site.

Vertebrates. Reptile data from pit-fall traps and qualitative observations in three years of study indicate that the lizard *Cnemidophorus tigris* is the most numerous and potentially the most important reptile on the playa fringe. This species feeds by searching through the litter under shrubs, using its snout to root through debris and breaking termite castings. The high biomass and high metabolic rate of this species suggest that *C. tigris* may rank with birds in importance as an insectivore.

C. tigris is also the dominant species on the bajada with numbers sufficiently large to provide enough recaptures for reliable density estimates. Data suggest that on the Jornada bajada this species has a high mortality during the active period. The August population in 1972 was composed of primarily juvenile animals and the September population was entirely juvenile animals. Data also suggest a high overwinter mortality of the young of the year and that survivors of one winter may remain in the population two or more years.

In 1972, the timing and methods of bird censuses on the playa were revised from those used in 1971. A weekly schedule was adhered to as closely as was feasible throughout the year using Emlen's strip census method. Using the results of May censuses of both years as the best measures, it is obvious that breeding densities were higher in 1972 than in 1971. For the insectivorous breeding passerines the numbers were 41.0/100 ha in 1971 and 66.1 in 1972. If quail, doves and raptors are included, the contrast between years is even greater; combined numbers were 44.5 vs. 79.4/100 ha and corresponding biomass figures were 22.2 vs. 105.8 g/ha. Ths same kind of difference was found for most of the other species categories. It seems certain that the higher rainfall in 1972 was indirectly responsible for the higher densities of that year.

As on the playa, bajada numbers and biomass were considerably higher for a given month in 1972 than in 1971. Higher rainfall in 1972 no doubt increased food in the form of seeds and insects which favored higher densities of all species of birds, whatever their trophic level or seasonal position.

Some negative, tentative conclusions can be made. The pattern of the birds on the bajada is unlike that on the playa where winter is the period of higher numbers and biomass; nor is it like that of most areas of higher latitude and altitude where abundance is much greater in the breeding season than in other seasons. These differences in seasonal patterns on the bajada and the playa are of interest since the two areas are so close together. Spermophilous migrants invaded both areas in the autumn but they were more numerous on the playa and stayed longer. This is apparently due to the higher seed production on the playa. The comparison for insectivorous birds yields different conclusions. The two areas exhibited patterns and levels that were quite similar. The principal notable difference was that on the bajada the biomass did not drop to such low levels in the autumn and winter as it did on the playa. Bajada breeding birds, with a higher percentage of insectivores, tend to remain throughout the year. These perennial residents tend to keep overall levels of insectivores more nearly uniform than on the playa where breeding species emigrate annually.

Mark-recapture estimates of rodent densities on the playa site were made in February, April, June and November, 1972. Each 50-trap grid was trapped for three consecutive nights to provide two nights for precensus and one night for census at each census period. Based on the 1971 trapping program, a few additional animals were picked up by additional trap-nights. To assess the reliability of the grids in providing an accurate estimate of densities of mammals over the entire site, long-distance movements for *Dipodomys merriami* were conducted, and the mark-recapture study was reexamined. The most significant change in rodent populations in 1972 was the low densities of all species in the first half of the year followed by recoveries of the populations of *D. merriami* and *Perognathus penicillatus,* and the explosive increase in *Sigmodon hispidus.* This is also thought to be a result of the 1971 drought. A more complete analysis of the 1971-72 data should provide the basis for supporting this hypothesis.

The bajada rodent grid consisted of a 1-ha plot with 100 trap stations 10 m apart. Trapping results revealed that the density of all rodent species dropped markedly in 1971 due to the dry conditions as noted previously. In 1972, species other than *D. merriami* were too low to obtain accurate estimates for each trapping period. However, numbers of *Perognathus penicillatus, P. intermedius* and *Neotoma albigula* were sufficiently high to examine fluctuations in their populations.

Soils. Studies of physical and chemical properties, litter, microbiology, spore germination, and cellulose decomposition in soils were also conducted. As a result of the 1971 drought, current microbiological studies were conducted on artificially watered plots. Water amendments had a relatively minor effect on the microbial population density. It is possible that the available substrate content of the soil is limited to such an extent that growth is restricted even when soil moisture levels are adequate. However, cellulose decomposition experiments showed the effect of the moisture amendments. The increases in rates obtained in the playa were not as pronounced as the effects seen in bajada soil presumably because of the continued high level of soil moisture from rainfall during the experiment.

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Throughout the course of this project we have been fortunate to have the able assistance of many people. Individuals contributing to the Jornada Validation Site work in 1972 are listed below as are the authors of the various sections.

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Graphic Assistance	David Walters John Schaub	
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* Graduate Students

DATA COLLECTION DESIGN

General Type of Measurement	Parameters Measured	Data Set Code	Reported on page 2.2.2.4-
Meteorological	Air Temperature; Playa, Bajada	A3UWJ02	12, 179
	Solar Radiation		
	Playa	A3UWJ04	20
	Bajada	A3UWJ66	185
	Precipitation		
	Playa	A3UWJ07	22
	Bajada	A3UWJ63	187
	Relative Humidity		
	Playa	A3UWJ03	26
	Bajada	A3UWJ65	190
	Wind		
	Playa	A3UWJ08	28
	Bajada	A3UWJ62	192
	Soil Temperatures		
	Playa	A3UWJ06	30
	Bajada	A3UWJ67	194
	Soil Moisture		
	Playa	A3UWJ05	34
	Bajada	A3UWJ65	197
Vegetation	Annuals		
	Playa fringe		
	Density, biomass	A3UWJ54	43
	Playa Bottom		
	Green living, standing dead biomass	A3UWJ51	52
	Litter biomass	A3UWJ52	52
	Root biomass	A3UWJ53	52
	Bajada		
	Density, biomass	A3UWJ74	210
	Perennials--small		
	Playa fringe		
	Density, biomass	A3UWJ54	57
	Playa bottom, playa edge		
	Green living, standing dead biomass	A3UWJ51	68, 77
	Litter biomass	A3UWJ52	68, 77
	Root biomass	A3UWJ53	68, 77
	Bajada		
	Density, biomass	A3UWJ74	217
	Perennials--large		
	Playa fringe		
	Shrub biomass; canopy volume	A3UWJ55	82
	Bajada		
	Shrub biomass; canopy volume	A3UWJ75	222

DATA COLLECTION DESIGN (CONT.)

General Type of Measurement	Parameters Measured	Data Set Code	Reported on page 2.2.2.4-
Invertebrates	Relative abundance, diversity, family composition; playa, bajada	A3UWJ21,25	118, 263
	Mesquite plant part mortality; borers, girdlers	A3UWJ01,02,03	123, 263
	Flush transect census	A3UWJ96	125, 273
	Pit-fall traps	A3UWJ22	127, 274
	Termite grids		130, 275
	Soil arthropods		278
Vertebrates	Reptiles and Amphibians		
	Playa		
	Species composition, density, home range, length, weight, sex, breeding condition, body temperature	A3UWJ13	135
	Bajada		
	Species composition, density, weight, sex	A3UWJ69	287
	Birds		
	Playa, bajada		
	Species composition, breeding density, non-breeding density, biomass, sex, nesting success, behavior, seasonal trends	A3UWJ16,60	141, 291
	Rodents		
	Playa, bajada		
	Species composition, density, movements, breeding condition, sex, population fluctuations, biomass	A3UWJ11,68	148, 298
	Lagomorphs		
	Playa, bajada		
	Relative abundance, density	A3UWJ15	161, 304
Soils	Soil survey		
	Physical and chemical properties		
	Litter		
	Biomass on playa, bajada	A3UWJ59,79	167, 308
	Soil microorganisms		
	Number/gram soil	A3UWJ30	169, 310
	Spore germination		
	Decomposition		

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INTRODUCTION

Studies at the Jornada Validation Site were initiated in 1970 with studies limited to the playa site. An alluvial fan site on the same watershed and an area treated with herbicide were added to the playa area for study in 1971.

In the Desert Biome program, validation studies were designed to provide initial state of the system values and inventories on which to base models of specific desert ecosystems, e.g., Chihuahuan Desert, Jornada. Subsequently, annual measurements are necessary to provide state of the system values for ecosystem components in order to test models run with the climatic parameters of the site as driving variables. These are the minimum requirements of a validation studies program.

At the Jornada Validation Site, we have conducted measurements of numerous parameters at more frequent intervals than required for validation. These more frequent estimates of primary productivity and population structure of vertebrate and invertebrate animals supply data that provide insights into short term changes in growth patterns and population structure. They also provide data useful in examining spatial relationships of ecosystem components. With the completion of two or three years of measurements for many ecosystem parameters, some insights into causal relationships emerge and are reported here. Analysis of spatial and temporal relationships among components of the Chihuahuan Desert ecosystems will continue throughout 1973.

The prediction of the results of human perturbations is one goal of the simulation models produced in the Desert Biome program. To validate the performance of such models, an area on the Jornada range was treated with herbicide in 1971 and 1972. Measurements similar to those made on the other areas were conducted on the herbicide-treated area.

The following sections of this report present summaries of the data collected in 1972. Where applicable, comparisons and generalizations based on the patterns emerging from previous years studies are made.

I. PLAYA

A. ABIOTIC

1. AIR TEMPERATURE

A standard climatic monitoring station was established on the southwest corner of the playa bottom in March, 1970. Air temperatures are monitored with a thermograph as part of a hygrothermograph instrument (Belfort Instrument Co.)*. The instrumentation is described by DSCODE A3UWJ02 (Biome Abstracts Vol. I, No. 2).

Monthly means and ranges of maximum and minimum air temperatures are given in Table 1. June and July are the warmest months with means of about 80 F, respectively. The maximum temperature of 106 F was recorded for the month of July in 1972. In contrast, the coldest months are December and January with means of about 42 F and 40 F, respectively. The minimum temperature of 6 F was recorded for the month of January in 1971. Long term (1892-1970) mean and extremes for a climatological station located at New Mexico State University at Las Cruces, New Mexico, are shown in Table 2 (Houghton, 1972). A comparison of the Las Cruces temperature data in Table 2 with that for the playa site in Table 1 indicates general similarity in the monthly means; however, a few differences are perhaps worth noting. In 1970, monthly means followed the long term averages closely (± 5 F), except for October which was 7 F below average. The apparent cool August in 1970 is explained by missing data during the early, warmer days of the month. In 1971, July was 7.2 F above average. In 1972, all months varied fairly close to the long-term average. In general, the mean air temperatures for the winter months of December, January and February are 5-10 F colder on the playa than in Las Cruces. By contrast, the mean air temperatures for the summer months of June, July and August are 2-5 F warmer on the playa during 1970-1972 than in Las Cruces during 1892 - 1970. A comparison of the specific data for 1970 for Las Cruces (Houghton, 1972) and the playa site holds the same as the above general comparisons. Thus, it appears that the playa site has greater extremes than the general climate of the area. This can probably be partly explained by its basin characteristics, since it will be a cold air sink and also a semi-protected warm spot.

Daily mean air temperatures for 1970, 1971 and 1972 are shown in Figure 1. These mean values tend not to vary as greatly as the daily maximums (Figure 2) and daily minimums (Figure 3), as one would expect. The seasonal trends in mean temperatures from year to year follow the weather cycles expected. Some seasons are more variable than others. From the scatter of data points in Figure 1, it is quite clear that the mean air temperatures from day to day fluctuate the most during the fall and winter months. By contrast, May, June and July are typically about the same from day to day. Also note that there are very few days in a year with mean air temperatures below 0 C or above 35 C. However, with great daily extremes, the daily means do not give the entire picture.

Daily maximum air temperatures for 1970, 1971 and 1972 are shown in Figure 2. During the summer months of any given year, you can expect at least one series of days with maximum temperatures of about 40 C (104 F). The highest temperature recorded was 106 F on 2 July 1972 for the playa. In Las Cruces, the record highest temperature was 109 F on 8 July, 1951 (Houghton, 1972). During the winter months, it is a rare occasion when the daily maximum does not get above freezing. Only during a few extremely cold days in early January, 1971, did this happen.

Daily minimum air temperatures for 1970, 1971 and 1972 are shown in Figure 3. Even though the daily maximums can be above 40 C (104 F) during the summer months, it is clear that the minimums usually drop to about 20 C (70 F). The typically clear desert nights with low humidities allow for rapid cooling at night. During the winter months, the distribution of minimum temperatures is very variable depending on the probability of the occurrence of major cold fronts reaching this area from the north. This can happen during any month from October to April, but it is most likely in January. Large frontal storms may drop the temperatures to below -10 C (14 F) for a series of days as happened in early January, 1971.

The end of the growing season on the playa for the winter deciduous plants can be related to the first freezing temperature in fall. This typically occurs toward the latter part of October. The specific dates for the first freezing temperatures on the playa for the three years are 12 October 70, 30 October 71, and 31 October 72. Probabilities based on longer term data for Las Cruces of occurrence of the first freezing temperatures are given in Table 3 (from Houghton, 1972). As indicated, in 5 out of 10 years the first freezing temperature (32 F) may occur before 29 October. The last freezing temperature in the spring on the playa typically occurs in April. The specific dates for the last freezing temperature on the playa for the three years are 3 May 70, 21 April 71, and 23 April 72. Probabilities for Las Cruces for this event are also given in Table 3. As indicated, in 5 out of 10 years the last freezing temperature may occur after 15 April.

Table 1. Air temperature data (F) acquired at the Jornada playa site during 1970, 1971 and 1972

Month	Minimum	Maximum	Hourly mean	Range of daily minima	Range of daily maxima	Range of daily means
1970						
April	18	83	57.7	18-56	56-83	43-70
May	30	96	71.8	30-66	68-96	54-83
June	47	105	79.6	47-74	82-105	70-90
July	62	106	83.0	62-80	83-106	71-91
August *	52	98	67.6	52-74	76-98	73-84
September	42	98	73.7	42-74	70-98	53-85
October	20	81	53.7	20-62	53-81	40-69
November	19	78	50.3	19-56	56-78	40-68
December	14	73	44.5	14-42	48-73	32-54
1971						
January	6	76	40.2	6-48	28-76	19-58
February	11	76	44.9	11-48	52-76	37-63
March	9	88	54.7	9-56	44-88	32-70
April	32	90	60.8	32-58	56-90	47-75
May	42	92	70.5	42-66	72-92	61-80
June	42	103	80.6	42-72	88-103	72-88
July	64	104	86.6	64-80	80-104	73-89
August	59	96	78.5	59-74	84-96	74-84
September	45	98	74.6	45-72	63-98	57-86
October	32	88	61.7	32-64	54-88	47-73
November	28	78	50.6	28-48	52-78	42-66
December	24	71	42.2	24-45	37-71	33-53
1972						
January	16	72	39.6	16-38	33-72	24-54
February	15	80	47.4	15-42	46-80	28-61
March	19	85	56.5	19-56	62-85	45-67
April	24	90	62.7	24-58	72-90	53-72
May	39	92	69.7	39-72	74-92	62-78
June	52	104	75.6	52-70	70-104	72-86
July	61	106	81.2	61-73	88-106	76-89
August	59	102	78.9	59-74	82-102	66-86
September	43	89	70.9	43-72	76-89	61-79
October	32	93	63.7	32-63	50-93	43-74
November	22	71	45.3	22-41	42-71	35-55
December	17	67	41.2	17-50	46-67	30-57

* Days for which there is missing data for this month are not included in the values given.

Table 2. Long-term climatic means and extremes for Las Cruces, New Mexico

LATITUDE 32° 17' N.
LONGITUDE 106° 45' W.
ELEV. (GROUND) 3881 Ft.

CLIMATOLOGICAL SUMMARY

Means and extremes for period 1892-1970

Station: STATE UNIVERSITY
NEW MEXICO

	Temperature (°F)								Precipitation Totals (Inches)								Mean number of days						
	Means			Extremes								Snow, Sleet						Temperatures Max.		Temperatures Min.			
Month	Daily maximum	Daily minimum	Monthly	Record highest	Year	Record lowest	Year	Mean degree days **	Mean	Greatest daily	Year	Mean	Maximum monthly	Year	Greatest daily	Year	Precip. 10 in. or more	90° and above	32° and below	32° and below	0 ° and below	Evaporation (Inches)	Month
(a)	79	79	79	79	--	79	--	79	79	79	--	79	79	--	79	--	79	79	79	79	79	53	(a)
Jan.	57.4	25.3	41.4	78	1970+	-10	1962	730	0.36	0.86	1936	0.5	5.0	1913	4.7	1947	1	0	*	25	*	2.98	Jan.
Feb.	62.2	28.9	45.6	86	1904	2	1899	540	0.42	1.25	1893	0.5	10.4	1956	9.0	1956	1	0	*	19	0	4.39	Feb.
Mar.	68.7	34.2	51.5	90	1908	11	1965	420	0.37	1.13	1900	0.2	8.0	1909	4.0	1909	1	*	0	13	0	7.60	Mar.
Apr.	77.0	41.6	59.3	96	1965	20	1948+	200	0.20	1.20	1905	T	1.0	1901	1.0	1901	1	1	0	3	0	10.09	Apr.
May	85.3	49.0	67.2	103	1951	27	1967+	40	0.30	0.97	1916	0	0	--	0	--	1	8	0	*	0	12.28	May
Jun.	93.9	58.8	76.4	107	1960+	36	1921+	0	0.59	2.43	1903	0	0	--	0	--	1	24	0	0	0	13.27	Jun.
Jul.	93.6	65.1	79.4	109	1951	42	1938	0	1.49	1.55	1955	0	0	--	0	--	4	25	0	0	0	12.01	Jul.
Aug.	91.6	63.3	77.5	105	1907	44	1925	0	1.72	6.49	1935	0	0	--	0	--	4	21	0	0	0	10.36	Aug.
Sep.	86.7	56.1	71.4	102	1945	30	1945	0	1.22	4.11	1941	0	0	--	0	--	3	10	0	0	0	8.36	Sep.
Oct.	77.6	43.6	60.6	93	1932	20	1898	160	0.70	1.38	1928	0	0	--	0	--	2	1	0	2	0	6.16	Oct.
Nov.	66.0	31.3	48.7	83	1952+	5	1948	490	0.45	1.20	1899	0.5	8.0	1961	8.0	1961	1	0	*	17	0	3.75	Nov.
Dec.	57.3	26.1	41.7	78	1958	1	1953+	720	0.50	0.99	1931	0.9	10.3	1931	9.0	1931	2	0	*	25	0	2.67	Dec.
Year	76.4	43.6	60.0	109	Jul. 1951	-10	Jan. 1962	3300	8.32	6.49	Aug. 1935	2.6	10.4	Feb. 1956	9.0	Feb. 1956+	22	90	1	104	*	93.92	Year

(a) Average length of record, years.

T Trace, an amount too small to measure.

** Base 65 F.

\+ Also on earlier dates, months, or years.

* Less than one half.

Table 3. Probabilities of last freezing temperatures in spring and first in fall. New Mexico State University, Dona Ana County, New Mexico *

Probability	Dates for given probability at temperature levels shown						
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower	36° F or lower	40° F or lower
Spring:							
1 year in 10 later than	Mar. 9	Mar. 24	Apr. 4	Apr. 18	May 1	May 15	May 24
2 years in 10 later than	Feb. 28	Mar. 16	Mar. 31	Apr. 13	Apr. 26	May 10	May 20
5 years in 10 later than	Feb. 9	Feb. 27	Mar. 20	Apr. 2	Apr. 15	Apr. 27	May 9
Fall:							
1 year in 10 earlier than	Nov. 9	Nov. 6	Nov. 5	Oct. 29	Oct. 19	Oct. 7	Sep. 29
2 years in 10 earlier than	Nov. 17	Nov. 11	Nov. 9	Nov. 1	Oct. 24	Oct. 11	Oct. 2
5 years in 10 earlier than	Dec. 5	Nov. 23	Nov. 14	Nov. 5	Oct. 29	Oct. 18	Oct. 10

* Period of record: 16, 20, 24, 28 and 32 degrees, 1921-1950; 36 and 40 degrees, 1931-1960.

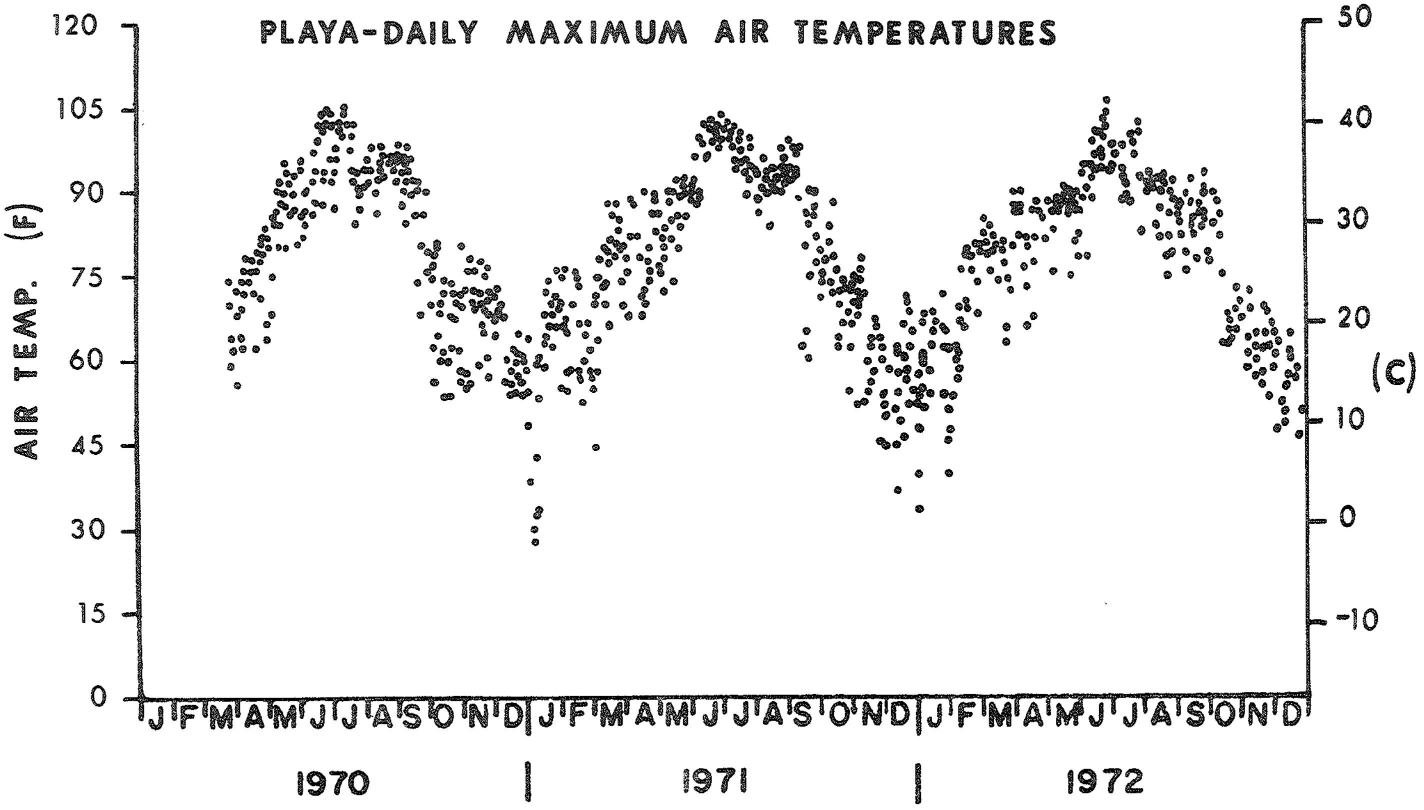

Figure 1. Daily mean air temperature for 1970, 1971 and 1972 at the playa.

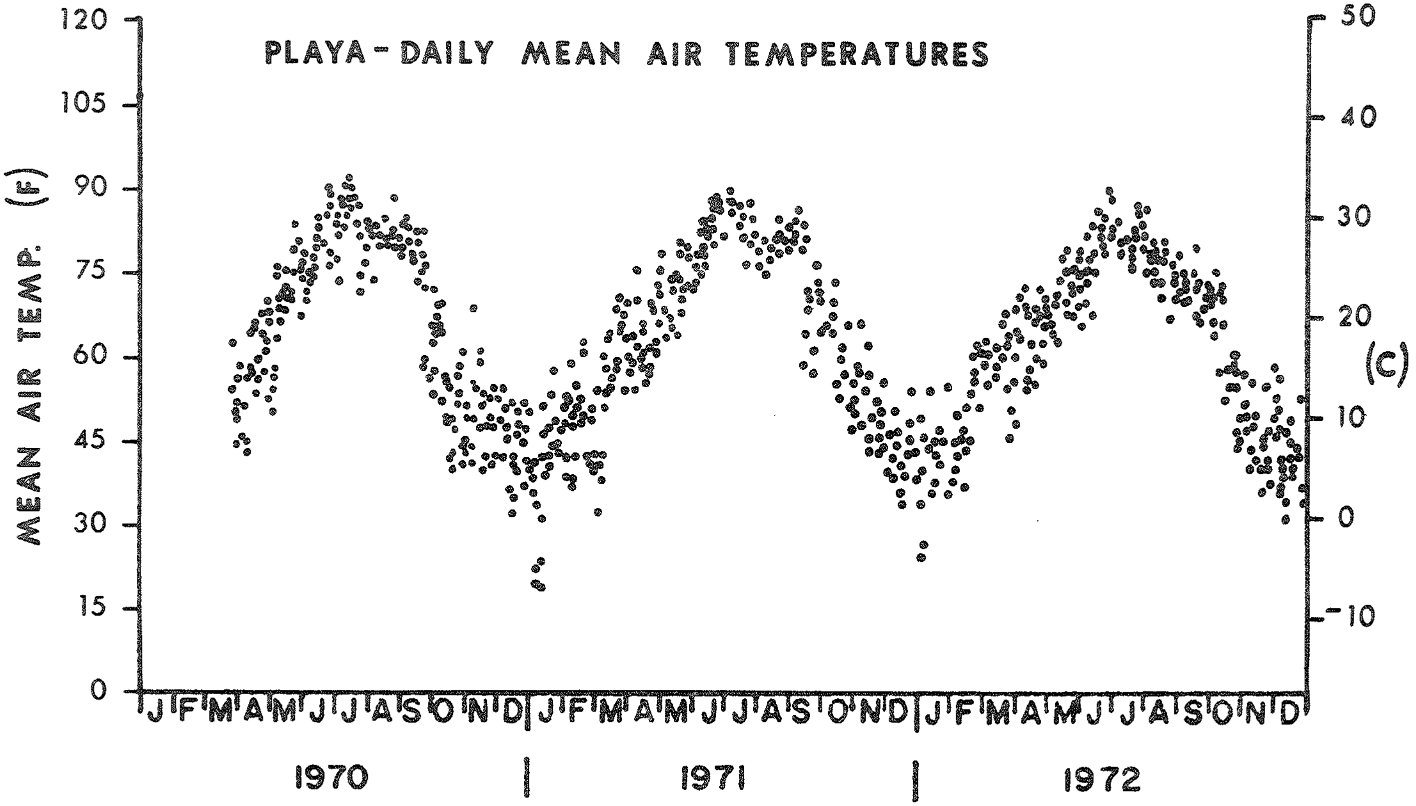

Figure 2. Daily maximum air temperatures for 1970, 1971 and 1972 at the playa.

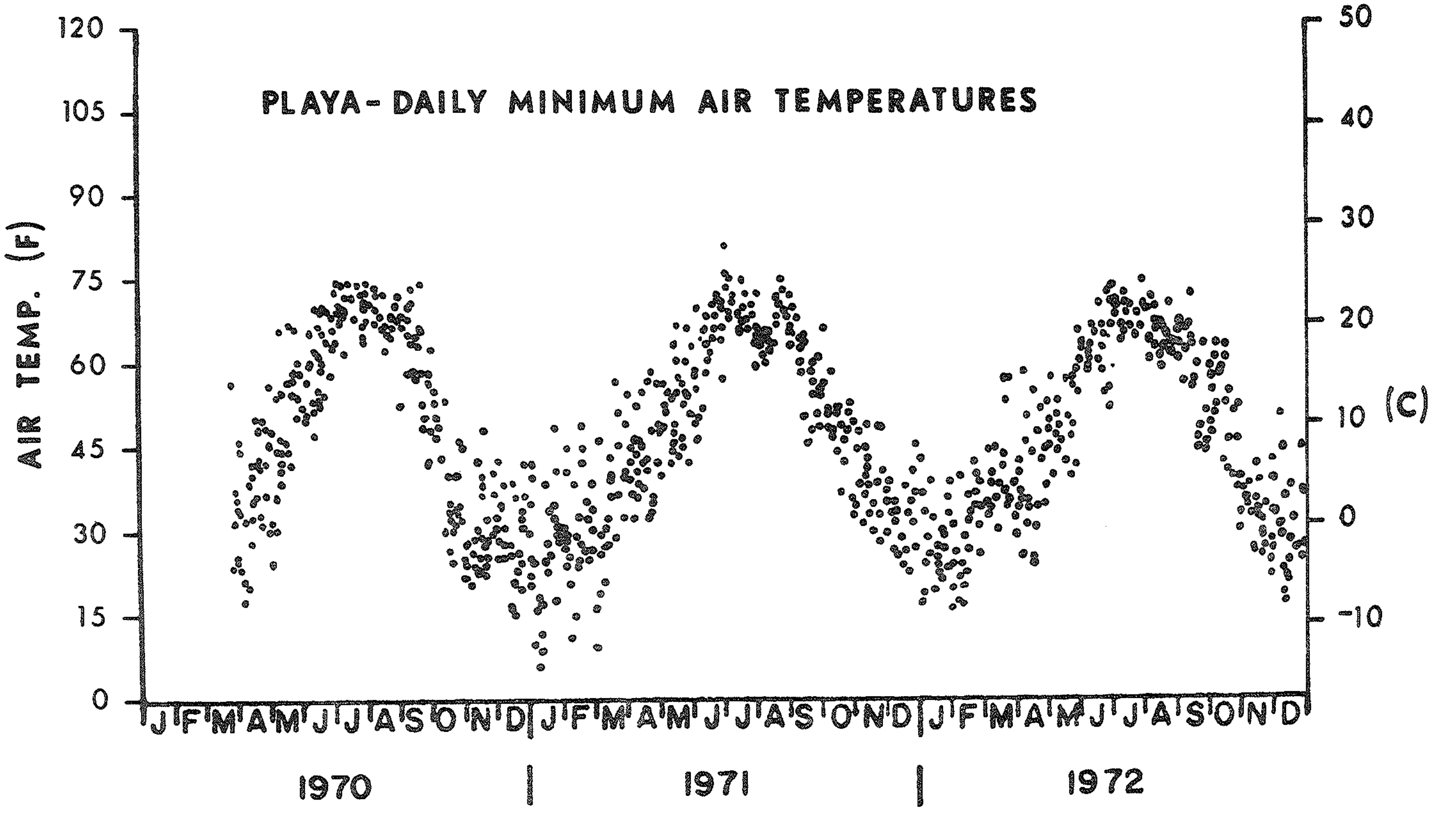

Figure 3. Daily minimum air temperatures for 1970, 1971 and 1972 at the playa.

I. A. 2 PLAYA SOLAR RADIATION

Total incoming solar radiation has been monitored at the playa study site since April, 1970. A pyroheliograph (Belfort Instrument Co.) was mounted level on the top of the weather station at a height of 2 m as described by DSCODE A3UWJ04 (Biome Abstracts Vol. 1 No. 2)

Daily total incoming radiation energy (langleys/day) was calculated. The results are shown in Figure 4. The seasonal trends follow the expected for the latitude of the study site (32° 32'). The maximum values are reached in May and June at about 800 l/day. The minimum energy input is in December at about 300 l/day. The points scattered below the dense band indicate those days with varying amounts of cloud cover. A few trends are evident. During late winter and early spring, the days are generally clear, thus very few points scatter below the general band. However, in late summer and early fall, the days are often cloudy, thus many more points fall below the general band. The probability of cloudiness varies with the month and data of this sort might be of interest. Other kinds of data may be needed from the total incoming radiation such as a prediction of net radiation given other information such as ground and vegetation reflectance. Total incoming radiant energy will also be needed as inputs into other kinds of environment models, such as in the prediction of soil surface temperatures. The measurement of total incoming radiation on the site should continue even though the maximums could be predicted quite accurately given the latitude. The frequency distribution of days with energy input less than maximum will be of importance.

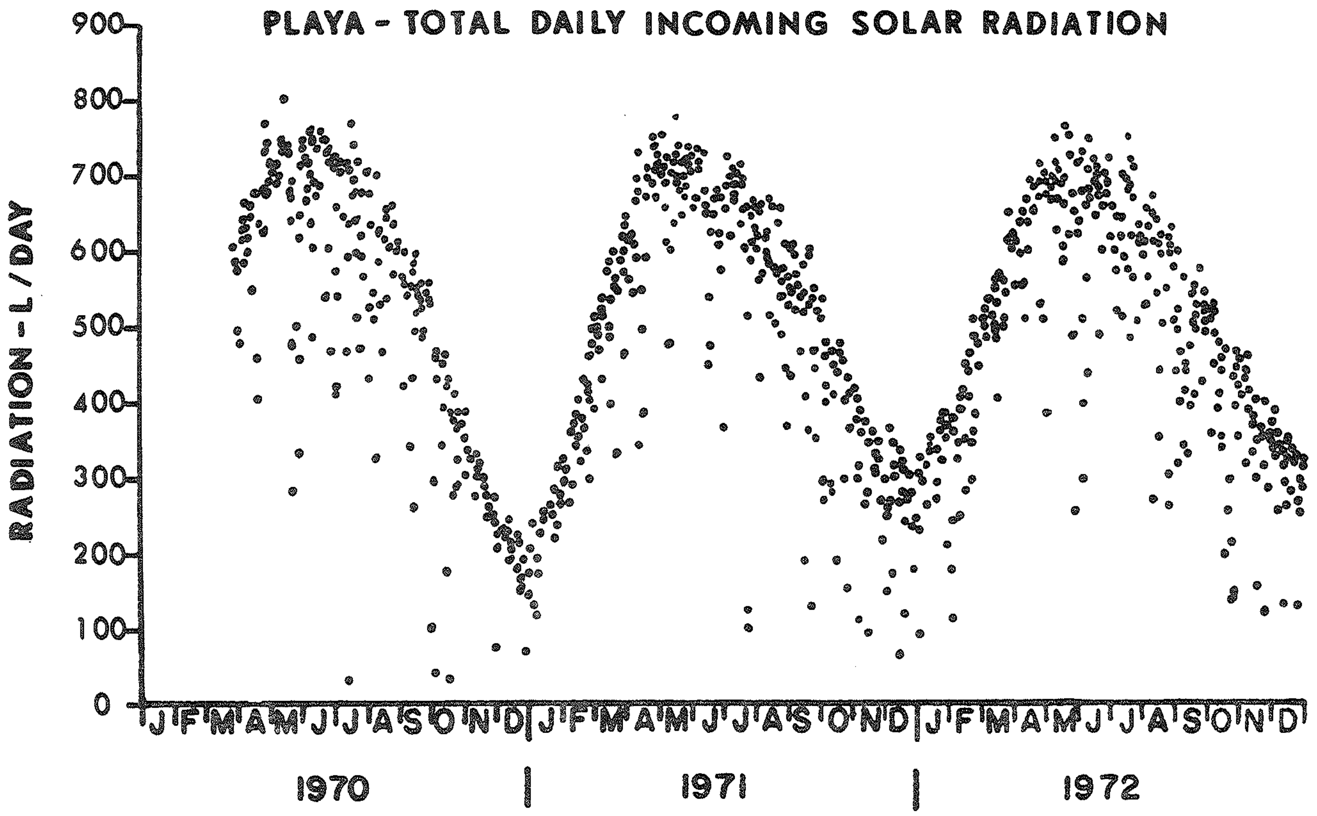

Figure 4. Daily total incoming solar radiation (langleys/day) for 1970, 1971 and 1972 at the playa.

I. A. 3 PLAYA PRECIPITATION

A recording rain gauge (weighting bucket type -- Belfort Instrument Co.) was installed near the playa weather station in April, 1971. Prior to this time, starting in March, 1970, a totalizing collector was used. The instrument is equipped with a day clock, thus rates of rainfall are recorded fairly accurately (for details see DSCODE A3UWJ07 in Biome Abstracts Vol. 1 No. 2).

Monthly total precipitation patterns for 1970, 1971 and 1972 are shown in Figure 5. The spring of 1970 was very dry with no rain in April, May and June. During the last two weeks in July, 8.5 cm of rain occurred. This flooded the playa bottom on the 24th. A few small rains kept the playa flooded for about three weeks. However, August was again relatively dry, with slightly more than 1 cm. Thus the playa dried out quickly. Both September and October received less than 2.5 cm, thus conditions remained relatively dry. The rest of the fall of 1970 and the winter and spring of 1971 remained very dry with no rain in November, February, March, and May, and with totals of less than 1 cm in December, January, April, and June. The totals for the months of July through October 1971 were all above 2.5 cm but less than 5 cm. This was insufficient to flood the playa. Soil moisture was only partly recharged (see discussion in Soil Moisture section). Plant growth was delayed until September and October (see Plant section). The rain totals of 1.6 and 2.4 cm during the cool months of November and December helped to recharge the soil moisture. The result was a burst of annuals in early spring of 1972, even though the months of February, March and April were rainless. The late spring, summer and fall months of 1972 were relatively wet, with totals about twice those of 1971 for the same months. The playa flooded three times during this period. The first flooding was very brief (about one week). It occurred on 19 July after 2.4 cm of rain. The surface of the playa bottom had already been moistened and partially sealed (swelling clays) by 1.8 cm of rain during 11-12 July. A number of rains fell in August, but none of sufficient magnitude to reflood the playa. On the first of September, 4.7 cm of rain fell and reflooded the playa bottom. Additional rains kept the bottom under water until about the first of October. However, on 19 October, 3.1 cm of rain occurred and flooded the playa for the third time. Additional small rains through the month and into November and cooler conditions kept the playa mostly under water until toward the end of November. December also received above average rainfall and a big spring bloom of annuals is predicted for 1973.

Monthly precipitations for just 1971 and 1972 are shown in Figure 6. This data is on the same scale as the precipitation patterns for the bajada site and will be referred to in that section for comparative purposes.

Monthly data for the number of precipitation events, total amounts, percent of yearly totals and average rate or intensity are given in Table 4 for 1971 and 1972.

In 1971, the most precipitation events occurred in August and September. These months are characterized by local thunderstorm activities, whereas fall rains (if they occur at all) are characterized by longer, slower rains associated with slower moving frontal storms. The totals for August and October are about the same, yet August had over twice as many events. The above characterization of different storm types is also evidenced by the rate of rainfall data. The rainfall intensities during July-October are generally 3-7 mm/hr, whereas in November and December the rates are about 1-2 mm/hr. In 1972, the most precipitation events occurred in June, August, October and December in what seems like alternating months. However, the intervening months had totals equal to or exceeding those for these four months, thus event data alone could be misleading.

Based on the data in Table 4 for monthly totals as a percent of yearly total, the four months of July, August, September and October had 82% and 71% of the yearly totals for 1971 and 1972 respectively. This demonstrates the known fact that the Chihuahuan Desert is characterized by a summer-early fall rainfall distribution.

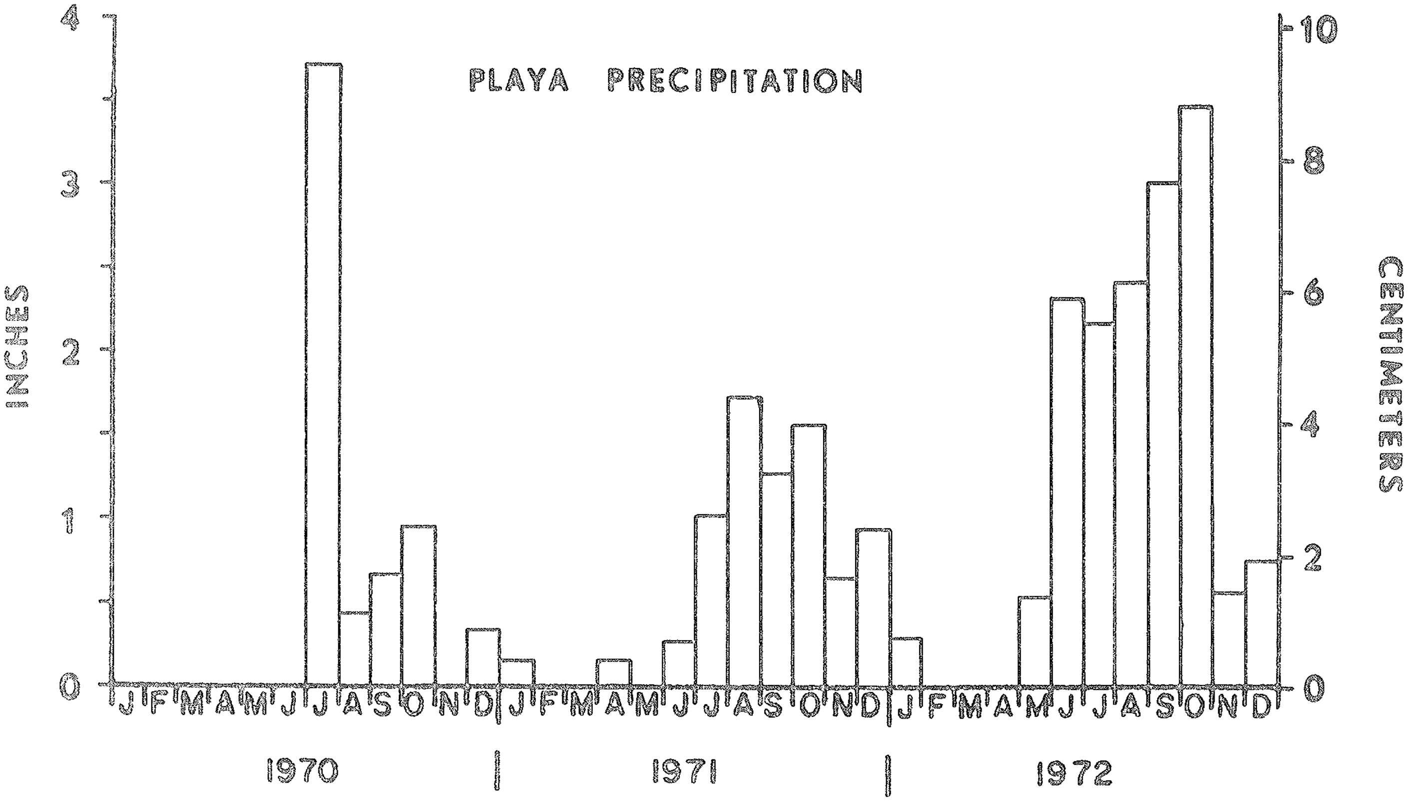

Figure 5. Monthly total precipitation patterns for 1970, 1971 and 1972 at the playa.

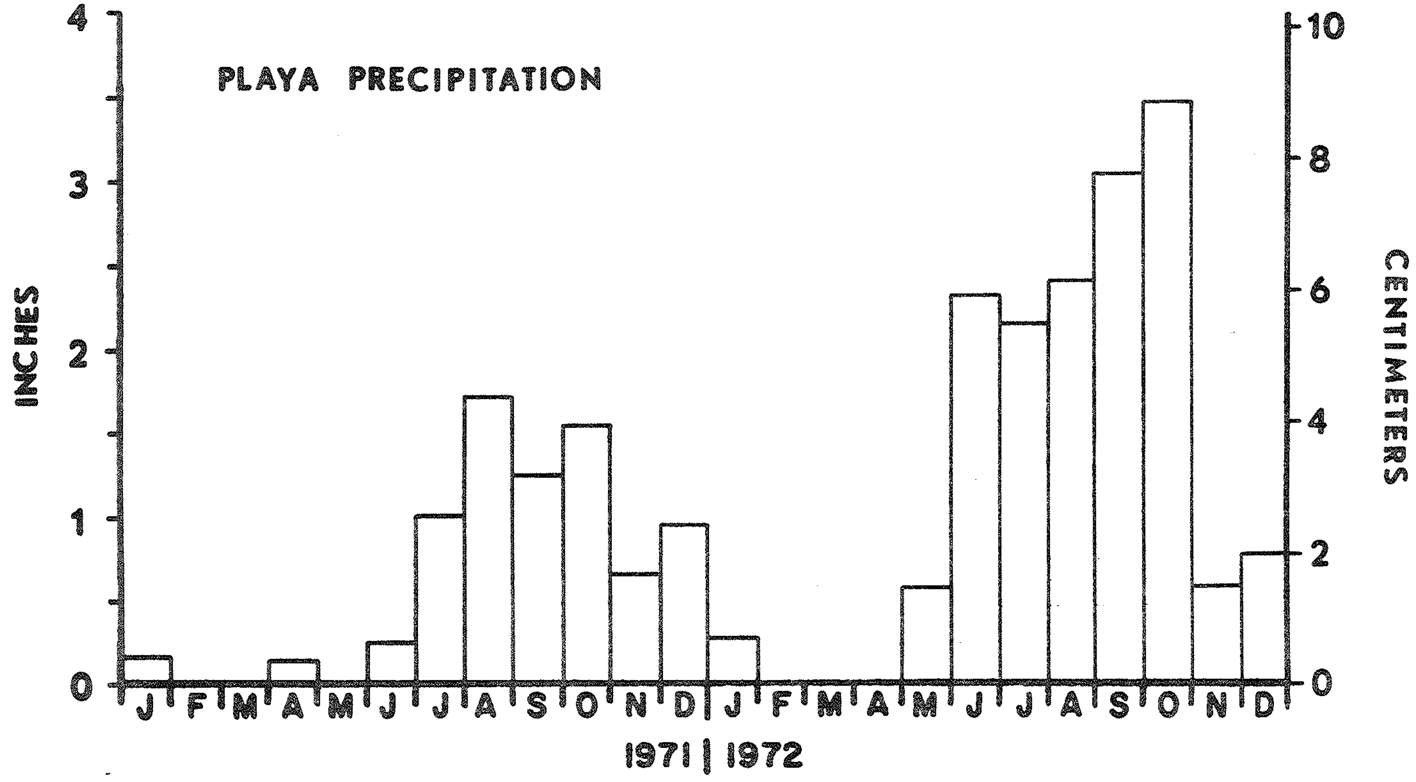

Figure 6. Monthly total precipitation patterns for 1971 and 1972 at the playa.

Table 4. Monthly precipitation data for the playa site. For each month, the number of precipitation events, total amounts, percent of yearly total and the average rate or intensity is given

Month	Number of events	Total Rainfall (inches)	Total Rainfall (millimeters)	Percent of total	Rate of Rainfall (in./hr.)	Rate of Rainfall (mm./hr.)
January	2	0.18	4.6	2	0.0*	0.0*
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	1	0.15	3.8	2	0.05	1.2
May	0	0	0	0	0	0
June	2	0.29	7.4	4	0.50	12.6
July	7	1.02	25.9	13	0.14	3.6
August	14	1.73	43.9	22	0.26	6.5
September	12	1.24	31.5	16	0.11	2.9
October	6	1.59	40.4	21	0.11	2.9
November	4	0.62	15.8	8	0.03	0.9
December	7	0.93	23.6	12	0.03	0.8
1971	55	7.75	196.9		0.09	2.2
January	5	0.28	7.1	2	0.05	1.3
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	2	0.55	14.0	3	0.26	7.0
June	16	2.35	59.7	15	0.14	3.4
July	9	2.18	55.4	14	0.31	7.8
August	13	2.40	61.0	15	0.09	2.2
September	7	3.05	77.5	20	0.16	4.1
October	23	3.42	86.9	22	0.18	4.6
November	5	0.59	15.0	4	0.04	1.0
December	12	0.74	18.8	5	0.08	2.0
1972	92	15.56	395.2		0.13	3.2

* Recording rain gauge not installed until April 1971.

I. A. 4 PLAYA RELATIVE HUMIDITY

A hygrothermograph was installed in the weather station on the southwest corner of the playa in March, 1970. Details for the instrumentation and recording system are described by DSCODE A3UWJ03 (Biome Abstracts Vol. I, No. 2).

Daily means are shown in Figure 7 for 1970, 1971 and 1972. The day-to-day average relative humidity is highly variable as evident from the broad scatter of data points. Seasonal cycles are quite evident, with the spring months of March, April, May and June having the lowest humidities. There is a distinct rise in average relative humidity during the rainy months of July, August and September. Humidities typically stay high during the fall months. With temperatures low, the dew point is reached during many days, usually at night and during the early morning hours.

Year-to-year differences are also evident from Figure 7. The fall of 1970 was drier than the fall of 1971 which in turn was drier than the fall of 1972. The spring of 1971 was very dry, particularily in late May and early June. The summer of 1972 had more days with average higher humidities than 1970 or 1971. The average humidities remained high during the fall of 1972.

Relative humidity data will probably be very valuable as input to various models being developed. It will probably be more useful if it is converted to values indicating water gradients, such as air water potential or water vapor pressure deficits. Many of these conversions involve calculations which are quite sensitive to small changes in relative humidity. Unfortunately, relative humidity is difficult to measure accurately with an inexpensive and simple instrument like the human-hair hygrograph. Periodic checks of our hygrography indicate drifts of 2-5% in the middle range of the instrument, i.e., around 25-75% humidities; but at higher humidities above 75%, the instrument seems to overestimate rather consistently, readings obtained with a gun psychrometer. Calibration curves may have to be used to correct for instrument bias in the extreme ranges.

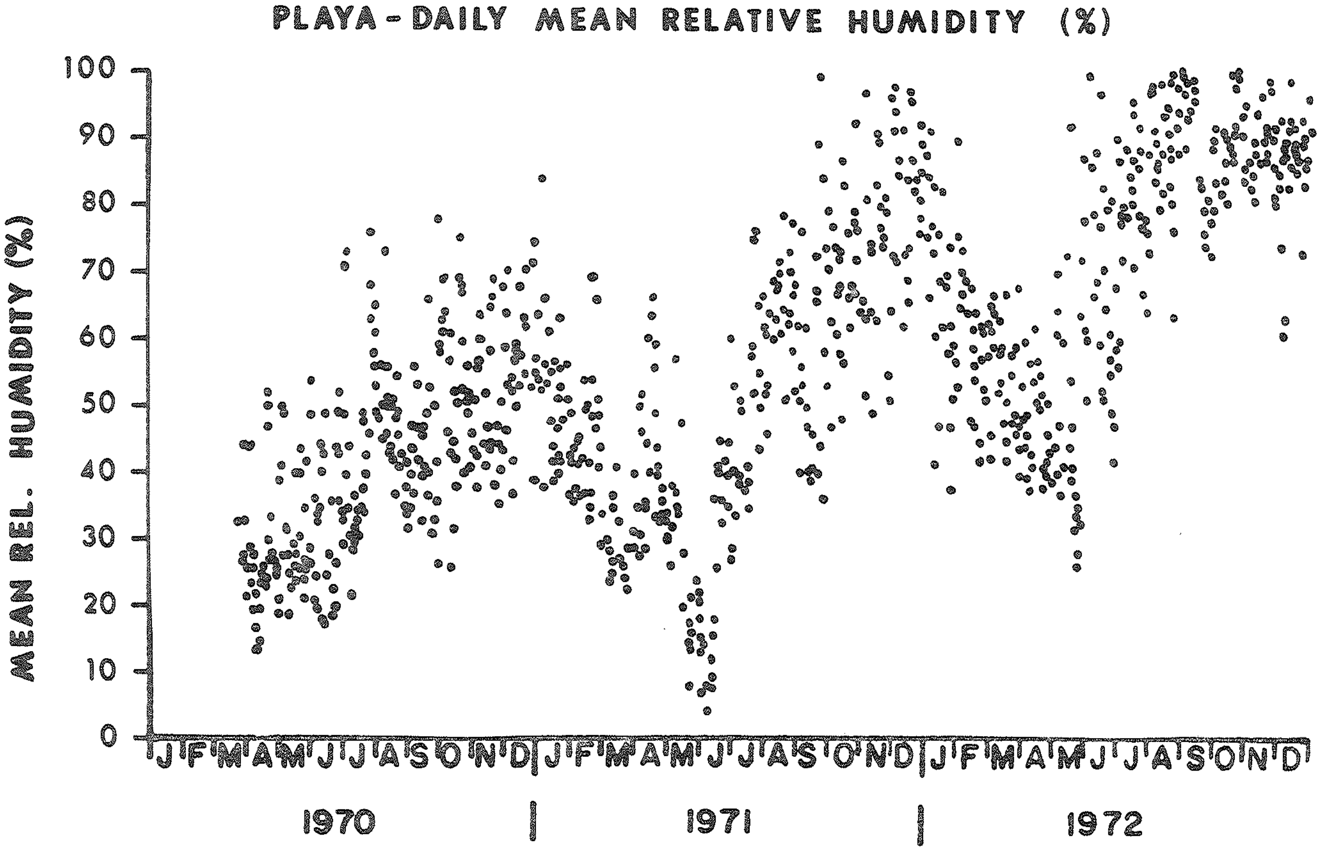

Figure 7. Daily mean relative humidities for 1970, 1971 and 1972 at the playa site.

I. A. 5 PLAYA WIND

An anemometer was installed on the playa study site in May 1971. The recorder on the anemometer registers the total miles of wind. The recorder is monitored once a week when the charts on the other weather station instruments are changed, thus total miles for the week are recorded. The average miles per hour for the week can be calculated. For further description see DSCODE A3UWJ08.

Average wind speed in miles per hour for each week starting in mid-May 1971 and ending in 1972 are given in Figure 8. As shown, week to week variability in average wind speed is considerable. However, seasonal differences can be noted. During the spring months of March, April and May the average wind speed varies from 5 to 10 mph whereas during the summer months the range is from 4 to 6 mph. During the fall and winter months the averages are highly variable. For example, during the first two weeks in December of 1972, the first week averaged 9 mph while the next week averaged slightly more than 3 mph.

Wind data will probably be needed as input for some of the models being developed. Some models will probably need wind data at a shorter time interval than available. The anemometer is equipped with circuit breakers which are adaptable to an event recorded. Such a recorder has been installed on the bajada and wind on an hourly basis rather than a weekly basis is being obtained. However, the manpower necessary to maintain the event recorded system (battery, recorder, charts, anemometer) is nearly equivalent to maintaining all the rest of the weather station, thus only one such system has been established and that on the bajada (see section II. A. 5).

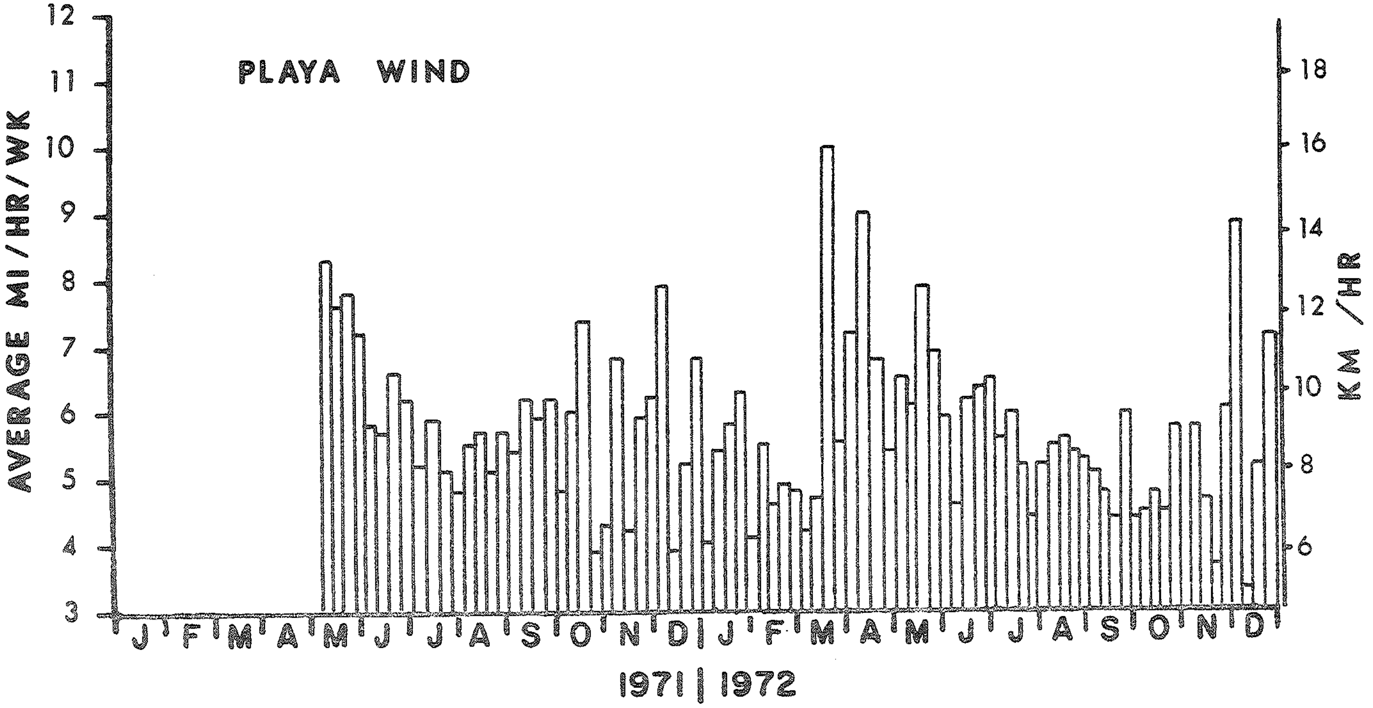

Figure 8. Average wind speed (miles/hr/week) on the playa site in 1971 and 1972.

I. A. 6 PLAYA SOIL TEMPERATURE

A soil thermograph was installed at the playa study site weather station in May, 1971. A two probe instrument was set up. The probes were buried in an open area next to the instrument shelter at depths of 10 cm and 50 cm. Temperatures are recorded continuously on a weekly strip chart. More details on the instrumentation are given in DSCODE A3UWJ06.

Daily average soil temperatures at 10 cm for 1971 and 1972 are shown in Figure 9. Day to day means do not vary greatly but shift either up or down a degree C or two. Seasonal changes are most striking, with daily averages peaking at a maximum of about 35 C in July and dropping to a minimum of near 0 C in December and January.

Changes in mean soil temperature at 10 cm are fairly sensitive to changes in short-term weather patterns as indicated in Figure 9. For example, in the latter part of December 1971 a series of seasonal warm days is indicated by a steady rise in temperature from near 0 C to about 8 C. Then in response to a series of colder days, it declined to near 0 C again. The same sort of responses can be seen for other times of the year, such as in October, 1972 when mean soil temperatures stayed relatively warm at over 20 C but then dropped rather suddenly to near 10 C as indicated by the break in the scatter of data points.

Daily average soil temperatures at 50 cm for 1971 and 1972 are shown in Figure 10. As would be expected, day-to-day means do not fluctuate as greatly as the means for the 10 cm depth. However, the seasonal (soil temperature) cycles (for 50 cm) are also striking although they do not show as wide of range as the means for 10 cm. The maximums also occur in July, but at the lower value of about 30 C. The minimums occur in December, January and February but at a higher mean of about 4 C.

Short-term weather patterns can also be detected by the 50 cm mean soil temperatures shown in Figure 10, however the sensitivity is not as great as that for the 10 cm depth. For example, the warming trend for the latter part of December, 1971, noted above, can also be detected, but the changes involve differences of 2-3 C, not 7-8 C as shown for 10 cm. The break in the scatter of data points seen in October, 1972 at 10 cm is also evident at 50 cm.

Soil temperatures at depths other than 10 cm and 50 cm will probably be needed by some investigators for some of their studies. Models will have to be developed to predict the entire soil temperature profile given data for two depths. Soil surface temperature will be quite important to some of the desert biologists. Soil temperature data will probably have to be combined with other data such as air temperature and incoming solar radiation in order to adequately predict soil surface temperatures.

Soil temperature data for the playa site is also available from thermistors buried with the network of gypsum resistance blocks. These blocks are buried at three depths (15 cm, 45 cm and 90 cm). The network of blocks covers three different areas of the playa site. The areas are the playa bottom proper, which supports a vine-mesquite grass community, the playa edges, which support a tobosa grass community, and the playa fringes, which support heterogeneous vegetation types from mesquite thickets to open burro-grass flats. Since the soil blocks (thermistors) are monitored on a somewhat irregular basis depending on season and weather patterns, the soil temperature data is not as continuous as that from the soil thermographs. Thus it was decided not to show this data in this report, however such data are shown in Research Memorandum 72-4 for 1970 and 1971. These data are part of DSCODE A3UWJ05 described in Biome Abstracts Vol. I, No. 2.; thus these data are available for 1972 upon request. In general, these data follow the soil thermograph data fairly closely. However, the month-to-month variations in soil temperature at 15 cm are largely due to differences in the time of day that the thermistors (soil blocks) were monitored and the general temperature conditions during the hours and days prior to measurement. The seasonal temperature changes for 45 cm are very similar to data for 50 cm from the thermograph. The temperatures at 90 cm are less variable and follow those of the 45 cm depth but with a distinct lag. The 90 cm temperatures are cooler during the spring and summer than at 45 cm, but are warmer during the fall and winter as would be expected.

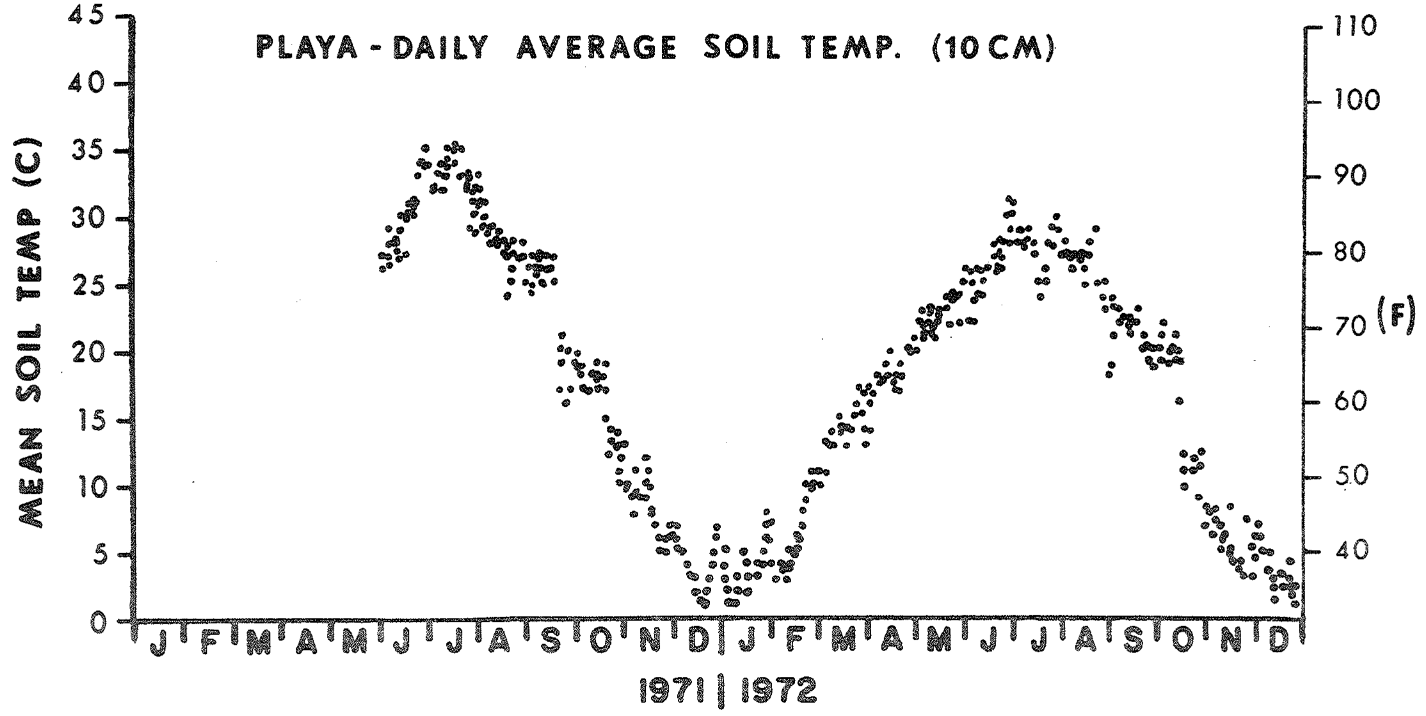

Figure 9. Daily mean soil temperatures at 10 cm for 1971 and 1972 at the playa site.

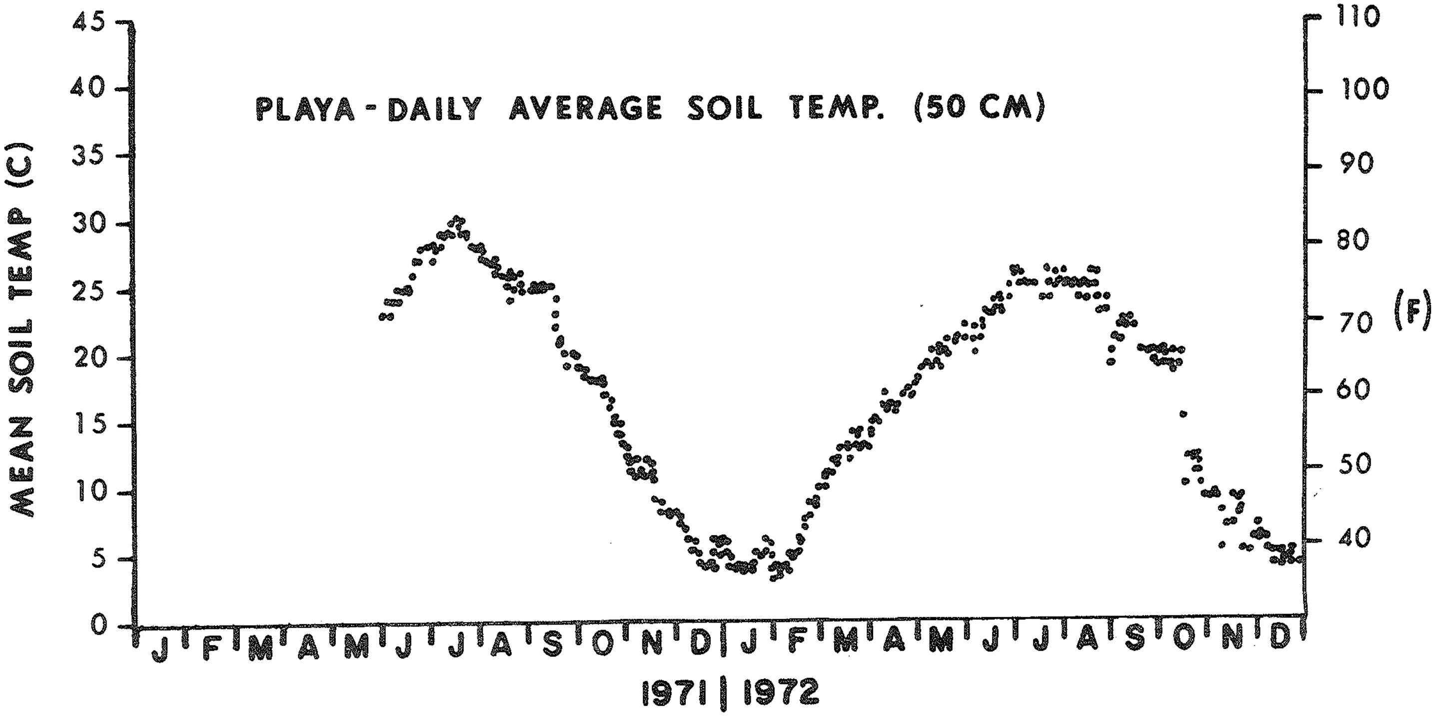

Figure 10. Daily mean soil temperatures at 50 cm for 1971 and 1972 at the playa site.

I. A. 7 PLAYA SOIL MOISTURE

Soil moisture has been monitored on the playa site since March, 1970. Moisture has been estimated as soil water potentials (negative Bars) using gypsum electrical resistance blocks of special design. Calibration of these specially designed blocks is still in progress. The most difficult problem to date is obtaining repeatable calibration points for these blocks embedded in clay soils at high pressures (100+ atm). The calibration curve for these blocks in sandy soils appears to be fairly reliable down to -130 atm.

Soil water potentials are being monitored at 3 depths and for 3 different areas of the playa. The depths at which a set of 3 gypsum blocks are buried are 15 cm, 45 cm and 90 cm. The three areas are the playa bottom, the playa edge and the playa fringe. The vegetation characterizing each of these areas and details of the monitoring system are given in DSCODE A3UWJ05 (Biome Abstracts Vol. I, No. 2).

Playa bottom soil water potentials at 15 cm for 1970, 1971 and 1972 are shown in Figure 11. The broken line across the figure indicates the present estimated upper limit of the calibration curve to obtain soil water potential from electrical resistance. For the heavy clay soil of the playa bottom, the actual soil water potential is probably somewhat higher (less negative) than that shown. Further calibration work is needed on these blocks. However, given these problems, it is obvious that the playa bottom soils dried rapidly in the spring of 1970, being very dry by May. The surface soils remained dry until the playa flooded on 24 July when soil water potential dropped to near zero(Figure 11). During September the soil started drying at 15 cm as plant growth was rapid (see later section). However, on the 27th of September, a 2.5 cm rain partially rewetted the soil at 15 cm. Then the drying trend continued before picking up again in the spring. The soils on the playa bottom remained very dry during the spring and early summer of 1971. A few small rains (see section I. A. 3) in July, August and September partially wetted the surface but only a few gypsum blocks in the playa bottom actually detected moisture at 15 cm. On 25 October 1971, over 2 cm of rain fell, which was sufficient to wet all the gypsum blocks at 15 cm as shown by the water potential being near zero(Figure 11). Occasional rains in November and December kept the soil water potential relatively high (toward zero). During the spring of 1972 the soil at 15 cm again dried, reaching the maximum dryness detectable by May. Then rains in June and July partially lowered the average playa bottom soil water potential by wetting some of the blocks but not all of them at 15 cm. By the end of July all the blocks were wet at 15 cm and after a short drying cycle in August, a large rain on 1 September rewet all the blocks. The playa bottom stayed wet at 15 cm during the rest of 1972.

Playa bottom soil water potentials at 45 cm for 1970, 1971 and 1972 are shown in Figure 12. The seasonal trends for soil moisture at this depth follow closely those for 15 cm, except for the latter part of 1971. As indicated, the small, scattered rains during the summer and fall of 1971 were of insufficient total amount to wet all the blocks at 45 cm. Thus the average soil water potential stayed near -60 bars during the fall and winter before drying out by May 1972. The soil at 45 cm was wet during the fall of 1972.

Playa bottom soil water potentials at 90 cm for 1970, 1971 and 1972 are shown in Figure 13. The season-to-season and year-to-year trends for soil moisture at 90 cm follow nearly exactly those for 45 cm except the drying cycles lag. This deep depth is below the rooting zone of the vegetation. Thus they do not dry out as rapidly in response to plant growth (transpiration). By the end of 1972, the soil at 90 cm was wet due to the heavy rains during the summer and fall.

Playa edge soil water potentials at 15 cm for 1970, 1971 and 1972 are shown in Figure 14. In 1970, the soil at 15 cm dried rapidly in late spring, reaching the maximum detectable by June. This contrasts with the same depth for the playa bottom (Figure 11) which dried out earlier in the spring. With the flooding in July, the soil was temporarily saturated, however, the soil dried rapidly in August. The burst of growth of tobosa grass after the water receded from the playa edge probably accounts for a great deal of this drying of the soil at 15 cm. A large (2.5 cm) rain on 27 September rewet the soil again. The soil remained moist until the warm, windy days in the spring, when it dried to the maximum. The small rain showers in August, 1971 were sufficient to wet all the gypsum blocks in the tobosa grass area at 15 cm depth. Again, growth of tobosa started to dry the soil at 15 cm but the 25 October rain noted earlier again saturated the tobosa soil. The playa edge soil at 15 cm went through a series of wetting and drying cycles during the summer of 1972. The soil at this depth in this area is very sensitive to precipitation patterns. After the large flooding rain of 1 September 1972, the playa edge soils at 15 cm remained moist the rest of the fall.

Playa edge soil water potentials at 45 cm for 1970, 1971 and 1972 are shown in Figure 15. The seasonal and yearly trends for soil moisture at 45 cm are identical to those for 15 cm except for a slight lag, indicating that the deeper soil depths are slower to dry out as is expected. For example, during the spring of 1970, the 15 cm depth dried out by June but did not dry out to the same level at 45 cm before the flooding in July. Also, in the spring of 1972, note that the 15 cm depth was drying rapidly in mid-April (Figure 14) whereas the 45 cm depth shows the lag and does not dry until late April. The soil at 45 cm was wet during the fall of 1972.

Playa edge soil water potentials at 90 cm for 1970, 1971 and 1972 are shown in Figure 16. Again, the season-to-season and year-to-year patterns of soil moisture for the 90 cm depth in the tobosa grass area are nearly identical to those for the 45 cm and 15 cm depths except for the characteristic lag in that the soils at this depth do not dry out as rapidly. Conversely, they also may not wet after small rain showers. During the summer of 1972, the soils at 90 cm did not dry out to the low water potentials acheived by the soils at 15 cm and 45 cm.

Playa fringe soil water potentials at 15 cm for 1970, 1971 and 1972 are shown in Figure 17. In contrast to the clay and sandy clay loam-textured soils for the playa bottom and edge respectively, the sandy soils around the playa fringes show very rapid wetting responses to smaller rains. The sandy soil has more rapid and deeper infiltration characteristics; thus the gypsum blocks moisten in response to smaller rains. The sandy soils also dry out relatively faster. Thus the soil blocks at 15 cm around the playa fringe show a more rapid response to the small showers characteristic of many of the summer thunderstorms. The soil dried rapidly at 15 cm during the dry spring of 1970. A small shower of less than 1 cm fell on 1 July which partially moistened some of the blocks, but they quickly dried again by mid-July. With the rains that flooded the playa on 24 July, the soil water potential dropped to near zero. During August, the soil dried rapidly, reaching the maximum detectable by mid-September. The 27 September rain again saturated the blocks at 15 cm but only temporarily because they dried out again in October and November. A rainfall of about 1 cm on 14 December 1970 again partially wet the soil at the 15 cm depth. Drying slowed during the winter months, but by April, 1971 they were at the maximum again. They remained dry until the late summer rains, which were all small, but relatively frequent, thus the soil at 15 cm remained fairly moist throughout the fall and winter. By March, 1971 the soil was again drying rapidly, reaching the maximum by April. With small rains in June, the soil again moistened and then dried. It went through a series of rapid wetting-drying cycles during the summer of 1972. However, with the cooler days of the fall and winter and with continued periodic rainfall, the soil at 15 cm remained moist during this period.

Playa fringe soil water potentials at 45 cm for 1970, 1971 and 1972 are shown in Figure 18. The season-to-season and year-to-year trends are very similar to those for the 15 cm depth except for the expected lag in drying and lack of wetting by small rains. In general, the deeper soils are less responsive to minor precipitation and other weather events. As shown by Figure 18, the average soil water potentials appear as a smoother curve than for the 15 cm depth and for the other playa areas. Part of this effect is that the average values reported here do not indicate the variability in the playa fringe. The soil blocks buried near the playa bottom typically are moister for longer periods of time after being wet, whereas the soil blocks buried at the furthest distance (80 m) from the bottom are drier for longer periods of time, since the soil is sandier and better drained. The soil moisture at 45 cm fluctuates relatively rapidly during summers of periodic rainfalls such as 1972. The soil water potential actually fluctuates more than what is indicated in Figure 18, since the lines connect the data points, but in many cases, the line should drop to zero (after a large rain) before coming back up to the next data point (after drying).

Playa fringe soil water potentials at 90 cm for 1970, 1971 and 1972 are shown in Figure 19. The trends for the 90 cm depth do not follow those for the shallower depths (15 and 45 cm). Note that the driest the data ever indicates is about -85 bars. The wettest the data shows (except for after the initial installation when the blocks are wet) is -15 bars. The possible explanation for this different trend may be that the blocks at 90 cm are placed under a semi-solid caliche layer. After it was initially broken through in 1970, it resolidified and now is a barrier to rapid water movement down to or up from the 90 cm depth. Note that the soil moisture at this depth does seem to reflect the general overall moisture status of the year. During 1971, which was very dry, the curve stays at low water potentials. However, during 1972, which was a very wet year, the curve dropped to higher water potential (less negative). Thus at least part of the moisture of the heavy rains in 1972 reached the deeper depths.

Literature cited

Houghton, F. E. 1972. Climatic Guide, New Mexico State University, Las Cruces, New Mexico. 1851-1971. New Mexico A.E.S. Research Report Number 230. 20 p.

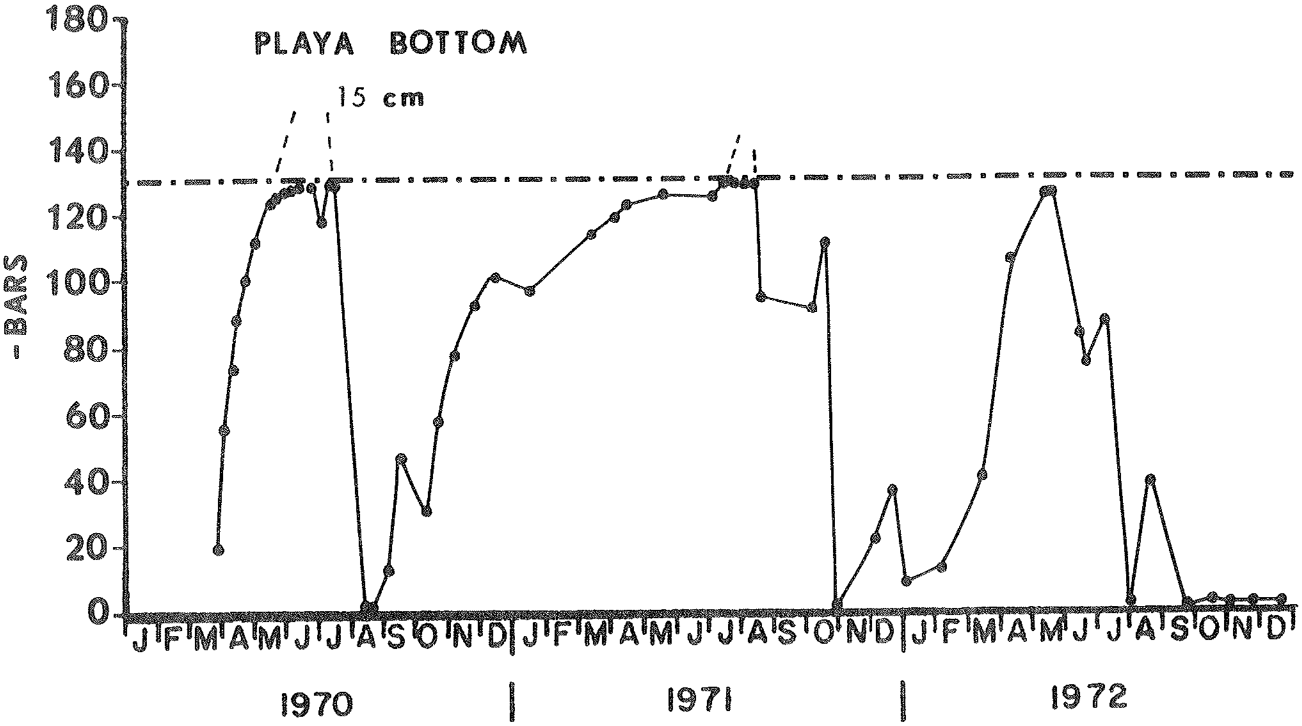

Figure 11. Soil water potentials at 15 cm for 1970, 1971 and 1972 on the playa botto bottom (vine-mesquite grass area).

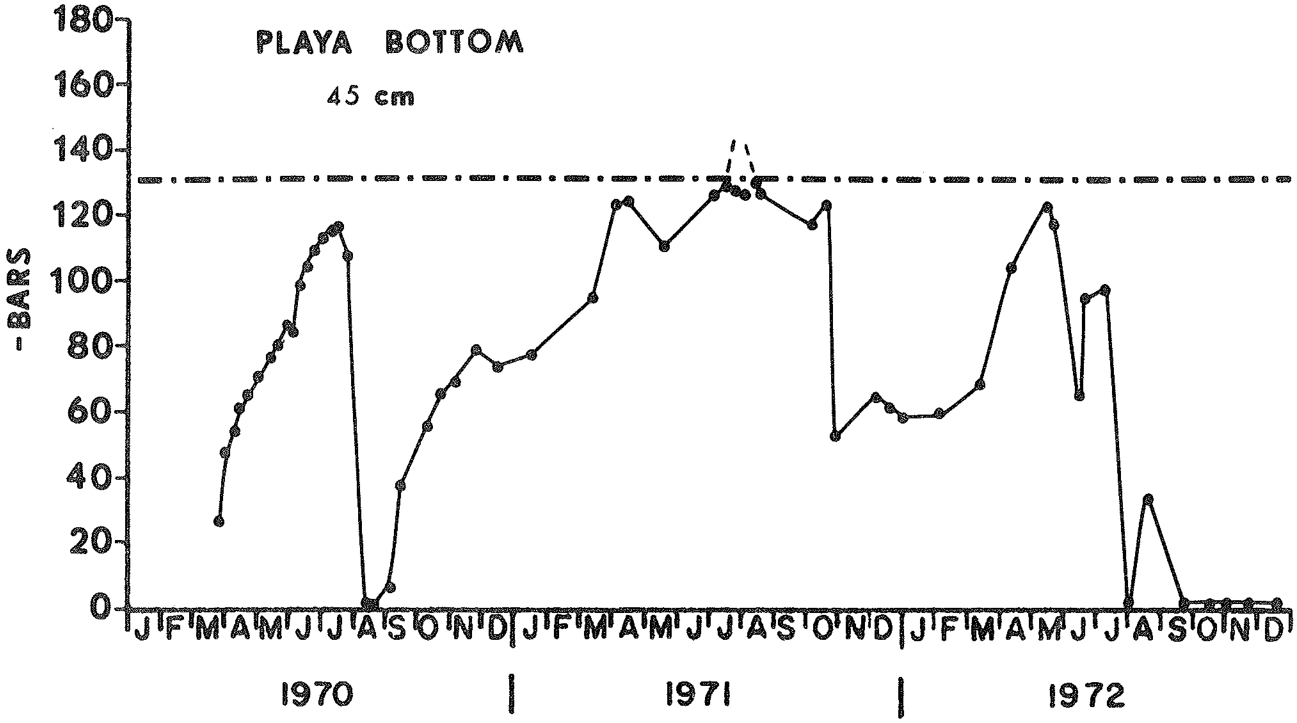

Figure 12. Soil water potentials at 45 cm for 1970, 1971 and 1972 on the playa bottom (vine-mesquite grass area).

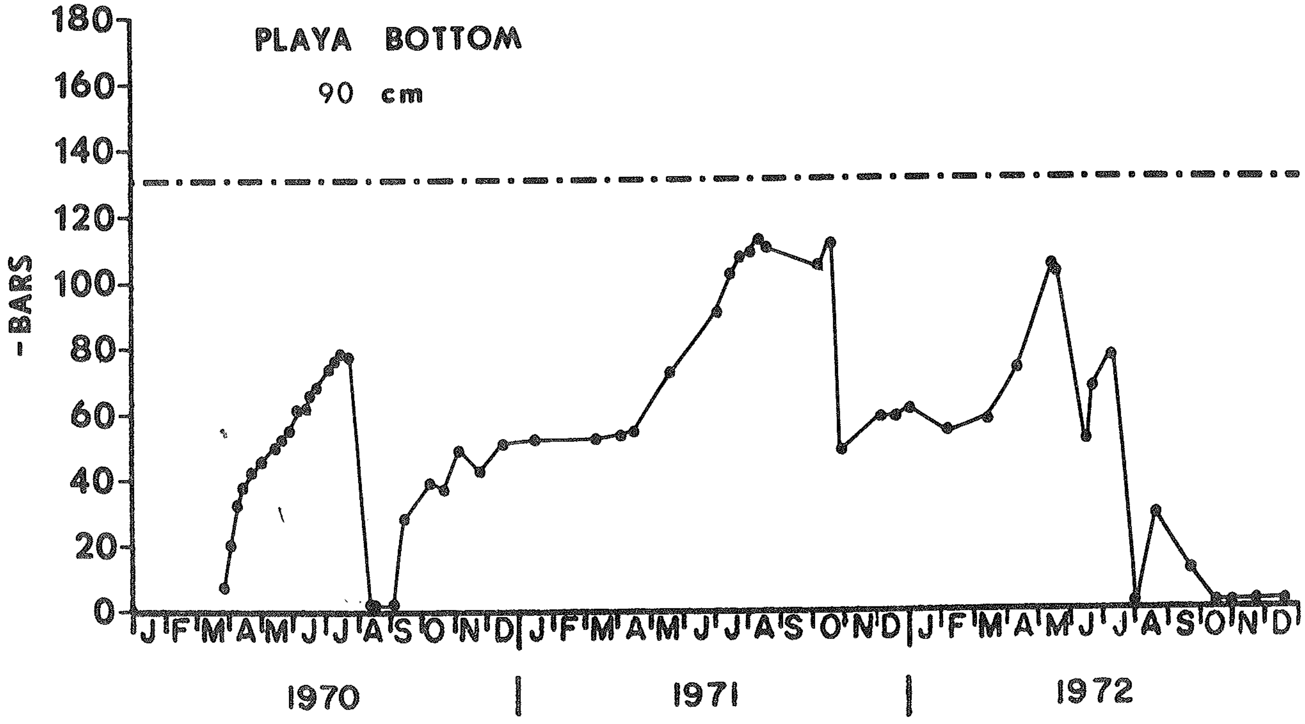

Figure 13. Soil water potentials at 90 cm for 1970, 1971 and 1972 on the playa bottom (vine-mesquite grass area).

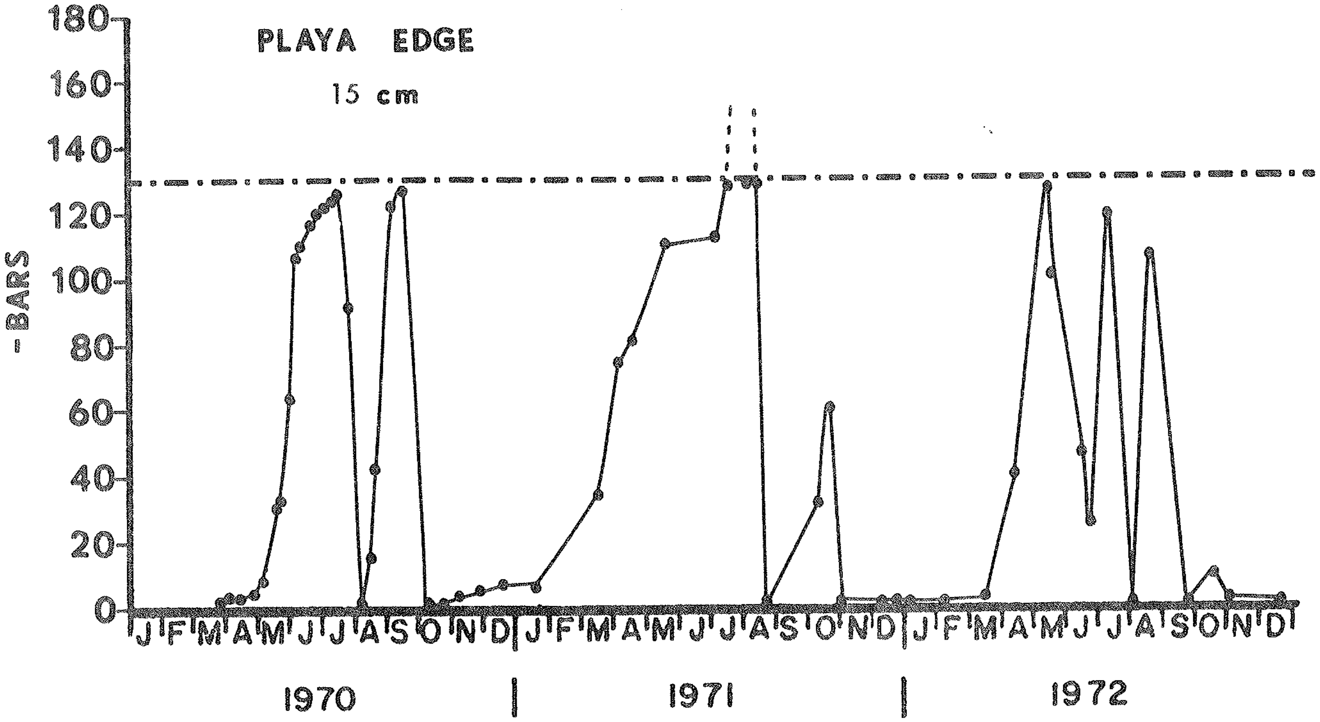

Figure 14. Soil water potentials at 15 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

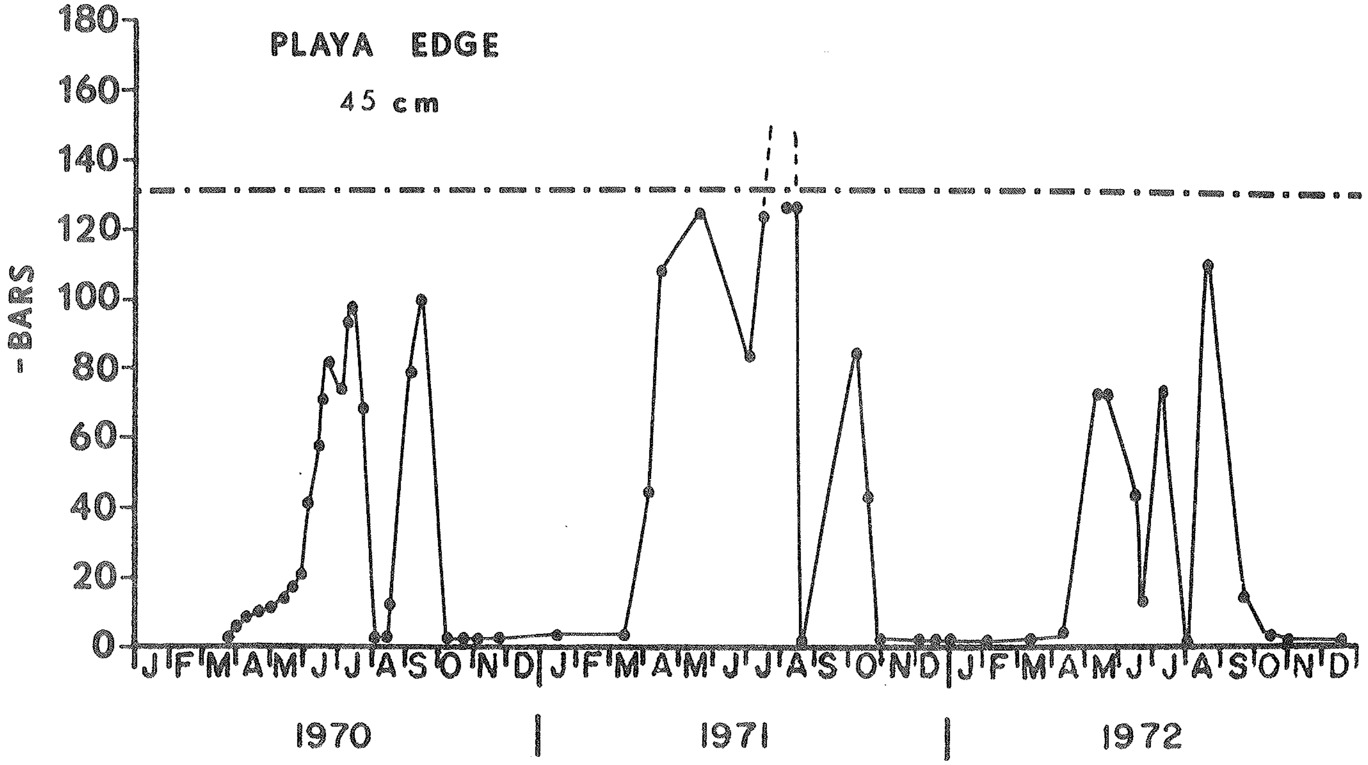

Figure 15. Soil water potentials at 45 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

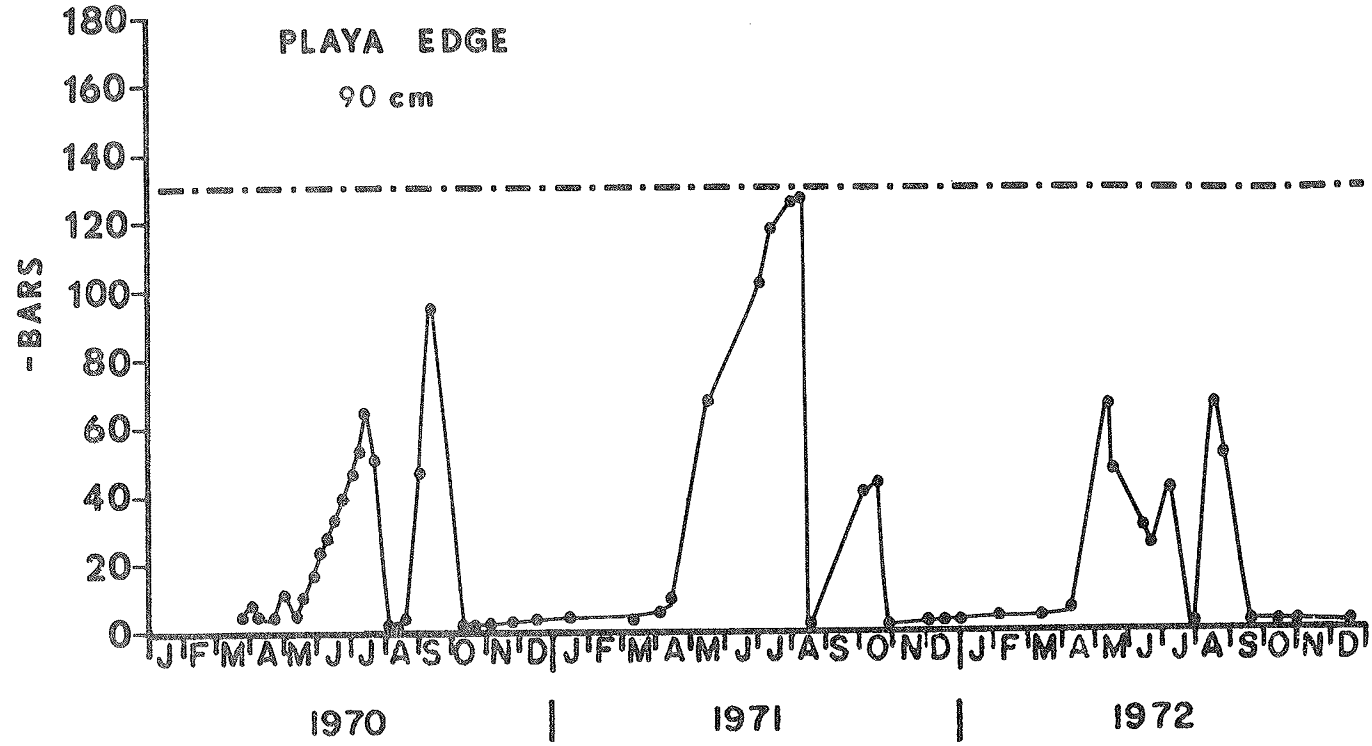

Figure 16. Soil water potentials at 90 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

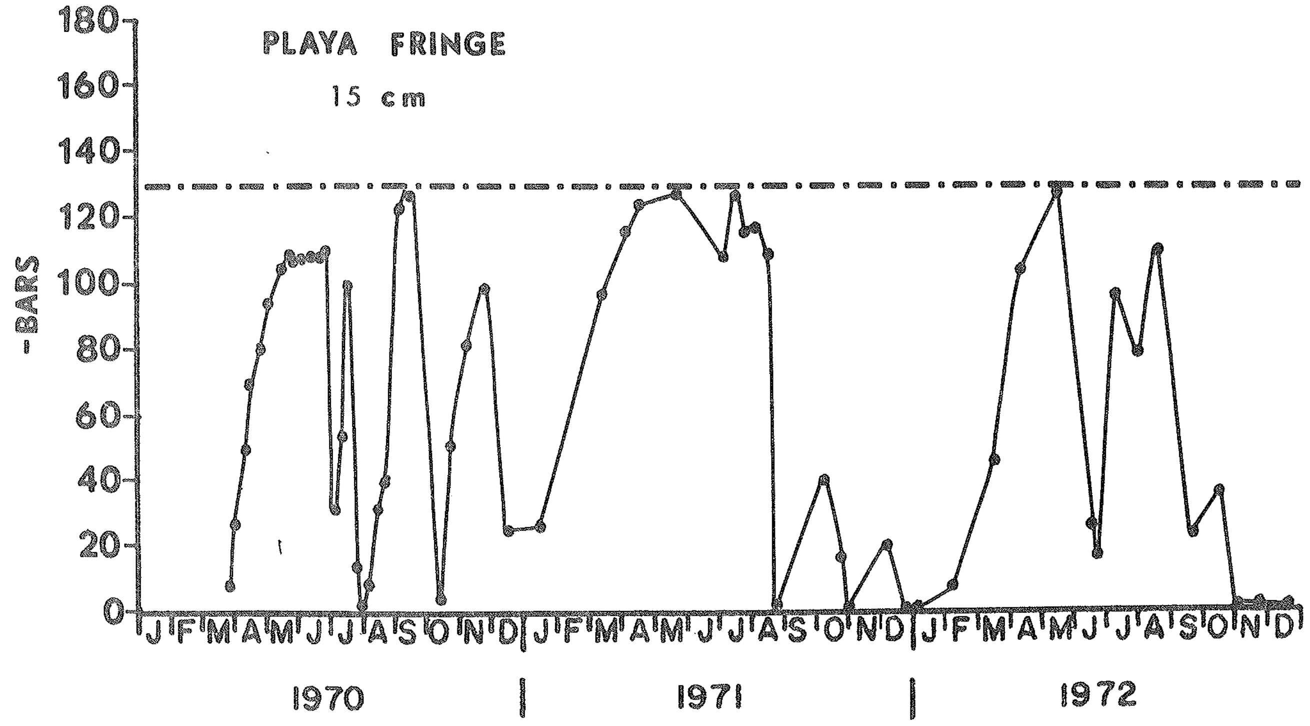

Figure 17. Soil water potentials at 15 cm for 1970, 1971 and 1972 around the playa fringe.

