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DESERT BIOME

ECOSYSTEM ANALYSIS STUDIES
U.S. INTERNATIONAL BIOLOGICAL PROGRAM

REPORT OF 1972 PROGRESS

IN THREE VOLUMES

MAY 1973

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VOLUME 1 - CENTRAL OFFICE; MODELLING; AQUATIC STUDIES

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1972 PROGRESS REPORT

CURLEW VALLEY VALIDATION SITE REPORT

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ABSTRACT

The validation studies of the Desert Biome program are to provide field data from representative desert types with which to validate predictive models of desert ecosystems. Specifically, the Curlew Valley project is to monitor abiotic elements and determine the status of biotic components through time on sites which are representative of the Great Basin Desert.

There are four, 1 km^2 terrestrial validation sites in Curlew Valley, Utah-Idaho Their placement covers the rainfall and salinity gradient that exists in the valley, the most common native vegetation of the Great Basin, and the common manipulation of destroying *Artemisia tridentata* (sagebrush) and seeding to *Agropyron cristatum* (crested wheat grass).

The Curlew Valley validation studies began in the spring of 1971. The following paragraphs provide a cursory description of the major findings to date.

Abiotic: -- The northern sites were in a less harsh environment than the southern sites with regard to precipitation. Mean annual precipitation in the north was 34 cm, and in the south 25 cm. This difference was reflected in the diversity of flora and fauna.

Plants: -- The vegetation of the southern sites had a lower profile and fewer species than the northern sites. There were about 85 species in the north and 15 in the south. Quadrat analysis showed that *Artemisia tridentata* biomass averaged about 6,000 kg/ha of dry weight in the north and 3,000 kg/ha in the south. Total root biomass was about 18,000 kg/ha dry weight for both the north and south shrub sites.

The vegetation on the southern sites responded to the decrease in precipitation from 1971 to 1972. Above-ground living material decreased and litter increased in 1972. Total root biomass did not change. However the dispersion shifted toward the soil surface. This may have been caused by an upward movement of salt in the soil caused by the lack of rainfall.

Invertebrates: -- Invertebrates were sampled by D-Vac, soil extraction, and pitfall traps. This report contains an assessment of invertebrate biomass on the sites as well as an annotated taxa list and major plant/insect associations.

The greatest dry weight biomass was found in the "annuals" vegetation type, followed by *Artemisia-Atriplex-Sitanion*, and *Agropyron* vegetation types. Average estimates of invertebrate biomass in the summer of 1972 were 260 g/ha in the *Art-Art-Sit* vegetation type. The pitfall traps produced the greatest amount of biomass followed by

soil extraction and D-Vac. However, there was overlap in habitat sampled by pitfall traps and D-Vac. A correction factor has yet to be worked out.

Vertebrates -- A live trapping program sampled small mammal populations on all sites in 1971 and 1972. Of the 10 species known to occur on the sites, *Peromyscus maniculatus* (deer mouse), *Perognathus parvus* (pocket mouse) and *Eutamias minimus* (chipmunk) were the most widely distributed and contributed the most to total rodent biomass. Total rodent biomass (dry weight) ranged from 15-167 g/ha, depending upon year and vegetation type

Lepus californicus (jackrabbit) was a major part of the herbivore biomass on the sites. A drive census gave dry weight biomass of 1,890 g/h- in 1971 and 350 g/ha in 1972 on the southern shrub site. Other sites had fewer animals.

Grazing by cattle occurred on all sites. Their activity was monitored on the southern sites in 1971 and 1972. Daily energy consumption per animal was about 17,782 kcal in 1971 and 20,023 kcal in 1972. About 35% of this was returned to the sites as feces.

A line-transect study of birds through the year indicated decreasing density through the summer, fall and winter. *Eremophila alpestris* (horned lark) was the most common species, reaching a dry weight biomass on some sites greater than all other avian species combined (50% g/ha in July). In general, the more open the site, the more avian diversity and biomass.

Soil: -- The soils of the northern site were highly variable due to differences in parent material, differing levels of former Lake Bonneville and sheet and gully erosion. In contrast, the soils of the southern sites were a very uniform silt loam throughout. There was high salinity at depths lower than 30-40 cm.