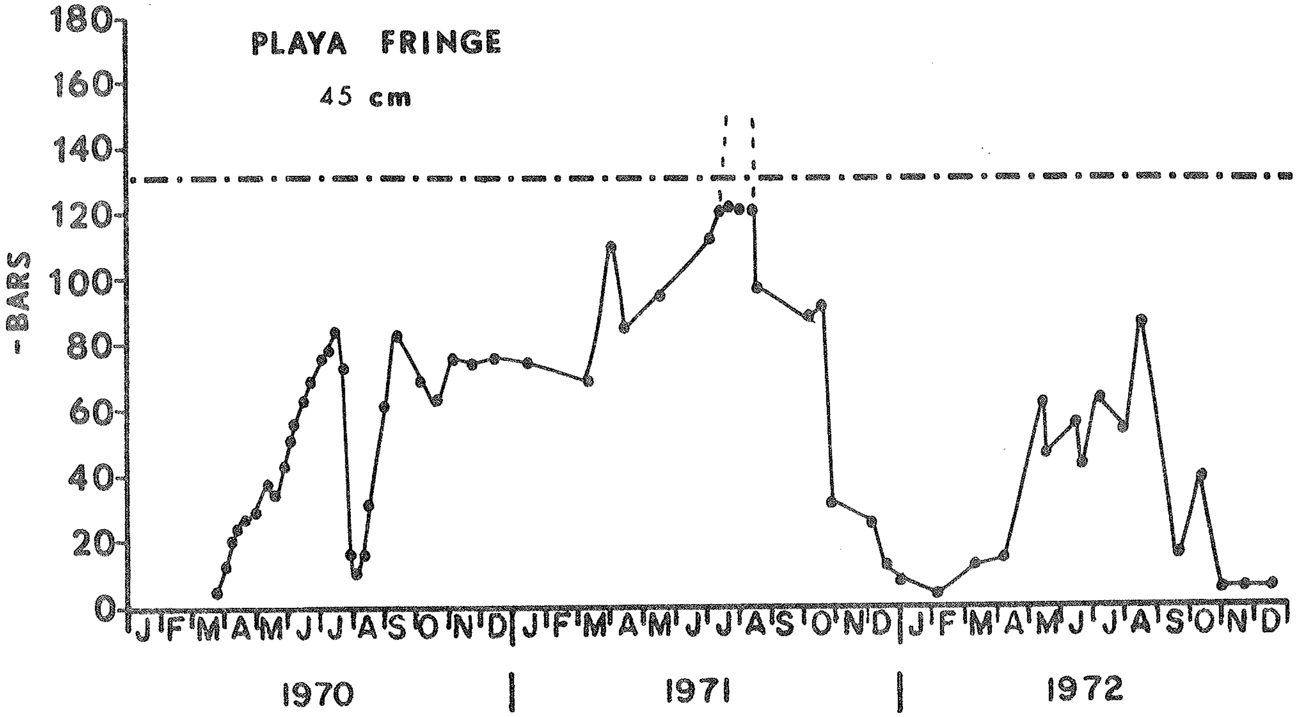

Figure 18. Soil water potentials at 45 cm for 1970, 1971 and 1972 around the playa fringe.

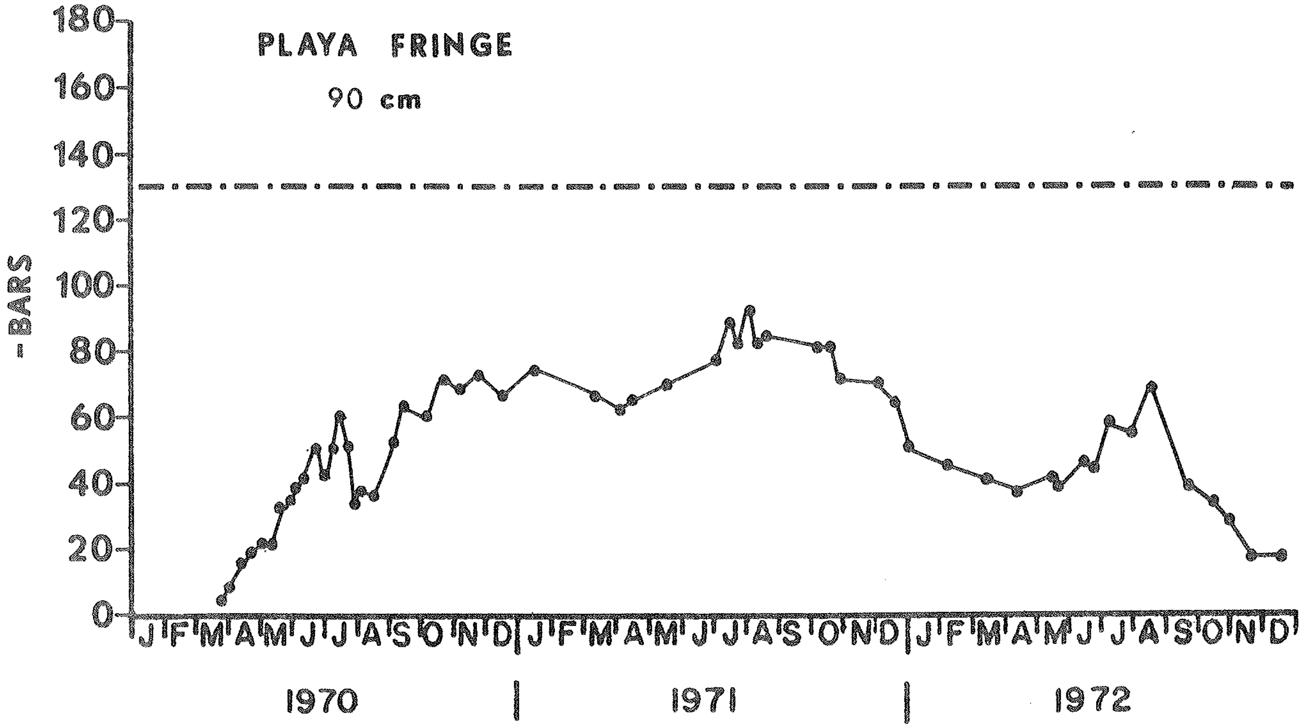

Figure 19. Soil water potentials at 90 cm for 1970, 1971 and 1972 around the playa fringe.

I.B. PLANTS

1. PLAYA ANNUALS

Playa fringe

The annual and small perennial vegetation on the playa study site was sampled in 1970 utilizing 40 stratified, random 0.5 m^2 quadrats from which the above-ground plant material was collected for biomass determination. In 1971 and 1972, 30 stratified, random points were utilized as the basis for the point centered quarter method at this site. The plants to which distances were measured were collected and sorted by species, oven-dried, and each species separated into vegetative and reproductive material and the weights recorded (DSCODE A3UWJ54).

Annual grass densities were calculated from the 1971 and 1972 sampling data. The greatest total density of annual grasses occurred on the August, 1972, sampling date (Table 1). Of the annual grasses sampled, only *Aristida adscensionis* and *Bouteloua barbata* were sampled on every date. *A. adscensionis* exhibited highest density on the June, 1972, sampling, whereas *B. barbata* density was greatest in August, 1972.

Biomass estimates on the playa fringe revealed annual grasses to have their greatest summed total biomass on the October, 1972, sampling date (Table 2). Likewise, the two most important species, *A. adscensionis* and *B. barbata*, expressed their greatest total biomasses in October, 1972. The maximum biomass estimate for these two grasses occurred subsequent to their maximum densities (Table 1), suggesting some mortality before maximum growth was attained.

Maximum reproductive biomass of the annual grasses expressed as percentage of total biomass occurred in October of both 1971 and 1972 (Table 3). *B. barbata* began producing reproductive structures after the June sampling date in 1972, but none of the other annual grasses sampled exhibited reproductive structures this early (Table 3).

Annual forb densities were calculated from the 1971 and 1972 sampling data. This plant category exhibited its greatest total density on the August, 1972 sampling date (Table 4). *Chenopodium incanum* exhibited the highest density of all species sampled and this occurred in June, 1972. *Euphorbia serrula* and *Tribulus terrestris* were the only annual forbs sampled on every date in 1971 and 1972. *E. serrula* and *T. terrestris* both expressed their greatest densities in June, 1972, with their second highest densities in August, 1972. The greatest densities of most of the annual forbs sampled occurred in June or August (Table 4).

Annual forb biomass estimates indicated maximum summed total biomass values occurred in October (Table 5). *Chenopodium incanum* exhibited its greatest total biomass in June, 1972, concomitant with its highest density (Table 4). *Euphorbia serrula* had its greatest total biomass in October, 1970, but in 1972 the month with the greatest total biomass was August. *Tribulus terrestris* expressed high total biomass values in October of both 1970 and 1972. Both *E. serrula* and *T. terrestris* exhibited relatively low total biomass values subsequent to dates with highest densities, as did the annual grasses.

Annual forb reproductive biomass expressed as a percentage of total biomass was generally greatest in August or October (Table 6). *Chenopodium incanum* and *Euphorbia serrula* exhibited greatest percentage reproductive biomass in August, 1972, whereas *Tribulus terrestris* expressed its greatest reproductive structure production in October. Species of *Eriogonum* and *Chenopodium* produced reproductive structures as early as June, but species of *Boerhaavia, Euphorbia, Kalistromia* and *Tribulus* did not produce reproductive structures until after June (Table 6).

Table 1. Estimated densities of annual grasses on the playa fringe at various dates in 1971 and 1972.

Density (no. per hectare)

Species	1971 6 October	27 June	1972 22 August	26 October
Aristida adscensionis	269	5,525	716	1,035
Bouteloua barbata	699	5,525	15,625	9,239
Chloris virgata	108	----	716	----
Eragrostis arida	54	----	----	1,035
Tragus berteronianus	54	----	----	----
Total	1,184	11,050	17,057	11,309

Table 2. Estimated biomass (g/ha) of annual grasses on the playa fringe at various dates in 1970, 1971 and 1972

Species	Plant Component	1970 10 Jul.	2 Oct.	1971 6 Oct.	27 Jun.	1972 22 Aug.	26 Oct.
Aristida adscensionis	Vegetative	---	---	8.1	67.4	7.2	3,364
	Reproductive	---	---	8.1	0	0	56.9
	Total	---	---	16.2	67.4	7.2	3,420.9
Bouteloua barbata	Vegetative	---	*	35.0	67.4	2,229.7	2,587
	Reproductive	---	*	21.0	0	134.4	1,663
	Total	---	460.0	56.0	67.4	2,364.1	4,250.0
Chloris virgata	Vegetative	---	---	3.2	---	64.4	---
	Reproductive	---	---	2.2	---	0	---
	Total	---	---	5.4	---	64.4	---
Eragrostis arida	Vegetative	---	---	1.6	---	---	20.7
	Reproductive	---	---	1.1	---	---	5.2
	Total	---	---	2.7	---	---	25.9
Tragus berteronianus	Vegetative	---	---	3.2	---	---	---
	Reproductive	---	---	1.6	---	---	---
	Total	---	---	4.8	---	---	---
Total	Vegetative	0	*	51.1	134.8	2,301.3	5,971.7
	Reproductive	0	*	34.0	0	134.4	1,725.1
	Total	0	460.0	85.1	134.8	2,435.7	7,696.8

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 3. Percent of annual grass biomass in reproductive structures at various dates in 1970, 1971, and 1972 on the playa fringe.

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

	1970		1971		1972	
Species	10 July	2 October	6 October	27 June	22 August	26 October
Aristida adscensionis	----	----	50.31	0	0	1.66
Bouteloua barbata	----	*	37.57	0	5.68	39.13
Chloris virgata	----	----	40.74	----	0	----
Eragrostis arida	----	----	40.74	----	----	20.08
Tragus berteronianus	----	----	32.65	----	----	----

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 4. Estimated densities of annual forbs on the playa fringe at various dates in 1971 and 1972.

	Density (no. per hectare)			
	1971	1972		
Species	6 October	27 June	22 August	26 October
Amaranthus blitoides	54	618	----	----
Amaranthus palmeri	----	----	4,997	2,069
Amaranthus pubescens	----	----	716	----
Boerhaavia gracillima	----	----	----	517
Boerhaavia spicata	----	7,360	6,398	----
Chenopodium incanum	----	14,112	4,997	----
Eriogonum abertianum	----	1,227	2,136	----
Eriogonum rotundifolium	----	4,907	7,818	5,100
Eriogonum trichopes	----	1,845	716	----
Euphorbia glyptosperma	645	9,205	2,136	----
Euphorbia micromera	----	6,752	6,398	3,104
Euphorbia serrula	699	7,360	7,102	2,587
Euphorbia serpyllifolia	----	----	8,523	6,134
Hymenoxys odorata	----	----	----	1,552
Iva ambrosiaefolia	----	----	----	1,035
Kalistromia parviflora	----	1,845	4,261	----
Leucelene ericoides	----	1,227	----	----
Pectis papposa	----	618	----	----
Portulaca oleracea	161	4,298	----	5,100
Salsola kali	----	----	716	----
Tidestromia lanuginosa	108	----	9,239	2,587
Tribulus terrestris	54	1,227	716	517
Xanthium strumarium	----	----	716	----
Total	1,721	62,601	67,585	30,302

Table 5. Estimated biomass (g/ha) of annual forbs on the playa fringe at various dates in 1970, 1971 and 1972

Species	Plant Component	1970 10 Jul.	 2 Oct.	1971 6 Oct.	 27 Jun.	1972 22 Aug.	 26 Oct.
Amaranthus blitoides	Vegetative	---	*	11.9	6.2	---	---
	Reproductive	---	*	10.8	0	---	---
	Total	---	9,240.0	22.7	6.2	---	---
Amaranthus palmeri	Vegetative	---	---	---	---	1,549.1	3,124
	Reproductive	---	---	---	---	21.5	4,655
	Total	---	---	---	---	1,570.6	7,779.0
Amaranthus pubescens	Vegetative	---	---	---	---	415.3	---
	Reproductive	---	---	---	---	43.0	---
	Total	---	---	---	---	458.3	---
Astragalus wooteni	Vegetative	*	---	---	---	---	---
	Reproductive	0	---	---	---	---	---
	Total	*	---	---	---	---	---
Boerhaavia gracillima	Vegetative	---	---	---	---	---	201.6
	Reproductive	---	---	---	---	---	41.4
	Total	---	---	---	---	---	243.0
Boerhaavia spicata	Vegetative	---	---	---	325.3	9,518.9	---
	Reproductive	---	---	---	0	419.7	---
	Total	---	---	---	325.3	9,938.6	---
Chenopodium album	Vegetative	---	*	---	---	---	---
	Reproductive	---	*	---	---	---	---
	Total	---	2,020.0	---	---	---	---
Chenopodium incanum	Vegetative	*	---	---	16,260	5,946.4	---
	Reproductive	0	---	---	724	542.7	---
	Total	1,000	---	---	16,984.0	6,489.1	---
Eriogonum abertianum	Vegetative	---	*	---	607	2,164.4	---
	Reproductive	---	*	---	6.1	704.9	---
	Total	---	8,410.0	---	613.1	2,869.3	---

Table 5. Estimated biomass (g/ha) of annual forbs on playa fringe (cont.)

Species	Plant Component	1970		1971	1972		
		10 Jul.	2 Oct.	6 Oct.	27 Jun.	22 Aug.	26 Oct.
Eriogonum rotundifolium	Vegetative	*	*	---	5,232	15,152.8	6,120
	Reproductive	0	*	---	319	6,346.6	2,346
	Total	1,210.0	7,660.0	---	5,551.0	21,499.4	8,466.0
Erigonum trichopes	Vegetative	*	*	---	178.4	300.7	---
	Reproductive	*	*	---	55.4	128.9	---
	Total	2,020.0	2,400.0	---	233.8	429.6	---
Euphorbia glyptosperma	Vegetative	---	---	71.0	209.0	121.1	---
	Reproductive	---	---	0	0	113.8	---
	Total	---	---	71.0	209.0	234.9	---
Euphorbia micromera	Vegetative	---	---	---	67.5	980.8	641.6
	Reproductive	---	---	---	0	874.6	600.0
	Total	---	---	---	67.5	1,855.4	1,241.6
Euphorbia serrula	Vegetative	---	*	41.9	67.7	3,359.2	1,283.0
	Reproductive	---	*	14.0	0	2,166.1	155.2
	Total	---	6,060.0	55.9	67.7	5,525.3	1,438.2
Euphorbia serpyllifolia	Vegetative	---	---	---	---	2,343.8	1,467.2
	Reproductive	---	---	---	---	454.3	756.3
	Total	---	---	---	---	2,798.1	2,223.5
Hymenoxys odorata	Vegetative	---	---	---	---	---	77.6
	Reproductive	---	---	---	---	---	0
	Total	---	---	---	---	---	77.6
Iva ambrosiaefolia	Vegetative	---	---	---	---	---	56.9
	Reproductive	---	---	---	---	---	0
	Total	---	---	---	---	---	56.9
Kalistromia parviflora	Vegetative	---	---	---	166.0	6,697.0	---
	Reproductive	---	---	---	0	412	---
	Total	---	---	---	166.0	7,109.0	---

Table 5. Estimated biomass (g/ha) of annual forbs on playa fringe (cont.)

Species	Plant Component	1970 10 Jul.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 26 Oct.
Leucelene ericoides	Vegetative	---	---	---	460.1	---	---
	Reproductive	---	---	---	12.3	---	---
	Total	---	---	---	472.4	---	---
Pectis papposa	Vegetative	---	*	---	6.2	---	---
	Reproductive	---	*	---	0	---	---
	Total	---	90.0	---	6.2	---	---
Portulaca oleracea	Vegetative	---	*	14.5	79.9	---	1,361.7
	Reproductive	---	*	4.8	0	---	637.5
	Total	---	10,930.0	19.3	79.9	---	1,999.2
Salsola kali	Vegetative	*	---	---	---	1,811.5	---
	Reproductive	*	---	---	---	0	---
	Total	40.0	---	---	---	1,811.5	---
Tidestromia lanuginosa	Vegetative	---	*	50.8	---	3,752.9	13,540.4
	Reproductive	---	*	25.9	---	1,605.7	3,259.6
	Total	---	3,530.0	76.7	---	5,358.6	16,800.0
Tribulus terrestris	Vegetative	---	*	8.1	18.4	222.0	1,587.2
	Reproductive	---	*	0	0	7.2	320.5
	Total	---	10,760.0	8.1	18.4	229.2	1,907.7
Xanthium strumarium	Vegetative	---	---	---	---	186.2	---
	Reproductive	---	---	---	---	0	---
	Total	---	---	---	---	186.2	---
Total	Vegetative	*	*	198.2	23,683.7	54,522.1	29,461.2
	Reproductive	*	*	55.5	1,116.8	13,841.0	12,771.5
	Total	4,270.0	61,100.0	253.7	24,800.5	68,363.1	42,232.7

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 6. Percent of annual forb biomass in reproductive structures at various dates in 1970, 1971, and 1972 on the playa fringe.

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

	1970		1971		1972	
Species	10 July	2 October	6 October	27 June	22 August	26 October
Amaranthus blitoides	----	*	47.58	0	----	----
Amaranthus palmeri	----	----	----	----	1.37	59.84
Amaranthus pubescens	----	----	----	----	9.38	----
Boerhaavia gracillima	----	----	----	----	----	17.04
Boerhaavia spicata	----	----	----	0	4.22	----
Chenopodium album	----	*	----	----	----	----
Chenopodium incanum	0	----	----	4.26	8.36	----
Eriogonum abertianum	----	*	----	0.99	24.57	----
Eriogonum rotundifolium	0	*	----	5.75	29.52	27.38
Eriogonum trichopes	*	*	----	23.70	30.00	----
Euphorbia glyptosperma	----	----	0	0	48.43	----
Euphorbia micromera	----	----	----	0	47.14	48.32
Euphorbia serrula	----	*	25.04	0	39.20	10.79
Euphorbia serpyllifolia	----	----	----	----	16.24	34.01
Hymenoxys odorata	----	----	----	----	----	0
Iva ambrosiaefolia	----	----	----	----	----	0
Kalistromia parviflora	----	----	----	0	5.8	----
Leucelene ericoides	----	----	----	2.60	----	----
Pectis papposa	----	----	----	0	----	----
Portulaca oleracea	----	*	24.87	0	----	31.89
Salsola kali	0	----	----	----	0	----
Tidestromia lanuginosa	----	*	33.77	----	29.96	19.4
Tribulus terrestris	----	*	0	0	3.14	16.80
Xanthium strumarium	----	----	----	----	0	----

* These categories were not known due to use of different sampling and recording techniques in 1970.

Playa bottom

The previous paragraphs describe the growth of annual plants around the sloping fringes of the playa. The following paragraphs will describe the growth of the major annual plants that occur on the level playa bottom.

Productivity of the annual plants on the playa bottom was estimated by the harvest method as described in DSCODES A3USJ51, A3UWJ52 and A3UWJ53 by US/IBP Abstracts Vol. I, No. 1. The species are separated in the field. The plant components are separated in the field, then ovendried and weighed in the laboratory. The weights by species and components are given in Table 7. Of the four species shown, *Hymenoxys odorata* and *Xanthium strumarium* contribute the greatest amount of biomass.

Cocklebur (*Xanthium strumarium*) growth trends in 1970, 1971 and 1972 are shown in Figure 1. Cocklebur is weedy in nature and is locally abundant in the Las Cruces area along roadsides and irrigated areas. It was probably introduced on the playa site through the cattle operations at the college ranch. The date of introduction probably was many years ago. It persists on the playa in low spots and by repeated disturbance of the playa bottom by cattle. Cocklebur had a burst of growth after the playa flooded in July, 1970, reaching a peak biomass of green living material of nearly 600 kg/ha (Figure 1). Nearly half of this was reproductive parts (burs). With the end of the growing season or beginning of the frost period in 1970, considerable amounts of cocklebur remained as standing dead, both as leafless stems and burs attached to these stems. During the winter and spring of 1971, most of the standing dead cocklebur was put into the litter compartment by the impact of the cattle on the playa in the spring. As discussed earlier in the abiotic part of this report, the spring and summer of 1971 was very dry. Only a few of the numerous cocklebur seeds germinated and grew with the small, late summer rains. Most of this growth was limited to small depressions in the playa. The total amount of standing crop biomass was estimated before most of this cocklebur set fruit. The total amount of cocklebur litter (mostly burs) remained relatively high at about 500 kg/ha until the fall of 1972, when it dropped to near 350 kg/ha (Table 7). During the growing season of 1972, cocklebur did not achieve any significant growth, even though 1972 was a relatively moist year. It grew a little in late spring, but with the repeated flooding from July to November, it showed little growth. Cocklebur appears to be highly intolerant to flooded conditions. Most of the burs on the ground as litter probably never did germinate. There was still an amount of standing dead stalks of cocklebur remaining in the fall of 1972 (Figure 1).

Bitterweed (*Hymenoxys odorata*) growth characteristics in 1970, 1971 and 1972 are shown in Figure 2. Bitterweed is a winter annual found throughout much of the Southwest. It tends to be weedy, increasing in overgrazed areas, roadsides and wasteplaces. It is poisonous to sheep and requires control measures in areas of local abundance (Dollahite, et al., 1973).

The growth pattern of bitterweed on the playa bottom is quite different than the other species. It establishes basal rosettes in the fall which overwinter in that stage. Then with warm days in the spring, rapid growth can occur as shown in Figure 2 for 1970 and 1972. In 1971 and 1972, bitterweed grew slowly through the winter months, reaching a peak in April. In 1971, it only reached a peak biomass of about 35 kg/ha because the spring was very dry and soil moisture became limiting early in the spring. If moisture is adequate until late in the spring, bitterweed will peak at about twice this amount (70 kg/ha) as it did in 1970 and 1972 in late May and early May, respectively. The amount of reproductive structures produced will amount to about 15 kg/ha. Reprods were not separated from the rest of the plant parts in 1970, but they probably peaked between 10-15 kg/ha as in the other two years. After bitterweed flowers and sets seed in May, the plant dies back. The leaves usually fall off the highly branched plant. The branches will persist as standing dead if they are left relatively undisturbed. However, if the playa is heavily grazed by cattle, as it was in the spring of 1970, the standing dead will be knocked down rapidly as shown in Figure 2. In general, this plant takes advantage of fall and early spring moisture, a strategy not used by the other annuals on the playa bottom.

Pigweed (*Amaranthus palmeri*) is another annual weed which has established on the playa bottom. Again, its introduction can probably be traced to the cattle operations at the college ranch. This weed is widespread throughout the southern plains and the Southwest, occurring in numerous areas including other drainage basins like our playa. We have also noticed it in the arroyos around our site. In and around Las Cruces, it occurs along river banks, irrigation ditches, gardens, and abandoned fields in the valley. Also around our site, other species of pigweed occur, including prostrate pigweed (*A. blitoides*) and pubescent amaranth (*A. pubescens*). These are less common and more typically occur along the edges of the playa bottom. As indicated in Table 7, pigweed reached a peak in biomass in September 1970 at 28 kg/ha. In 1971, pigweed only grew a little with the fall rains but was picked up at about 1 kg/ha in late September. In 1972, it grew intermittently with the flooding of the playa bottom. It peaked in late August, before the flooding on 1 September. The peak biomass at this time would have been about 15 kg/ha although this is strictly a subjective estimate since we didn't get in a sampling date due to the flooding.

Puslane (*Portulaca oleracea*) is a fleshy, prostrate annual which occurs in the wet, open areas on the playa bottom, after significant moisture has occurred. It generally follows the pattern of growth shown by pigweed. These two species generally occupy the same areas on the playa bottom. It peaks in biomass at the same time as pigweed as indicated in Table 7. It hit a peak of about 120 kg/ha in September, 1970, and about 25 kg/ha in September, 1971. It probably reached about 100 kg/ha in late August, 1972, before the September flooding.

Table 7. Biomass in kg/ha for four annual species and their component parts on the playa bottom study area for 1970, 1971 and 1972

es*Part**	2 May 70	30 May 70	30 June 70	17 Aug 70	10 Sept 70	20 Oct 70	10 Dec 70	5 Apr 71	21 May 71	15 July 71	20 Aug 71	25 Sept 71	4 Nov 71	12 Feb 72	15 Apr 72	15 June 72	18 July 72	30 Dec 72
Gr. lv.				6	28	2						1				.03	.6	
Rep.												.1						
St. dd.							4						4	.6	1			
Lt.													1					
Gr. lv.	2	65		.6	3	7	15	31	35			0.4	0.4	16	69	5		
Rep.									12						14	13		
St. dd.		.5	32	3			4	7		9	9	4	6	2		26	35	
Lt.			.3	5					2	6	3	4	2	3	4	9	14	
Gr. lv.				14	117	72						24	3			.2	2	
St. dd.							9							1				2
Lt.							3	2						2		1		
Gr. lv.				65	415	576						22	18			.2		
Rep.					22	309	116	78				9	5	2		1		
St. dd.	.4			.1			323	258	46	75	33	33	23	42	14	48	30	45
Lt.	363	322	376	244	117	79	346	558	348	514	512	541	474	526	464	517	405	356
Rt:																		
0-1 dm				6427	3707	7012		3916										
1-2 dm				1462	2586	2416		2603										
2-3 dm				1370	5711	2242		1029										
Total				9260	12004	11670		7542										

n pa = *Amaranthus palmeris*, Hy od = *Hymenoxys odorata*, Po ol = *Portulaca oleracea*, Xa st = *Xanthium strumarium*

. lv. = Green living, St. dd. = Standing dead, Lt. = Litter, Rep. = Reproductive, Rt. = Roots

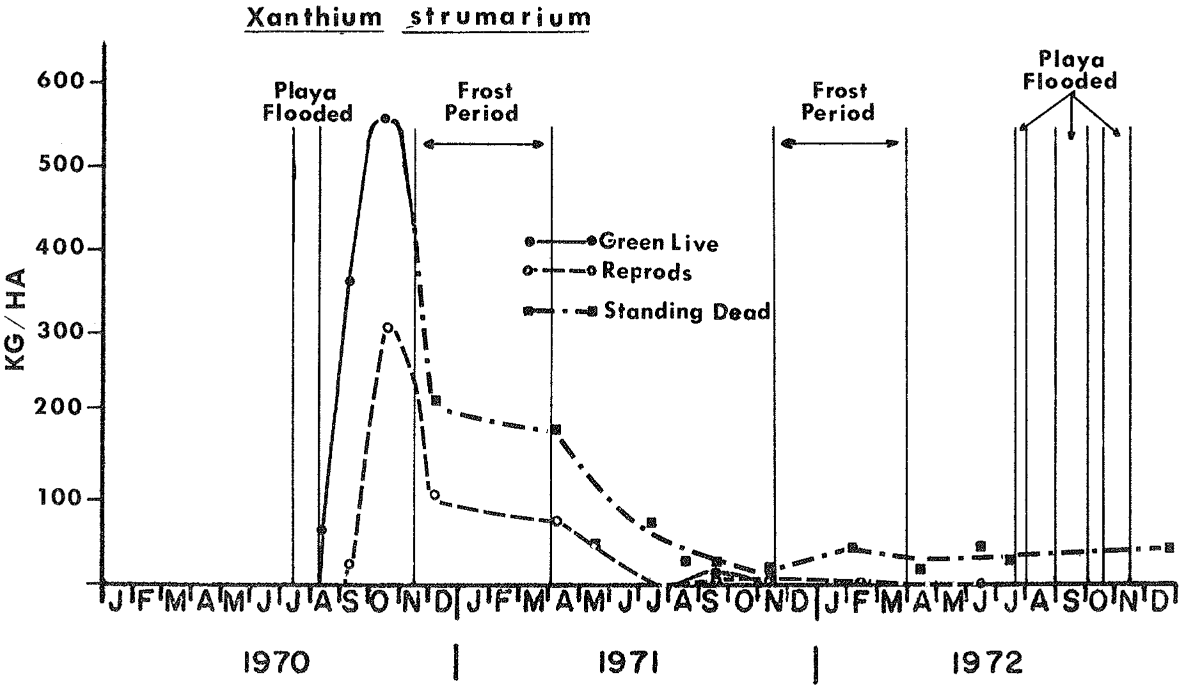

Figure 1. Biomass components of cocklebur (*Xanthium strumarium*) for 1970, 1971 and 1972 on the playa bottom.

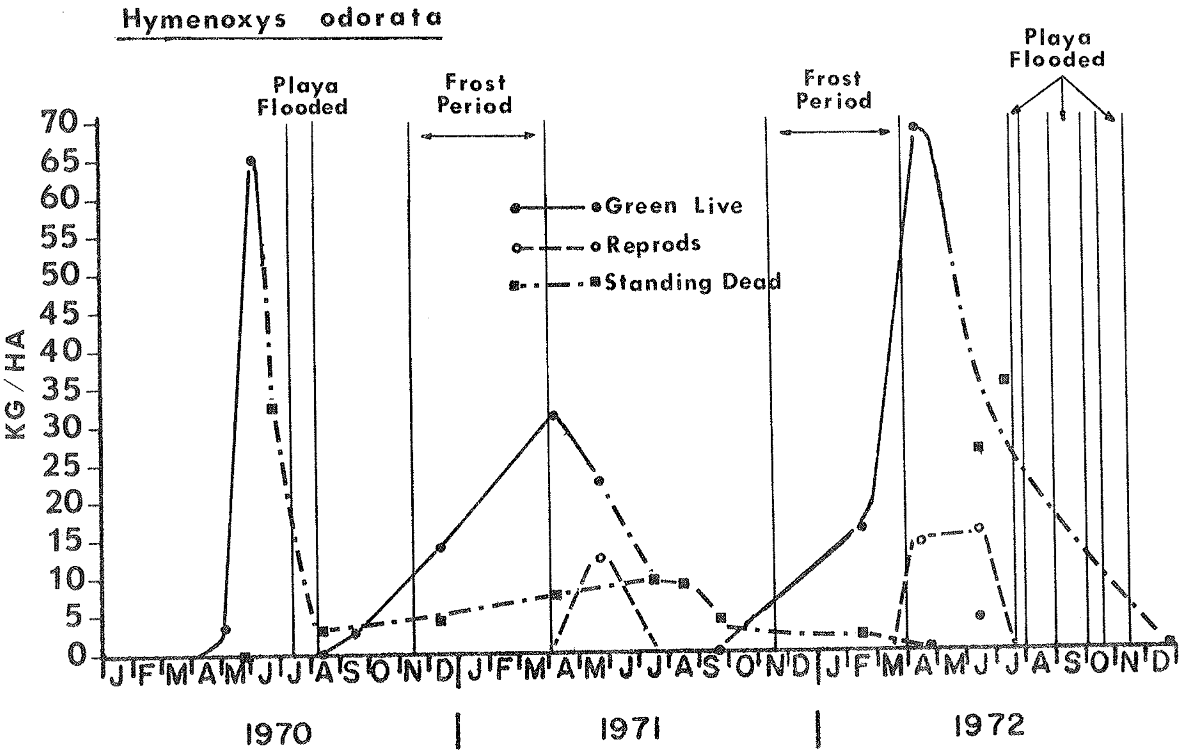

Figure 2. Biomass components of bitterweed (*Hymenoxys odorata*) for 1970, 1971 and 1972 on the playa bottom.

I.B.2 PLAYA PERENNIALS

Small perennials -- playa fringe

The small perennial vegetation was sampled concomitantly with the annual vegetation utilizing quadrats in 1970 and the point centered quarter method in 1971 and 1972, as described previously (I.B.1). See DSCODE A3UWJ54.

Densities of the perennial grasses sampled were calculated from the 1971 and 1972 data. The greatest total density of perennial grasses occurred on the August sampling date (Table 8). *Erioneuron pulchellum* and *Scleropogon brevifolius* were clearly the most prominent perennial grasses on the playa fringe. Both of these grasses exhibited their highest densities in August, 1972. Comparison of the 1971 and 1972 data indicated that *E. pulchellum* and *S. brevifolius* were successful in establishing individuals in 1972.

Biomass estimates for the perennial grasses on the playa fringe indicated this group of plants to have highest summed total biomass in October, 1970 (Table 9). The October, 1972, perennial grass summed total biomass was high, but not as high as August of 1972. The value in October, 1971, was the lowest recorded. In 1972, the greatest summed total biomass (Table 9) corresponded to the highest total density (Table 8). Greatest individual biomass for *E. pulchellum* and *S. brevifolius* in 1972 coincided with their highest densities.

Maximum reproductive biomass of the perennial grasses expressed as percentage of the total biomass apparently occurred in October (Table 10). The October, 1972, values were greater than those of 1971. *Scleropogon brevifolius* appeared to begin producing reproductive structures earlier than *Erioneuron pulchellum* in 1972.

Densities of perennial forbs and sub-shrubs were calculated from the 1971 and 1972 data. Perennial forbs exhibited their greatest total density in October, 1972, whereas the sub-shrubs' greatest total density occurred on the June, 1972, sampling (Table 11). The fluctuations in density of these plants is likely attributable to heterogeneity in the area and seedling initiation and mortality. The highest individual perennial forb density was that of *Perezia nana* on the June, 1972, sampling date. *Calliandra humilis* possessed the greatest sub-shrub density which was in June, 1972. Although the number of perennial forb species was high in October, 1971, their individual densities were not as high as these values in October, 1972, indicating 1972 to have had better growth conditions.

Biomass estimates of perennial forbs and sub-shrubs revealed both of these plant categories to have had the greatest summed total biomass in October, 1972 (Table 12). The perennial forbs exhibited this same October maximum in 1970, whereas in this year, the sub-shrubs possessed greatest biomass in July. Both plant categories had low summed total biomass values in 1971. *Allonia incarnata* exhibited the largest individual total biomass

(Table 12) and this coincided with its greatest density (Table 11). *Perezia nana* had its maximum total biomass on the June, 1972, sampling (Table 12) coinciding with its greatest density (Table 11). *Calliandra humilis* possessed greatest total biomass in October, 1972, which was later than its maximum density in June.

Perennial forbs and sub-shrubs typically exhibited maximum reproductive biomass percentages in October (Table 13). Possible exceptions to this were *Croton pottsii*, *Sida leprosa*, and *Cassia bauhinioides*. *Caccia bauhinioides* appeared to have produced large reproductive biomass percentage in both June and October of 1972.

Table 8. Estimated densities of perennial grasses on the playa fringe at various dates in 1971 and 1972.

Density (no. per hectare)

Species	1971 6 October	1972 27 June	 22 August	 26 October
Aristida purpurea	161	----	----	----
Erioneuron pulchellum	753	2,453	12,784	8,721
Hilaria mutica	538	----	----	----
Muhlenbergia arenacea	161	----	----	----
Muhlenbergia porteri	431	----	----	----
Panicum obtusum	161	----	----	----
Scleropogon brevifolius	1,237	5,525	7,102	4,582
Sporobolus cryptandrus	----	----	----	517
Sporobolus flexuosus	----	----	716	----
Total	3,442	7,978	20,602	13,820

Table 9. Estimated biomass (g per hectare) of perennial grasses on the playa fringe at various dates in 1970, 1971, and 1972.

Species	Plant Component	1970		1971	1972		
		10 Jul.	2 Oct.	6 Oct.	27 Jun.	22 Aug.	26 Oct.
Aristida longiseta	Vegetative	*	----	----	----	----	----
	Reproductive	0	----	----	----	----	----
	Total	15,920	----	----	----	----	----
Aristida purpurea	Vegetative	----	*	270.5	----	----	----
	Reproductive	----	*	14.5	----	----	----
	Total	----	28,640.0	285.0	----	----	----
Erioneuron pulchellum	Vegetative	*	*	52.7	177.8	1,172.3	2,565.0
	Reproductive	0	*	7.5	0	49.8	924.0
	Total	16,740.0	18,110.0	60.2	177.8	1,222.1	3,489.0
Hilaria mutica	Vegetative	*	*	118.4	----	----	----
	Reproductive	0	*	5.4	----	----	----
	Total	7,510.0	6,490.0	123.8	----	----	----
Muhlenbergia arenacea	Vegetative	----	----	8.0	----	----	----
	Reproductive	----	----	1.6	----	----	----
	Total	----	----	9.6	----	----	----
Muhlenbergia porteri	Vegetative	*	*	206.9	----	----	----
	Reproductive	0	*	4.3	----	----	----
	Total	3,480.0	820.0	211.2	----	----	----
Panicum obtusum	Vegetative	----	*	29.0	----	----	----
	Reproductive	----	0	0	----	----	----
	Total	----	210.0	29.0	----	----	----
Scleropogon brevifolius	Vegetative	*	*	358.7	2,400.6	16,462.4	9,265.7
	Reproductive	0	0	12.4	6.1	248.6	1,451.1
	Total	4,710.0	5,180.0	371.1	2,406.7	16,711.0	10,716.8

Table 9. Playa fringe continued

Species	Plant Component	1970 10 Jul.	2 Oct.	1971 6 Oct.	27 Jun.	1972 22 Aug.	26 Oct.
<u>Sporobolus</u> <u>cryptandrus</u>	Vegetative	----	----	----	----	----	294.7
	Reproductive	----	----	----	----	----	15.5
	Total	----	----	----	----	----	310.2
<u>Sporobolus</u> <u>flexuosus</u>	Vegetative	*	----	----	----	1,338.9	----
	Reproductive	0	----	----	----	0	----
	Total	330.0	----	----	----	1,338.9	----
Total	Vegetative	*	*	1,044.2	2,578.4	18,973.6	12,125.4
	Reproductive	0	*	45.7	6.1	298.4	2,390.6
	Total	48,690.0	59,450.0	1,089.9	2,584.5	19,272.0	14,516.0

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 10. Percent of perennial grass biomass in reproductive structures at various dates in 1970, 1971, and 1972 on the playa fringe

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

Species	1970 10 July	2 October	1971 6 October	1972 27 June	22 August	26 October
Aristida longiseta	0	----	----	----	----	----
Aristida purpurea	----	*	5.09	----	----	----
Erioneuron pulchellum	0	*	12.46	0	4.09	26.49
Hilaria mutica	0	*	4.37	----	----	----
Muhlenbergia arenacea	----	----	16.49	----	----	----
Muhlenbergia porteri	0	*	2.04	----	----	----
Panicum obtusum	----	0	0	----	----	----
Scleropogon brevifolius	0	0	3.34	0.25	1.49	13.54
Sporobolus cryptandrus	----	----	----	----	----	5.0
Sporobolus flexuosus	0	----	----	----	0	----

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 11. Estimated densities of perennial forbs on the playa fringe at various dates in 1971 and 1972

Density (no. per hectare)

Species	1971 6 October	1972 27 June	22 August	26 October
Allionia incarnata	54	1,227	----	2,069
Ammocodon chenopodioides	161	1,845	----	517
Astragalus tephrodes	----	----	716	1,035
Bahia absinthifolia	----	----	----	1,035
Cassia bauhinioides	269	618	2,841	1,552
Croton pottsii	325	4,298	716	2,587
Euphorbia albomarginata	108	----	----	517
Perezia nana	108	4,907	1,420	4,582
Sida leprosa	213	1,227	----	1,035
Sphaeralcea subhastata	216	----	----	517
Talinum angustissimum	431	----	1,420	----
Zephyranthes longifolia	54	----	----	----
Total	1,939	14,122	7,113	15,446
Sub-shrub				
Calliandra humilis	54	1,845	1,420	1,035
Zinnia pumila	----	618	----	1,035
Total	54	2,463	1,420	2,070

Table 12. Estimated biomass (g per hectare) of perennial forbs and sub-shrubs on the playa fringe at various dates in 1970, 1971, and 1972

Species	Plant Component	1970 10 Jul.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 26 Oct.
Allionia incarnata	Vegetative	----	----	10.8	79.8	----	26,897.0
	Reproductive	----	----	1.1	0	----	18,497.0
	Total	----	----	11.9	79.8	----	45,394.0
Ammocodon chenopodioides	Vegetative	----	----	41.9	627.3	----	20.7
	Reproductive	----	----	3.2	24.5	----	0
	Total	----	----	45.1	651.8	----	20.7
Asclepias brachystephana	Vegetative	*	----	----	----	----	----
	Reproductive	0	----	----	----	----	----
	Total	320.0	----	----	----	----	----
Astragalus tephrodes	Vegetative	----	----	----	----	186.2	1,387.0
	Reproductive	----	----	----	----	0	0
	Total	----	----	----	----	186.2	1,387.0
Bahia absinthifolia	Vegetative	----	----	----	----	----	176.0
	Reproductive	----	----	----	----	----	0
	Total	----	----	----	----	----	176.0
Cassia bauhinioides	Vegetative	*	*	21.5	828.1	206.0	2,706.0
	Reproductive	0	*	0	247.2	7.1	714.0
	Total	710.0	530.0	21.5	1,075.3	213.1	3,420.0
Croton pottsii	Vegetative	*	*	68.2	7,583.0	1,331.8	3,860.0
	Reproductive	0	*	0	393.0	7.2	0
	Total	270.0	9,210.0	68.2	7,976.0	1,339.0	3,860.0
Euphorbia albomarginata	Vegetative	----	*	20.5	----	----	170.6
	Reproductive	----	*	5.4	----	----	5.2
	Total	----	130.0	25.9	----	----	175.8

Table 12. Playa fringe, continued

Species	Plant Component	1970 10 Jul.	2 Oct.	1971 6 Oct.	1972 27 Jun.	22 Aug.	26 Oct.
Hoffmanseggia densiflora	Vegetative	*	*	----	----	----	----
	Reproductive	0	0	----	----	----	----
	Total	260.0	300.0	----	----	----	----
Perezia nana	Vegetative	*	*	9.7	2,705.2	575.1	1,481.4
	Reproductive	0	0	1.1	92.2	0	0
	Total	80.0	240.0	10.8	2,797.4	575.1	1,481.4
Sida leprosa	Vegetative	----	*	6.4	607.4	----	51.8
	Reproductive	----	0	0	18.4	----	0
	Total	----	230.0	6.4	625.8	----	51.8
Sphaeralcea coccinea	Vegetative	*	*	----	----	----	----
	Reproductive	0	*	----	----	----	----
	Total	700.0	13,550.0	----	----	----	----
Sphaeralcea subhastata	Vegetative	----	----	67.0	----	----	10.3
	Reproductive	----	----	0	----	----	0
	Total	----	----	67.0	----	----	10.3
Talinum angustissimum	Vegetative	----	----	43.1	----	326.6	----
	Reproductive	----	----	4.3	----	21.3	----
	Total	----	----	47.4	----	347.9	----
Zephyranthes longifolia	Vegetative	----	----	31.9	----	----	----
	Reproductive	----	----	0	----	----	----
	Total	----	----	31.9	----	----	----
Total	Vegetative	*	*	321.0	12,430.8	2,625.7	36,760.8
	Reproductive	0	*	15.1	775.3	35.6	19,216.2
	Total	2,340.0	24,190.0	336.1	13,206.1	2,661.3	55,977.0

Table 12. Playa fringe, continued

Sub-shrub	Plant Component	1970 10 Jul.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 26 Oct.
Calliandra humilis	Vegetative	----	*	1.6	412.0	2,314.6	3.850.0
	Reproductive	----	0	0	0	0	0
	Total	----	30.0	1.6	412.0	2,314.6	3,850.0
Gutierrezia sarothrae	Vegetative	*	*	----	----	----	----
	Reproductive	0	0	----	----	----	----
	Total	4,110.0	3,480.0	----	----	----	----
Zinnia pumila	Vegetative	----	----	----	105.1	----	1,459.4
	Reproductive	----	----	----	0	----	56.9
	Total	----	----	----	105.1	----	1,516.3
Total	Vegetative	*	*	1.6	517.1	2,314.6	5,309.4
	Reproductive	0	0	0	0	0	56.9
	Total	4,110.0	3,480.0	1.6	517.1	2,314.6	5,366.3

* These categories were not known due to use of different sampling and recording techniques in 1970.

Table 13. Percent of perennial forb biomass in reproductive structures at various dates in 1970, 1971, and 1972 on the playa fringe

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

Species	1970 10 July	 2 October	1971 6 October	1972 27 June	 22 August	 26 October
Allionia incarnata	----	----	9.24	0	----	40.75
Ammocodon chenopodioides	----	----	7.10	3.76	----	0
Asclepias brachystephana	0	----	----	----	----	----
Astragalus tephrodes	----	----	----	----	0	0
Astragalus wooteni	*	----	----	----	----	----
Bahia absinthifolia	----	----	----	----	----	0
Cassia bauhinioides	0	*	0	22.99	3.33	20.88
Croton pottsii	0	*	0	4.93	0.54	0
Euphorbia albomarginata	----	*	20.85	----	----	2.96
Hoffmanseggia densiflora	0	0	----	----	----	----
Perezia nana	0	0	10.19	3.30	0	0
Sida leprosa	----	0	0	2.94	----	0
Sphaeralcea coccinea	0	*	----	----	----	----
Sphaeralcea subhastata	----	----	0	----	----	0
Talinum angustissimum	----	----	9.07	----	6.12	----
Zephyranthes longifolia	----	----	0	----	----	----
Sub-shrub						
Calliandra humilis	----	0	0	0	0	0
Gutierrezia sarothrae	0	*	----	----	----	----
Zinnia pumila	----	----	----	0	----	3.75

* These categories were not known due to use of different sampling and recording techniques in 1970.

Small perennials--playa bottom

The previous section described the growth of small perennials (forbs and grasses) around the sloping fringe of the playa. The following paragraphs will describe the growth of the major small perennial plants on the level playa bottom and the edges next to the fringe.

Productivity of the small perennial grasses and forbs on the playa bottom was estimated by the harvest method as described in DSCODES A3UWJ51, A3UWJ52 and A3UWJ53. The results for the playa bottom proper for six species and their component parts are shown in Table 14. Of the six species, *Panicum obtusum* contributes the most to the total standing crop of this plant group.

Vine-mesquite grass (*Panicum obtusum*) growth varies sharply with the seasons as shown in Figure 3. In the early spring of each year (March), vine-mesquite grass begins growth at the base of the previous year's culms. Growth is very slow and did not exceed 100 kg/ha in 1970 and 1971, reaching near this value in May. Then in years with dry springs (1970 and 1971), there is a die-back so that by July,there is very little green leaf material (Figure 3). However, in years with relatively moist springs (1972), there will not be a die-back, although growth may be slow if the soils are not very moist as was the case in 1972. If the playa floods in July,as it did in 1970 and 1972, when the playa water recedes, growth is reinitiated and becomes very rapid, for example, in 1970 standing green biomass reached a peak at about 1100 kg/ha by September. The same appeared to be true in 1972 although the playa flooded before our scheduled harvest date. The standing crop at the time of flooding on 1 September 1972 looked about the same as it did at the peak in September, 1970. With the September flooding in 1972 vine-mesquite grass died back to about half its original biomass, although in general it withstood the flooding without total death. There was some regrowth as shown by the estimated line for October, 1972 (Figure 3). Then with the third flooding in late October, there was die-back again, which became standing dead as the playa dried during the late fall of 1972. During the relatively dry summer of 1971, vine-mesquite grass did not show the burst of growth in August. It did have a little growth in September and October with the small rains that occurred; however, the cooler fall temperatures kept the peak biomass to less than 400 kg/ha. Vine-mesquite grass produces considerable amounts of seed In 1970, the seed crop reached a peak of about 85 kg/ha. About the same level appeared to have been reached in 1972. However, in 1971, only about 30 kg/ha of reproductive parts were produced as would be expected from the small amount of total vegetative production for 1971. The data for litter are quite variable due to sampling problems, although trends are evident. The amount of vine-mesquite grass litter on the soil surface can decrease rapidly due to decomposition during and following flooding periods (Table 14). This trend is particularly evident in 1970, when litter biomass went from about 1200 kg/ha in June to about 30 kg/ha in October. The amount of litter can increase rapidly if standing dead material is being knocked down by cattle, as occurred in the spring of 1971. The total amount of litter on the playa bottom was only about 300 kg/ha at the end of 1972, primarily due to rapid decomposition during the three flooding periods of 1972. In general, vine-mesquite grass does very well on the playa bottom. It has the ability to rapidly cover an open area because of its vegetative reproductive mechanism of producing long stolons. It will form almost a complete sod if undamaged by grazing and trampling. Within two enclosures established in 1970 vine-mesquite grass is noticeably more abundant. Within a larger enclosure on the southwest corner of the playa the standing crop is very heavy, indicating the entire playa bottom could potentially have a solid cover of vine-mesquite grass if left undisturbed during one or two good years. However, vine-mesquite grass is called an "ice-cream" plant by the range ecologists (Pieper, 1970). Cattle appear to seek vine-mesquite grass, of which they first graze the seed heads and then later regraze the rest of the plant (Pieper, 1970). They graze the dried herbage as readily as the green. Vine-mesquite grass was found to have the highest yearly average digestability out of six range grasses examined(Hatch et al., 1968). Thus, as a valuable forage grass, the cattle operations on the NMSU college ranch have heavily utilized vine-mesquite, especially during the spring calving.

White-flowered mallow (*Sida leprosa*) productivity for 1970, 1971 and 1972 is tabulated in Table 14. The seasonal shifts in biomass of its above-ground parts are shown in Figure 4. This low, small, perennial herb follows the same general changes as vine-mesquite grass. White-flowered mallow has small amounts of growth in the early spring, usually running about 5 kg/ha during drier springs (1970 and 1971) but up around 20 kg/ha during wetter springs (1972). If May, June and July are dry, then mallow will die back as shown for 1970 and 1971. However, if the summer rains start in June or July, mallow will respond with a burst of growth as shown for 1972. Otherwise, mallow will respond to the typical rains in late July, August or September. If the playa floods, mallow will exhibit a large burst of growth as shown for 1970 when it reached a peak at over 130 kg/ha. If the playa does not flood, as in the summer of 1971, then mallow will probably have only a small amount of growth, assuming some lighter rains. In September, 1971, white-flowered mallow only reached a peak biomass of about 60 kg/ha. Production of flowers and fruits occurs after the plants begin to reach maximum size. Unfortunately, in 1970 the reproductive structures were not separated from the rest of the plant parts but were included with green living biomass. In 1971, with reduced growth at about 60 kg/ha, the reprods made up 5 kg/ha of this growth. In 1972, reprods again were not separated in the July clipping since at this time they only made a small part of the total standing crop. By the later dates, repeated flooding disrupted our clipping schedule and no data were obtained on reprods biomass during September. However, observations indicated mallow peaked in biomass and flowering in late August after the brief late July flooding. Litter data for mallow is very sporadic since it is very difficult to harvest this small, fragile plant. Data are generally an underestimate of true litter biomass, since above-ground biomass during the growing season always exceeded the amount of litter found on the ground following the growing season.

Table 14. Biomass in kg/ha for six perennial species and their component parts on the playa bottom study area for 1970, 1971 and 1972

										DATE									
Species*	Part**	2 May 70	30 May 70	30 June 70	17 Aug 70	10 Sept 70	20 Oct 70	10 Dec 70	5 Apr 71	21 May 71	15 July 71	20 Aug 71	25 Sept 71	4 Nov 71	12 Feb 72	15 Apr 72	15 June 72	18 July 72	30 Dec 72
Cy es	Gr lv.					47	34						3	5				.03	
	St. dd.							29	29	7	2		1		4	.7	.2	.4	1.4
	Lt.							1	13	7	.6	2				.6			
He ci	Gr. lv.	1	1		5	5				.1		.2	.03	8			.5	2	
	St. dd.							4	14						4	3	.8	.2	
	Lt.	8	85					4		2	1	3				.3			
Ho de	Gr. lv.	1	1	1	3	32	36	.2	.4	1	.06	.8	17	16		3	2	10	
	St. dd.							6		.3	2	2			3	.1	.3		8
	Lt.							.3		.4	.2	4			2	.4			
Si le	Gr. lv.	6	5	6	4	133	132	.7	5	5	2	3	62	45		18	21	72	
	Rep.												5						
	St. dd.	.08						44	22	5			3		9	4	2	.7	8
	Lt.	1		.03	1			19	6	6	5		3	.8	2			.3	
So el	Gr. lv.		3		6	6	.6			.1		1	.6				.5	8	
	St dd.			5					.9										
	Lt.		.3				.4		2	2	1		3						2
Pa ob	Gr. lv.	94	52	41	252	1175	796		26	53	9	17	259	314		52	105	140	
	Rep.				20	76	85	80	62	6	7		32	4	5	2	.1		14
	St. dd.	377	169	186	15	9		779	612	190	118	73	48	4	223	109	155	104	757
	Lt.	1128	1094	1170	922	269	34	530	514	548	1195	615	412	823	516	732	620	400	306
	Rt:																		
	0-1 dm	8399		7888	9809	12765	12216		9476			11288							
	1-2 dm	2060		1701	3564	3553	6126		5042			3716							
	2-3 dm	--		1746	2363	2077	4539		1552			1940							
	total	10459		11335	15736	18394	22881		16070			16944							

* Cy es = *Cyperus esculentus*, He ci = *Helianthus ciliaris*, Ho de = *Hoffmanseggia densiflora*, Si le = *Sida leprosa*, So el = *Solanum elaegnifolium*, Pa ob = *Panicum obtusum*

** Gr. lv. = Green living, St. dd. = Standing dead, Lt. = Litter, Rep. = Reproductive, Rt. = Roots

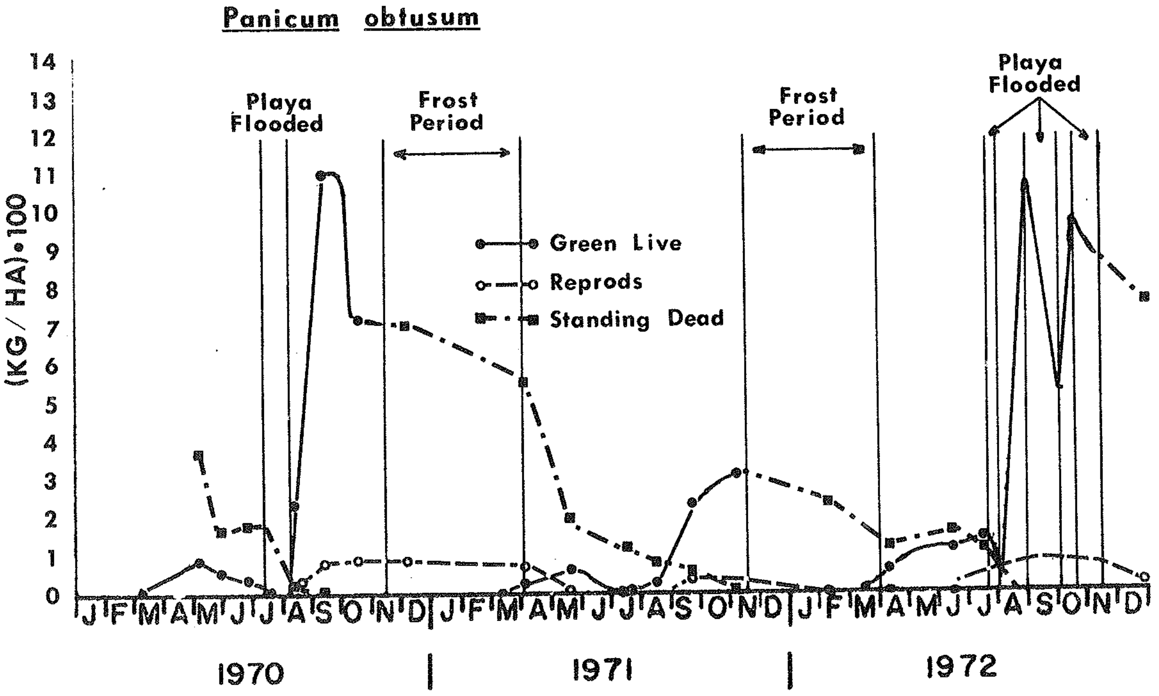

Figure 3. Biomass components of vine-mesquite grass (*Panicum obtusum*) for 1970, 1971 and 1972 on the playa bottom.

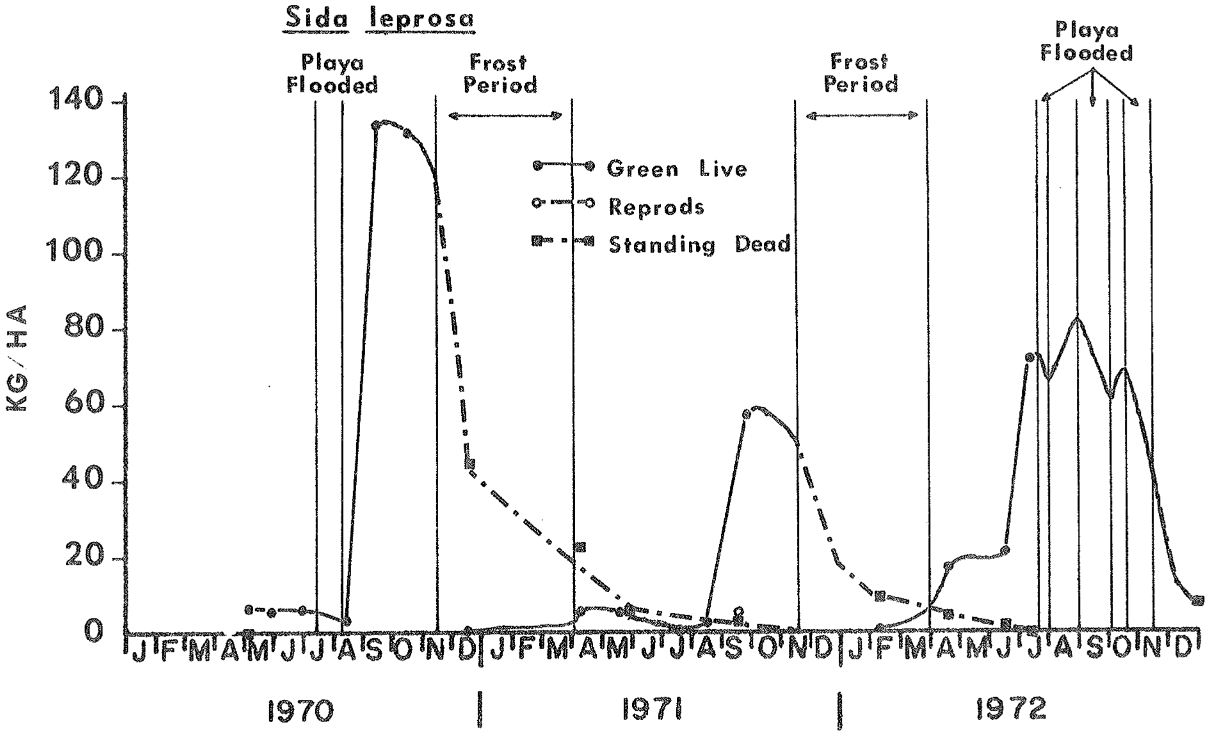

Figure 4. Biomass components of white-flowered mallow (*Sida leprosa*) for 1970, 1971 and 1972 on the playa bottom.

Yellow nut grass (*Cyperus esculentus*) production trends for 1970, 1971 and 1972 are shown in Figure 5. This small, sedge-like plant is scattered around in patches on the playa bottom, being intermingled with vine-mesquite grass. Yellow nut grass is perennial by an underground rhizomatous rootstock. It is a common weed in bermuda grass lawns throughout the southwest urban areas. It is difficult to eradicate and is the topic of considerable research by weed scientists. For a recent treatment, consult a paper by Stoller and Wax (1973). Yellow nut grass grew rapidly after the playa flooded in July, 1970, reaching a peak biomass of about 50 kg/ha. About 30 kg/ha of this persisted as standing dead during the winter and spring of 1971. Standing dead was reduced to less than 10 kg/ha with the trampling of cattle, which grazed the playa heavily in the spring of 1971. The dry summer of 1971 only allowed a small amount of growth in September and October, when a few small rains occurred. The total biomass was only about 6 kg/ha. The standing dead persisted until about April, 1972, when it was less than 1 kg/ha. Yellow nut grass did not have a great amount of growth during the wet summer of 1972 as evidenced by the low amount of standing dead in December at about 2 kg/ha. It did not appear to be favored by the repeated flooding. The spreading and general success of vine-mesquite grass may also partially account for its low success in 1972. Also of interest is the extremely low frequency of spike production on the species. We had to search diligently in 1970 when it was the most abundant in order to find fruit heads for identification of the species. The litter data for yellow nut grass shown in Table 14 are also highly variable, primarily because the litter of this grass-like plant is extremely difficult to separate from the litter of vine-mesquite grass. The amounts of litter shown are always an underestimate of what must have to be there after the growing season based on above-ground biomass data.

Indian rushpea (*Hoffmanseggia densiflora*) biomass changes for 1970, 1971 and 1972 are shown in Figure 6. This small perennial herb follows the same general trends as vine-mesquite grass and white-flowered mallow. It will grow a little in the spring if there is some soil moisture, but when the soil dries as it typically does in April, May and June, it will die back. This trend was evident in all three years, even in 1972 which had some rain in June. In September, 1970, rushpea reached a peak biomass of about 35 kg/ha in response to the rains which flooded the playa in late July. Then it died back with the frost in November, 1970. This low-growing perennial is fairly frost tolerant and a small amount of green living material was found in December, 1970. This increased to a small peak of 1 kg/ha in May 1971, but then died back with the very dry conditions in the late spring of 1971. It responded to the small rain showers in September when it peaked at about 20 kg/ha and persisted at this level until the November frosts. In 1972, rushpea again had the typical early spring growth, but then died back somewhat until the small rains in June and July revived its growth. After the playa flooded for the first time in late July, rushpea was observed to have a rapid growth. Although the peak is not known for sure, it is estimated to be around the same level as for 1970 (Figure 6.) It appeared to go through a die-back and regrowth phase with the second flooding of the playa in September, 1972. The amount of standing dead rushpea in December, 1972, was a little higher than that found in December, 1970, which might indicate that the peaks shown in August and October may be slightly underestimated. The standing dead material of rushpea is very fragile, as indicated by the rapid drop in standing dead biomass relative to the peaks of standing live biomass which precedes it. The small, glaucous pinnate leaves drop off soon after the first hard frost. Again, the litter data for rushpea are highly variable and underestimated like the previously-mentioned herbaceous species, since once the plant material is on the ground it becomes very difficult to collect adequately. Comparing the years, it is evident that 1971 was a low production year due to the very dry spring and the small, scattered rains in late summer as shown for rushpea (Figure 6.)

Blueweed (*Helianthus ciliaris*) occurs in the lowest areas on the playa bottom, i.e., where the water persists for the longest time after flooding. Being patchy and not very widespread over the playa bottom, blueweed never reaches a very high amount of standing crop biomass; usually less than 10 kg/ha. Its growth trends are indicated by the data for this species in Table 14. Blueweed will also exhibit some early spring growth with subsequent die-back if conditions get dry. Then, when soil moisture is recharged either by flooding or small rains of insufficient size to flood the playa, blueweed will respond with growth and subsequent flower and fruit production. The peak of flowering appears to be later in the summer for this member of the sunflowers, thus this response may be controlled by photoperiod. Blueweed is a common irrigation ditch bank weed in Las Cruces and occurs in wet areas in the southwest.

Bull nettle (*Solanum elaeagnifolium*) is another plant which is very successful in disturbed urban areas and in some areas on our playa site. Bull nettle is very common in vacant lots around Las Cruces. Like blueweed, it is very spotty on the playa bottom and never makes up much of the standing crop. Its growth trends are very similar to those for blueweed, which is evident by comparing the data for the two species in Table 14. Bull nettle will also exhibit early spring growth, but not grow rapidly until the major summer rains, if and when they occur. Comparing years, bull nettle peaked at about 6 and 8 kg/ha in 1970 and 1972, respectively. However, in 1971 it only obtained a standing crop of about 1 kg/ha in August and September. Thus bull nettle also shows that 1971 was a low production year on the playa bottom.

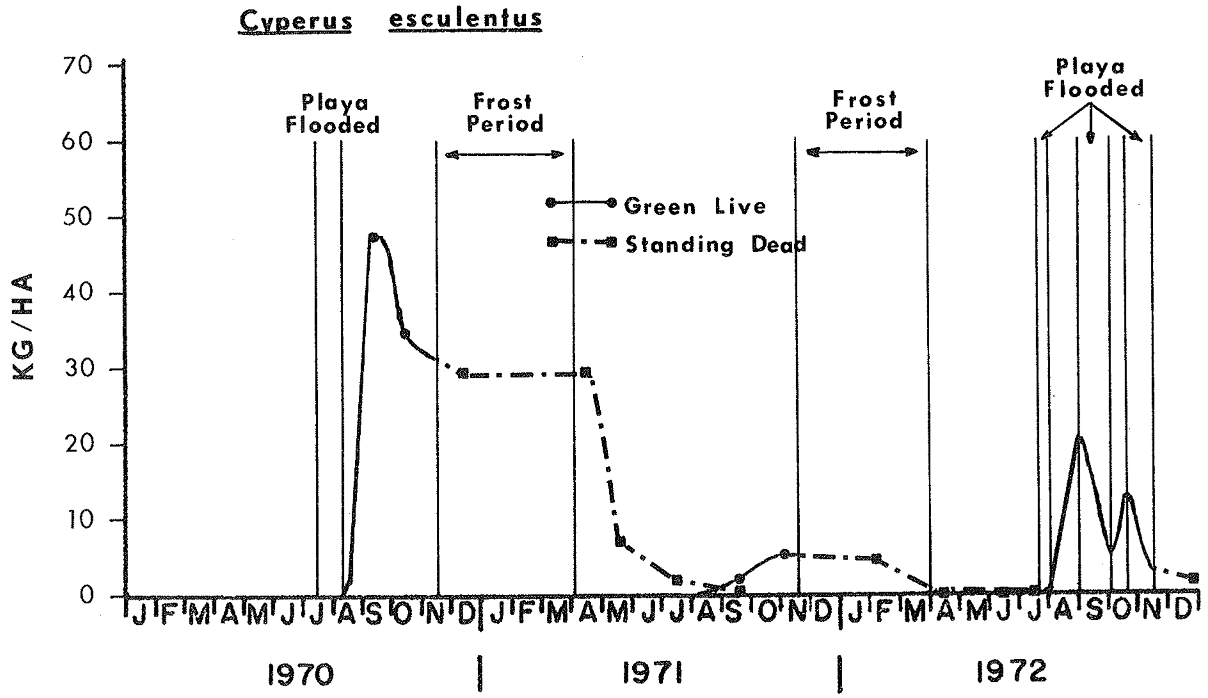

Figure 5. Biomass components of yellow nut grass (*Cyperus esculentus*) for 1970, 1971 and 1972 on the playa bottom.

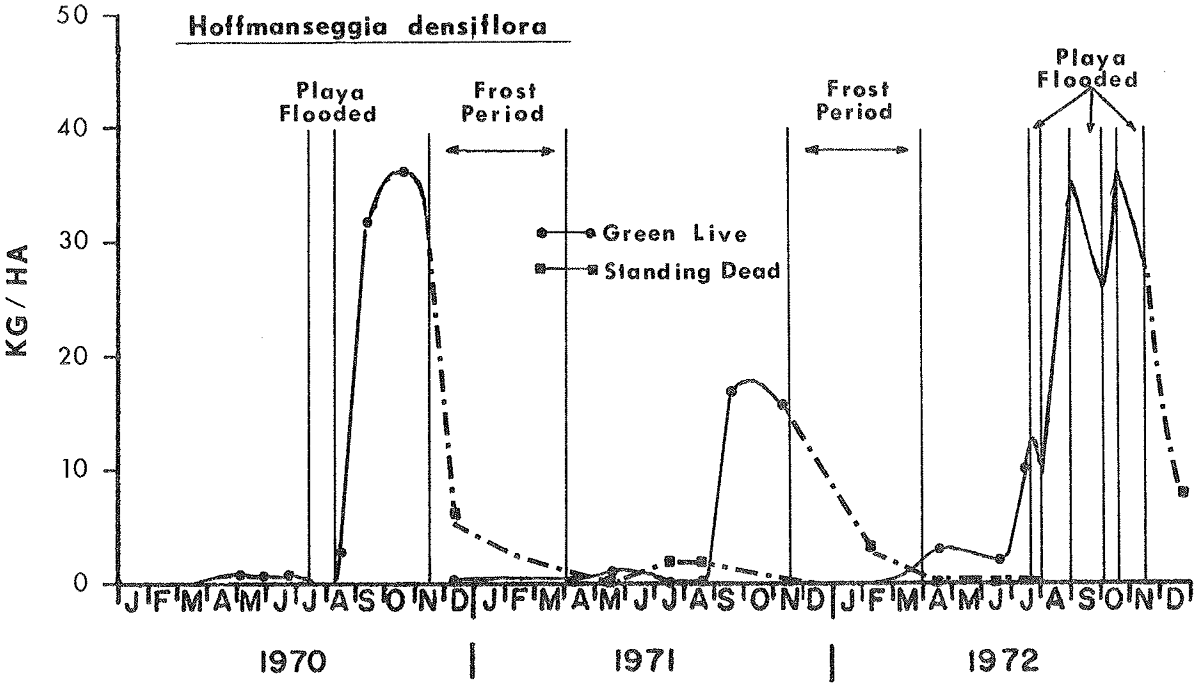

Figure 6. Biomass components of indian rushpea (*Hoffmanseggia densiflora*) for 1970, 1971 and 1972 on the playa bottom.

Small perennials -- playa edge

In the preceding sections, the growth of those small perennial grasses and forbs which occur on the playa fringe and playa bottom proper was described. On the west and east edges of the playa bottom there are areas dominated by tobosa grass. These areas exist where additional water enters the playa basin during periods of runoff. The soils in these edge areas are sandy clay loams rather than the clays which characterize the playa bottom proper. The following paragraphs will describe the grasses and forbs which characterize these areas. The data are shown in Table 15. Of the four species listed, tobosa (*Hilaria mutica*) and false mesquite (*Calliandra humilis*) make up most of the standing crop. Vine-mesquite grass (*Panicum ostusum*) and bull nettle occasionally are picked up in random quadrats clipped on the playa edges, but it is evident that these data are highly sporadic due to these chance occurrences. Thus, these last two species will not be described again here since they are more typical of the playa bottom proper. Data collection methods are described in DSCODES A3UWJ51, A3UWJ52 and A3UWJ53.

Tobosa grass (*Hilaria mutica*) growth trends for 1970, 1971 and 1972 are shown in Figure 7. This big, coarse bunchgrass will grow rapidly if there is good soil moisture, e.g. following a flooding of the playa. Since it occurs on the edges of the playa where the water recedes sooner than on the bottom, tobosa will begin growth before vine-mesquite. An interesting characteristic of the growth of tobosa is the rapid turnover from green living to standing dead so that certain parts of this bunchgrass will be standing dead while other parts are still growing towards maturity. This phenomenon is evident by observing that the level of standing dead biomass is increasing while the level of green live leaves is still rapidly increasing (Figure 7). This contrasts sharply with vine-mesquite grass which will phase from standing live to standing dead in a continuous manner (Figure 3). A small amount of green material persists during the winter at the base of the large clumps. The amount of green biomass generally increases in early spring as temperatures warm, but this may die back during the late spring if conditions are dry. Tobosa can rapidly reach a peak biomass of over 500 kg/ha if moisture conditions and temperature regimes are near optimum. This rapid growth is evident for all three years (Figure 7), with the peaks of standing dead following behind those for standing live. The production of seed follows shortly after a period of rapid growth. The seeds are easily scattered once ripened. Our estimate of spike inflorescence biomass at 175 kg/ha in September, 1970, is probably slightly underestimated due to this sampling problem. The same holds for the other sampling dates. The data on litter are quite variable due to sampling problems, redistribution and decomposition. The same is true for the root data, which are still incomplete due to the lag time in obtaining these data. It is clear that the bulk of the root biomass is in the top 10 cm (Table 15). Additional data are needed before anything can be said about possible seasonal patterns in root biomass. Tobosa is an important range grass in southern New Mexico. It occurs most typically in lower areas (swales) with finer textured soils. It also appears to increase in areas heavily grazed. Because of its importance, it has received considerable attention from the range scientists. Its value as a forage grass has been the topic of a number of range science theses (Kiesling, 1968; Boggino, 1970; De La Torre, 1970). In a study examining greenhouse productivity and water use efficiency of tobosa along with other grasses and shrubs, Dwyer and DeGarmo (1970) found that shoot and root production decreased rapidly as soil moisture level decreased. The production dropped to about one-fourth field capacity. They also found that tobosa produced short, leafy culms which tended to tiller at higher moisture levels.

False mesquite (*Calliandra humilis*) production on the playa edge shows the same basic trends as tobosa (Figure 8). It will grow rapidly after the playa floods, given warm temperatures as in 1970 and 1972. False mesquite reached a peak biomass of about 600 kg/ha in September, 1970, and probably approached this level by September, 1972, although no harvest data are available to confirm this impression. In 1971, growth only reached about 75 kg/ha again reflecting the environmental and productivity differences shown by this extreme year. False mesquite strongly resembles seedlings of mesquite (*Prosopis glandulosa* var. *torreyana*) as its name implies. False mesquite is perennial by a large, woody underground rootstock and is known to have deep roots. This corresponds to its occurrence in the playa edge where the sandy clay loam soils are deep, whereas the playa bottom clay soils form a hardpan at about 30 cm.

Table 15. Biomass in kg/ha for four perennial species and their component parts on the playa edge study area for 1970, 1971 and 1972

		DATE															
Species*	Part**	2 May 70	30 June 70	10 Aug 70	5 Sept 70	22 Oct 70	8 Dec 70	5 Apr 71	15 July 71	20 Aug 71	25 Sept 71	4 Nov 71	19 Feb 72	20 Apr 72	15 June 72	18 July 72	30 Dec 72
Ca hu	Gr. lv.			60	576	17				13	91				1	10	
	St. dd.						73	32									3
	Lt.							34	88	13			6				
Hi mu	Gr. lv.	147	63	1159	2330	1863	488	51	76	16	1472	5719	96	268	347	1218	13
	Rep.			34	176	4					19	53			.4		1.4
	St. dd.	3835	3881	478	2372	1875	2649	5619	4981	2792	2152	991	4594	196	6667	6274	3734
	Lt.	2114	4563	560	3023	1841	1562	3199	4157	3325	2027	3548	2307	431	1672	1892	2734
	Rt:																
	0-1 dm	11034	5920	16591		8869		7521		6746							
	1-2 dm	1853	1681	3020		8876		4258		1390							
	2-3 dm	--	1307	2025		6072		562		1315							
	total	12888	8988	21636		23717		12340		9450							
Pa ob	Gr. lv.				364						1						
	Rep.				34		29										6.5
	St. dd.				10		289		1								82
	Lt.				45		43										
So el	Gr. lv.					61				89					9		
	St. dd.						25	36	255	113							
	Lt.	148							6	298	109	209					

* Ca hu = <u>Calliandra humilis</u>, Hi mu = <u>Hilaria mutica</u>, Pa ob = <u>Panicum obtusum</u>, So el = <u>Solanum elaegnifolium</u>

** Gr. lv. = Green living, St. dd. = Standing dead, Lt. = Litter, Rep. = Reproductive, Rt. = Roots

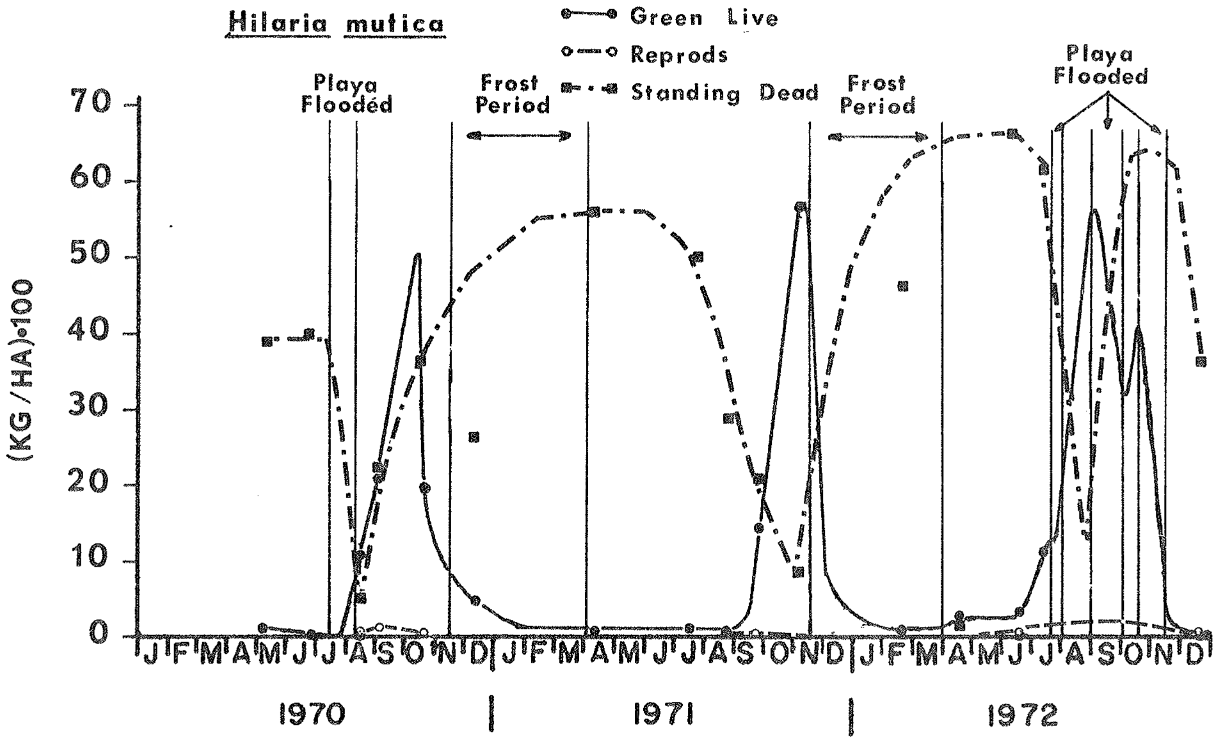

Figure 7. Biomass components of tobosa (*Hilaria mutica*) for 1970, 1971 and 1972 on the playa edge.

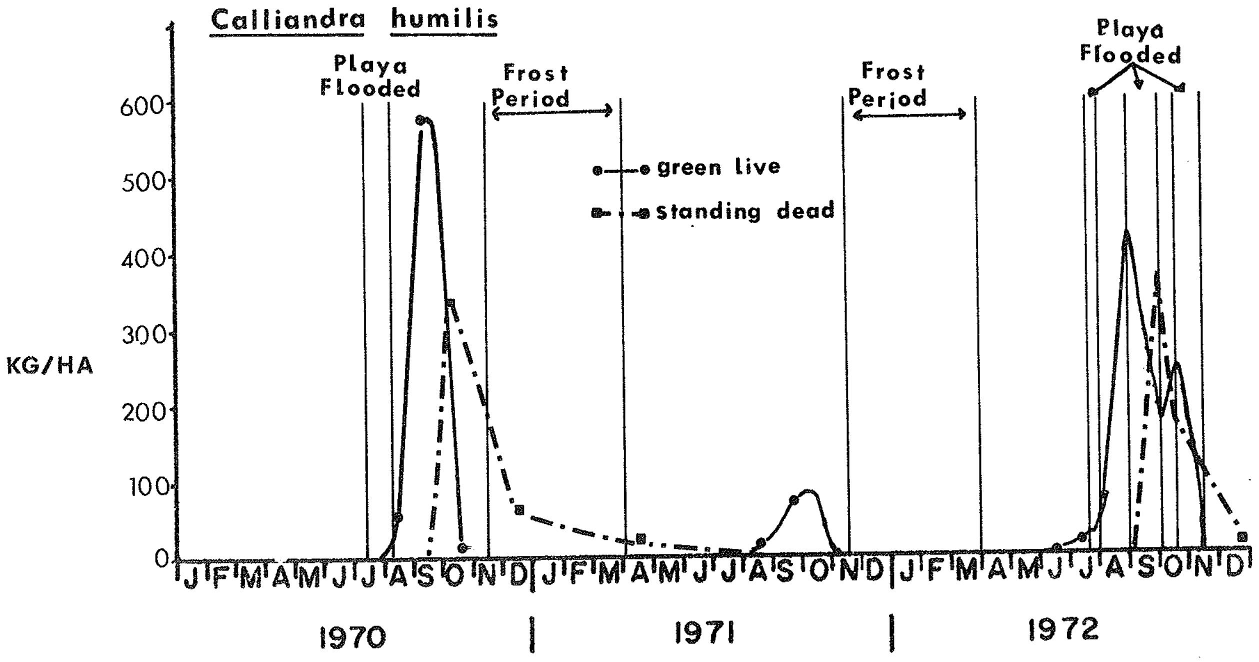

Figure 8. Biomass components of false mesquite (*Calliandra humilis*) for 1970, 1971 and 1972 on the playa edge.

Large perennials--playa fringe

In the previous sections under the headings of small perennials (grasses and forbs) on the playa fringe, bottom and edge, the biomass components of the major species that fit in these categories were described. The following paragraphs will describe the biomass components and changes in these components of the major large perennials that occur on the playa fringe. Before describing each individual species, a general description of the vegetation around the playa is needed. This descriptive data will include initial biomass and cover estimates which will be needed by any simulation model of this system as starting conditions. (Data collection methods are described in DSCODE A3UWJ55)

The vegetation around the playa varies from areas of dense mesquite to relatively open shrub-grassland. In the spring of 1970, studies were undertaken to estimate the initial composition and characteristics of this vegetation. Since the total area of a 100 m band around the playa bottom was estimated at 16.7 ha, a total count was impractical. Forty 5 m by 100 m belts were randomly positioned around the fringe in a stratified orientation to the cardinal compass directions, i.e., ten belts each in the N, E, S, and W directions. Each 100 m long belt was sectioned into five 20 m lengths; thus each section was 5 m by 20 m or 100 m^2. In each section of each belt the number and size dimensions (canopy height and width) of each species were recorded. From these measures the density, canopy cover and canopy volume were calculated for each species. The average values for these measures and calculations for six of the species around the playa fringe are shown in Table 16. Mesquite (*Prosopis glandulosa* var. *torreyana*) is the most dominant species, based on its density (480 ind./ha), canopy ground cover (14.6%), canopy silhouette area (68 dm^2/ind.) and canopy volume (3.6 m^3/ind.). The next most characteristic species is long-leafed mormon tea (*Ephedra trifurca*), based on its density (412 ind./ha), canopy ground cover (3.1%) and canopy volume (0.4m^3/ind.). All the other species have less than 1% ground cover. Snakeweed* (*Xanthocephalum sarothrae*) has the highest density (586 ind./ha) but since it is a smaller plant (0.03 m^3/ind.) its ground cover is small (0.64%). Soap-tree yucca (*Yucca elata*) is a very conspicuous plant due to its striking growth form, yet only contributes 0.25% ground cover. However, soap-tree yucca is ecologically important as a nesting site for birds (see section I.D.2). Thus the characteristics of the plant species given (Table 16) only indirectly indicate their ecological importance to other taxa, and other characteristics, such as growth form, may be of greater significance in some species.

Biomass components for these species can be estimated using the size characteristics for each species. For each species, off-site destructive sampling was used to obtain regression equations relating biomass (by plant part) to canopy ground cover and canopy volume. The biomass estimation equations for mesquite, mormon-tea, snakeweed and soap-tree yucca are

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*Data for snakeweed include some measurements on *Xanthocephalum microcephala*, a species very similar to *X. sarothrae* except for smaller inflorescences.

given in Table 17. Numerous regression models were explored in order to obtain a good estimation while retaining the simplest relationship possible. Models using various transformations of the data were explored. However, in almost all cases, a linear or second order term in the independent variables (cover and volume) resulted in the simplest equation with the best fit to the observed data. The lack of fit of a particular model was based primarily on plots of observed and expected against the independent variables and on plots of residuals. The usual coefficients of determination (r^2) and standard errors were of little value due to small sample sizes and the use of regression models without an intercept term. The zero-intercept models are reasonable in that zero cover or volume must equal zero biomass. The intercept models explored had very small intercept terms (as expected) and were omitted as they added little to the estimation power of the equations. The results of the biomass estimations using these equations are shown in Table 18. For each species and its component part, the estimated amount of biomass existing on the playa fringe in June, 1970, is given. Mesquite (*Prosopis glandulosa* var. *torreyana*) has the greatest standing crop at 4950 kg/ha. This is roughly split between live woody stems and dead woody stems, with leaves contributing about 140 kg/ha to the total above-ground standing crop biomass. Total below-ground biomass is roughly about 3800 kg/ha, which includes the taproot to a depth of about 2 m and the long lateral roots over 0.5 cm diameter. This is probably about a 10% underestimate of the true root biomass during the growing season but may be closer during the non-growing season when the fine roots die back. Soap-tree yucca has the second greatest total above-ground standing crop at about 1000 kg/ha. However, most of this biomass is due to the massive caudex which characterizes this species. Also, a considerable amount of dead leaves will persist on the larger caudexes, averaging about 275 kg/ha. The green leaves contribute about 25 kg/ha to the standing crop of soap-tree yucca. Long-leafed mormon-tea (*Ephedra trifurca*) has the third greatest standing crop biomass at 433 kg/ha. The older woody stems contribute the most to this total at about 215 kg/ha. The younger green stems make up about 170 kg/ha, which is the greatest total amount of green tissue of all the species on the site. However, this tissue is relatively hard and probably has a low photosynthetic rate on a leaf weight basis, although this needs to be tested. The standing dead branches contribute about 50 kg/ha to the total above-ground biomass. Total below-ground biomass is about 130 kg/ha. Snakeweed (*Xanthocephalum sarothrae*) was the most dense species on the playa fringe as noted earlier. As a sub-shrub, it does not maintain a large quantity of standing crop biomass at most times; about 35 kg/ha on the average in June, 1970. About half of this is green leafy material, but this will vary with the season, peaking higher after early growth, but less when the older tissue lignifies. This sub-shrub also has a low root-to-shoot ratio. The other three species shown in Table 18 contribute less to the total standing crop on the playa fringe. They rank from creosote-bush (*Larrea divaricata*) at about 17 kg/ha, to Torrey's mormon tea (*Ephedra torreyana*) at 9 kg/ha, to four-winged saltbush (*Atriplex canescens*) at only 1 kg/ha. Of these latter three species, only creosote-bush is being monitored for continuous growth patterns, primarily for a comparison with the bajada site, which is characterized by this species.