Lichens and algal crusts covered a significant portion of the soil surface of the sites. A rough estimate on the southern sites gave 32% coverage and 200 kg/ha for lichens, and 75% coverage and 159 kg/ha for algal crusts.

Most of the biological activity in the soils was located in the top 3 cm of soil. Vigorous carbon and nitrogen fixation took place during the wet periods by the lichens and algal crusts. Much of the nitrogen subsequently dispersed, possibly as volatilized ammonia. Although there appeared to be excess nitrogen in the soil, no excess carbon was available to immobilize it. Microbial numbers decreased gradually with depth. Maximum density was between 5-20 cm in the soil profile.

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INTRODUCTION

A major objective of the Desert Biome program is to develop predictive models of desert ecosystems. If the models are to have general applicability, they must be validated with data from various types of deserts. The task of the Curlew Valley validation sites is to provide such data for the Great Basin Desert.

Validation at Curlew Valley began February, 1971. The first objective was to make an inventory of the four sites and to begin monitoring abiotic components of the system. For most plants and animals the inventory consists of biomass determinations per hectare per species or taxon. The exceptions were nonvascular plants and microbes where measurements of activity were more meaningful than biomass determinations. Those components of the ecosystem that move in and out of the sites must be monitored and their impact assessed. Cattle, some birds and jackrabbits are the important components in this respect. A similar situation exists with invertebrates in that they are nearly impossible to sample at some stages of their life cycle. Hence their inventory must be conducted through an entire year.

Two changes in emphasis have been instituted as a result of the first year's work. First, budget constraints have necessitated that the program be cut back to only two sites -- the southern two sites. Only spot checks on certain parameters were done on the northern sites in 1972. Second, some emphasis is now being given to studying the validation sites as discrete systems in their own right, rather than as a source of model validation data. It is likely that this emphasis will increase in 1973.

SITE DESCRIPTION AND DEVELOPMENT

Curlew Valley is a basin of some 3,460 km^2 astride the Utah-Idaho border. It drains to the south into the Great Salt Lake at an elevation of approximately 1,200 m. The area was formerly a bay of Lake Bonneville which drained to the north at the end of the Pleistocene.

The climate is a continental one with a wide range in temperature and low rainfall. Most of the precipitation comes in winter and early spring. Annual amounts average about 40 cm in the north and 25 cm in the southern part of the valley. Temperatures commonly approach 40 C in July and range down to -30 C in January. Radiant cooling at night effects a 15-20 C day-night temperature differential.

The vegetation in the valley exhibits a mosaic pattern. Near the salt flats in the south, there are halophytic plants such as pickle weed (*Allenrolfia occidentalis*). In successive zones progressing away from the lake are greasewood (*Sarcobatus vermiculatus*), shadscale (*Atriplex confertifolia*), and sagebrush (*Artemisia tridentata*) The dispersion pattern generally reflects the north-south gradient in the amount of salinity and moisture. Everywhere except in the southernmost part of the valley, patches of the native vegetation have been removed for irrigated crops, dry farming and crested wheat grass (*Agropyron cristatum*) seedlings.

There are four, 1 km^2 validation sites in the Curlew Valley: one each in shrub and crested wheat grass in the northern and southern part of the valley. This placement covers the rainfall gradient that exists in the valley, the most common native vegetation (sagebrush), and the frequently used manipulation of destroying sagebrush and then seeding to crested wheat grass. The southern sites, which are adjacent, are about 25 km southwest of Snowville, Utah, in sections 5-8, T 13 N, R 9 W at 1,320 m elevation. The land is controlled by the Bureau of Land Management. The northern sites, which are also adjacent, are about 8 km northwest of Holbrook, Idaho, in sections 2-3, T 14 S, R 32 E at 1525 m elevation. These sites are on land administered by the United States Forest Service and Bureau of Land Management.

The sites are positioned and delimited in such a way as to facilitate sampling. Each site is marked off in a 100m grid with metal posts. Each hectare has a reference number reading from the northwest corner of the site from left to right. Most sampling is stratified based on major vegetation types within the sites.

Aerial photographs were made of the four validation sites in Curlew Valley on June 8, 1971, October 12, 1971, and August 3, 1972. Technical details can be obtained from progress reports (RM 72-7, 73-6) submitted by Paul T. Tueller, University of Nevada, Reno, to the Biome Central Office. The transparencies are stored with the Central Office. Tables 1 and 2 summarize the work done (DSCODE A3UTK10).

Table 1. Summary of aerial photography made of Curlew Valley Validation Sites

Date	June 8, 1971	October 12, 1971	August 3, 1972
Film types	Color Infrared	Color Negative	Color Infrared Color Negative
Approximate Amount Used	430 feet	430 feet	Color IR 100 feet Color Neg. 100 feet
No. of frames	2150	2150	Color IR 500 Color Neg. 500
Time of Day	9:30 AM	1:40 PM	9:30 AM
Weather	Mostly Clear	Mostly Clear	Clear
Lens	150 mm	50 mm	150 mm

Table 2. Actual scales and photographic coverages obtained of Curlew Valley validation sites

Date	Approximate Scale	Type of Coverage
June 8, 1971	1:2, 133	Complete coverage of all four sites
October 12, 1971	1:600	.2% of all four sites
	1:2,133	Edges of all four sites
	1:15,000	Complete coverage of all four sites
	1:21,000	Complete coverage of all four sites
August 3, 1972	1:1,000	Low level photo-transects through selected vegetation types.

DATA COLLECTION DESIGN

The types of data collected on the four validation sites at Curlew Valley are summarized in Table 3. The procedures used to measure each parameter are described in detail within the appropriate sections that follow.

Table 3. Information matrix of data collected on four Curlew Valley Validation sites

System Component	Parameters Measured	DSCODE	North Shrub			North Grass			South Shrub			South Grass			Reported on page
			71	72	73	71	72	73	71	72	73	71	72	73	
Remote Sensing	I.R. Aerial Photography	A3UTK10	x	x		x	x		x	x		x	x		6
Meteorological	Weather					x	x	x				x	x	x	
	Air Temperature	A3UBJM2,4				x	x	x				x	x	x	17
	Relative Humidity					x	x	x				x	x	x	
	Wind Speed (2 meters)					x	x	x				x	x	x	
	Wind Speed (.5 meters)											x	x	x	
	Precipitation (recording gauge)											x	x	x	
	Precipitation (overflow					x	x	x							
	cans)					x	x	x				x	x	x	
	Soil Surface Temperature						x						x	x	
	Soil Temperature (7 depths)												x	x	
	Radiation - Snowville Incoming Global (from 1971)	A3UBJW1													17
Vegetation (Above Ground)	Line Intercept Analysis	A3UBJA1,2	x			x									79
	Species		x			x									
	Extent (Along transect line)		x			x									
	Size Class (Height)		x			x									
	Basal Diameter (cm^2)		x			x									
	Quadrat Analysis	A3UBJB3,4	x			x			x	x	x	x	x	x	79
	Species		x			x			x	x	x	x	x	x	
	Size Class (Height)		x			x			x	x	x	x	x	x	
	Density		x			x			x	x	x	x	x	x	
	Cover Area (cm^2)		x			x			x	x	x	x	x	x	
	Basal Area (cm^2)		x			x			x	x	x	x	x	x	
	Biomass (off site)	A3UBJC1-4	x			x			x	x	x	x	x	x	79
	Species		x			x			x	x	x	x	x	x	
	Size Class		x			x			x	x	x	x	x	x	