Table 16. Vegetation characteristics for the major shrub species on the playa site for June 1970[†]

Species	Density (ind/ha)	Height (m/ind)	Width (m/ind)	L.L.	Ground Cover $ ($m^2/100m^2$-%)	U.L.	Silhouette (dm^2/ind)	Volume (m^3/ind)
Prosopis glandulosa	494	.66	1.35	12.4	15.3	18.2	70 *	3.6 *
Ephedra trifurca	417	.59	.84	2.7	3.2	3.6	39 *	.40*
Ephedra torreyana	154	.21	.39	.16	.26	.35	6.4*	.02*
Xanthocephalum sarothrae	586	.27	.34	.55	.66	.77	7.2*	.03*
Larrea divaricata	20	.67	.77	.03	.11	.20	25 ¢	.14¢
Yucca elata - leaves	152	.42	.27	.18	.24	.29	5.7¢	.03¢
Atriplex canescens	2	.74	.82		.01		48 *	.41*

* upper half of spheroid
¢ cone
$ mean per cent ground cover with upper (U.L.) and lower (L.L.) 95% Confidence limits

[†] The number of individuals per 100 m^2 section of each belt were used to calculate the mean density. The size dimensions of the canopy of each individual were used to calculate mean height, width, ground cover, silhouette area and volume of the canopies for each species. The area and volume calculations for the canopies of each species use the formulae which seem to best fit their natural shapes.

Table 17. Estimation equations for biomass (B) of large perennials on the playa by their component parts based on canopy ground cover (A) and canopy volume (V)

Species	Component	Equation based on Canopy Area (A)	Equation based on Canopy Volume (V)
Prosopis glandulosa var. torreyana (11)*	Leaves	$B = 2.7 + 59.7A + 3.8A^2$	$B = 79.1V$
	Live Stems	$B = 93.6 + 136.2A^2$	$B = 1385.8V$
	Dead Stems	$B = 138.8A^2$	$B = 1313.1V$
	Total Above Grnd	$B = 286.7A^2$	$B = 2778.0V$
	Total Below Grnd	$B = 220.2A^2$	$B = 2130.5V$
Ephedra trifurca (10)	Green Stems	$B = 888.3A - 65.1A^2$	$B = 1239.1V - 160.2V^2$
	Corky Stems	$B = 1220.9A - 180.7A^2$	$B = 1798.5V - 373.7V^2$
	Dead Stems	$B = 129.0A + 56.1A^2$	$B = 211.0V + 53.3V^2$
	Total Above Grnd	$B = 2238.3A - 189.8A^2$	$B = 3248.6V - 480.6V^2$
	Total Below Grnd	$B = 664.0A$	$B = 779.8V$
Ephedra torreyana (10)	Green Stems		$B = 1335.7V$
	Corky Stems		$B = 1056.6V$
	Total Above Grnd		$B = 2392.3V$
	Total Below Grnd		$B = 2251.5V$
Xanthocephalum sarothrae (15)	Leaves		$B = 961.5V$
	Stems		$B = 1251.4V$
	Total Above Grnd		$B = 2212.8V$
	Total Below Grnd		$B = 460.0V$
Yucca elata (10)	Green Leaves		$B = 6218.5V$#
	Dead Leaves		$B = 208750.0V$¢
	Caudex		$B = 545850.0V$¢
	Tuber		$B = 866720.0V + 205.7 \times 10^5 V^2$
Atriplex canescens (3)	Leaves	$B = 150.6A$	$B = 141.6V$
	Live Stems	$B = 1189.6A$	$B = 1117.9V$
	Dead Stems	$B = 526.6A$	$B = 493.8V$
	Total Above Grnd	$B = 1866.8A$	$B = 1753.4V$
	Total Below Grnd	$B = 800.8A$	$B = 752.1V$

based on leaf volume
¢ based on caudex volume
* number of plants used in determining coefficients in the equations

Table 18. Biomass estimates for large perennials on the playa fringe for June 1970 (Estimates based on equations given in Table 17)

Species	Component	Biomass (kg/ha)* L.L.	mean	U.L.	Estimated by Equation
Prosopis glandulosa var *torreyana*	Leaves		141		V
	Live Stems		2470		V
	Dead Stems		2340		V
	Total Above Grnd	3620	4950	6280	V
	Total Below Grnd		3790		V
Ephedra trifurca	Green Stems		170		V
	Corky Stems		216		V
	Dead Stems		48		V
	Total Above Grnd	373	433	494	V
	Total Below Grnd		129		V
Ephedra torreyana	Green Stems		5.1		V
	Corky Stems		4.1		V
	Total Above Grnd	6.2	9.2	12.2	V
	Total Below Grnd		8.6		V
Xanthocephalum sarothrae	Leaves		15		V
	Stems		20		V
	Total Above Grnd	28	35	42	V
	Total Below Grnd		7		V
Yucca elata	Green Leaves		26		V
	Caudex		710		V
	Dead Leaves		272		V
	Total Above Grnd	714	1008	1301	V
	Tuber		1750		V
Atriplex canescens	Leaves		.2		A
	Live Stems		1.7		A
	Dead Stems		.8		A
	Total Above Grnd		2.7		A
	Total Below Grnd		1.2		A
Larrea divaricata	Leaves		1		V
	Live Stems		10		V
	Dead Stems		6		V
	Total Above Grnd	3	17	31	V
	Total Below Grnd		8		V

* Means are based on the biomass within each 100m^2 section of each belt. The lower (L.L.) and upper (U.L.) 95% confidence limits are based on the variation in biomass between sections of the belt transects.

V = biomass estimate based on volume equations in Table 17.

A = biomass estimate based on area equations in Table 17.

Playa fringe perennial: *Yucca elata*

Incremental leaf production of eight *Yucca elata* shrubs on the playa fringe was monitored during 1971 and 1972. The method used was to record the number and mean length of new leaves added to the canopy from the central apex. In addition, the number and mean length of canopy leaves becoming standing dead were recorded. From a size series of living and standing dead leaves, regression equations were derived to estimate leaf biomass (Figs. 9 and 10). The standing dead leaves were harvested and weighed, allowing comparison of the actual weights to those estimated from the regression equation.

Further growth dynamics of *Y. elata* were studied utilizing the belt transect data described above as initial values for density, leaf volume and total above-ground biomass. Estimations of leaf volume from leaf biomass data, and caudex and standing dead leaf biomass from leaf volume estimates were calculated on a monthly basis using regression equations derived from a size series of *Y. elata* plants. Total above-ground biomass was estimated as the sum of calculated living leaf and caudex biomass. Phenological comments are based on cursory field observations.

On the playa, *Y. elata* appeared to annually exhibit three bursts of new leaf production, one in early spring (March-May), one in late smmmer (July-September), and one in mid-winter (December) (Fig. 11). The late summer burst of new leaf production was consistently of greater magnitude, followed in order of magnitude by the early spring and December bursts. The bursts of new leaf production were usually followed in time by a burst of new standing dead leaf biomass, suggesting a translocation of materials from the old leaves into the new. The exceptions to this trend occurred at the December bursts of both 1971 and 1972, and the late summer burst of 1972. These exceptions may be due to increased moisture availability at these times, allowing adequate mineral uptake from the soil. The actual standing dead leaf biomass was reasonably close to the values obtained from the regression equation (Fig. 12).

Yucca elata net living leaf biomass on the playa site increased only slightly during 1971, but exhibited a marked increase during the latter part of 1972 (Fig. 13) This variation probably reflected the increased moisture availability in 1972. *Yucca elata* caudex biomass as estimated naturally follows the trends of leaf biomass (Fig. 14). It has not been established that the caudex indeed has this growth correlation to leaf growth. More detailed caudex measurements are desirable. Total above-ground biomass presented (Fig. 15) has the same pattern as the caudex biomass, which is also related to the method of estimating the components.

Yucca elata began flowering as early as April and mature fruits were developed by June. Peduncles attained a mean height of about 200 cm. Of 100 individuals observed on the playa in 1972, 19 flowered, but 11 of these inflorescences were chewed off by cattle before they matured and regrowth did not occur. It was apparent that cattle may have a marked effect on the reproductive capacity of *Y. elata*.

Based on observations made on one mature inflorescence 160 cm tall, only 21.8% of the potential flowering sites produced flowers and of these only 62.8% produced mature fruit. The large number of seeds produced per fruit should, however, compensate for the low percentage of fruit production. These seeds germinate readily in the laboratory, thus the absence or low frequency of *Y. elata* seedlings must be due to environmental factors.

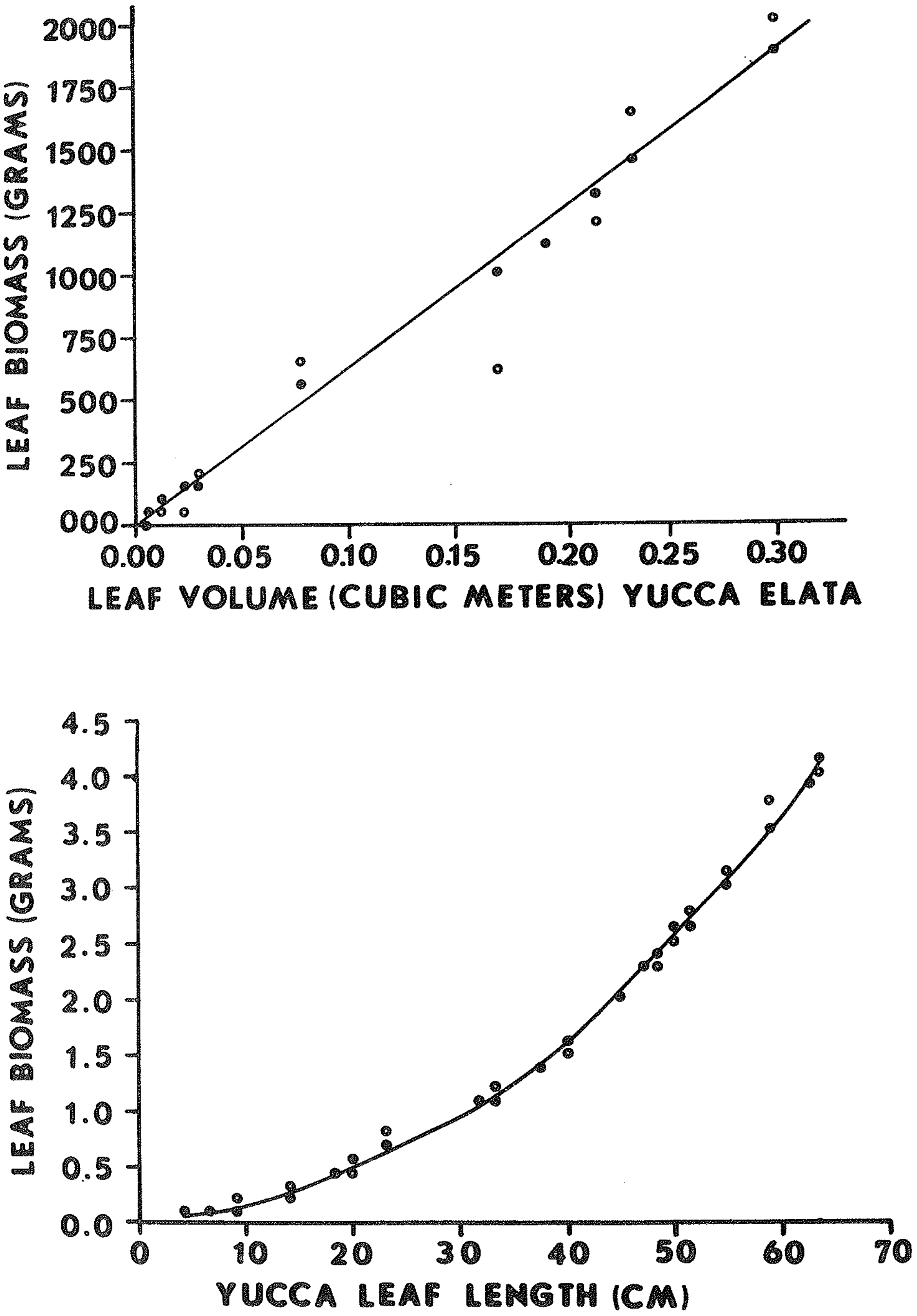

Figure 9. (Top) Regression of leaf biomass (B) onto canopy volume (V) of leaves for *Yucca elata*. The equation of the linear regression line is B = 6218 V.

(Bottom) Regression of leaf biomass (B) onto green leaf length (L) for *Yucca elata*. The equation of the curvilinear regression line is $B = .0047 L + .00093 L^2$.

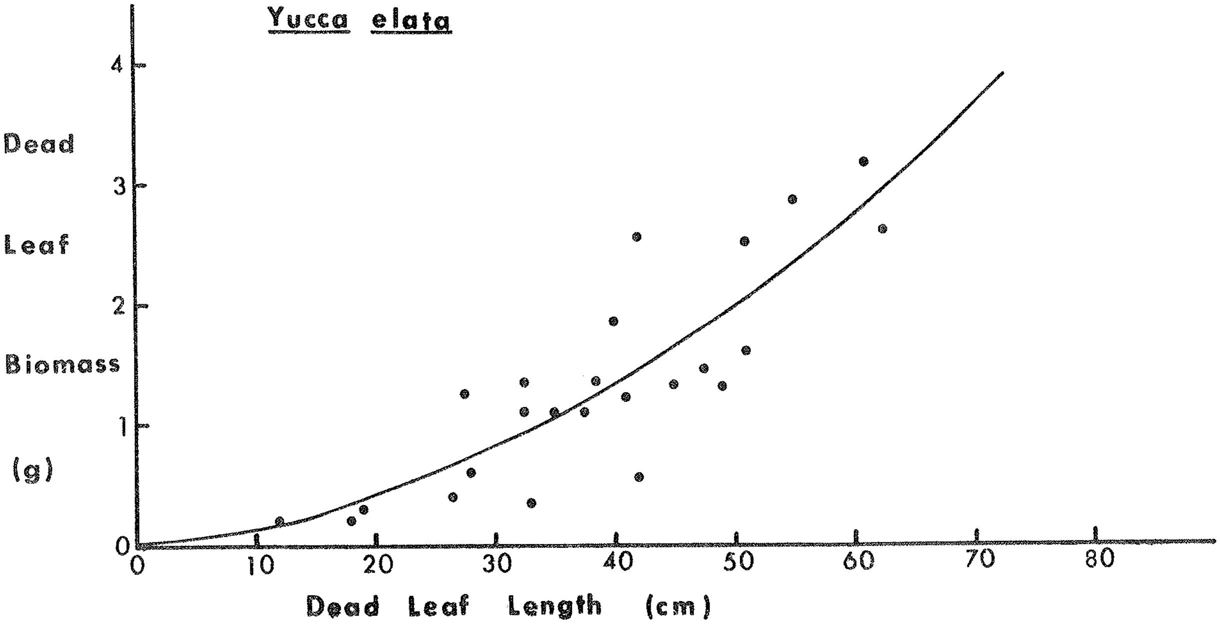

Figure 10. Regression of standing dead leaf biomass (B) onto dead leaf length (L) for *Yucca elata*. The equation of the curvilinear regression line is $B = .0088 L + .00063 L^2$.

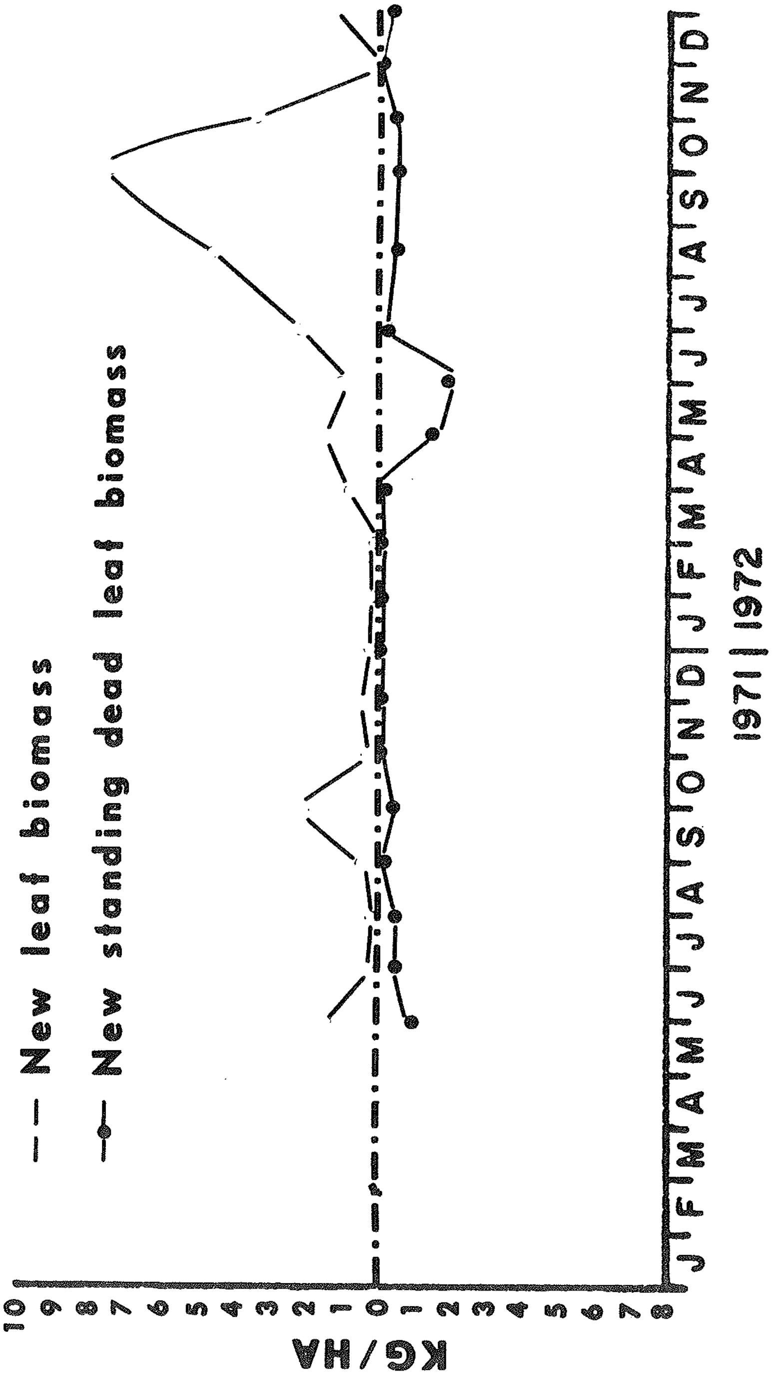

Figure 11. Monthly absolute leaf biomass gains and losses for *Yucca elata* on the playa fringe.

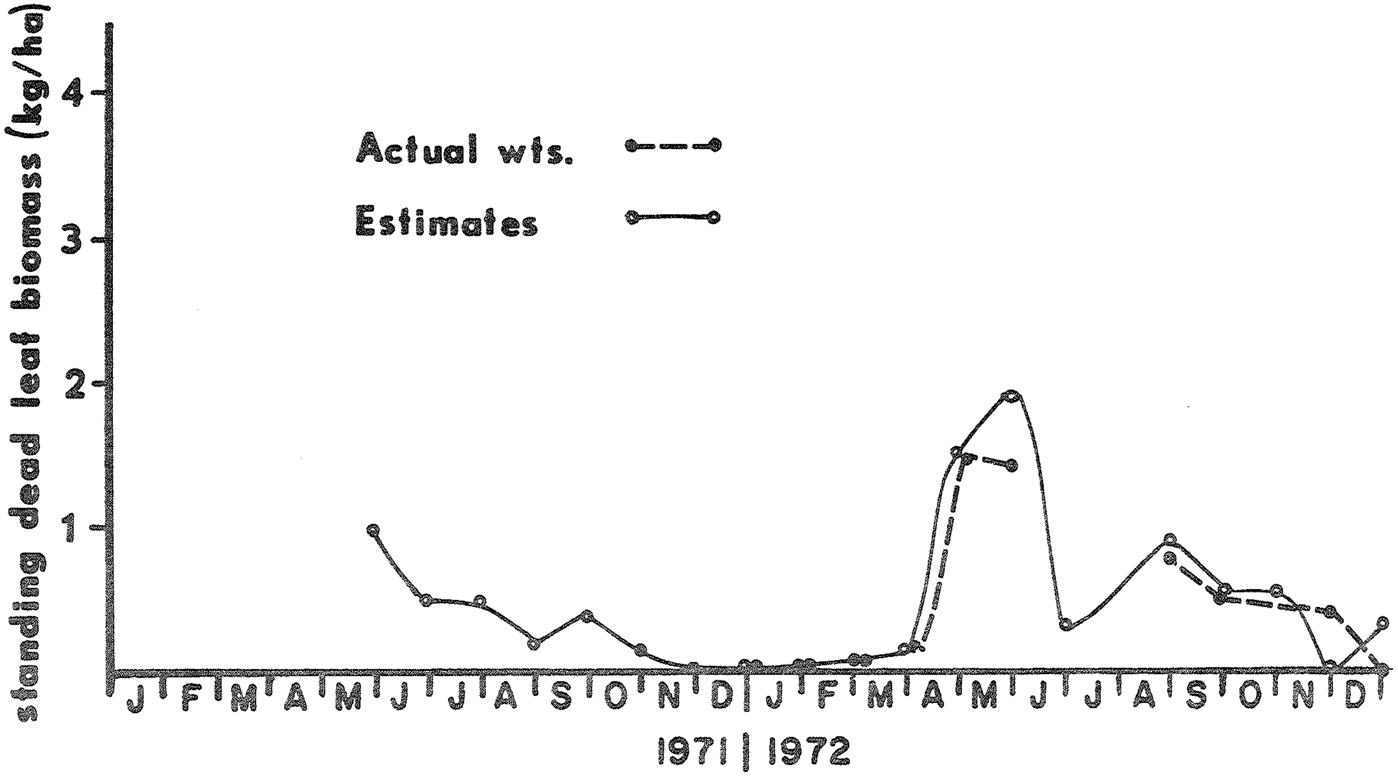

Figure 12. Monthly losses of live leaves to standing dead leaves for *Yucca elata* on the playa fringe. In 1972 the monthly increments of new standing dead leaves were harvested (actual wts.). In both 1971 and 1972, the standing dead leaf increments were estimated from lengths (estimates). The data for July, 1972 are missing.

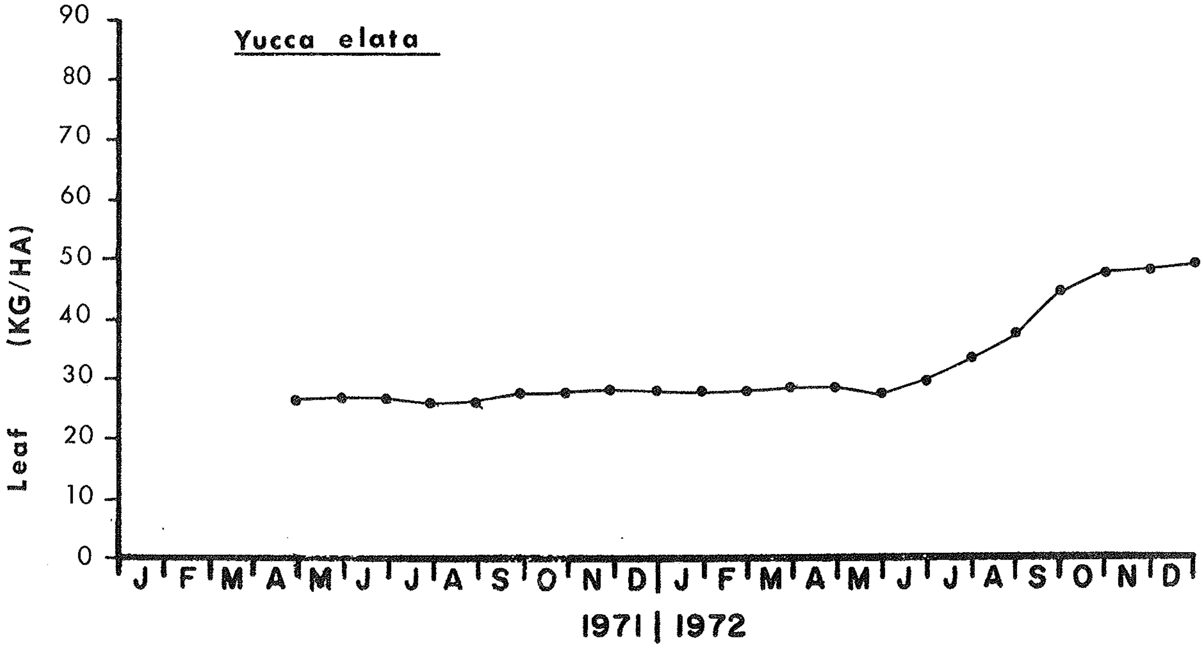

Figure 13. Monthly standing crop of living leaf biomass for *Yucca elata* for 1971 and 1972 on the playa fringe.

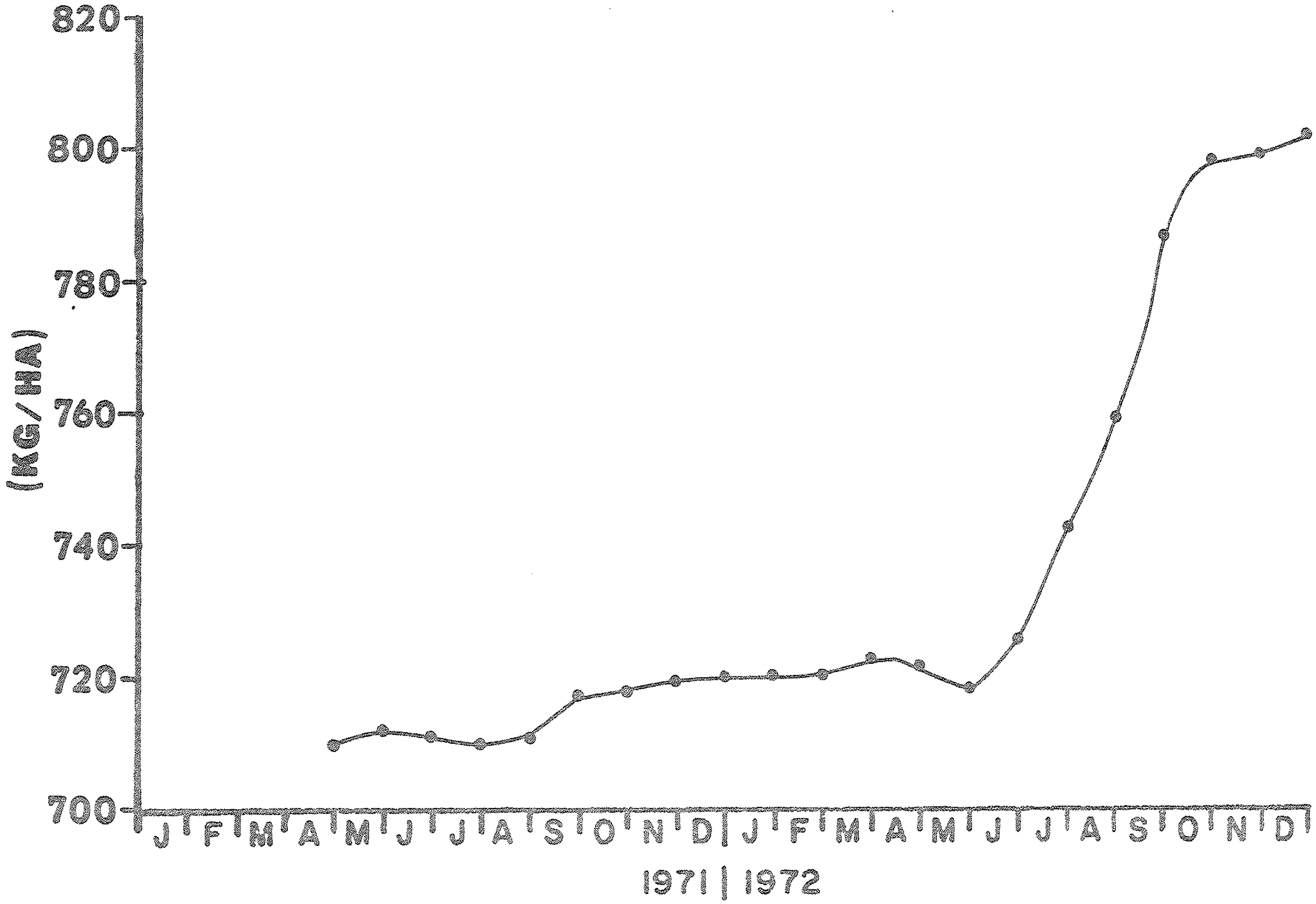

Figure 14. Monthly standing crop of caudex biomass for *Yucca elata* in 1971 and 1972 on the playa fringe.

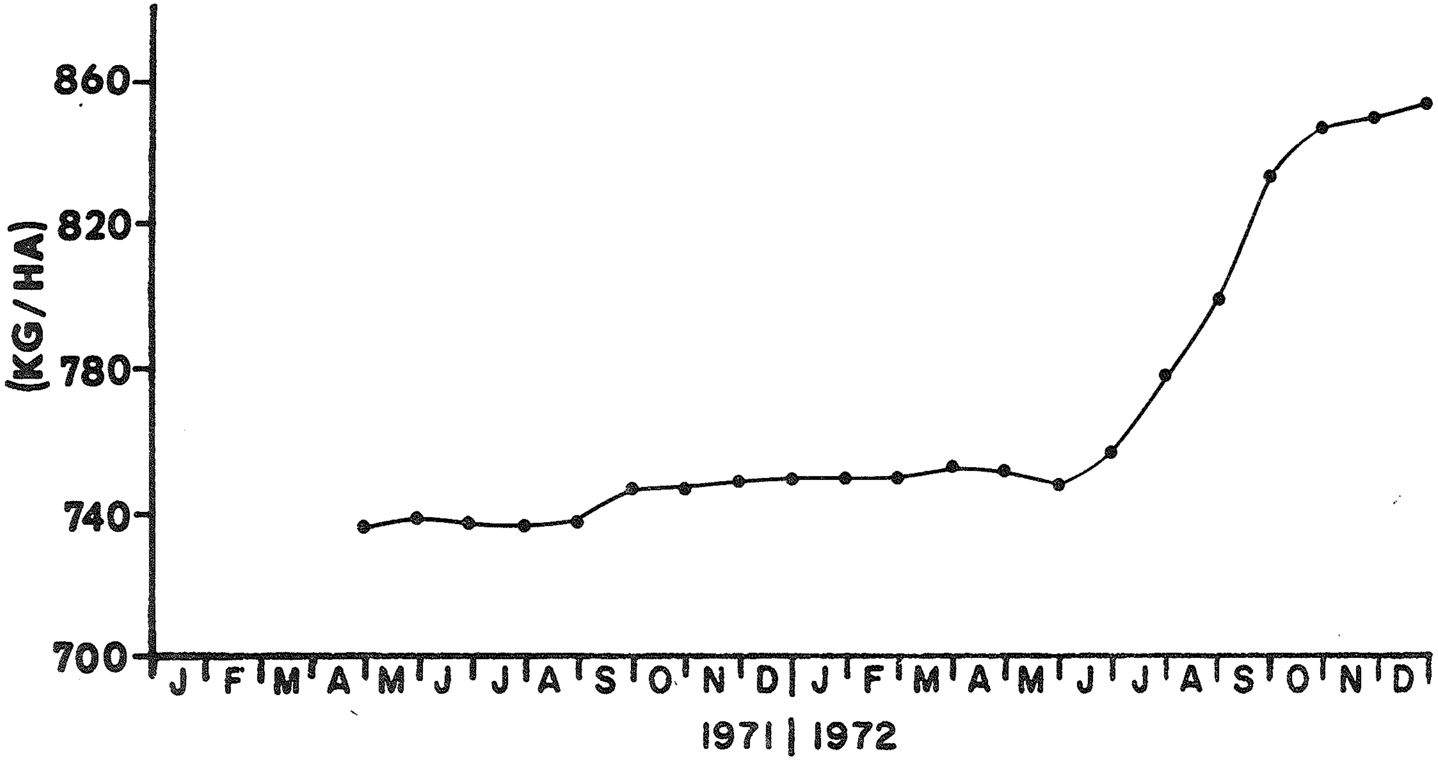

Figure 15. Monthly standing crop of total above-ground biomass for *Yucca elata* in 1971 and 1972 on the playa fringe.

Playa fringe perennial: *Xanthocephalum sarothrae*

The growth of eight *Xanthocephalum* plants on the playa fringe was monitored during 1971. In 1972, the number of plants monitored was increased to 15, however, six of the eight plants initially measured in early 1971 did not survive the dry spring of 1971. The plants were selected at random within sectors of the playa fringe. Growth measurements involved recording the height and width of the canopy each month. During the growing season, the canopy dimensions of the live portions of this sub-shrub were monitored. During the non-growing season, the size of the standing dead canopy from the previous growing season was measured. These measures were carried through the growing season of the next year. Phenological states of the plants were noted each month.

Biomass estimates were obtained from the size measurements. From the height and width of the canopies, a mean monthly canopy volume was computed. Using the equations for relating biomass by component part to canopy volume given in Table 17, biomass changes through time can be estimated from the changes in canopy volume through time. The regressions of leaf and stem biomass onto canopy volume are shown in Figure 16. A simple linear relationship appears to hold in both cases. The regressions of reproductive structures and root biomass onto canopy volume are shown in Figure 17. The slope of the linear regression line of reproductive structures will change with the state of development of this plant part. The immature inflorescence buds will have a lower biomass than mature inflorescences (often called flowers in this member of the sunflower family). In turn, the immature seeds (within the small heads) will have a lower biomass than mature seeds. Thus an inflorescence full of heads with mature seeds should have the greatest biomass. The regression relationship shown in Figure 17 (top) was determined from plants destructively sampled during this latter stage of full maturity, but prior to scattering of the seeds. Thus the slope shown should represent about the maximum. However, if used during the earlier stages of development, this equation will tend to overestimate actual reproductive biomass. The data for estimating root biomass from canopy volume are more variable, thus confidence in the estimates is lower. A comparison of the relative magnitudes of the slopes for root and stem biomass indicates this species has a relatively high shoot-to-root ratio of about three.

Season-to-season and year-to-year biomass changes in *Xanthocephalum* are shown in Figure 18. During the dry spring months of 1971, there was no new leaf growth until June. As mentioned earlier, of the eight plants tagged for growth measures, only two grew at all in 1971. Growth was slow until a peak in September during the flowering period. After this time, biomass dropped off rather rapidly. In January, 1972, the green leaf biomass was essentially zero. However, this species is fairly cold-tolerant and resumed a small amount of green leaf production in February, 1972. Biomass increased steadily throughout the spring and summer months, again reaching a peak in September during flowering. During the fall months, most of the seeds formed are scattered; a check of the inflorescence heads in December showed that most were empty of seeds.

The disintegration and eventual conversion to litter of the dead stems for the six plants that were tagged but died during the spring of 1971 is shown in Figure 19. As indicated, the standing dead canopies remained pretty much intact until the late spring of 1972 when they began to shatter. However, even in December 1972, some fragments of the canopies remained.

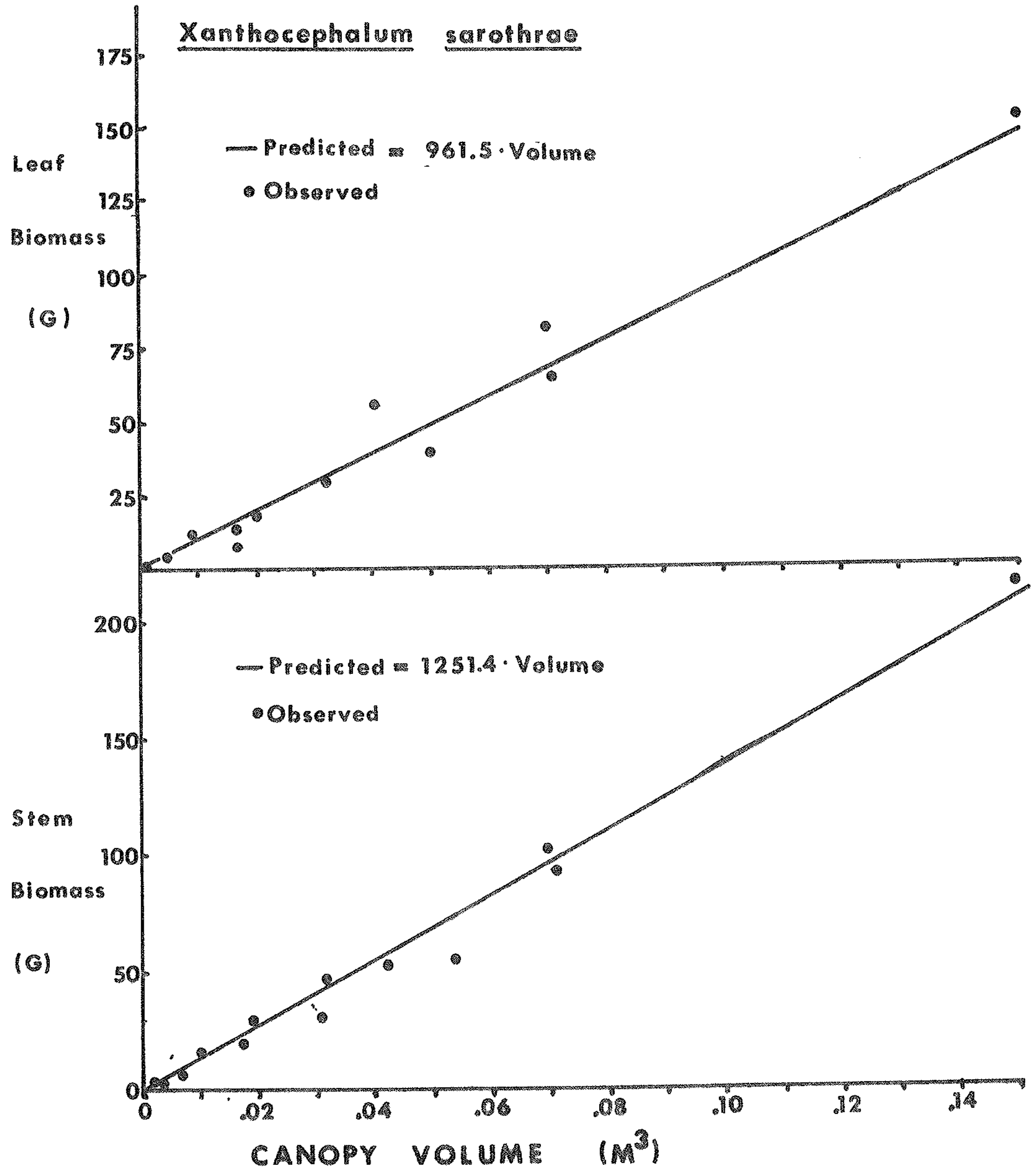

Figure 16. (Top) Regression of leaf biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 961.5 V.

(Bottom) Regression of stem biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 1251.4 V.

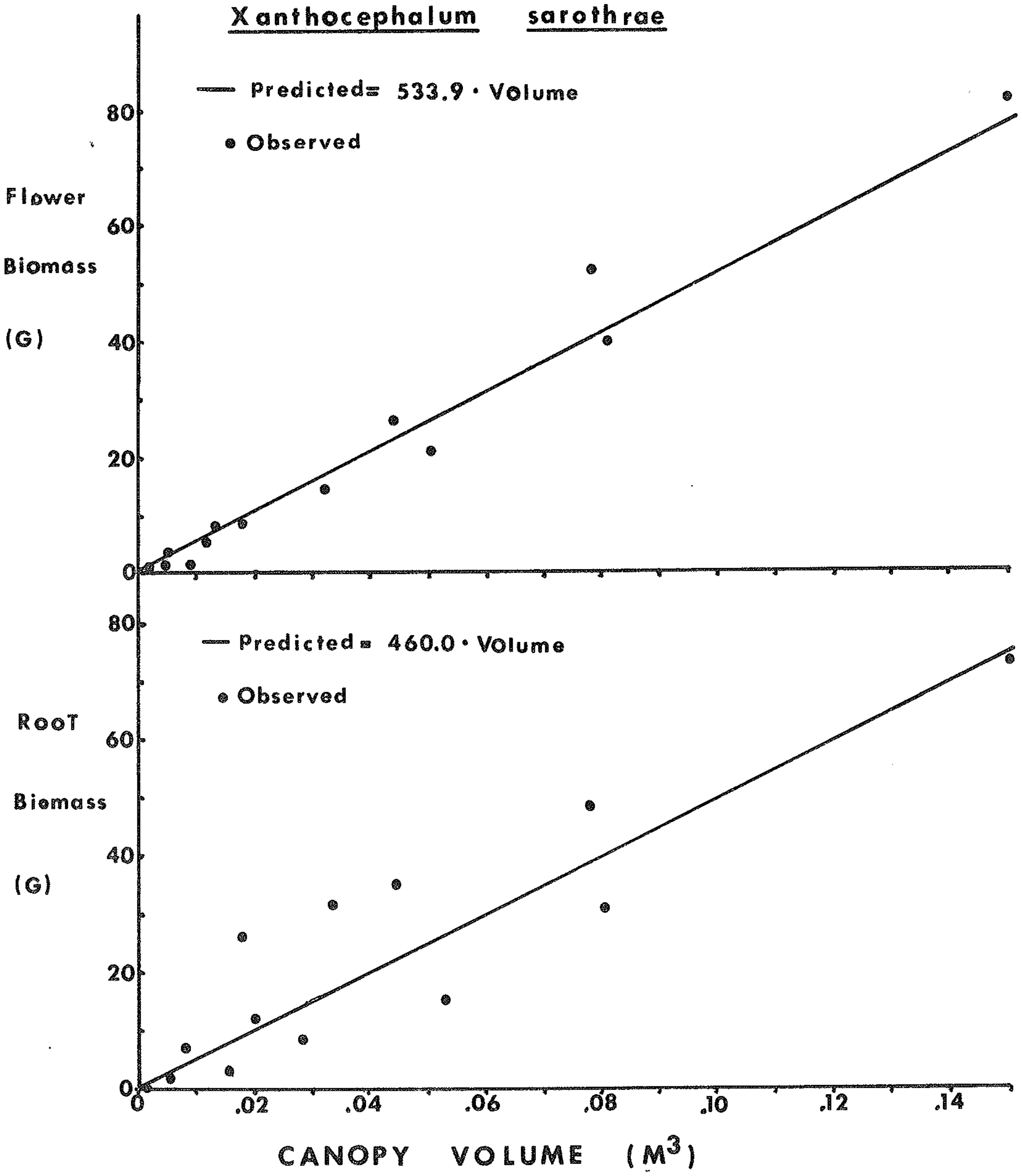

Figure 17. (Top) Regression of flower biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 533.9 V.

(Bottom) Regression of root biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 460.0 V.

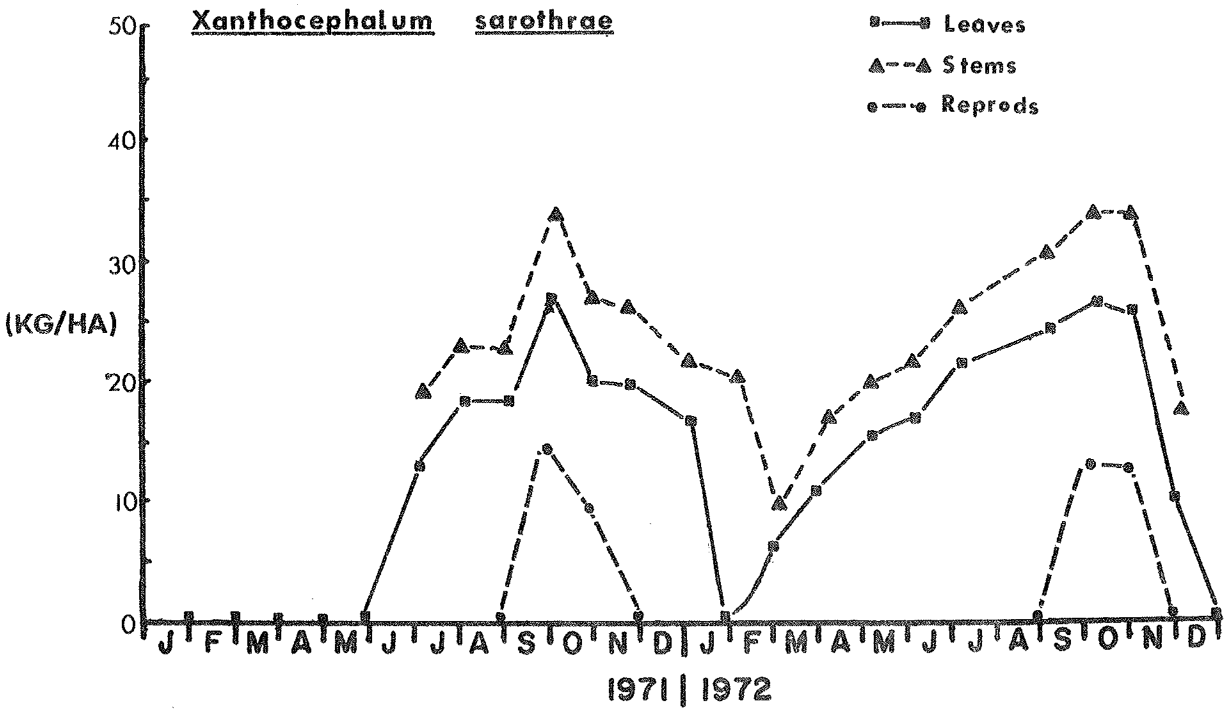

Figure 18. Monthly standing crop of leaf, stem and reproductive biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the playa fringe.

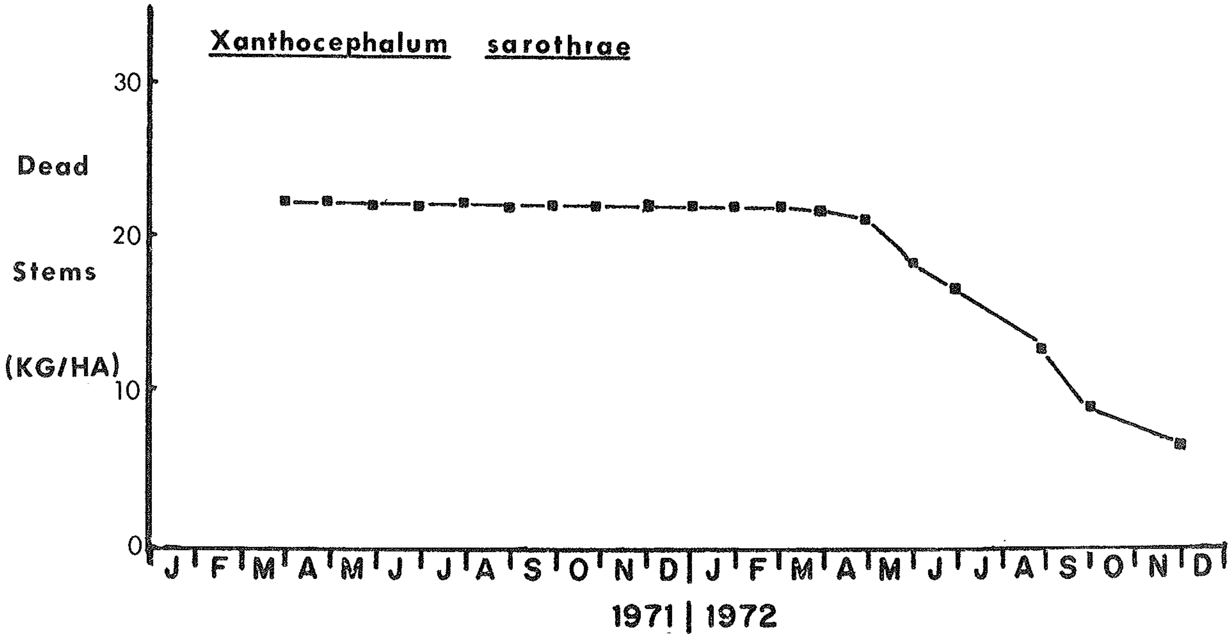

Figure 19. Monthly standing crop of dead stem biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the playa fringe.

Playa fringe perennial: *Ephedra trifurca*

The growth pattern of eight long-leafed mormon-tea (*Ephedra trifurca*) plants from around the playa fringe was monitored during 1970, 1971 and 1972. On each plant, a number of growth nodes were tagged for repeated measurements through time. Measurements were made on the length of old and new green stems arising from the node. In 1970 and 1971 the lengths of the old and new stems were not separated, but were combined into one total length. In 1972, the length measures were kept separate for old and new stems and the number of old and new stems at each node were recorded. From a length series of stems collected near the site, a regression equation was derived to estimate green stem biomass from green stem lengths (Fig. 20). The relationship is not the cleanest, due primarily to a too narrow range of lengths, but also due to using a mixture of old and new stems in the lengths. Studies are underway to determine separate regression equations for old and new stems and to include the number of such stems at a node. This should allow for a more accurate prediction of green stem biomass dynamics.

Initial biomass states of *E. trifurca* were studied utilizing the belt transect data described earlier (Table 18 and text). These initial estimates for stems and roots were based on the equations given in Table 17. The relationship of green stem biomass and dead stem biomass to canopy volume is shown in Figure 21. Slightly curvilinear regression lines gave the best fit to the observed data; however, with more data for larger plants, the relationship may in fact be generally linear.

On the playa fringe, *E. trifurca* appeared to show two periods of growth, one in late spring and another in late summer (Fig. 22). In 1970, frequency of measurement was insufficient to tell if a late summer growth period occurred, however since the late summer and fall of 1970 was very dry, it is likely that no late summer growth occurred. The spring and summer of 1971 were also very dry, and as indicated there was a rather steady decline in green stem biomass from the late spring estimate of 232 kg/ha to an estimated low of 130 kg/ha. It is evident that the green stems of *E. trifurca* have a high mortality rate under drought conditions. Part of this death was also due to browsing by small mammals and rabbits. Fall and winter precipitation did improve drought conditions such that a rapid rate of recovery of green stems was evident in the spring of 1972. The green stem biomass increased to a total of about 366 kg/ha. As shown in Figure 22 for 1972, this increase in total standing crop of green stems was due to a steady increase in new green stems, which peaked in August. At this time, the new stems reached full maturity as indicated by a cease in activity of their apical tip. They were then classified as old stems resulting in an increase in this category, which had been declining due to death. The total standing crop of green stems entered 1973 at about 215 kg/ha.

Ephedra trifurca is a gymnospermae and belongs to the family Ephedraceae. It is dioecious with the flowers in inflorescences that are conelike. The cones develop from axillary buds which form the previous fall. The buds overwinter in an apparent dormant state and then begin to expand and take on the conelike form in March. The buds enlarge rapidly in March and open during the latter part of the month or in early April. Abscission of buds is often high before full cone formation. After the cones open and pollen is shed or received, the cones appear to mature rapidly and soon fall to the ground in high numbers. Many cones do not develop mature seeds and insect damage to cones is often high. In 1972, records were kept on the number of buds and cones which developed on *E. trifurca*. On March 4 there was an average of 2300 developing cones per plant. By April 8, when the cones were fully mature and beginning to drop, there was an average of 1300 mature cones per plant. A sample of mature male cones gave an average weight of 0.01 g/cone. A sample of mature female cones gave an average weight of 0.018 g/cone. Based on the density of mormon-tea plants on the playa and assuming about a 1:1 ratio of male plants to female plants, the biomass of mature cones produced on the playa fringe in April 1972 was about 7.7 kg/ha.

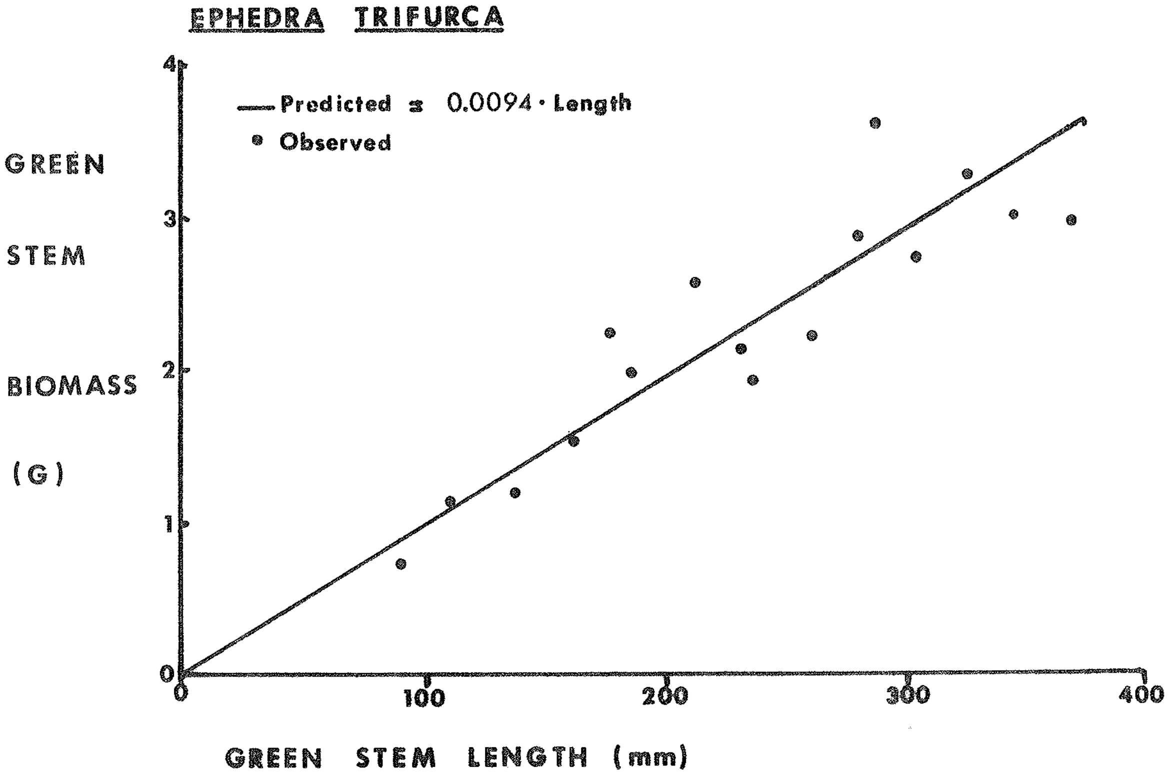

Figure 20. Regression of green leaf biomass (B) onto green leaf length (L) for *Ephedra trifurca*. The equation of the linear regression line is B = 0.0094 L.

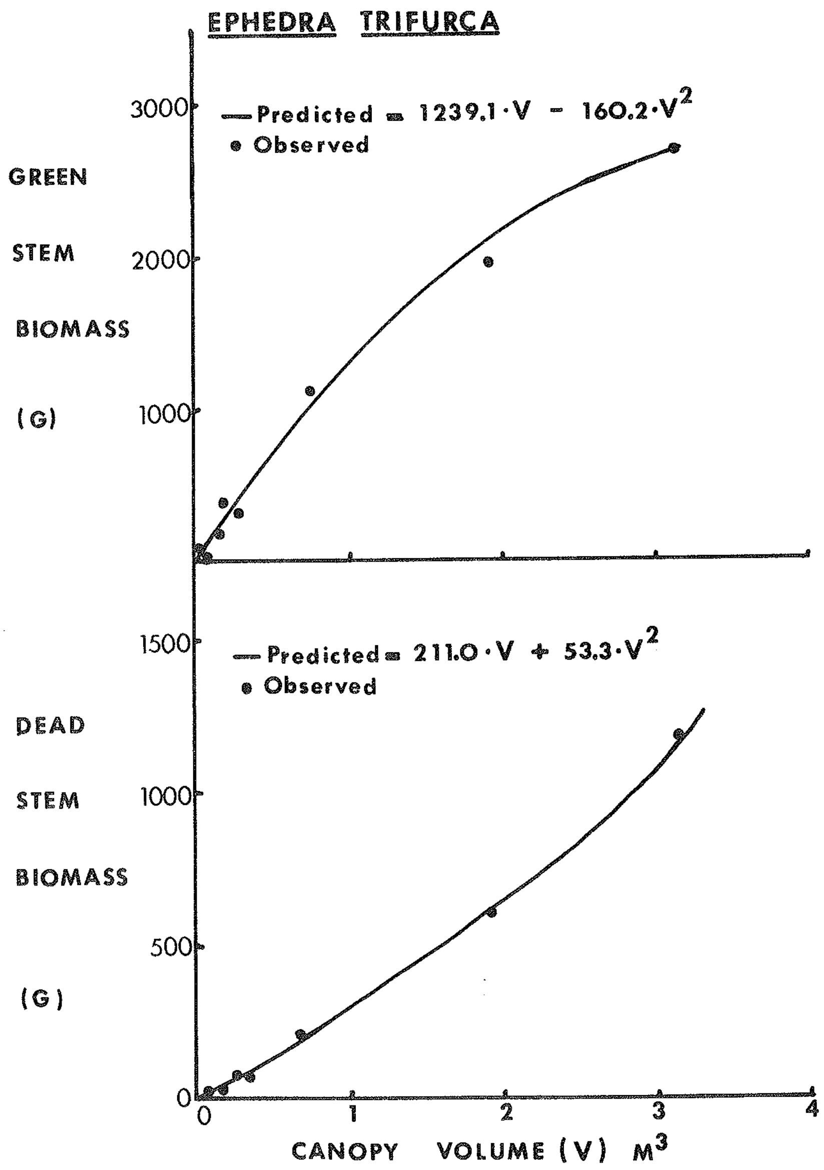

Figure 21. (Top) Regression of green stem biomass (B) onto canopy volume (V) for *Ephedra trifurca*. The equation of the curvilinear regression is $B = 1239.1\ V - 160.2\ V^2$.

(Bottom) Regression of dead stem biomass (B) onto canopy volume (V) for *Ephedra trifurca*. The equation of the curvilinear regression is $B = 211.0\ V + 53.3\ V^2$.

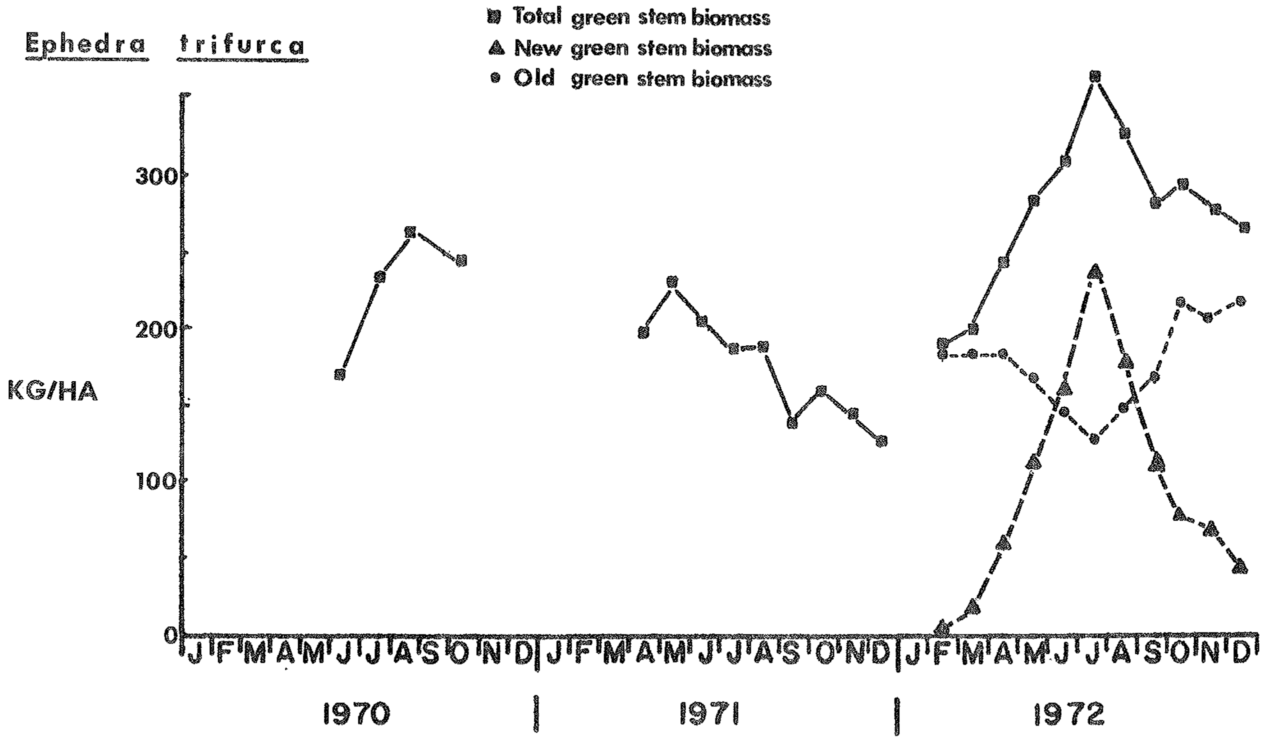

Figure 22. Monthly standing crop of green stem biomass for *Ephedra trifurca* in 1970, 1971 and 1972 on the playa fringe.

Playa fringe perennial: *Prosopis glandulosa* var. *torreyana*

The growth pattern of 10 mesquite (*Prosopis glandulosa* var. *torreyana*) plants occurring around the fringes of the playa was monitored in 1970, 1971 and 1972. On each randomly selected plant a number of nodes on branches produced in previous years were tagged with wooden tree labels and wool yarn to facilitate measurements of leaf growth. At each node, a measurement of the total length of leaves was recorded. In 1970, only 32 nodes were tagged. The sample size was increased to 115 nodes in 1971 and to 155 nodes in 1972. From a length series of leaves at nodes collected near the site, a regression equation was derived to relate leaf biomass to leaf length (Fig. 23). In recent studies, the number of leaves at each node was also recorded. Using this information along with the data on total length may allow a more accurate estimate of leaf biomass at a node than that shown in Figure 23, which has a fair amount of scatter of observed data about the estimated regression line.

The growth pattern of mesquite includes the production of new shoots during the growing season. These new shoots represent an added biomass of leaves and wood. At each of the tagged nodes mentioned above, the presence or absence of new shoots collected from plants near the site was recorded and regression equations derived to predict the amount of new leaf and stem biomass added by a shoot of any given length (Fig. 24). As might be expected, the estimation of wood biomass from the given regression line is more exact than leaves, which are quite variable. These relationships of leaf and wood biomass to new shoot length should be determined at other times of the year than towards the end of the growing season as in the above regression. The slope of the regression may change slightly with the season.

The reproductive pattern of mesquite involves the formation of inflorescence spikes at nodes and in rare cases on new shoots. Along with the length-of-leaf measurements mentioned above, the occurrence and lengths of inflorescence spikes at tagged nodes were recorded during the growing season. Again, regressions and average weights can be used to estimate the biomass of these reproductive structures. The average weight of a single inflorescence with mature flowers is 0.11 g. Since the number of fruits produced per inflorescence is highly variable, it is better to treat the single fruit. The average length of fruits collected from plants near the site in 1972 was 10 cm with an average weight of 1.5 g. The average number of seeds produced was 10. The number of seeds and the weight of the fruit are highly dependent on the length of the fruit. The number of seeds (N) can be estimated from the length (L) of the fruit by the regression equation: $N = 1.01\ L$ (cm). The biomass (B) of the fruit in grams can be estimated from the length (L) of the fruit by the regression equation: $B = 0.16\ L$ (cm).

Initial biomass estimates for mesquite were obtained using the belt transect studies described above (Table 18 and text). The initial biomass estimates for leaves, stems and roots are based on the equation given in Table 17. The relationship of leaf and live stem (wood) biomass to canopy volume are shown in Figure 25. The linear regression given appears to fit the data well; however, the problem of under-sampling plants with large canopy volumes gives the few data points with large values undue weight in determining the slope of the line. Additional collections of large plants are needed to further evaluate this relationship. The relationships of dead stems and root biomass to canopy volume are shown in Figure 26. As might be expected, the closeness of fit of the observed data to the linear regression line is not as good for these two components relative to the closeness of fit for leaves and live stems. The massive basal crown in mesquite varies greatly relative to its position with the ground surface; thus root biomass is not as predictable.

The production of leaf biomass at nodes for 1971 and 1972 is shown in Figure 27. The pattern of leaf production in 1970 is not given due to only a few data points. However, mesquite seemed to follow the pattern observed in 1971. It showed a rapid burst of new leaves early in the spring, as shown, followed by a slight reduction in standing crop during the hot, dry, late spring and early summer months. This may be followed in turn by a slight increase in new leaves with the typical summer rains. In 1971, the production of leaf biomass peaked at about 300 kg/ha. In 1972, the growing season started early in March; however a hard frost on April 1 killed all the leaves on mesquite. The leaves killed were on the plants on the playa fringe. Mesquite plants on the bajada were only partially affected by the frost. Cold air drainage is a factor on the playa. Regrowth was delayed until late May. Then growth was rapid, with leaf biomass peaking at 200 kg/ha. Leaves drop off rapidly at the end of the growing season but a few petioles persist into the winter.

The production of new shoots at nodes for 1971 and 1972 is shown in Figure 28. The biomass of leaves on new shoots and the woody biomass of the shoots produced from year to year follows environmental conditions closely. In 1971, when conditions were relatively dry, the production of new shoots was relatively low with leaf and stem biomass peaking at 9 kg/ha and 6 kg/ha respectively. In 1972, when precipitation was greater, the production of shoots was much greater, with leaf and stem biomass peaking at 37 kg/ha and 24 kg/ha respectively. The biomass of leaves produced on new shoots may equal or surpass the biomass of leaves produced at old nodes in years of high shoot production.

The production of reproductive structures (inflorescence spikes, fruits) for 1971 and 1972 on the playa by mesquite was very limited. In 1971, the production of inflorescences and fruits was negligible. In 1972, the production of reproductive structures was relatively low because most had formed before the April 1 frost and thus were killed.

The biomass changes in live stems and roots from year to year can best be approximated from changes in canopy volume or the other biomass components being monitored. The biomass estimates from the original belt transect samplings in June, 1970, are based on canopy volume (Table 18). These estimates approximate the state of mesquite in 1970. After the

1972 growing season, the canopy volumes of the 10 plants being monitored was remeasured. The biomass of mesquite on the site can be estimated from these measures. The biomass in 1971 can be approximated from the relative changes in monitored components in 1971 and 1972. The results of these biomass approximations are given in Table 19. The standing crop of live stems increased from 2470 kg/ha to 3130 kg/ha. The standing crop of dead stems changed from 2340 kg/ha to 2740 kg/ha. The total root biomass was estimated to have changed from 3790 kg/ha to 4800 kg/ha. The change from 1970 to 1971 was only 5%. This is small relative to the 17% change from 1971 to 1972.

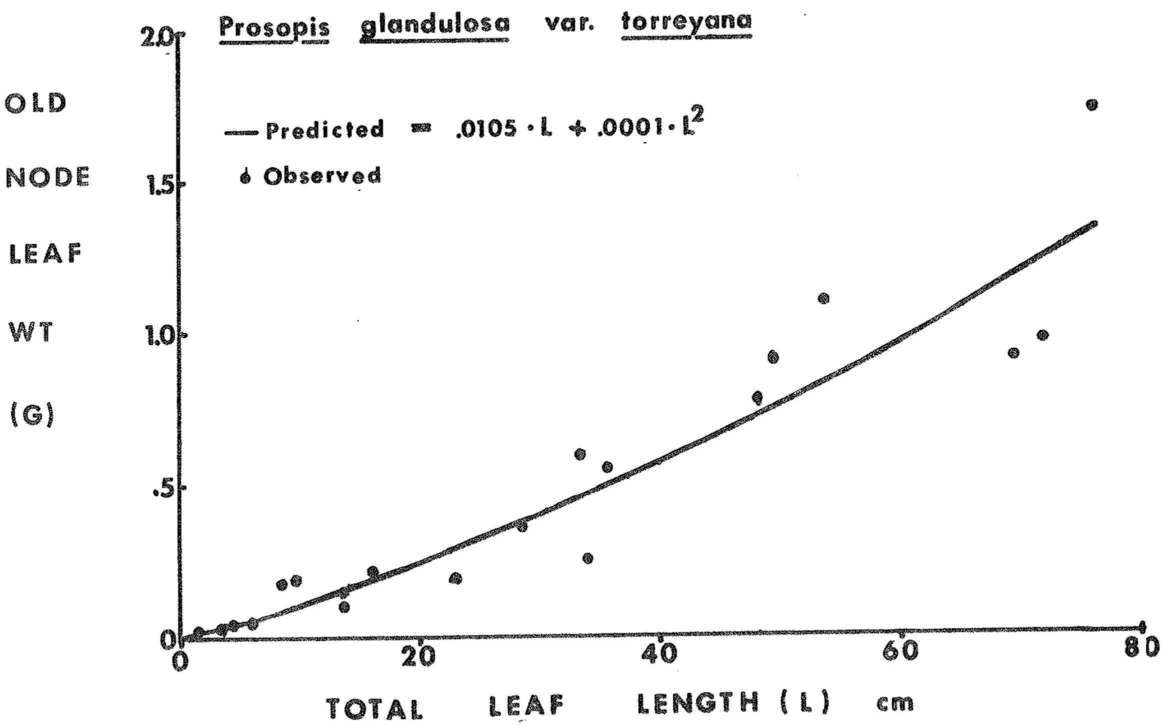

Figure 23. Regression of leaf biomass (B) at a node onto total leaf length (L) at the node for *Prosopis glandulosa* var. *torreyana*. The equation of the curvilinear regression line is $B = 0.0105\ L + .0001\ L^2$

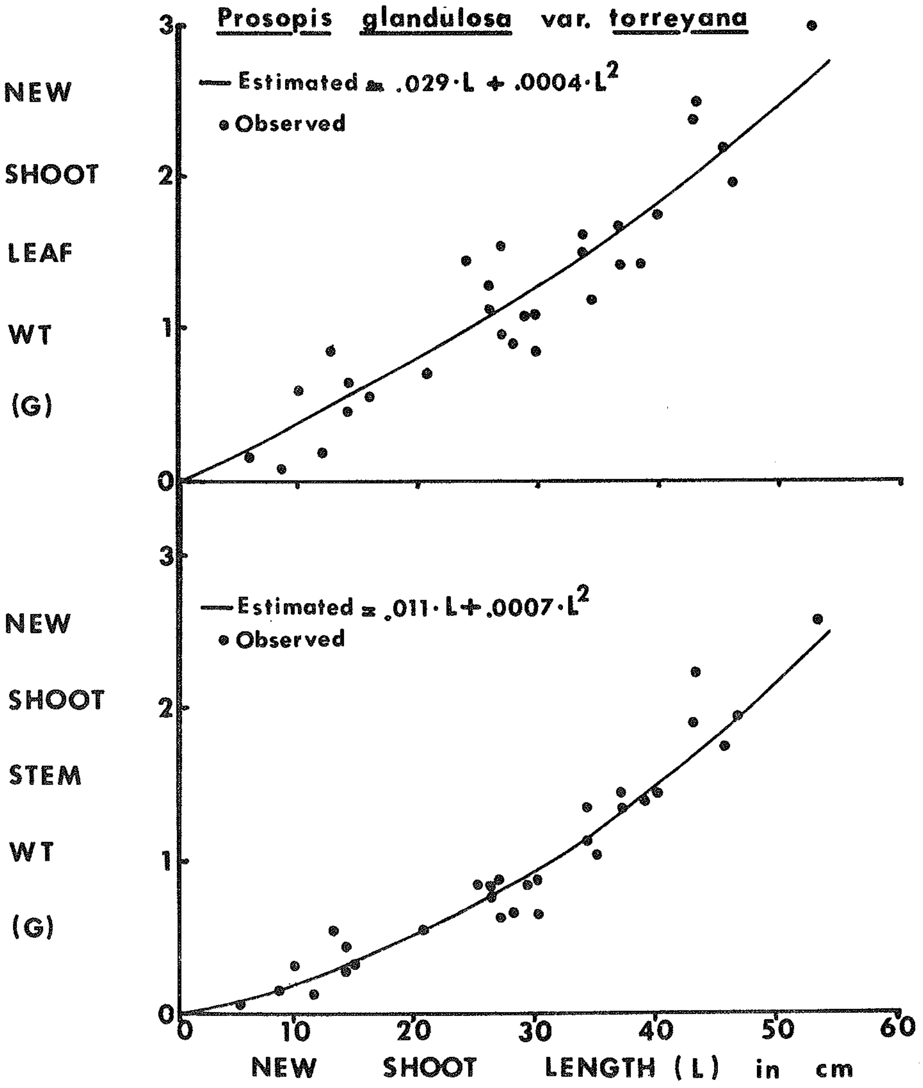

Figure 24. (Top) Regression of leaf biomass (B) of new shoots onto new shoot length (L) for *Prosopis glandulosa* var. *torreyana*. The equation of the curvilinear regression line is $B = .029\ L + .0004\ L^2$.

(Bottom) Regression of stem biomass (B) of new shoots onto new shoot length (L) for *Prosopis glandulosa* var. *torreyana*. The equation of the curvilinear regression is $B = .011\ L + .0007\ L^2$.

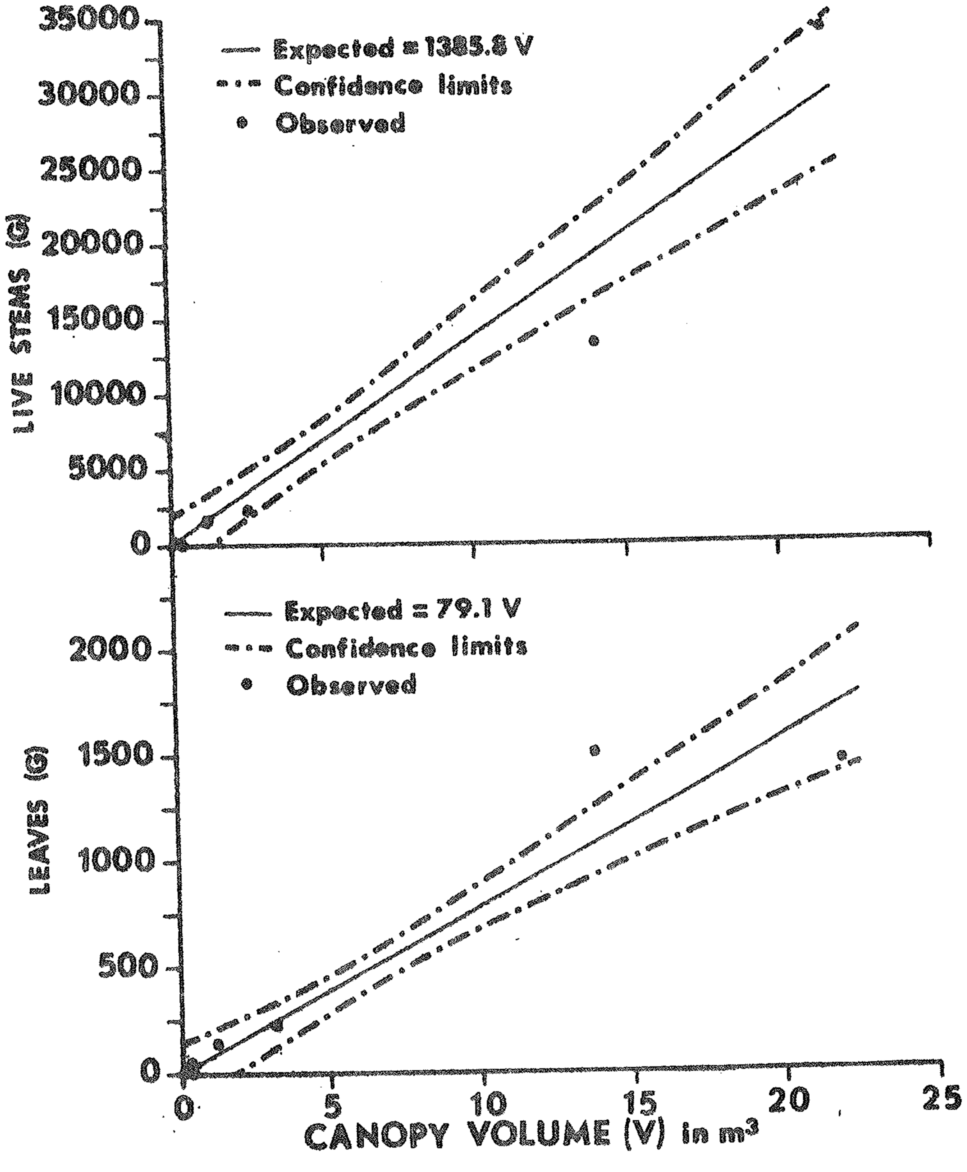

Figure 25. (Top) Regression of live stem biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 1385.8 V.

(Bottom) Regression of total leaf biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 79.1 V.

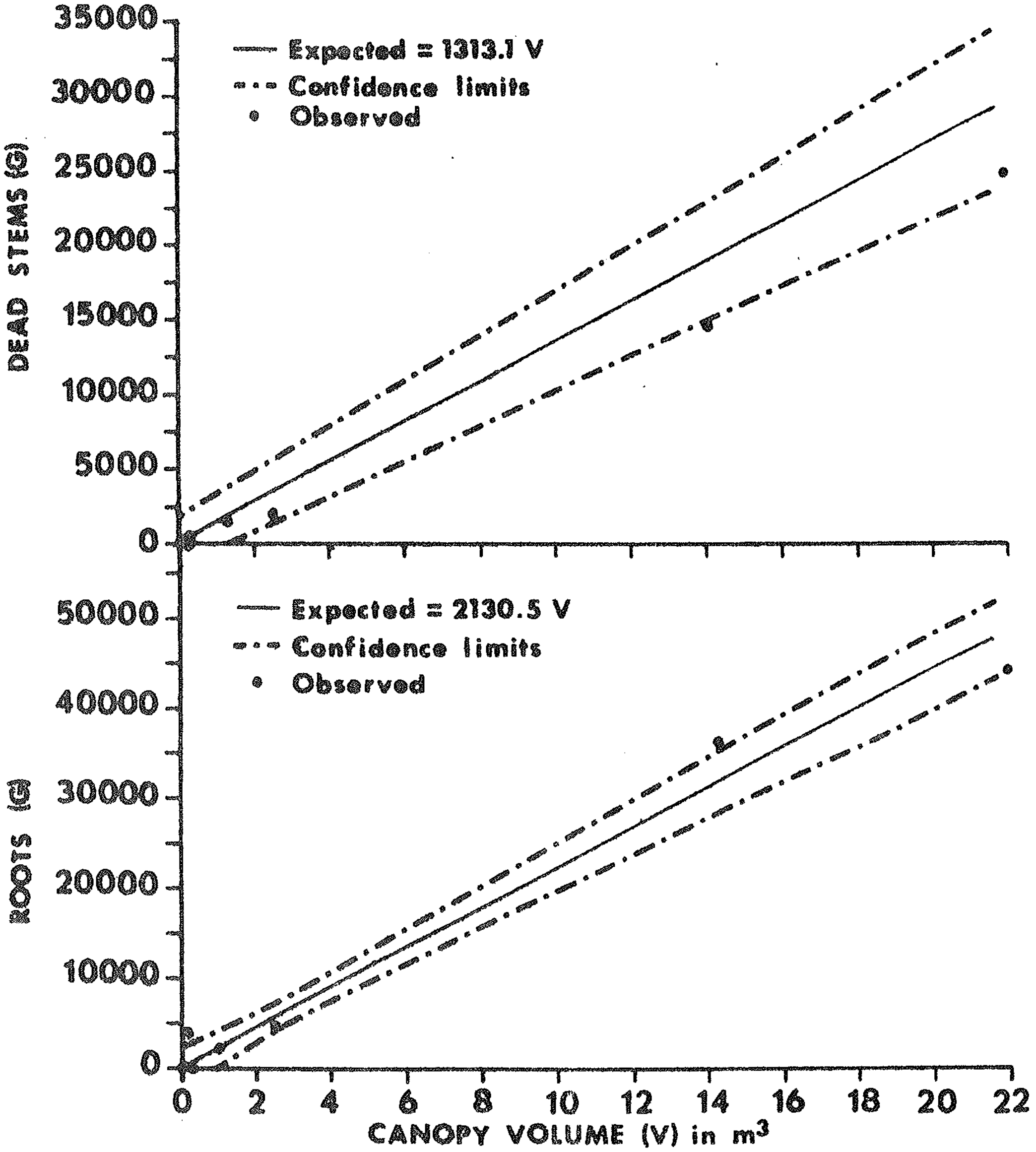

Figure 26. (Top) Regression of dead stem biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 1313.1 V.

(Bottom) Regression of total root biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 2130.5 V.

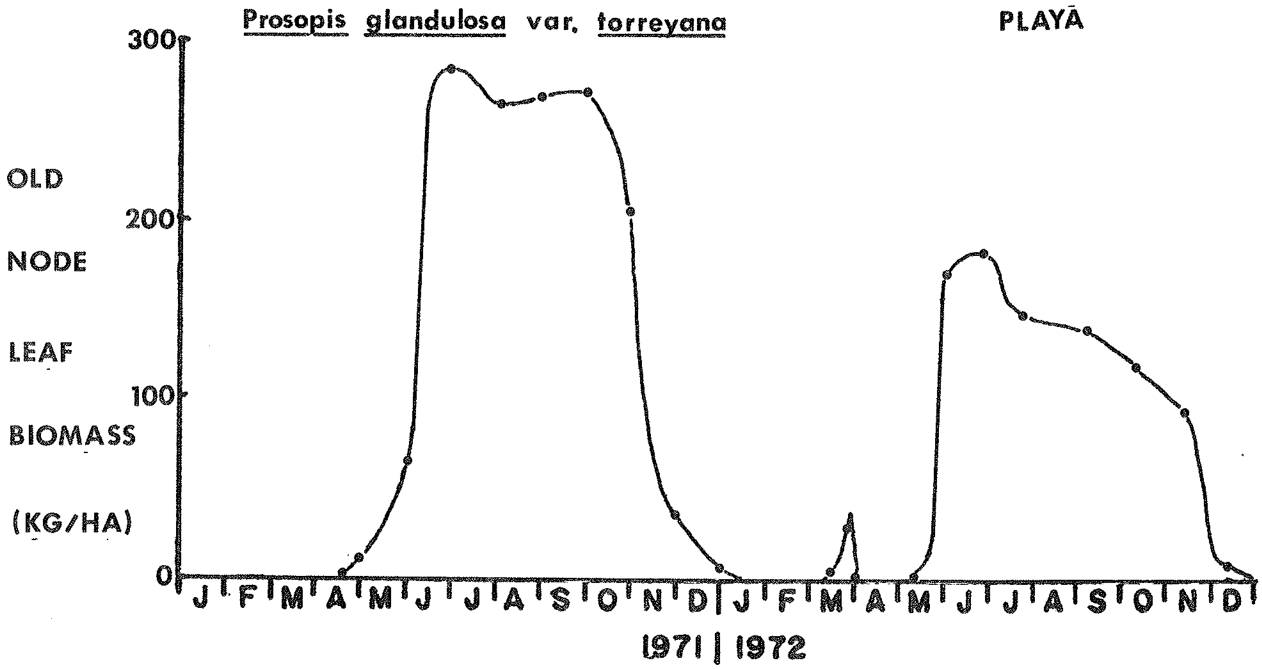

Figure 27. Monthly standing crop of old node leaf biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the playa fringe.

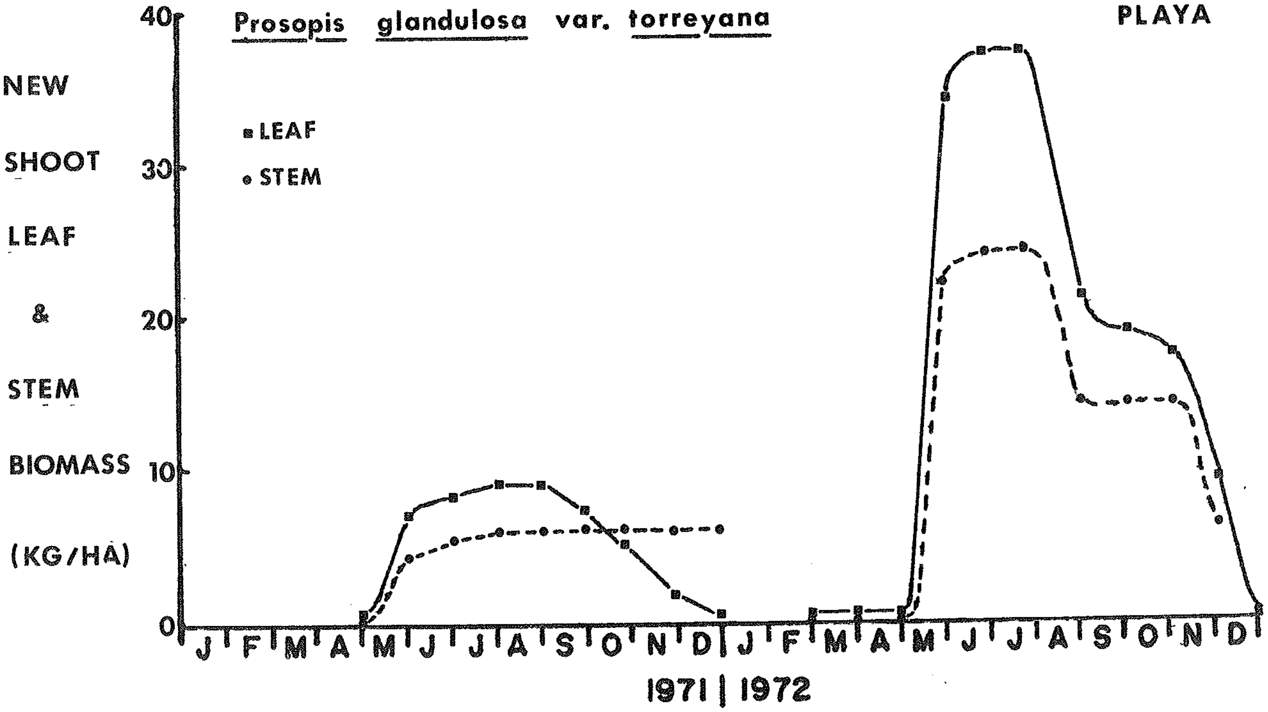

Figure 28. Monthly standing crop of new shoot leaf and stem biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the playa fringe.

Table 19. Canopy size and biomass estimates for the 1970, 1971 and 1972 growing seasons by *Prosopis glandulosa* var. *torreyana* on the playa fringe with percent change from the previous year also given.

Component	1970	1971	1972
Canopy Cover (%)	15.3	15.9	18.5
Canopy Volume (M^3/ind)	3.6	3.8	4.4
Live Stems (kg/ha)	2470	2600	3130
Dead Stems (kg/ha)	2340	2420	2740
Roots (kg/ha)	3790	3985	4800
Per cent (%) Change		5	17

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I.C. INVERTEBRATES

1. SHRUB INSECT TAXA -- PLAYA (DSCODES A3UWJ21, A3UWJ25)

Relative abundance, family composition and diversity of arthropods on playa shrubs in 1971 are summarized in Table 1. The most consistently important species on *Ephedra trifurca* were Homopterans which feed on plant juices. The shifts from Membracids to Psyllids reflect population shifts resulting from either temperature extremes or phenology of the host plant or both. The high density of spiders (Aranae) in July and marked shift in species composition are related to reduction in total numbers and biomass of herbivores. In July the number and biomass of predators exceeded that of herbivores.

On *Prosopis*, as on *Ephedra*, Homopterans (Psyllids) were the most important herbivores. Another important group in mid-summer were scale insects, Coccidae, which may complete their life in a few weeks. *Prosopis* supported the greatest biomass and species diversity per plant of all of the shrubs on the playa fringe. The Homopterans (Psyllids) were also important on *Larrea*. Following the onset of rains in August, 1971, Lygaeids emerged and apparently utilized *Larrea divaricata* as a food source. Due to drought conditions through mid-summer, samples of arthropods on the grass *Panicum obtusum* were made at the end of the growing season, and on *Yucca elata* before and after the rains. In July *Yucca elata* supported primarily predators (e.g. spiders and soft-winged flower beetles) and in August the only insects on *Yucca* were "visitors" (flies and ants both of which feed on exudates produced by the plant). The ant species on *Yucca* include honey pots, *Myrmecocystus* sp., and *Dorymyrmex* sp. These ants plus *Formica* were also found on *Prosopis*, *Larrea* and *Ephedra* at certain times of the year. The groups important on *Panicum* when it was stem cured were seed weevils and leaf hoppers. The mid-summer sample on *Panicum obtusum* yielded only ants, *Formica perpilosa*. *Hilaria mutica* yielded an assortment of forms although it is probable that most of the forms (spiders, some ants and the walking sticks) were seeking prey which were using the dense clumps of the grass as shelter from the extreme climatic conditions (Table 2).

Table 1. Relative abundance and number of taxa on plants on playa fringe†

Host Plant	Family	May	June	July	Aug.	Sept.	Nov.
Ephedra trifurca	Membracidae	++ (8)					
	Formicidae	++ (8)	+ (6,17,18)	+ (2,5)	+ (5,11)	++ (9)	
	Myrmeleontidae		+ (6,17,18)				
	Psyllidae		++ (6,17,18)		++ (5,11)		+++ (3)
	Acarinae		+ (6,17,18)				
	Miridae		+ (6,17,18)		+ (5,11)		
	Tachinidae		+ (6,17,18)				
	Hymenoptera		+ (6,17,18)		++ (5,11)		
	Diptera				++ (5,11)	+ (9)	++ (3)
	Lepidoptera		+ (6,17,18)		+ (5,11)		
	Neuroptera		+ (6,17,18)				
	Aranae			* (2,5)	+ (5,11)		+ (3)
	Coleoptera			+ (2,5)			
	Cecidomyidae			+ (2,5)			
	Fulgoridae			++ (2,5)			
	Cicadellidae				+ (5,11)		
	Megachilidae			+ (2,5)			
	Hemerobiidae			+ (2,5)			
	Isoptera					+ (9)	

† Relative abundance is expressed as % of total number, i.e. 5-25% +, 25-50% ++, 50-75% +++, 75-100% *. The number in ( ) is number of taxa on shrubs and the number of entries in ( ) indicates the number of shrubs sampled.

Table 1. continued

Host Plant	Family	May	June	July	Aug.	Sept.	Nov.
Prosopis juliflora	Membracidae	+ (23)	+ (2,27,30)	+ (5,13)	+ (6,13)		
	Psyllidae	+++ (23)	+ (2,27,30)	+ (5,13)	+ (6,13)	++ (12)	* (3)
	Formicidae	+ (23)	+++ (2,27,30)	++ (5,13)	* (6,13)	++ (12)	
	Aranae		+ (2,27,30)				
	Hymenoptera		+ (2,27,30)		+ (6,13)		
	Coccidae		+++ (2,27,30)	++ (5,13)	+ (6,13)		
	Diptera				+ (6,13)		
	Cicadellidae					+ (12)	
Larrea divaricata	Aranae		+ (22)				++ (4)
	Psyllidae		+ (22)			+ (5)	++ (4)
	Hymenoptera		+ (22)				
	Thysanoptera		++ (22)				
	Formicidae				++ (4)	++ (5)	
	Cleridae				++ (4)		
	Diptera				++ (4)		
	Lygaeidae				++ (4)		+++ (4)
	Miridae					++ (5)	
	Cicadellidae					+ (5)	
	Acrididae					+ (5)	
	Coleoptera						+ (4)
Guterrezia sarothrae	Formicidae				* (11)	++ (8)	
	Diptera					++ (8)	
	Hymenoptera					+ (8)	
	Lepidoptera					+ (8)	

Table 1. (cont.)

Host Plant	Family	May	June	July	Aug.	Sept.	Nov.
Yucca elata	Aranae			+++ (1,12)	+ (10)		
	Diptera			++ (1,12)	++ (10)		
	Malachiidae			* (1,12)			
	Formicidae				+ (10)		
Panicum obtusum	Aranae						+ (3)
	Bruchidae						+ (3)
	Cicadellidae						+++ (3)

Table 2. Relative abundance and number of taxa on playa grasses

Host Plant	Family	July	Aug.	Sept.	Oct.	Nov.
Panicum obtusum	Formicidae	* (1)				+ (6)
	Hemiptera					+ (6)
	Cicadellidae					+ (6)
	Membracidae					+ (6)
	Psyllidae					+ (6)
	Diptera					+ (6)
Hilaria mutica	Aranae	+ (1,6)	++ (5)		+ (4)	+ (10)
	Mordellidae	+ (1,6)				
	Diptera	+ (1,6)	+ (5)			++ (10)
	Hemiptera	+ (1,6)	+ (5)		+ (4)	
	Phasmidae	+ (1,6)				
	Formicidae	* (1,6)	++ (5)		+ (4)	
	Acrididae		+ (5)			
	Thysanoptera				++ (4)	

† Relative abundance is expressed as % of total number, i.e. 5-25% +, 25-50% ++, 50-75% +++, 75-100% *. The number in ( ) is number of taxa on grasses and the number of entries in ( ) indicates the number of grasses sampled.

Mesquite Borers and Girdlers

Six mesquite shrubs (*Prosopis glandulosa*) were selected at random to assess the mortality of plant parts due to activity of node borers (Bostrichidae) and girdlers (*Oncideres* sp.). Length measurements of damaged branches were made and collection of leaves that died as a result of this insect activity allowed assessment of plant part mortality. Most of the damage reported resulted from activity of Bostrichids in June. Biomass of leaves, wood and whole plant was calculated on the basis of equations provided by J. Ludwig (see section I.B.2). The data are summarized in Table 3 (DSCODE A3UWK01, 03).

Wood mortality due to node borers was between 1 and 2% of the total wood standing crop in all but the largest shrub. The percent mortality of leaves decreased from 6.6% to between 1 and 2% of the standing crop in the 7-12 kg shrubs. However, if one considers these data in terms of new growth balanced against mortality, these numbers are probably highly significant considerations in the growth dynamics of mesquite.

Table 3. Biomass mortality resulting from activities of node borers (Bostrichidae) on randomly selected mesquite shrubs from the playa fringe in 1972.

Estimated Plant Biomass (kg)	g wood killed	% wood killed	g leaves killed	% leaf biomass killed
10.26	50.57	1.5	5.7	1.5
11.85	3.08	.08	2.0	.45
9.32	62.73	2.0	6.6	1.9
8.95	42.97	1.4	5.1	1.5
1.17	9.16	2.3	2.5	5.6
7.72	23.98	.93	3.6	1.2

Biomass of trophic groups

Table 4. Summary of insect biomass on the playa fringe for 1971. Data summarized by host plant species and trophic status. Biomass in g/ha^{-1}.

Plant Species		May		June		July		August		Sept.	Nov.
		27	15	16	30	13	26	10	11	25	6
Prosopis glandulosa	Herbivores	214.3	26.7	79.4	224.7	56.1	153.5	522.6	137.7	142.0	.26
	Predators	11.8	4.0	7.5	0	2.7	0	3.5	15.2	1.6	0
	Detritivores	.25	.11	.08	0	.04	0	.14	0	0	0
Larrea divaricata	Herbivores		.21			.45		.11		.60	.12
	Predators		.12			.03		.02		0	.06
	Detritivores		0			0		0		0	0
Ephedra trifurca	Herbivores	3.2	7.2	2.2	6.1	1.4	4.1	6.3	5.4	5.7	.91
	Predators	.48	4.8	.77	3.8	1.5	.95	1.5	1.8	2.0	.31
	Detritivores	0	0	.03	0	.13	0	0	0	.81	0
Gutierrezia sarothrae	Herbivores							3.4		3.7	
	Predators							.7		4.3	
	Detritivores							0		0	
Yucca elata	Herbivores					.03		0.00			
	Predators					.06		0.01			
	Detritivores					0		0.00			

I.C.2 HIGHLY MOBILE AND GROUND SURFACE ARTHROPODS -- PLAYA

A number of species of large and potentially important insect populations cannot be estimated by pit-fall traps or by D-Vac samples. These insects include crickets, grasshoppers, cicadas, tarantula hawks, carpenter bees and certain lepidoptera. Several techniques using sweep nets were rejected because less than 50% of the flushed insects were captured and secretive insects such as the crickets were not sampled at all. As a consequence we tested a technique which holds promise for arriving at estimates of relative abundance of these (see DSCODE A3UWJ96 for data collection methods).

The census technique is a modification of the flush-distance method used for rabbit populations. Two observers traverse the study site recording the estimated distance to and kind of insect flushed, or the distance to a shrub or other cover from which sounds emerge (cricket chirping or cicada buzz). Estimates based on sound obviously underestimate density but such estimates may be corrected by assuming singing males represent pairs (for example in crickets). For flying insects a corridor 20 m wide was used with observers forming the outer parallel lines providing the sampling unit. Transects were run across the playa validation site in July and early August. These data are summarized in Table 5. Transects were selected to bisect the playa and stratified to sample each quadrat of the fringe area.

Estimates were found to be time-temperature dependent. Early in the A.M., low estimates were obtained because insects had low body temperatures and were less mobile; also in the late A.M.most sought shelter and were not as susceptible to flushing.

The high density of grasshoppers was primarily associated with the favorable condition of *Panicum obtusum* on the playa bottom. *Panicum* retained considerable green vegetative biomass during most the summer. In early August, *Panicum* was over 30 cm tall and supported extremely high populations of microlepidoptera in addition to the grasshoppers. In one transect run in the west exclosure (*Hilaria mutica* area) we estimated 20.8 singing crickets/ha. The Gryllidae appear to prefer the dense and persistant cover provided by tobosa grass clumps.

In summary, density estimates provided by transects coupled with mean dry weight per insect obtained from concurrent samples appear to provide a suitable technique for estimating biomass of a number of difficult-to-sample species.

Table 5. Density estimates (number/hectare) of a variety of insect groups (families) based on flush transects

Family and Common Name	Density July 12	 13	 27	 August 8
Pompillidae - Tarantula hawks	9.0	11.7		2
Pieridae - Yellow butterflies	11.0	5.0		17.0
Microlepidoptera	80.0	50.0	350	1800
Acrididae - Grasshoppers	640	617		400
Gryllidae - Crickets	4	12		2

I.C.3. GROUND BEETLES AND OTHER SURFACE DWELLING ARTHROPODS -- PLAYA

Mark-recapture data were obtained for ground beetles and other arthropods in the pitfall trap grids on the playa. Beetles were marked with individual paint-spot codes and other arthropods were marked with a single paint spot (DSCODE A3UWJ22).

Density estimates for the beetle, *Eleodes longicollis*, are given in Table 5. The May, June and July samples were represented by sufficient recaptures to be reliable. Other arthropods are summarized below in Table 7.

Table 6. Density estimates of *Eleodes longicollis* on the playa validation site, 1972

	April	May	June	July
Density (No/ha)	161	77	35	65

Table 7. Arthropods sampled in playa can traps in a 30-day period

Common Name	Number
Brown spiders	28
Crickets, A	3
B	6
Wolf spiders	16
Tarantulas	7
Millipedes	8
Sun spiders	33
Black Widow spiders	5
Centipedes	3
Tarantula hawks	2
Velvet ants	12
Beetles: *Trox* sp., *Lebia*, *Pyrota*, etc.	110

The most meaningful comments concerning these animals and their relationship can be obtained from the following notes of Dr. Martha Whitson:

ARTHROPOD DATA: CAN TRAPS 1972 June - July Martha Whitson

A complete census of all arthropods in can traps was conducted on June 13, June 21, June 30, July 12, and July 14 for the bajada, and on June 14, June 15, July 12, and July 18 for the playa. In addition, the following were always recorded during June and July during the twice weekly can-trap check for lizards: wolf spiders, tarantulas, beetles, centipedes, millipedes, vinegaroons, scorpions, and sun spiders.

Marking with enamel paint was done for the following: wolf spiders, tarantulas, vinegaroons, and millipedes. Recaptures occurred only for a few tarantulas, causing some question as to whether the paint stays on the arthropod exoskeleton.

It is believed that such a can-trap census is a value for estimating populations of those species that are normally hole dwellers or that feed primarily by going into the holes of their prey. It should be possible to assess the total grid environment in terms of the total number of such holes or cavities available. The percentage of can traps occupied out of the total number of can traps available should give a good estimate for the total grid. This data could also be of value in comparing the relative abundance of these species on the playa and bajada.

The various species are represented as voucher specimens in the lab of Tony Smith. Below a short explanation of each species is given. Data collected are presented on the following pages.

A. Wolf spiders--apparently only one species was represented. A marking program was conducted from June 2 to July 7 when it was discontinued; either the paint was not remaining on the spiders, or it was actually killing those that were painted, for only one recapture occurred and fewer and fewer spiders were found. The spiders were removed from the trap each time and placed at least 10 ft. from the trap. It appears that a wolf spider is a permanent resident of a can trap, for they have an elaborate system of tunnels for at least 6-8 inches in the dirt below the trap into which they retreat when disturbed. Also, the only recapture was found 7 days after first marked in the same can trap.

B. Tarantulas--none of these were seen in May or early June. Of the nine marked, two were recaptured, both in the same can trap of their first capture. The paint on both recaptures, however, had faded considerably.

C. Millipedes--none appeared in the can traps during May or early June. No recaptures occurred, and perhaps the paint fades rapidly on millipedes.

D. Vinegaroons--three were captured and marked on the bajada. None were found in the cans during May.

E. Sun spiders--several had been observed on both the playa and bajada in May.

F. Scorpions--several were seen at both sites during May. In addition, from 10-15 were found below the soil surface in early May when the can traps were dug out on the playa.

G. Garden spiders--this is a small, black spider with white and red markings on the abdomen, and is represented in the collection. None appeared at either site until mid-July. They were web spiders, and were not removed from the traps.

H. Black widows--these were common at both sites in May. These were not removed from the traps.

I. Centipedes--none were found during May.

J. Tarantula hawks--apparently these crawl into the traps after prey as they were common during the entire time from May-July, especially on the bajada. They cannot survive in the traps over a day or two, as most found were dead.

K. Mutilidae--the large species with a solid red abdomen were the only ones found. None were found in May or early June.

L. Miscellaneous beetles-- genera listed in Table 6. These were usually discovered within a few days of a large rain, and were much more common on the playa bottom. Of all the species presented, only *Trox* sp. had been observed in May or early June.

M. Small, brown spiders--these appeared to be all of one species, and were the most common arthropod on the can traps. Due to their abundance and to the fact that they lived in permanent webs in the can traps, they were not removed from the traps, but rather a count was made during sampling (Table 6). They were more common on the bajada, and occurred during May at both sites.

N. Crickets--three species were found: Species A, black with white lines on each side of the thorax; Species C, solid black and larger than A; Species B, small and light tan with grey markings. All are in the collection. Species A and B occurred infrequently in May, and Species C was not seen until mid-June.

The appearance of certain species was correlated with the first summer rains, especially tarantulas, millipedes, vinegaroons, centipedes, mutilidae, miscellaneous

I.C.4 TERMITES -- PLAYA

Termite activity was studied using modifications of two methods described by Nutting (1972). In order to evaluate the activity of termites on the surface and potential food material available to termites, we selected points at random stratified to insure adequate representation of the entire site. These points were used as the center of a 0.5 m radius circle. All of the wood or other suitable food for termites was collected, identified and weighed. Active surface colonies were also recorded. These samples were collected at monthly intervals (June, July, August).

In June we also established a series of toilet paper grids on the playa and bajada. These grids were 10 m x 10 m containing 100 rolls per grid. The grids were checked at monthly intervals and each roll was recorded on grid sheets as to presence and numbers of termites in the roll, or if there was evidence of termite activity.

Sampling stations and active termite colonies are shown in Fig. 1. The playa fringe had a mean wood weight of 8.93 kg/ha that would be suitable as food for termites. There was considerable variance in the amount of wood available in each quadrat plus or minus one standard deviation (mean wt · quadrat^{-1} = 11.46 ± 21.6). In June there was no surface activity in any of the plots (Fig. 1 and Table 8). Surface activity in these termites (*Gnathamitermes perplexus*, identified by Dr. Floyd Werner) is related to soil surface moisture. In July two of the sampling quadrats had active encrusting termites and in August three of the quadrats had surface activity (Fig. 1). The absence of active termites in some samples was probably related to the absence of food. However, the sample plots having surface-active termites were not the plots with the most wood on the surface.

Table 8. Wood weight and active termites on the surface at the Jornada playa site, 1972

Date	$\bar{x}$ wood wt/m^2 ± SD	Number of Surface Active Termites/m^2
June 7	4.52 ± 4.01	0
July 11	14.04 ± 25.28	2.34
August 1	25.70 ± 41.73	31.2

The toilet paper grids provided data on surface activity and spatial distribution of termite activity on the playa fringe (Table 9). Grids at 10 and 26 are in clay-sand soils with scattered clumps of tobosa grass (*Hilaria mutica*) and few shrubs. In June these plots had few termites and low activity. Plot 26 where there was little ground cover

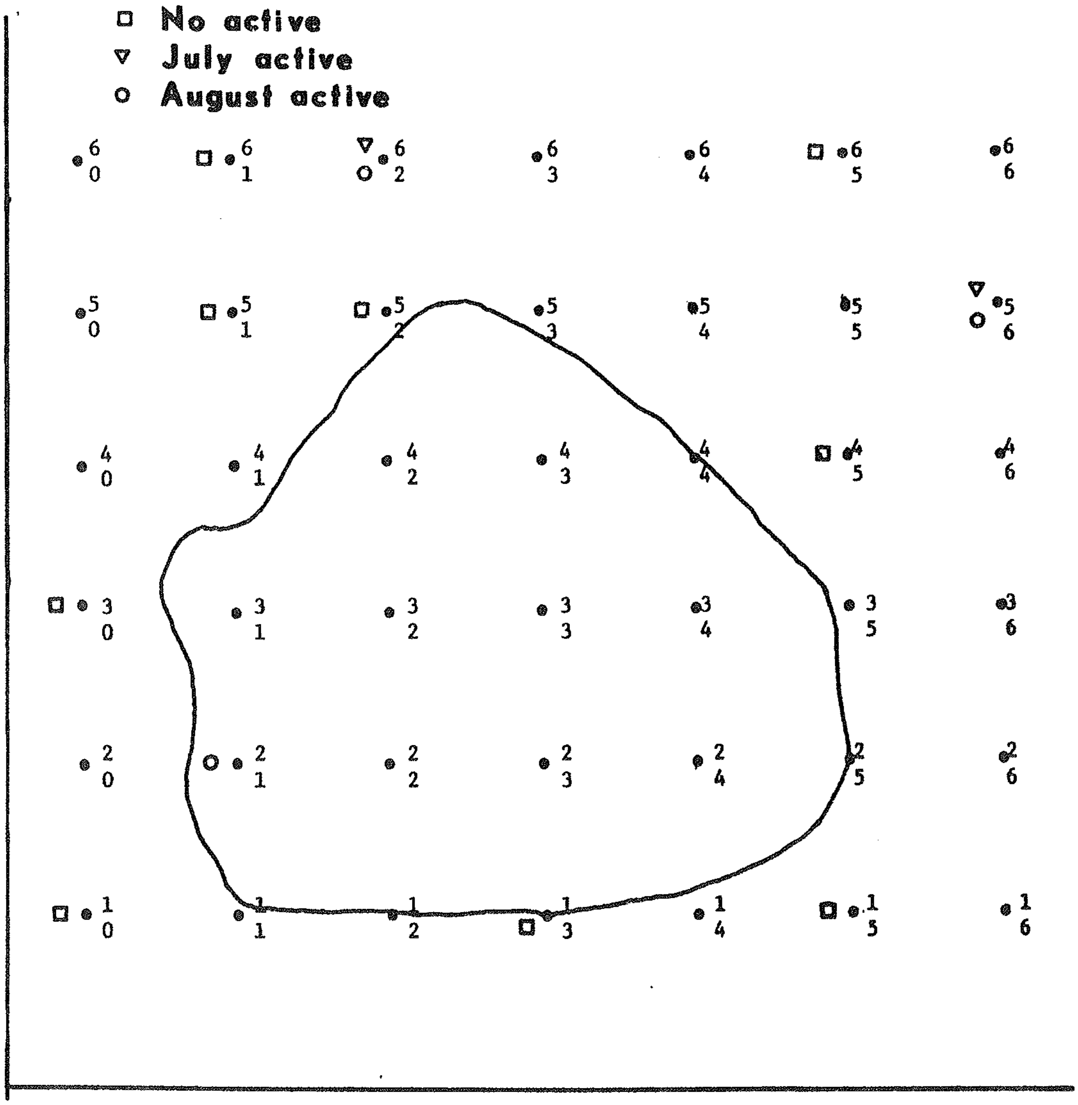

Figure 1. Location of sampling stations for presence of wood and active termite colonies on the playa site, 1972.

Table 9. Termite activity as evaluated by toilet paper grids on the playa, 1972, where percent rolls is based on rolls exhibiting feeding by termites and number = number of termites

Grid Marker	61		10		26		65	
Date	% Rolls	Number	% Rolls	Number	% Rolls	Number	% Rolls	Number
7 July	26	124	12	40	2	9	61	936
21 July	59	218	47	802	32	184	75	211
9 August	51	1,232	52	938	18	0	93	1,193
21 September	75	1,150	90	782	40	5	98	2,485
4 October	84	1,083	71	312	37	40	98	823

exhibited low activity throughout the season. On the other grids termite activity peaked when soil moisture and soil temperatures were high. Based on these data, we could expect that in areas with sufficient wood, termite densities at the surface might approach 10,000/ha. In addition to recording distribution and relative intensity of termite activity, we will attempt to arrive at figures for feeding rates based on the weight of paper removed by termites.

Literature Cited

Nutting, W. L. 1972. Colony characteristics of termites as related to population density and habitat. U.S./IBP Desert Biome Research Memo. RM 72-34.

I.D. VERTEBRATES -- PLAYA

1. REPTILES AND AMPHIBIANS

Lizards (DSCODE A3UWJ13)

With the exception of the horned lizards, *Phrynosoma* sp., and fence lizard, *Sceloporus magister*, lizards were sampled by pit-fall traps. Each lizard captured was identified by a unique toe clip, weighed, sexed (if possible), and released. Other reptiles were hand captured as encountered and the requisite data recorded.

In one sampling period in June, we attempted to apply a paint mark to lizards captured in the pit-fall traps and then, by walking flush transects, obtain mark-recapture estimates using sighted paint-blotch lizards as recaptures. While we encountered problems with this technique due to sloughing of skin etc., if applied with caution, we feel this technique may provide more reliable estimates of lizard density than can be obtained from pit-fall recapture studies only.

The data from pit-fall traps and our qualitative observations in three years of study indicate that *Cnemidophorus tigris* is the most numerous and potentially most important reptile on the playa fringe (Figure 1). This species feeds by searching through litter under shrubs, using its snout to root through debris and breaking termite castings. The high biomass and high metabolic rate of this species suggest that *C. tigris* may rank with birds in importance as an insectivore.

The population density of *C. tesselatus* crashed in 1971 and failed to recover in 1972 (Figure 1). The high density of nearly 20/ha in 1970 followed two years of above-normal rainfall (Houghton, 1972). This suggests that *C. tesselatus* may be able to co-exist with *C. tigris* when moisture conditions are favorable but that *C. tesselatus* is unable to tolerate drought conditions. *C. tigris* exhibited population increase or stability even over the 1971 drought.

The population estimates of *Phrynosoma cornutum* varied little between 1970 and 1972. Density estimates in this species are difficult because horned lizards do not have a home range or territory but rather wander at random over an area that exceeds 30 ha. Our estimates are based on Lincoln Indexes calculated on the basis of area worked by crews reporting horned lizard captures. A density estimate of 4/ha is probably fairly accurate since it was obtained at a period of peak activity of horned lizards and IBP field workers. That estimate was based on recaptures and a sampling period of 25 days. At this density, these lizards could have a significant impact on the population dynamics of harvester ants, removing an estimated 10% of the forager population of *Pogonomyrmex rugosus* (Edwards and Whitford, in press).

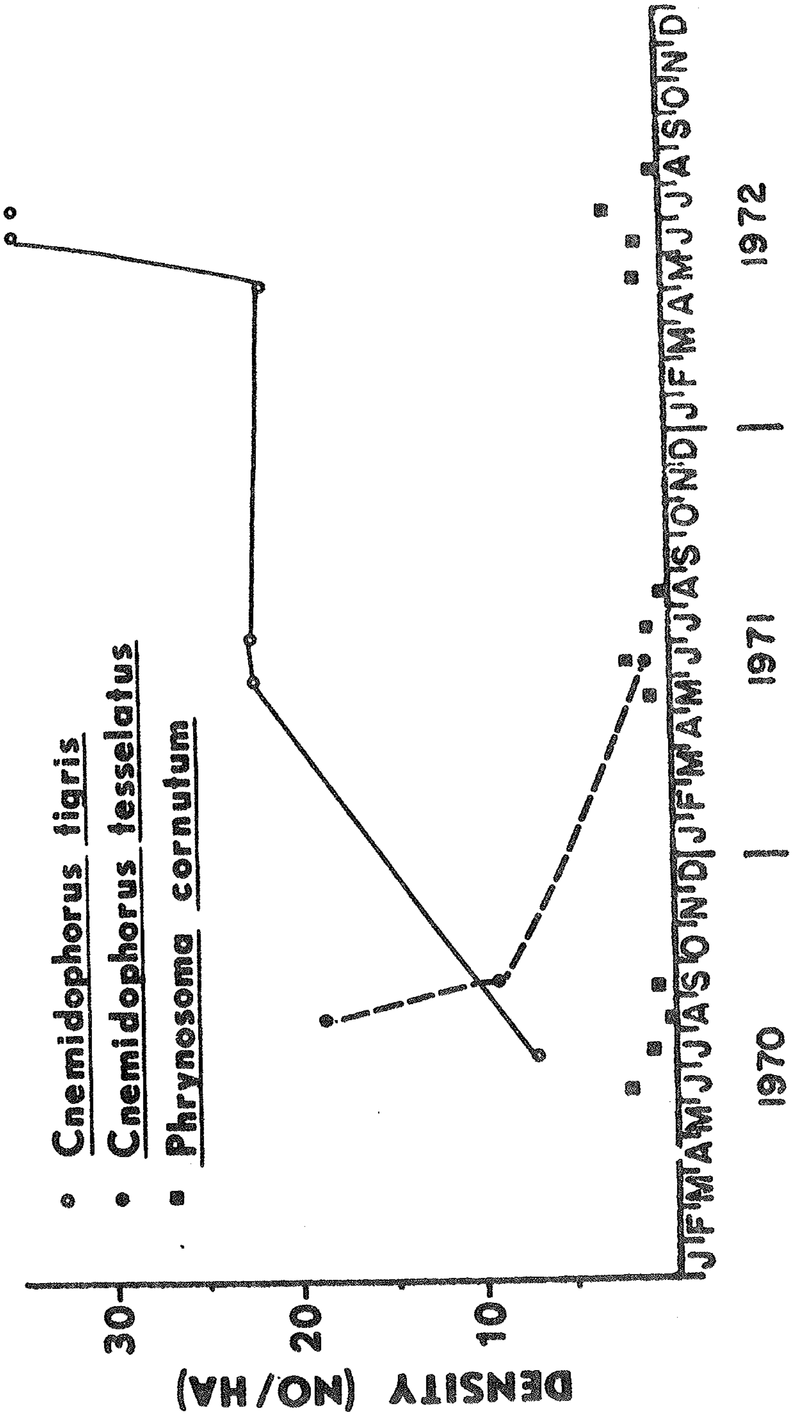

Figure 1. Fluctuation in densities of three species of lizards on the playa site.

Table 1. Changes in density estimates and biomass of lizard populations on the playa fringe in 1970, 1971 and 1972 (LW = live weight, DW = dry weight)

Pre Peak

	1970					1971					1972				
Months	6	7	8	9	10	5	6	7	8	9	5	6	7	8	9
Cnemidophorus tigris															
Density(no/ha)		7.2					22.5	22.7			21.4	35.0	35.2		
$\overline{x}$ wt. (gms)		16.5	18.5	2.0		11.3	18.2	17.5		8.8	20.2	17.0	16.5	16.2	12.0
Biomass (LW)		131.6					409.3	466.7			431.5	594.3	580.8		
Biomass (DW)		39.6					122.8	140			129.5	178.3	174.2		
Cnemidophorus tesselatus															
Density(no/ha)			18.7	8.0			1.3								
$\overline{x}$ wt. (gms)			17.1	11.5	4.5	3.8	16.3	19.0		1.4	8.5	12.7	20.4		
Biomass (LW)			319.4	92.0			21.2								
Biomass (DW)			95.8	27.6			6.4								
Phrynosoma cornutum															
Density(no/ha)	2.0	1.2	.21	.69		.21	2.3	1.3	.21		.99	.93	4.0	.1	
$\overline{x}$ wt. (gms)	30.0	36.9		12.9		41	36.1				25.1	32.1	41.8	38.0	
Biomass (LW)	60.0	44.3		8.9		8.2	82.8				24.8	29.9	167.2	3.8	
Biomass (DW)	18.0	13.3		2.7		2.5	24.8				7.5	9.0	50.2	1.1	

In each year of this study the adult *Cnemidophorus* and *Phrynosoma* disappeared in early August nearly coincident with the appearance of the young of the year. This phenology has been reported by numerous workers yet the causes remain obscure. We have some evidence that in *P. cornutum*, hatchlings prefer the same ants as do adults. This was not expected because of the great size difference between adults and hatchlings. If that feeding preference is confirmed during this coming year, it would support the hypothesis that adults entering hibernation at a period of peak food availability reduces intraspecific competition. An alternate hypothesis is that when reproduction is complete, adults store fat as rapidly as possible, then retreat to hibernation. This would reduce predator mortality and insure a larger breeding stock for the next year. If we consider the adult primarily as a reproductive unit, this is an attractive hypothesis (Table 1).

A special effort was applied to estimating density and mapping *Sceloporus magister*. This species lives in the large mesquite clumps (*Prosopis glandulosa*) on the playa fringe and appears to favor these clumps (Figure 2). The only *S. magister* captured away from mesquite clumps were hatchlings. *S. magister* captured in clumps were primarily large adults, indicating that adults of this species probably live several years, with nearly 100% mortality of hatchlings and suitable habitat limiting population size.

Populations of *Uta stansburiana* have not reached densities sufficient for population estimates. Tinkle (1961) reported high population densities of this species in areas with similar vegetation but where *Cnemidophorus* densities were not high. It is possible that interaction with *Cnemidophorus* limits *Uta* populations in this area.

Snakes

Snakes captured at the playa site are listed in Table 2. This could be called the "year of the snake" on the Jornada because the number of these delightful reptiles encountered this year exceeds the sum of those encountered in previous years.

Rattlesnakes were active around the playa from May through July. One *C. viridis* was recaptured on the road near South Well, approximately 3.2 km east of the playa 45 days after its previous recapture. We can probably assume that the numbers of snakes captured represent minimum densities since most individuals were recaptured several times. Therefore we could consider these numbers/30 ha. The most numerous species around the playa were mammal predators, e.g. rattlesnakes and gopher snakes. Two species are lizard predators, e.g. *Masticophis* and *Salvadora*. *Hypsiglena* is largely insectivorous and *Heterodon* is primarily an anuran predator.

Table 2. Snakes captured on the playa study area during 1972

Species	Total number Captured	Number Recaptured
Crotalus atrox (western diamondback)	2 .07	1
Crotalus viridis (prairie rattlesnake)	5 .17	5
Pituophis melanoleucus (gopher snake)	3 .1 .03	0
Masticophis sp. (coachwhip snake)	2 .07	0
Salvadora hexalepis (patchnose snake)	2 .07	0
Hysiglena torguata (night snake)	1	0
Heterodon nasicus	1 .03	0

Anurans

Anuran species were picked up in pit-fall traps from mid-June through October. Adult anurans were actively foraging until the playa flooded in July. *Bufo debilis* was the only species captured from 15 June to 7 July. From 7 July on we captured nearly equal numbers of *Scaphiopus hammondi* and *Bufo debilis*. These two species represent the playa fringe anurans. *Bufo cognatus* and *Scaphiopus couchi* which breed in the flooded playa apparently overwinter and forage in some other habitat.

Reptiles--General notes and comments

Periodic walking transects were made on the playa and bajada sites to obtain data on emergence times of reptile species.

22 February - 1430-1600 hr. Air temperature = 24 C. No lizards were seen at either the playa or bajada.

11 March - 1000-1400 hr. Air temperature = 26 C. One *Uta stansburiana* at the edge of the playa at 1100 hr. This lizard was very active. No survey of bajada.

14 April - 1030-1230 hr. Air temperature = 18 C. No lizards seen on the playa edge. One *U. stansburiana* active at NW corner of bajada site.

2 May - 1330-1500 hr. No lizards seen on bajada. Temperature = 28 C. 1100-1300 hr. three *C. tigris* seen at east and south grids on playa.

6 May - 0945-1200 hr. Temperature = 26 C. One *C. tigris*, SE area of bajada grid. 1230-1330 hr. Two *C. tigris* active on north grid of playa.

Dr. Martha Whitson also provided a summary of lizards brought by roadrunners to their young at a nest in Las Cruces between March 16 and March 30. In this time period the roadrunners collected 15 *Uta stansburiana*, 20 *Cnemidophorus tigris*, and one each of *Phrynosoma modestum*, *Sceloporus magister*, *Phrynosoma cornutum*, and *Holbrookia texana*. Thus these species must have had limited activity in March.

I.D.2 BIRDS -- PLAYA (DSCODE A3UWJ16)

In 1972 the timing and methods of census of birds on the playa were revised from those used in 1971. A weekly schedule was adhered to as closely as was feasible throughout the year. The method used was basically the strip census method of Emlen (1971). A standard route was walked on each census effort and all birds seen were counted and their distances from the observer and the census line estimated. The route is 1600 m long, following a square pathway around the perimeter of the playa bottom. Full adherence to Emlen's method requires that a Coefficient of Detection (CD value) be calculated for each species seasonally. We now have sufficient data to permit calculation of C.D. values, and Stuart Pimm of our group and Dr. Charles Romesberg, Utah State University, have developed a computer program to do the sorting and arithmetic; but processing of the data is not complete and so the data given herein are counts uncorrected for variation in detectability.

For the sake of completeness and of breadth and significance of conclusions, data for both 1971 and 1972 are included in all Figures and Tables presenting census results. All data on numbers and biomass are given as monthly means. The total number of species included in censuses has reached 69; obviously too many to list each species separately. Accordingly, we devised the following system of groupings of ecologically similar species: breeding species (BS), including those primarily insectivorous species which breed on the area; Mourning Doves and Scaled Quail (DQ) and raptors (RS), which are given special separate status because of their distinctive diets and because they are year-round residents (most of the BS group are summer residents); non-breeding insectivorous species (OI); non-breeding seedeaters (SE), primarily finches and sparrows; aquatic species (AO), ducks and shorebirds that appear when the playa is flooded; and a small residue of miscellaneous species (MS).

The data for numbers of birds treated in these ways are given in Table 3 and biomass estimates based on the numbers are given in Table 4. The numerical results are given in graphical form in Figures 2 and 3.

Using results of May censuses of both years as the best measures, it is obvious that breeding densities were higher in 1972 than in 1971. For the insectivorous breeding passerines (BS) the numbers were 41.0/100 ha in 1971 and 66.1 in 1972. If quail and doves and raptors present in May are assumed to be breeding and thus included, the contrast between years is even greater; combined numbers were 44.5 vs 79.4 birds/100 ha and corresponding biomass figures were 22.2 vs 105.8 g/ha. The same kind of difference was found for most of the other species categories for most of the other months for which results may be compared. It seems certain that the higher rainfall in 1972 was indirectly responsible for the higher densities of that year. Seed-eaters, insectivores, and raptors all apparently responded to increases in productivity at lower trophic levels with perhaps the greatest increase among the seed-eating doves and sparrows.

Seasonal variations are also noteworthy. The general trend, as indicated by the rows of overall totals of both Tables 3 and 4, was for both numbers and biomass to reach their peak in the non-breeding season. The highest densities in 1971 were in August; in 1972 they were in September but levels were high from August through December (and continue high into 1973). Comparison of the graphs reveals that in 1972 (when more months were included), the high densities of fall and winter were largely accounted for by high numbers of doves and quail and of the OS group. These seed-eaters may well have responded to the high production of seeds in and around the playa itself which received an exceptionally large amount of water in late summer and autumn of 1972. Seed production also may have been responsible, albeit indirectly, for the relatively high densities of raptors in September, November and December. Certainly, the presence of standing water in the playa in August and September was the determining factor in the added presence of an aquatic category.

Efforts were made in both 1971 and 1972 to locate as many nests as possible and to determine their outcome. Results of these efforts are summarized in Table 5. As already described, the density of birds in the breeding season in 1972 was higher than in 1971 (18 vs 13 pairs). The discrepancy between years was higher in terms of nests attempted and even higher in the number of successful pairs. The conclusions to be drawn from these comparisons are that under conditions of drought (as in 1971) the number of resident pairs is moderately reduced, that only a small number (31%) even attempt to nest, and that their nests tend to be unsuccessful. The result is negligible reproductive recruitment. A corollary of these conclusions is that breeding season density is not a very accurate indicator of the effects of drought upon desert bird populations.

Comparison of results from the playa with those of the bajada and of other areas will be found in the section on bajada birds (II.D.2).

Table 3. Monthly mean playa bird densities (birds/100 ha), 1971-1972

Species Category *	May	July	Aug.	Dec.	J	F	M	A	M	J	J	A	S	O	N	D
B S	41.0	30.6	30.6	1.4	6.9	6.3	14.6	11.1	66.1	53.7	60.4	38.0	5.6	2.8	8.3	2.8
O I	13.9	0.0	2.8	0.0	1.4	0.7	2.8	2.8	5.0	2.8	5.6	15.7	23.6	8.3	1.4	0.0
S E	6.9	8.3	0.0	63.9	8.3	14.6	13.2	13.9	0.0	7.4	11.1	109.3	384.7	397.2	316.7	478.7
D Q	3.5	30.6	47.2	1.4	0.0	0.0	0.0	2.8	6.1	21.3	20.1	413.9	190.3	75.0	93.1	45.4
R S	0.0	0.0	2.8	4.2	0.0	0.0	0.7	2.8	7.2	0.0	0.0	1.9	4.2	0.0	6.9	3.7
A Q	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	162.5	2.8	0.0	0.0
M S	0.7	1.4	0.0	1.4	0.0	1.4	1.4	2.8	3.3	0.9	0.0	9.3	18.1	2.8	0.0	0.0
TOTAL	66.0	70.8	83.3	72.2	16.7	22.9	32.6	36.1	87.8	86.1	97.2	588.0	788.9	488.9	426.4	530.6

* See text for explanation of categories.

Table 4. Monthly mean playa bird biomass (g live wt/ha), 1971-1972

Species Category *	May	July	Aug.	Dec.	J	F	M	A	M	J	J	A	S	O	N	D
B S	18.0	13.4	13.4	0.6	3.0	2.8	6.4	4.9	29.0	23.5	26.5	16.6	2.5	1.2	3.6	1.2
O I	2.8	0.0	0.6	0.0	0.3	0.1	0.6	0.6	1.0	0.6	1.1	3.1	4.7	1.7	0.3	0.0
S E	1.9	2.2	0.0	17.3	2.2	3.9	3.6	3.8	0.0	2.0	3.0	29.5	103.9	107.2	85.5	129.2
D Q	4.2	36.1	55.7	1.7	0.0	0.0	0.0	3.3	7.2	25.1	23.7	488.4	224.6	88.5	109.9	53.6
R S	0.0	0.0	27.0	40.6	0.0	0.0	6.8	27.0	69.6	0.0	0.0	18.4	40.6	0.0	66.7	35.7
A Q	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	421.2	7.3	0.0	0.0
TOTAL	26.8	51.8	96.7	60.1	5.5	6.8	17.3	39.5	106.7	51.2	54.3	556.1	797.4	205.9	265.9	219.8

* See text for explanation of categories.

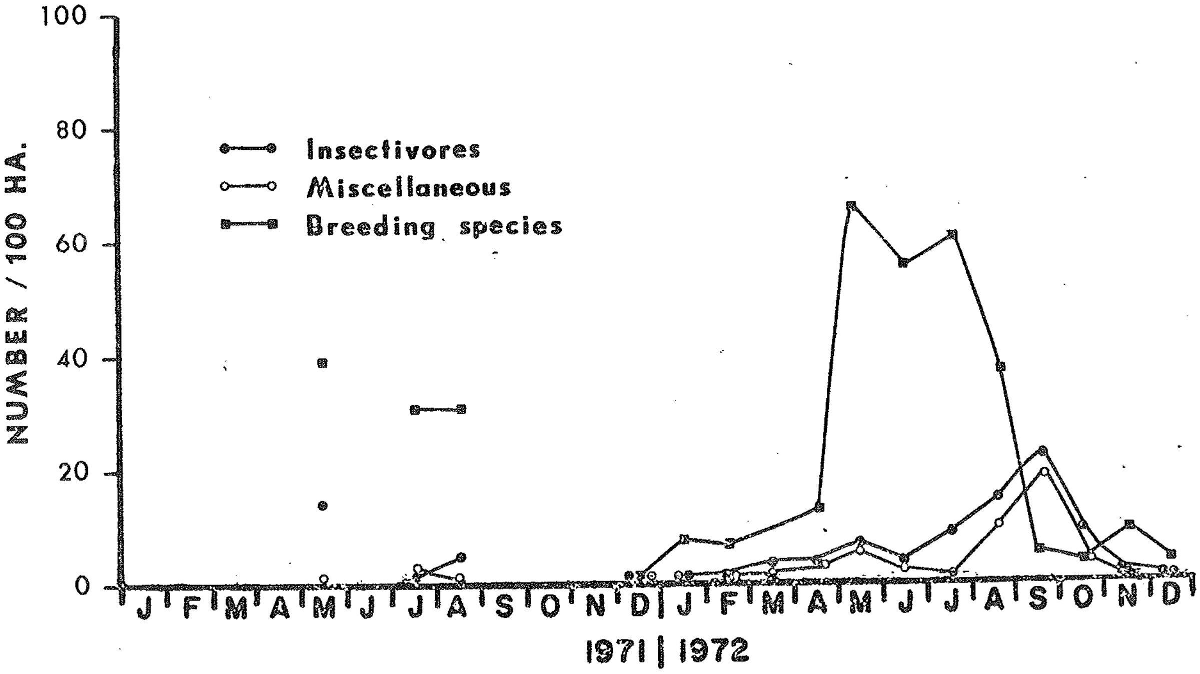

Figure 2. Mean monthly density of breeding species, non-breeding insectivores, and miscellaneous species, playa 1971-1972.

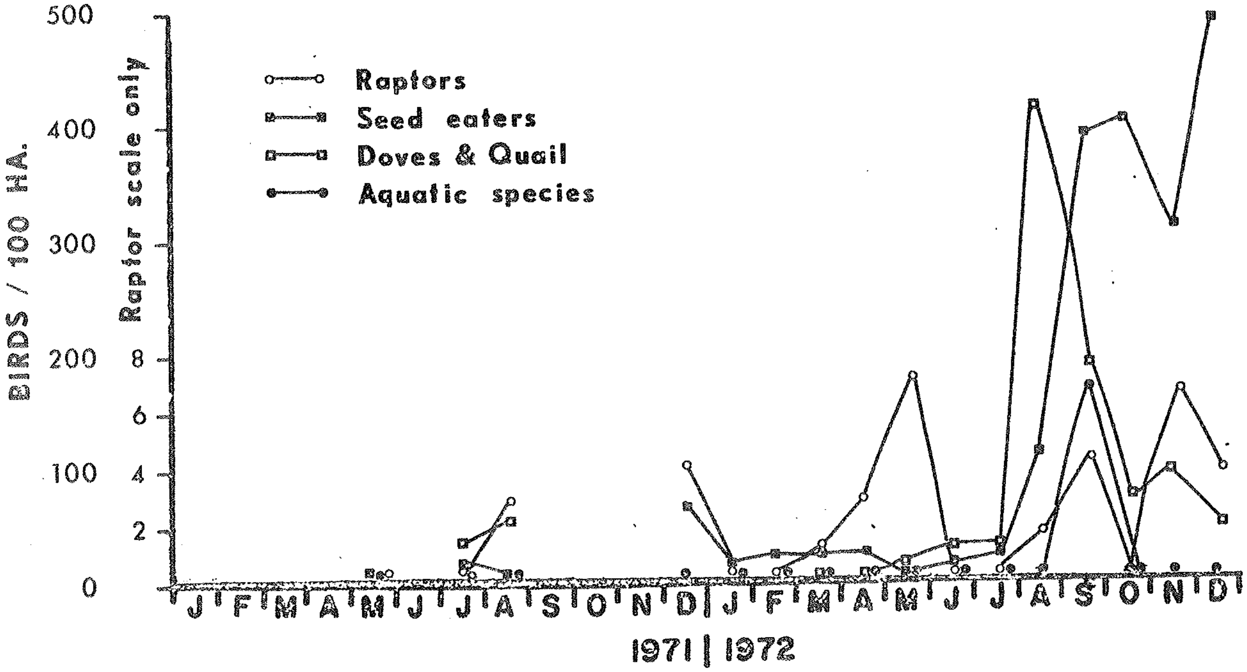

Figure 3. Mean monthly density of doves and quail, non-breeding seed-eaters, aquatic species, and raptors; playa 1971-1972.

Table 5. Nesting results, playa 1971-1972

No. Pairs:	Present		Nesting		Successful	
Species	1971	1972	1971	1972*	1971	1972*
Scaled Quail	1	2	0	1+	0	1
Cactus Wren	2	1	2	1(2)	1	1
Loggerhead Shrike	2	2	1	2	1	2
Mockingbird	2	3	1	2(3)	1	2
Crissal Thrasher	0	1	0	1(2)	0	1(2)
Scott's Oriole	2	2	0	2(3)	0	2
Western Kingbird	2	2	0	2(3)	0	2(3)
Ash-throated Flycatcher	0	1	0	0	0	0
Say's Phoebe **	0	1	0	1	0	1
Meadowlark sp.	2	1	0	1	0	1
Black-throated Sparrow	2	2	0	1+	0	0+
	13	18	4	14(19)	2	15(17)

\+ Indicates that probably the figure was higher than indicated but that firm evidence is lacking.

* Figures in parentheses indicate numbers of nests in a given category. These are higher than the numbers of pairs because some pairs nested twice.

** Say's Phoebe nests very early and may have been overlooked in 1971.

I.D.3 RODENTS -- PLAYA

Mark-recapture estimates of rodent densities on the playa site were made in February, April, June, and November on the four grids established in 1970 (see Whitford and Ludwig, 1971, for diagram and location of grids). Each 50-trap grid was trapped for three consecutive nights to provide two nights for precensus and one night for census at each census period. Based on the 1971 trapping program, we found that few additional animals were picked up by additional trap-nights. Two traps were placed at alternate trap stations and rotated to the single trap station on successive days. Traps were baited with cracked milo. Population estimates were obtained by the Lincoln Index. This estimator was used because Ettershank (1973, manuscript submitted), in a study of the efficiency of population estimators using computer simulated animal populations with varying natality and mortality, showed that the only multiple recapture estimator that was reliable was the Jolly method and that the Lincoln Index provided as reliable an estimate if computed for each trapping period.

To assess the reliability of our grids in providing an accurate estimate of densities of mammals over the entire site, we conducted long distance movements in *Dipodomys merriami*, and re-examined a mark-recapture study using four traps at 10 m intervals in each direction at each large grid post (see Fig. 4). The grid was trapped for three consecutive days (June 6-8).

Due to the large number of pack-rat nests (>80) in the base of mesquite bushes (*Prosopis glandulosa*) around the playa, we decided to conduct an exhaustive trapping program with large traps to check on the reliability of our estimates of population densities of *Neotoma albigula* from trapping grid records. Consequently we intensively trapped the south and west perimeter of the playa, placing two traps per nest and trapping for three consecutive nights. We trapped a total of 60 nests for a total of 360 trap-nights (DSCODE A3UWJ11).

The most significant changes in rodent populations in 1972 were the low densities of all species in the first half of the year followed by recoveries of the populations of *D. merriami* and *Perognathus penicillatus* and the explosive increase in *Sigmodon hispidis* (Table 6). The 1971 drought apparently resulted in the virtual absence of recruitment of young in the populations of rodents and possibly a higher mortality rate in the adult population. A more complete analysis of the 1971-72 data should provide the basis for support of this hypothesis. Corrected biomass values for 1971 appear in Table 7.

Population fluctuations in *D. merriami* since the initiation of validation studies are summarized in Fig. 5. Peak populations early in 1970 followed two years of above-average rainfall which included above-average spring and winter precipitation (Houghton, 1972), e.g., 1968 = 13.17 inches, 1969 = 11.91 inches. In 1970 there was a virtual absence of rainfall from January until July. The peak population in June, 1970, reflects addition of juveniles to the population. The mid-summer crash to a density of approximately 13/ha from 74/ha undoubtedly reflects density-dependent mortality due to limited food supply. Summer rains in 1970 produced a good seed crop, allowing some population recovery. Peaks in 1971 represent juveniles entering the population. Drought conditions in 1971, further limiting food supplies, drove the population to very low density.

Population fluctuations of the bajada population followed the pattern of the playa population except that there was a greater peak in early summer, 1971, in the bajada population. This probably reflects differential reproductive success due to differences in food bases of the two populations. *D. merriami* has been shown to utilize *Larrea divaricata* seeds as a primary food source (Gaby, 1970). *Larrea* responds quickly to summer rains by flowering and fruiting and consequently is a more reliable food source than the seeds of annual grasses and forbs on which the playa population would be dependent. The 1971 drought conditions undoubtedly contributed to the drop in densities of less than 10/ha in both populations in the winter of 1972. Under more favorable conditions the density of the bajada population would probably have dropped to no less than 20/ha. Considering these relationships, we hypothesize that *D. merriami* on the bajada will return to a winter density of ≅ 20/ha (while the playa will exhibit a population of about 10/ha).

The marked increase in population density of *Sigmodon hispidis* was entirely due to the recruitment of young of the year. During 1970 and 1971, *Sigmodon* density was very low and this species was considered insignificant. The moist conditions of spring and early summer, 1972, provided an adequate supply of high quality grasses which supported high reproduction and survival of young. *S. hispidis* has been reported to feed primarily on green plant parts and to prefer grasses and grass seeds (Fleming, 1970; and Fleharty and Olson, 1969). The population data and climatic data for the playa area suggest that in wet years *S. hispidis* could be an important consumer. Moreover, (Petryszyn and Fleharty, 1972) found that *S. hispidis* clips a considerable amount of vegetation that is left in unconsumed piles. Continued studies of the *S. hispidis* population in tobosa swale areas of the playa site should provide further insight into the relationship between climatic factors and the population dynamics of this species

The trapping at the grid posts on the playa study area was conducted one week before the census of the trapping grids, which allowed use of both sets of data to examine long distance moves in *D. merriami*. About 1/3 (34%) of the animals recaptured more than once had made moves in excess of 100 m in the 10-day period (Fig. 4). The longest straight line move was in excess of 500 m and the average between 250 m and 300 m. These data were obtained prior to the peak of the growing season and may reflect foraging forays. The percent of the population making long distance movements and the distances involved were similar to 1971.

These movements do not represent dispersal movements because animals return to original traps apparently moving over large areas and utilizing more than one burrow. French, et al.,

(1968) referred to these movements in kangaroo rats as dispersal. The marked reduction in long distance movements in *D. merriami* on the bajada (see section II.D) in late summer suggests that long distance wandering may be in response to a scattered food source. These movements do provide a source of error in all population estimators except perhaps the Lincoln Index when pre-census and census are made on successive days.

The trapping grid design apparently provides an accurate estimate of the composition of the rodent fauna over the playa validation site. The spatial relationships and specific habitat preferences of the rodent species was discussed previously (Kay, 1972). *Perognathus flavus* and *Dipodomys spectabilis* each accounted for 4% of the rodents trapped on the whole playa area and *Perognathus penicillatus* accounted for 9% of the rodent population.

Reproduction in *D. merriami* showed two peaks in 1972 with juveniles entering the population in early spring and in the summer. Pregnant females were abundant in the April census preceding the entry of summer juveniles into the population (Fig. 6). Males have scrotal testes over much of the year and some receptive animals are found in the population at nearly all sampling periods. This pattern has persisted in both wet and dry years and may be characteristic of *D. merriami* (Bradley and Mauer, 1971; and Reynolds, 1960). This absence of synchronized breeding cycles in *D. merriami* suggests an interesting reproductive adaptation. The presence of receptive females and reproductive males in the population during most of the year insures that the population can respond to rainfall events outside the "normal" summer rainfall season. Reproduction under these conditions provides additional recruitment to the population which might be extremely important in preventing crashes in years with apparent rainfall patterns like 1971.

The intensive trapping effort for *Neotoma albigula* demonstrated that most of the 80+ woodrat nests counted around the periphery of the playa were abandoned. A total of seven animals were captured in the 360 trap nights. Two animals were recaptured in the same location as initially trapped. Six were adults and one immature. The mean live weight of the adults was 244.7 g (range 195 to 308 g). In the suitable habitat available, e.g. mesquite clumps of sufficient size, the density of woodrats averages approximately 1/ha.

While mesquite bushes provide suitable habitat for woodrat nests, the vegetation around the playa is marginal to supply the water requirements of these animals. Lee (1963) showed that *N. lepida* required succulent vegetation such as prickly pear cactus and creosote bush to satisfy its water needs. Cacti are virtually absent around the playa and creosote bush is sparse. Mesquite bark probably provides succulent tissue only during the growing season, and early spring de-barking of mesquite is probably due to the activity of *Neotoma* and *Sylvilagus*. The vegetation along the feeder arroyos on the bajada appears to provide a more complete habitat for woodrats. Intensive studies of woodrat populations on the bajada may be conducted in 1973.

Table 6. Density (no./ha), live weight (LW) biomass (g/ha), estimated dry weight (DW) biomass (g/ha) and standing crop (kcal/ha) of rodent species on the Jornada (Chihuahuan Desert) playa validation site in 1972

			Pre	Peak	Post	
		February	April	June	August	November
Dipodomys merriami	Density	4.7	5.0	5.3	11.7	3.0
	Biomass (LW)	196.5	226.5	215.9	470.8	291.63
	Biomass (DW)	59.0	68.0	64.8	141.2	87.5
	Standing crop	393.1	453.1	431.7	941.6	583.0
Dipodomys ordii	Density	0.44	*1	0.44	3.3	*2
	Biomass (LW)	23.2		19.3	165.2	
	Biomass (DW)	7.0		5.8	49.6	
	Standing crop	46.5		38.5	330.4	
Perognathus penicillatus	Density	*1	*2	*7	4.8	2.0
	Biomass (LW)				80.6	15.0
	Biomass (DW)				24.2	4.5
	Standing crop				161.3	30.0
Sigmodon hispidis	Density	*1	*1	*1	4.0	28.0
	Biomass (LW)				186.0	117.2
	Biomass (DW)				55.8	35.06
	Standing crop				372	234.13
Mus musculus					*1	*1
Neotoma albigula				*5	*5	
Onychomys torridus					*1	
Perognathus flavus			*5	*12	*3	
Perognathus intermedius			*3	*1		
Peromyscus maniculatus				*1	*2	
Reithrodontomys megalotis				*2		

* indicates total number of animals captured in sampling period

Table 7. Corrected values, based on Lincoln Index, for rodent biomass on the playa for 1971.

	1970								1971						
	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Jan	Mar	Apr	May	Jul	Sep	Dec
Dipodomys ordii																
Density		1.0	1.0	1.5	.33	.16	.16	.50	.67	2.5	1.4	.50	3.3	4.6	15	.16
Biomass		52	52	78.5	15.5	7.8	9.7	29	32	128.5	71	27	163	184	27.5	10.9
Dipodomys spectabilis																
Density			.16	1.6	.84	.67	3.4	1.3		.84	.50	1.5	27	1.5	1	
Biomass			23	23	87	65	524	162	23	107	62	242	264	172	150	
Perognathus penicillatus																
Density		.16	.16	1	22	1.3	1.5	.8	3.4	.3	1.5	.3	6.4	10.6	8.4	
Biomass		3.0	3.0	19	39	20	23	15	50.4	4.3	23	5.0	89	.38	97	
Peromyscus maniculatus																
Density		14	3.2	13.8	1	.3	5.6	1.2	.8	7.3	4.7	2.4	3.5	.16	.16	
Biomass		424	98.4	416	14.7	7.9	144	33	19	140	108	47	60	5	2.7	
Sigmodon hispidus																
Density										.3		.67	.3	.5	.16	
Biomass		16						17	12	33		67	35	74	29	
Onychomys torridus																
Density							.16	13			.16	.16	.3			
Biomass							3.2	6.3			4.0	4.0	7			
Perognathus flavus																
Density				1	1.7				.5	.16	1.9	.3	21	7.7	.8	
Biomass				10	13		2.4		3.5	1.1	13	2.4	45	48.3	7.0	
Neotoma albigula																
Density		.5		.5	.5		.3	.16	.16	1		.3	.5		.67	.16
Biomass		.2		71	82		21	23	15	144		74	157	24	70	40
Reithrodonotomys megalotis																
Density			.16							.6		.3	2	.5	.16	
Biomass			1.3							6.3		3.9	16	4.0	2	
Dipodomys merriami																
Density		5.55	5.4	9.4	4.5	2.4	5.5	6.8	5.9	4.0	4.8	2.6	10.0	18.2	17.8	2.5
Biomass		268.1	251.2	452	193.5	92.1	244	299	238	168	201.8	100.2	444	818.6	817.4	111

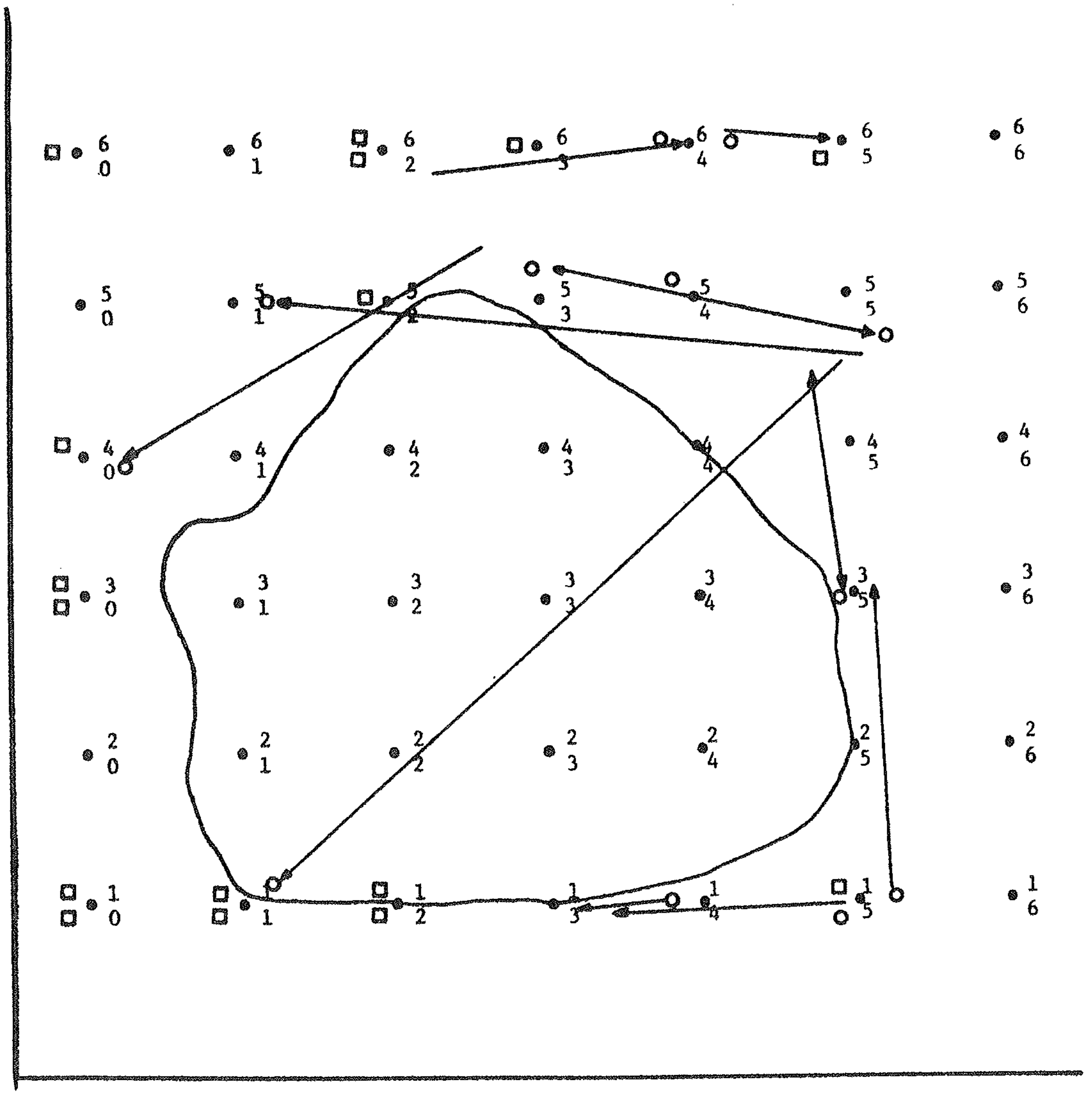

Figure 4. An assessment of movements of individual *Dipodomys merriami* on the playa, June 1972. Circles indicate *D. merriami* making long distance moves; squares represent animals taken at the same hectare marker.

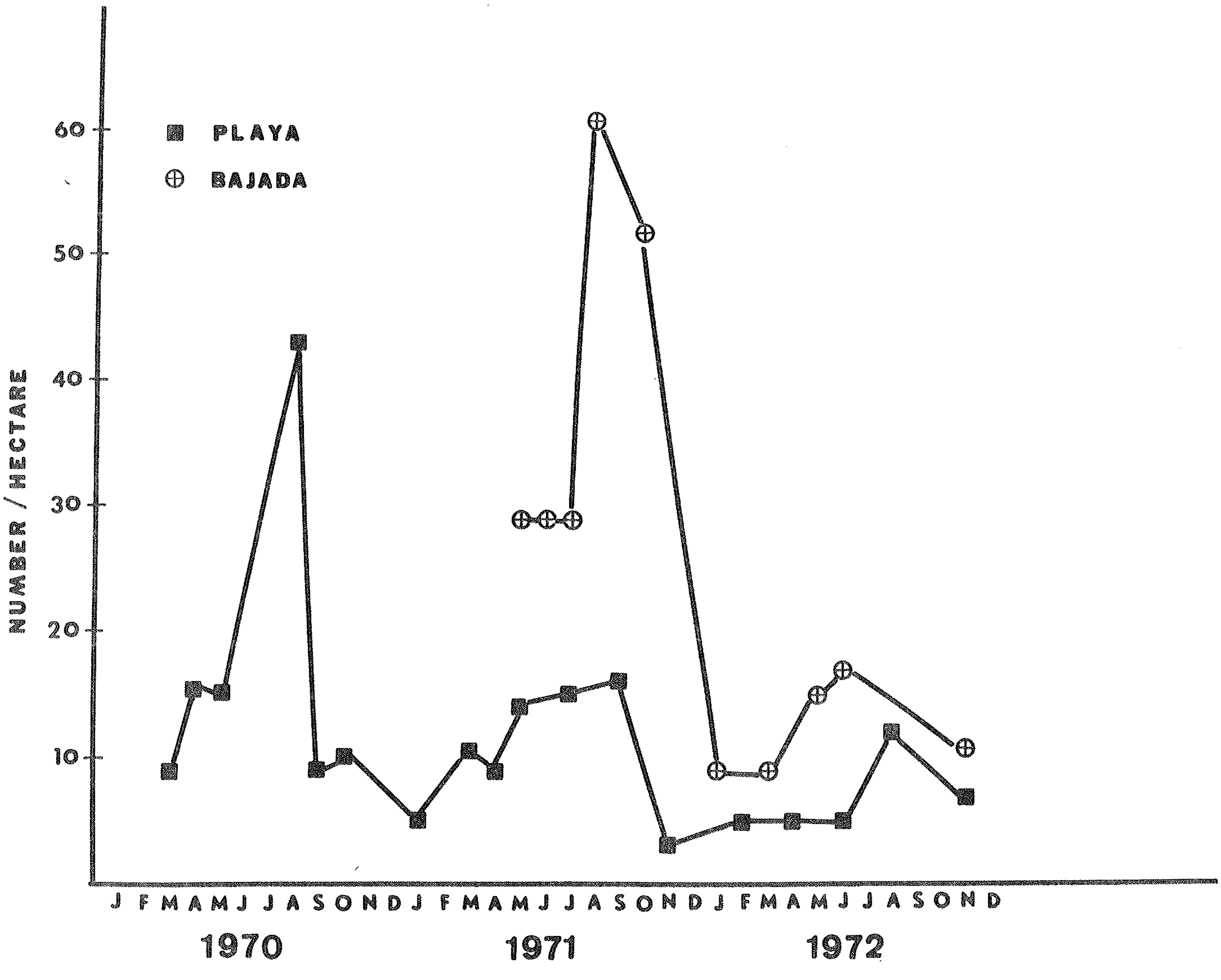

Figure 5. Comparison of fluctuations in the estimated population density of the *Dipodomys merriami* population on the playa and bajada areas, 1970-1972.

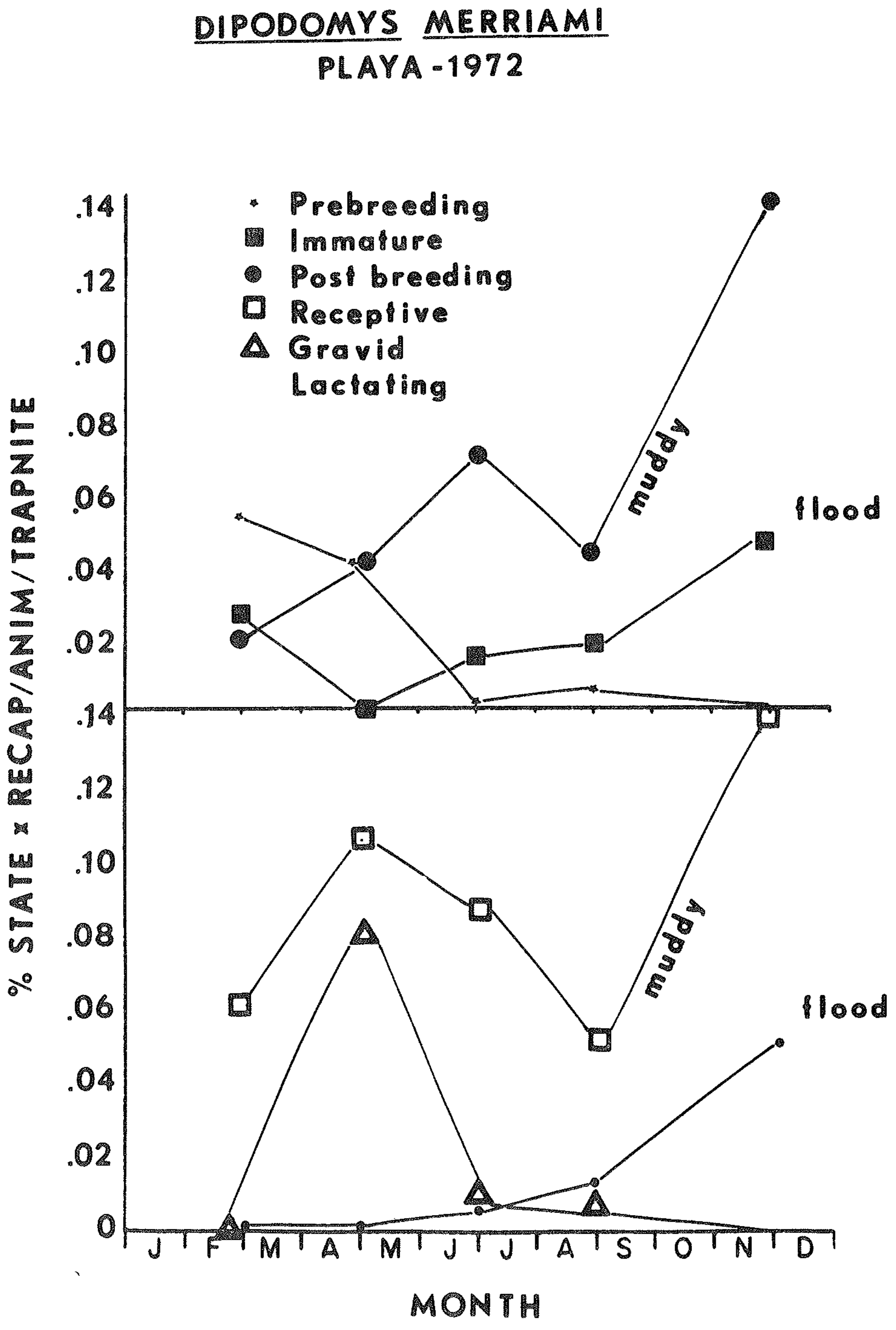

Figure 6. Reproductive characteristics of the *Dipodomys merriami* population on the playa site (1972).

An indication of the shape of the survivorship curve for a species can be obtained from examining the length of time individual animals remain in the trapable population. This parameter should be fairly reliable when derived from a regular trapping program such as that used in our studies. When the percent of total number of animals of a species was plotted against months in the trapable population (Figure 7) we find that Chihuahuan Desert rodents exhibit a type III survivorship curve. In *D. merriami*, 55% of the animals trapped only once were juvenile or non-breeding adult size animals, 17% were pregnant or lactating and 28% were scrotal males or receptive females. This composition was similar in the other species. Less than 5% of the *D. merriami* and less than 8% of all other species remained in the trapable population for more than three months. As in other populations of rodents, juvenile mortality and emigration probably account for the disappearance of most of these animals. No animals of any species remained in the trapable population for more than two years.

An estimate of the maximum natural life expectancy can be obtained from Table 8. *D. merriami* and *P. maniculatus* both approach two years as maximum ecological life expectancy. The other rodent species appear to have ecological life expectancies of 1 to 1.5 years.

Table 8. An estimate of ecological life expectancy: maximum length of time any individual remained in the trapable population of playa rodents

Species	Maximum number months in trapable population
Dipodomys merriami	22
Dipodomys ordii	17
Dipodomys spectabilis	14
Neotoma albigula	12
Perognathus flavus	14
Peromyscus maniculatus	21
Perognathus penicillatus	19
Reithrodontomys megalotis	9
Sigmodon hispidus	8

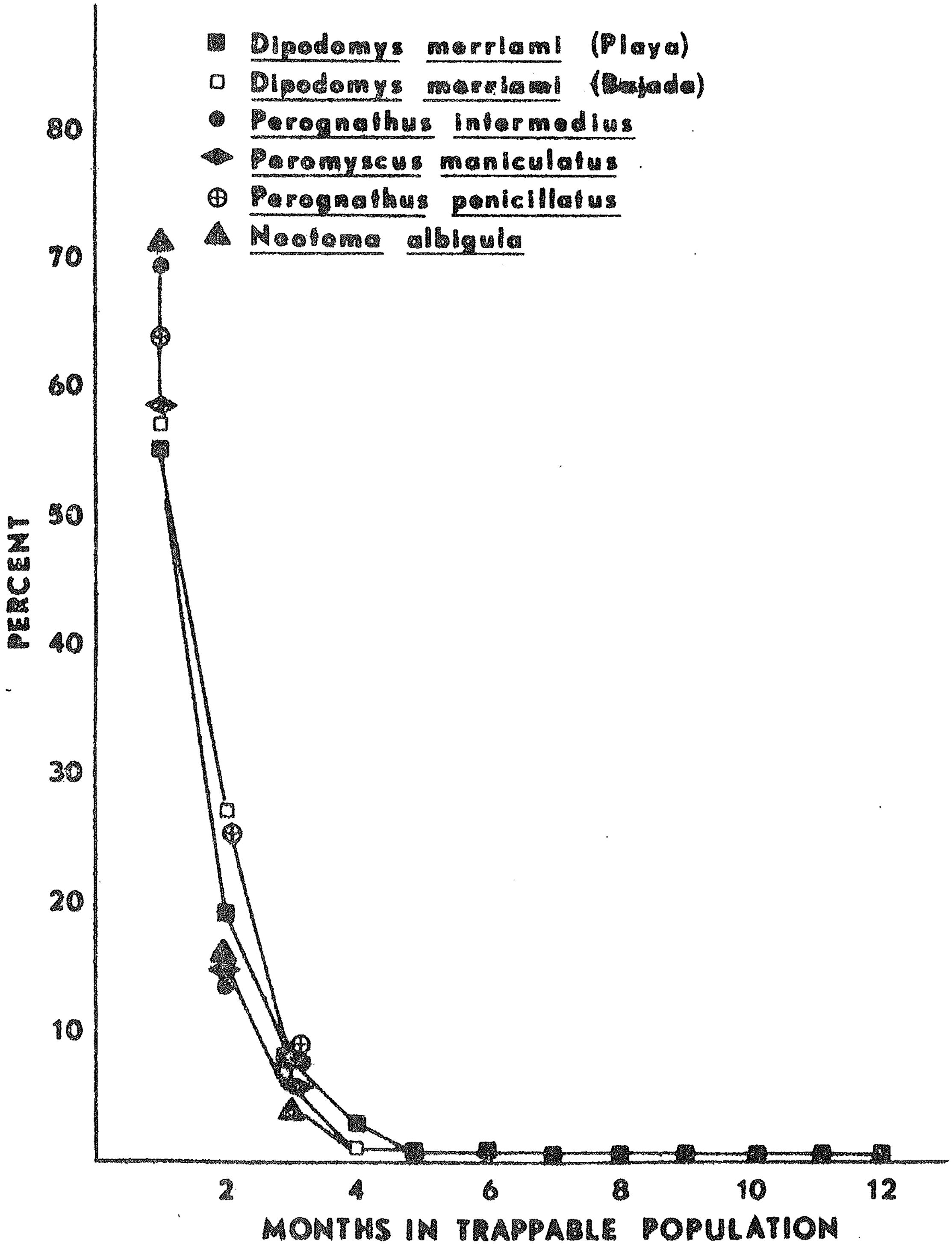

Figure 7. Comparison of survivorship curves for several species of Chihuahuan Desert rodents based on mark-recapture data for playa and bajada sites, 1971-1972.

Survivorship comparisons

An estimate of survivorship can be obtained by recording the length of time animals remain in a trapable population. If we assume that emigration = immigration, then the length of time a given animal remains in a trapable population indicates its ecological life span. This measure is probably accurate for animals in the population for at least two months. The disappearance of individuals trapped only one time may overestimate juvenile mortality but probably not significantly.

Survivorship curves for both the playa and bajada populations of *D. merriami* are presented in Figs. 6 and 7 for comparison. The mortality rate was higher in 1971 than in 1970 in the playa population. Data for 1973 are necessary to obtain an accurate estimate of survivorship in 1972, but the trend appears to indicate higher survivorship in both playa and bajada populations in 1972. Adequate food supplies in 1970 and 1972 would contribute to better physiological condition of *D. merriami* in 1970 and 1972 than in 1971. Food supply probably operates as a factor in survivorship because survivors from a "good year" cohort would be able to call on cached food reserves in a "bad year" that would be unavailable to the cohort of that year. Survival for at least four months thus works to ensure continued physiological superiority because these animals have had an opportunity to cache food, thus should require less forage time and, consequently, lower probability of predation.

The maximum ecological life expectancy of *D. merriami* ranged between 14 months and 22 months (Figs. 8 and 9). In general it appears that populations of *D. merriami* suffer 90%+ mortality within the first three months after emergence from the maternal burrow. Thus density levels are maintained by production of young in most months of the year, a necessary reproductive adaptation for a species with such a turnover rate.

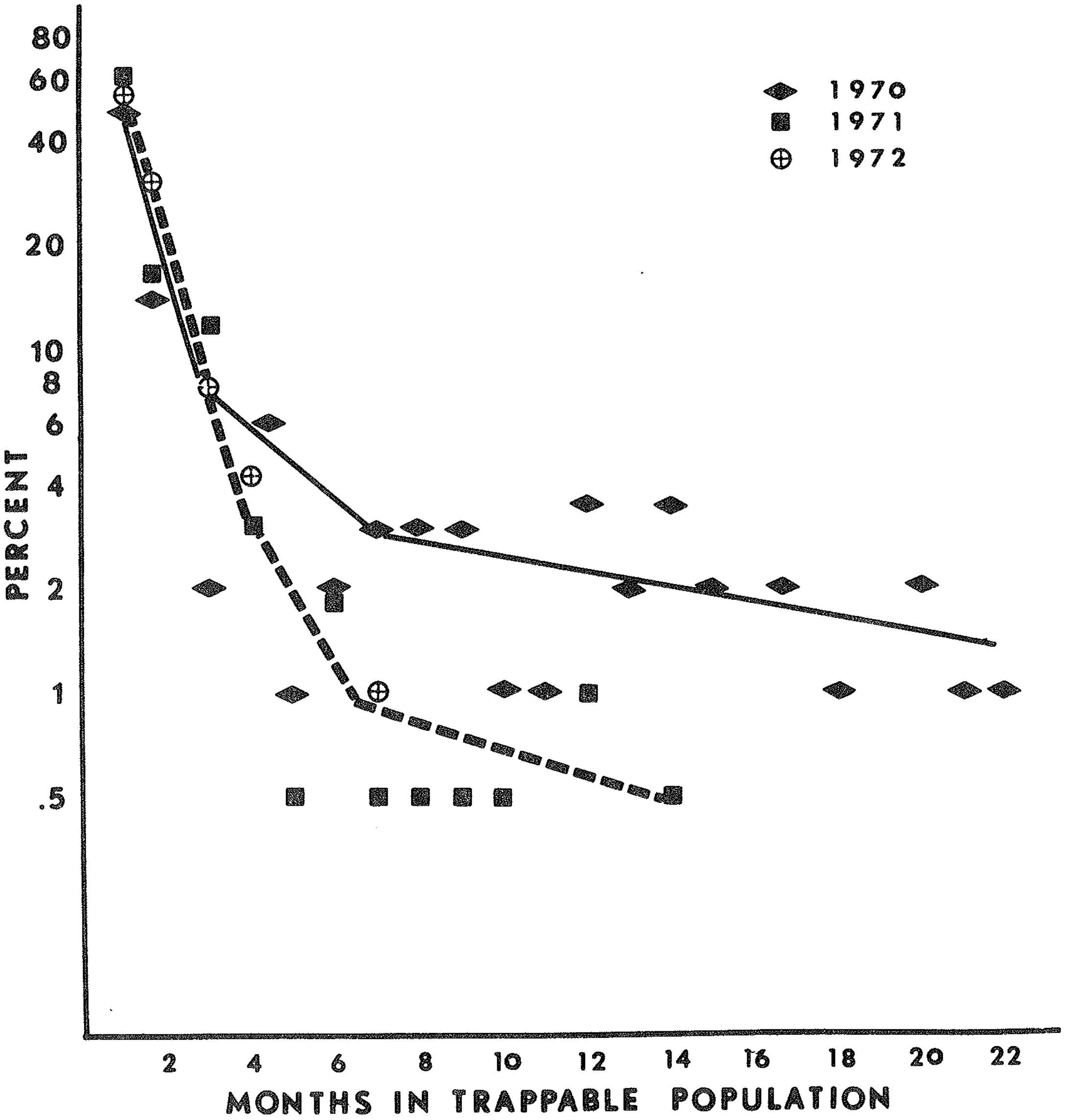

Figure 8. Survivorship in *Dipodomys merriami* population on the playa grid.

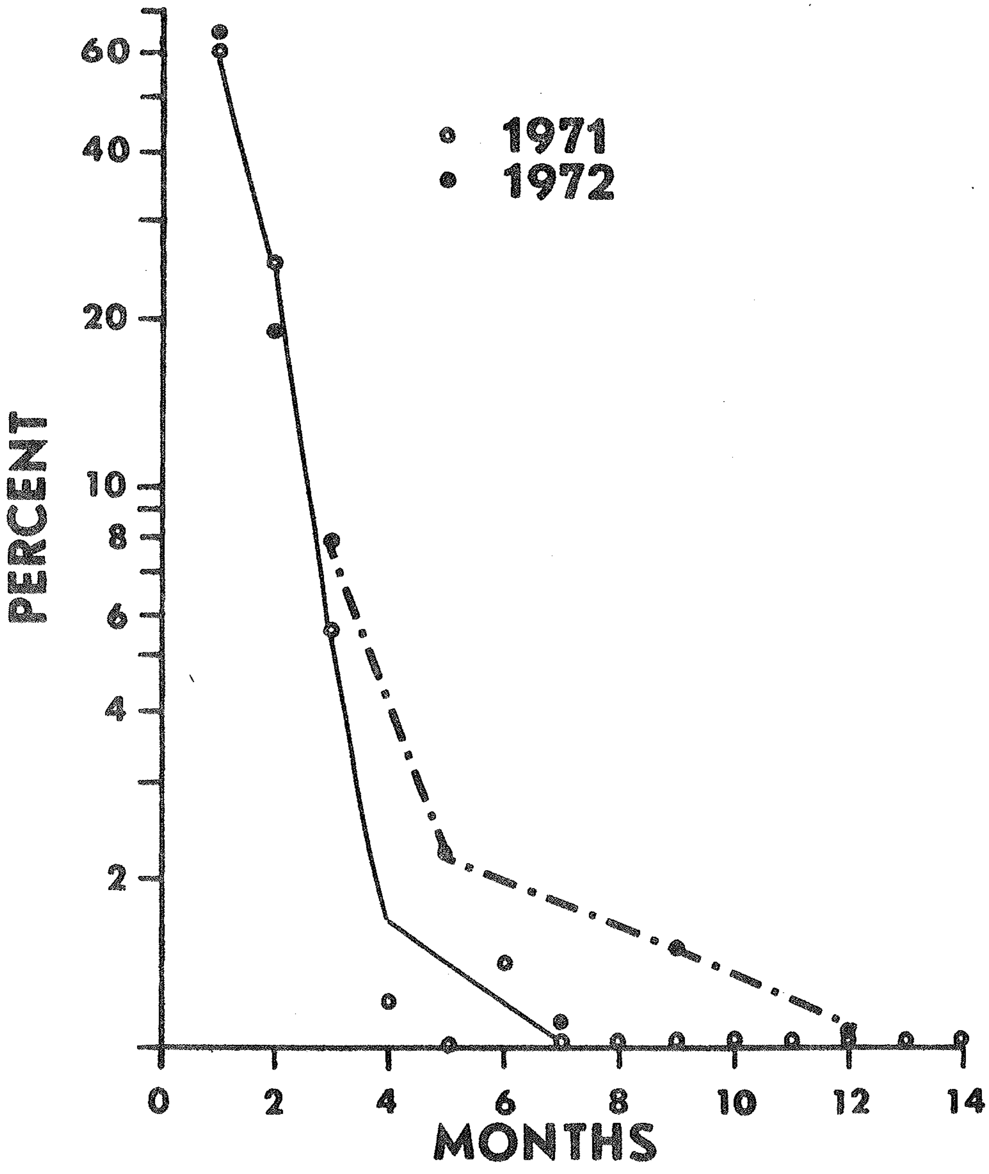

Figure 9. Survivorship in *Dipodomys merriami* population on the bajada grid.

I.D.4 LAGAMORPHS -- PLAYA (DSCODE A3UWJ15)

A strip census flushing technique was used to estimate lagamorph densities. The observer walked around the perimeter of the validation site using the corner posts of the hectare plots to estimate flushing distance and to plot locations of rabbits on the data forms. Density (number per hectare) was computed by the equation $D = (N/2\,\bar{R}L) \cdot 10000$, where N = number of flushes, $\bar{R}$ = mean flushing distance and L = length of line traversed.

The data on lagamorph densities are summarized in Table 9. There was partial recovery of the jackrabbit population from the crash that occurred in the summer of 1971 due to the extremely dry conditions. The most striking feature of the population estimates of the current year is the rapid changes noted in jackrabbit densities when transects were run in close succession. The abundance of both cottontail rabbits and jackrabbits was zero or close to it in August, both in the bajada and playa. We suggest that these marked variations in population estimates may result from shifts of the bulk of the population between feeding areas. There appeared to be cyclic peaks of 2-3 days in duration about every two weeks on the harvester ant area south of the playa. At these times a number of rabbits would be seen feeding in the early morning and flushed from forms later in the day. If this does indeed reflect the bahavior of jackrabbits, density estimates based on single sampling periods must be used with caution when assessing the impact of these animals. We will test this hypothesis if feasible during 1973.

Table 9. Variations in lagamorph densities estimated by flush transects on the playa

	June	July	August	September	October	November	December
				Lepus californicus			
Density	.41	.65	1.0	.4	.14	.44 .90 1.34 .67	.6
				Sylvilagus auduboni			
Density	.34	.21	0	.11	.23		

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I.E. CHEMICAL ANALYSIS

Data have not yet been received from the laboratory. This section will be covered in the report of 1973 research progress.

I.F. SOILS

1. PHYSICAL AND CHEMICAL PROPERTIES -- PLAYA

The playa study area is in the Desert-Soil Geomorphology Project of Soil Survey Investigations, Soil Conservation Service, Dona Ana County, New Mexico. This area encompasses the northeastern part of the Dona Ana Mountains, the adjacent piedmont slopes, and the basin floor where the playa study site is located. The present soil information is derived from data and a soil map provided by Leland H. Gile, Soil Scientist, Soil Survey Investigations, Soil Conservation Service, University Park, New Mexico. The soils of this area are discussed in greater detail elsewhere (Gile et al., 1970; Hawley and Gile, 1966; and Ruhe, 1967).

The physiographic-geomorphic surface areas pertinent to the playa site are the surrounding piedmont slopes of the Dona Ana Mountains and the playa basin. The major slope south of the playa consists of individual alluvial fans and coalesced alluvial fans formed from alluvium derived from the mountains. The slopes are composed of two geomorphic surfaces; the higher elevational Organ with slopes ranging from 10% next to the mountains to 2% on the lower fan piedmont, and the lower elevational Jornada surface with slopes ranging from about 5% to less than 1%. The playa basin contains a third geomorphic surface, the nearly level La Mesa surface. These surfaces are mapped (Figure 1) and described (Table 1). The Jornada and La Mesa surfaces occur directly on the playa study site (Figure 1).

The Jornada surface sediments date from late to mid-Pleistocene. Many of these soils have prominent horizons of silicate clay accumulation, and all have prominent carbonate accumulation horizons commonly within about 61 cm of the surface. The argillic horizons are usually near the surface unless they have been buried by younger deposits. The Jornada surface dominant soils on the playa study site are the Berino and Stellar (Table 1). The Berino occupies the southern, western, and northwestern playa fringe, and the Stellar forms the eastern and northeastern playa fringe (Figure 1).

The La Mesa surface sediments initiated development in mid-Pleistocene. These soils have strong genetic horizons with the carbonate accumulation horizons being most distinctive. In some areas the argillic horizon has been partly to completely carbonate-engulfed, or has been mixed by soil fauna, or both. The playa north fringe and the playa bottom soils are composed of the La Mesa surface, the Dalby taxadjunct on the playa bottom and the Jal-Headquarters complex on the north fringe (Figure 1; Table 1).

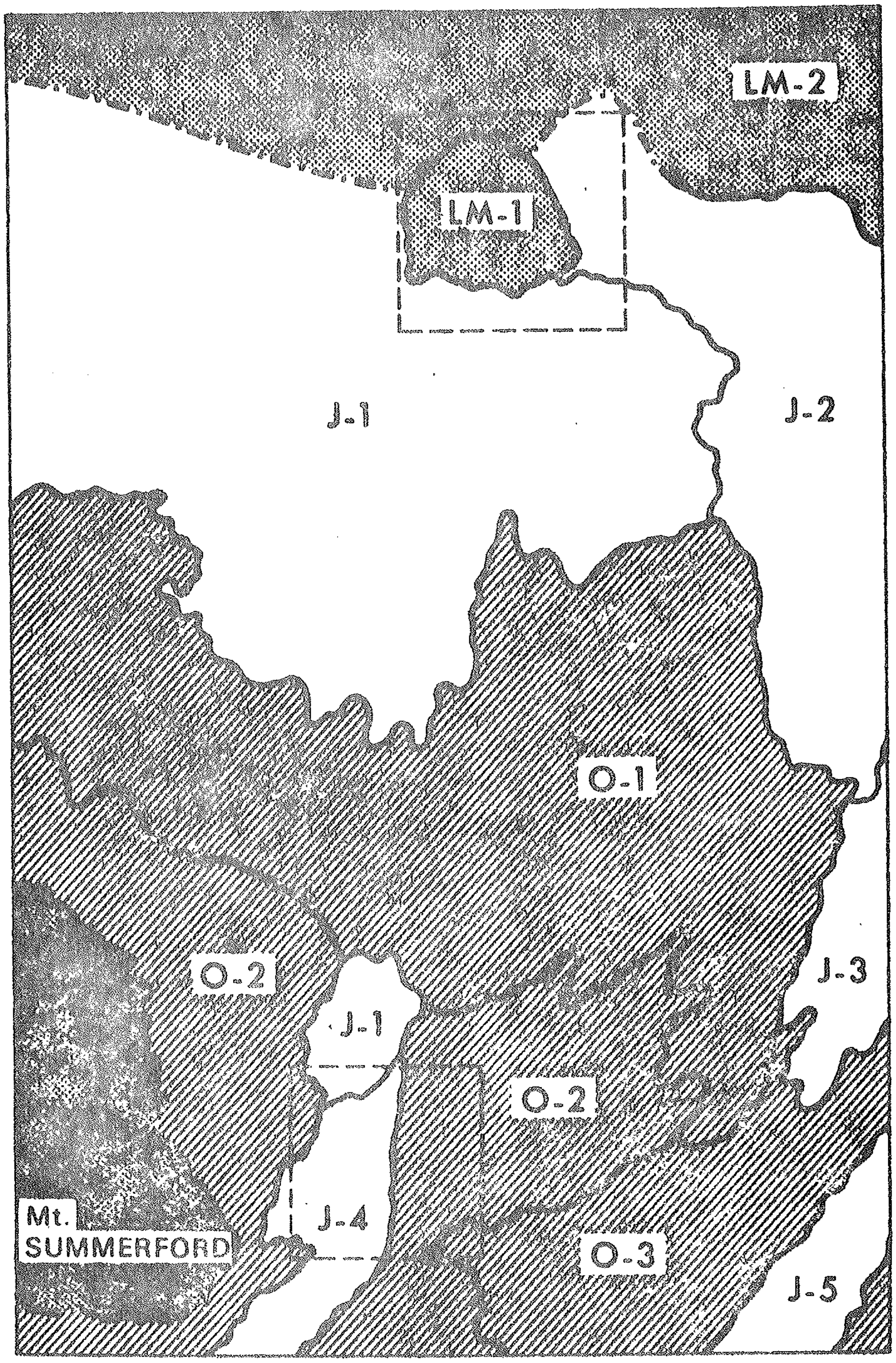

Figure 1. Soil map of the Jornada study area, the playa (upper) site and bajada (lower) site being demarcated. See Table 1 for interpretation of map codes.

Table 1. Dominant soils of the Jornada study site and some of their properties

Surface	Mapping Unit Code	Dominant Soils	Dominant Soil Type	Classification	Usual Reaction with dilute HCl
Jornada	J-1	Berino	sandy loam	Typic Haplargids, fine-loamy	Noncalcareous in upper horizons
Jornada	J-2	Stellar	clay loam	Typic Haplargids, fine	Noncalcareous in upper part of the B horizon
Jornada	J-3	Doña Ana	sandy clay loam	Typic Haplargids, fine-loamy	Calcareous throughout
Jornada	J-4	Jal -	sandy clay loam	Typic Calciorthids, fine-carbonatic	Calcareous throughout
Jornada	J-5	Nickel -	sandy loam to very gravelly	Typic Calciorthids, loamy-skeletal	Calcareous throughout
		Delnorte complex	sandy loam	Typic Paleorthids, loamy-skeletal, shallow	Calcareous throughout
Organ	0-1	Onite	sandy loam	Typic Haplargids, coarse-loamy	Noncalcareous in upper horizons
Organ	0-2	Hawkeye -	sandy loam	Aridic Entic Haplustolls, sandy	Noncalcareous in upper horizons
		Alladin Complex	sandy loam	Aridic Entic Haplustolls, coarse-loamy	Noncalcareous in upper horizons
Organ	0-3	Canutio -	sandy loam	Typic Torriorthents, loamy-skeletal	Calcareous throughout
		Canutio variant Complex	sandy loam	Typic Torriorthents, coarse-loamy	Calcareous throughout
La Mesa	LM-1	Dalby Taxadjunct	clay	Typic Torrerts, very fine	Calcareous throughout
La Mesa	LM-2	Jal -	sandy clay loam	Typic Calciorthids, fine-carbonatic	Calcareous throughout
		Headquarters Complex	sandy clay loam	Typic Haplargids, fine-loamy	Calcareous throughout

I.F.2 SOIL LITTER -- PLAYA

The amount of litter on the soil surface can be estimated directly by the use of areal sampling methods or indirectly by assuming yearly additions from biotic categories and a relatively constant turnover of litter from year to year. In June of 1972, a total of 40 quadrats, each 1 m by 2 m were randomly positioned around the playa fringe. The larger material in the quadrats was collected by hand and the smaller material was vacuumed with a portable hand vacuum cleaner. However, due to a delay in completing the sorting of this voluminous amount of litter material, the data for this 1972 surface litter sampling is not available. Thus to provide some data on surface litter, the indirect method described above will be presented (DSCODE A3UWJ59).

On the playa fringe, the major plant groups and species contributing material to litter each year are the annual forbs and grasses, the small perennial forbs and grasses, small sub-shrubs and large shrubs. The annuals and small perennials will die back each year, thus their total biomass will eventually represent a contribution to the litter compartment. The total biomasses for these categories at different dates in 1971 and 1972 are shown in Table 2. It is evident that the total amount of potential litter from these five plant categories was small in 1971, amounting to less than 2 kg/ha. However, in 1972 the growth of annual forbs was large, particularly in August. The total biomass in the fall exceeded 100 kg/ha. Of the large shrubs on the playa fringe, mesquite is deciduous and thus each year it contributes its total leaf biomass to soil litter. This amounted to 300 kg/ha and 200 kg/ha in 1971 and 1972, respectively (Table 3). Long-leafed mormon-tea also contributed an estimated 50 kg/ha to soil litter in 1972.

On the playa edge, the major species contributing to litter each year is tobosa. In estimating the biomass components of this species, the litter is also collected since the harvest method is used. An examination of Table 15, Section I.B.2, small perennials, playa edge, will show that the litter in July 1971 reached over 4000 kg/ha. In 1972, the peak was found in December at about 3000 kg/ha.

On the playa bottom, the major species contributing to litter each year is vine-mesquite grass. The harvest method is also used on the playa bottom. The results for vine-mesquite litter are given in Table 14, I.B.2, small perennials, playa bottom. In 1971 the peak litter biomass was found in July at about 1200 kg/ha. In 1972 the peak litter biomass was found in April at about 700 kg/ha. However, peak leaf biomass was probably around 1100 kg/ha and the small amounts of litter found reflects rapid decomposition due to repeated flooding of the playa.

Table 2. Above-ground biomass estimates (in g/ha) for annuals and small perennials on the playa fringe in 1971 and 1972*

	1971 October 6	1972 June 27	August 22	October 26
Annual Grasses	85	135	2,435	7,700
Forbs	254	24,800	68,360	42,230
Perennial Grasses	1,090	2,580	19,270	14,520
Forbs	336	13,200	2,660	56,000
Sub-shrubs	2	520	2,300	5,370
Total (kg/ha)	1.77	41.2	95.0	125.8

* These above-ground biomasses will contribute to soil litter in the given year or the next year, depending on the rate of breakage of above-ground to litter.

Table 3. Shrubs contributing their leaf biomass (in kg/ha) to soil litter each given year

Species†	Growth Pattern	1971	1972
Prosopis glandulosa Var. torreyana	Deciduous	300	200
Ephedra trifurca	Evergreen	*	50
Xanthocephalum sarothrae	Deciduous	28	27
Yucca elata	Evergreen	2	8

* new leaf biomass data not available.

† The perennials are assumed to have a complete annual turnover in their new leaf biomass.

I.F.3 MICROBIOLOGICAL STUDIES -- PLAYA

Estimation of microbial population densities

As a result of the drought during 1971, current studies were done on plots which were artificially watered. The water amendments were added over an eight-week period at twice-weekly intervals to a total of 0, 5 and 10 inches. Soil cores from the 0-10 cm horizon were taken at weekly intervals, serially diluted in sterile buffer and plated on standard methods plate count agar (DSCODE A3UWJ30).

Results of these experiments are shown in Figure 2. There was an initial increase in colony-forming units (CFU) which was independent of water amendment followed by a period during which the CFU count remained essentially constant. After July 1 the effects of water amendment were more evident with the 5-in amendment plot showing the greatest increase. However, as can be seen in Figure 2, the range of CFU counts at each water treatment level was within an order of magnitude. Thus water amendment had a relatively minor effect on the microbial population density. In part, this can be attributed to ample rainfall as indicated by the moisture profile (Section I.A.7). It is also possible that the available substrate content of the soil is limited to such an extent that growth is restricted even when soil moisture levels are adequate.