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	73	Reported on page
Vegetation (Above Ground) Cont.	Cover Area (cm^2)		x			x			x	x	x	x	x	x	
	Basal Area (cm^2)		x			x			x	x	x	x	x	x	
	Phenology		x			x			x	x	x	x	x	x	
	Sex		x			x			x	x	x	x	x	x	
	Dry Weight		x			x			x	x	x	x	x	x	
	Caloric Value		x			x			x	x			x		
	Biomass of Shrub Components	A3UBJS3								x	x				80
	Species (ARTTRI and ATRCON)									x	x				
	Actual Size (cm)									x	x				
	Basal Area (cm^2)									x	x				
	Dry Weight Roots (g)									x	x				
	Dry Weight Woody Stems (g)									x	x				
	Dry Weight Young Stems (g)									x	x				
	Dry Weight Leaves (g))									x	x				
	Dry Weight Inflorescence (g)									x	x				
	Dry Weight Seeds (g)									x	x				
	Dry Weight Deadwood (g)									x	x				
	Total Dry Weight (g)									x	x				
	Estimated Age (years)									x	x				
	Biomass of Grass Components	A3UBJY4								x					
	Species									x					80
	Dry Weight New Growth									x					
	Dry Weight Old Growth									x					
	No. Seed Heads									x					
Litter	Biomass of Litter Components	A3UBJD1-4	x			x			x	x	x	x	x	x	80
	Dry Weight Wood (g)								x	x	x	x	x	x	
	Dry Weight > 2mm (g)								x	x	x	x	x	x	
	Dry Weight < 2mm (g)								x	x	x	x	x	x	
	Dry Weight Fecal Litter(g)								x	x	x	x	x	x	
	Total Dry Weight								x	x	x	x	x	x	

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	73	Reported on page
Below Ground	Root Biomass	A3UBJE1-4	x			x			x	x	x	x	x	x	80
	Dry Weight 0-20 cm (g)		x			x			x	x	x	x	x	x	
	Dry Weight 20-40 cm (g)		x			x			x	x	x	x	x	x	
	Dry Weight 40-60 cm (g)		x			x			x	x	x	x	x	x	--
Vegetation	Nutrient Analysis For each plant part by species:	A3UMM01		x			x			x			x		
	Calories/g Dry Weight			x			x			x			x		
	Ash Content %			x			x			x			x		
	Ash Free Calories/(g)			x			x			x			x		
	% Protein			x			x			x			x		
	% Carbohydrates			x			x			x			x		
	% Fat			x			x			x			x		
	Chemical Analysis For each plant part by species:	A3UMM2A,B		x			x			x			x		--
	Phosphorous %			x			x			x			x		
	Potassium %			x			x			x			x		
	Calcium %			x			x			x			x		
	Magnesium %			x			x			x			x		
	Silicon %			x			x			x			x		
	Zinc %			x			x			x			x		
	Copper ppm			x			x			x			x		
	Iron ppm			x			x			x			x		
	Manganese ppm			x			x			x			x		
	Boron ppm			x			x			x			x		
	Aluminum ppm			x			x			x			x		
	Titanium ppm			x			x			x			x		
	Cobalt ppm			x			x			x			x		
	Molybdenum ppm			x			x			x			x		
	Strontium ppm			x			x			x			x		
	Barium ppm			x			x			x			x		
	Lead ppm			x			x			x			x		
	Sodium ppm			x			x			x			x		
	Sodium %			x			x			x			x		

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	73	Reported on page
Invertebrates	Biomass - off site (D-Vac)	A3UBJF1, 3	x			x			x			x			--
	Vegetation Species		x			x			x			x			
	Plant Height		x			x			x			x			
	Invertebrate Taxon		x			x			x			x			
	Number		x			x			x			x			
	Dry Weight (mg)		x			x			x			x			
	Biomass - on site (D-Vac)	A3UBJT1								x			x		128
	Plant Species									x			x		
	Plant Height									x			x		
	Plant Width									x			x		
	Invertebrate Species									x			x		
	Stage									x			x		
	Weight/Individual (mg)									x			x		
	Total Number									x			x		
	Total Dry Weight (g)									x			x		
	Biomass - on site (soil samples)	A3UBJT1								x			x		128
	Plant Species									x			x		
	Plant Height									x			x		
	Plant Width									x			x		
	Invertebrate Species									x			x		
	Stage									x			x		
	Weight/Individual (mg)									x			x		
	Total Number									x			x		
	Total Dry Weight (g)									x			x		
	Biomass - on site (Pitfall)	A3UBJV 3-4								x			x		--
	Vegetation Type									x			x		
	Vegetation Species									x			x		
	Invertebrate Taxa									x			x		
	Stage									x			x		
	Total Number									x			x		
	Total Dry Weight (g)									x			x		

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	North shrub 72	North shrub 73	North grass 71	North grass 72	North grass 73	South shrub 71	South shrub 72	South shrub 73	South grass 71	South grass 72	South grass 73	Reported on page
Invertebrates Cont.	Biomass - on site (D-Vac)	A3UBJX1,2									x			x	--
	Vegetation Species										x			x	
	Vegetation Height (cm)										x			x	
	Vegetative Cover %										x			x	
	Air Temperature (C)										x			x	
	Soil Surface Temperature (C)										x			x	
	Invertebrate Taxa										x			x	
	Stage										x			x	
	Number										x			x	
	Total Dry Weight (g)										x			x	
	Insect Emergence - on site (Emergence Traps)	A3UBJX5,6									x			x	--
	Vegetation Species										x			x	
	Vegetation Height (cm)										x			x	
	Vegetative Cover %										x			x	
	Air Temperature (C)										x			x	
	Soil Surface Temperature (C)										x			x	
	Invertebrate Taxa										x			x	
	Stage										x			x	
	Number										x			x	
	Total Dry Weight (g)										x			x	
	Biomass - on site (Pitfall)	A3UBJZ1,2									x			x	--
	Vegetation Type										x			x	
	Vegetation Species										x			x	
	Invertebrate Taxa										x			x	
	Stage										x			x	
	Total Number										x			x	
	Total Dry Weight (g)										x			x	
Vertebrates Birds	Line Transect - on site	A3UBJG1-4	x	x		x	x		x	x		x	x		219
	Species		x	x		x	x		x	x		x	x		

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	73	Reported on page
Vertebrates Birds (Cont.)	Number		x	x		x	x		x	x	x	x	x	x	
	Age (when possible)		x	x		x	x		x	x	x	x	x	x	
	Density		x	x		x	x		x	x	x	x	x	x	
	Biomass - off site	A3UBJG1-4													
	Collection		x			x			x			x			219
	Species		x			x			x			x			
	Age		x			x			x			x			
	Sex		x			x			x			x			
	Weight		x			x			x			x			
	Retrice Length		x			x			x			x			
	Remige Length		x			x			x			x			
	Gonadal Condition		x			x			x			x			
	Molt stage		x			x			x			x			
	Williamson Territorial														
	Census			x											
	Species			x											
	No. Singing Males			x											
Mammals Rodents	Biomass - on site	A3UBJH1-4	x	x		x	x		x	x	x	x	x	x	237
	Species		x	x		x	x		x	x	x	x	x	x	
	Sex		x	x		x	x		x	x	x	x	x	x	
	Age		x	x		x	x		x	x	x	x	x	x	
	Nipple Condition		x	x		x	x		x	x	x	x	x	x	
	Vaginal Condition		x	x		x	x		x	x	x	x	x	x	
	Testical Condition		x	x		x	x		x	x	x	x	x	x	
	Weight		x	x		x	x		x	x	x	x	x	x	
	Density		x	x		x	x		x	x	x	x	x	x	
Lagomorphs	Jackrabbit Biomass	A3UBJI1	x			x			x	x	x				260
	Density (Drive Count)		x			x			x	x	x				

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	73	Reported on page
Cattle	Cattle Use and Impact	A3UBJR3,4							x	x		x	x		269
	Weight per Individual (kg)								x			x			
	No. of Cattle on Site								x	x		x	x		
	Time Spent Eating								x	x		x	x		
	Time Spent Standing								x	x		x	x		
	Time Spent Lying								x	x		x	x		
	Time Spent Ruminating								x	x		x	x		
	Daily Distance Traveled								x	x		x	x		
Soils	Soil Survey and Chemical Analysis	A3UBJQ1-4	x			x			x			x			273
	Soil Water Fraction by Volume (Gamma Probe)	A3UBJP1							x	x	x	x	x	x	18
	Various Depths 2.5-66 cm								x	x	x	x	x	x	
	Soil Water % by Volume (Neutron Probe)	A3UBJP2							x	x	x	x	x	x	18
	Various Depths 31-183 cm								x	x	x	x	x	x	
	Soil Water Potential (Soil Psychrometer)	A3UBJP3									x			x	--
	Various Depths 1-200 cm										x			x	
Lichens	Estimated Biomass	A3UBJO2	x			x			x			x			288
	Percent Ground Cover		x			x			x			x			
	Species Inventory		x			x			x			x			