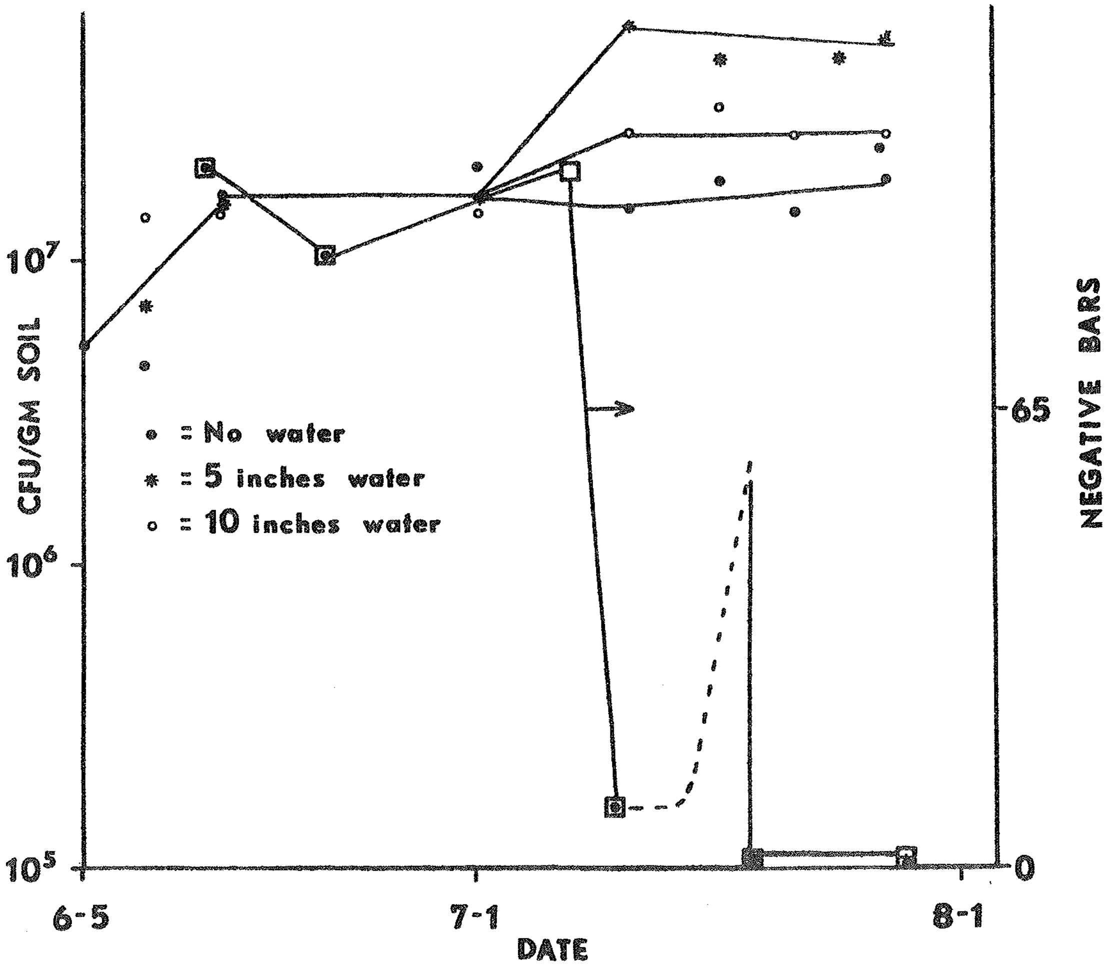

Figure 2. Colony-forming units in playa soil.

I.F.4 SPORE GERMINATION -- PLAYA

Spore germination experiments initiated in 1971 were continued into 1972. Results are summarized in Figure 3. Stations 1 and 5 were not flooded in the July flooding whereas Station 3 was flooded in July and in September. The total plate counts confirm the results shown in Figure 2, since no changes in count were detected during the sampling period. There was a drop in the spore count at Station 3 in late June; however, the count increased during July and was essentially constant during the remainder of the sampling period. We conclude from our results thus far that bacterial spores are quite refractory to nutrient-induced germination.

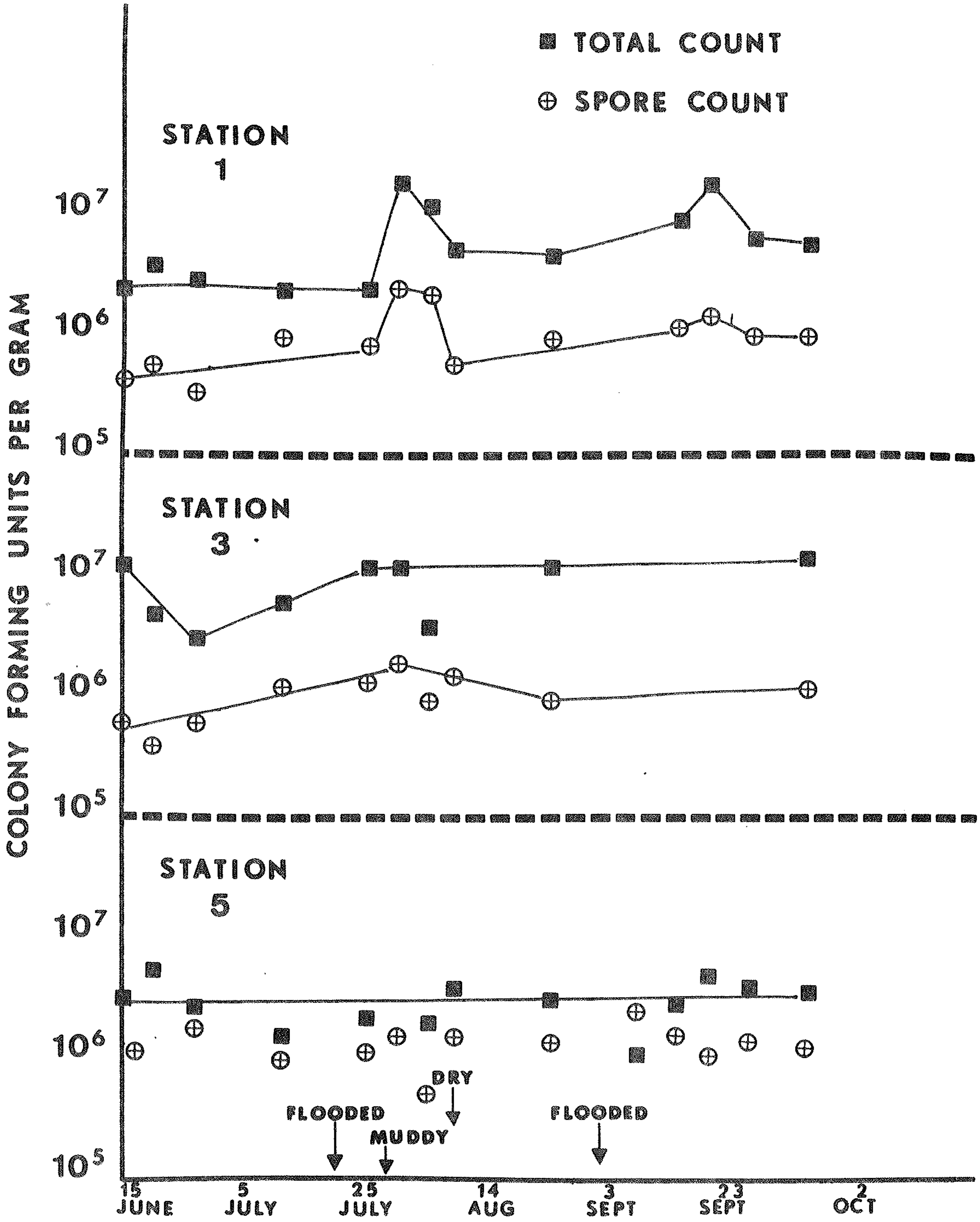

Figure 3. Spore and vegetative cell counts in playa soil.

I.F.5 DECOMPOSITION STUDIES -- PLAYA

Cellulose decomposition experiments were done in the watered plots as described previously. Filter paper (Whatman No. 1) was cut into 10 x 14 cm rectangles and sewn into fine mesh dacron veil material. The bags were buried 5 cm deep in the soil and at 14-day intervals triplicate bags were removed, dried and washed. Decomposition rates were calculated from the differences between the initial and final weights corrected for adhering soil particles.

Results of decomposition experiments summarized in Table 4 show the effect of moisture amendment. The increases in rates obtained in the playa were not as pronounced as the effects seen in bajada soil. This was probably due to the continued high level of soil moisture from rainfall during the experiment. It is interesting that no consistent effect of moisture amendment was noted on soil plate counts (Figure 3) whereas decomposition activity was increased. This result suggests that playa microorganisms were subject to substrate limitation to such an extent that moisture alone was not sufficient to permit measurable growth. However, microbial activity such as cellulose decomposition was apparently a function of available moisture.

Table 4. Effect of moisture on cellulose decomposition

Site	Moisture Amendment *	mg cellulose decomposed per day
Playa	0	36 ± 2.0
Playa	5 in.	44 ± 4.0
Playa	10 in.	49 ± 3.0
Bajada	0	7 ± 1.0
Bajada	5 in.	30 ± 3.0
Bajada	10 in.	68 ± 2.0

* Water added over 8 week period.

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I.G. PRODUCTIVITY AND NUTRIENT CYCLING

1. PRIMARY PRODUCTIVITY STUDIES -- PLAYA

Productivity in the playa was estimated using three approaches. Photosynthetic activity was estimated using $^{14}CO_2$ in light and dark bottles. Overall biosynthetic activity was followed by incorporation on ^{3}H thymidine in light and dark bottles. Heterotrophic potential was estimated by incorporation of uniformly labeled ^{14}C glucose. Results are summarized in Tables 1 and 2. From the $^{14}CO_2$ fixation data it is evident that photosynthetic carbon fixation was relatively low. Exact amounts of carbon fixed could not be calculated; however, the highest fixation obtained on July 21 represents no more than 1 μ mole of carbon fixed per liter in 7 hr of high solar radiation. This low figure indicates that primary productivity was negligible. This conclusion is supported by the thymidine and glucose incorporation experiments which show clearly that incorporation of these compounds was the same in light and dark experiments. It is also worth mentioning that there was no visual evidence of algal blooms in either the July or the September-October floodings. The data presented in Tables 1 and 2 support the notion that the playa was based on heterotrophic (decomposer) productivity. Thymidine and glucose incorporation remained at relatively high levels during both flood periods indicating that non-photosynthetic activity was constant.

Further work is needed to more precisely define the nature of the first trophic level in the playa during flooding.

Table 1. Productivity studies during July flooding

$^{14}CO_2$ fixation

Date	Time	cpm $^{14}CO_2$ fixed/liter
7-21	7 hr.	226,300
7-22	7 hr.	43,700
7-23	7 hr.	9,900
7-25	7 hr.	7,500

^3H Thymidine uptake

Date	Time	cpm ^3H Thymidine incorporated/liter Light	Dark
7-21	7 hr.	23,000	24,700
7-22	7 hr.	22,500	28,500
7-23	7 hr.	68,000	97,700
7-25	7 hr.	591,180	543,000

^{14}C Glucose uptake

Date	Time	cpm ^{14}C Glucose incorporated/liter Light	Dark
7-21	7 hr.	247,100	297,700
7-22	7 hr.	84,700	98,200
7-23	7 hr.	165,300	151,000
7-25	7 hr.	696,400	686,800

Table 2. Productivity studies during September-October flooding

$^{14}CO_2$ Fixation

Date	Time	cpm $^{14}CO_2$ fixed/liter
9-20	7 hr.	2,000
10-24	7 hr.	14,380
10-27	7 hr.	7,500

^{3}H Thymidine Uptake

Date	Time	cpm ^{3}H Thymidine fixed/liter Light	Dark
9-20	7 hr.	372,800	520,070
10-24	7 hr.	612,200	760,080
10-27	7 hr.	125,400	229,200

^{14}C Glucose Uptake

Date	Time	cpm ^{14}C Glucose incorporated/liter Light	Dark
9-20	7 hr.	114,800	127,900
10-24	7 hr.	273,800	242,700
10-27	7 hr.	27,400	162,000

I.G.2 ISOTOPIC STUDIES ON NUTRIENT CYCLING IN AQUATIC ANIMALS -- PLAYA

From the results described in the section on primary productivity the question arose as to the degree of utilization of microorganisms by aquatic vertebrates and invertebrates. To investigate this question a laboratory strain of *Escherichia coli* was grown on uniformly labeled ^{14}C glucose for 48 hr. The cells were washed free of culture medium and then killed by heating at 70 C for 15 min. The washed, killed cell crop was then suspended in playa water. Ten animals each of the following were added to separate cell suspensions and incubated for 24 hours: *Chopiopus hammondi, Apus longicaudis* and *Streptocephalus texanus*. The animals were removed from the cell suspension with a strainer and washed free of surface contamination with running tap water. Solubilization of the animals was accomplished with hyamine hydroxide and 1 ml samples were counted in the liquid scintillation counter using Aquasal (New England Nuclear) as the scintillator fluid.

Results of these experiments which are summarized in Table 3 clearly show a considerable incorporation of radioactivity by the test animals. This result suggests that utilization of playa aquatic microflora by vertebrates and invertebrates may be of considerable importance as a nutrient source, especially during early development. Further work on this aspect of nutrient cycling is needed since the study was not repeated due to rapid drying of the playa. Future work will be done using native microflora in playa water and will be carried on through several developmental stages of the test animals.

Table 3. Utilization of bacteria by aquatic animals

Animal	Initial Cpm*	Final Cpm	% Utilized	Cpm/Animal
Tadpole	11,803	4,432	63	10,411
Fairy Shrimp	30,399	20,396	33	6,500
Tadpole Shrimp	34,089	20,475	41	15,500

*Bacterial cells were labeled with ^{14}C glucose. Cpm represents relative density of bacterial cells added.

II. BAJADA

A. ABIOTIC

1. AIR TEMPERATURE

Instrumentation to monitor air temperatures in a standard weather bureau shelter was established on the bajada study site in May, 1971. Instrumentation and recording details are described in DSCODE A3UWJ02 (Biome Abstracts Vol. I No. 2). The shelter was located on a level area 10 m from the major arroyo and toward the south end of the area.

Monthly means and ranges are given in Table 1. The warmest months are June and July, with means of about 80 F and 84 F respectively. In comparison to the playa site (see Table 1, section I.A.1), these means are about the same, with the playa being slightly warmer in 1971 yet slightly cooler in 1972. In comparison to the long-term means for Las Cruces (see Table 2, section I.A.1), the bajada site is 3-5 F warmer in June and July. The coldest months are December and January with means of about 45 F and 46 F respectively. Compared to the playa site, the bajada is generally 3-6 F warmer on the average in winter months, perhaps reflecting its upland position relative to cold air drainage. Compared to the long-term average for Las Cruces, the bajada site is 2-4 F warmer in these two winter months.

Daily mean air temperatures are shown graphically in Figure 1. The seasonal trends are quite clear. The striking feature of these day-to-day plots is the general uniformity of means during spring and early summer, but with great fluctuations within a month during the fall and winter. Note that the daily means do not exceed 35 C (95 F). Daily means rarely fall below 0 C, except for a few days in January, 1972. However, extremes are more interesting and probably of greater biological significance.

Daily maximum air temperatures for 1971 and 1972 are shown in Figure 2. During June and July it is not uncommon for temperatures to reach or exceed 40 C (104 F). Often, these high temperatures will persist for a few days in succession during a hot-dry spell. The highest temperature recorded was 108 F on 2 July, 1972. This is only one degree less than the highest temperature ever recorded for Las Cruces on 8 July, 1951 (Houghton, 1972). During the winter, the daytime maximum never stayed below freezing. The temperature exceeded freezing at least for a few hours each day. This contrasts sharply with the playa site which does have days in which the maximum does not exceed 0 C (see section I.A.1).

Daily minimum air temperatures for 1971 and 1972 are shown in Figure 3. During the hot summer months the temperature will typically drop to around 20 C (70 F) at night. It is rare for the temperature to stay above 80 F at night (Table 1). During the winter, the minimum can be well below freezing; however, in comparison to the playa, the minimums for the bajada are generally about 10 F above those for the same period as the playa. This again emphasizes the playa as a cold air sink.

The end of the growing season for the winter deciduous plants on the bajada can be correlated with the first freezing temperatures in the fall. The dates for 1971 and 1972 were 10 December and 2 November respectively. In contrast to the playa, the dates are considerably later, again showing the differences between an upland area and a basin. In comparison to the probabilities of the first freezing temperatures for Las Cruces (see Table 3, section I.A.1), the bajada would seem to be less likely to have an early frost; however, long-term data would be needed for the bajada in order to obtain the necessary probabilities for a good comparison. The last freezing temperature in the spring for 1972 was on 29 March. This frost did considerable damage to a number of plant species which had already leafed out.

Table 1. Air temperature data (F) acquired at the Jornada bajada site during 1971 and 1972

Month	Minimum	Maximum	Hourly mean	Range of daily minima	Range of daily maxima	Range of daily means
1971						
June	60	102	80.5	60-79	88-102	77-90
July	66	104	84.5	66-80	81-104	73-90
August	62	98	76.5	62-75	86-98	75-85
September	48	98	75.8	48-76	62-98	55-87
October	38	88	62.4	38-66	62-88	50-72
November	34	78	51.8	34-56	52-78	44-66
December	28	71	43.8	28-45	38-71	35-59
1972						
January	15	74	45.9	15-46	37-74	24-60
February	22	78	47.3	22-54	78-44	32-65
March	31	82	63.7	31-58	63-82	50-70
April	36	91	63.9	36-65	71-91	57-76
May	48	92	70.3	48-72	76-92	63-80
June	60	102	79.9	60-74	72-102	66-87
July	66	108	83.3	66-80	88-108	76-91
August	61	106	77.8	61-81	75-106	71-90
September	50	94	71.3	50-71	78-94	68-81
October	42	94	63.7	42-66	51-94	44-77
November	32	72	48.0	32-44	52-72	36-57
December	25	68	45.8	25-47	44-68	35-56

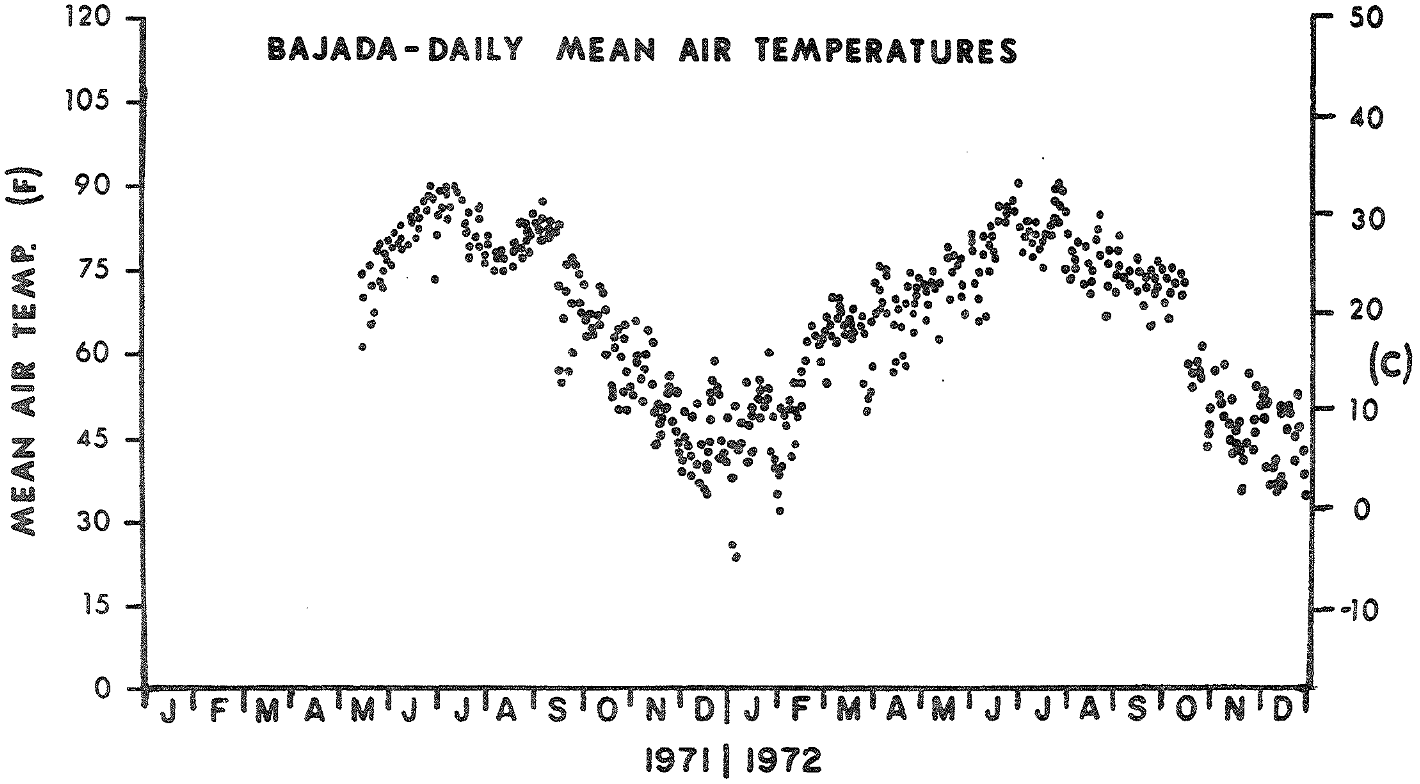

Figure 1. Daily mean air temperatures for 1971 and 1972 at the bajada.

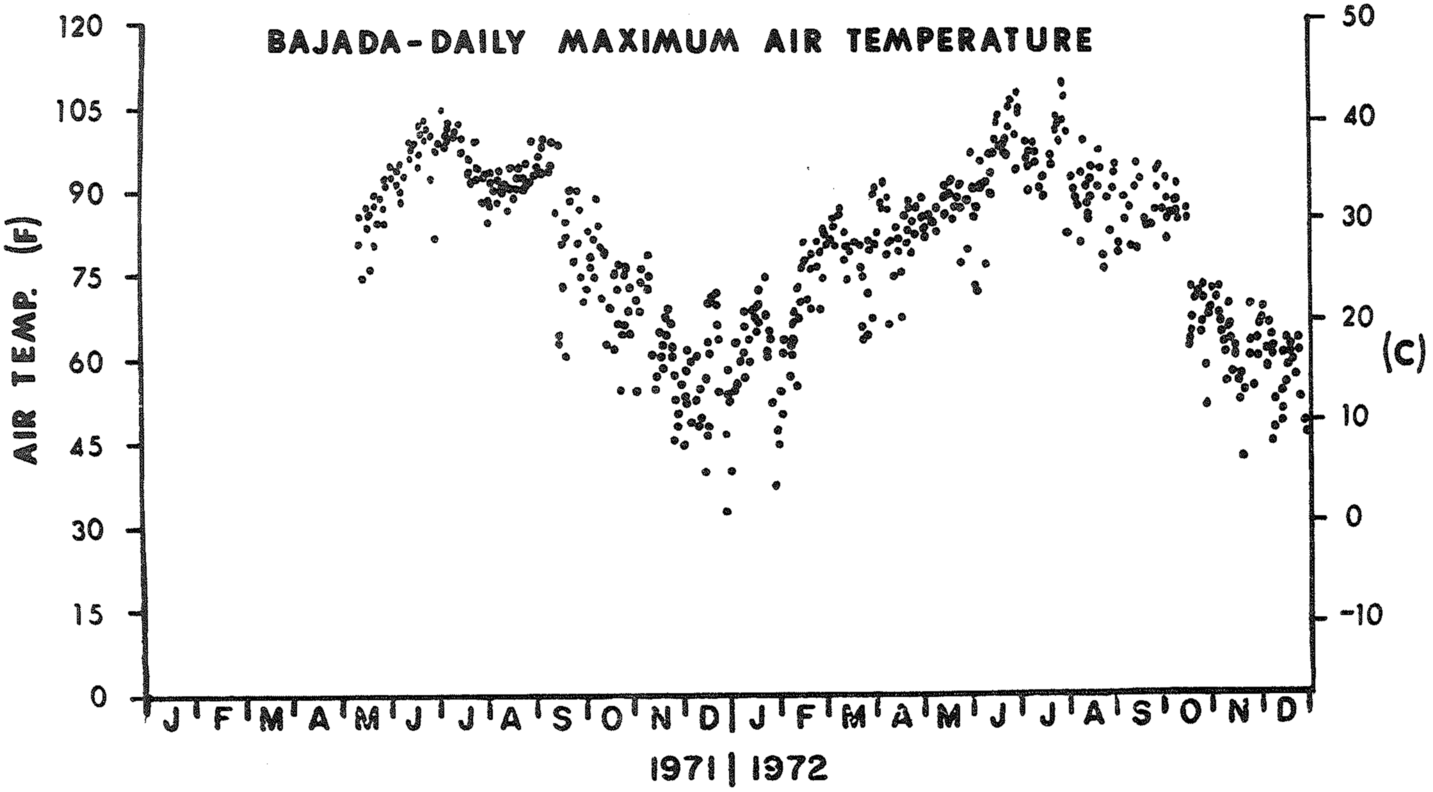

Figure 2. Daily maximum air temperatures for 1971 and 1972 at the bajada.

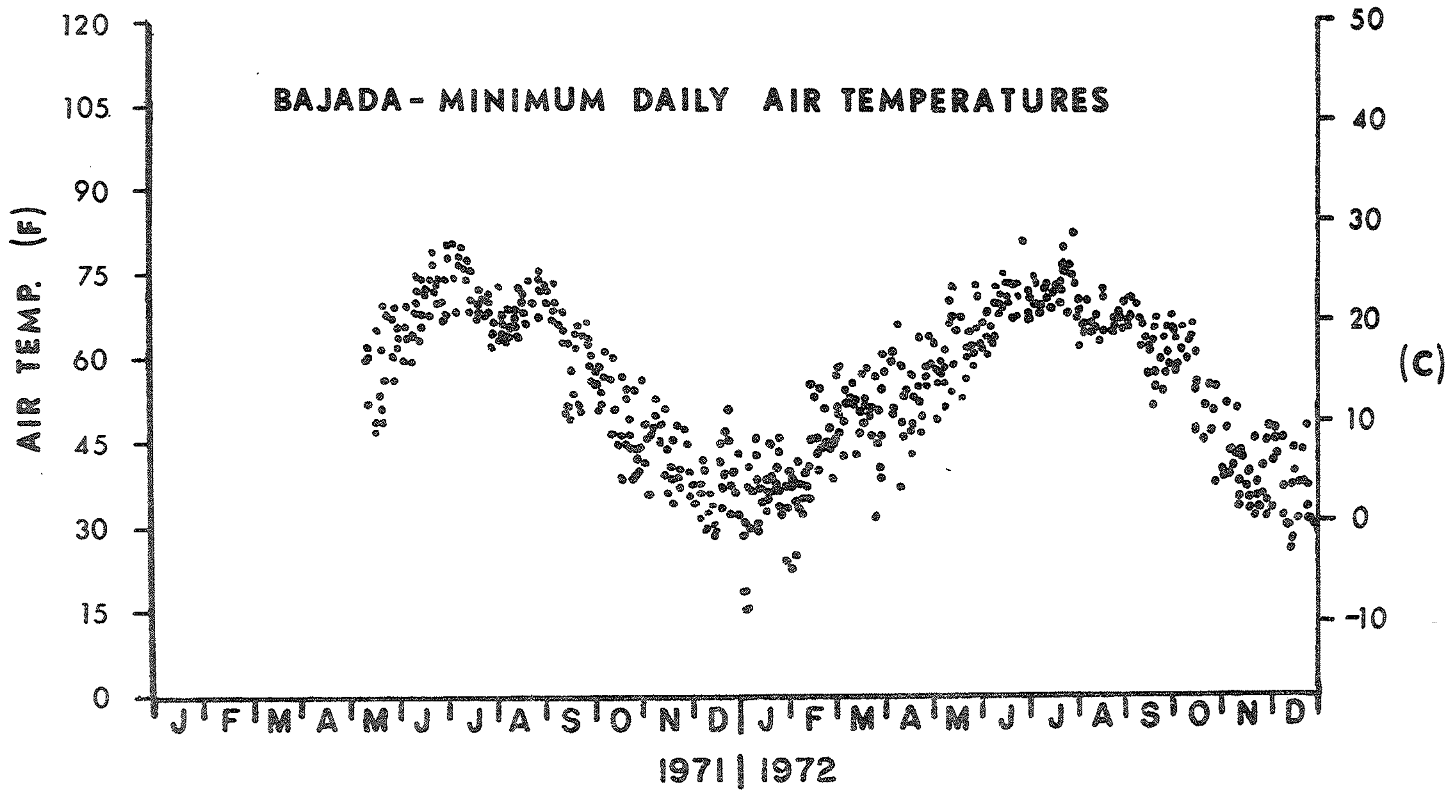

Figure 3. Daily minimum air temperatures for 1971 and 1972 at the bajada.

II.A.2 BAJADA SOLAR RADIATION

Total incoming solar radiation has been monitored at the bajada study site since May, 1971. A pyroheliograph (Belfort Instrument Co.) is mounted on top of the weather station instrument shelter at a height of 2 m. Additional methodology is described in DSCODE A3UWJ66.

The results of calculations for daily total incoming radiant energy (langleys/day) are shown in Figure 4. Given the latitude of the study site (32^o 32'), the maximums for most days during a given season follow what would be expected. The maximums reach around 800 ly/d during May, June and July. The minimums are about 300 ly/day during December. The number of cloudy days varies with the seasons, as indicated by the scatter of data points below the general band. The fall and early winter days are more frequently cloudy than spring and early summer days. A few days are cloudy enough that total incoming radiation energy falls below 100 langleys.

The results for the bajada are highly correlated with those for the playa as would be expected. In case of instrument failure on the bajada, data can be taken from the instrument on the playa with very little chance of error, or vice versa.

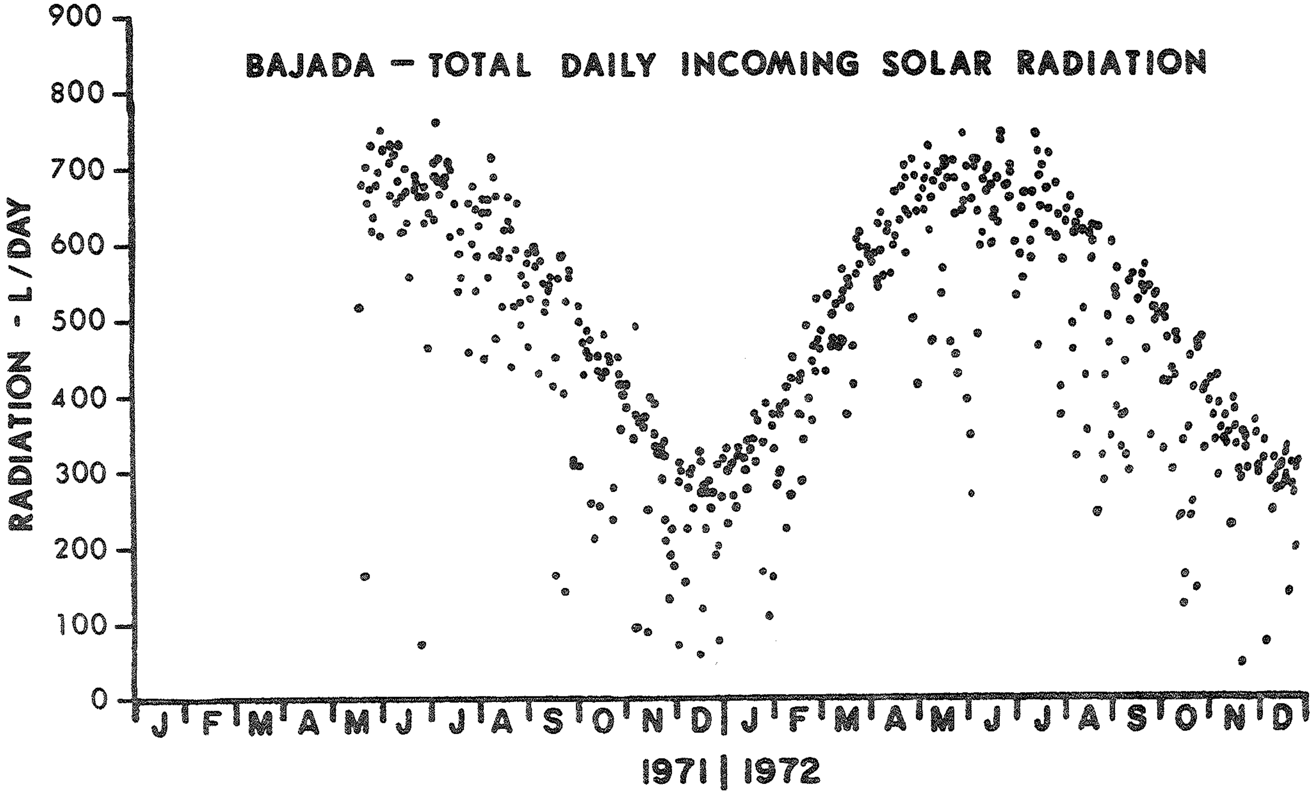

Figure 4. Daily total incoming solar radiation (langleys/day) for 1971 and 1972 at the bajada.

II.A.3 BAJADA PRECIPITATION

A continuously recording rain gauge (weighting bucket type - Belfort Instrument Co.) was set up on the bajada site near the existing weather station in May, 1971. A daily clock in the instrument drives a strip chart that provides data on the time, duration and amount of each rainfall event. Details are described in DSCODE A3UWJ63.

Monthly total precipitation patterns for 1971 and 1972 are shown in Figure 5. As would be expected, the patterns are very similar to those described for the playa which is about 1.6 km north of the bajada. However, by comparing Figure 5 with Figure 6 from section I.A.3, one interesting difference can be noted. The monthly totals for some months are considerably higher on the playa than on the bajada. For example, note September, 1972, where a total of about 7.7 cm (3 in) fell on the playa, but only about 3.0 cm (1.2 in) fell on the bajada. Most of this difference can be attributed to 1 September when 5.3 cm fell on the playa, but only 0.4 cm of rainfall occurred on the bajada. This phenomenon when heavy rains occur on the playa but little or no rain occurs on the bajada has been noted on other days as well. The reverse phenomenon has not happened yet. Along with this phenomenon, but due in part to a more general trend, the playa has had more rainfall in 1971 and 1972 (compare Table 2 here with Table 4 of section I.A.3). This is of particular interest since the bajada is at a higher elevation than the playa (obviously), thus one might expect higher rainfall at higher elevations. However, the presence of Mt. Summerford immediately to the west of the bajada site may have a partial rain shadow effect since during the summer rainy season the winds are often from the west.

Monthly data for the number of precipitation events, total amount, percent of yearly totals, and average rate are given in Table 2 for 1971 and 1972. The data for January to June do not exist, but based on the playa data for this period (Table 4, section I.A.3) only a small amount of rain occurred in January and April with no rain in February, March and May. The most precipitation events occurred in August and September in 1971 and in June, August, October, and December in 1972. The maximum number of events for a month was 24 in October, 1972. The maximum total rainfall also occurred during this month (85 mm). The intensity of rainfall pattern described for the playa (section I.A.3) is supported by the data for the bajada.

Based on the percentage data in Table 2, the months of July, August, September, and October had 75% and 70% of the yearly totals for 1971 and 1972 respectively.

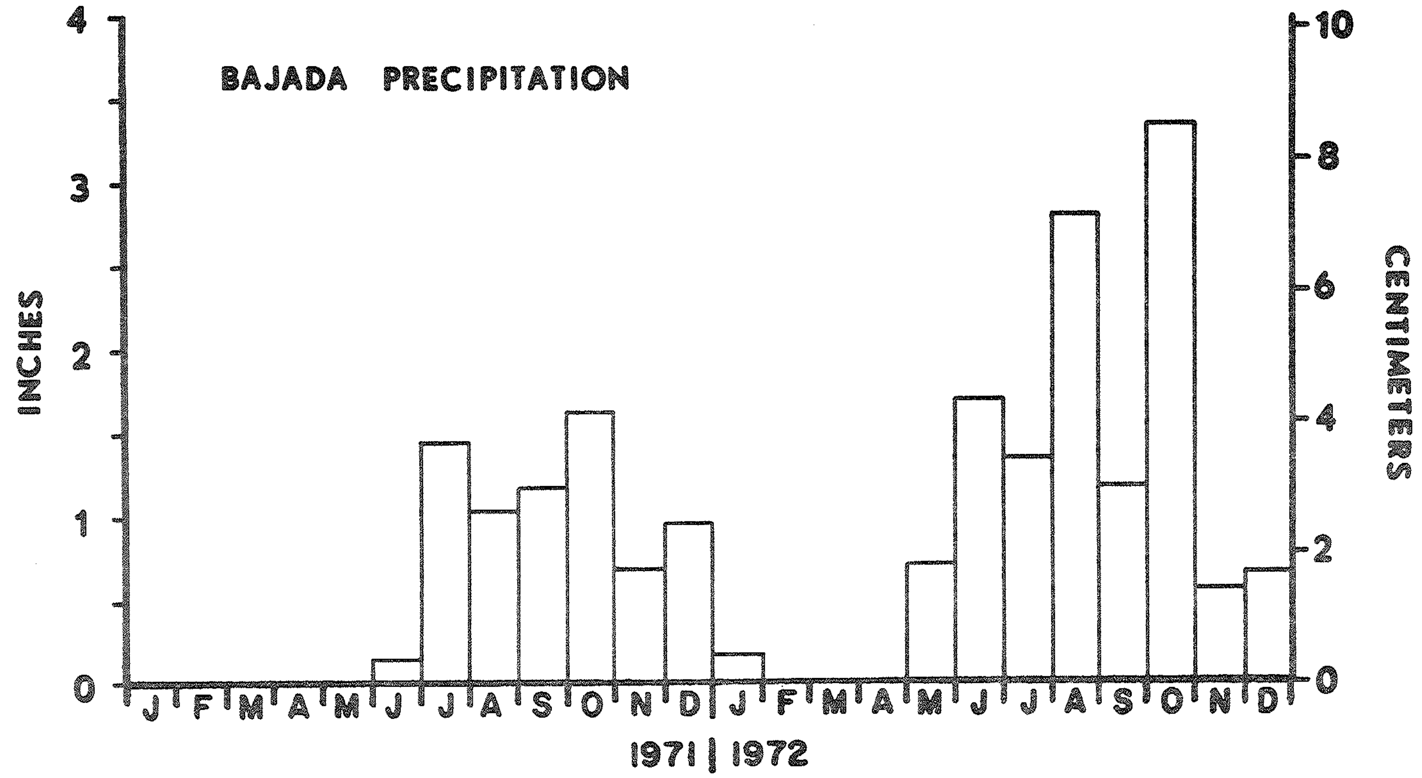

Figure 5. Monthly total precipitation patterns for 1971 and 1972 at the bajada.

Table 2. Monthly precipitation data for the bajada site, listing for each month, the number of precipitation events, total amounts, percent of yearly total and the average rate or intensity

Month	Number of Events	Total Rainfall (inches)	Total Rainfall (millimeters)	% of Total	Rate of Rainfall (in./hr.)	Rate of Rainfall (mm./hr.)
January	*	*	*	*	*	*
February	*	*	*	*	*	*
March	*	*	*	*	*	*
April	*	*	*	*	*	*
May	*	*	*	*	*	*
June	1	0.14	3.6	2	0.28	7.1
July	5	1,44	36.6	20	0.22	5.7
August	11	1.01	25.5	14	0.17	4.7
September	12	1,29	32.8	18	0.11	2.8
October	6	1.61	40.9	23	0.12	3.1
November	4	0,69	17.5	10	0.04	1.0
December	7	0.91	23.1	13	0.06	1.5
1971	46	7.09	180.0		0.10	2.6
January	5	0.18	4.6	1	0.04	0.9
February	0	0	0	0	0	0
March	0	0	0	0	0	0
April	0	0	0	0	0	0
May	5	0.71	18.0	6	0.36	9.0
June	18	1.71	43.4	14	0.09	2.3
July	6	1.35	34.3	11	0.20	5.0
August	14	2.80	71.1	22	0.11	2.7
September	9	1.19	30.2	10	0.26	6.7
October	24	3.35	85.1	27	0.17	4.3
November	4	0.53	13.5	4	0.03	0.9
December	10	0.65	16.5	5	0.06	1.6
1972	93	12.47	316.7		0.11	2.9

* Rain gauge not installed until June 1971.

II.A.4 BAJADA RELATIVE HUMIDITY

On the bajada site, relative humidities have been monitored with a hair-hygrothermograph since May, 1971. The instrument was placed in a standard weather bureau shelter. Details are described by DSCODE A3UWJ65.

Daily mean relative humidities are shown in Figure 6. The day-to-day and week-to-week variations in average relative humidity are considerable, as evident from the broad band of scattered data points. However, season-to-season changes are also quite evident. The spring months of March, April, May, and June are relatively dry. The May to mid-June period of 1971 was very dry, with mean relative humidities less than 20%. During the rainy months of July, August and September, the relative humidity averages considerably higher than the spring months. During the fall months, the mean humidity stays relatively high, partly because of colder air temperatures nearer the dew point.

Year-to-year differences are fairly striking, as shown in Figure 6. The spring of 1971 was considerably drier than the spring of 1972 as evidenced by the lower mean relative humidities. The summer of 1972 was somewhat more moist as indicated by the precipitation data in section I.A.3 and as evidenced by the generally higher mean relative humidities. The fall of 1972 was also slightly more moist than the fall of 1971, but the difference is not very striking.

Site-to-site differences are also of interest. By comparing the data shown for the playa site in Figure 7 of Section I.A.4 with the data for the bajada shown in Figure 6, a few differences are evident. The most striking difference is during the fall months when the playa average relative humidities are higher than the comparable data for the bajada. Most of this difference is probably due to the cooler temperatures on the playa bottom due to its position in the landscape as a cold air sink. Thus with colder temperatures and with the same general air mass as for the bajada, the relative humidities on the playa will consistently read higher.

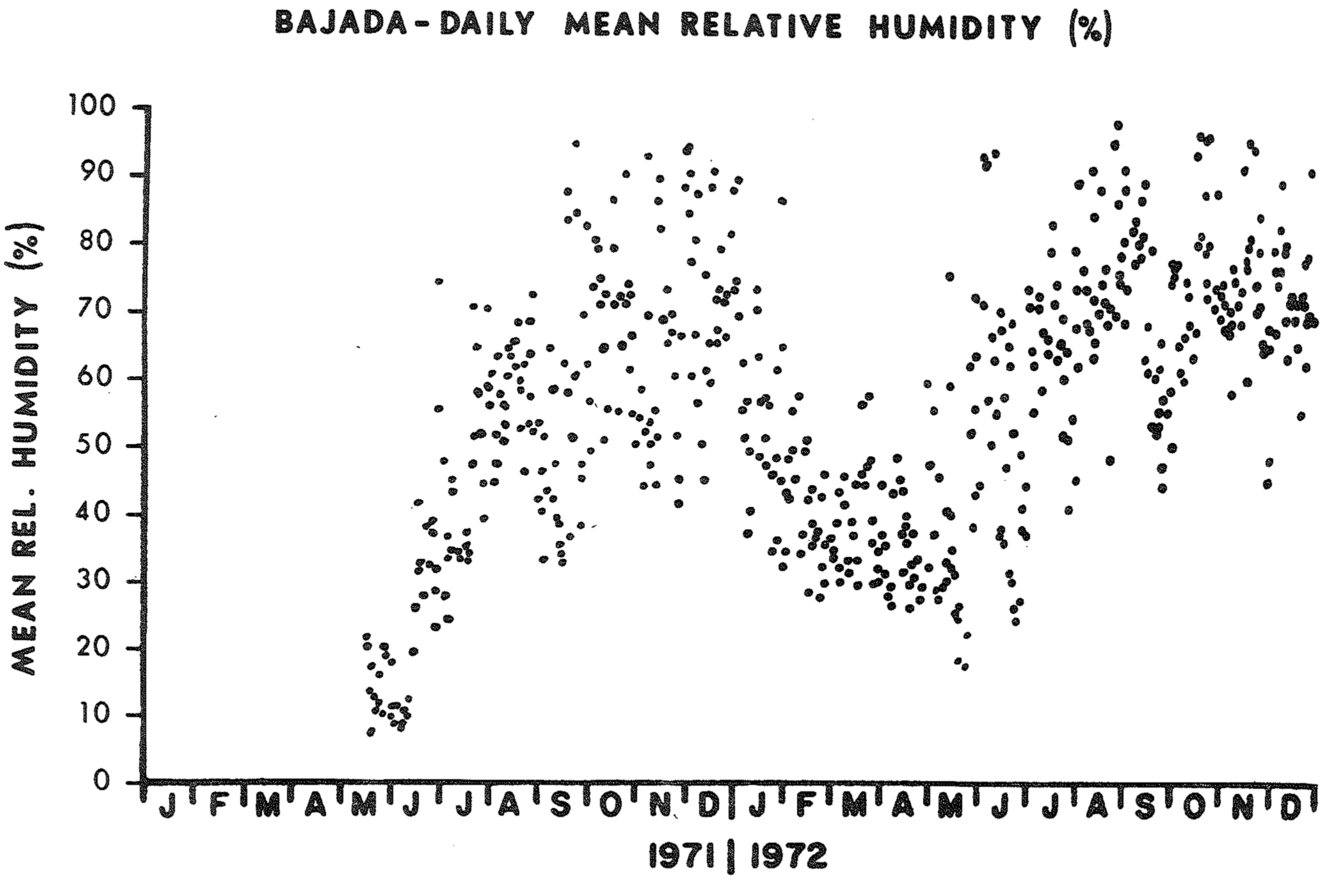

Figure 6. Daily mean relative humidities for 1971 and 1972 at the bajada site.

II.A.5 BAJADA WIND

An anemometer was set up on the bajada site in May, 1971. The anemometer records total wind miles. The meter is read once a week, thus the total miles for the week are obtained. Given the times when the record started and stopped, the average miles per day and per hour can be calculated. Data description is given by DSCODE A3UWJ62.

Average wind speeds in miles per hour for each week beginning in May, 1971, and up to the end of 1972 are shown in Figure 7. Week-to-week changes are highly variable; however, seasonal trends are evident. The spring months appear to average consistently higher at about 7 mph than the summer months which average about 5 mph. The fall and winter months are highly variably from week to week, often being 2-3 mph different in average wind speed. For example, the first week in December, 1972, averages about 12 mph whereas the second week of the same month averages about 5 mph.

Comparing the wind data for the bajada (Figure 7) against that for the playa (Figure 8, section I.A.5) indicates a high correlation between the two, as would be expected. Slight differences could probably be related to wind direction with respect to the presence of Mt. Summerford due west of the bajada and about 1.6 km southwest of the playa.

In the fall of 1972, an event recorder was installed in the bajada weather station. It monitors wind speed on a per mile basis from the anemometer which is equipped with a circuit breaker system. Wind data can then be monitored on a mile per hour basis for each hour of each day rather than on average miles per hour for the entire week. These data are not available yet.

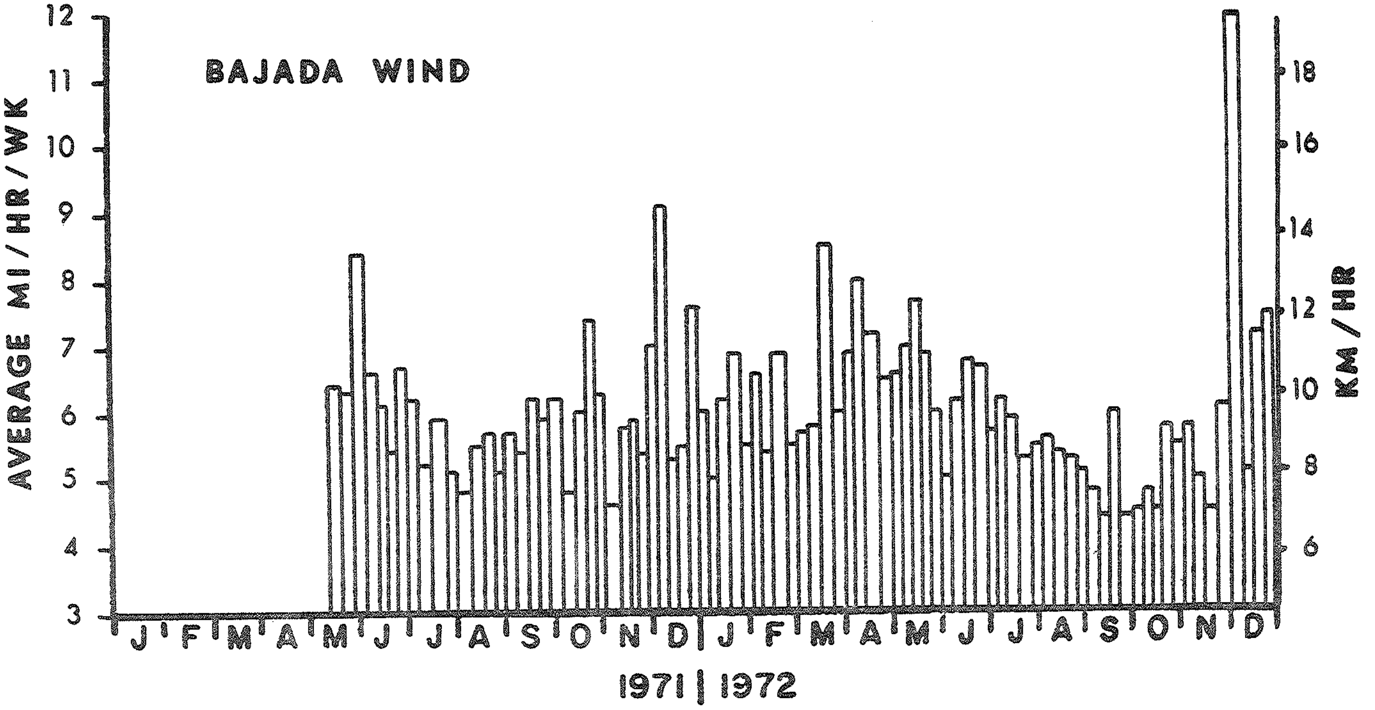

Figure 7. Average wind speed (miles/hr/week) on the bajada site in 1971 and 1972.

II.A.6 BAJADA SOIL TEMPERATURE

Soil temperatures at 10 cm and 50 cm have been monitored at the bajada site with a soil thermograph since May, 1971. The two temperature-sensitive probes were buried in an open area immediately south of the instrument shelter for the bajada weather station. The thermograph records temperatures continuously on a strip chart which is changed once a week. Further details are described in DSCODE A3UWJ67.

Daily average soil temperatures at 10 cm for 1971 and 1972 are shown in Figure 8. Day-to-day variations in means do not fluctuate a great deal. However, week-to-week changes can be considerable (ranging from 5-10 C) as seen for late August to early September in 1971. These are probably due to sudden changes in other weather factors such as air temperature and solar radiation.

Seasonal changes are quite striking with maximums reaching near 40 C in July and minimums reaching 0 C in December and January. These trends closely follow those for the playa. (compare Figure 9, section I.A.6, with Figure 8) as would be expected.

Daily average soil temperatures at 50 cm for 1971 and 1972 are shown in Figure 9. The day-to-day means are less variable than those for the same time periods at 10 cm. However, these temperatures do reflect short-term weather patterns, but not as distinctly as for the 10 cm data. The extremes are not as great, with a maximum in July of 35 C which is about 5 C less than the maximum at the 10 cm depth. The minimums occur in December, January and February at about 5 C which is about 5 C greater than for the 10 cm depth.

Additional soil temperature data for the bajada site are available from thermistors buried in conjunction with the gypsum soil blocks. The blocks (thermistors) are buried at three depths; 15 cm, 45 cm and 90 cm. The blocks are placed in three different areas. The areas are: the upland alluvial fan surfaces (which support a creosote bush community), the minor arroyos (which dissect the fan and support a tarbush, yucca and mariola community) and the major arroyo or wash (which dissects the center of the site and supports a mesquite, apache plume and desert willow community). These data will not be given here since they follow closely the data from the soil thermograph. The data are described and stored under DSCODE A3UWJ61, and are available on request. The data from the thermistor system for 1971 are reported in Whitford et al. (1972).

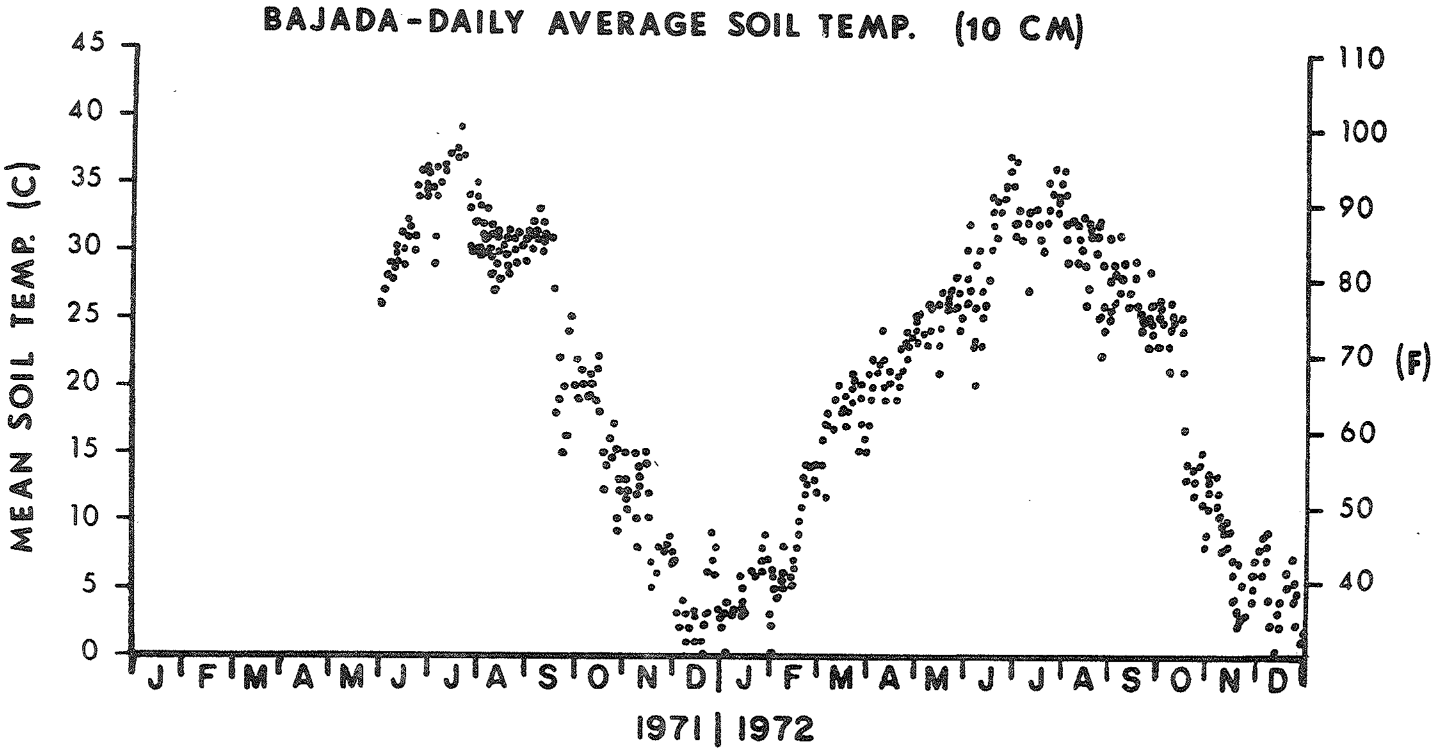

Figure 8. Daily mean soil temperatures at 10 cm for 1971 and 1972 at the bajada site.

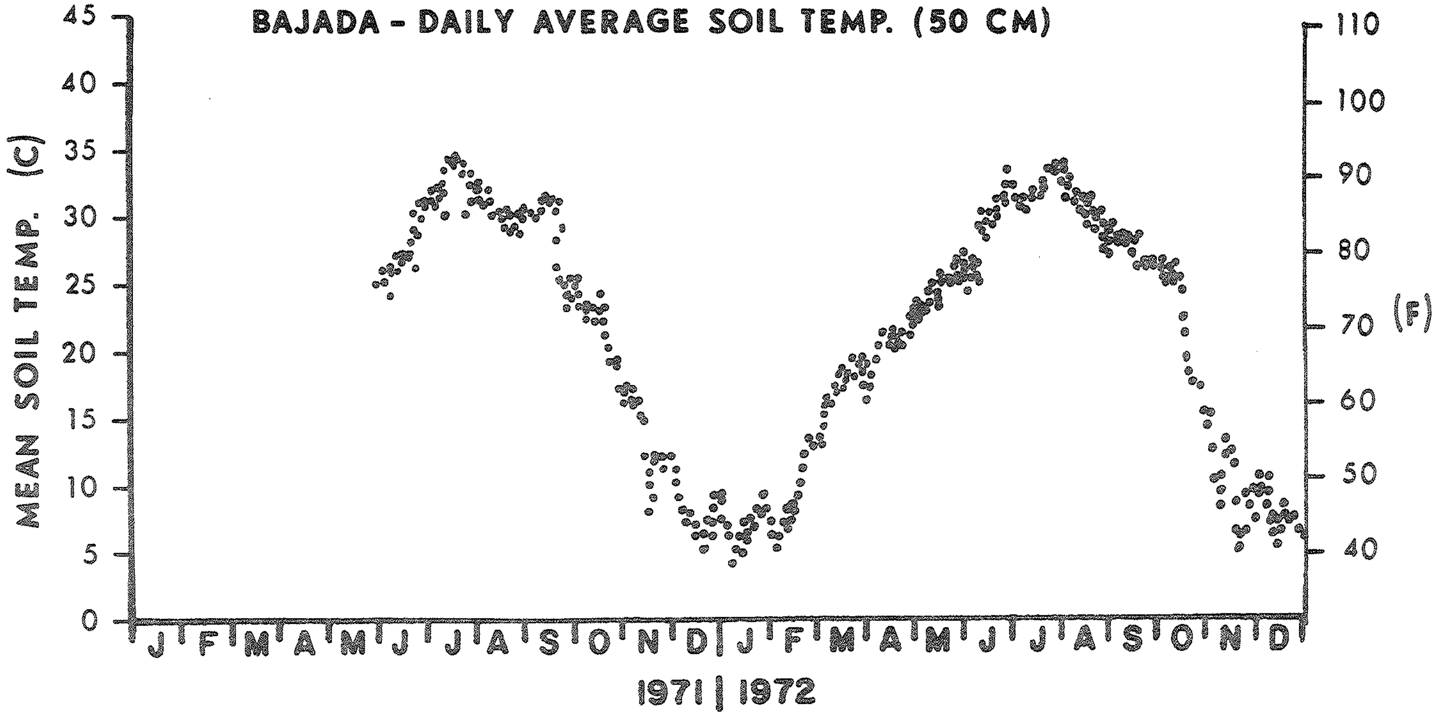

Figure 9. Daily mean soil temperatures at 50 cm for 1971 and 1972 at the bajada site.

II.A.7 BAJADA SOIL MOISTURE

Soil moisture has been monitored on the bajada site since mid-July, 1971. Moisture has been estimated as soil water potential using electrical resistance type gypsum blocks of special design. Calibration curves for soil water potential from electrical resistance (soil-test micro-amp meter) were determined using pressure plate and pressure membrane apparatus up to 130 atm. For the relatively sandy soils of the bajada, the curves appear to be fairly reliable based on repeated determinations at various pressures.

Soil water potentials are being monitored on the bajada for three different areas. The areas are the upland surfaces of the alluvial fan (bajada) which support creosote-bush, the minor arroyos which support tarbush, yucca and mariola, and the major arroyo, which supports mesquite, apache plume and desert willow. Soil water potentials are being monitored at three depths. The gypsum blocks are placed at the depths of 15 cm, 45 cm and 90 cm. Further details of methods and data are described by DSCODE A3UWJ65.

Bajada upland soil water potentials at 15 cm for 1971 and 1972 are shown in Figure 10. The broken line across the Figure indicates the present upper limit of the gypsum block calibration curve. As shown, the average soil water potential for the bajada uplands at 15 cm progressively became higher (less negative) during July and August, 1971, but then leveled off until the 25th of October, when over 2 cm of rain fe At this time all the blocks at 15 cm were moistened. Previously, some blocks were moist and some were not, giving an intermediate average. With additional small rains, the soils at 15 cm remained moist at near 0 C until February, when they began to dry rapidly and reached the maximum by April, 1972. Rains in June moistened most of the blocks at 15 cm, but they dried out quickly. A large rain on 1 September rewet all the blocks. They dried quickly in September but were again moistened by rains in October and remained moist during the fall of 1972.

Bajada upland soil water potentials at 45 cm for 1971 and 1972 are shown in Figure 11. During 1971, the small rains did not effectively moisten the gypsum blocks in the soil at this depth. This corresponds to the results found for the playa fringe (Figure 18, Section I.A.7) which is fairly similar to the bajada uplands in soil texture. The fall rains reduced the soil dryness somewhat but the soils remained at fairly high tensions until late summer of 1972. The large rains then partially moistened the soils; however it appears that some of the gypsum blocks are buried within or beneath a semi-impervious calcium carbonate layer (caliche). Thus even large rains such as those in the fall of 1972 do not completely wet all the blocks.

Bajada upland soil water potentials at 90 cm for 1971 and 1972 are shown in Figure 12. At this depth, the effect of the caliche layer is even more pronounced as the gypsum blocks remain relatively dry from year to year. Some slight seasonal trends are evident in that the soils moisten somewhat during the fall and then dry slightly in the spring. The curve is slightly lower (soils moister) in the fall of 1972 than in the fall of 1971, which follows the wetter summer and fall of 1972. The results at 90 cm for the upland areas are very similar to those at 90 cm for the playa fringe (Figure 19, section I.A.7).

Bajada minor arroyo soil water potentials at 15 cm for 1971 and 1972 are shown in Figure 13. As indicated, the soils moistened at 15 cm with the small rains in July, but then remained level until the larger rain on October 25. The soils at 15 cm in the bottom of the small washes then remained wet until February, 1972. Then the soil dried rapidly, reaching the maximum by April. Rains in June again moistened the soil, but it dried rapidly in July. The large rain on 1 September, 1972, wet the blocks completely and they remained moist throughout the fall. As indicated in Figure 13, the soils at 15 cm are quite sensitive to even small amounts of precipitation. The coarser sands and the position in the topography of these small or minor arroyos account for this sensitivity.

Bajada minor arroyo soil water potentials at 45 cm for 1971 and 1972 are shown in Figure 14. The seasonal and yearly trends for soil moisture at 45 cm are very similar to those for 15 cm except for a lag of about a week or two. The deeper depth soils do not dry out as rapidly as one would expect. For example, in the spring of 1972, the 15 cm depth was essentially dried out to the maximum detectable by April, but at 45 cm the soils were still drying and did not reach the maximum until May. The soils at this depth remained moist throughout the fall after the large rain on 1 September, 1972.

Bajada minor arroyo soil water potentials at 90 cm for 1971 and 1972 are shown in Figure 15. The season-to-season and year-to-year patterns of soil moisture at 90 cm are nearly identical to those at 45 cm. The lag is almost non-existent. Note that at this depth in the minor arroyos, the characteristic effect of a caliche layer is not evident. The calcium carbonate layer is not as shallow nor as compact in the minor arroyos compared to the bajada uplands.

Bajada major arroyo soil water potentials at 15 cm for 1971 and 1972 are shown in Figure 16. The small rains of July, August and September of 1971 kept the soil moist at 15 cm. The coarse sands and fine gravels in the bottom of the major arroyo in the site have a high infiltration ratio. Also, the shallow depths of these unstable water courses do not appear to have any substantial amounts of plant roots except near the large shrubs. This may account for the lack of drying in the summer months. The cool fall months have lower evaporative stresses. Small rains kept the soils at 15 cm moist until late February, 1972, then the soil at this depth dried out by May. The rains in June again wet all the blocks, which then partially dried in July, but wet again in August. Then, as in 1971, the soil at 15 cm remained moist throughout the fall 1972.

Bajada major arroyo soil water potentials at 45 cm for 1971 and 1972 are shown in Figure 17. The seasonal and yearly trends are similar to the 15 cm depth except for two noticeable differences. First, the small rains during the summer of 1971 did not always reach this deeper depth, thus the soil water potential remains at a higher tension until the fall. Second, the drying rate at 45 cm is considerably slower than at 15 cm. Where the soil was very dry by May at 15 cm, the tension was considerably lower in May at 45 cm. The small rains in July and August, 1972, did not moisten the deeper depths as much as at 15 cm. However, by September, the blocks were moist at 45 cm and remained so during the rest of the fall of 1972.

Bajada major arroyo soil water potentials at 90 cm for 1971 and 1972 are shown in Figure 18. The season-to-season and year-to-year trends of soil moisture at 90 cm are nearly identical to those at 45 cm. Again note that in the major arroyo the caliche layer is deeper than 90 cm and is not as impervious as on the uplands.

Literature Cited

Houghton, F. E. 1972. Climatic Guide, New Mexico State University, Las Cruces, New Mexico. 1851-1971. New Mexico A.E.S. Research Report Number 230. 20 pp.

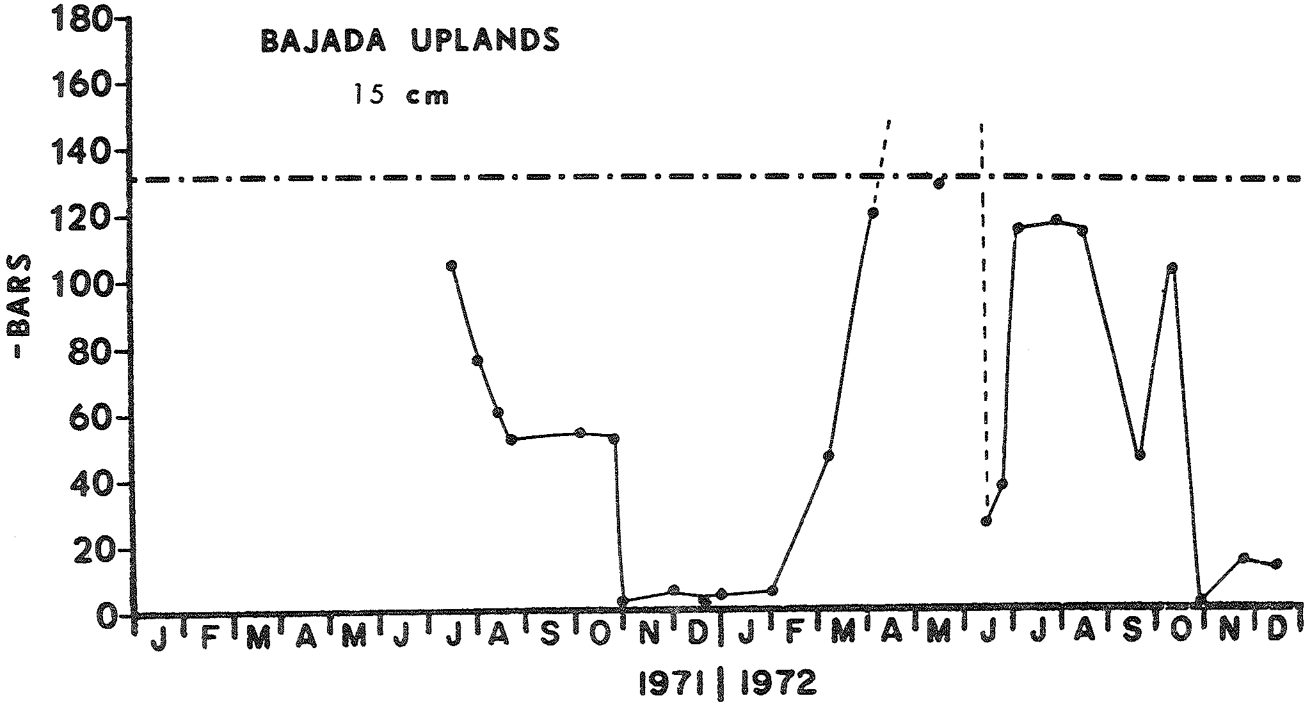

Figure 10. Soil water potentials at 15 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

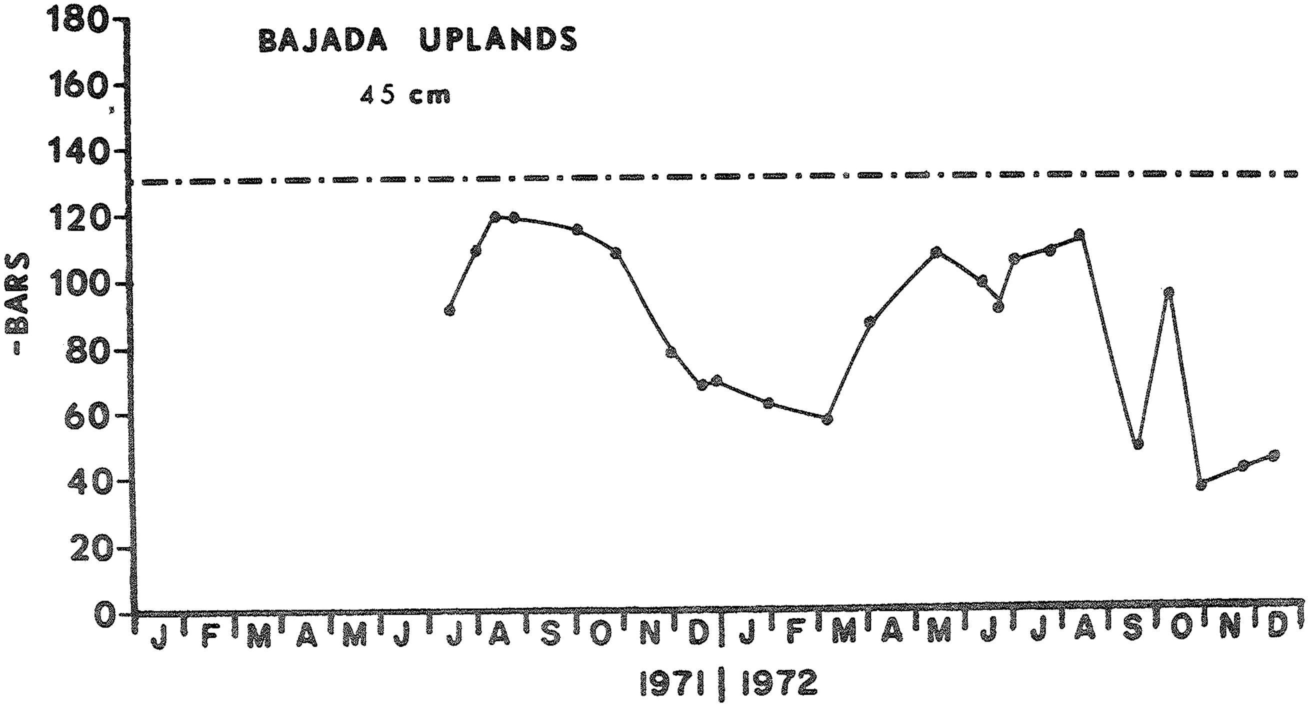

Figure 11. Soil water potentials at 45 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

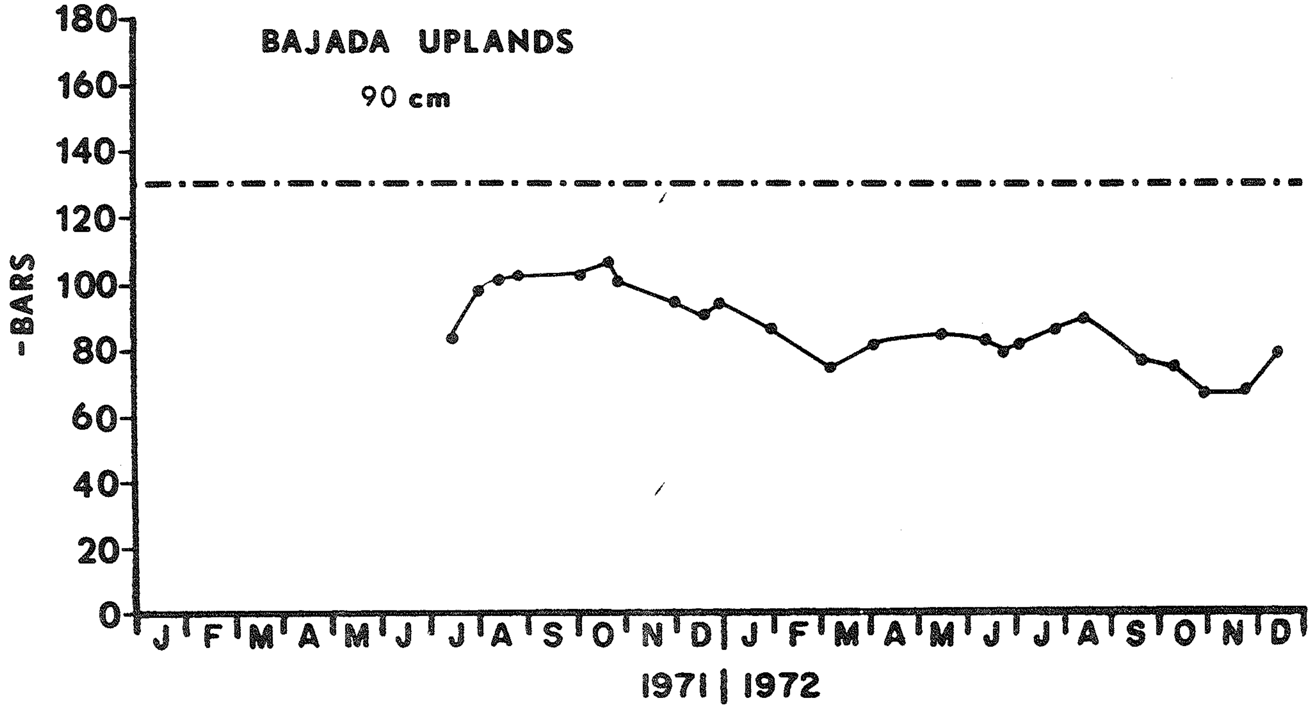

Figure 12. Soil water potentials at 90 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

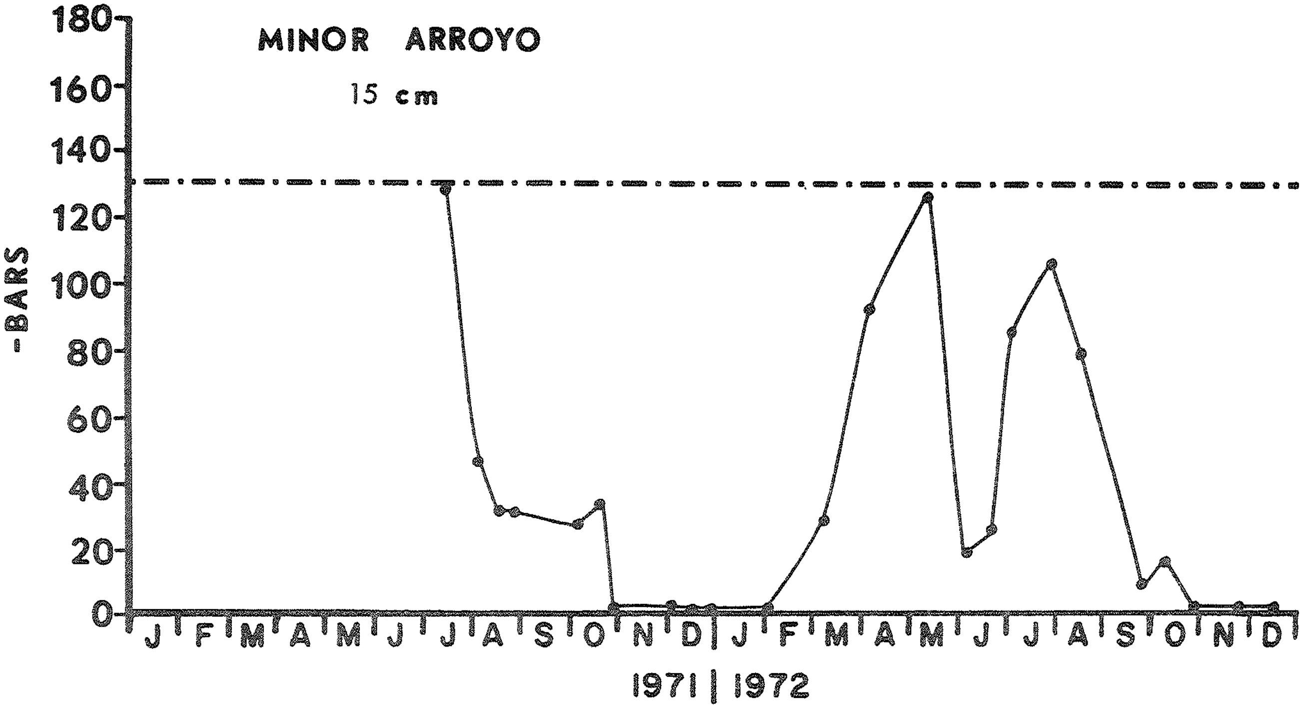

Figure 13. Soil water potentials at 15 cm for 1971 and 1972 in the bajada minor arroyos.

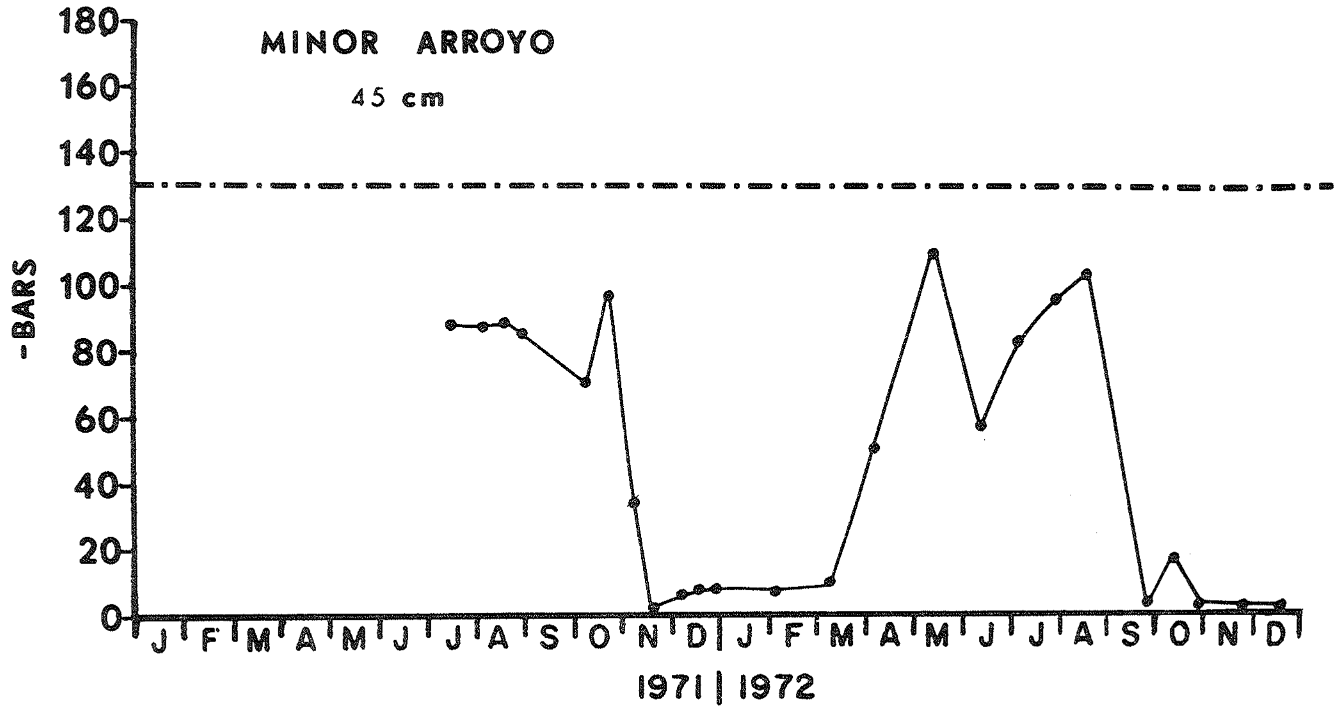

Figure 14. Soil water potentials at 45 cm for 1971 and 1972 in the bajada minor arroyos.

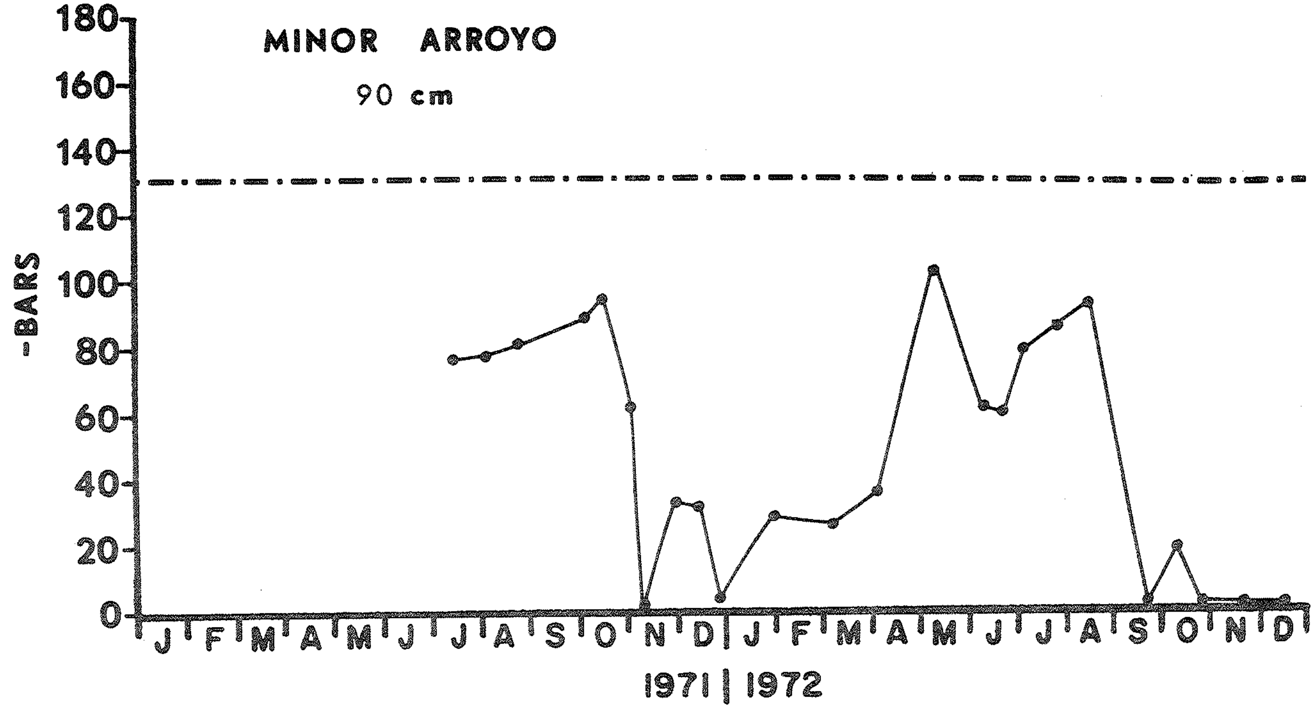

Figure 15. Soil water potentials at 90 cm for 1971 and 1972 in the bajada minor arroyos.

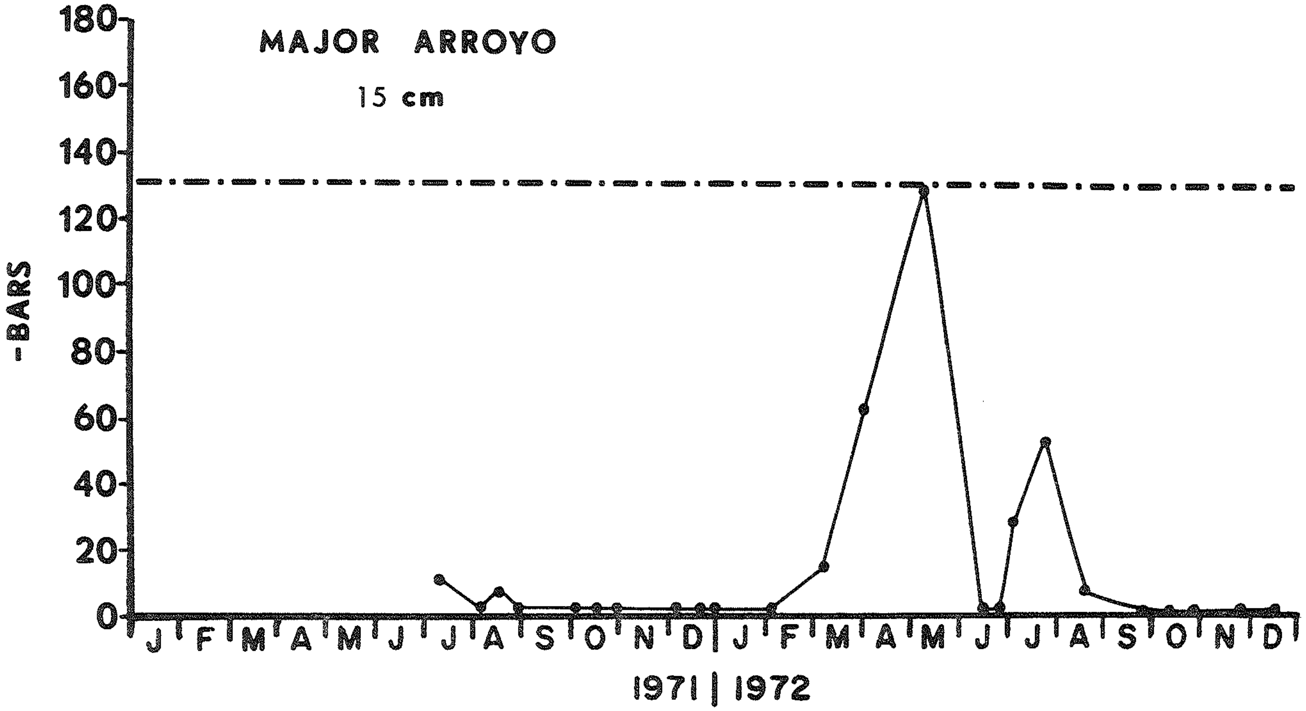

Figure 16. Soil water potentials at 15 cm for 1971 and 1972 in the bajada major arroyo.

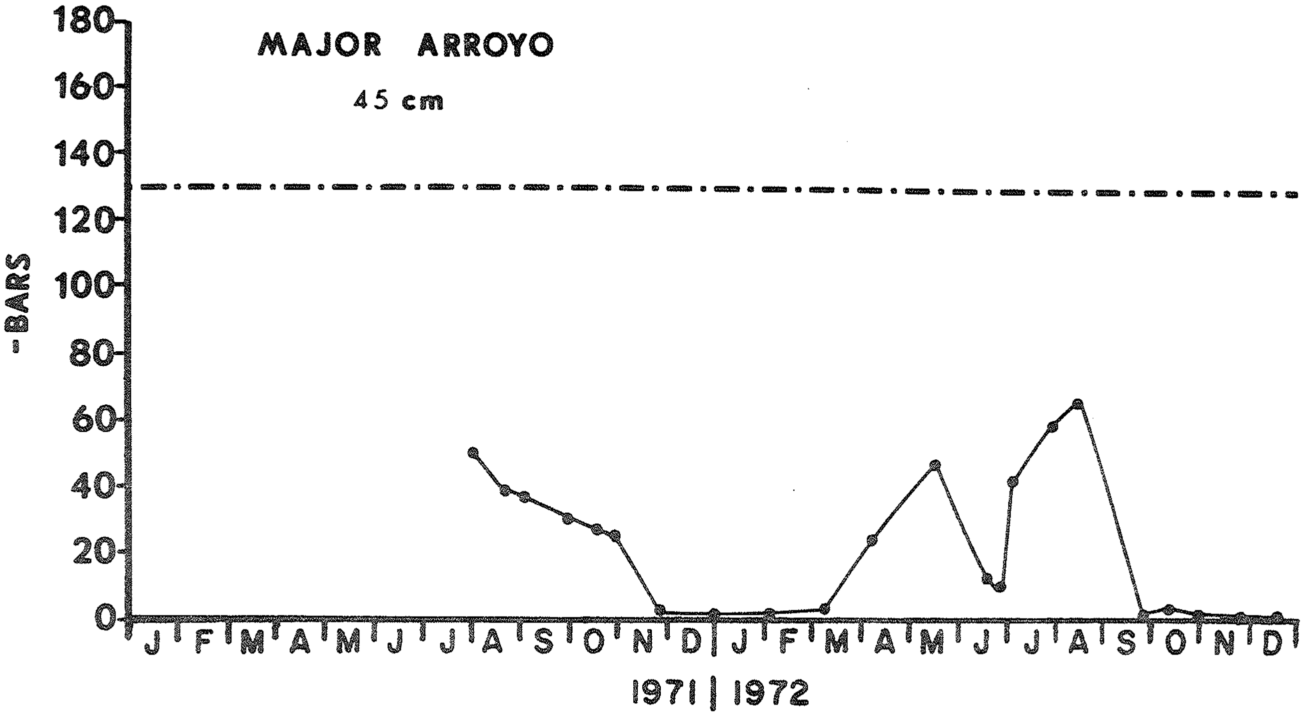

Figure 17. Soil water potentials at 45 cm for 1971 and 1972 in the bajada major arroyo.

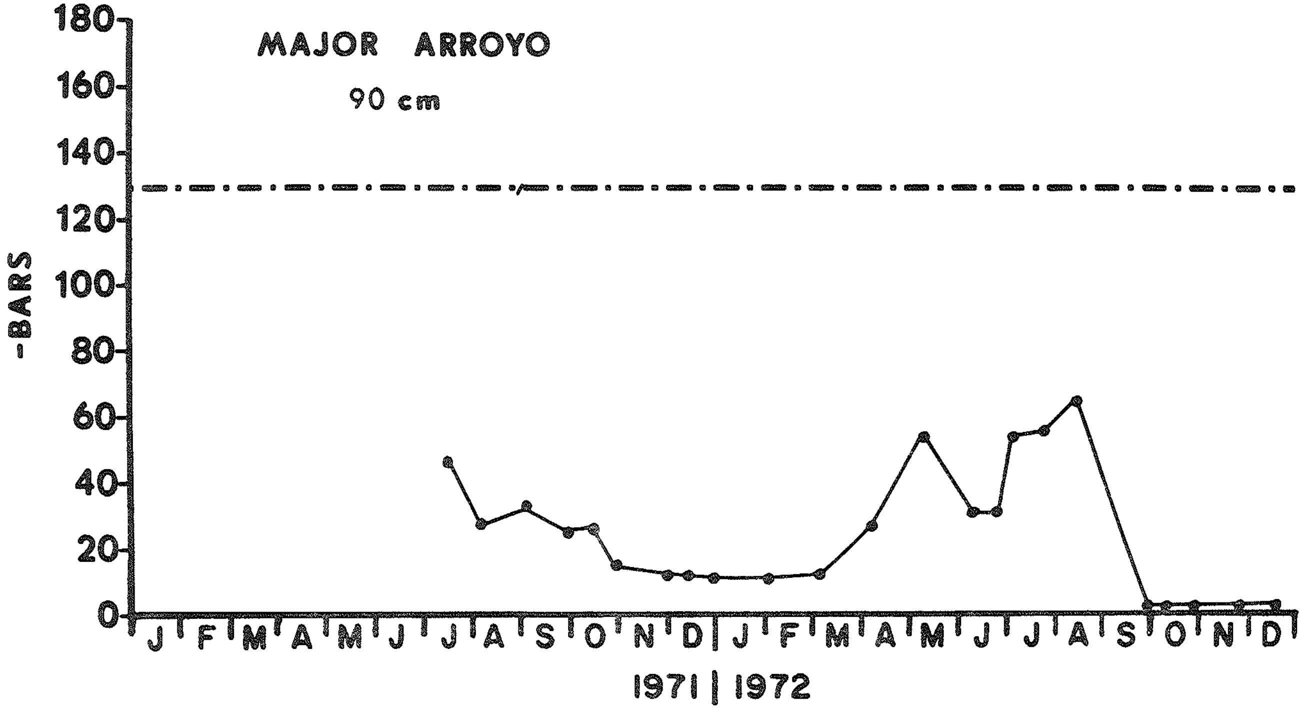

Figure 18. Soil water potentials at 90 cm for 1971 and 1972 in the bajada major arroyo.

II.B. PLANTS

1. ANNUALS -- BAJADA

The annual and small perennial vegetation on the bajada study site was sampled in 1971 and 1972 utilizing 25 stratified, random points as the basis for the point centered quarter method. The plants to which distances were measured were collected and sorted by species, oven-dried, and each species separated into vegetative and reproductive components and weights recorded (DSCODE A3UWJ74).