Continued

Table 3. Continued

System Component	Parameters Measured	DSCODE	North shrub 71	North shrub 72	North shrub 73	North grass 71	North grass 72	North grass 73	South shrub 71	South shrub 72	South shrub 73	South grass 71	South grass 72	South grass 73	Reported on page
Soil Algae	Estimated Biomass	A3UBJ11,								x			x		296
	Percent Ground Cover	A3ULA04								x			x		
	Species Inventory									x			x		
Microbes	Biological Analysis	A3UBJK1	x			x									
	Total No. Microorganisms		x			x									298
	Numbers of Bacteria		x			x									
	Numbers of Actinomycetes		x			x									
	Numbers of Fungi		x			x									
	Soil Moisture Content		x			x									
	Soil Organic Matter		x			x									
	Soil Temperature Profile (10 cm)		x			x									
	CO_2 Evolution Rate		x			x									
	Soil pH Determination		x			x									
	Soil ATP Assay		x			x									
	Off site samples	A3UBJJ1-7 &													299,301,306,313
		A3USQ01-6							x	x	x	x	x	x	301,306
	Chemical analysis								x	x		x	x		
	NH_4								x	x		x	x		
	NO_3								x	x		x	x		
	Total organic nitrogen								x	x		x	x		
	Organic carbon								x	x		x	x		
	Soil Moisture								x	x	x	x	x	x	
	Soil pH								x	x	x	x	x	x	
	Biological analysis														
	(plate count)								x	x		x	x		
	Aerobic Bacteria Numbers								x	x		x	x		
	Streptomycete Numbers								x	x		x	x		
	Anaerobic bacteria Nos.								x	x		x	x		
	Fungal Numbers								x	x		x	x		
	Biochemical analysis								x	x	x	x	x	x	
	Proteolytic activity								x	x	x	x	x	x	
	Dehydrogenase activity								x	x	x	x	x	x	
	Phosphate activity								x	x		x	x		
	Respiratory activity								x	x	x	x	x	x	
	Nirtogen Fixation								x	x		x	x		
	Ammonification								x	x		x	x		
	Denitrification								x	x		x	x		

FINDINGS

CONTENTS

Page Number 2.2.2.1.-

A. ABIOTIC

INTRODUCTION

Since many of the abiotic measurements are made at the same location and share some part of their procedures, they shall be presented together. This report contains data on air temperature, radiation, precipitation, humidity, wind, soil temperature, and soil moisture.

METHODS

The recording of meteorological data was initiated on both the north and south sites in August of 1971. The northern Curlew Valley weather station is on the grass site, hectare 51. Instruments are housed 1.25 m above ground level in a Weather Measure IS1 instrument shelter; U.S.W.B. Spec. 450.0615 Rev. 8/28/67. Air temperature and relative humidity are taken with a recording hygrothermograph; U.S.W.B. Spec. No. 450.8202, Science Associates No. 225. Wind speed is taken at 2 m above ground level by a totalizing anemometer; U.S.W.B. Spec. No. 150.6104 Rev. 10/1/64, Science Associates NO. 403. This has a contact closure every 1.61 km (1 mile) which is being used to pulse an event recorder; Weather Measure No. P521. Precipitation is taken by a weighing, recording, 20-cm rain gauge from Belfort Instrument Company.

Temperature is recorded to the nearest degree Fahrenheit, humidity to the nearest percent and precipitation to the nearest .004 cm (.01 inch). Recording charts chart data continuously; however, data are recorded for the data bank bihourly or as amount of activity since last recording. The DSCODES are A3UBJM2 for the north sites and A3UBJM4 for the south sites. In addition, weekly data are collected when the charts are changed every 7 days. Data taken include the weekly maximum and minimum temperature, the present wet and dry bulb temperatures and amounts of precipitation collected in an 20-cm rain can adjacent to the weather station. A Star pyranometer has been installed in conjunction with a volt-time integrator for measurement of global radiation at Snowville, Utah; DSCODE A3UBJW1.

In the spring of 1972 an 18-channel digital data acquisition system was installed on the southern site. This system collected soil temperature, air temperature, vapor pressure and wind speed at several vertical strata. It also recorded total incoming and net radiation. Unfortunately this system was improperly designed or installed and proved unreliable. We prefer to rely on spring-operated strip chart weather instruments and plan to use the automated system only for detailed abiotic profiles taken over 24-hour periods once each month.

Additional equipment installed in 1972 were remote-reading thermographs for measuring soil temperatures on the north and south sites and another totalizing anemometer on the south site to record wind speeds at 0.5 m.

In August, 1971, access tubes for measuring soil moisture were installed at several locations on the southern sites. These tubes have been used for periodic measurements of soil moisture by both the neutron and gamma probe methods. Thermocouple psychrometers from Wescor Corp. have been purchased and calibrated but not extensively used as yet. Several more soil psychrometers will be installed in April, 1973, for measuring the sum of matric and osmotic potentials. An S-B Systems microvoltometer is being used for making field measurements of water potential. Both density and thermocouple psychrometer sample change-data were collected in 1971 for the south site soils.

Gamma probe data are listed under DSCODE A3UBJP1. Neutron probe data are listed under DSCODE A3UBJP2.

No soil moisture work has been done on the north sites.

RESULTS

All of the data collected through December, 1972, are summarized in the following Tables and Figures. The northern sites had a less stressful abiotic environment than those of the south. The northern sites were cooler in summer, warmer in winter and received more precipitation than the southern sites.

Long-term mean annual precipitation totaled 34 cm on the northern sites and 25 cm on the southern sites. Curlew Valley had a relatively wet year in 1971 and very dry in 1972.

The northern sites generally had snow accumulations of 45 cm with snow cover from November into March. The southern sites accumulated less than 25 cm of snow and had significant snow cover in December and January only.

Frequent and prolonged gaps in the weather data occurred. Dusty conditions in summer coupled with extreme cold in winter caused frequent instrument failure. The remoteness of the sites made it impractical to check the stations more than once a week, particularly in winter. The time lapse between instrument failure, instrument repair and reinstallation was a minimum of 2 weeks.

The wind recording instrumentation installed in 1971 was designed to record wind totals continuously. Unfortunately the power system for the event recorder was insufficient. Wind was recorded only as kilometers per week. The system is being redesigned and it will soon be operating as originally intended.

Relative humidity presented a particular problem. The present instrumentation made consistently erroneous recordings, regardless of how often the hair element was changed and recalibrated.

A.1. AIR TEMPERATURE

Table 1 provides monthly minima, maxima and mean temperatures, and ranges of these values by month, for the latter part of 1971 and for 1972 for the northern sites. Graphic representation of daily minima, maxima and mean are given in Figures 1-6. Corresponding data for the southern sites are presented and illustrated in Table 2 and Figures 7-12.

Table 1. Monthly air temperature (C) on northern sites

Date	Min.	Max.	Hourly Mean	Range of Daily min.	Range of Daily max.	Range of Daily mean
Aug 71	1	34	21	1 - 17	9 - 34	6 - 24
Sep 71	-10	32	10	-10 - 11	9 - 32	1 - 20
Oct 71	-14	25	4	-14 - 6	- 6 - 32	- 9 - 13
Nov 71	-16	15	-2	-16 - 1	- 3 - 15	- 6 - 6
Dec 71	-23	5	-7	-23 - 1	- 8 - 5	-13 - 2
Jan 72	-24	7	-5	-24 - 1	-13 - 7	-17 - 2
Feb 72	-11	12	-2	-11 - 3	- 8 - 12	-12 - 4
Mar 72	-12	19	3	-12 - 3	0 - 19	- 5 - 11
Apr 72	- 9	19	3	- 9 - 2	0 - 19	- 4 - 8
May 72	- 2	31	10	- 2 - 8	9 - 31	1 - 16
Jun 72	2	33	14	2 - 11	19 - 33	9 - 21
Jul 72	4	36	18	4 - 15	14 - 36	9 - 22
Aug 72	5	36	20	5 - 16	22 - 36	14 - 25
Sep 72	- 4	28	13	- 4 - 12	11 - 28	5 - 19
Oct 72	-10	23	8	-10 - 9	1 - 23	- 1 - 15
Nov 72	-13	6	0	-13 - 4	- 3 - 6	- 5 - 7
Dec 72	-29	2	-3	-29 - -2	-10 - 2	-15 - 1