The greatest total density of annual grasses occurred on the April, 1972, sampling date (Table 1). *Bouteloua barbata* was apparently the more important annual grass on the bajada site in 1972.

Biomass estimates on the bajada site revealed annual grasses to have their grestest summed total biomass on the April, 1972, sampling date (Table 2), coinciding with the greatest total density.

Maximum reproductive biomass of the annual grasses, expressed as percent of total biomass, occurred in September, 1971 (Table 3). Neither species of annual grass sampled on the bajada site in 1972 exhibited reproductive structures at sampling times.

Annual forbs exhibited their greatest total density on the October, 1972, sampling date (Table 4), and a total density only slightly less than the maximum occurred in April, 1972. *Euphorbia micromera* possessed the greatest individual density which occurred in October, 1972, with *Descurainia pinnata* having the second greatest individual density in April, 1972. There appeared to be a group of annual forbs present in the spring and another group in the fall.

Maximum summed total biomass of annual forbs on the bajada site occurred in April, 1972, and the second greatest occurred in October, 1972 (Table 5). These biomass estimates reflected the spring and fall groups of annual forbs.

Greatest reproduction by annual forbs on the bajada site also occurred at two times corresponding to the maximum densities and biomass (Table 6). These spring and fall strategy groups were not as apparent on the playa fringe.

Table 1. Estimated densities of annual grasses on the bajada site on various dates in 1971 and 1972

Density (no. per hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Aristida adscensionis	19	----	----	----
Bouteloua barbata	6	152	45	----
Total	25	152	45	0

Table 2. Estimated biomass (g/ha) of annual grass on the bajada at various dates in 1971 and 1972

	Plant Component	4 Sept. 1971	4 April 1972	28 June 1972	19 Oct. 1972
Aristida adscensionis	Vegetative	1.0	----	----	----
	Reproductive	0	----	----	----
	Total	1.0	----	----	----
Bouteloua barbata	Vegetative	0.5	7.6	.45	----
	Reproductive	0.1	0	0	----
	Total	0.6	7.6	.45	----
Total	Vegetative	1.5	7.6	.45	0
Total	Reproductive	0.1	0	0	0
	Total	1.6	7.6	.45	0

Table 3. Percent of annual grass biomass in reproductive structures at various dates in 1971 and 1972

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Aristida adscensionis	0	----	----	----
Bouteloua barbata	16.67	0	0	-----

Table 4. Estimated densities of annual forbs on the bajada site on various dates in 1971 and 1972

Density (no. per hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Amaranthus fimbriatus	6	----	----	----
Astragalus nuttallianus	----	305	----	----
Boerhaavia spicata	6	----	----	213
Chaenactis stevioides	----	305	----	----
Cryptantha angustifolia	----	762	----	----
Cryptantha crassisepala	----	152	----	----
Cryptantha micrantha	----	914	----	----
Descurainia pinnata	----	4877	----	213
Dithyrea wislizeni	----	----	45	----
Eriogonum abertianum	----	1067	771	638
Eriogonum rotundifolium	----	----	816	2339
Eriogonum trichopes	----	----	136	----
Erodium texanum	----	----	91	----
Euphorbia micromera	102	----	589	4892
Euphorbia serrula	6	----	136	----
Euphorbia setiloba	19	----	45	----
Euphorbia serpyllifolia	----	----	----	1063
Iva ambrosiaefolia	----	305	45	851
Lepidium lasiocarpum	----	1677	----	----
Mollugo cerviana	----	----	----	213
Pectis papposa	89	----	181	213
Phacelia coerulea	----	457	----	----
Portulaca sp.	----	----	91	----
Streptanthus validus	----	----	----	638
Tidestromia lanuginosa	6	----	----	----
Total	234	10,821	2,946	11,273

Table 5. Estimated biomass (g/ha) of annual forbs on the bajada at various dates in 1971 and 1972

Species	Plant Component	1971 9 September	4 April	1972 28 June	19 October
Amaranthus fimbriatus	Vegetative	1.0	----	----	----
	Reproductive	0.1	----	----	----
	Total	1.1	----	----	----
Astragalus nuttallianus	Vegetative	----	15.2	----	----
	Reproductive	----	15.2	----	----
	Total	----	30.4	----	----
Boerhaavia spicata	Vegetative	1.2	----	----	53.2
	Reproductive	0	----	----	2.1
	Total	1.2	----	----	55.3
Chaenactis stevioides	Vegetative	----	6.1	----	----
	Reproductive	----	3.0	----	----
	Total	----	9.1	----	----
Cryptantha angustifolia	Vegetative	----	914.4	----	----
	Reproductive	----	914.4	----	----
	Total	----	1,828.8	----	----
Cryptantha crassisepala	Vegetative	----	15.2	----	----
	Reproductive	----	4.6	----	----
	Total	----	19.8	----	----
Cryptantha micrantha	Vegetative	----	27.4	----	----
	Reproductive	----	27.4	----	----
	Total	----	54.8	----	----
Descurainia pinnata	Vegetative	----	195.1	----	2.1
	Reproductive	----	146.3	----	0
	Total	----	341.4	----	2.1
Dithyrea wislizeni	Vegetative	----	----	2.2	----
	Reproductive	----	----	0	----
	Total	----	----	2.2	----

Table 5. (cont.)

	Plant	1971		1972	
Species	Component	9 September	4 April	28 June	19 October
Eriogonum abertianum	Vegetative	----	21.3	75.3	57.4
	Reproductive	----	0	1.4	10.6
	Total	----	21.3	76.7	68.0
Eriogonum rotundifolium	Vegetative	----	----	104.3	693.2
	Reproductive	----	----	4.1	365.7
	Total	----	----	108.4	1,058.9
Eriogonum trichopes	Vegetative	----	----	8.2	----
	Reproductive	----	----	2.7	----
	Total	----	----	10.9	----
Erodium texanum	Vegetative	----	----	6.8	----
	Reproductive	----	----	0	----
	Total	----	----	6.8	----
Euphorbia micromera	Vegetative	15.3	----	4.5	170.2
	Reproductive	4.1	----	0	157.4
	Total	19.4	----	4.5	327.6
Euphorbia serrula	Vegetative	0.6	----	1.4	----
	Reproductive	0.1	----	0	----
	Total	0.7	----	1.4	----
Euphorbia setiloba	Vegetative	1.0	----	0.4	----
	Reproductive	0.9	----	0	----
	Total	1.9	----	0.4	----
Euphorbia serpyllifolia	Vegetative	----	----	----	12.8
	Reproductive	----	----	----	4.2
	Total	----	----	----	17.0
Iva ambrosiaefolia	Vegetative	----	42.7	63.0	10.6
	Reproductive	----	0	0	0
	Total	----	42.7	63.0	10.6

Table 5. (cont.)

Species	Plant Component	1971 9 September	4 April	1972 28 June	19 October
Lepidium lasiocarpum	Vegetative	----	570.2	----	----
	Reproductive	----	268.3	----	----
	Total	----	838.5	----	----
Mollugo cerviana	Vegetative	----	----	----	2.1
	Reproductive	----	----	----	2.1
	Total	----	----	----	4.2
Pectis papposa	Vegetative	4.5	----	2.7	44.7
	Reproductive	0.9	----	0	29.8
	Total	5.4	----	2.7	74.5
Phacelia coerulae	Vegetative	----	27.4	----	----
	Reproductive	----	18.3	----	----
	Total	----	45.7	----	----
Portulaca sp.	Vegetative	----	----	2.7	----
	Reproductive	----	----	0	----
	Total	----	----	2.7	----
Streptanthus validus	Vegetative	----	----	----	14.9
	Reproductive	----	----	----	0
	Total	----	----	----	14.9
Tidestromia lanuginosa	Vegetative	0.4	----	----	----
	Reproductive	0.2	----	----	----
	Total	0.6	----	----	----
Total	Vegetative	24.0	1,835.0	271.5	1,061.2
	Reproductive	6.3	1,397.5	8.2	571.9
	Total	30.3	3,232.5	279.7	1,633.1

Table 6. Percent of annual forb biomass in reproductive structures at various dates in 1971 and 1972

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

	1971		1972	
Species	9 September	4 April	28 June	19 October
Amaranthus fimbriatus	9.09	----	----	----
Astragalus nuttallianus	----	49.84	----	----
Boerhaavia spicata	0	----	----	3.79
Chaenactis stevioides	----	32.61	----	----
Cryptantha angustifolia	----	50.0	----	----
Cryptantha crassisepala	----	23.23	----	----
Cryptantha micrantha	----	50.0	----	----
Descurainia pinnata	----	42.85	----	0
Dithyrea wislizeni	----	----	0	----
Eriogonum abertianum	----	0	1.83	15.59
Eriogonum rotundifolium	----	----	3.79	34.54
Eriogonum trichopes	----	----	24.77	----
Erodium texanum	----	----	0	----
Euphorbia micromera	21.13	----	0	48.05
Euphorbia serrula	14.29	----	0	----
Euphorbia setiloba	47.37	----	0	----
Euphorbia serpyllifolia	----	----	----	24.71
Iva ambrosiaefolia	----	0	0	0
Lepidium lasiocarpum	----	32.0	----	----
Mollugo cerviana	----	----	----	48.84
Pectis papposa	16.67	----	0	39.95
Phacelia coerulea	----	40.04	----	----
Portulaca sp.	----	----	0	----
Streptanthus validus	----	----	----	0
Tidestromia lanuginosa	33.33	----	----	----

II.B.2 PERENNIALS -- BAJADA

Small perennials

The small perennial vegetation on the bajada site was sampled concomitantly with the annual vegetation utilizing the point centered quarter method as described previously (II.B.1). See DSCODE A3UWJ74.

Erioneuron pulchellum appeared to be the most important perennial grass sampled on the bajada site and its maximum density occurred in April, 1972, coinciding with the greatest total perennial grass density (Table 7). *E. pulchellum* maximum density on the bajada site was less than that on the playa fringe and occurred earlier in the season.

Biomass estimates of the perennial grasses on the bajada site indicated that maximum summed total biomass of these plants occurred in April, 1972 (Table 8), coinciding with maximum total density. *Erioneuron pulchellum*, on the other hand, exhibited its greatest total biomass in October, 1972, subsequent to its greatest density.

Maximum reproductive biomass of the perennial grasses, expressed as percent of total biomass, occurred in the fall (Table 9). The possible exception to this as exhibited by *Muhlenbergia porteri* was likely due to the failure of the sampling technique to include this species in October, 1972.

Perennial forb maximum total density occurred in October, 1972 (Table 10). *Perezia nana* and *Bahia absinthifolia* were apparently the most important perennial forbs on the bajada site and these species exhibited their greatest densities on the October, 1972, sampling date.

Total biomass estimates for the perennial forbs indicated their maximum summed values occurred in October, 1972 (Table 11), coincident with maximum densities. *Perezia nana* exhibited maximum total biomass in October, 1972, concomitant with maximum density, whereas *Bahia absinthifolia* exhibited maximum total biomass prior to maximum density in 1972.

Perennial forb reproductive biomass percentages varied between 1971 and 1972 (Table 12). *Perezia nana* exhibited greatest reproductive biomass percentage in April, 1972, whereas flowering of other species occurred in June of 1972. By October of 1972, the reproductive parts of sampled species were gone, but were present on some on September of 1971.

Table 7. Estimated densities of perennial grasses on the bajada site on various dates in 1971 and 1972

	Density (no. per hectare)			
	1971		1972	
Species	9 September	4 April	28 June	19 October
Erioneuron pulchellum	128	1,677	363	638
Distichlis stricta	6	----	----	----
Muhlenbergia porteri	89	305	45	----
Total	223	1,982	408	638

Table 8. Estimated biomass (g/ha) of perennial grasses on the bajada at various dates in 1971 and 1972

	Plant	1971		1972	
	Component	9 September	4 April	28 June	19 October
Erioneuron pulchellum	Vegetative	6.4	201.2	80.3	310.5
	Reproductive	0	0	0.4	174.4
	Total	6.4	201.2	80.7	484.9
Distichlis stricta	Vegetative	13.4	----	----	----
	Reproductive	0.1	----	----	----
	Total	13.5	----	----	----
Muhlenbergia porteri	Vegetative	226.0	1,451.8	98.1	----
	Reproductive	0.9	70.2	0	----
	Total	226.9	1,522.0	98.1	----
Total	Vegetative	246.8	1,653.0	178.4	310.5
	Reproductive	1.0	70.2	0.4	174.4
	Total	247.8	1,723.2	178.8	484.9

Table 9. Percent of perennial grass biomass in reproductive structures at various dates in 1971 and 1972

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Distichlis stricta	0.74	----	----	----
Erioneuron pulchellum	0	0	0.50	35.97
Muhlenbergia porteri	0.40	4.61	0	----

Table 10. Estimated densities of perennial forbs on the bajada site on various dates in 1971 and 1972

Density (no. per hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Bahia absinthifolia	57	610	317	1,063
Baileya multiradiata	----	914	317	851
Croton pottsii	----	152	45	----
Dyssodia acerosa	6	----	----	----
Perezia nana	51	610	363	1,276
Talinum angustissimum	6	----	91	----
Zephyranthes longifolia	6	----	----	----
Zinnia grandiflora	19	----	----	----
Zinnia pumila	----	----	----	425
Total	145	2,286	1,133	3,615
Shrub				
Larrea divaricata	----	----	----	4,466*

* seedlings

Table 11. Estimated biomass (g/ha) of perennial forbs and shrubs on the bajada at various dates in 1971 and 1972

Species	Plant Component	1971 9 September	1971 4 April	1972 28 June	1972 19 Oct.
Bahia absinthifolia	Vegetative	10.9	48.8	156.7	36.1
	Reproductive	0	0	0.4	0
	Total	10.9	48.8	157.1	36.1
Baileya multiradiata	Vegetative	----	82.3	182.0	10.6
	Reproductive	----	0	1.4	0
	Total	----	82.3	183.4	10.6
Croton pottsii	Vegetative	----	12.2	7.2	----
	Reproductive	----	0	0	----
	Total	----	12.2	7.2	----
Dyssodia acerosa	Vegetative	22.6	----	----	----
	Reproductive	0.9	----	----	----
	Total	23.5	----	----	----
Perezia nana	Vegetative	7.1	48.8	62.2	550.8
	Reproductive	0.5	12.2	0	0
	Total	7.6	61.0	62.2	550.8
Talinum angustissimum	Vegetative	8.8	----	9.6	----
	Reproductive	0.1	----	0.4	----
	Total	8.9	----	10.0	----
Zephyranthes longifolia	Vegetative	8.1	----	----	----
	Reproductive	0	----	----	----
	Total	8.1	----	----	----
Zinnia pumila	Vegetative	----	----	----	2.1
	Reproductive	----	----	----	0
	Total	----	----	----	2.1
Zinnia grandiflora	Vegetative	64.9	----	----	----
	Reproductive	0.2	----	----	----
	Total	65.1	----	----	----
Total	Vegetative	122.4	192.1	417.7	599.6
	Reproductive	1.7	12.2	2.2	0
	Total	124.1	204.3	419.9	599.6
Shrub					
Larrea divaricata	Vegetative	----	----	----	23.4*
	Reproductive	----	----	----	0
	Total	----	----	----	23.4*

* seedlings

Table 12. Percent of perennial forb biomass in reproductive structures at various dates in 1971 and 1972

Percent Reproductive Biomass Per Hectare

(% of Total Biomass Per Hectare)

Species	1971 9 September	4 April	1972 28 June	19 October
Bahia absinthifolia	0	0	0.25	0
Baileya multiradiata	----	0	0.76	0
Croton pottsii	----	0	0	----
Dyssodia acerosa	3.81	----	----	----
Perezia nana	6.49	20.00	0	0
Talinum angustissimum	1.12	----	4.0	----
Zephyranthes longifolia	0	----	----	----
Zinnia grandiflora	0.31	----	----	----
Zinnia pumila	----	----	----	0

Large perennials

In the previous section under the heading of small perennials, the data for grasses and forbs were described. The following paragraphs and sections will describe the major large perennials that occur on the bajada. Before describing the biomass changes of the individual species through time, a description of the initial biomass on the bajada site by species is needed. Also, a description of the general vegetation characteristics should be useful. For data collection methods, see DSCODE A3UWJ75.

The vegetation on the bajada varies from the upland areas on the alluvial fan proper to the large arroyos (washes) which dissect the fan or bajada. The upland areas are characterized by creosote bush (*Larrea divaricata*). The smaller washes, or arroyos, are characterized by tarbush (*Flourensia cernua*), mariola (*Parthenium incanum*) and yuccas (*Yucca elata* and *Y. baccata*). The large arroyos are characterized by Apache plume (*Fallugia paradoxa*), desert willow (*Chilopsis linearis*) and mesquite (*Prosopis glandulosa* var. *torreyana*). Data for these vegetational components and their associated characteristics are given in Table 13. The data are based on a belt transect sampling of the 25 ha bajada site. The area was stratified and forty 5 m by 100 m belts were randomly positioned. Each belt was divided into five sections, each 5 m by 20 m or 100 m^2 in area. Within each section of each belt, the number and size dimensions (canopy height and width) of each species were recorded. From these measures the density, canopy cover and canopy volume were calculated. The averages for these measured and calculated characteristics are shown in Table 13. Creosote bush is the most dominant species, based on its density (4844 ind/ha) and canopy ground cover (23.7%). Two species with about a 1% ground cover are mesquite and tarbush, at 1.05 and 1.0% respectively. Snakeweed (*Xanthocephalum sarothrae*) has the second highest density after creosote bush, but due to its small size only contributes about 0.65% to the ground cover. Tarbush has the third highest density at about 200 ind/ha. Mesquite, being a large plant as indicated by the mean silhouette area per plant (20.3 dm^2) and its mean canopy volume per plant (4.9 m^3), is an important species even though its density is estimated at about 25 ind/ha. As noted earlier, most of these individuals occur along the large arroyo on the bajada site. Some individuals are very large, measuring 4-5 m high and 7-10 m across. The same is true for Apache plume and desert willow. They are restricted to the large arroyo and were only picked up on a part of the sampling. Nevertheless, they are large plants with rapid growth and reproductive rates; thus they are ecologically important to organisms inhabiting the large arroyo. Of the other shrubs, zinnia (*Zinnia pumila*) and mariola have a density of about 30/ha. Mariola is larger than zinnia and is characterized by its pungent, aromatic nature. Of the grasses, only bush muhly (*Muhlenbergia porteri*) has a relatively large cover (0.72%). This bushy grass grows within the canopies of the shrubs and may be important in the long-term dynamics of the site.

Biomass components for the large perennials were estimated using the size dimensions of the individuals of each species. Off-site destructive sampling was used to obtain regression equations relating the biomass of component parts of each species to the canopy cover and canopy volume. Plants were excavated near the bajada site, partially separated in the field, bagged and brought back to the laboratory for oven drying and weighing. About ten individuals of the more important species were collected. In the field, what appeared to be a rather uniform size series of individuals from small to large was collected. However, since canopy cover and volume increase as the square of the radius of the plants, the final distribution of data points used in the regression analyses tended to be skewed toward more smaller plants than larger plants. There may also have been an unconscious bias in the field to avoid the large plants. A data transformation such as square roots or logs of canopy cover and volume would give a more uniform distribution of data points; however, we found in our regression analyses that these transformations tend to overcorrect and poor linear relationships result. Using untransformed canopy cover areas and canopy volumes usually appeared to have a linear relationship with biomass. This held more true for canopy volume than it did for canopy area, which often appeared to have a curvilinear relationship with biomass. Usually a weakly curved portion of a parabola (quadratic or second order polynomial) would give a good fit to the relationship of biomass to canopy area. The biomass estimation equations for creosote bush, tarbush, mariola, zinnia, Apache plume, and Spanish bayonet (*Yucca baccata*) are given in Table 14. Equations for species also common on the playa and reported in Table 17, section I.B.2, are not repeated here. As with the data for the playa species, in most cases the simplest possible regression model with zero intercept and linear in the independent variable (cover and volume) gave the best fit to the biomass data for the bajada species. For tarbush, zinnia and Spanish bayonet, biomass was more linearly related to canopy area than it was to canopy volume. The overall residuals of the data points to the linear regression line also had the best overall distribution. The other species appeared to have a clearer relationship of biomass to canopy volume than to canopy cover, thus canopy volume was used to estimate biomass for these species. The results of the biomass estimations using the equations in Table 14 and Table 17, section I.B.2, are shown in Table 15. For each species and its component parts, the estimated amounts of biomass existing on the bajada site in April, 1971, are given. Creosote bush has the greatest standing crop biomass at about 3500 kg/ha. Of this, about 208 kg/ha is leaf material. Live stems make up about ten times this amount at 2080 kg/ha. Root biomass is close to the amount of live stems, estimated at about 1760 kg/ha. If one corrected for fine root loss during excavation and collection (say about 10%), then live stem biomass and root biomass would be about equal. The amount of standing dead stems in the above-ground canopy of creosote bush was estimated at about 1160 kg/ha. However, this component is quite variable from plant to plant and seems to relate to the age of creosote bush plant, but not necessarily its size. A creosote bush can be quite old based on its crown diameter and have a great amount of large, old, dead stems in its canopy. A younger creosote bush plant may be just as large in size, but have a very small amount of dead stem material. Some clues as to the past history of a site can be obtained by observing this characteristic of creosote bush. Soap-tree yucca has the second greatest total above-ground biomass, but as noted earlier in section I.B.2, this is due primarily to the large, heavy caudex which characterizes this species. Of the total of the rest is persistent dead leaves on the caudex at 325 kg/ha. The green leaf material is estimated at 55 kg/ha. Spanish bayonet differs in that it does not have a large above-ground caudex, thus the bulk of its above-ground biomass is due to green leaves (20.6 out to 24.4 kg/ha). It does have a distinct below-ground tuber, like soap-tree yucca, although not as deep or large. Snakeweed, tarbush, mariola and zinnia, along with the two yuccas, characterize the standing crop of the smaller arroyos which dissect the bajada site. Of these, soap-tree yucca contributes the most leaf biomass at 55 kg/ha with snakeweed, Spanish bayonet, tarbush, mariola and zinnia following at 23, 21, 8, 0.8 and 0.7 kg/ha, respectively. Mesquite, Apache plume and desert willow typify the standing crop of the large arroyo, which divides the bajada site into two halves. Mesquite and Apache plume have about the same standing crops at 373 and 368 kg/ha, respectively. Desert willow is not listed in Table 15 since it is not common except along the major arroyo and was not picked up with enough frequency by the belt transects to give reliable estimates. However, this species is a large plant, with large fragrant flowers and large dehiscent fruits, and thus is an important species along the large arroyo. Another large species which occurs off the south end of the bajada site is desert hackberry (*Celtis reticulata*). It is also found only in the major arroyo and probably serves a number of important ecological functions for the animal populations on the site.

Table 13. Vegetation characteristics for the large perennial species on the bajada site in April, 1971

Species	Density (ind/ha)	Height (m/ind)	Width (m/ind)	L.L.	Ground Cover $ ($m^2/100m^2$-%)	U.L.	Silhouette (dm^2/ind)	Volume (m^3/ind)
SHRUBS:								
Larrea divaricata	4844	.54	.69	22.3	23.7	25.1	19 ¢	.12¢
Prosopis glandulosa	27	1.36	1.90	.48	1.05	1.62	203 *	4.94*
Xanthocephalum sarothrae	261	.43	.50	.43	.65	.87	17 *	.09*
Flourensia cernua	196	.67	.71	.65	1.00	1.35	37 *	.30*
Parthenium incanum	32	.62	.72	.05	.15	.24	35 *	.21*
Zinnia pumila	29	.28	.34	.001	.04	.077	8.2*	.04*
Ephedra trifurca	24	.76	.86	.07	.19	.31	51 *	.53*
Fallugia paradoxa	19	.67	.78	.09	.20	.31	41 *	.60*
GRASSES:								
Aristida sp.	31	.39	.29	.01	.03	.05	8.9*	.04*
Muhlenbergia porteri	97	.50	.73	.23	.45	.68	29 *	1.16*
SUCCULENTS:								
Yucca elata - leaves	123	.45	.60	.22	.44	.66	14 ¢	.07¢
Yucca baccata	33	.75	.70	.05	.15	.25	26 ¢	.12¢
Opuntia sp.	86	.29	.41	.11	.14	.18	9.3*	.04*

$ mean with (L.L.) and upper (U.L.) 95% Confidence limits
* upper half of spheroid
¢ cone

NOTE: The number of individuals per 100 m^2 section were used to calculate the mean density. The size dimensions of the canopy of each individual were used to calculate mean height, width, ground cover, silhouette area and volume of the canopies for each species. The area and volume calculations for the canopies of each species use the formuli which seem to best fit their natural shapes.

Table 14. Estimation equations for biomass (B) of large perennials on the bajada by their component parts based on canopy ground cover (A) and canopy volume (V)

Species	Component	Equation based on Canopy Area (A)	Equation based on Canopy Volume (V)
Larrea divaricata (11)*	Leaves	B = 105.3A	B = 345.8V
	Live Stems	$B = 714.9A + .024A^2$	B = 3448.5V
	Dead Stems	$B = 365.3A + .015A^2$	B = 1920.4V
	Total Above Grnd	B = 1530.7A	B = 5835.9V
	Total Below Grnd	$B = 760.6A + .009A^2$	B = 2919.1V
Flourensia cernua (8)	Leaves	B = 88.0A	B = 123.0V
	Live Stems	B = 828.4A	B = 1163.3V
	Dead Stems	B = 506.8A	B = 700.4V
	Total Above Grnd	B = 1425.4A	B = 1986.9V
	Total Below Grnd	B = 596.1A	B = 810.9V
Parthenium incanum (5)	Leaves	B = 57.5A	B = 115.6V
	Live Stems	B = 609.9A	B = 1234.2V
	Dead Stems	B = 685.5A	B = 1396.4V
	Total Above Grnd	B = 1374.1A	B = 2788.4V
	Total Below Grnd	B = 257.4A	B = 517.9V
Zinnia pumila (10)	Leaves	B = 172.2A	B = 951.1V
	Stems	B = 668.9A	B = 3726.4V
	Total Above Grnd	B = 845.5A	B = 4701.6V
	Total Below Grnd	B = 89.8A	B = 493.0V
Fallugia paradoxa (3)	Leaves		B = 563.0V
	Live Stems		B = 31376.8V
	Dead Stems		B = 224.3V
	Total Above Grnd		B = 31940.0V
	Total Below Grnd		B = 1890.0V
Yucca baccata (3)	Green Leaves	B = 1340.6A¢	B = 6370.4V¢
	Caudex	B = 43.2A¢	B = 204.0V¢
	Dead Leaves	B = 204.2A¢	B = 983.7V¢
	Tuber	B = 1995.9A¢	B = 9500.4V¢

¢ based on leaf ground cover area (A) or leaf canopy volume (V)
* number of plants used in determining coefficients of the equations

NOTE: Equations for bajada species also found on the playa and reported earlier (Table 17, section I.B.2) are not repeated here.

Table 15. Biomass estimates for large perennials on the bajada site for April, 1971

Species	Component	Biomass (kg/ha)* L.L.	mean	U.L.	Estimated by Equation
Larrea divaricata	Leaves		208		V
	Live Stems		2080		V
	Dead Stems		1160		V
	Total Above Grnd	3230	3520	3810	V
	Total Below Grnd		1760		V
Prosopis glandulosa var. *torreyana*	Leaves		11		V
	Live Stems		186		V
	Dead Stems		176		V
	Total Above Grnd	157	373	589	V
	Total Below Grnd		286		V
Xanthocephalum sarothrae	Leaves		23		V
	Stems		29		V
	Total Above Grnd	33	52	71	V
	Total Below Grnd		11		V
Flourensia cernua	Leaves		8		A
	Live Stems		83		A
	Dead Stems		51		A
	Total Above Grnd	93	143	193	A
	Total Below Grnd		60		A
Parthenium incanum	Leaves		.8		V
	Live Stems		8.3		V
	Dead Stems		9.4		V
	Total Above Grnd	6.7	18.8	30.9	V
	Total Below Grnd		3.5		V
Zinnia pumila	Leaves		.7		A
	Stems		2.6		A
	Total Above Grnd	.1	3.3	6.5	A
	Total Below Grnd		.4		A
Ephedra trifurca	Green Stems		13		V
	Woody Stems		16		V
	Dead Stems		4		V
	Total Above Grnd	12	32	53	V
	Total Below Grnd		10		V
Fallugia paradoxa	Leaves		6		V
	Live Stems		361		V
	Dead Stems		3		V
	Total Above Grnd		368		V
	Total Below Grnd		22		V

Table 15. (cont.)

Species	Component	Biomass (kg/ha)* L.L.	Biomass (kg/ha)* mean	Biomass (kg/ha)* U.L.	Estimated by Equation
Yucca elata	Green Leaves		55		V
	Caudex		853		V
	Dead Leaves		326		V
	Total Above Grnd		1234		V
	Tuber		3341		V
Yucca baccata	Green Leaves		20.6		A
	Caudex		.7		A
	Dead Leaves		3.1		A
	Total Above Grnd	7.6	24.4	41.3	A
	Tuber		30.7		A

* Means with lower (L.L.) and upper (U.L.) 95% Confidence limits based on biomass between sections of belts variability.

V = estimation based on volume equations of Table 14 or Table 17, section IB-2.

A = estimation based on ground cover area equations of Table 14 or Table 17, section ~~IB~~-2.

NOTE: Estimates are based on equations in Table 14 and Table 17, section I.B.2.

Yucca elata

In the previous section the general vegetation was described. The following paragraphs and sections mill the biomass changes of the individual species (starting with *Yucca elata* through time.

Incremental leaf production of ten *Yucca elata* plants on the bajada study site was monitored during 1971 and 1972. The method used was to record the number and mean length of new leaves added to the canopy from the central apex. In addition, the number and mean length of canopy leaves becoming standing dead were recorded. Starting in 1972, the standing dead leaves were also harvested and weighted allowing comparison of the actual weights to those estimated from a regression equation relating standing dead leaf biomass to leaf length (Figure 10, section I.B.2). The new leaf biomass was estimated from a regression equation relating biomass to new leaf length (Figure 9, section I.B.2).

Further growth dynamics of *Y. elata* were studied utilizing the belt transect data described above as initial estimates of density, leaf volume, and caudex volume. Initial leaf biomass was estimated from leaf volume and initial caudex biomass was estimated from caudex volume (Table 17, section I.B.2). Using these relationships derived from a size series of *Y. elata* plants, monthly changes in caudex and standing dead leaf biomass can be estimated. Total above-ground biomass was estimated as the sum of calculated living leaf and caudex biomass. Phenological comments are based on cursory field observations.

Yucca elata on the bajada site annually exhibited two bursts of new leaf production (Figure 1), as did this species on the playa fringe (Figure 11, section I.B.2). In order of decreasing magnitude, these bursts occurred in late summer and early spring respectively. In 1971 and the spring of 1972, these bursts of new leaf production occurred a month earlier on the bajada than on the playa, but at about the same time in the summer of 1972. As on the playa, increased new standing dead leaf production followed increased leaf production, suggesting translocation of material from older leaves. However, this did not hold for the biggest burst of growth in the summer of 1972 when no increase in standing dead leaves followed the increase in new green leaves. The production of standing dead-leaf biomass as estimated from the regression equations was very close to the actual weights determined by harvest (Figure 2).

Net standing crop of live-leaf biomass for *Yucca elata* on the bajada site is shown in Figure 3. As on the playa, the only significant increase in leaf biomass was during the summer of 1972, with little change in 1971. The 1972 increase on the bajada was not as great as that on the playa (Figure 13, section I.B.2). Most of this difference can be explained by the slightly higher density on the playa.

Standing crop biomass of *Yucca elata* caudex (Figure 4) and total above-ground (Figure

5) as estimated, reflect the leaf biomass trends. Studies using direct caudex measurements are needed to clarify the relationship between leaf and caudex biomass.

Yucca elata initiated inflorescence growth very sporadically in the very dry spring of 1971. Only two individuals began sending up flower stalks in early May and reached full maturity in about three weeks. On June 1, the flowering stalks were 160 cm and 225 cm high. By June 5, the flowers which did not develop fruits began to drop off. Only a few mature fruits survived. In 1972, flowering stalks began to emerge on April 3. The stalks elongated to about 50 cm by April 8. By May 1 most individuals had flowers fully developed on their inflorescences. Of 100 individuals observed, 52 had produced inflorescences; however, 39 of these were chewed off by a single bull which broke through a fence and onto the site. This dramatizes the effect a single grazer may have on the reproductive potential of *Y. elata*. By May 13, all surviving inflorescence stalks were fully open-panicled, with older flowers beginning to drop off. Again fruit set was low.

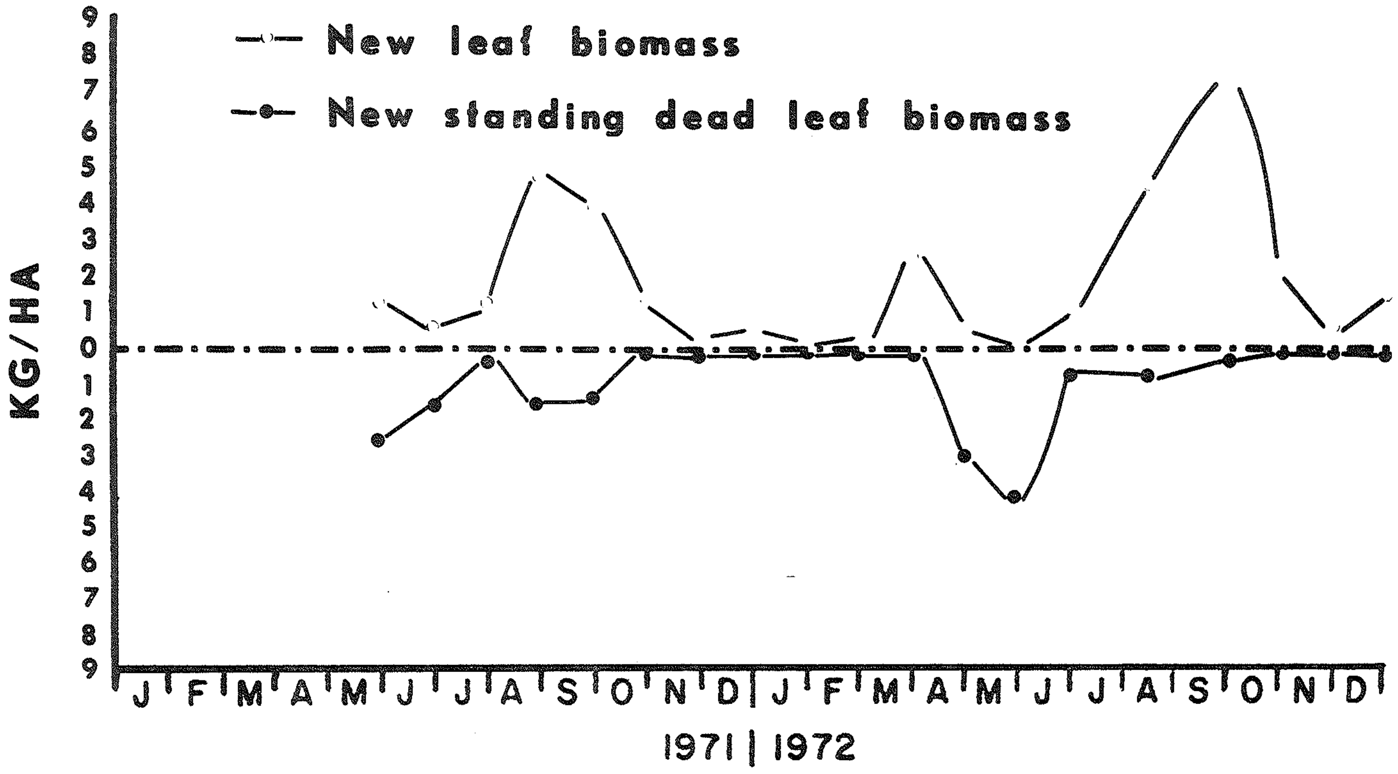

Figure 1. Monthly changes in new leaf and standing dead-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada.

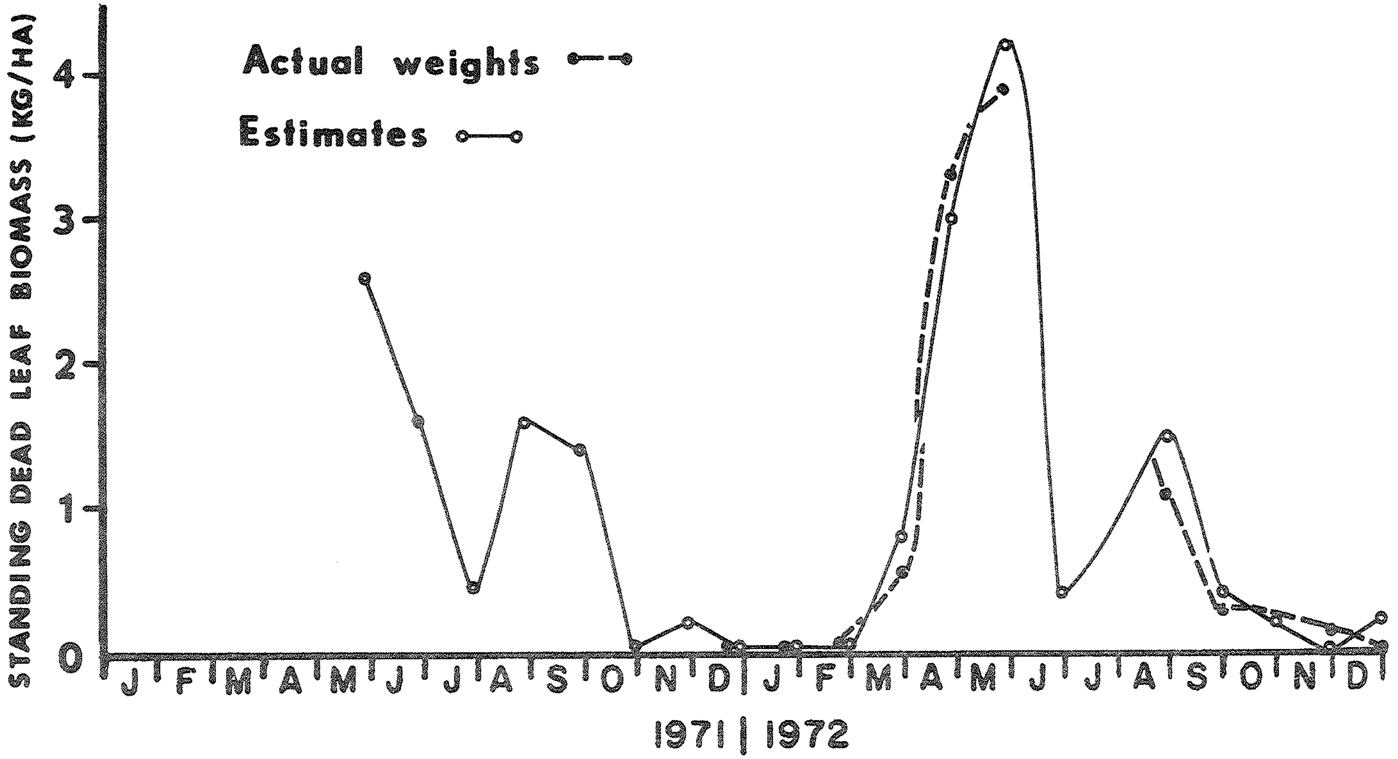

Figure 2. Monthly changes in standing dead-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada. Estimates based on a regression equation relating dead-leaf biomass to dead-leaf length are given along with actual weights determined from harvest of dead leaves.

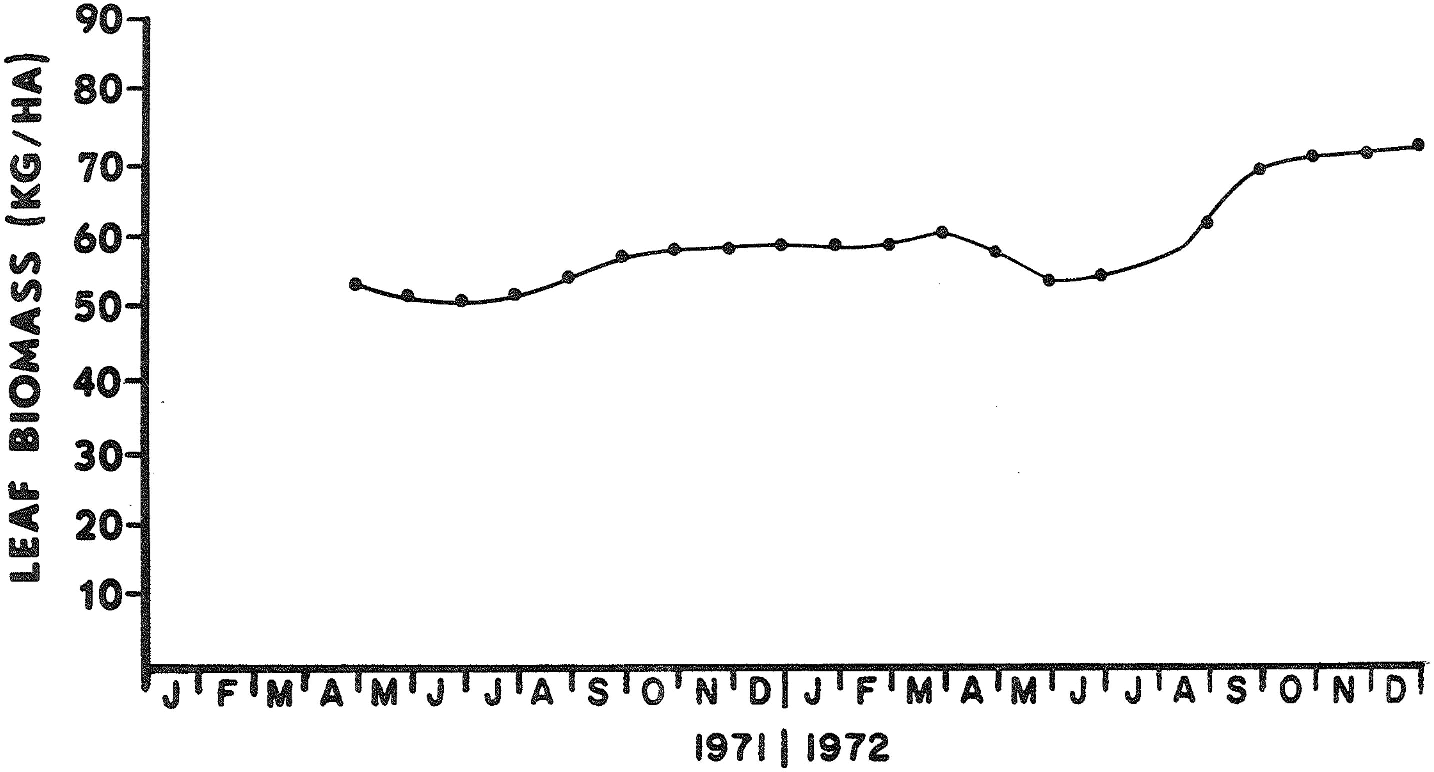

Figure 3. Monthly net standing crop of green-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada.

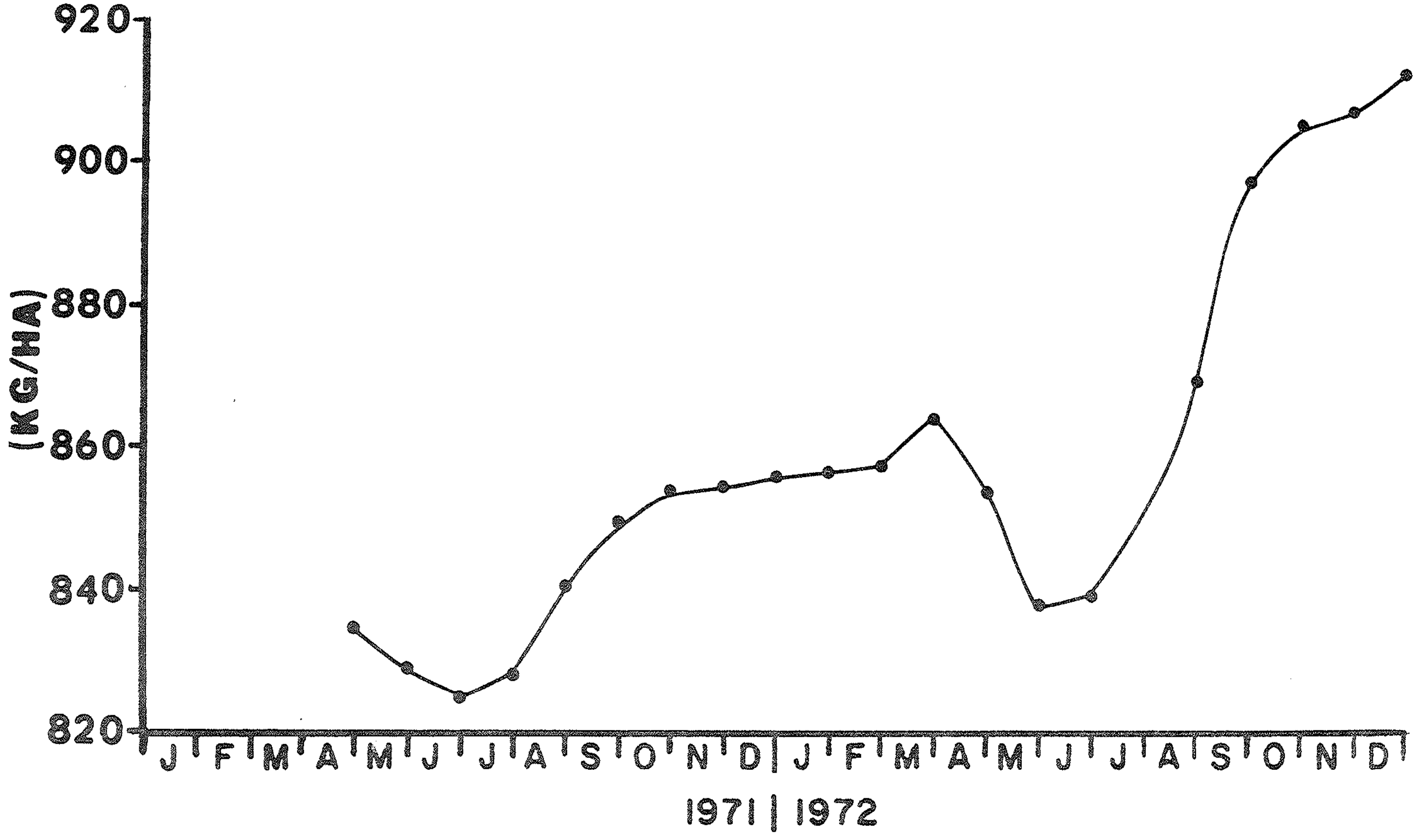

Figure 4. Monthly standing crop of caudex biomass for *Yucca elata* in 1971 and 1972 on the bajada.

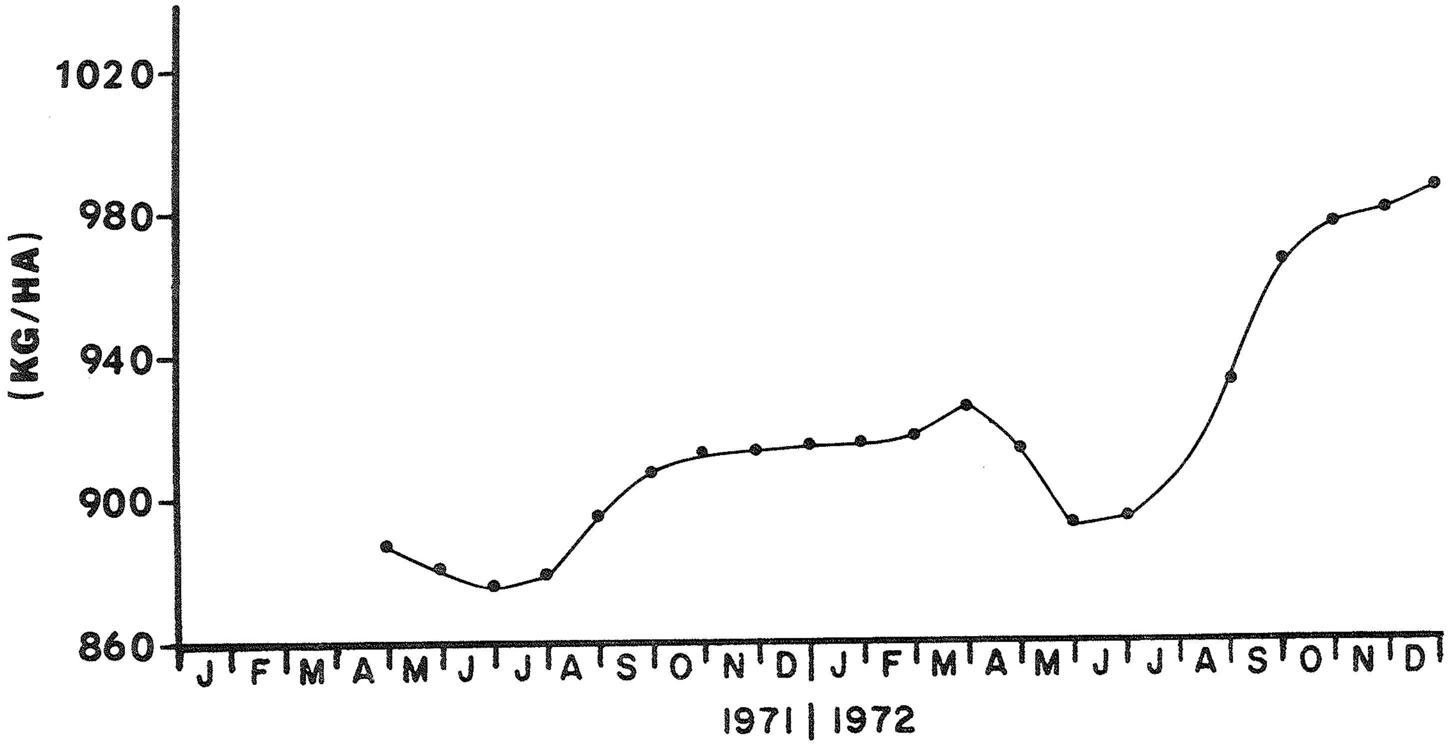

Figure 5. Monthly standing crop of total above-ground biomass for *Yucca elata* in 1971 and 1972 on the bajada.

Yucca baccata

Incremental leaf production of seven *Yucca baccata* plants on the bajada study site was monitored during 1971 and 1972. The method used was to record the number and mean length of new leaves added to the leaf canopy from the central apex. The amount of new-leaf biomass added was estimated from the lengths using a regression equation (Figure 6). In addition, the number and mean length of canopy leaves becoming standing dead were recorded. The amount of standing dead-leaf biomass was estimated from leaf length using a regression equation (Figure 7).

Further growth dynamics of *Yucca baccata* were studied using the belt transect data described in section II.B.2. Initial estimates of density and leaf volume were used to initialize the changes in leaf biomass through time. Phenological comments are based on cursory field observations.

Yucca baccata exhibited at least two bursts of new leaf production annually (Figure 8). The burst of greatest magnitude occurred in the summer, with a smaller burst in early spring. As with *Yucca elata*, *Y. baccata* shows an increase in leaf death shortly after an increase in leaf production. One exception to this occurred in October, 1971, when new leaves were produced without subsequent leaf death.

Net standing crop of live-leaf biomass for *Yucca baccata* on the bajada site is shown in Figure 9. The initial leaf biomass of 20.6 kg/ha changed only slightly during the two years it has been monitored. It increased slightly in the late fall of 1971, but then decreased in the spring of 1972. No significant gain was seen in the summer and fall of 1972. The standing crop of leaf biomass was estimated at 20.1 kg/ha in December, 1972. In fact, the total standing crop may be underestimated since our sampling method does not handle losses of leaves to browsers very well.

In 1971, no *Yucca baccata* were observed flowering on the bajada. In 1972, approximately 30% of the population flowered, reaching a maximum in early April. However, 80% of those flowers were severely damaged by a frost. Another 5% were chewed off by the bull which got onto the site. The remaining inflorescences produced few fruits and only the larger individuals were successful.

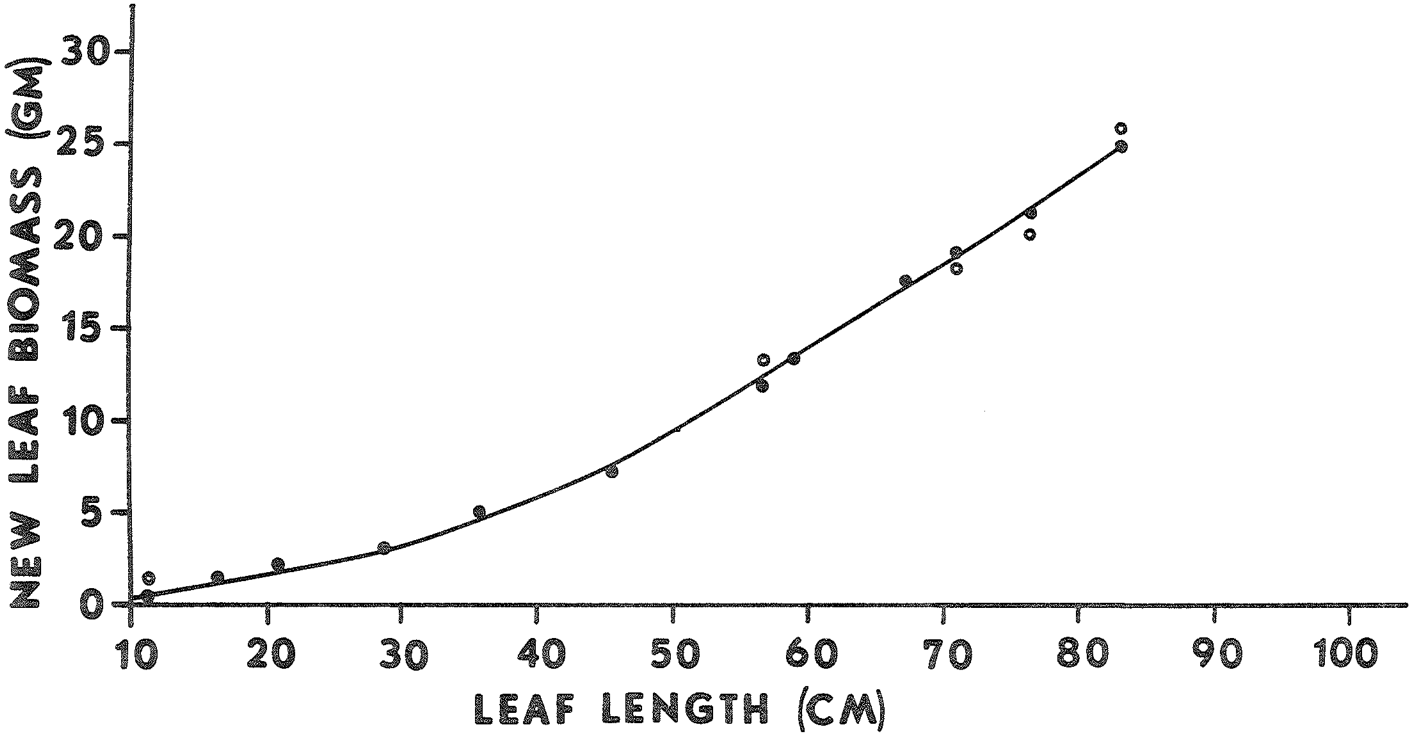

Figure 6. Regression of live-leaf biomass (B) onto live-leaf length (L) for *Yucca baccata*. The equation of the curvilinear regression line is $B = -0.0021\ L + 0.0038\ L^2$.

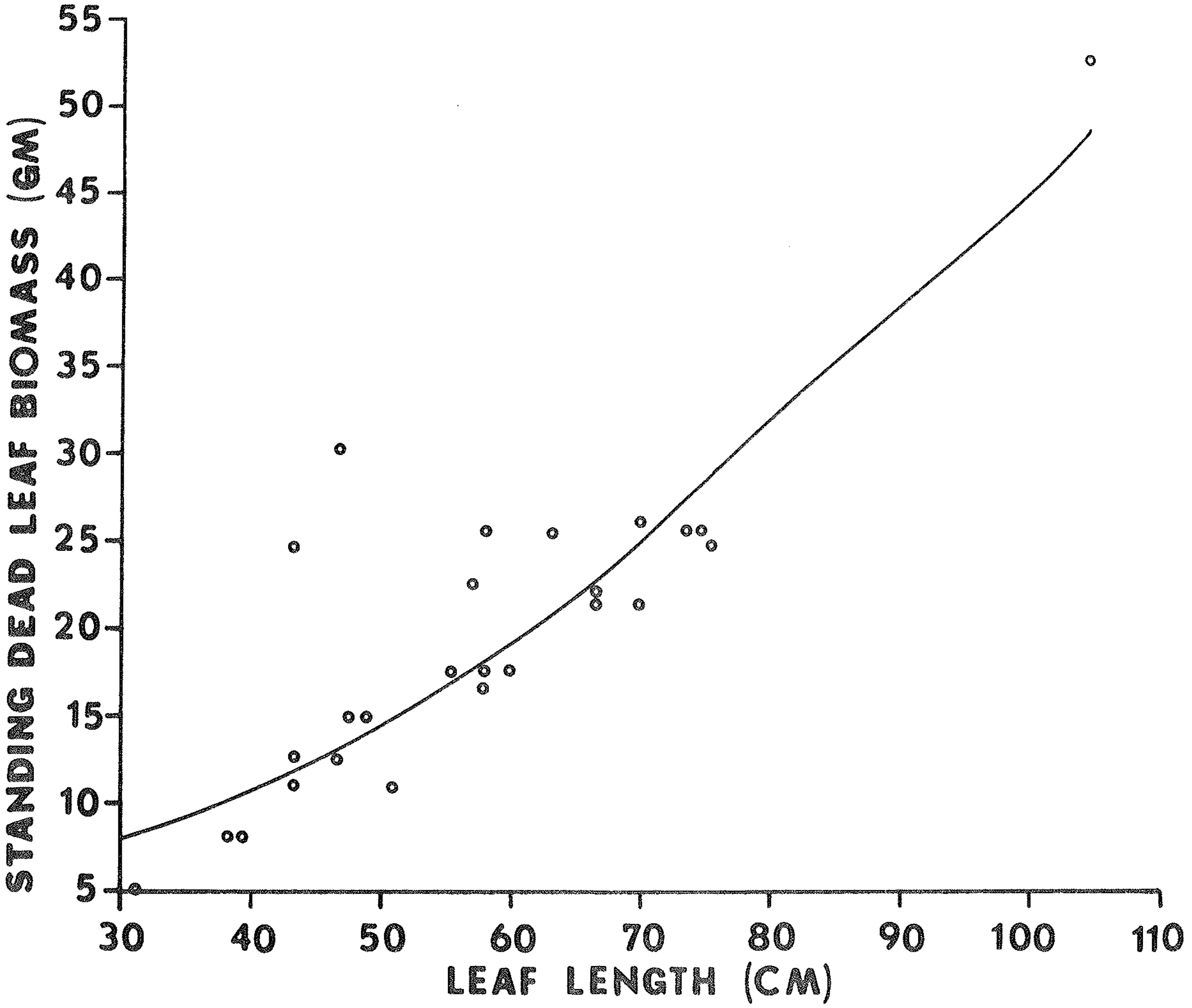

Figure 7. Regression of standing dead-leaf biomass onto dead-leaf length (L) for *Yucca baccata*. The equation of the curvilinear regression line is $B = 0.207\ L + 0.0023\ L^2$.

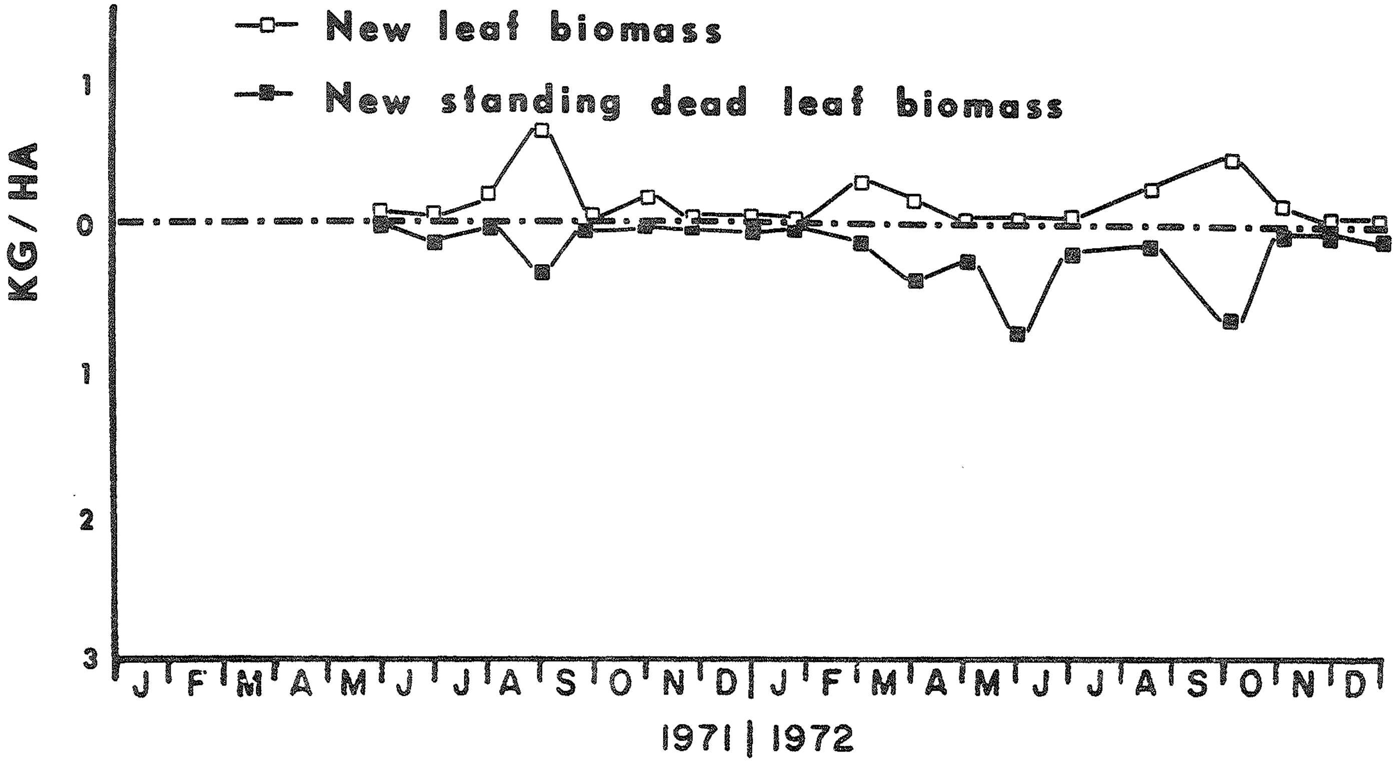

Figure 8. Monthly absolute leaf biomass gains and losses for *Yucca baccata* in 1971 and 1972 on the bajada.

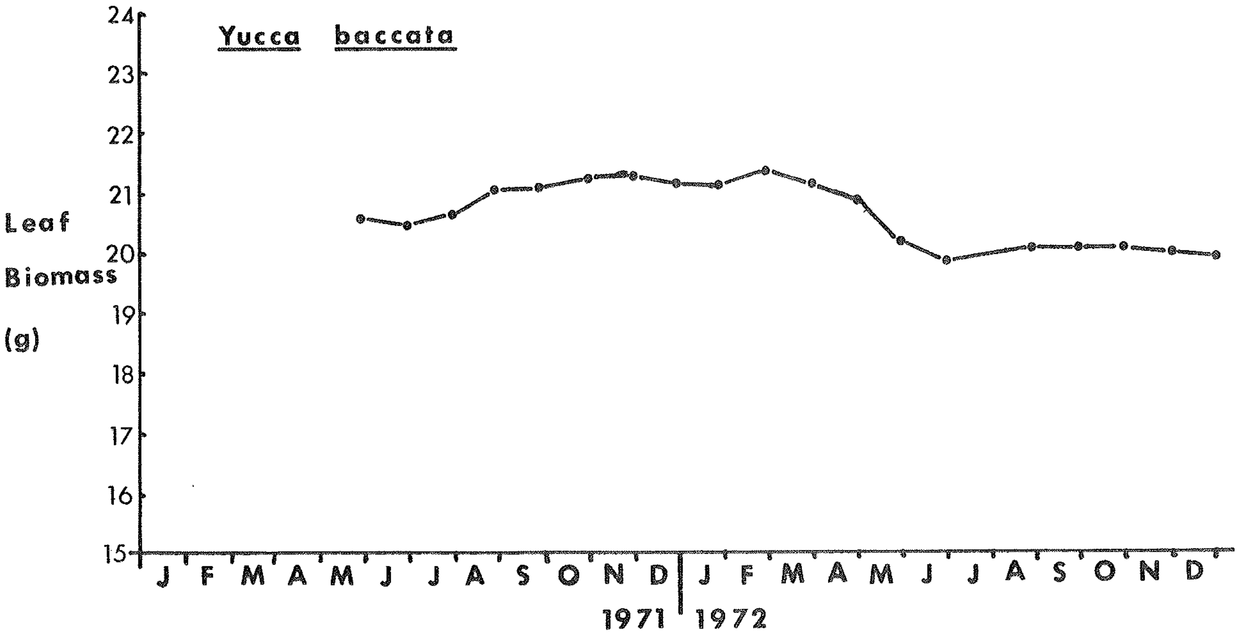

Figure 9. Monthly standing crop of live-leaf biomass for *Yucca baccata* in 1971 and 1972 on the bajada.

Xanthocephalum sarothrae

The growth of 10 *Xanthocephalum* plants located along the small arroyos on the bajada was monitored during 1971 and 1972. The plants were selected at random, based on a random count system for the plant populations along the small washes. Growth was measured by monitoring the height and width of the canopies each month. During the growing season these size dimensions of the canopy will increase, allowing for an estimation of changes in biomass based on the relationships between biomass and canopy volume (Figures 16 and 17, section I.B.2--*Xanthocephalum*). Using these relationships and the mean monthly canopy volumes, biomass changes through time were computed (Figure 10). During the spring of 1971, leaf and stem biomass were monitored at about 30 and 40 kg/ha respectively. After an initial slight die-back, the canopy volume increased to a maximum in September, when the plants flowered. The fall die-back of leaf and live stems was not as rapid as on the playa site, which corresponds with the generally warmer temperatures on the bajada. Some plants maintained a small amount of green-leaf biomass during the coldest month of January in 1972. Growth resumed in February, 1972 and increased slowly until it peaked in September. Fall die-back occurred in November. *Xanthocephalum* flowers in late August and early September, reaching maximum seed production in late September and October. Unlike many of the other desert species, *Xanthocephalum* appeared to flower under some photoperiodic control. Many other species are more opportunistic.

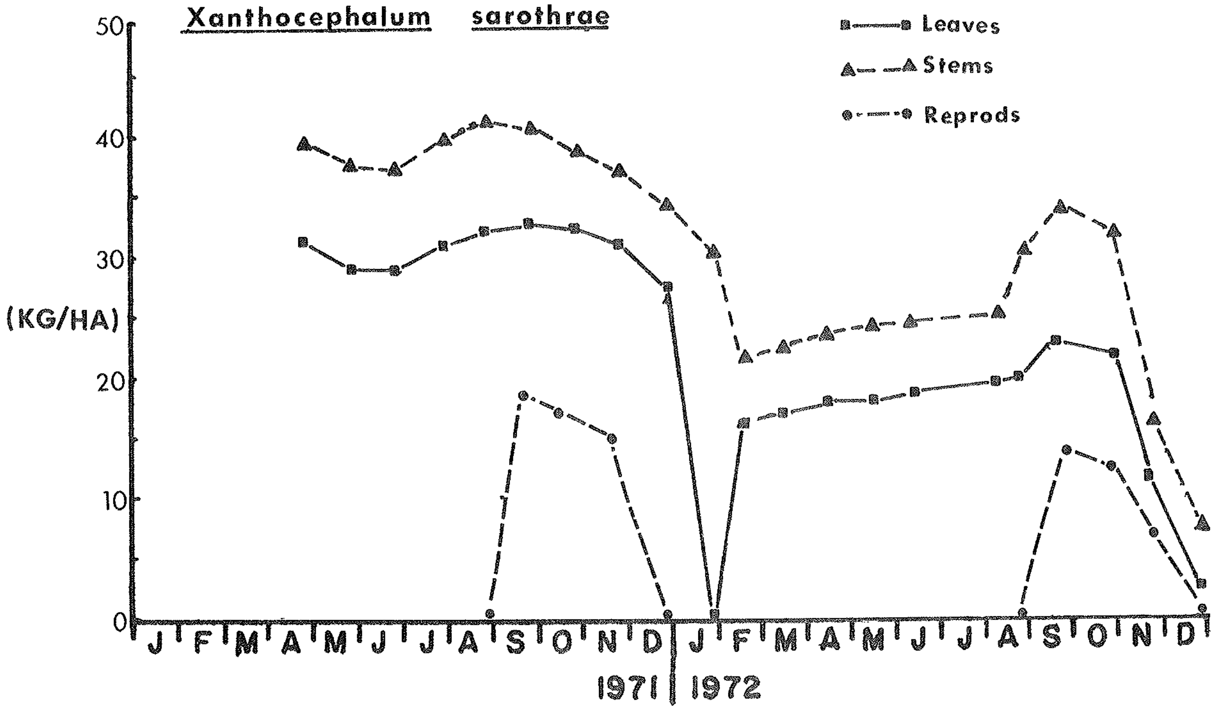

Figure 10. Monthly standing crop of leaf, stem and reproductive biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the bajada.

Larrea divaricata

The growth characteristics of 25 creosote bush (*Larrea divaricata*) plants on the bajada have been monitored since May, 1971. On each randomly selected plant a number of growth points (active apical tips) were tagged with wool yarn to facilitate monthly measurements. Measurements were made on the length from the node immediately in front of the tag to the tip of the youngest leaf. In 1971, a total of 141 growth points were initially tagged in May. In 1972, a total of 213 growth points were initially tagged in March. From a length series of growth points collected near the site, two regression equations were derived to estimate new leaf and new stem biomass from growth point length (Figure 11). A range of growth points from 10 to 70 mm at 10 mm intervals was used, taken from seven different plants towards the end of the growing season in 1971 (October). In 1972, lengths of growth points were measured which exceeded 70 mm, thus these regression studies will have to be repeated for longer lengths. Since the 10 mm interval is arbitrary, the lengths will be collected in a more continuous series at the unit of measure of 1 mm. Also, the biomass-to-length relationship needs to be investigated at other times of the year.

At each growth point, the number of reproductive structures (floral buds, flowers or fruits) was recorded each month. This allowed a quantitative check on the phenological state of the plants on the bajada. From a collection of 3128 fruits, it was computed that the mean biomass of a fruit was 22 mg.

Initial biomass estimates of *L. divaricata* were obtained using the belt transect data described above (Table 15). The initial biomass estimates were based on the equations given in Table 14. The relationship of leaf and live stem biomass to canopy volume is shown in Figure 12. Based on available data, the amounts of biomass of leaves and live stems appear to be linearly related to the canopy volume of creosote bush. The relationship of roots and dead stems to canopy volume is shown in Figure 13. As one might expect, the closeness of fit of the observed data to a linear regression line for these two plant components is less than for leaves and live stems. The root biomass among plants of similar canopy volume is quite variable. Part of this variation may be due to difference in age of the plant crown and the position of the crown relative to the ground surface. Also, differences in thoroughness in collection of roots in the field may contribute to this variation. The relationship of flower biomass to canopy volume is shown in Figure 14. The purpose in showing this poor relationship is to illustrate the necessity of using other methods for estimating the biomass of reproductive plant parts in this species. One would expect the biomass of flowers and fruits to vary greatly from season to season and year to year.

Another growth characteristic of creosote bush is that, as a growth point increases in length, there is an addition of new growth points since lateral stems are produced, each with an active growth point. This relationship is illustrated in Figure 15. As the length of a growth point approaches 100 mm, there is a tendency for a rapid increase in growth points

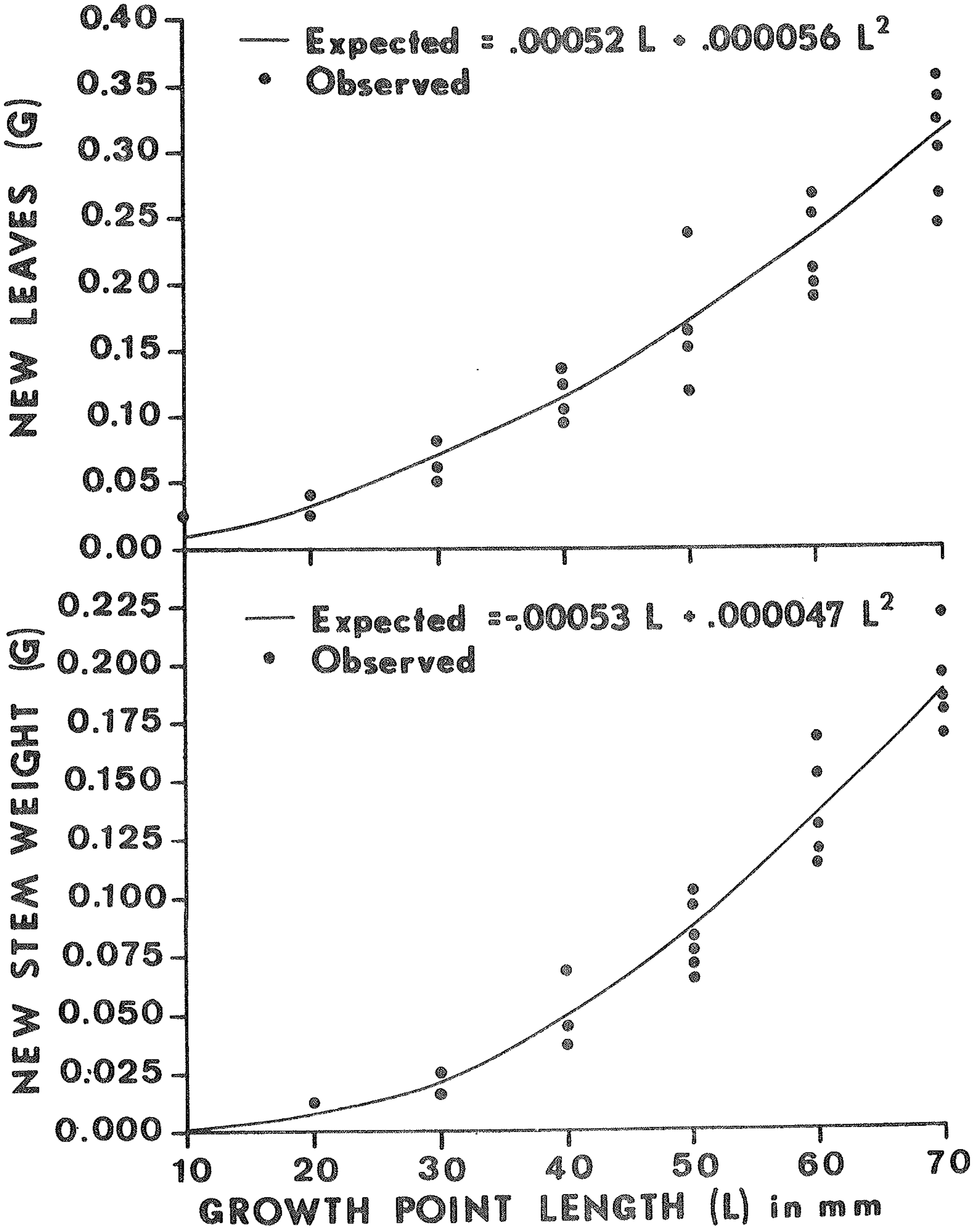

Figure 11. (Top) Regression of leaf biomass (B) onto growth point length (L) for *Larrea divaricata*. The equation of the curvilinear regression line is $B = 0.00052\ L + 0.000056\ L^2$.

(Bottom) Regression of stem biomass (B) onto growth point length (L) for *Larrea divaricata*. The equation of the curvilinear regression line is $B = 0.00053\ L + 0.000047\ L^2$.

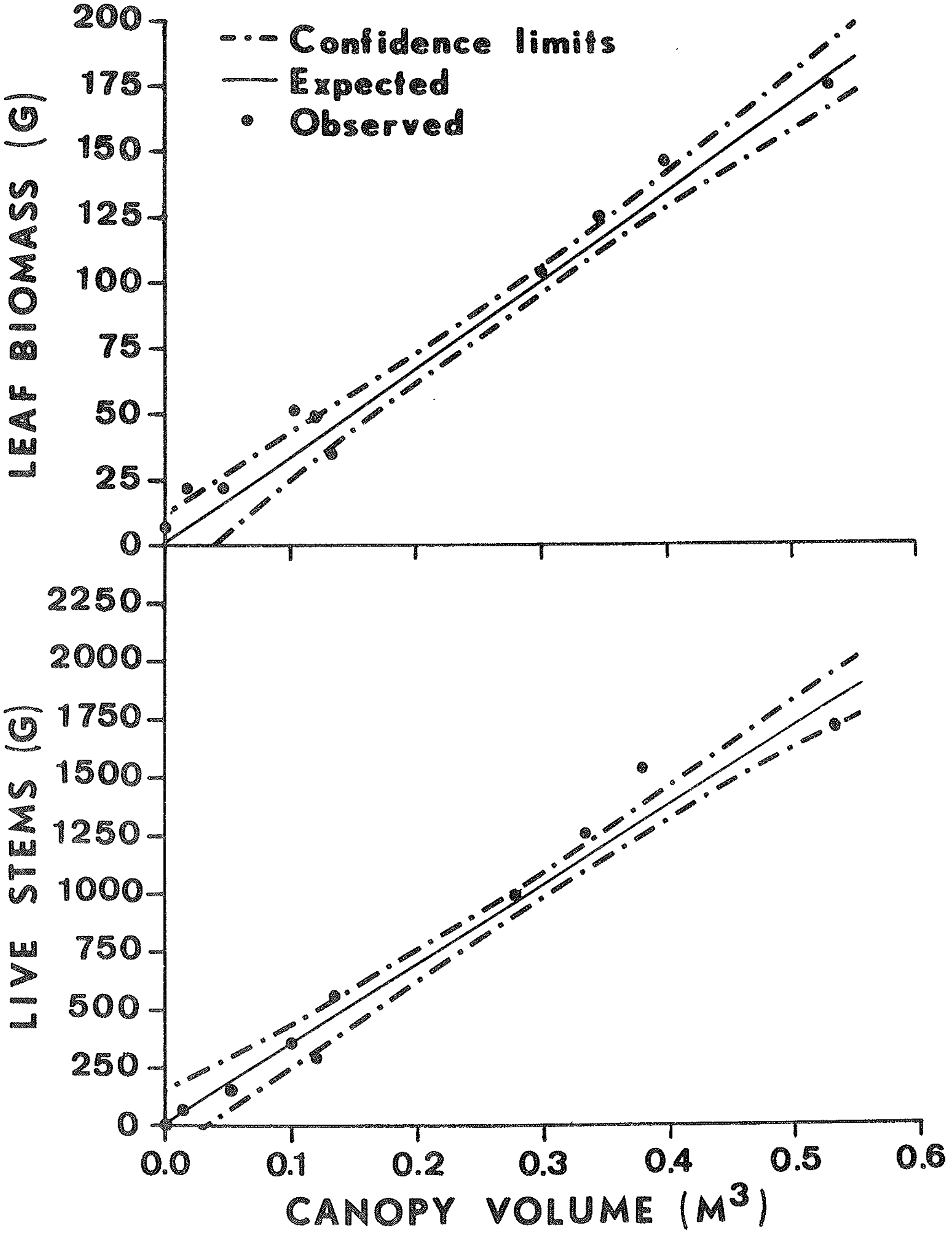

Figure 12. (Top) Regression of total leaf biomass (B) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 345.8 V.

(Bottom) Regression of total live stem biomass (B) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the

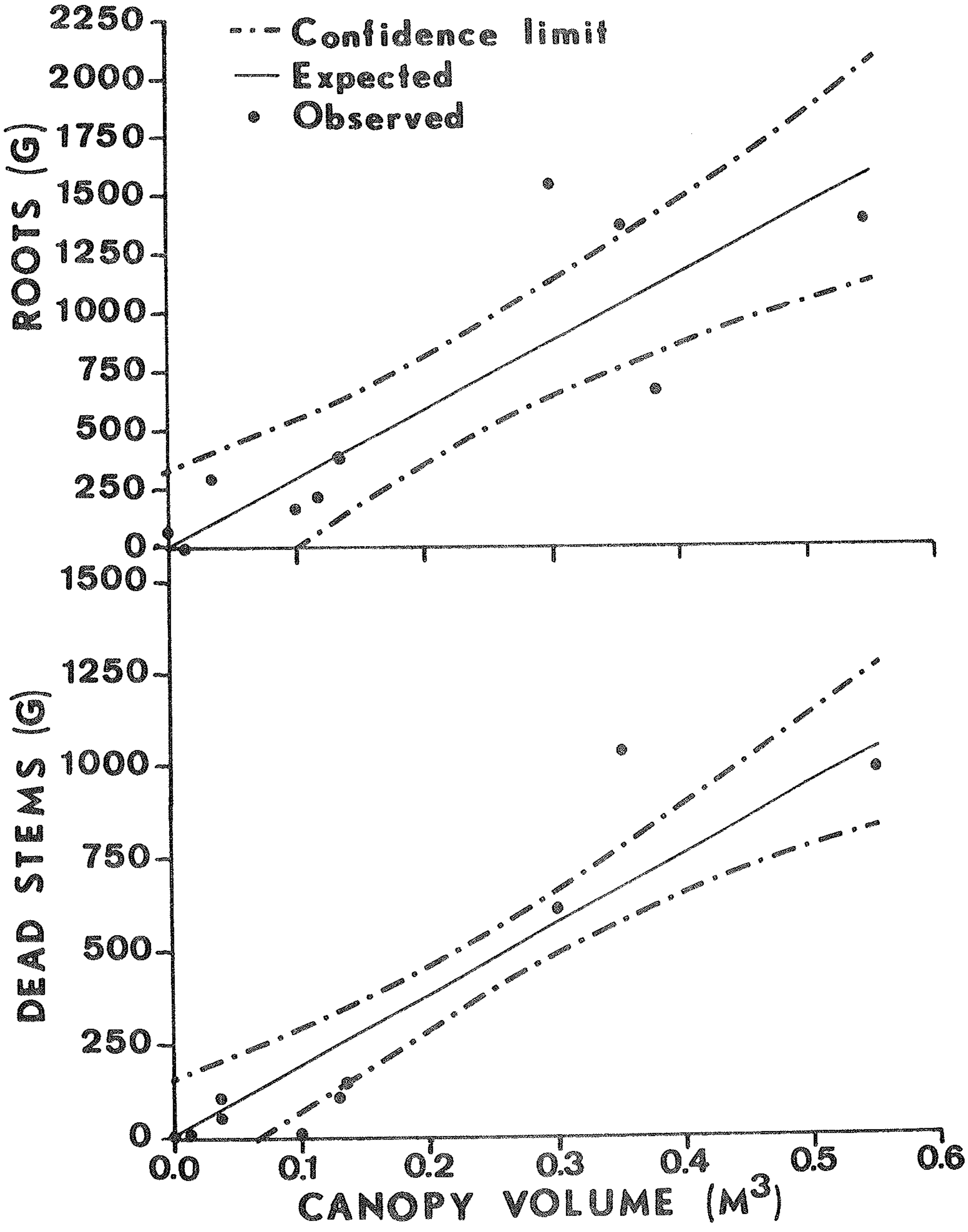

Figure 13. (Top) Regression of total root biomass (B) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 2919.1 V.

(Bottom) Regression of total dead stem biomass (V) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression is B = 1920.4 V.

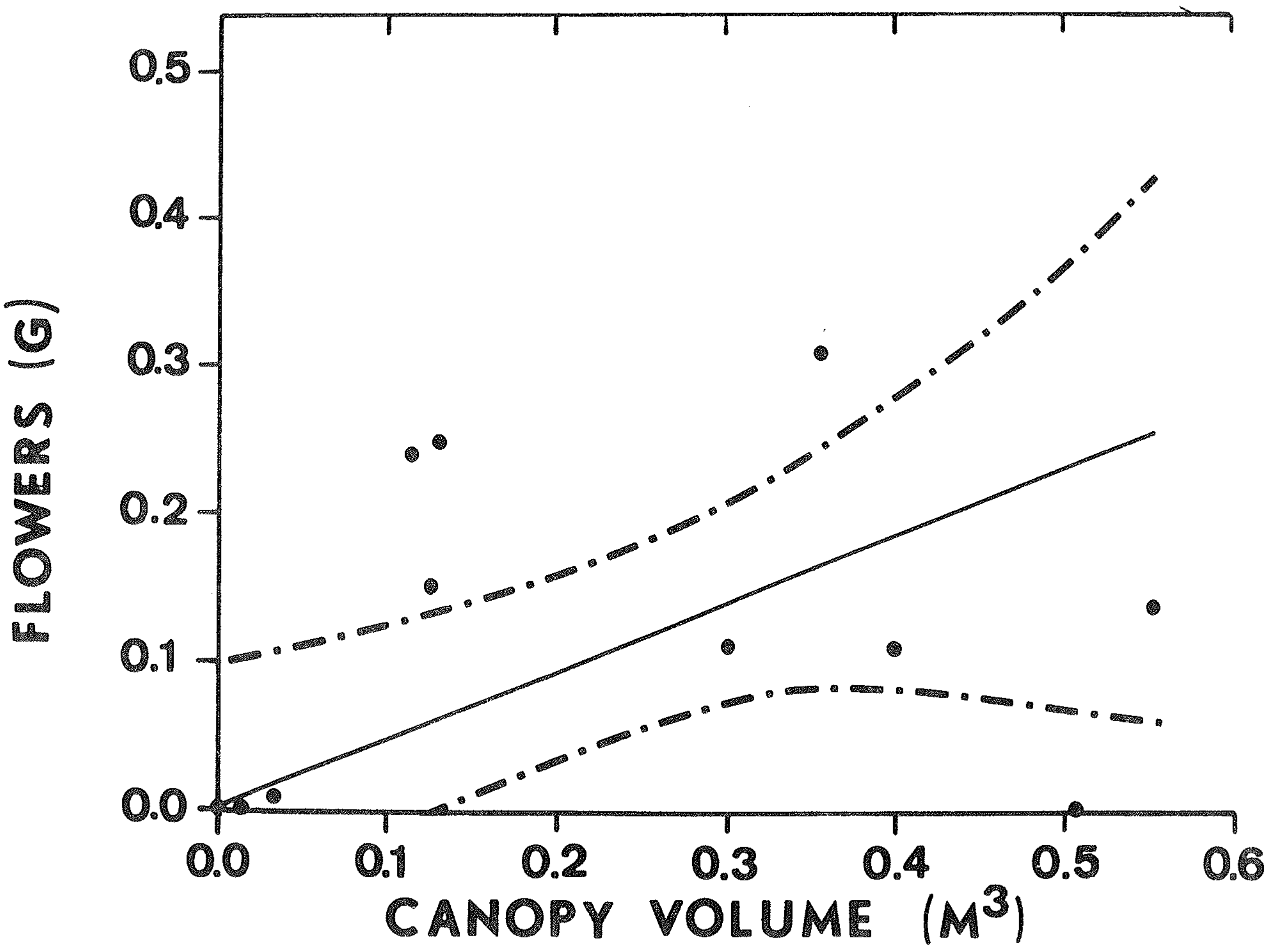

Figure 14. Regression of flower biomass (B) at the end of the 1971 growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 0.436 V, with confidence limits shown by the broken lines. Observed

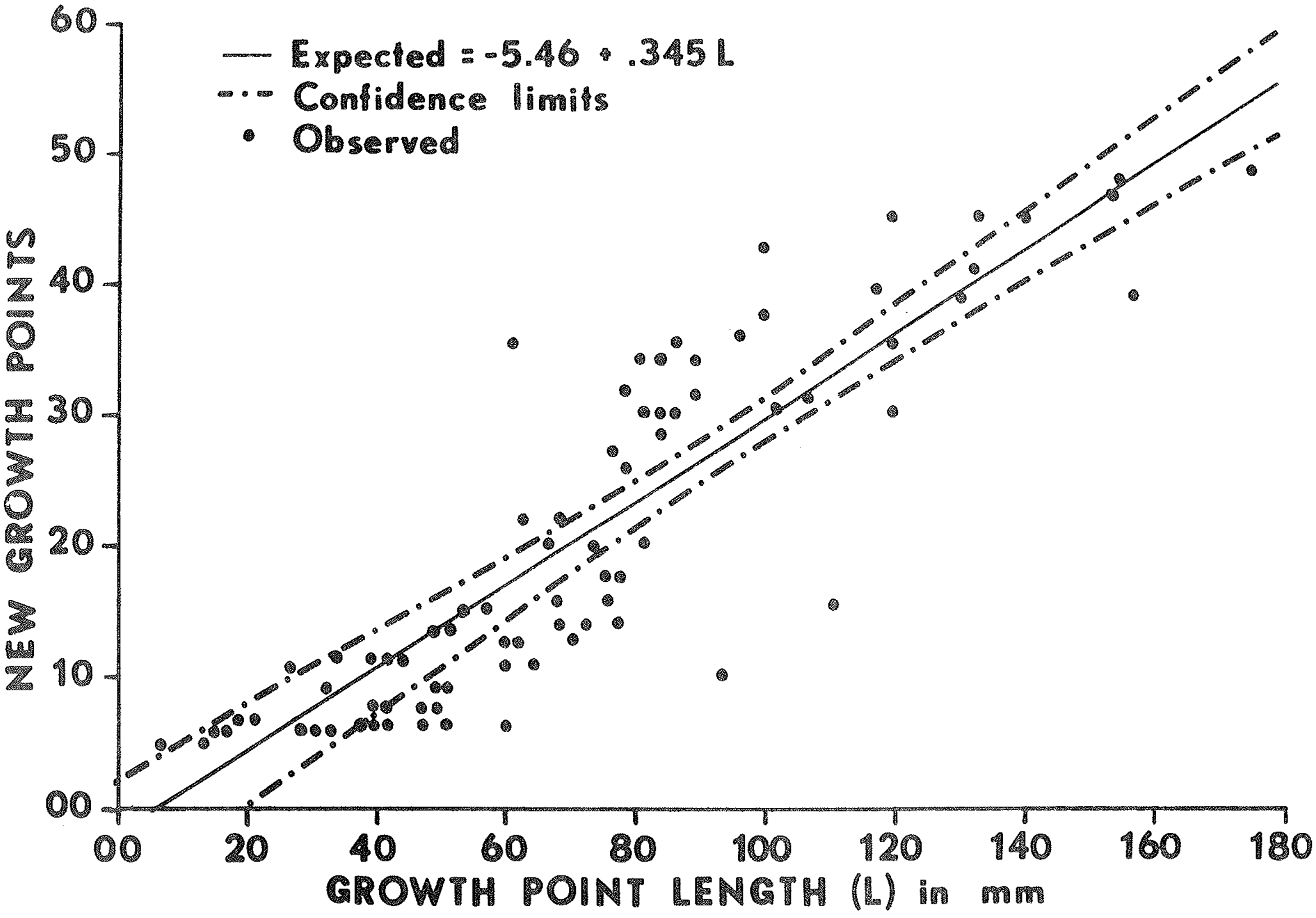

Figure 15. Regression of new growth points (P) onto growth point length (L) for *Larrea divaricata*. The equation of the linear regression line is $P = -5.46 + 0.345 L$.

to 40. Then, with greater lengths, the increase in new growth points tends to level off since creosote bush has a natural pruning action for older stems deeper in the canopy.

The production of leaf biomass for 1971 and 1972 on the bajada by creosote bush is shown in Figure 16. As discussed repeatedly before, the fall of 1970 and the spring of 1971 were very dry. Any leaf material persisting on creosote bush in the spring of 1971 was standing dead. There was no detectable production of new green leaves until August. The greatest growth during 1971 was when leaf biomass peaked at about 100 kg/ha. In 1972, there was a small amount of growth in March, but this leveled off during April and May. Beginning in June and continuing until October, there was a rapid increase in leaf biomass until it peaked at about 340 kg/ha in early November, which is about the end of the growing season. The peak biomass in 1972 exceeded that of 1971 by about 3.5 times. Total productivity is even greater than this because in 1972, growth started in June whereas in 1971 growth did not increase greatly until September.

The production of new stem biomass for 1971 and 1972 on the bajada by creosote bush is shown in Figure 17. Since new stem production is a function of growth point length, like leaf production, the basic pattern of the growth is the same. As mentioned above, in the winter there is a shedding of a number of stems produced during the active growing season. During a moist winter such as 1972-73, a certain amount of green-leaf and stem biomass will remain active. Positive growth is evidenced by elongation of growth points. For further deatils on the growth characteristics see Chew and Chew (1965) and Oechel et al. (1972).

The production of reproductive structures (floral buds, flowers and fruits) for 1971 and 1972 on the bajada by creosote bush is shown in Figure 18. In 1971 there was a period of reproduction that followed vegetative growth in August and September. The total production of fruits reached a peak biomass of 150 kg/ha. The floral bud and flower stages were relatively short. Some fruits persisted on the plants into the winter months. In 1972 there was a burst of floral bud formation in April and May. However, the rate of bud abortion was high and the total fruit production was relatively small at 6 kg/ha. Following growth in the summer there was a second period of fruit production. This period was longer, with buds, flowers and fruits being produced into the fall with a peak biomass of fruits at 30 kg/ha.

The biomass changes in the other plant components can be estimated at the end of the growing season based on canopy volume changes by the equations for creosote bush in Table 14. The biomass estimates for creosote bush given in Table 15 are based on these equations which are determined for plants collected at the end of the 1971 growing season. The estimates shown in Table 15 actually reflect canopy volumes found in April, 1971, which are a result of growth in 1970. Thus, these estimates can be taken as the biomass component at the end of the 1970 growing season. The biomass estimates for the end of the 1971 and 1972 growing seasons can be estimated based on canopy volume changes either measured directly as in 1972 or estimated from changes in the number of growth points and biomass changes in monitored plant components. The results of these biomass estimates for 1970, 1971 and 1972 are shown in Table 16. Based on the initial estimates for the end of the 1970 growing season, the standing crop biomass of live stems increased to 2420 kg/ha in 1972. The 3% change in 1971 was relatively small compared to the 11% change in 1972. The standing crop biomass of dead stems was about 1350 kg/ha in 1972. The root biomass was estimated at about 2060 kg/ha at the end of the 1972 growing season.

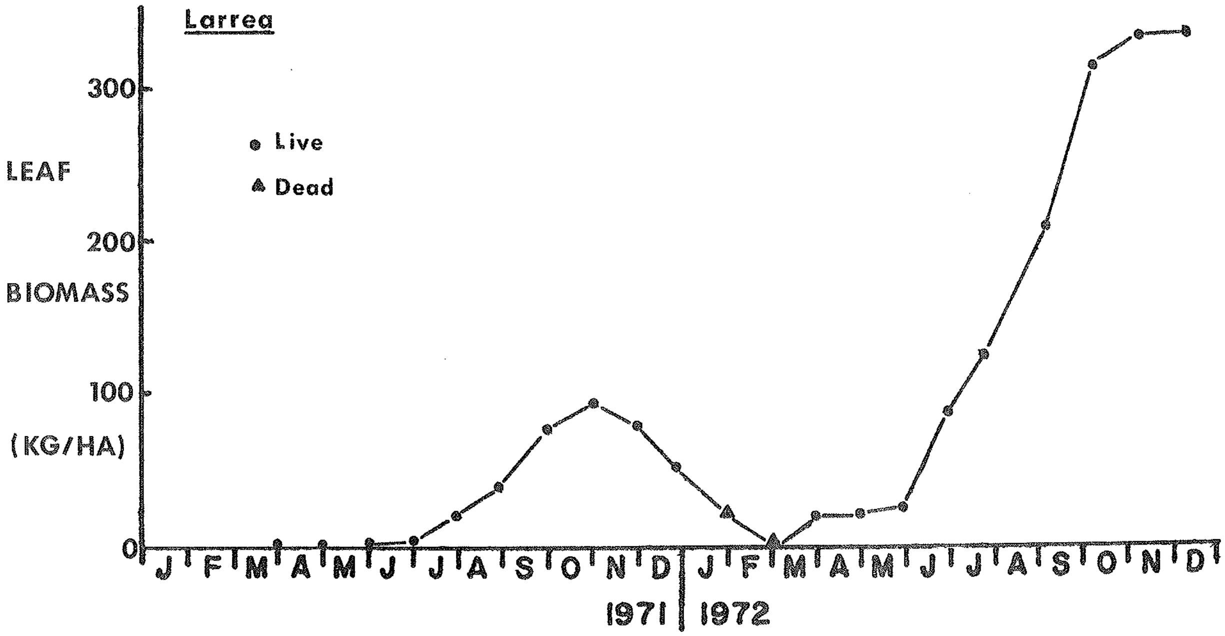

Figure 16. Monthly standing crop of leaf biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

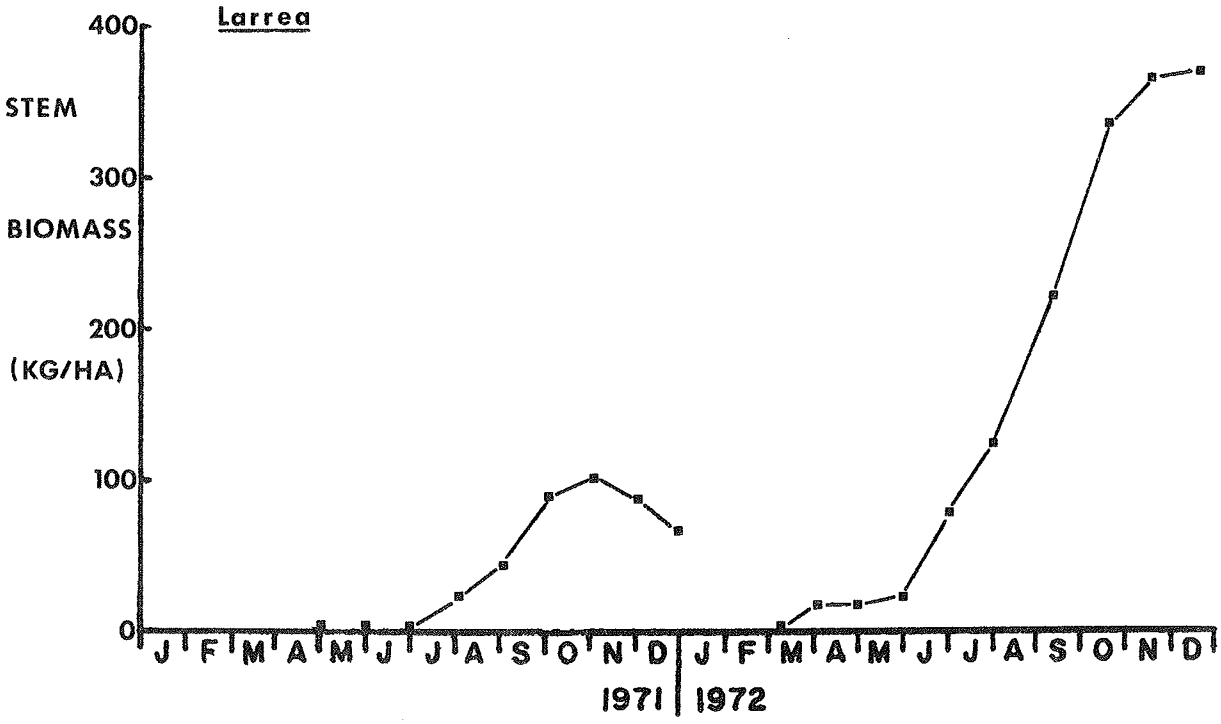

Figure 17. Monthly standing crop of new stem biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

Table 16. Canopy size and biomass estimates at the end of the 1970, 1971 and 1972 growing seasons for *Larrea divaricata* on the bajada, including percent change from year to year

Component	1970	1971	1972
Canopy cover (%)	23.7	24.4	26.9
Canopy Volume (m^3/ind)	.124	.129	.145
Live Stems (kg/ha	2080	2150	2420
Dead Stems (kg/ha	1160	1200	1350
Roots (kg/ha	1760	1820	2060
% Change		3	11

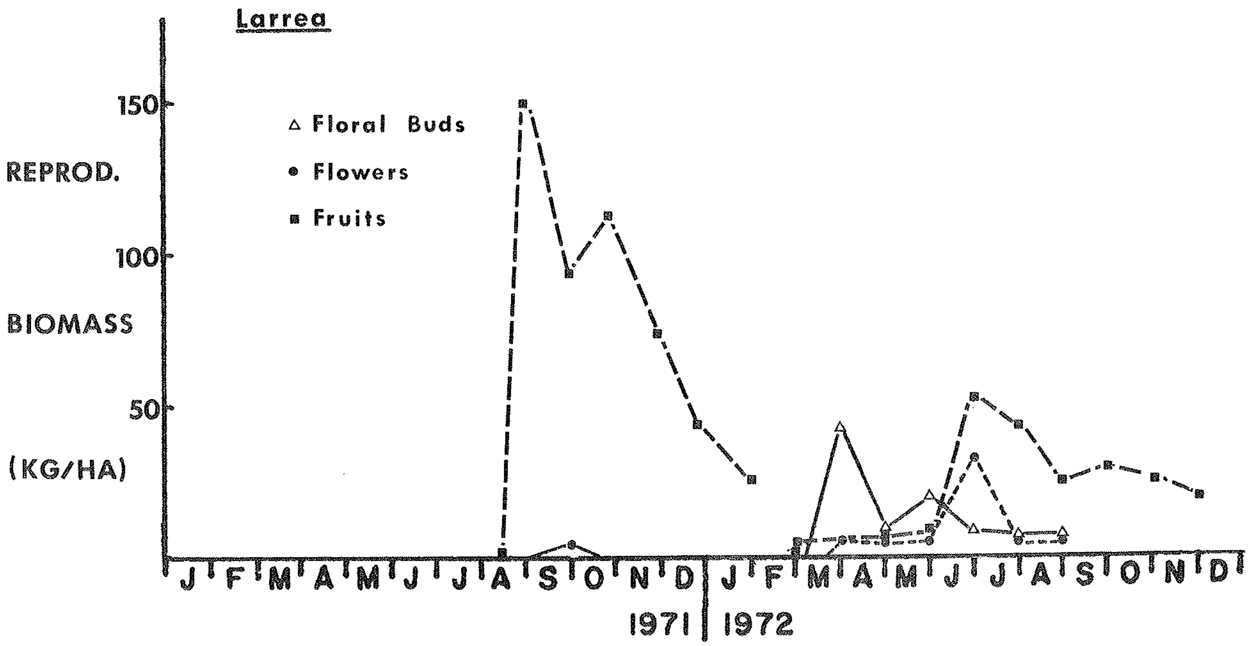

Figure 18. Monthly standing crop of reproductive structures biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

Prosopis glandulosa var. *torreyana*

The growth pattern of five mesquite plants occurring along the major arroyo on the bajada was monitored in 1971 and 1972. The methodology used in measuring the growth of these plants was the same as that for the 10 mesquite plants on the playa (section I.B.2). The sample size of nodes measured on the bajada was 68 in 1971, but this was increased to 126 in 1972. The equation for estimating leaf biomass from leaf length was given in Figure 23, section I.B.2. The number of new shoots produced on these five mesquite plants was determined at the end of the growing season for 1971 and 1972. Again, the equations given in Figure 24, section I.B.2, were used to estimate leaf and stem biomass from the length of the new shoots. The reproductive pattern of mesquite was observed at monthly intervals throughout the growing season in 1971 and 1972. The initial biomass estimates for mesquite on the bajada were determined by the belt transect studies described above (Table 15, section II.B.2) and using the equations given in Table 14.

The production of leaf biomass at old nodes for 1971 and 1972 is shown in Figure 19. In late March and early April of 1971, leaf biomass peaked rapidly at about 30 kg/ha. In May and June, which were very dry, there was a loss in leaf biomass down to about 23 kg/ha where it leveled off during the moist months of July, August and September. In October and November the biomass of leaves dropped rapidly as the end of the growing season was reached and passed. In 1972, the leaf buds again broke in March; however, on April 1 a frost occurred and the parts of the plants exposed to cold air drainage were damaged, as evidenced by leaf and inflorescence death. Leaves and inflorescences on the sides of the plants away from the arroyo were not killed, thus the standing crop of leaves only dropped to about 5 kg/ha. Growth of new leaves was slow and did not peak until June at about 20 kg/ha. Leaf die-back was rapid in October and November, 1972.

The production of new shoots at nodes for 1971 and 1972 is shown in Figure 20. The biomass of leaves on the new shoots and the woody biomass of the shoots produced from year to year are given. In 1971, when conditions were dry, the production of new biomass via new shoots was low with leaf and stem biomass peaking at 0.9 kg/ha and 0.6 kg/ha, respectively. In 1972, which had some spring moisture from fall and winter precipitation, there was a slightly greater production of new shoots, with leaf and stem biomass peaking at 1.0 kg/ha and 0.7 kg/ha, respectively. The rate of production of new shoots by mesquite seems to be a rather accurate reflection of the environmental conditions for growth in any given year.

The production of reproductive structures (inflorescence spikes and fruits) for 1971 and 1972 on the bajada by mesquite was poor. Only a few inflorescences were formed in 1971 and no mature fruits were formed from these, probably because of the very dry period from April to July. In 1972 many of the inflorescences formed in March were damaged by the April 1 frost. Of the surviving flowers, only a few fruits were found on the site, probably amounting to less than 0.1 kg/ha.

The biomass changes in other plant components of mesquite from year to year can be estimated from changes in the components which are being monitored for biomass changes. Other methods of estimating changes can involve the use of relationships of biomass and plant size. The use of canopy volume to estimate overall biomass changes is possible from the original belt transect data and from repeated measurements of the canopy volume of the mesquite plants being monitored. The results of biomass estimates for total live stems, dead stems and roots using canopy volume changes are given in Table 17. The standing crop of live stems increased from 186 kg/ha to 216 kg/ha. The standing crop of dead stems increased from 176 kg/ha in 1971 to 208 kg/ha in 1972. Root biomass was estimated to have changed from 286 kg/ha in 1971 to 337 kg/ha in 1972. The change from 1971 to 1972 was 15%.

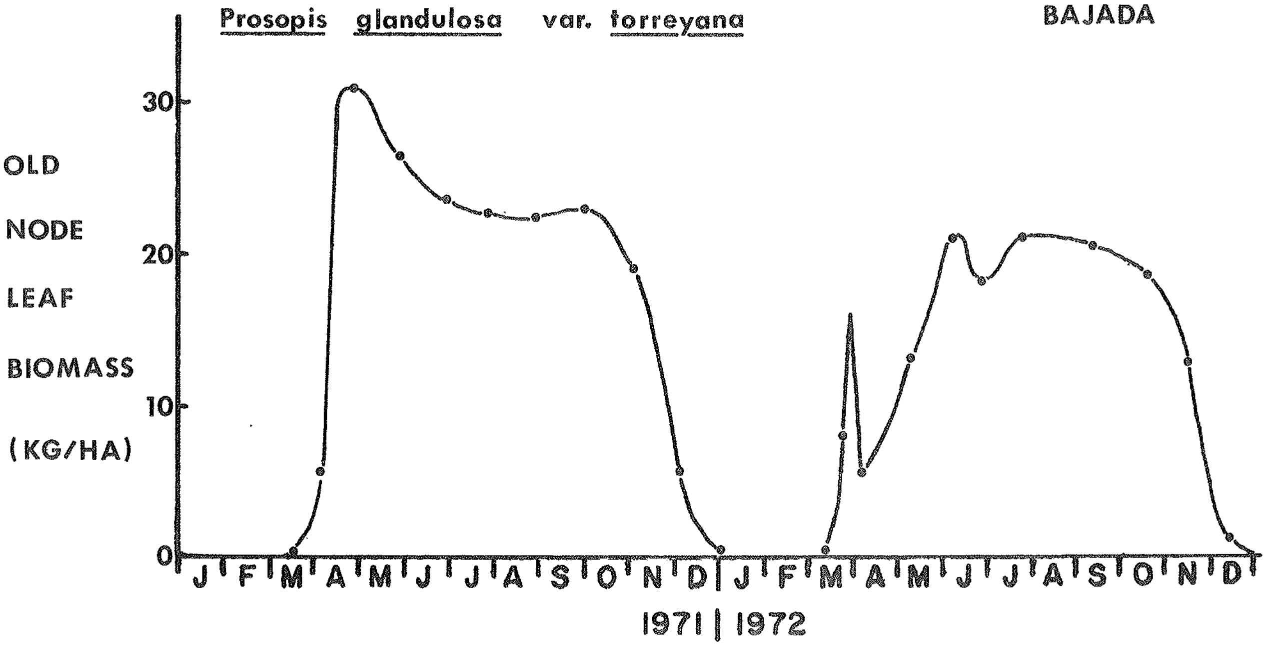

Figure 19. Monthly standing crop of old node leaf biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the bajada.

Table 17. Canopy size and biomass estimates for the 1971 and 1972 growing seasons by *Prosopis glandulosa* var. *torreyana* on the bajada, including percent change over the previous year

Component	1971	1972
Canopy Cover (%)	1.05	1.17
Canopy Volume (m^3/ind)	4.94	5.52
Live Stems (kg/ha)	186	216
Dead Stems (kg/ha)	176	208
Roots (kg/ha)	286	337
Per cent (%) Change	15	

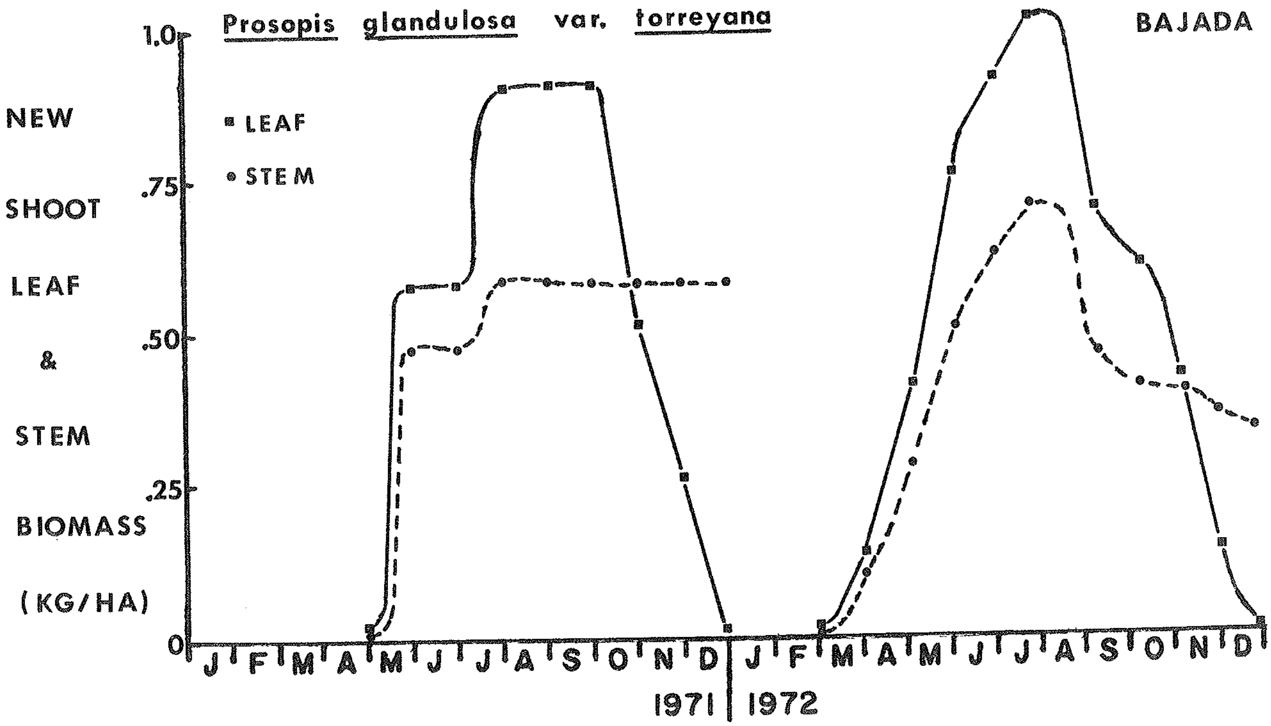

Figure 20. Monthly standing crop of new shoot leaf and stem biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the bajada.

Flourensia cernua and *Parthenium incanum*

Tarbush (*Flourensia cernua*) and mariola (*Parthenium incanum*) are shrub species which occur in and along the bajada minor arroyo system. These two species were monitored for growth during 1971 and 1972 utilizing a harvest method. These shrubs are winter deciduous in this area and produce leaves on new shoot growth. Annual growth is thus distinct, which allowed the use of a clipping technique. From 30-100 new shoots per shrub were clipped at random each month from several shrubs of each species. The harvested shoots from each shrub were separated into leaf, stem, flower, and fruit components. The biomass of these components was calculated on a weight per shoot basis. The monthly biomass means for tarbush and mariola are presented in Tables 18 and 19 respectively.

Although considerable variation often occurred between samples, the general patterns of growth and production of the various plant components is quite evident. These shrubs exhibited greater plant component production in 1972, probably due to the increased moisture.

Flourensia cernua had maximum leaf biomass per new shoot in September of both 1971 and 1972 (Table 18), but the 1972 maximum of 170 mg/shoot was considerably higher. *Flourensia* new-stem biomass exhibited an increasing trend through 1972 with maximum biomass occurring in December. In 1972, the samples indicated that flowering occurred only during September, and fruits were present from October to December with maximum fruit biomass occurring in October. The unusually high fruit biomass reported for December, 1972 (Table 18), is probably due to sampling bias.

Parthenium incanum 1971 plant components all peaked in October (Table 19). In 1972, based on the incompletely analyzed data, *Parthenium* leaf biomass per new shoot peaked in July, flower production peaked in August, and new shoot biomass was still increasing in September. Fruit production in 1972 had not commenced as of the September sampling, but was already in progress as early as August in 1971.

Brickellia laciniata, Chilopsis linearis and *Fallugia paradoxa*

Bricklebush (*Brickellia laciniata*), desert willow (*Chilopsis linearis*) and Apache plume (*Fallugia paradoxa*) are shrub species which occur in and along the bajada major arroyo system. These species were monitored for growth during 1971 and 1972 utilizing a harvest method. These shrubs are winter deciduous in this area and produce leaves on new shoot growth. Annual growth is thus distinct, which allowed the use of a clipping technique. From 30-100 new shoots were clipped at random each month from several shrubs of each species. The harvested shoots from each shrub were separated into leaf, stem, flower, and fruit components. The biomass of these components was calculated on a weight per shoot basis. The monthly biomass means for Acache plume, desert willow and bricklebush are presented in Tables 20, 21 and 22, respectively. For *Fallugia*, 75-100 old nodes per

Although considerable variation often occurred between samples (Tables 20, 21 and 22), the general patterns of growth and production of the various plant components is clear. All of these shrub species exhibited greater production of plant components in 1972, probably due to the increased moisture.

Fallugia paradoxa exhibited maximum 1971 new shoot leaf biomass in September (Table 20), but this maximum occurred in August of 1972. *Fallugia* new-stem biomass exhibited a general increasing trend through 1972 with maximum weight occurring in December. Reproductive structures of *Fallugia* exhibited maximum biomass in early spring (March-April) and fall (September) and these structures were present throughout the year beginning as early as March. *Fallugia* leaf biomass per old node appeared to peak in June, 1972, but exhibited increases in the winter of 1971.

Chilopsis linearis exhibited maximum 1971 plant components biomass in August, the earliest sampling date of that year (Table 21). It is likely that at least some of the components had peaked earlier. In 1972, *Chilopsis* maximum new leaf biomass occurred in July, maximum new stem biomass occurred in August, and maximum flowering occurred in April and flowering continued through August. Maximum fruit production by *Chilopsis* occurred in June, 1972, subsequent to maximum flowering. The last two months data were not analyzed at the time of writing, but most of these plant components appeared to have peaked prior to October, 1972.

Brickellia laciniata exhibited maximum new shoot leaf and stem biomass in June of 1972 (Table 22). The 1972 data are difficult to compare with that of 1971, since *Brickellia* was sampled only in October and November of 1971, and these months for 1972 are not presently analyzed. *Brickellia* initiated flowering in August of 1972 and there were no fruits produced during that month.

Literature Cited

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Oechel, W. C., B. R. Strain, and W. R. Odening. 1972. Tissue water potential, photosynthesis, C^{14} labeled photosynthate utilization and growth in the desert shrub *Larrea divaricata*. Ecol. Mono. 42:127-141.

Table 18. *Flourensia cernua* monthly plant component mean biomass per new growth shoot*

	Leaf Weight	Stem Weight	Flower Weight	Fruit Weight
1971				
August	59	10		0
September	106	20		4
October	104	31		14
November	68	21		16
December	49	19		7
1972				
March	44 ± 17	5 ± 3	0	0
April	45 ± 15	7 ± 5	0	0
May	30 ± 7	7 ± 1	0	0
June	56 ± 13	21 ± 7	0	0
July	91 ± 14	41 ± 19	0	0
August	144 ± 34	37 ± 20	0	0
September	170 ± 48	75 ± 36	166 ± 116	0
October	166 ± 81	82 ± 54	0	158 ± 135
November	114 ± 31	129 ± 51	0	31 ± 61
December	81 ± 46	146 ± 43	0	213 ± 22

* Weights presented as mg per shoot ± SD.

Table 19. *Parthenium incanum* monthly plant component mean biomass per new growth shoot*

	Leaf Weight	Stem Weight	Flower Weight	Fruit Weight
1971				
August	58	29		31
September	58	25		29
October	66	45		58
November	54	35		16
December	41	34		24
1972				
March	45 ± 23	5 ± 4	0	0
April	53 ± 15	8 ± 4	0	0
May	51 ± 11	9 ± 2	0	0
June	86 ± 28	25 ± 12	1 ± 2	0
July	140 ± 40	63 ± 31	20 ± 8	0
August	125 ± 46	82 ± 31	104 ± 20	0
September	106 ± 26	106 ± 31	91 ± 28	0

* Weights presented as mg per shoot ± SD.

Table 20. *Fallugia paradoxa* monthly plant component mean biomass per new growth shoot and mean leaf biomass per old node*

	Leaf Weight	Stem Weight	Flower Weight	Fruit Weight	Leaf Weight per old node
1971					
August	42	23	0	7	24
September	72	39	0	1	31
October	42	32	3	2	31
November	54	42	6	3	19
December	51	38	10	5	20
1972					
March	53 ± 20	29 ± 12	19 ± 8	12 ± 14	33 ± 6
April	73 ± 18	46 ± 16	10 ± 4	17 ± 13	36 ± 6
May	64 ± 12	41 ± 10	9 ± 6	12 ± 16	36 ± 13
June	54 ± 21	44 ± 7	8 ± 6	2 ± 2	55 ± 11
July	93 ± 51	81 ± 48	4 ± 3	3 ± 3	34 ± 5
August	107 ± 40	57 ± 40	9 ± 7	0	42 ± 25
September	85 ± 22	67 ± 6	14 ± 4	24 ± 6	42 ± 6
October	84 ± 11	75 ± 25	13 ± 6	19 ± 32	33 ± 5
November	33 ± 16	66 ± 28	7 ± 1	3 ± 3	19 ± 1
December	60 ± 14	102 ± 31	6 ± 1	1 ± 1	14 ± 4

* Weights presented as mg per shoot or old node ± SD.

Table 21. *Chilopsis linearis* monthly plant component mean biomass per new growth shoot*

	Leaf Weight	Stem Weight	Flower Weight	Fruit Weight
1971				
August	705	227		49
October	623	201		40
November	89	43		34
1972				
March	49 ± 22			
April	391 ± 97	91 ± 24	97 ± 32	0
May	433 ± 83	130 ± 29	90 ± 20	1 ± 2
June	639 ± 114	224 ± 47	34 ± 28	231 ± 175
July	1,007 ± 234	505 ± 165	80 ± 57	181 ± 212
August	876 ± 171	524 ± 76	7 ± 8	38 ± 66
September	454 ± 106	343 ± 62	0	107 ± 93
October	48 ± 49	117 ± 29	0	83 ± 81

* Weights presented as mg per shoot ± SD.

Table 22. *Brickellia laciniata* monthly plant component mean biomass per new growth shoot*

	Leaf Weight	Stem Weight	Flower Weight	Fruit Weight
1971				
October	64	150		95
November	83	55		119
1972				
March	32 ± 12	6 ± 2	0	0
April	90 ± 10	35 ± 7	0	0
May	136 ± 27	70 ± 2	0	0
June	295	200	0	0
July	276	128	0	0
August	245	120	118	0

* Weights presented as mg per shoot ± SD.

II.C. INVERTEBRATES

1. BAJADA SHRUB ARTHROPODS (DSCODES A3UWJ21, A3UWJ25)

The bajada shrubs exhibited shifts in the arthropod fauna through the season similar to the shifts exhibited on shrubs on the playa. The important groups were various families of leaf hoppers, plant hoppers, etc., which feed on plant juices, parasitic wasps, and various groups of ants which apparently utilize plant exudates as a food source, e.g., *Myrmecocystus* and *Dorymyrmex*. Various spiders were the predominant predators on all species of plants. The numbers and biomass of plant feeders such as issids, fulgorids, lygaeids, psyllids, membracids etc., appear to be a direct function of primary production. The particular group that predominates at any one period is probably a function of season and/or phenology of the host plant. Predator populations while responding to primary production exhibited lags in peaks and crashes typical of predator populations. The activity of formicids on plants is predominantly a function of the phenology of the plants. These insects are relatively independent of the climatic extremes associated with drought but are apparently most active on plants in active growth phases when exudate production is highest. These relationships will be examined further when the collection of 1972 and 1973 shrub arthropod data is analyzed (for relative abundance and host plant, see Tables 1 and 2).

Mesquite borers and girdlers (DSCODES A3UWK01, 02, 03)

Studies of mesquite part mortality resulting from the activity of node borers (Bostrichidae) and girdlers (*Oncideres* sp.) were conducted on seven randomly selected *Prosopis glandulosa* plants on the bajada using techniques outlined in I.C.1. These data are summarized in Figure 1 and Table 3. In shrubs with less than 5 kg standing crop biomass, these insects accounted for more than 10% loss of wood and leaves and,in all but the largest shrubs, accounted for between 2 and 5% of the standing biomass. The mortality effect of these insects was relatively greater on the bajada than on the playa. These data suggest that the mortality due to wood borers etc. may nearly balance the new wood production on the bajada and thus account for the more uniformly sized bajada mesquite. This hypothesis and further examination of the relationships between wood mortality, plant growth patterns and insect damage will be conducted in detail in a process study in 1973.

Table 1. Relative abundance and number of taxa on plants on bajada uplands

Host Plant	Family	May	June	July	Aug.	Oct.	Nov.
Ephedra trifurca	Psyllidae	+ (14)					
	Hymenoptera	++ (14)					
	Fulgoridae			++ (2)			
	Mantidae			++ (2)			
Larrea divaricata	Membracidae	+ (14)		+ (4,7,8)			+ (11)
	Psyllidae	+ (14)				+ (11)	+ (11)
	Formicidae	++ (14)					+ (11)
	Cicadellidae		+ (26)	++ (4,7,8)	+ (19)	+ (11)	+ (11)
	Aranae		+ (26)				
	Fulgoridae		+ (26)				
	Homoptera		+ (26)				
	Curculionidae			+ (4,7,8)			
	Aranae			++ (4,7,8)	+ (19)	+ (11)	+ (11)
	Coleoptera			+ (4,7,8)			
	Mirmidae			+ (4,7,8)	+ (19)	+ (11)	++ (11)
	Issidae			++ (4,7,8)			
	Acrididae			+ (4,7,8)			
	Phasmidae			+ (4,7,8)			
	Hymenoptera			++ (4,7,8)	+ (19)	+ (11)	+ (11)
	Dolichopodidae			++ (4,7,8)			
	Lygaeidae			++ (4,7,8)		+ (11)	
	Diptera				+ (19)	+ (11)	+ (11)
	Hemiptera				+ (19)		

Table 1. (cont.)

Host Plant	Family	May	June	July	Aug.	Oct.	Nov.
Parthenium incanum	Aranae			+ (8)			
	Diptera			+ (8)	+ (13)		
	Hemiptera			+ (8)			
	Cicadellidae			+ (8)			
	Issidae			+ (8)			
	Geometridae			+ (8)			
	Thysanoptera			+ (8)			
	Formicidae			+ (8)	+ (13)		
	Nabidae				+ (13)		
	Tingidae				+ (13)		
	Fulgoridae				++ (13)		
	Psyllidae				++ (13)		
	Hymenoptera				+ (13)		
Guterrezia sarothrae	Lygaeidae			+ (9)			
	Curculionidae			+ (9)			
	Diptera			+ (9)	+ (7)	+ (12)	
	Cicadellidae			++ (9)	++ (7)		
	Hymenoptera			+ (9)	+ (7)		
	Formicidae			+ (9)	+ (7)	+ (12)	
	Aranae				+ (7)	+ (12)	
	Nabidae				+ (7)		
	Mirmidae					++ (12)	

Table 1. (cont.)

Host Plant	Family	May	June	July	Aug.	Oct.	Nov.
Prosopis juliflora	Membracidae	+ (11)		+ (4,13)			
	Psyllidae				++ (6)	* (2)	+++ (3)
	Formicidae	+++ (11)	+ (30)	++ (4,13)	+ (6)		++ (3)
	Coccidae	+ (11)					
	Aranae	+ (11)	+ (30)	+ (4,13)			
	Hymenoptera		+++ (30)	+ (4,13)			
	Diptera			+ (4,13)	++ (6)	+ (2)	+ (3)
	Chrysomelidae			++ (4,13)			
	Syrphidae			+ (4,13)			
Flourensia cernua	Aranae		+ (21)	+++ (2,3,9)			
	Chrysomelidae		+ (21)				
	Tingidae		+ (21)				
	Psyllidae		++ (21)		++ (20)	+++ (4)	
	Issidae		+ (21)	++ (2,3,9)			
	Formicidae			+++ (2,3,9)	++ (20)	++ (4)	
	Thysanoptera			++ (2,3,9)			
	Flatidae			+ (2,3,9)			
	Diptera				+ (20)		
	Hymenoptera				+ (20)		
Yucca elata	Chrysomelidae			+ (5)			
	Curculionidae			+ (5)			
	Diptera			+++ (5)	+++ (15)		
	Bombyliidae			+ (5)			
	Stratiomyidae			+ (5)			

NOTE: Relative abundance is expressed as % of total number, i.e. 5-25% +, 25-50% ++. 50-75% +++, 75-100% *. The number in ( ) is number of taxa on shrubs and the number of entries in ( ) indicates the number of shrubs sampled.

Table 2. Relative abundance and number of taxa on plants on bajada arroyo

Host Plant	Family	July	Aug.	Oct.	Nov.
Chilopsis linearis	Aranae	+++ (9)			
	Coleoptera	+ (9)			
	Coccinelidae	+ (9)			
	Hymenoptera	+ (9)	++ (9)		
	Lepidoptera	+ (9)	+ (9)		
	Diptera		+ (9)		
	Psyllidae		+ (9)		
	Formicidae		+ (9)		
Fallugia paradoxa	Aranae	++ (13,15)	+ (11)		
	Diptera	++ (13,15)	+ (11)	++ (3)	+ (12)
	Flatidae	+ (13,15)			
	Formicidae	+ (13,15)			
	Cicadellidae	+ (13,15)			
	Chrysomelidae	+ (13,15)	+++ (11)		* (12)
	Cecidomyidae	+ (13,15)			
	Hymenoptera	+ (13,15)			
	Tingidae			++ (3)	
	Chrysopidae			++ (3)	

Table 2. (cont.)

Host Plant	Family	July	Aug.	Oct.	Nov.
Larrea divaricata	Aranae	+ (10)			
	Cicadellidae	+ (10)			
	Issidae	++ (10)			
	Membracidae	+ (10)			
	Acrididae	+ (10)			
	Diptera		+ (10)		
	Mirmidae		++ (10)		
	Hymenoptera		+ (10)		
	Formicidae		+ (10)		
Flourensia cernua	Psyllidae	* (8)			
Guterrezia sarothrae	Coleoptera	++ (6)			
	Dolichopodidae	+ (6)			
	Muscidae	+ (6)			
	Formicidae	++ (6)			
	Curculionidae	+ (6)			
	Lepidoptera	+ (6)			
Prosopis juliflora	Aranae	+ (13)			
	Formicidae	+++ (13)			
	Flatidae	+ (13)			

NOTE: Relative abundance is expressed as % of total number, i.e. 5-25% +, 25-50% ++, 50-75% +++, 75-100% *. The number in ( ) is number of taxa on shrubs and the number of entries in ( ) indicates the number of shrubs sampled.

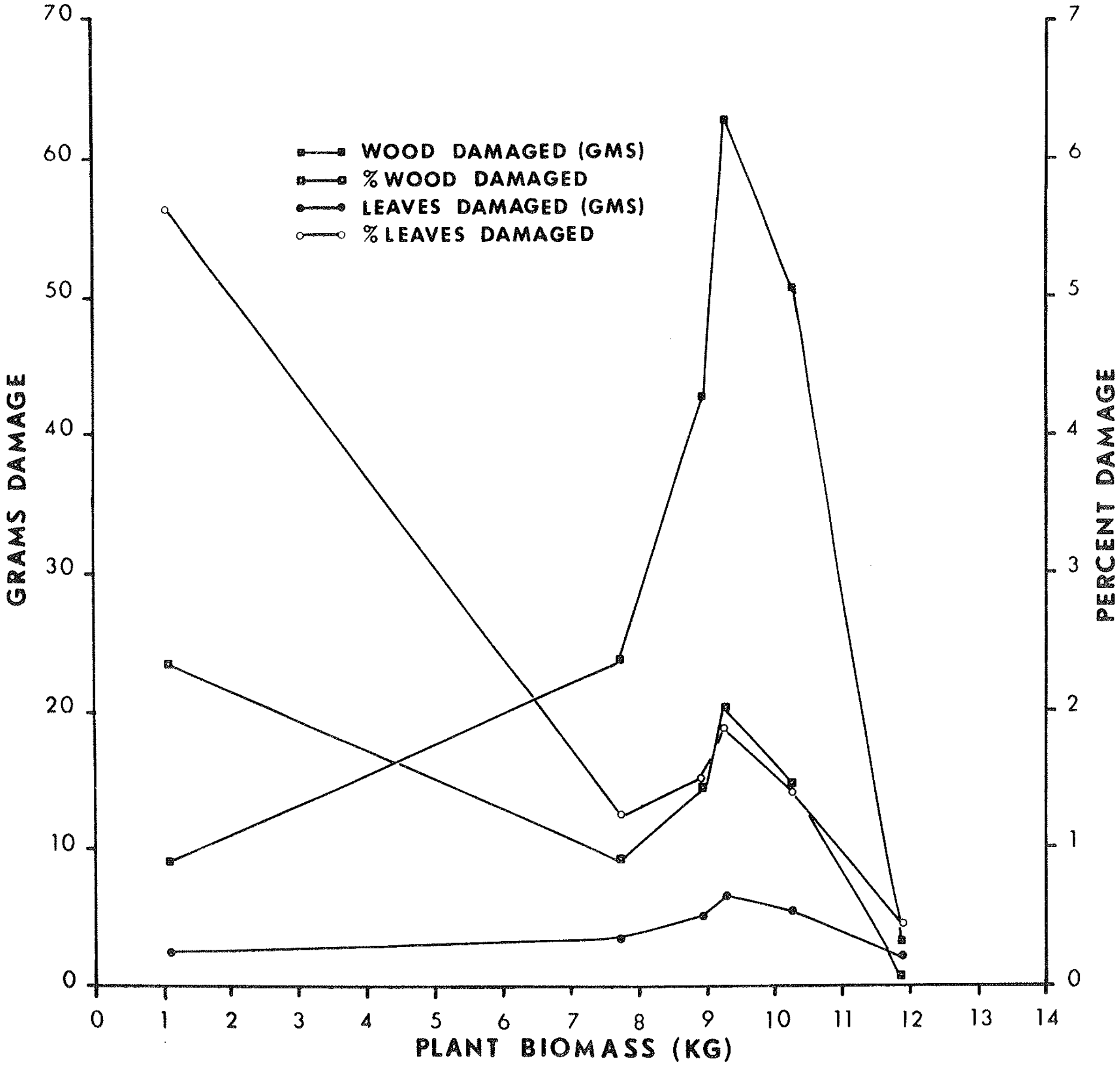

Figure 1. The relationship between wood and leaf mortality and plant biomass of *Prosopis glandulosa*, 1972. Damage caused by node borers, Bostrichidae.

Table 3. Biomass mortality resulting from activities of node borers, Bostrichidae, and girdlers, *Oncideres* sp., on randomly selected mesquite shrubs from the bajada in 1972

Estimated Shrub Biomass (kg)	Kg. wood killed	% wood killed	Kg. leaves killed	% leaf biomass killed
20.96	.56	8.0	.05	6.4
7.31	.34	13.8	.03	12.0
19.40	.16	2.5	.02	2.7
5.71	.08	4.0	.01	6.0
39.35	.06	0.4	.01	.8
25.10	.23	2.8	.03	2.7
14.15	.52	11.1	.05	8.9

Biomass of trophic groups

The effects of drought on insect biomass on plants on the bajada provided some interesting patterns. There was a general decrease in total insect biomass on *Larrea* , *Flourensia* and *Prosopis* from May through July, 1971. By late July the severity of the drought had apparently had sufficient effect on the rain-dependent shrubs like *Larrea* and *Flourensia* to result in the virtual elimination of herbivores from these plants (Table 4). There was an apparent lag in the decline of predatory insects as indicated by the higher biomass in predators when compared with herbivores in late July (Table 4). There was also an interesting increase in biomass of herbivores on both *Larrea* and *Flourensia* from August through early November. Late summer and fall rains in 1971 resulted in growth in these shrubs through mid-November. Plants on the playa ceased growing in late October due to frost resulting from cold air drainage. The more moderate thermal environment of the bajada resulted in an extended growing season and recovery of insect biomass even on *Prosopis* , which did not occur on the playa fringe.

Table 4. Summary of insect biomass (g/ha) on the bajada upland for 1971 arranged by host plant species and trophic status of insect groups

Plant Species		May 31	June 14	July 1	July 14	July 27	Aug 11	Oct 7	Nov 6	
Larrea divaricata	Herbivores	36.4	26.3	21.2	9.57 6.5	1.0	14.0	35.4	54.5	29.36
	Predators	9.6	10.8	3.7	3.8 3.3	2.4	2.2	6.1	3.2	5.87
	Detritivores	0	0	0	0	0	0	0	0	0
Ephedra trifurca	Herbivores	.38			.07					.075
	Predators	.10			0					.02
	Detritivores	0			0					0
Flourensia cernua	Herbivores		6.97	2.16	1.96 3.7	.03	19.3	53.7		1366
	Predators		.48	0	.03	.04	1.5	.4		04
	Detritivores		0	0	0 .02	0	0	0		0
Prosopis glandulosa	Herbivores	4.8	1.45	066	.08	1.9	.78	.64	.14	1.41
	Predators	.18	1.0		.04	.02	.25	.04	.02	0.25
	Detritivores	0	.006		0 .02	0	0	0	0	.001

The relationship between the water status of the plant and insect biomass supported is evident when a comparison between shrubs on the bajada upland are compared with the insect biomass on shrubs lining the arroyo. Although the density and biomass of these shrubs is low in comparison to the upland shrubs, the biomass support is considerably greater and these plants contribute a significant portion of the total insect production for the site (Table 5).

Table 5. Summary of insect biomass (g/ha) on the bajada arroyo for 1971 arranged by host plant species and trophic status of the insect groups

Plant species			July 14	July 27		Aug 11	Oct 7	Nov 6
<u>Fallugia paradoxa</u>	Herbivores	1.75	.82	.33	.58	6.4	.013	.02
	Predators	0.9	.38	.06	.22	.16	.03	3.6
	Detritivores		0	0	0	0	0	0
<u>Larrea divaricata</u>	Herbivores	58	122.8			109.2		
	Predators	7.82	19.4			11.9		
	Detritivores		0			0		
<u>Prosopis glandulosa</u>	Herbivores	0.50		2.0				
	Predators	0.12		.46				
	Detritivores			0				

II.C.2 HIGHLY MOBILE AND GROUND SURFACE ARTHROPODS -- BAJADA

Transects were run on the bajada at several times during the day on 14 July and 8 August, using techniques outlined in I.C.2. Transects were run both perpendicular and parallel to the arroyo. These data are summarized in Table 6 (DSCODE A3UWJ96).

The lower densities of grasshoppers and microleps on the bajada undoubtedly reflect the absence of *Panicum* and lower density of annual grasses and forbs that serve as a food base for these groups. The density of crickets was similar to the playa, probably because these insects have fairly generalized feeding habits, and suitable habitat and cover for these animals is similar in the two areas. In both areas, there was a decrease in Pompillidae density in August. These insects appear to forage heavily on insect-attracted flowers. Peak flowering of shrubs and forbs occurred in mid-July.

The estimated densities of crickets and grasshoppers would seem to indicate that these insects are of considerable importance in this ecosystem. The following hypothesis should be tested:

Arthropods such as crickets, grasshoppers, and microleps achieve fairly high populations in years when forb and grass production is high. If these conditions follow less favorable growth years, these populations will have a small effect on primary production. Significant impact of these groups requires consecutive favorable years that allow high early-growing-season densities that could hit the new growth of forbs and grasses during active growth.

Table 6. Population estimates (no/ha) of several families of arthropods on the bajada site based on flush transects

FAMILY	COMMON NAME	DENSITY	
		July 14	August 8
Gryllidae	crickets	6.7 (13.4*)	1.3 (2.6*)
Pieridae	yellow butterflies	4	0
Microlepidoptera		20	20
Aerididae	grasshoppers	320	40
Pompillidae	tarantula hawks	4	0

* corrected

II.C.3 GROUND BEETLES AND OTHER SURFACE ARTHROPODS -- BAJADA

Ground beetles were removed from can traps and marked with an identifying color by enamel airplane dope. A marking system using spot patterns on the elytra and pronotum allowed marking of up to 1000 individuals. Other arthropods in the cans were marked with enamel paint also, e.g., wolf spiders, tarantulas, vinegaroons and millipedes. We recorded recaptures of two tarantulas, one wolf spider and no millipedes. It was concluded that paint spots either fade or possibly harm the animals and the marking practice was discontinued in July (for data collection methods, see A3UWJ22).

The only species of ground beetles on the bajada for which we had sufficient recaptures to compute Lincoln Index density estimates was *Stenomorpha* sp. (Table 7). We captured six *Eleodes* sp. and 58 *Eleodes longicollis* in May, June, and July, but no recaptures were recorded.

Summaries of arthropods recorded in the 100 trap grid are shown in Table 8.

Table 7. Population density estimates for *Stenomorpha* sp. on the bajada in 1971 and 1972 based on pit-fall traps/mark-recapture studies

Date	1971			1972	
	Aug.	Sept.	Oct.	June	July
Density (No. ha^{-1})	70.8	298	101	28	67

Table 8 Large arthropods taken in the bajada pit-fall trap grid in a 30-day sampling period, June-July 1972

Common Name	Number trapped
Wolf Spiders	4
Millipedes	8
Vinegaroon	3
Sun Spiders	2
Scorpions	2
Black (red-white stripes) Spider	4
Black-widow Spiders	6
Tarantula hawks	18
Centipedes	7
Velvet ants	17
Brown spiders	316
Crickets, species A	19
Crickets, species B	6
Crickets, species C	20

II.C.4 TERMITES -- BAJADA

Termites were studied on the bajada by the techniques described in I.C.4. The average surface wood available as termite food was 58.7 g/m^2. Surface termite activity in wood sample areas was noted in June and July in one sample area each month. The locations of wood sample areas and toilet paper grids are shown in Figure 2. As on the playa, there was considerable variation in termite activity in different areas as assessed by toilet paper grids (Table 9). Termite activity was greatest on grids 51 and 44. Grid 51 straddles a minor arroyo, thus providing a relatively deeper soil and more stable moisture characteristics than 20, where the soil is shallow and dries quickly. The greatest activity on 20 was coincident with high moisture in the upper shallow soils (see soil moisture section). The grid at 24 is on somewhat deeper soil than 20 but shallower than the soil at 44. These data suggest that surface feeding of termites may be predicted from a combination of soil temperature and soil moisture conditions. We also noted that the rolls under the canopy of shrubs exhibited greater termite activity than those on open soil.

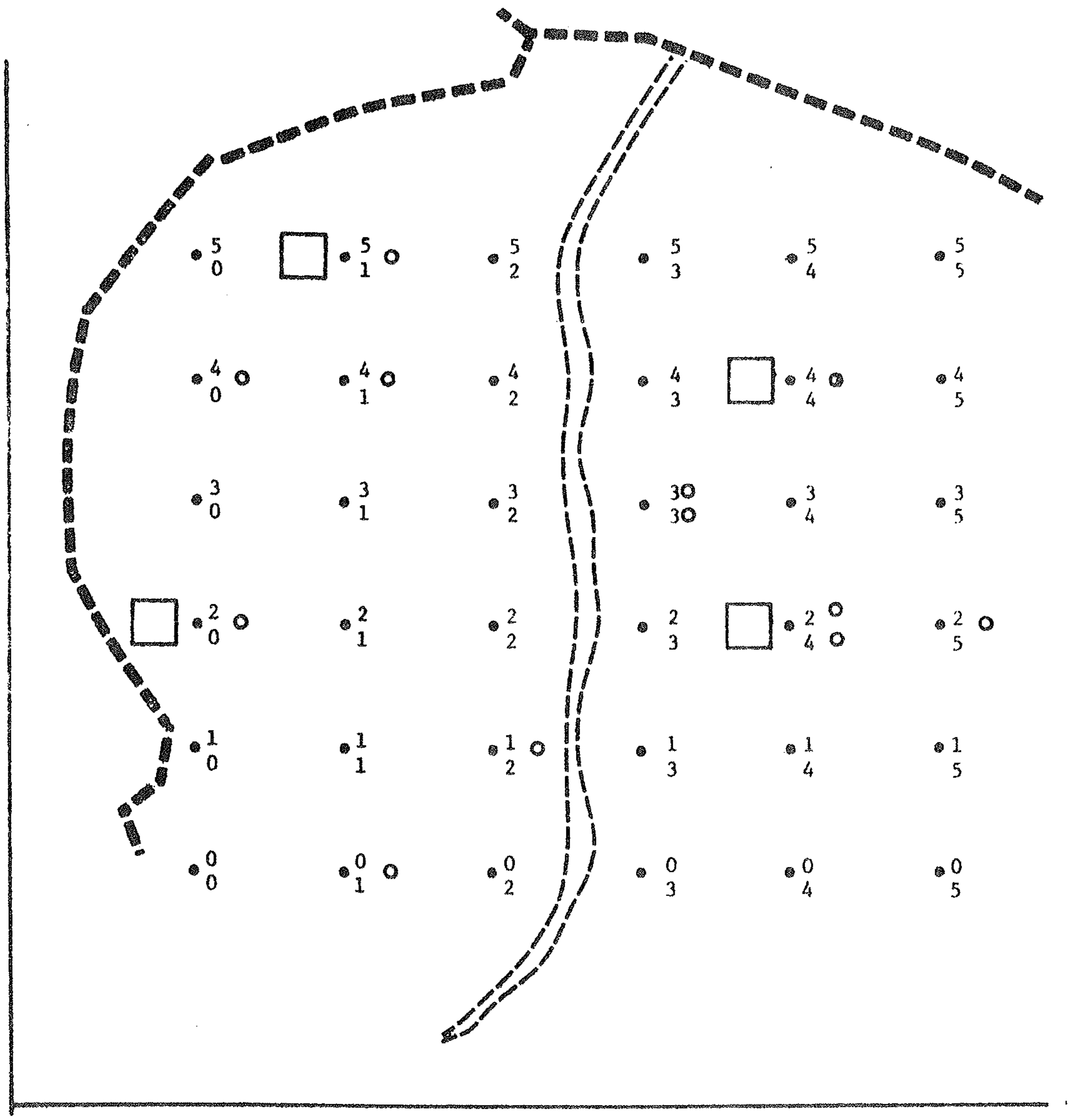

Figure 2. Locations of wood sampling areas and toilet paper grids on the bajada for monitoring termite activity.

Table 9. Termite activity assessed on the toilet paper grids on the bajada site in 1972

Grid Marker	20		24		51		44	
Date	% Rolls	Number	% Rolls	Number	% Rolls	Number	% Rolls	Number
21 July	18	0	13	9	25	149	0	0
10 August	3	0	17	59	39	804	22	82
20 September	36	561	21	402	68	1538	53	1387
10 October	26	2	41	88	50	390	49	221

NOTE: Percent effected = percentage of rolls that exhibited recent feeding activity. Number of termites = number shaken from rolls on the survey date.

II.C.5 SOIL ARTHROPODS -- BAJADA

Soil samples were collected in various areas of the arroyo on the bajada site to obtain estimates of soil arthropod populations. This area was chosen for sampling because it represents an area of organic accumulation and consequently the habitat most likely to support populations of soil arthropods. Soil samples were obtained from the top 25 cm of soil, brought to the laboratory and sub-samples examined by flotation, modified from Salt and Hollick (Southwood, 1966).

There were striking differences in density and composition of soil arthropod populations in different areas of the arroyo. The lowest densities were recorded from soil samples from unvegetated areas in the middle of the arroyo (Tables 10-14). Soil mites were absent from these samples and nematodes predominated. The highest densities recorded were from mid-arroyo under mixed vegetation (*Fallugia paradoxa*, *Chilopsis linearis* and *Prosopis glandulosa*) and in several of these samples soil mites accounted for ≅ 20% of the soil arthropods (Tables 10-14 and Fig. 3). The variance in density was partially due to differences in soil moisture (Figures 4 & 5) but primarily due to site differences. Flooding acted as a catastrophic density-independent mortality factor (Figure 3).

Studies of soil arthropod populations are extremely expensive in terms of man hours. The limited data obtained in our studies represents nearly the full-time efforts of a technician for the summer. Another problem encountered is the lack of expertise in handling these small arthropods, e.g., mounting for identification and identification itself. Therefore it is proposed that an alternative to the current method be sought.

Literature Cited

Southwood, T. R. E. 1966. Ecological Methods. Methuen & Co. London. 391 pp.

Table 10. Numbers (no./100 g soil) and types of soil fauna from soil samples taken from the bajada arroyo under Apache plume (*Fallugia paradoxa*) stands

Date	% Soil Moisture	Mites	% Mites	Nematodes	% Nematodes	Others
June 1, 1972	3.2	0	0	5	33.3	10
June 2, 1972	4.0	1	5.5	4	22.2	13
June 8, 1972	5.2	3	13.0	12	52.2	8
June 15, 1972	2.8	6	13.0	22	47.8	10
June 22, 1972	4.8	3	4.7	20	31.3	41
June 29, 1972	4.4	2	3.8	14	26.9	36
June 20, 1972	6.4	1	2.2	10	22.2	34
July 13, 1972	7.2	0	0	3	30.0	7
July 14, 1972	12.0	2	5.1	11	28.2	26
July 20, 1972	8.0	0	0	0	0	0
July 24, 1972	5.2	0	0	0	0	4
July 27, 1972	4.0	0	0	2	20.0	8
August 3, 1972	4.4	0	0	3	20.0	12
August 10, 1972	No value	0	0	0	0	14

Table 11. Numbers and types of soil fauna from samples taken at mid-arroyo under mixed vegetation

Date	% Soil Moisture	Mites	% Mites	Nematodes	% Nematodes	Others
June 1, 1972	1.6	0	0	6	50.0	6
June 2, 1972	2.8	0	0	4	50.0	4
June 8, 1972	5.2	6	5.2	10	18.8	16
June 9, 1972	4.4	5	17.2	14	48.3	10
June 15, 1972	4.8	8	14.0	27	47.4	22
June 22, 1972	5.6	9	22.5	16	40.0	15
June 29, 1972	4.0	6	15.4	20	51.3	23
June 30, 1972	3.2	7	10.8	29	44.6	33
July 13, 1972	4.0	3	6.1	20	40.8	26
July 14, 1972	12.0	2	4.3	17	36.2	28
July 20, 1972	6.4	0	0	4	100.0	0
July 24, 1972	4.0	0	0	3	50.0	3
July 27, 1972	3.2	6	17.6	17	50.0	11
August 3, 1972	5.6	6	14.0	22	51.2	15
August 10, 1972	2.8	10	14.1	31	43.7	30

Table 12. Numbers and types of soil fauna from samples taken at mid-arroyo in open areas

Date	% Soil Moisture	Mites	% Mites	Nematodes	% Nematodes	Others
June 1, 1972	3.2	0	0	6	66.7	3
June 2, 1972	4.0	0	0	10	83.3	2
June 8, 1972	5.2	0	0	13	81.3	3
June 15, 1972	5.6	0	0	21	87.5	3
June 22, 1972	4.0	0	0	17	81.0	4
June 29, 1972	4.0	0	0	11	45.8	13
June 30, 1972	4.8	0	0	16	61.5	10
July 13, 1972	4.4	0	0	10	47.6	11
July 14, 1972	11.6	0	0	0	0	0
July 24, 1972	8.4	0	0	0	0	2
July 27, 1972	4.0	0	0	6	85.7	1
August 3, 1972	3.2	0	0	11	36.7	19
August 10, 1972	5.2	0	0	7	41.2	10

Table 13. Numbers and types of soil fauna from soil samples taken from under mesquite (*Prosopis glandulosa*) at the edge of the arroyo

Date	Mites	Nematodes	Others
June 1, 1972	0	10	3
June 2, 1972	0	17	9
June 8, 1972	6	0	0
June 15, 1972	0	19	8
June 22, 1972	0	23	19
June 29, 1972	3	21	12
June 30, 1972	1	27	20
July 13, 1972	2	16	7
July 14, 1972	0	0	2
July 20, 1972	0	5	4
July 24, 1972	0	11	14
July 27, 1972	4	17	21
August 3, 1972	1	29	17
August 10, 1972	3	31	35

Table 14. Numbers and types of soil fauna from soil samples taken from under mixed vegetation at the edge of the arroyo

Date	Mites	Nematodes	Others
June 1, 1972	0	0	0
June 2, 1972	3	14	20
June 8, 1972	6	27	20
June 15, 1972	14	29	26
June 22, 1972	10	36	41
June 29, 1972	6	21	35
June 30, 1972	7	27	37
July 13, 1972	4	37	25
July 14, 1972	0	0	0
July 20, 1972	0	16	14
July 24, 1972	0	18	30
July 27, 1972	6	31	37
August 3, 1972	8	37	32
August 10, 1972	4	29	40

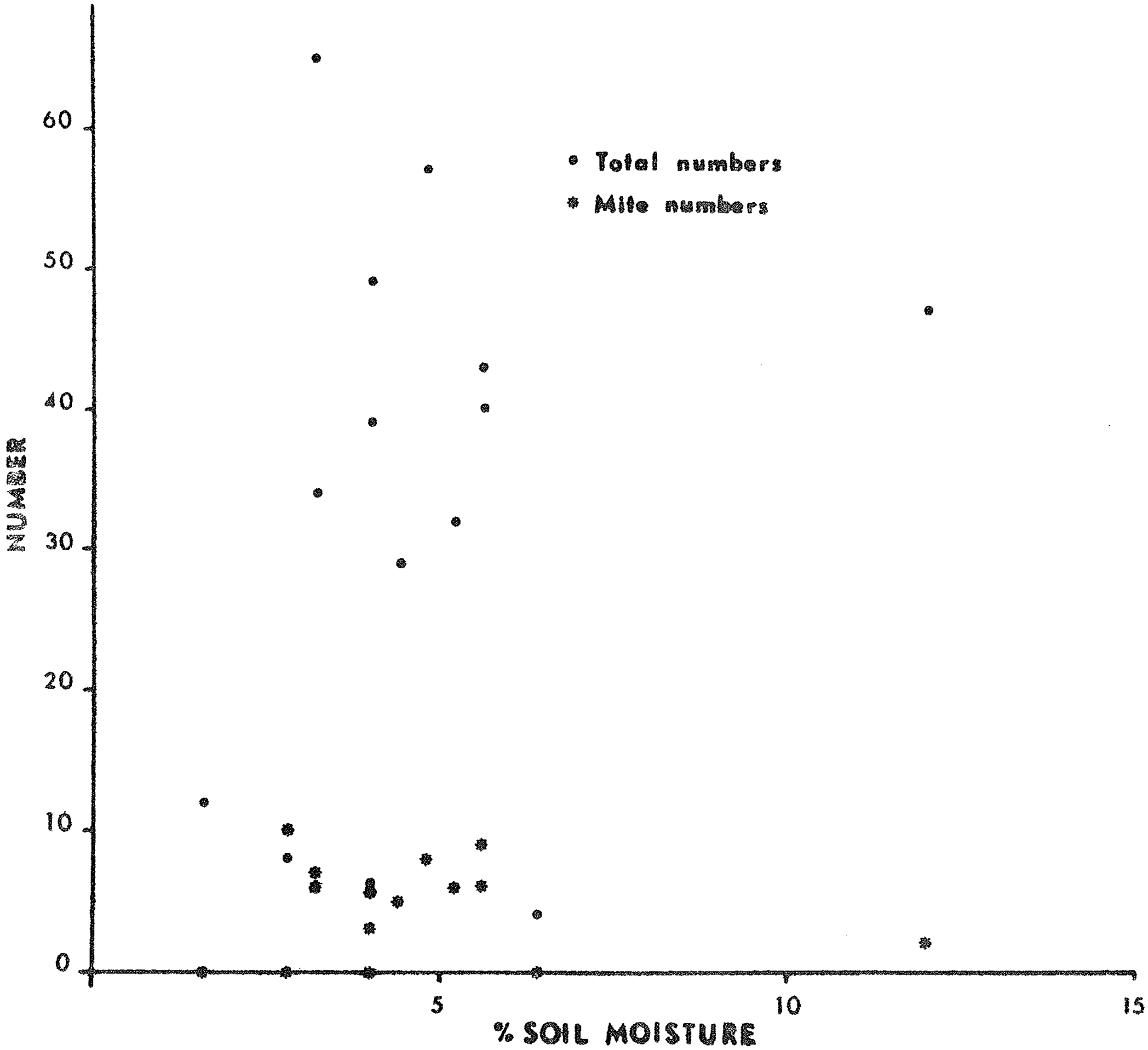

Figure 3. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled in an arroyo area under *Fallugia paradoxa*.

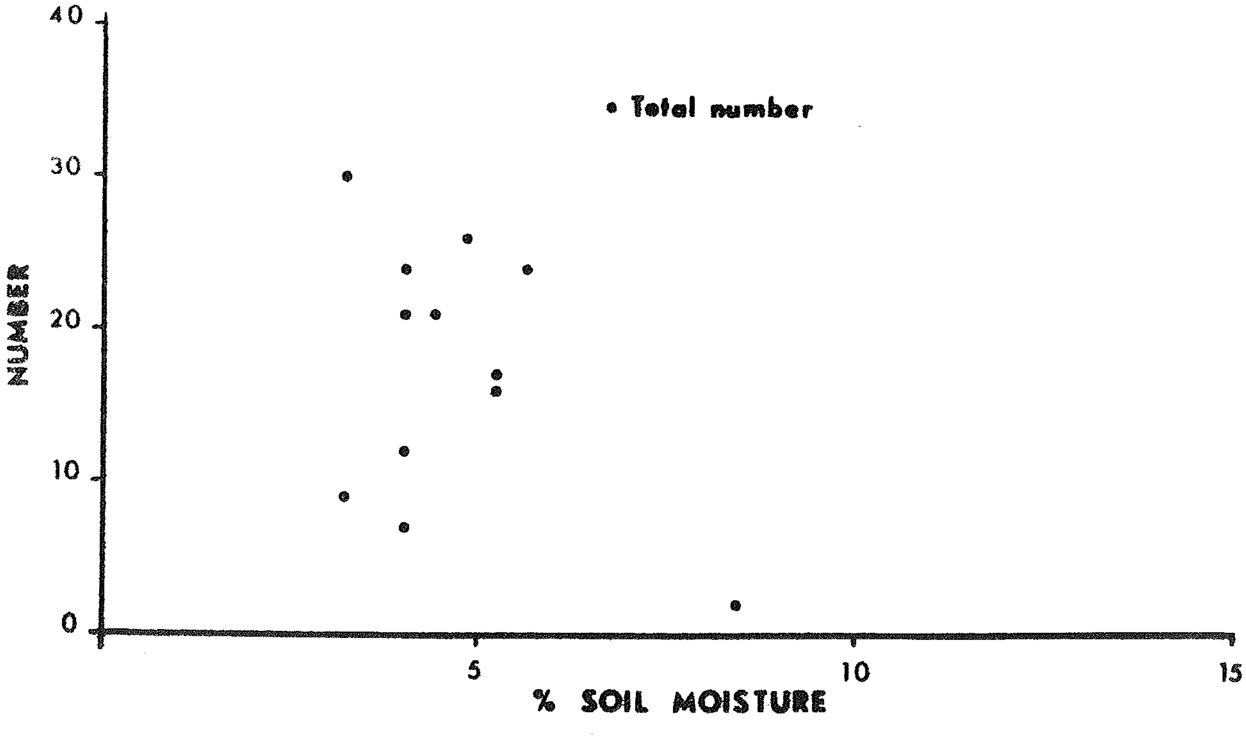

Figure 4. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled in an unvegetated portion of arroyo bottom.

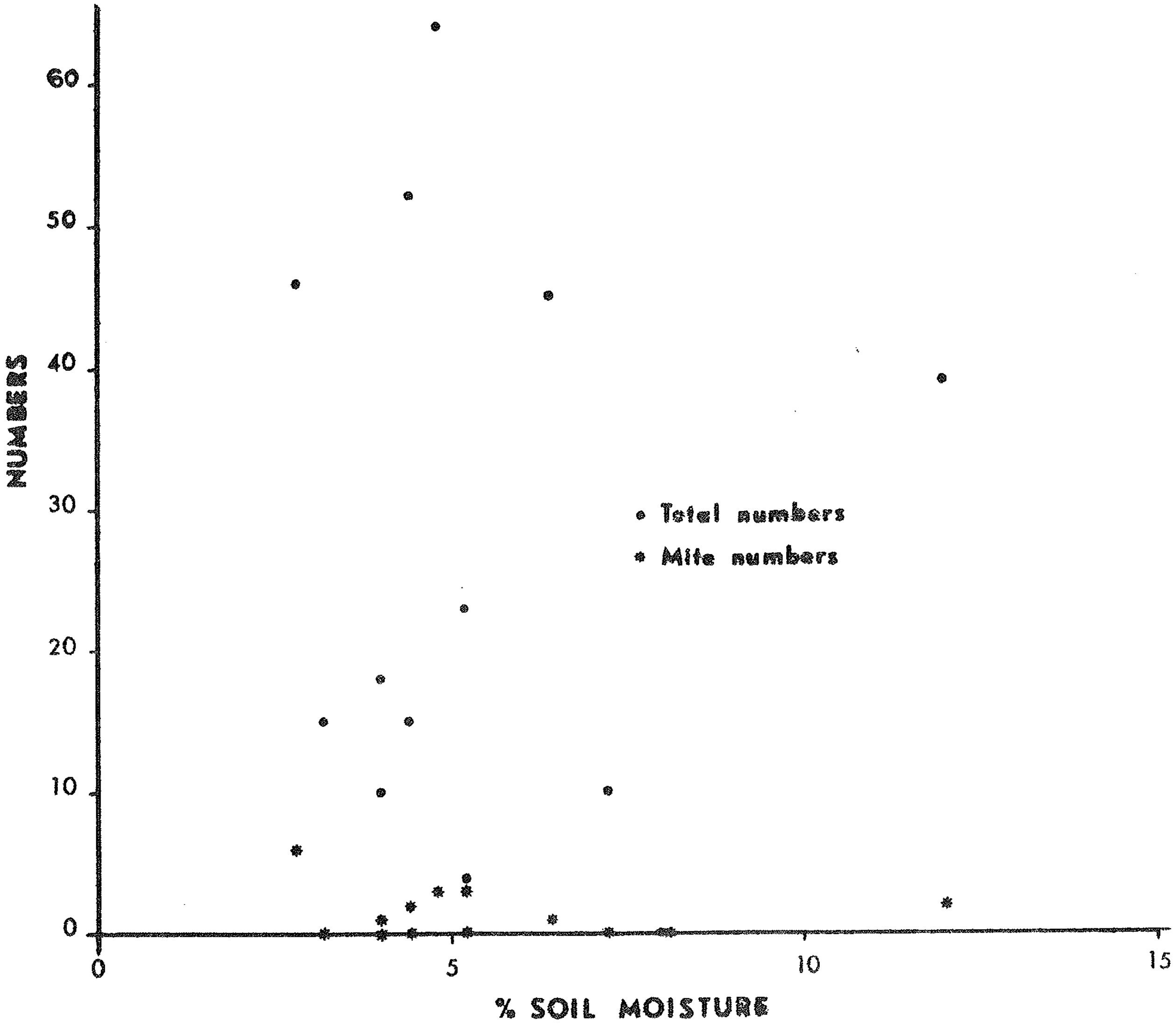

Figure 5. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled under mixed vegetation in the bajada arroyo.

II.D. VERTEBRATES

1. REPTILES -- BAJADA

Lizards, except for *Phrynosoma modestum*, were studied by mark-recapture techniques using a 100 trap station pit-fall grid (DSCODE A3UWJ69). The grid is 10 x 10 with trap spacing of 10 m. *P. modestum* were hand captured as encountered. Each lizard was given a unique identification by toe removal, weighed, sexed and other pertinent notes taken as removed from traps.

The dominant species on the bajada, *Cnemidophorus tigris*, are sufficiently numerous to provide enough recaptures for reliable estimates of density (Table 1 and Figure 1). An examination of these data suggests that on the Jornada *C. tigris* has high mortality during the active period. Lizards from 1971 which were recaptured in 1972 disappeared from the population by July, 1972. The August population was composed of primarily juvenile animals and the September population was entirely juvenile animals. Juvenile animals enter the trapable population in August and exhibit rapid growth in August and September (e.g., ≅ 7 mm SV and 1.8 g in 20 days for a rate of 0.09 g/day and 0.35 mm SV/day). The lowest densities were in July prior to emergence of the young. Adult mortality in June and July, 1971, was estimated at 22% and in June and July, 1972, was estimated at 52%. Hatching success was obviously lower in 1971 than in 1972 based on the September population estimates.

While we have but two years of population data we can infer some things about survivorship and age structure in the *C. tigris* population. Thirty six percent of *C. tigris* marked in 1971 were recaptured in 1972: 23% were adult lizards as determined by SV lengths in 1971 and 12.7% were juveniles (1971 hatchlings that overwintered). These data suggest a high overwinter mortality of the young of the year and that survivors of one winter may remain in the population two or more years.

Holbrookia texana is more limited by habitat than is *C. tigris*. *H. texana* rarely leaves the arroyo system on the bajada, thus the seemingly lower density when expressed on the basis of the entire area.

Uta stansburiana is not as habitat limited as is *H. texana*. This species is apparently undersampled by pit-fall traps; normal densities are too low to provide adequate mark-recapture data for population estimates. *Uta* is an annual turnover species and consequently requires special effort to provide continuous or adequate population density estimates.

Habitat requirements and/or food preferences or both virtually exclude *Phrynosoma cornutum* from the bajada. *P. cornutum* feeds almost exclusively on *Pogonomyrmex* spp. (Edwards and Whitford, in press) which are represented by *P. californicus* on the bajada. *P. californicus* and *P. cornutum* normally do not overlap in activity (Whitford, 1972) thus *P. cornutum* has no food base in this area. *P. modestum* appears to have low population density but intensive sampling would be necessary to substantiate this.

One rattlesnake (*Crotalus atrox*, 580 mm SV) was marked on the bajada on June 7 and recaptured June 16 and July 7. Other snakes captured on the bajada included one night snake (*Hypsiglena torguata*), one bull snake (*Pituopis melanoleucus*), one coachwhip snake (*Masticophis flagellum*), two patch-nosed snakes (*Salvadora hexalepis*), and one ground snake (*Tantilla* sp.). On the bajada there appears to be a balance in the snake fauna between predators of lizards and predators of mammals.

Table 1. Density and biomass of bajada lizards in 1971 and 1972*

						pre		peak	post		
			1971						1972		
Months	May	Jun	Jul	Aug	Sep	May	Jun	Jul	Aug	Sep	Oct
Cnemidophorus tigris	x̄										
Density (No·ha^{-1})	28.52	31.7	25.1	25.8	31.5	32.5	42.8	20.7	58.0	66.7	~~55~~ 844.14
x̄ wt/lizard (gms)	13.51	16.1	14.0	12.65	11.3	18.3	17.2	16.1	10.4	2.6	12.92
biomass (LW)		510.4	351.4		356.0	594.8	736.2	333.3	603.2	173.4	
biomass (DW)	115.80	153.1	105.4	97.91	106.8	178.4	220.9	100.0	181.0	52.0	146.46
Holbrookia texana											
Density		2+	1+			6+	9.7	1+	5.2	3+	4.98
x̄ wt/lizard (gms)		5.4	6.0			8.4	8.0	8.8	4.85	.9	6.19
						50.4	77.6	8.8	25.22	2.7	32.94
Uta stansburiana											
Density		3.5	1+			3+	3+	12+	18+	4+	8
x̄ wt/lizard (gms)		3.0	1.0			4.7	4.2	1.2	.85	.95	2.38
						14.1	12.6	14.4	15.3	3.8	3.61
						4.23	3.78	4.32	4.59	1.14	
Phrynosoma modestum											
Density			2+			1+	.31	7+	0	1+	1.86

* Density estimates computed where possible by the Lincoln Index. A + by a number indicates total number captured on the 1 ha · grid during that month. Density estimates based on sample area of 1.44 ha since sample area includes a zone around the grid.

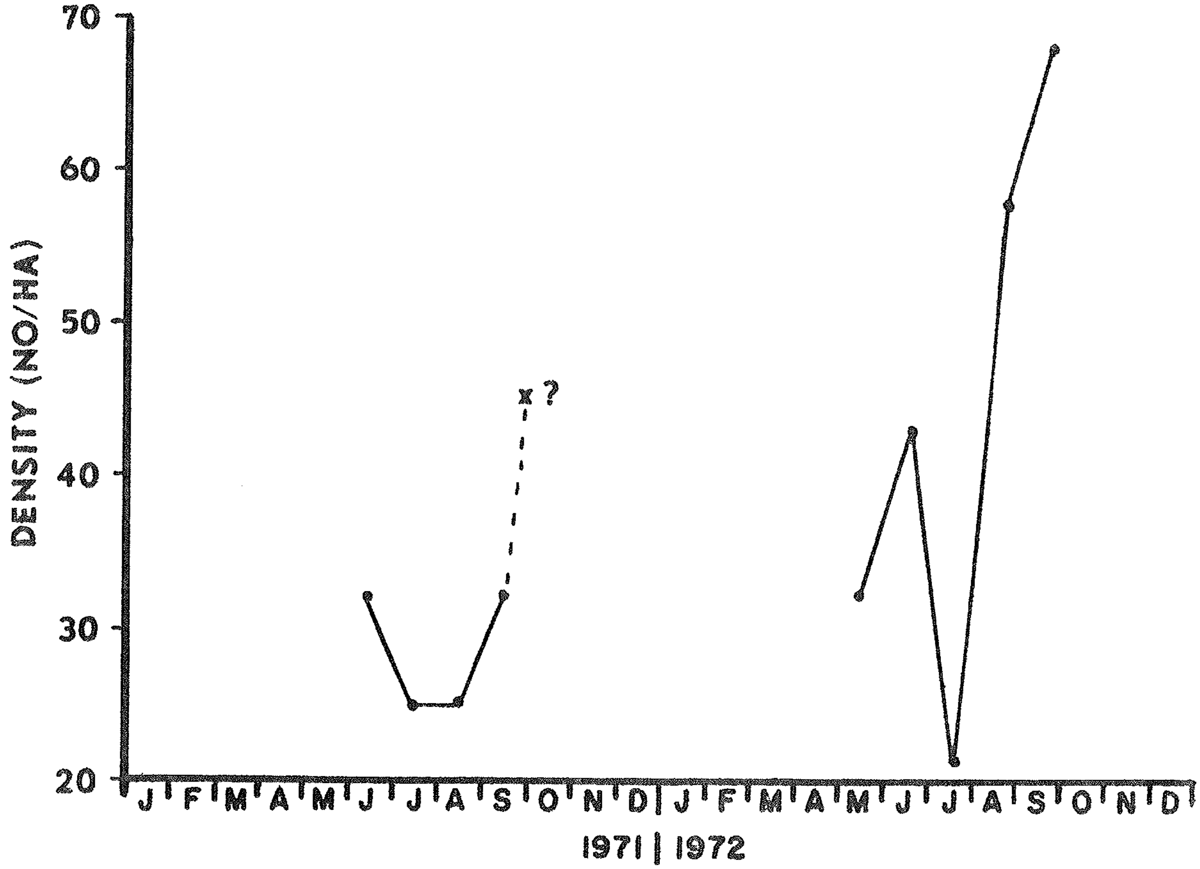

Figure 1. Fluctuations in estimated *Cnemidophorus tigris* populations on the bajada.

II.D.2 BIRDS --BAJADA (DSCODE A3UWJ6Q)

As on the playa area, the birds of the bajada were censused in 1972 on an approximately weekly schedule using Emlen's strip census method. In the case of the bajada, the route is 2200 m long, 800 of which follow the course of the main arroyo that bisects the plot.

The results of censuses in terms of numbers and biomass are given in Tables 2 and 3 and Figures 2-4. Most of the species categories are the same as those described for the playa: BS = breeding species, OI = non-breeding insectivorous species, DP = doves and quail, SE = other seed-eaters, RS = raptors, and MS = miscellaneous other species. Two groups of miscellaneous species have been treated separately: JA = jays, mainly Pinyon Jays, a flock of which accounted for most of the total density recorded in September, 1972 (Figure 3); and WO = woodpeckers, which have appeared intermittently on the bajada (Figure 3).

The totals of the Tables again reveal the general changes from year to year and from season to season. As on the playa, numbers and biomass were considerably higher for a given month in 1972 than in 1971. From the Figures it can readily be seen that this trend is common to all of the species groups. It can be inferred that the higher rainfall of 1972 produced conditions--probably increased food in the form of insects and seeds--that favored higher densities of all species of birds, whatever their trophic or seasonal position.

The seasonal pattern of abundance on the bajada is somewhat irregular and difficult to interpret. There seems to have been a peak in late spring-early summer followed by a mid-summer decline and a higher peak in autumn which gave way to low densities in winter-early spring. Clearly, more samples are required before we can be at all confident about any consistent seasonal pattern, but some negative tentative conclusions can be made now. The pattern of the birds on the bajada is unlike that on the playa, where winter is the period of highest numbers and biomass; nor is it like that of most areas of higher latitude (and altitude) where abundance is much greater in the breeding season than in other seasons.

Differences between the seasonal patterns on the bajada and the playa are of some interest since the two areas are so close together. In Figures 5, 6 and 7, the patterns for the areas are plotted for biomass of seed-eating birds (including quail and doves), insectivorous birds (breeding and non-breeding species combined), and for raptors. For seed-eaters, the fall and winter levels on the playa were far higher than on the bajada. Spermophilous migrants invaded both areas in the autumn but they were more numerous on the playa and stayed longer. The controlling feature over this difference seems certainly to have been the greater seed production on the playa. The comparison for insectivorous birds yields different conclusions. The two areas exhibited patterns and levels that were quite similar. The principal notable difference was that on the bajada the biomass did not drop to such low levels in the autumn and winter as it did on the playa. From Figure 2 it can be seen that bajada breeding birds, with a high percentage of insectivores, tend to remain throughout the year; these perennial residents tend to keep overall levels of insectivores more nearly uniform than on the playa where breeding species emigrate annually. Raptors were scarce on the bajada at practically all times, but they contributed considerable biomass to the playa total, especially in autumn and winter. The greater raptor biomass on the playa is probably also related to greater seed production, which makes for higher densities of mammals, the principal food of raptors.

It is interesting to compare the patterns of densities of birds on the bajada and playa with those of other areas in the general region. The nearby Jornada desert grassland sites of the US/IBP Grassland Biome network have exhibited annual and seasonal changes very similar to those of the playa: 1972 levels were much higher than those of 1971; breeding season densities have been low relative to those of fall and winter; most breeding birds are migratory and are replaced by an autumn influx of seed-eating and raptorial migrants which raise densities to the highest levels of the years.

Farther afield, the Desert Biome IBP sites of southern Arizona provide logical material for comparison (Russell et al., 1972). Densities on the Arizona sites tend to be higher than those of the Jornada; a number of different species are involved, and details of seasonal changes are different, but some interesting parallels occur in overall seasonal patterns. The Silverbell bird community is rather similar to that of the bajada in its lack of a pronounced seasonal cycle. The Santa Rita site resembles the playa and the Jornada grassland site in exhibiting highest density in winter, apparently as a result of influxes of seed-eaters (Brewer's Sparrow, Black-throated Sparrow, Gambel Quail, and Mourning Dove). These similarities and differences among sites are parallel to variation in vegetation. The bajada and Silverbell sites are in areas of typical open desert scrub vegetation whereas the playa, Jornada Desert Grassland, and Santa Rita sites include large amounts of grasses and other seed-bearing herbs along with tall shrubs or trees. In summary, the bird communities of true desert scrub areas in the Southwest exhibit an unusual seasonal pattern of abundance with no regular season of high or low abundance, while those of desert grassland areas are even more unusual in comparison with temperate areas in general, namely with greatest densities in winter. The controlling feature of the latter is probably availability of seeds.

Nesting was also studied on the bajada. There were no successful nests in 1971 and only a few were attempted. In 1972, however, 10 nests were known to be successful: Loggerhead Shrike (3), Crissal Thrasher (1), Scott's Oriole (1), Black-throated Sparrow (3), and Black-tailed Gnatcatcher (2). Thus, the response of the bajada birds to the more favorable conditions in 1972 was even greater than that of playa birds.

Table 2. Monthly mean bajada bird densities (birds/100 ha), 1971-1972

Species Category *	F	M	A	M	J	J	A	S	O	N	D
1971											
B S breeding		18.6	11.4	24.6	45.0	36.2		21.4	21.1	26.4	
O I non-breed insect		4.3	0.0	1.1	4.3	1.0		0.0	3.4	0.0	
S E seed		0.0	0.0	1.1	0.7	0.0		1.4	17.1	25.7	
D Q doves & quail		0.0	0.0	0.0	0.0	1.9		0.0	10.9	9.3	
R S raptors		0.0	0.0	0.0	0.0	0.0		0.0	2.3	2.9	
J A jays		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	
W O woodpeckers		2.9	0.0	0.0	0.0	0.0		0.0	1.1	0.7	
M S misc		0.0	0.0	0.0	0.0	0.0		0.0	0.6	0.0	
TOTAL		25.7	11.4	26.9	50.0	39.0		22.9	56.6	65.0	
1972							11 months				
B S	8.6	24.3	42.9	81.1	74.3	71.4	65.7	51.4	34.3	26.7	27.1
O I	0.0	0.0	2.9	14.3	0.0	0.0	2.9	4.3	14.3	8.6	4.3
S E	7.9	0.0	0.0	5.7	0.0	5.7	15.7	11.4	100.0	31.4	5.7
D Q	0.0	1.4	5.7	13.1	2.9	2.9	98.6	21.4	0.0	5.7	15.7
R S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J A	0.0	0.0	0.0	0.0	0.0	0.0	1.4	132.9	0.0	1.0	0.0
W O	0.7	0.0	5.7	1.7	0.0	0.0	0.0	0.0	5.7	0.0	4.3
M S	0.0	0.0	0.0	2.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	17.1	25.7	57.1	118.3	77.1	80.0	184.3	221.4	154.3	73.3	57.1

* See text for explanation of categories.

Table 3. Monthly mean bajada bird biomass (live weight/ha), 1971-1972

Species Category *	F	M	A	M	J	J	A	S	O	N	D
						1971					
B S		6.3	3.9	8.4	15.3	12.3		7.3	7.2	9.0	
O I		0.9	0.0	0.2	0.9	0.2		0.0	0.7	0.0	
S E		0.0	0.0	0.3	0.2	0.0		0.4	4.6	6.9	
D Q		0.0	0.0	0.0	0.0	2.2		0.0	12.9	11.0	
R S		0.0	0.0	0.0	0.0	0.0		0.0	22.2	28.0	
J A		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	
W O		2.0	0.0	0.0	0.0	0.0		0.0	0.8	0.5	
M S		0.0	0.0	0.0	0.0	0.0		0.0	0.0	0.0	
TOTAL		9.2	3.9	8.9	16.3	14.8		7.7	48.3	55.4	
						1972					
B S	2.9	8.3	14.6	27.6	25.3	24.2	22.3	17.5	11.7	9.1	9.2
O I	0.0	0.0	0.0	2.9	0.0	0.0	0.6	0.9	2.9	1.7	0.9
S E	2.1	0.0	0.0	1.5	0.0	1.5	4.2	3.1	27.5	8.5	1.5
D Q	0.0	1.7	6.7	15.5	3.4	3.4	115.3	25.3	0.0	6.7	18.5
R S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J A	0.0	0.0	0.0	0.0	0.0	0.0	1.3	122.3	0.0	0.9	0.0
W O	0.5	0.0	4.0	1.2	0.0	0.0	0.0	0.0	4.0	0.0	3.0
M S	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
TOTAL	5.5	9.9	25.9	48.6	28.7	29.1	144.8	168.9	45.5	26.9	33.1

* See text for explanation of categories.

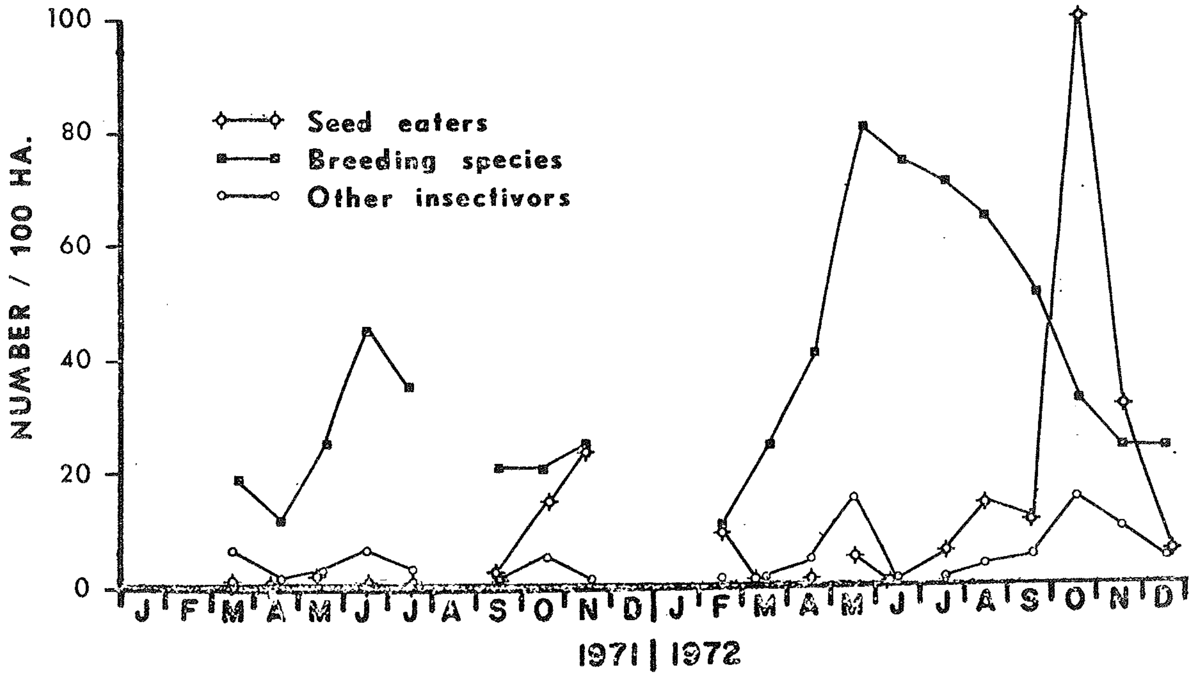

Figure 2. Mean monthly density of breeding species, non-breeding insectivores and non-breeding seed-eaters, bajada, 1971-1972.

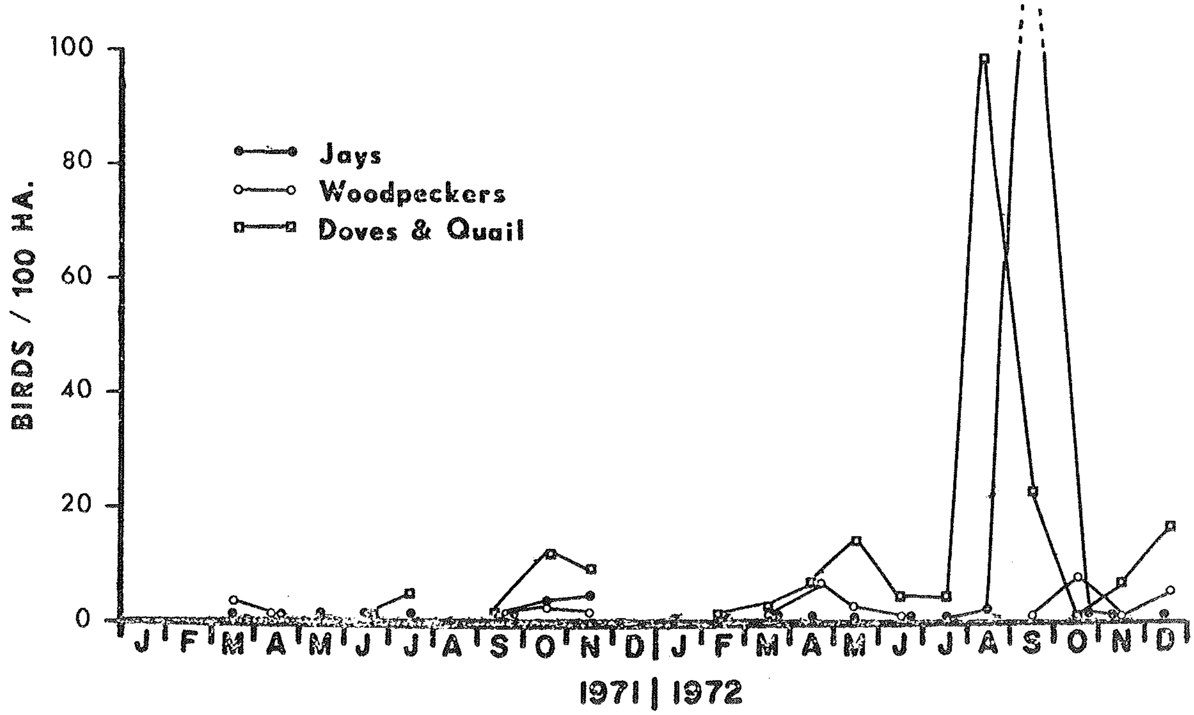

Figure 3. Mean monthly density of doves, quail, woodpeckers, and jays, bajada, 1971-1972

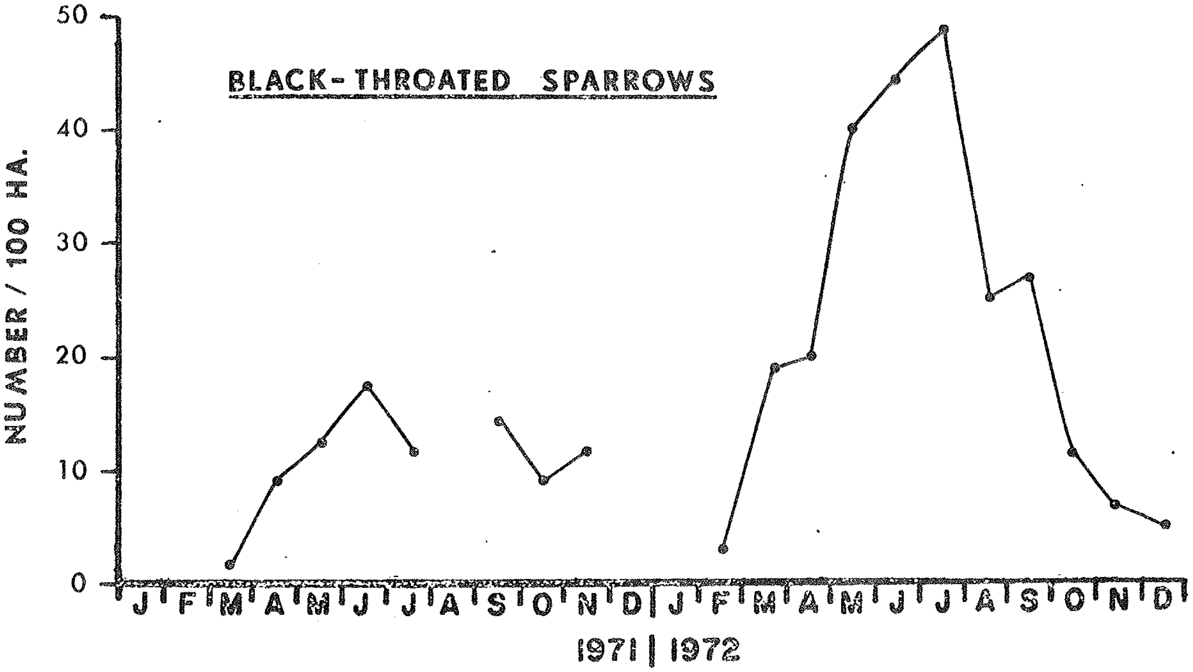

Figure 4. Mean monthly density of Black-throated Sparrows, bajada, 1971-1972.

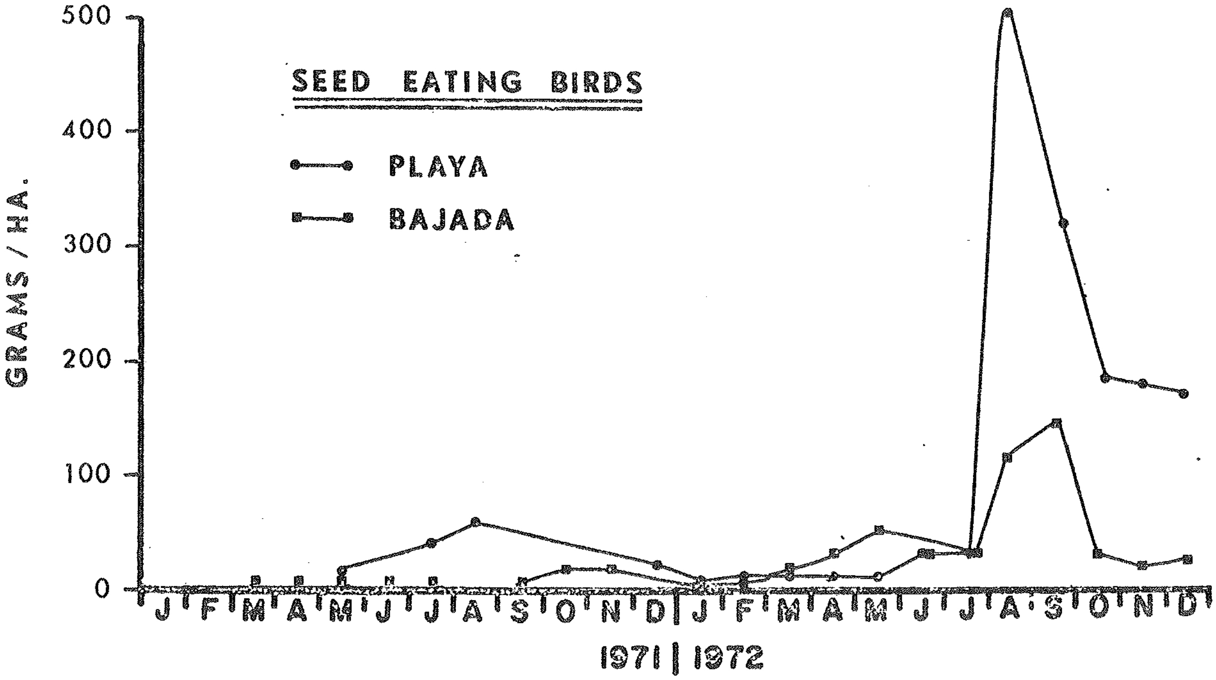

Figure 5. Comparison of biomass of all seed-eating birds on playa and bajada, 1971-1972.

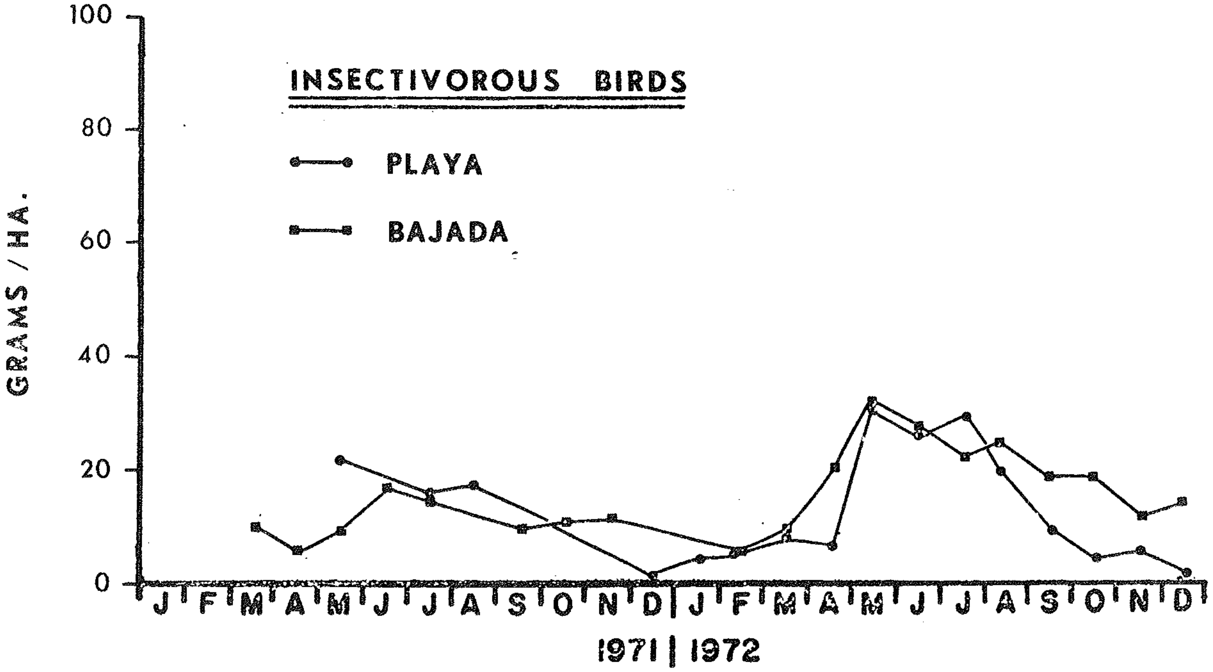

Figure 6. Comparison of biomass of all insectivorous birds on playa and bajada, 1971-1972.

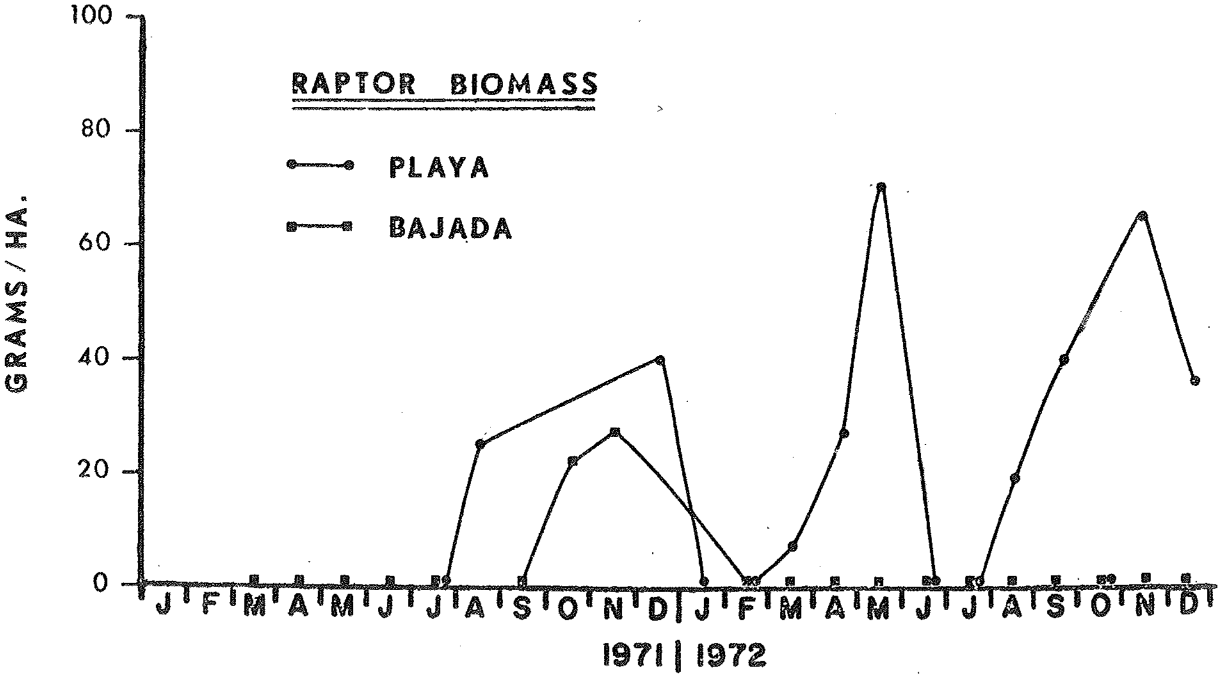

Figure 7. Comparison of biomass of raptors on playa and bajada, 1971-1972.

II.D.3 RODENTS -- BAJADA

The bajada rodent grid was trapped in January, March, May, July and November (DSCODE A3UWJ68). The trapping grid was a one hectare plot with 100 trap stations 10 m apart. Alternate trap stations were set with two Sherman traps and the double traps shifted to one trap station on alternate nights. Traps were baited with cracked milo and opened for three successive nights. The first two nights were considered pre-census and the third, census, for computation of the Lincoln Index. Each animal received a unique toe clip for recording data,and sex and breeding condition were noted. Field weights were obtained with Pesola balances; accuracy ± 2 g.

The 100 m hectare posts marking the 25 ha plot were trapped for two periods; May 30 - June 1 and July 18 - 20. Four traps were placed at each post and the procedures were the same as used on the sampling grid.

Fluctuations in the *D. merriami* population between 1971 and 1972 were discussed in I.D.3. The data on the bajada rodents are summarized in Table 4. The density of all rodent species dropped markedly in 1971 probably as the result of dry conditions as noted previously. In 1972, the density of most species on the bajada site was so low that a density estimate could not be calculated except as noted in Table 4.

The reproductive cycle in *D. merriami* on the bajada differed from the playa *D. merriami* in some respects (Figure 8). The *D. merriami* on the bajada exhibited no reproductive activity in the fall of 1971 as did the playa population. In other respects the two populations exhibited a similar reproductive cycle with a peak in the spring and some reproduction evident in winter, 1971.

While the population density of species other than *D. merriami* are too low to obtain accurate estimates for each trapping period, three species are sufficiently numerous that we can examine fluctuations in their populations (Figure 9). *Perognathus penicillatus* and *P. intermedius* exhibited out-of-phase population peaks in 1971, undoubtedly resulting from differences in breeding cycle in these two species. The timing of recruitment of young in these species suggests temporal separation in peak impact of young on food resources. In addition, the *P. penicillatus* population appears to have recovered from the effects of the 1971 drought in the fall, 1972, but there appeared to be little response in the *P. intermedius* population. Indeed Hoover (1973) suggested that the bajada is marginal habitat for *P. intermedius*. This hypothesis would be supported by the failure of the *P. intermedius* population to recover in 1972. Hoover (1973) also showed that the peak in population activity coincided with *P. penicillatus* and *P. intermedius* in an area where the two species do not overlap, but on the bajada their population and activity peaks were not coincident. These data combined with the studies of Hoover should clarify the ecological relationships of these two species.

Neotoma albigula also exhibited peaks of recruitment into the population in late summer. In these species, recruitment of young appears to coincide with the rains of late summer. However, breeding must occur prior to the onset of rains in order for the young to reach the size at which they leave the nest. Thus, recruitment occurred in 1971 even though the growth of annual forbs and grasses and fruiting in *Larrea* had not occurred. This resulted in heavier than normal mortality in most populations except *Neotoma albigula*, a non-granivorous species (Figure 9 and Figure 7 in I.D.3).

Peromyscus maniculatus, *Peromyscus eremicus*, *Onychomys torridus*, *Dipodomys ordii*, *Perognathus flavus* and *Spilosoma spilosoma* have consistently exhibited population densities of one or less than one per hectare since the trapping program was initiated. Consequently, we feel it is safe to assume that these species have little impact on the ecosystem.

Long distance moves in *D. merriami* were recorded during the two trapping sessions in which traps were set over the entire 25 ha grid. These data are summarized in Figure 10. In the May 30 - June 1 study, 33% of the *D. merriami* recaptured more than once exhibited moves of 100+ m. In the July study, only 11% exhibited such movements and only one animal moved more than 200 m. This difference strongly suggests that the long distance moves are more common when food supplies are sparse. The movements are not dispersal of of juvenile animals. The reduction in long distance moves by individual *D. merriami* in July coincided with the disappearance of young animals in the population and as a consequence should have included a higher percentage of "wanderers" than the May study if the wandering represented dispersal movements.

There appeared to be a relationship between seed production and long distance movement of *D. merriami* on the bajada. In mid-June prior to heavy seed production in *Larrea*, 38% of the *D. merriami* recaptured moved in excess of 100 m in the three day study period. In mid-July after large fruit had set on *Larrea*, only 12% of the *D. merriami* recaptured exhibited long distance moves. This again contrasts with the playa population in which 33% exhibited long distance movements in July. This difference is not attributable to differences in reproductive cycles or recruitment times in the two populations since these data are nearly identical for both populations. However the food base of the two populations must differ due to difference in plant communities in the two areas. The high percentage of long distance movements on the playa area in July may represent search for preferred fruits.

There are obvious spatial discontinuities in the distribution of rodent population on the bajada. Soils associated with arroyos are important in providing habitat for *P. penicillatus* and *P. intermedius* (Hoover, 1973). Mesquite and *Yucca baccata* which provide habitat and food for *Neotoma albigula* are restricted to edges of water courses. The uneven distribution of *D. merriami* is also related to water courses and areas where sheet flow from drainage escape results in larger *Larrea* and more reliable seed crops. These areas also provide soils of suitable depths above the caliche for burrows of kangaroo rats.

Table 4. Density (no./ha), live weight biomass (g/ha), estimated dry weight biomass (g/ha) and standing crop (kcal/ha) of rodent species on the Jornada (Chihuahuan Desert) bajada site in 1972 over a sampling area of 1.69 ha.

			Pre		Peak	Post
		January	March	May	July	November
Dipodomys merriami	Density	8.9	9.2	15.4	16.8	11.05
	Biomass (LW)	401.9	452.9	705.8	743.4	477.13
	Biomass (DW)	120.6	135.9	211.7	223.0	143.1
	Standing crop	803.9	905.7	1411.7	1486.8	954.3
Perognathus intermedius			*2	*2		
Perognathus penicillatus	Density		*1	*1	*3	10.65
	Biomass (LW)					133.6
	Biomass (DW)					40.1
	Standing crop					266.3
Peromyscus eremicus						*2
Peromyscus maniculatus						*3
Onychomys torridus					*1	*2
Neotoma albigula	Density	*2	*5	1.2	3.6	*2
	Biomass (LW)			153.8	526.2	
	Biomass (DW)			46.1	157.9	
	Standing crop			307.6	1052.3	
Dipodomys ordii					*1	
Spermophilus spilosoma				*1		

* indicates total number captured.

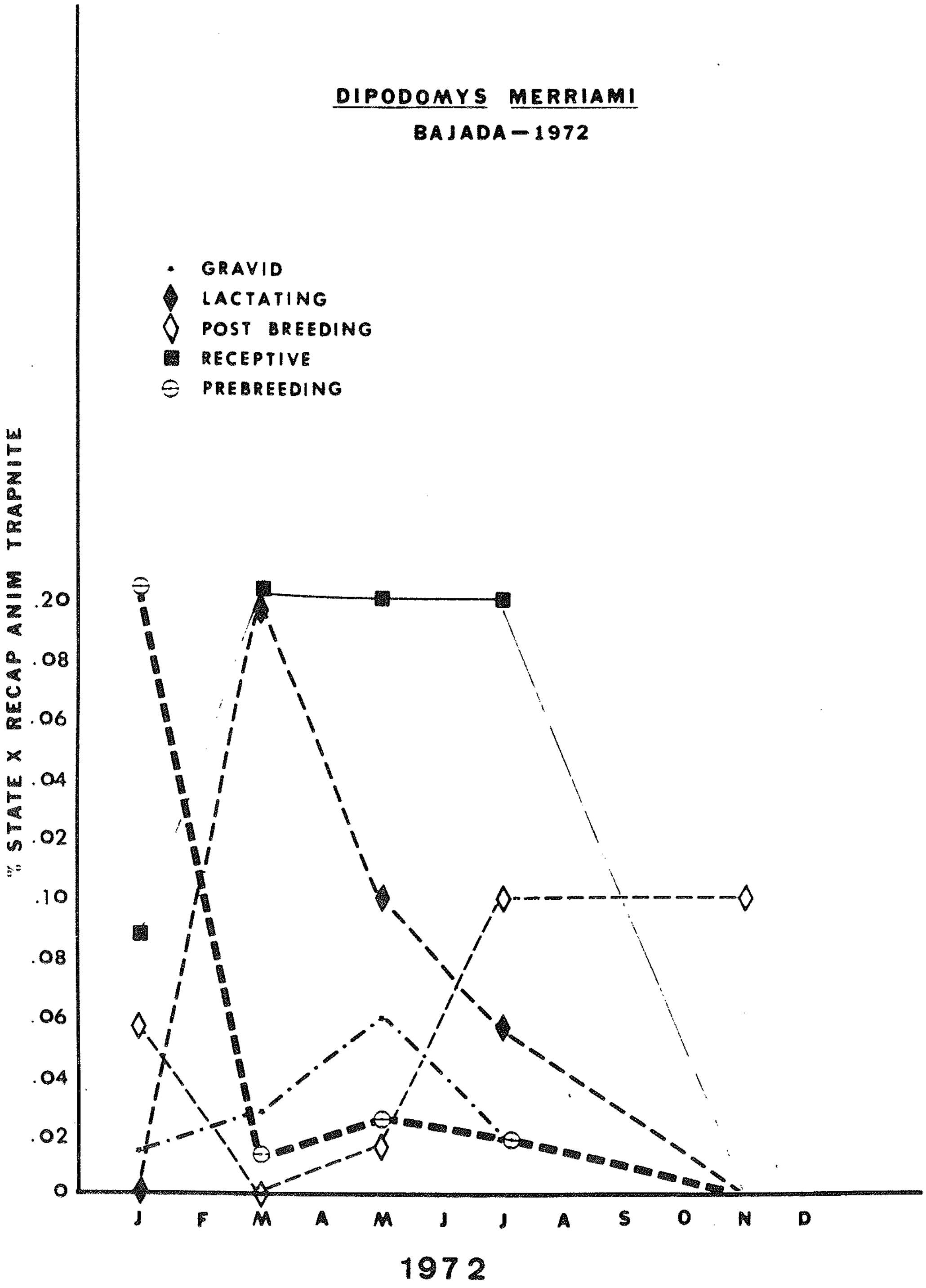

Figure 8. Reproduction condition of the population of *Dipodomys merriami* on the bajada.

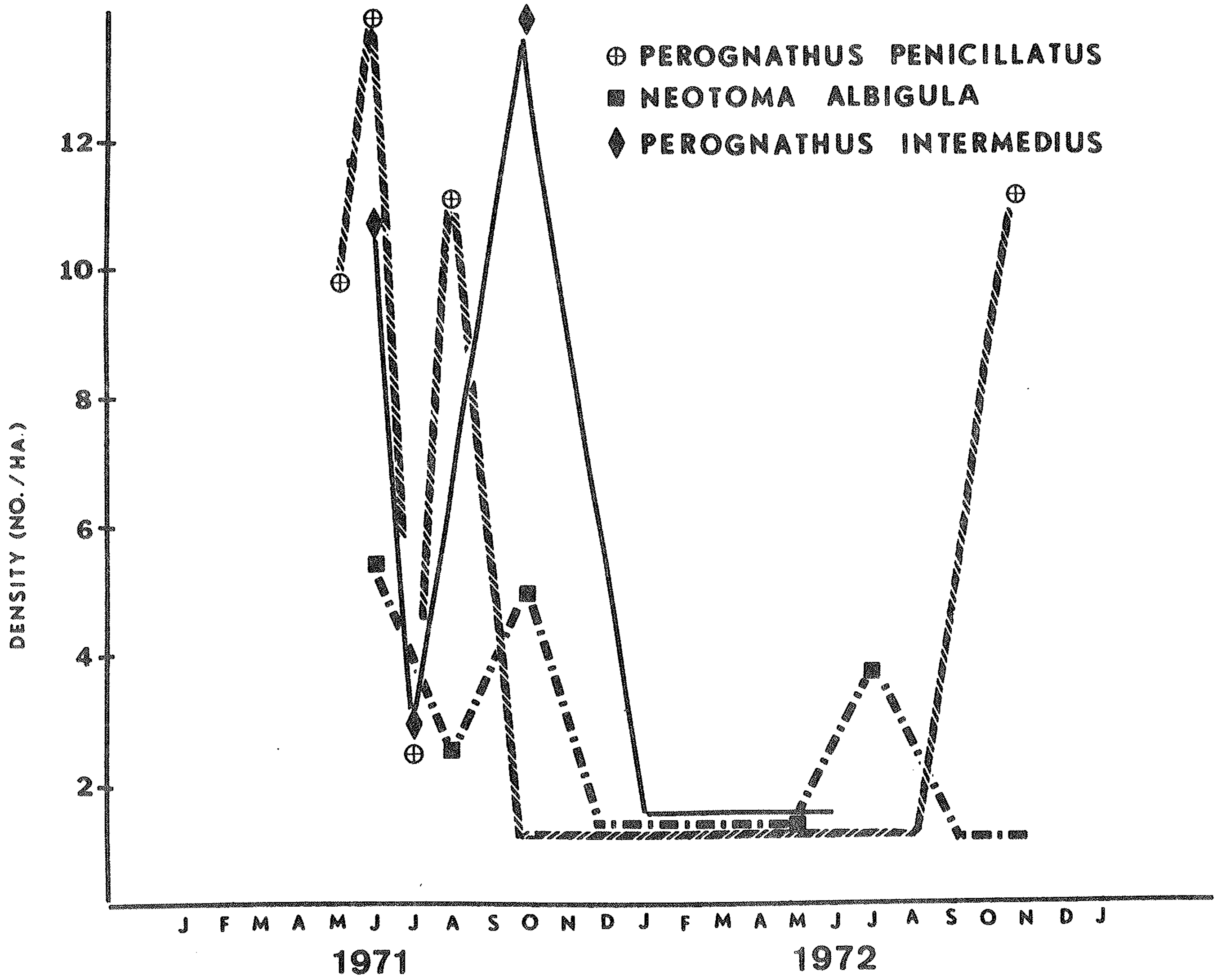

Figure 9. Population fluctuation of rodent species on the bajada.

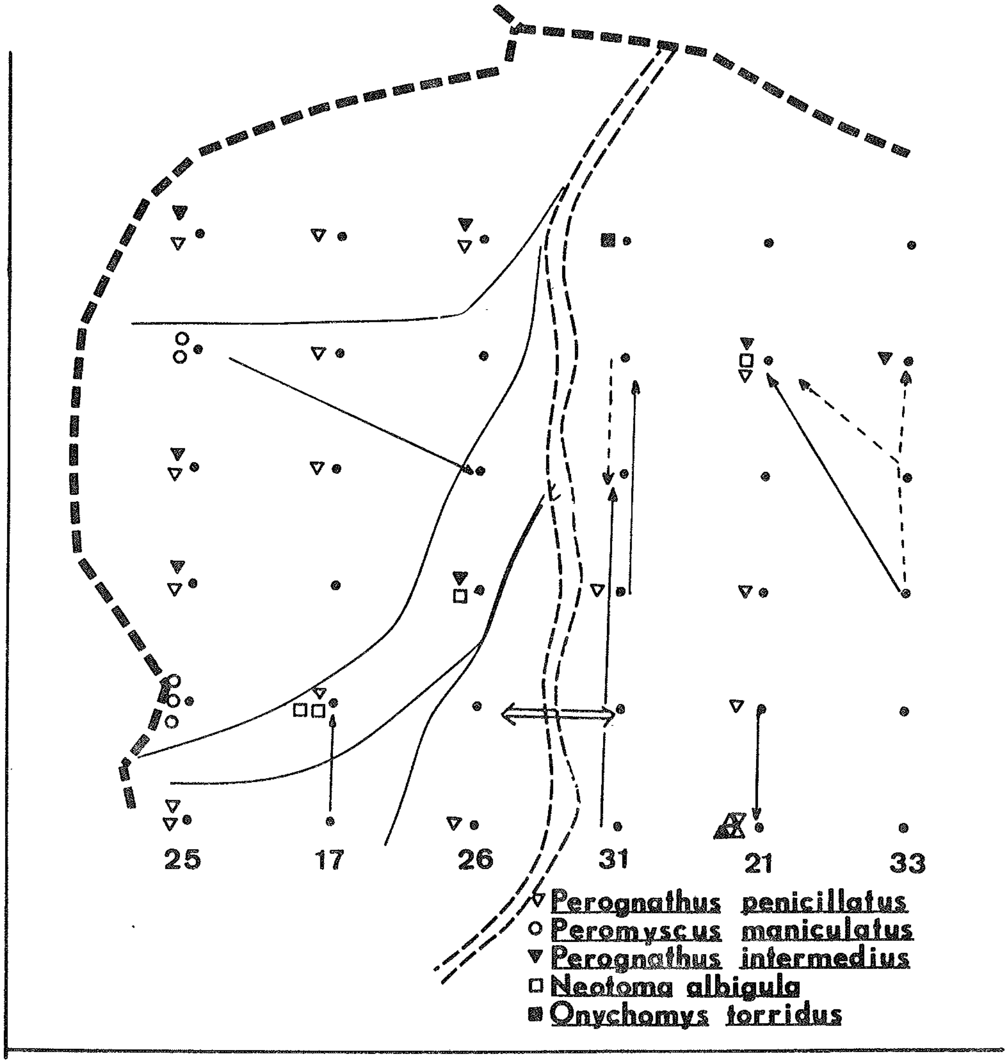

Figure 10. Long distance moves of *Dipodomys merriami* and trapping stations where other species were captured May-June 1972. Numbers at bottom of figure indicate numbers of animals captured on that line of the grid.

II.D.4 LAGAMORPHS -- BAJADA (DSCODE A3UWJ15)

Density estimates of bajada lagamorphs were obtained using the flush transect techniques described in I.D.4. Jackrabbits on the bajada were fairly predictable with regard to location of a form, in that jackrabbits were flushed from nearly the same point each time. Field workers noted that several jackrabbits became accustomed to human activity in the vicinity of their forms and that these individuals would not flush unless approached to within five meters. Cottontails, *Sylvilagus auduboni*, were always associated with the arroyo systems. Immatures of both species were frequently seen in September, accounting for the increase in relative density in that month. Given that movements, mortality and flushing behavior are variables that affect density estimates, it is suggested that the mean density for 1971 be considered as 0.4/ha for *Lepus californicus* and 0.4/ha for *Sylvilagus auduboni*. The variations in estimated densities (Table 5) are due to recruitment of young and the aforementioned variables.

Table 5. Variations in lagamorph densities determined by flush transects on the bajada

	June	July	August	September	October
			Lepus californicus		
Density	.42	.20	0	.57	.25
			Sylvilagus auduboni		
Density	.36	.83	0	1.25	0

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II.E. CHEMICAL ANALYSIS

Data on chemical and energy content of ecosystem compoents will be presented in subsequent progress reports.

II.F. SOILS

1. PHYSICAL AND CHEMICAL PROPERTIES -- BAJADA

The bajada study area is in the Desert Soil-Geomorphology Project of Soil Survey investigations, Soil Conservation Service, Doña Ana County, New Mexico. This area encompasses the northeastern part of the Doña Ana Mountains and the piedmont slopes upon which the bajada site is located. The present soil information is derived from data and a soil map provided by Leland H. Gile, Soil Scientist, Soil Survey Investigations, Soil Conservation Service, University Park, New Mexico. The soils of this area are discussed in greater detail elsewhere (Gile et al., 1970; Hawley and Gile, 1966; and Ruhe, 1967).

The physiographic-geomorphic surfaces pertinent to the bajada site are the slopes and summits of the Doña Ana Mountains, west and south of the site, and the adjacent piedmont slopes upon which the site is established. The slopes consist of individual alluvial fans and coalesced alluvial fans formed from mountain-derived alluvium. The slopes are composed of two geomorphic surfaces, the higher elevational Organ with slopes ranging from 10% next to the mountains to 2% on the lower fan piedmont, and the lower elevational Jornada surface with slopes ranging from about 5% to less than 1%. These surfaces are mapped (section I.F.1, Fig. 1) and described (section I.F.1, Table 1).

The Jornada surface sediments date from late to mid-Pleistocene. Many of these soils have prominent horizons of silicate clay accumulation, and all have prominent carbonate accumulation horizons commonly within about 61 cm of the surface. The argillic horizons are usually near the surface unless they have been buried by younger deposits. The Jornada surface dominant soils on the bajada site are the Berino and Jal (section I.F.1, Table 1). The Berino occupies a small portion of the northwestern quarter of the bajada site and the Jal occupies most of the western half (section I.F.1, Fig. 1).

The Organ surface sediments are less than 5,000 years old and thus lack strong genetic horizons. Weak carbonate accumulation horizons occur within a few cm of the surface but may be deeper in stable, high precipitation areas. The Organ surface sediments generally border the mountain slopes and overlie or are inset against the older Jornada surface. Dominant soils of these surface sediments occurring on the bajada study site are the Hawkeye-Alladin and Canutio complexes (section I.F.1, Table 1). The Hawkeye-Alladin occupies most of the eastern half of the bajada site, east of the major arroyo, and a small area in the northwestern corner, whereas the Canutio complex occurs in only a small area in the southeastern corner of this site (section I.F.1, Fig. 1).

II.F.2 LITTER -- BAJADA (DSCODE A3UWJ79)

The amount of litter on the soil surface can be estimated by using a harvest sampling of areal quadrats positioned randomly on the bajada site. In June 1972, a total of 25 quadrats, each 1 m by 2 m were sampled. The larger material was harvested by hand whereas the smaller material was vacuumed with a portable hand vacuum. Due to a delay in completing the sorting of the litter material collected, these surface litter data are not available for this report.

An estimate of the amount of soil surface litter that potentially must be put onto the site each year from the plants can be obtained by considering the amount of leaf biomass which is produced each growing season and then shed during and after the end of the growing season. For example, annual plants that complete their life cycle during the growing season contribute to the litter compartment with death and subsequent breakage. Further, perennial plants that are deciduous, such as mesquite, lose their leaves to litter at the end of each growing season. Even perennials which are evergreen have a turnover of leaf material about equivalent to the amount of new leaf material produced during the active part of the growing season.

The amount of biomass potentially contributed to soil surface litter by annuals and small perennials in 1971 and 1972 is shown in Table 1 for different sampling dates. In 1971, the five groupings of plants contributed less than 0.5 kg/ha. However, in 1972 the spring growth of annual forbs raised the potential amount of litter to about 4 kg/ha. In the fall of 1972, a second growth of primarily annual forbs gave a potential contribution of about 3 kg/ha.

The amount of leaf biomass potentially contributed to soil surface litter by large perennial plants in 1971 and 1972 is shown in Table 2. The amounts shown are the peak biomasses of new leaves produced by the major species which is assumed to about equal the amount lost in the given year or early in the next year. The major contributor is creosote bush (*Larrea divaricata*) with about 100 kg/ha and 350 kg/ha in 1971 and 1972, respectively. Mesquite (*Prosopis glandulosa*) and snakeweed (*Xanthocephalum sarothrae*) each contributed about 30 kg/ha and 20 kg/ha in 1971 and 1972, respectively. The yuccas (*Y. elata* and *Y. baccata*) contribute about 10 kg/ha each year. Other deciduous species not shown in Table 2 but which probably each contribute about 5 kg/ha of leaf material are desert willow (*Chilopsis linearis*), Apache plume (*Fallugia paradoxa*), tarbush (*Flourensia cernua*), and mariola (*Parthenium incanum*). Thus even in a relatively dry year, like 1971, one can expect about 200 kg/ha of leaf litter produced by the perennials. In a better year for growth, the total potential leaf litter produced by these perennials may exceed 400 kg/ha.

Table 1. Above-ground biomass estimates (g/ha) for annuals and small perennials on the bajada in 1971 and 1972

	1971		1972	
Group	9 Sept.	4 April	28 June	19 Oct.
Annual Grasses	2	8	.5	0
Forbs	30	3230	280	1630
Perennial Grasses	250	1725	180	485
Forbs	58	204	420	600
Subshrubs	65	0	0	2
Total (kg/ha)	.4	4.1	.9	2.7

NOTE: These above-ground biomasses will contribute to soil litter in the given year or the next year, depending on their resistance to breakage.

Table 2. Shrubs contributing leaf biomass (kg/ha) to soil litter each given year or next due to deciduousness or annual turnover of leaves if evergreen

Species	Growth Pattern	1971	1972
Larrea divaricata	Evergreen	100	350
Prosopis glandulosa var. *torreyana*	Deciduous	30	20
Xanthocephalum sarothrae	Deciduous	32	21
Yucca elata	Evergreen	5	8
Total (kg/ha)		167	399

II.F.3 ESTIMATION OF MICROBIAL DENSITY -- BAJADA (DSCODE A3UWJ30)

As described in I.F.3, bajada soil counts were done on plots with 0, 5 and 10 inch water amendments. Data from these experiments are summarized in Figure 1. The moisture tension curve represents the soil moisture for the unamended plot. The CFU data showed considerable fluctuation during the sampling period. However, the most interesting aspect of these results is that the counts in the water-amended plots were the same as in the control plot. This result suggests that microorganisms in bajada soil were nutrient limited to such an extent that moisture alone was not a sufficient stimulus to permit growth. A similar pattern was noted in playa soil (section I.F.3, Figure 2).

In the light of data presented here and in paragraph 2, I.F.3, a pattern of substrate-moisture interdependence is emerging. Obviously, it cannot be stated categorically which factor is limiting microbial growth since moisture without substrate will not support growth nor will growth occur in the reverse situation. It is suggested, therefore, that future studies include an assessment of the availability of utilizable substrate as well as the effects of moisture on soil microbial growth and activity.

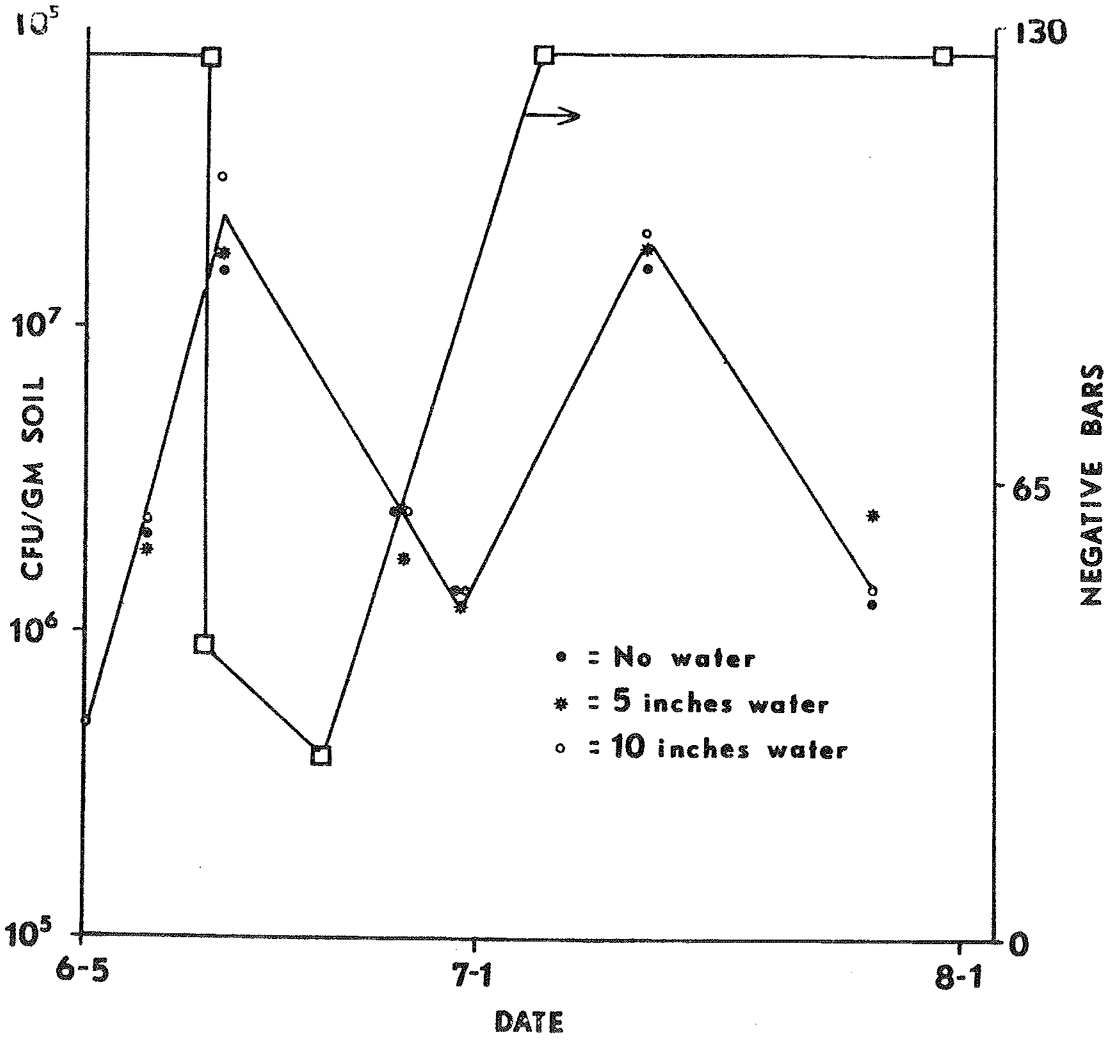

Figure 1. The effect of moisture amendment on colony forming units in bajada soil.

II.F.4 DECOMPOSITION STUDIES -- BAJADA

Decomposition experiments were carried out in conjunction with microbial population density measurements in water-amended plots. Data from these experiments and the playa studies are shown in Table 3. The results clearly show a dependence of the rate of cellulose decomposition on moisture amendment. Thus, in contrast to the lack of a moisture effect on soil plate counts, microbial activity such as cellulose decomposition was moisture limited. The greater effect of moisture on bajada decomposition compared to the effects on the playa was probably a reflection of the lower soil moisture content in unamended bajada soils. It is not clear from the results whether the higher decomposition rate in bajada soils in the 10 in. amendment plot is an indication of greater potential for decomposition than in playa soil or if the results were due to an experimental artifact. The repeat studies planned for 1973 should provide answers to this question.

Table 3. Effect of moisture on cellulose decomposition

Site	Moisture Amendment *	mg cellulose decomposed per day
Playa	0	36 ± 2.0
Playa	5 in.	44 ± 4.0
Playa	10 in.	49 ± 3.0
Bajada	0	7 ± 1.0
Bajada	5 in.	30 ± 3.0
Bajada	10 in.	68 ± 2.0

*Water added over 8 week period.

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III. MANIPULATION SITE

A. ABIOTIC

Independent meteorological data not reported.

B. PLANTS

The vegetation on the manipulation site was sampled in the summer of 1971 in order to estimate existing biomass of plant species before the herbicide treatment was applied. The belt transect method used for the initial surveys on the playa and the bajada was employed. The equations given in Table 17, section I.B.2, and Table 14, section II.B.2, were used to estimate biomass of the species on the manipulation site in common with the other two sites. Nine 5 m by 100 m belts were positioned randomly on the 9 ha site, one belt stratified within each hectare. Within each belt, the number and size dimensions (canopy height and width) of each species were recorded. From these measures, density, canopy cover and canopy volume were calculated. Canopy cover or volume was used to estimate biomass of leaf and live stem material by species using the equation mentioned above. In the summer of 1972, these belt transect studies were repeated to estimate the effects of the herbicide treatment. The results for the comparison of before and after herbicide treatment (1971 vs. 1972) with respect to species density, canopy cover, leaf biomass, and live stem biomass, are given in Table 1. It is clear that the herbicide had a marked effect on all the shrub species on the site. *Larrea* density (live plants) decreased nearly 50%. The canopy cover decreased even more dramatically from 9.3% to 1.7%. Leaf and stem biomass follow the trend of canopy cover. Mesquite (*Prosopis*) was also affected, but not quite as drastically. It's density of live plants decreased about 40% and it's percent cover about 55%. Tarbush (*Flourensia*) and wolfberry (*Lycium*) were also markedly affected, with their density, cover and biomass decreasing by over 90%. The grasses did not show any dramatic changes in canopy cover and densities probably vary within year-to-year climatic effects. Prickley-pear (*Opuntia*) did not show any change. The site was treated with a second herbicide application in the fall of 1972. The belt studies will be repeated in the summer of 1973 to estimate further effects.

Table 1. Vegetational characteristics for perennial species on the Jornada namipulation site in 1971 (before herbicide treatment), and in 1972 (after the first herbicide treatment)

Species	Density (ind/ha) 1971	Density (ind/ha) 1972	Canopy Cover % 1971	Canopy Cover % 1972	Leaf (kg/ha) 1971	Leaf (kg/ha) 1972	Live Stems (kg/ha) 1971	Live Stems (kg/ha) 1972
Shrubs:								
Larrea divaricata	1017	862	9.3	2.8	106	23	1055	234
Prosopis glandulosa	77	77	2.6	2.0	24	17	415	301
Flourensia cernua	980	77	2.9	0.1	12	0.14	238	11
Lycium pallidum	1800	240	1.6	0.1	*	*	*	*
Condalia lycioides	26	3	0.1	<0.1	*	*	*	*
Grasses:								
Hilaria mutica	171	77	0.2	0.1	*	*	*	*
Muhlenbergia porteri	642	796	0.8	1.3	*	*	*	*
Scleropogon breviforius	222	700	<0.1	<0.1	*	*	*	*
Sporobolus flexuosus	26	144	<0.1	0.1	*	*	*	*
Succulents:								
Opuntia sp.	4	7	<0.1	<0.1	*	*	*	*

* equation to estimate biomass not available.

III. C. CONSUMERS

1. MANIPULATION SITE -- SMALL MAMMALS: ANTS

The small mammal population on the manipulation site had a lower species diversity than the bajada but similar densities of the rodents were present (Table 1). Densities of harvester ant nests were the same as 1971 except for one colony of leaf cutters *(Acromyrmex* sp.). This colony was possibly located as a result of the defoliation.

Table 1. Rodent densities on the manipulation site, July 1972*

SPECIES	NO/HA
Dipodomys merriami	22.9
Onychomys torridus	0.7
Perognathus penicillatus	0.7
Peromyscus maniculatus	2.1

*Densities based on Lincoln Index estimates from four consecutive nights of mark-recapture study.

2. MANIPULATION SITE -- BIRD CENSUS (S. L. PIMM)

My observations might be of interest concerning the census which I carried out. Below is my estimation of the numbers which, for this one census is probably as good as the data which will come out after computerization. This is because I deliberately chose a strip width that would flush all the birds at least once. From the distribution of sightings (singing males, nests, etc.) for the 20.25 ha area, estimate is as follows:

Black-throated Sparrows	12 (one pair was carrying food)
Mourning Doves	6 (three nests were found; two with sitting birds but no eggs and one with one egg)
Verdin	4
Loggerhead Shrike	2 ads + 2 very well fledged young
Cactus Wren	2
Total	28
Biomass	58.3 grams ha^{-1}
Species diversity	1.437 nats

My general conclusion is that the biomass recorded (nearly 5 x as high as the bajada) is reasonably realistic. That it is so much higher than that recorded for the bajada is perhaps a reflection of the fact that the mesquite, which is seemingly so important for birds, was little affected by the spray and was considerably more common here than on the bajada. That there were 3 pairs of Mourning Doves on the area (more than had been recorded for all the Jornada so far) is an indication that this site is in no way a replicate of the bajada as far as the birds are concerned.

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IV. SUPPLEMENT

A ROLE OF CONSUMERS IN A DESERT ECOSYSTEM

A SUMMARY AND PROPOSAL

(Stuart Pimm and W. G. Whitford)

We are now in our third full year of studies dealing with the structure and function of desert ecosystems. These studies have provided us with insight into the complexities of interactions within these systems and have also provided the basis for methods of examining functional relationships in somewhat different ways than we have in the past. In an attempt to understand the role and potential importance of animal species in a desert ecosystem, we have developed a scheme using compartments (rather than individual species) as biotic components of an ecosystem. Animal compartments are designated by their use of portions of the plant community; thus we speak of a compartment of seed consumers, or a compartment of leaf consumers, a compartment of detritivores and a scavenger compartment. The rationale for such an approach is developed below, based on the data from the Jornada Validation Site.

Consumers at the Playa and the Bajada

Each of the compartments in Figure 1 represents a wide range of species which we may attempt to simplify for modelling purposes by either considering only one or two species in each compartment or by obtaining an "average" species for each compartment. Further simplification might lead us to consider only those compartments which are important. If, by importance, we consider only relative biomass, the system resembles Figure 2. The area in the boxes is proportional to standing crop. The biomass of the various compartments through time, for the playa and the bajada is shown in Figures 3-9.

Integrative properties within groups

The biomass of lizards and insect-eating birds is shown in Figures 4 and 6. For these groups there is a remarkable correspondence both in actual biomass and the variation of biomass through time, between sites. The main differences in the lizard data lie in the early disappearance of adult lizards on the playa which may be related to appearance of young lizards in late summer. This close correlation is not due to the high mobility of either bird or lizard populations. Different species of birds are involved on the two sites, and for the lizards, although *C. tigris* is the most common species, there are differences in the other species which vary from year to year. A possible explanation of this phenomenon lies in the nature of insects as a food supply. Insects are extremely unpredictable in their numbers and abundant populations are found locally with respect to time, space, and species. Insectivores dependent on a few species of insects would be subject to similar large fluctuations in their numbers, and would have a high probability of at least local extinction. Generalism (the potentiality to take a large variety of prey species) enables an organism to reduce the unpredictability of its food supply. The greater the number of prey species which are taken, the lower the variability of the total food source. Because the insectivore numbers represent a function of overall insect biomass over an area, overall insect biomass is more likely to be related to such variables as rainfall and temperature, than a single insect species whose abundance varies according to a variety of factors, i.e., availability and timing of its food supply, parasitism, predators, patterns of dispersal, etc. Thus the food supply of insectivore numbers represents a function of such factors as temperature and rainfall which are closely correlated between the playa and the bajada. This can be verified by consideration of the lizard data in more detail. Figure 10 shows the response of three species of lizards to the different conditions on the playa over three years. Populations between years can go down, or up, or remain the same. It can be seen that for these three species all three patterns are seen in the same year. *C. tesselatus* disappeared from the site despite the increase in insects over the years 1970-72. However, the total activity of lizards on the site showed an increase over the three years, both in biomass and the amount of time spent out of the burrows. Though the data are few, the best relationship to rainfall data is found in the integral of biomass over time, for all the lizard species, rather than with any particular species.

This phenomenon involves the concept of redundancy. Redundancy is where several species share a similar function in a community so that when one is reduced or eliminated through some factor, that particular function is maintained by the other species. When one species is reduced, perhaps because the climate is too severe, the food is utilized by a climatically more tolerant species.

An example of this has been described by Hoover (1973) for the two species of pocket mice *Perognathus intermedius* and *P. penicillatus*. In the area where these two species coexist the exact balance in species abundance is determined by the different physiologies of the two species and their behavioral interactions. The boundary between the two species changes with the different climates in different years; however, at any time there is always at least one species present to exploit the food resources and the numbers exploiting that food source vary little.

The conclusion is that by considering an aggregate of species, variability in numbers of any one species due to that species' physiological or behavioral specializations will be averaged out. The prediction of an aggregate of species biomass, and their impact on their food resources will thus undoubtedly be less complex than the prediction of these variables for a particular species.

Integrative properties between groups

The groups shown in Figures 3 to 9 were derived from both trophic and taxonomic considerations. Do different classes of organisms complement each other when they exploit similar food resources? Do, for example, the seed-eating activities of ants, mammals, and birds complement each other such that a change in the numbers of one of these groups will be compensated for by a change in the numbers of one of the remaining groups? The fact that there are at least two different taxonomic groups which can exploit each major food source may provide the system with an important degree of stability. The response to increasing or decreasing food supplies will involve the increase or decrease of the population. The former may be rapid, but increasing the population takes time due to the time involved in reproduction and survival of newly-recruited invididuals to sexual maturity. Such time lags occur because the population will be growing fastest when food is most plentiful and the peak population will be reached after the food abundance has started to decline. Such a system oscillates through time. This pattern might apply in the desert rodents. Seed-eating rodents crashed in numbers both on the playa and bajada during December, 1971, and January, 1972, a period of obvious seed shortage following two dry years. Seed production during 1972 was greatly increased, especially on the playa after it flooded. The survival of first-year rodents was increased on both sites to a similar degree (Figs. 11,12). However, this increase was tempered by the increased numbers of birds, especially on the playa where the seed production was greatest (Figure 3).

The rapid utilization of the food resource by the birds probably has the effect of lessening the rate of increase of the rodent numbers, and reducing any over-shooting of the carrying capacity, with subsequent over-grazing. Thus, where birds are able to rapidly utilize such a food resource we may expect oscillations involving the dramatic crashes of rodent populations to be reduced. This stabilizing influence is achieved by having a wide range in the rates of response to a change in the availability of a particular food resource. This can be seen to operate for the other major food resources. Standing live herbage is eaten by insects with rapid rates of increase and by lagomorphs with a much slower rate of increase. Seed consumers include birds and the rodents, the former with a very high mobility, which gives them the properties of having a high rate of increase when a limited area is considered, and harvester ants which can vary their foraging intensity. Insect consumers include birds (residents with low rates of increase and migrants with high mobility) and lizards. Lizards, by virtue of their physiological flexibility, have the capacity for very large rates of increase in their capacity to utilize a food resource. Apart from their reproductive capacity, they have the ability to alter their body weight (both as individual species, and as a community by varying species composition) and also to vary their activity. Figure 4 shows that not only was lizard biomass great in 1972 but the lizards were active for much longer periods during the year. Thus they possess both long-term and short-term capacities to respond to changing food supplies. Perhaps this explains why, on biomass considerations, lizards appear to be by far the most important insectivore in the unpredictable desert environment. This same argument applies to harvester ants in the seed-eating community.

The conclusion here is that the widely differing responses to changes in food supplies, especially between different classes of organisms taking the same type of food, may be of crucial importance in maintaining community stability. Attempts to model ecosystems using one species as a representative of a particular consumer group (e.g., a grasshopper, to represent the herbivorous insects) may lack stability because of this. Although seed-eating birds are usually scarce compared to rodents, their importance may lie in their ability to utilize, at short notice, abundances of seeds. At such times their numbers may exceed those of the rodents.

A Proposal

We have presented data which indicate that meaningful understanding of the functional relationships in desert ecosystems may be achieved by examination of compartments of consumers having certain properties in common. These data argue that there is redundancy in the species composition of consumers in an ecosystem. This redundancy would result in stability because if one species is removed, its function may be taken over by another species. Therefore, it is argued that while a single species may not be "important" (defined as resulting in permanent change in the system when removed), a compartment is of maximum importance.

The data presented in support of these ideas were obtained indirectly, by observation and estimation of the sizes of these components, and inferences were drawn based on these observations. The indirect methods of study provide the basis for ecosystem simulation modelling as presently conducted by the Desert Biome program. The data and hypothesis presented here suggest an approach to modelling and study of an ecosystem which can complement the current efforts and has the potential for markedly increasing our understanding of ecosystem function.

If an ecosystem were reduced in complexity from species or small groups of species to compartments of species, it should be possible to examine interactions between compartments and by appropriately designed "process studies" obtain the data necessary to model such compartment interactions. A process study of this type might examine the interaction between the "annual plant compartment", "perennial plant compartment" and "seed consumer compartment" in which the relationships were elucidated by various manipulative or experimental techniques and the resulting model tested by additional manipulations. If the hypothesis of redundancy in species composition in a desert ecosystem is as important as we think it is, an adequate testing of that hypothesis is called for.

Literature Cited

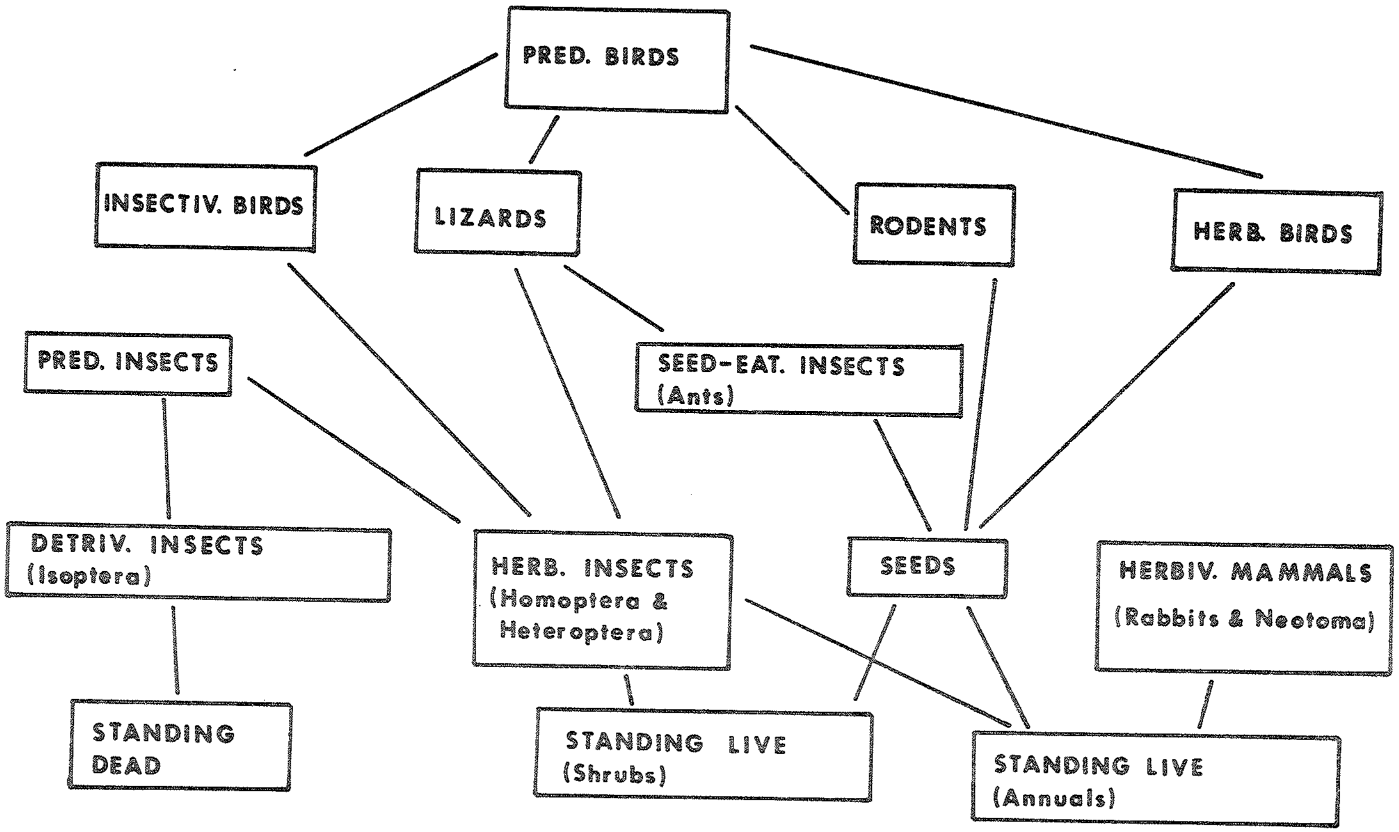

Figure 1. Consumer compartments in a desert ecosystem based on Jornada Validation Site data.

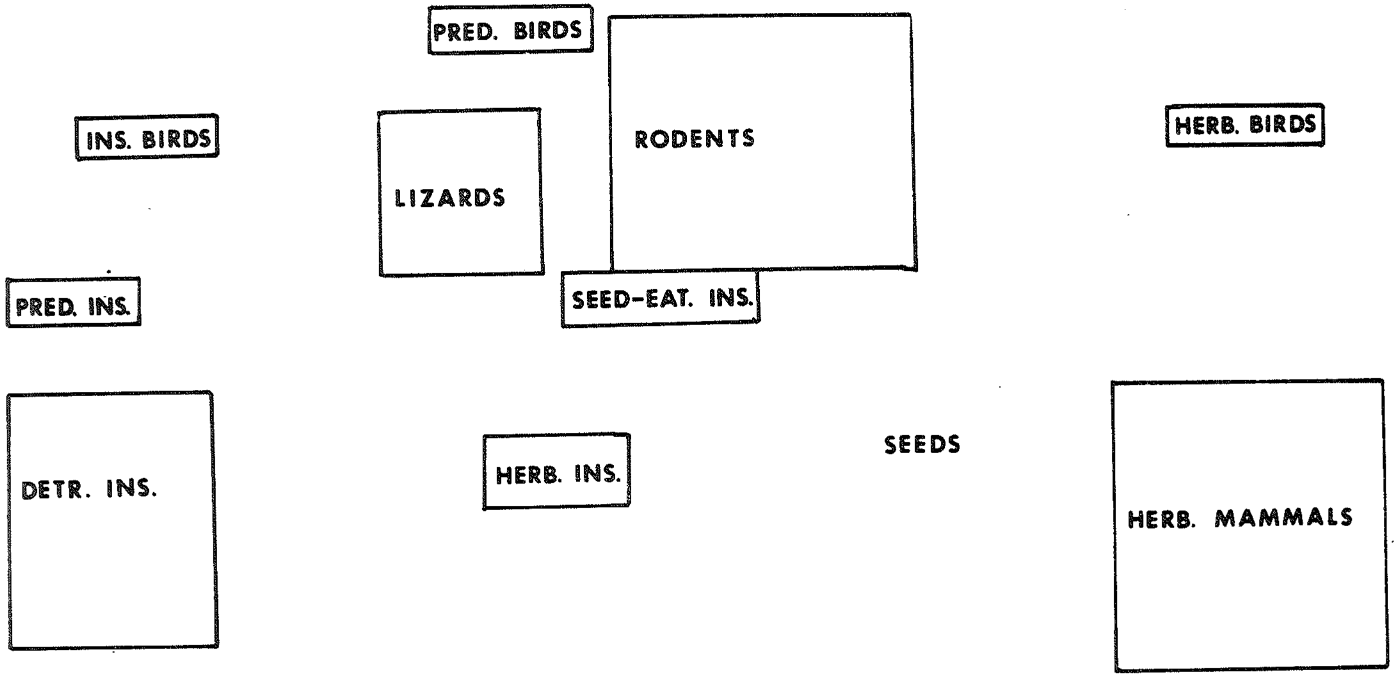

Figure 2. Relative biomass of consumer compartments in a desert ecosystem. Sizes of boxes represent relative biomass.

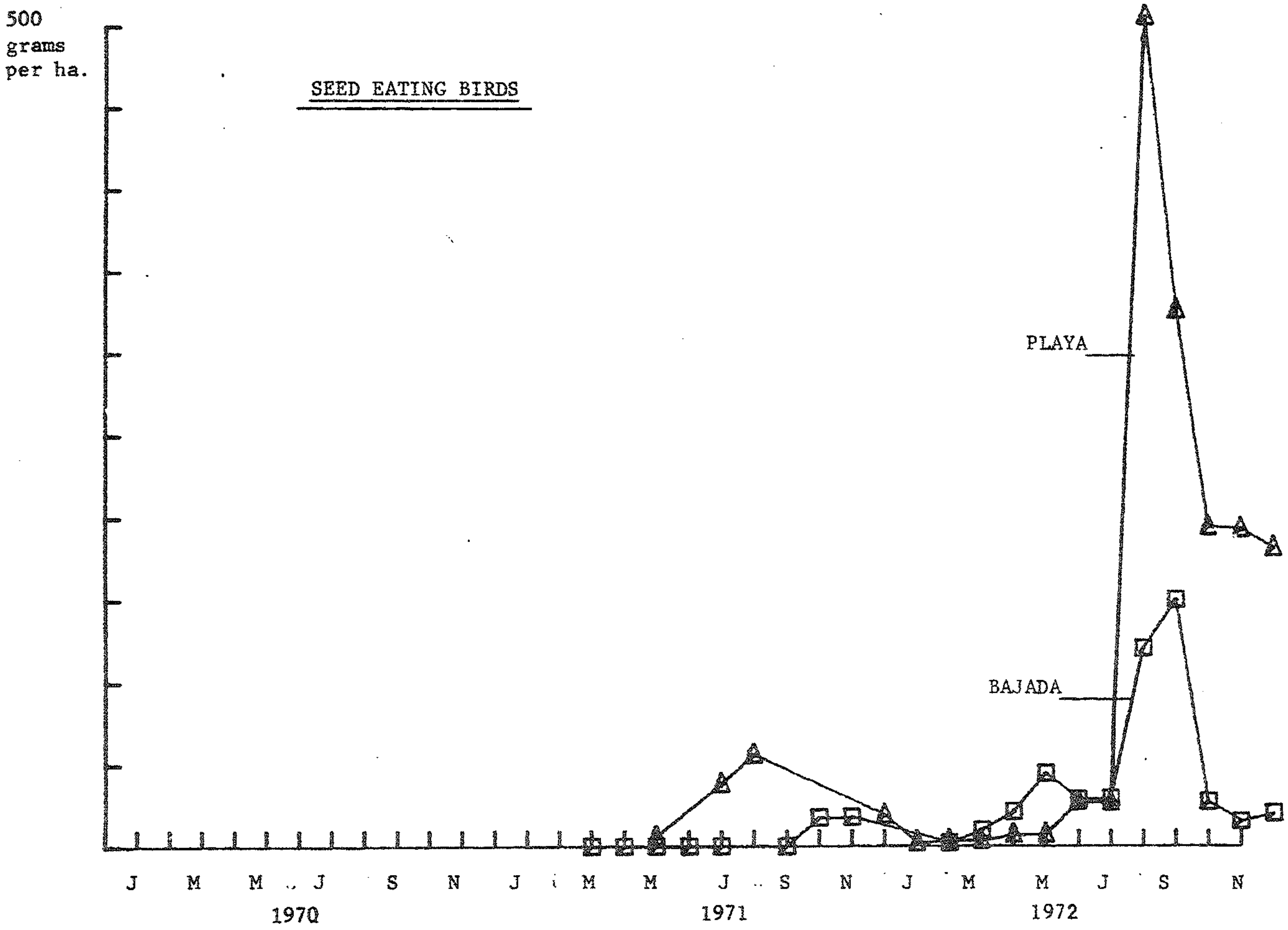

Figure 3. Fluctuations in biomass of seed-eating birds, Jornada Validation Site.

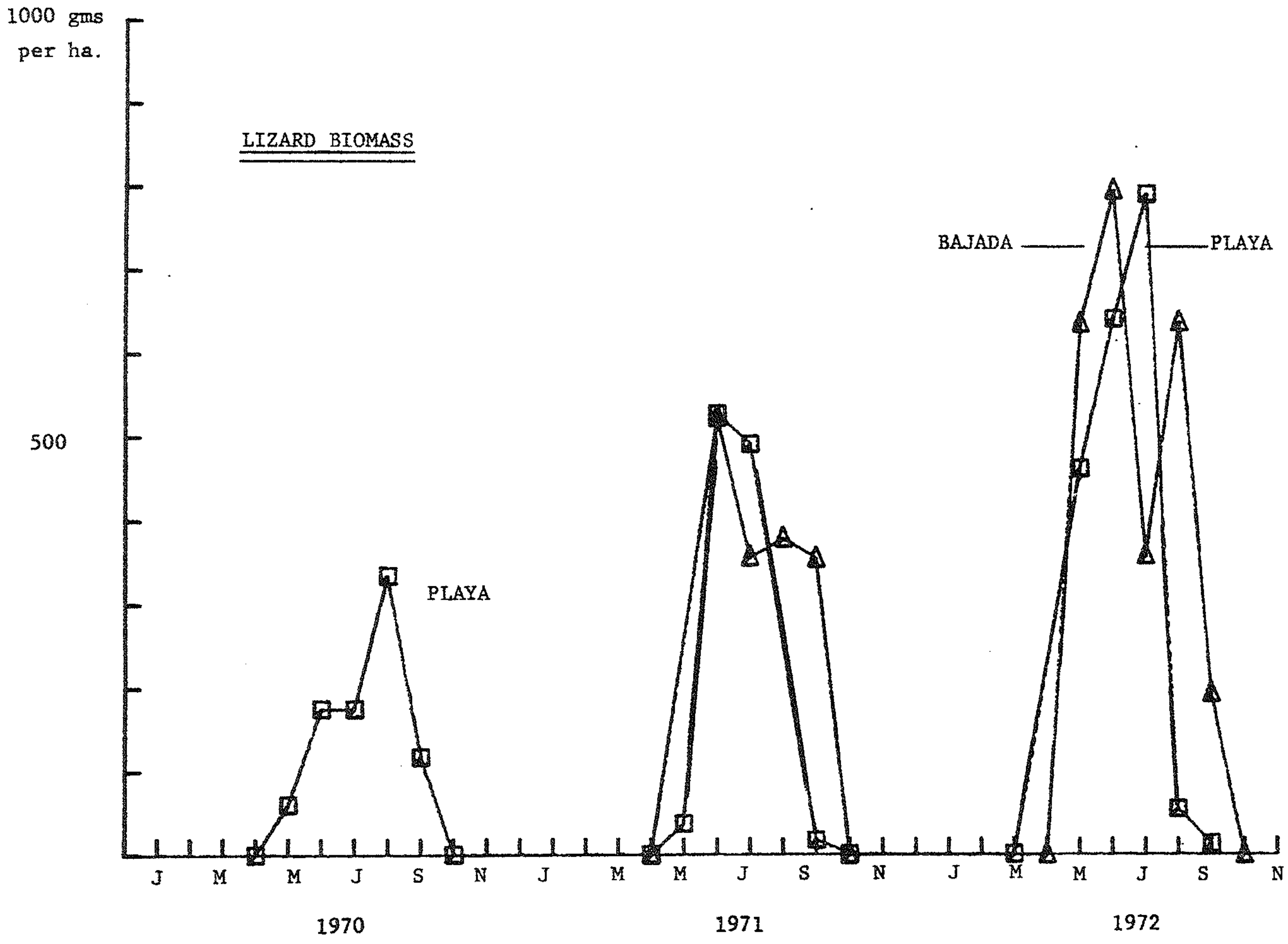

Figure 4. Fluctuations in biomass of lizards, Jornada Validation Site.

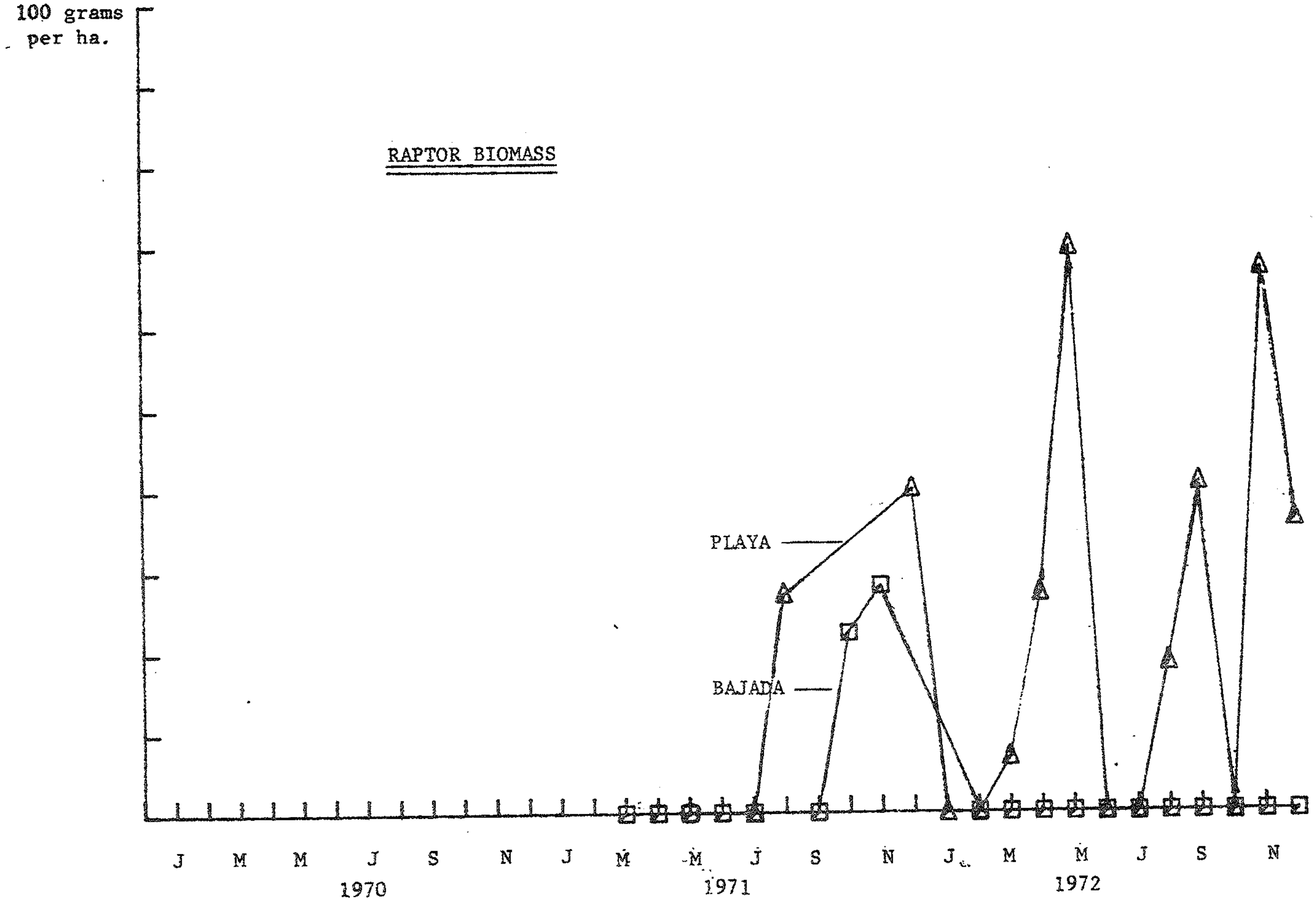

Figure 5. Fluctuations in biomass of raptors, Jornada Validation Site.

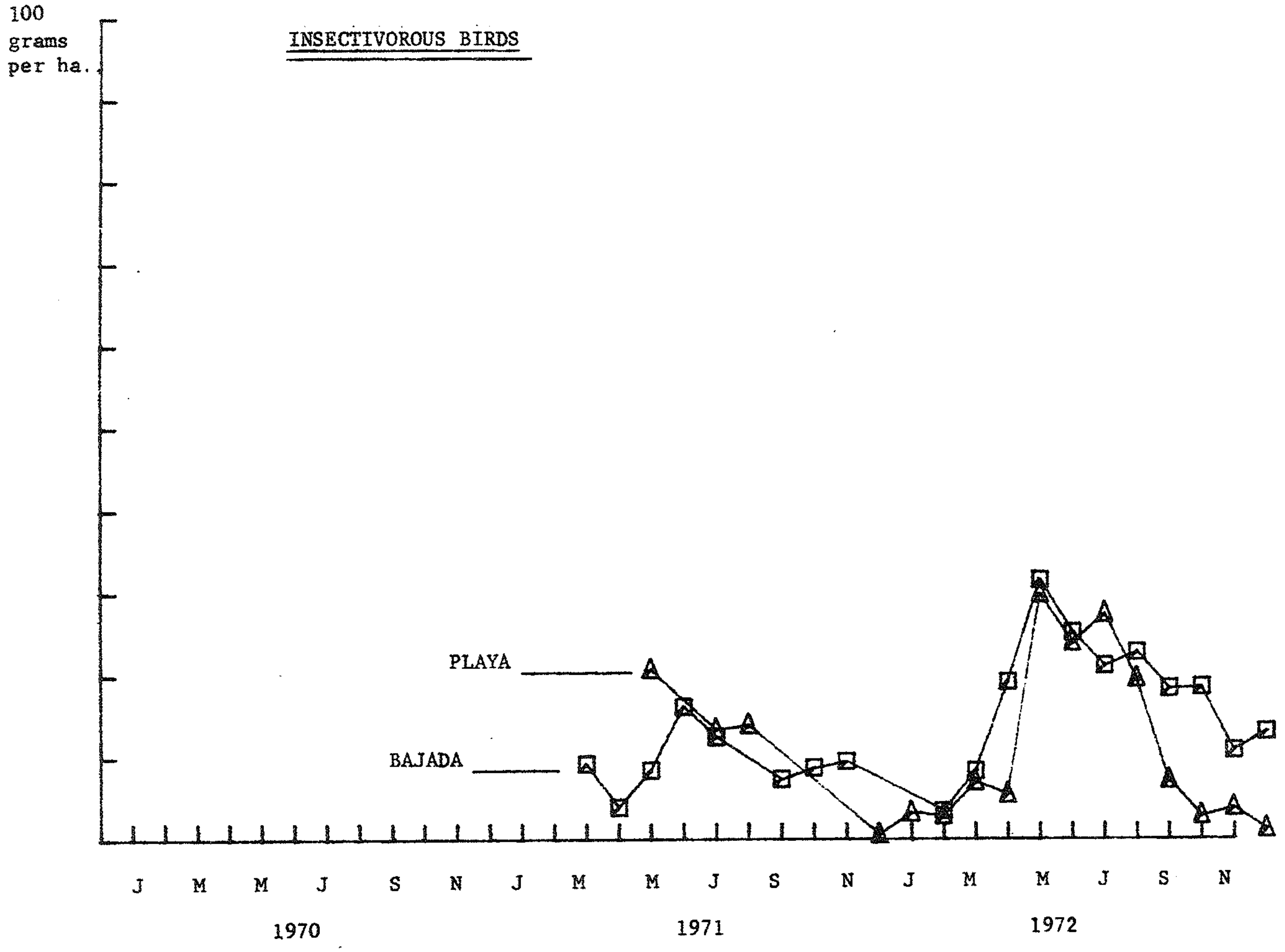

Figure 6. Fluctuations in biomass of insectivorous birds, Jornada Validation Site.

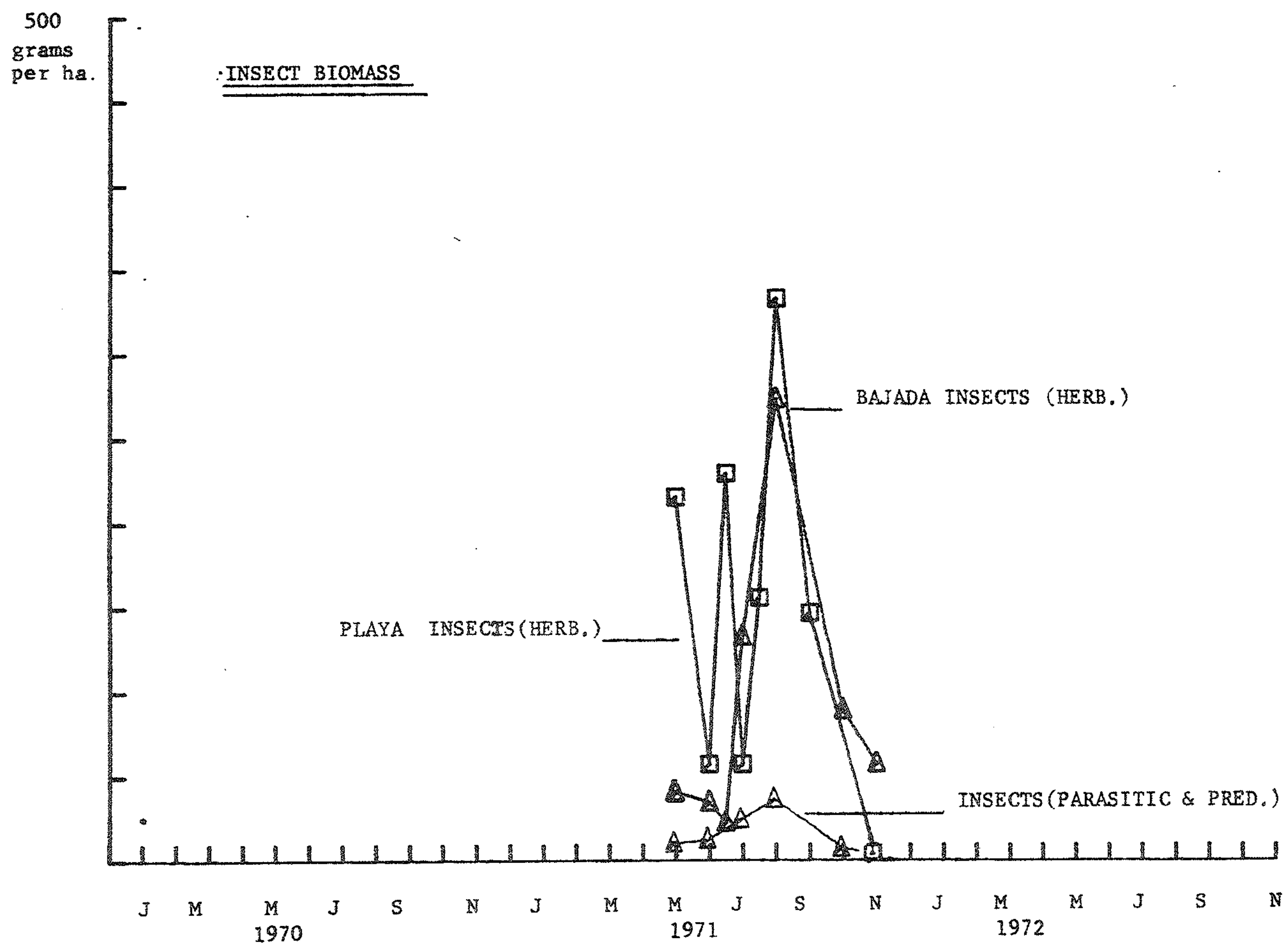

Figure 7. Fluctuations in biomass of insects, Jornada Validation Site.

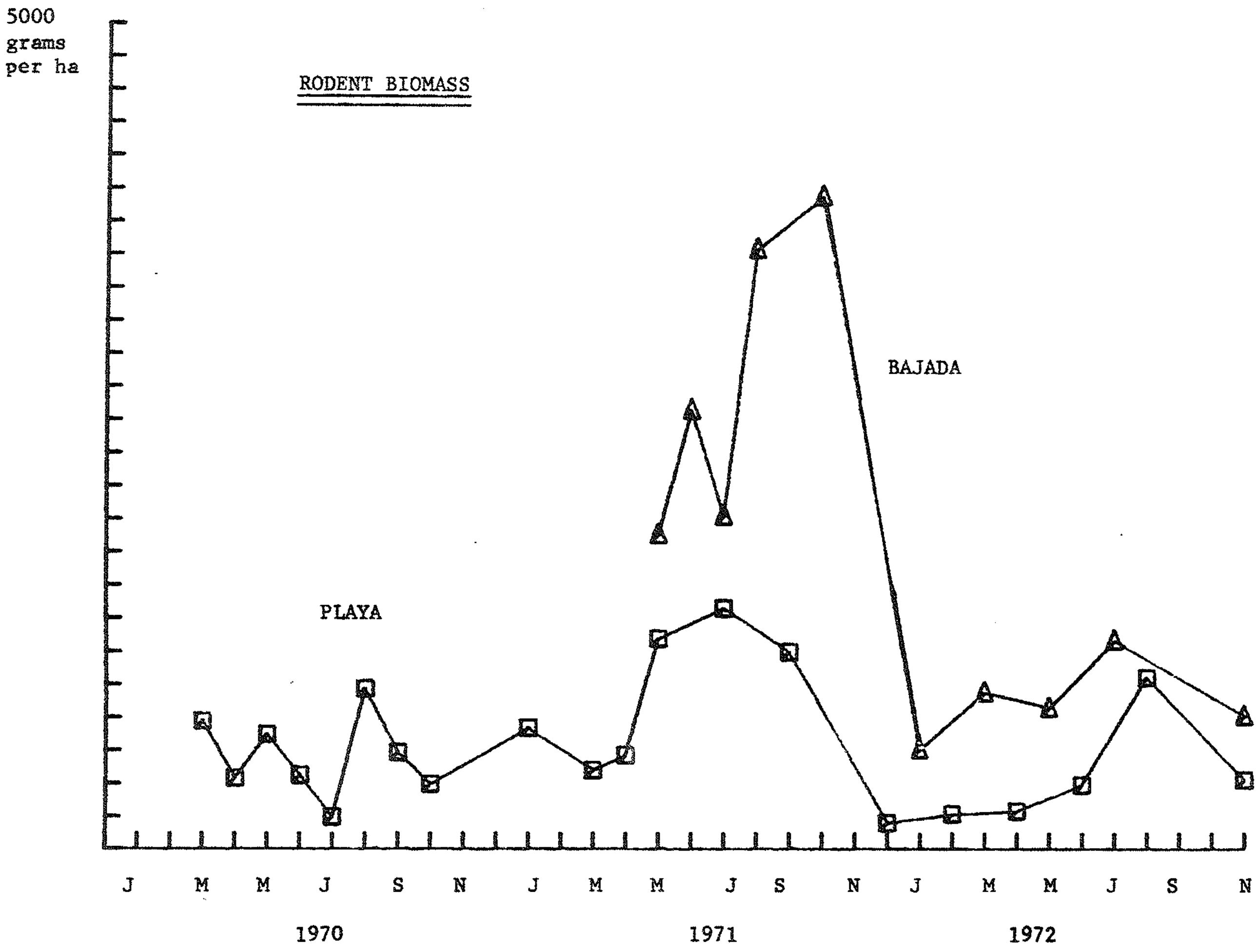

Figure 8. Fluctuations in biomass of rodents, Jornada Validation Site.

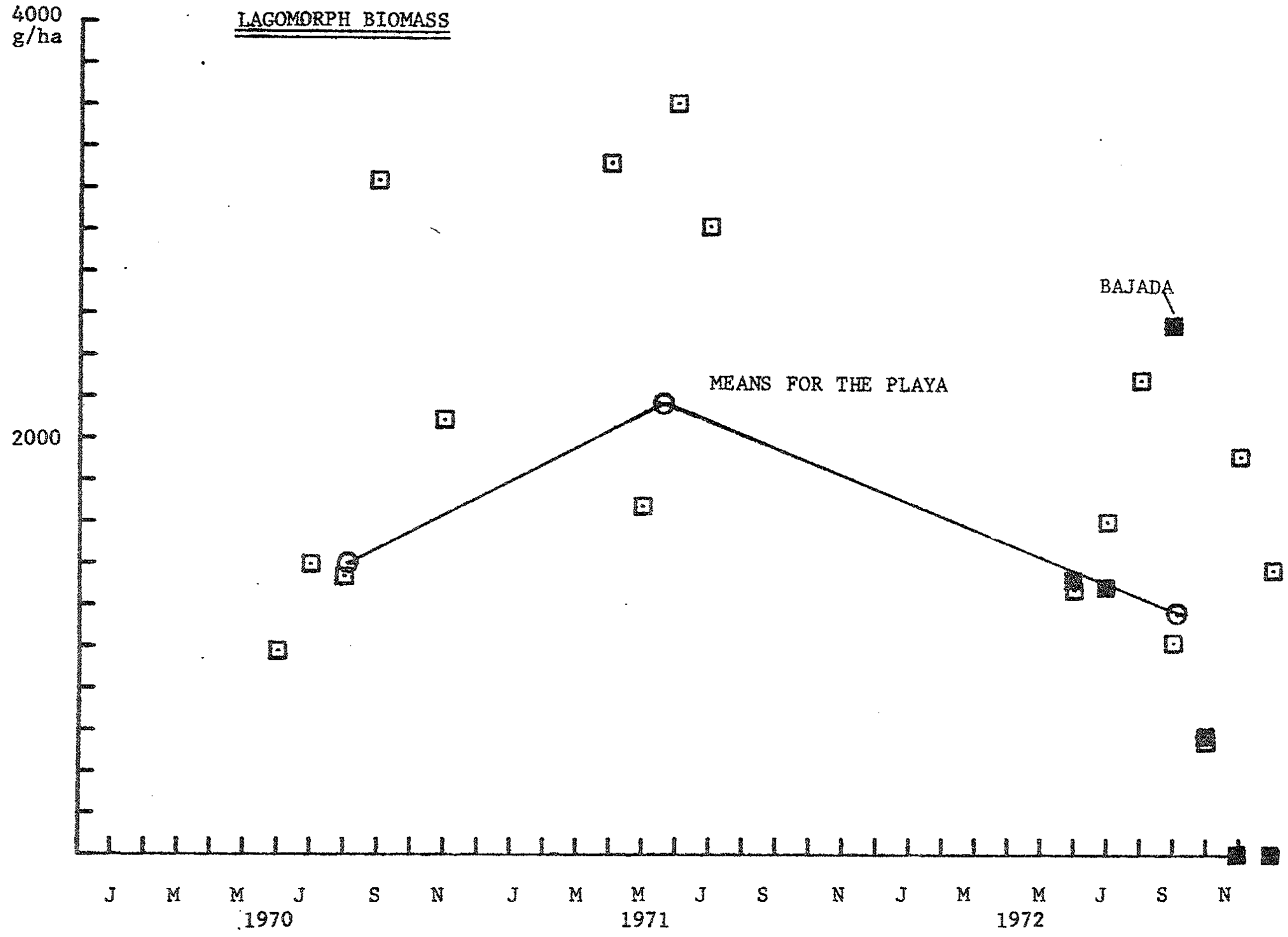

Figure 9. Fluctuations in biomass of lagomorphs, Jornada Validation Site.

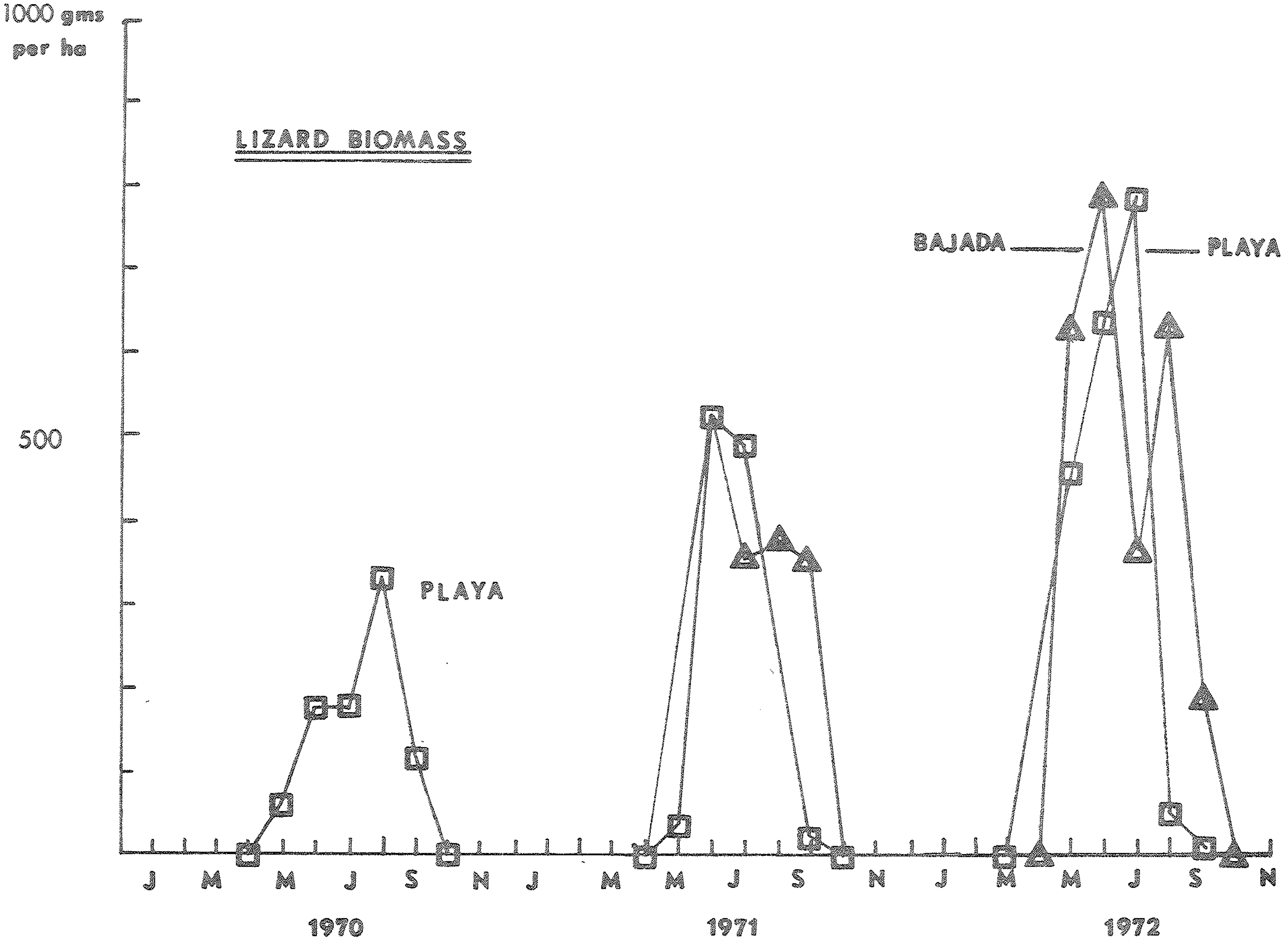

Figure 10. Density estimates of lizards on playa site, 1970-1972.

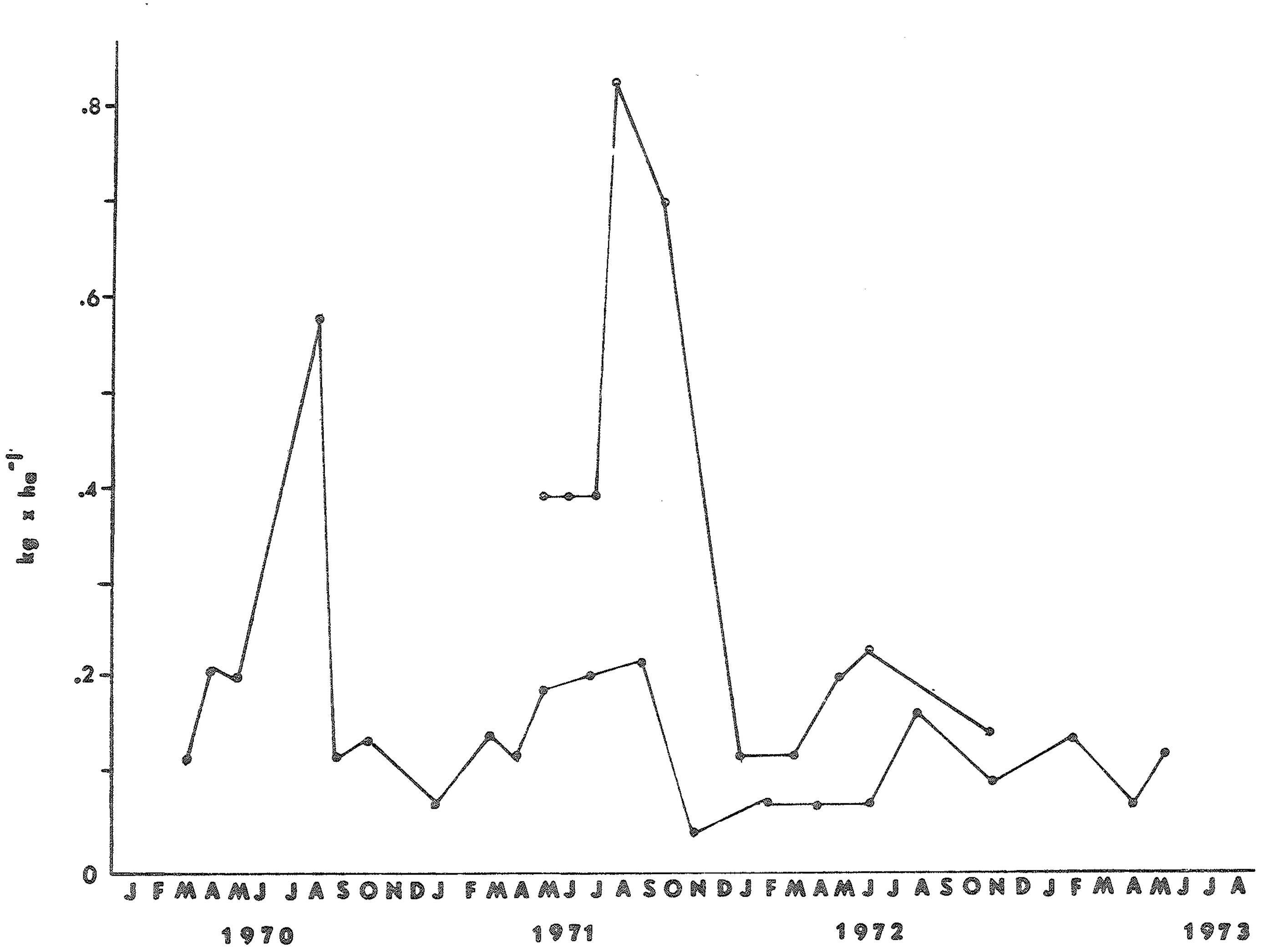

Figure 11 and 12. Survivorship of *D. merriami* 1970 - 1973 on the playa and bajada respectively.