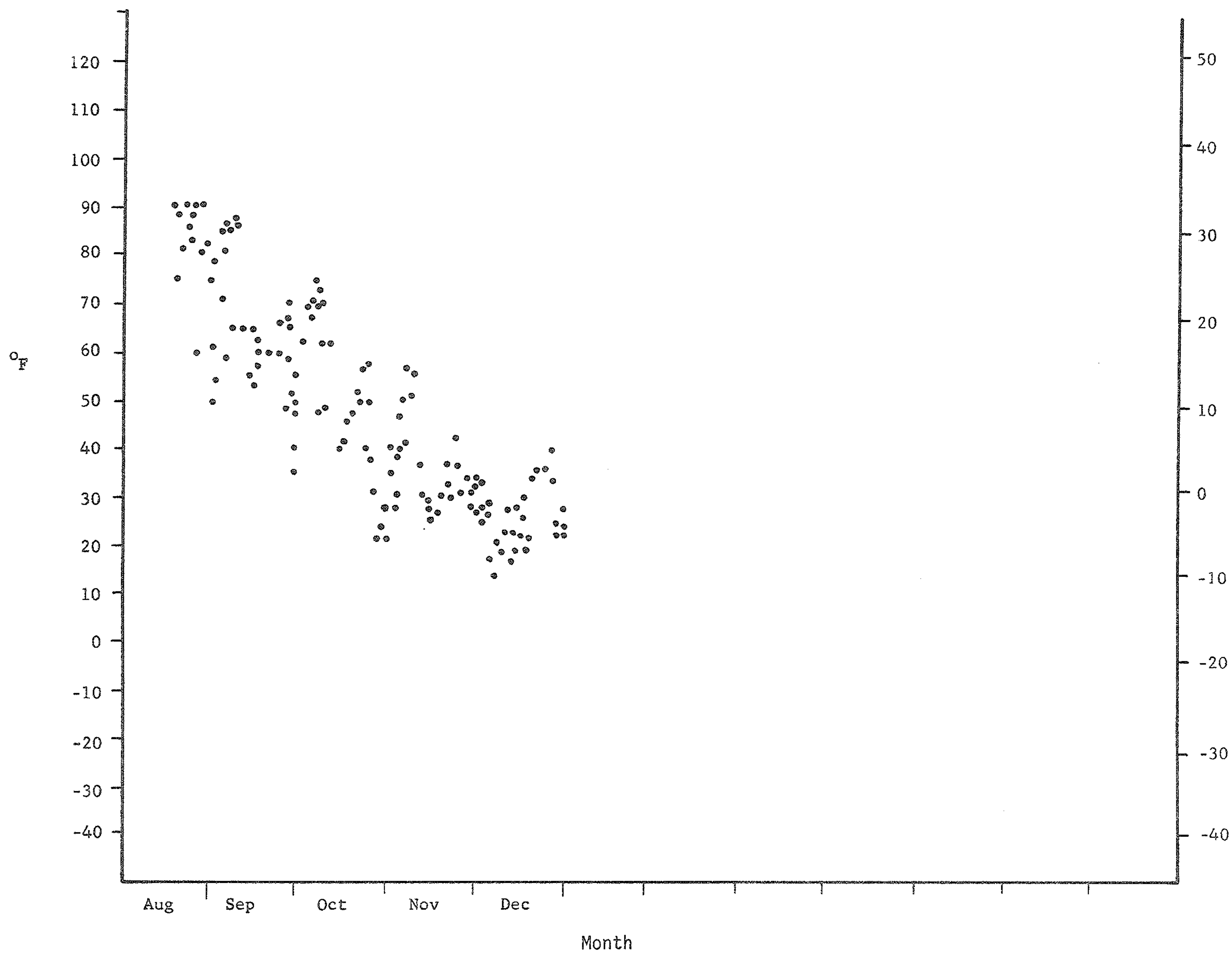


Figure 1. Daily maximum air temperature on northern sites, 1971.

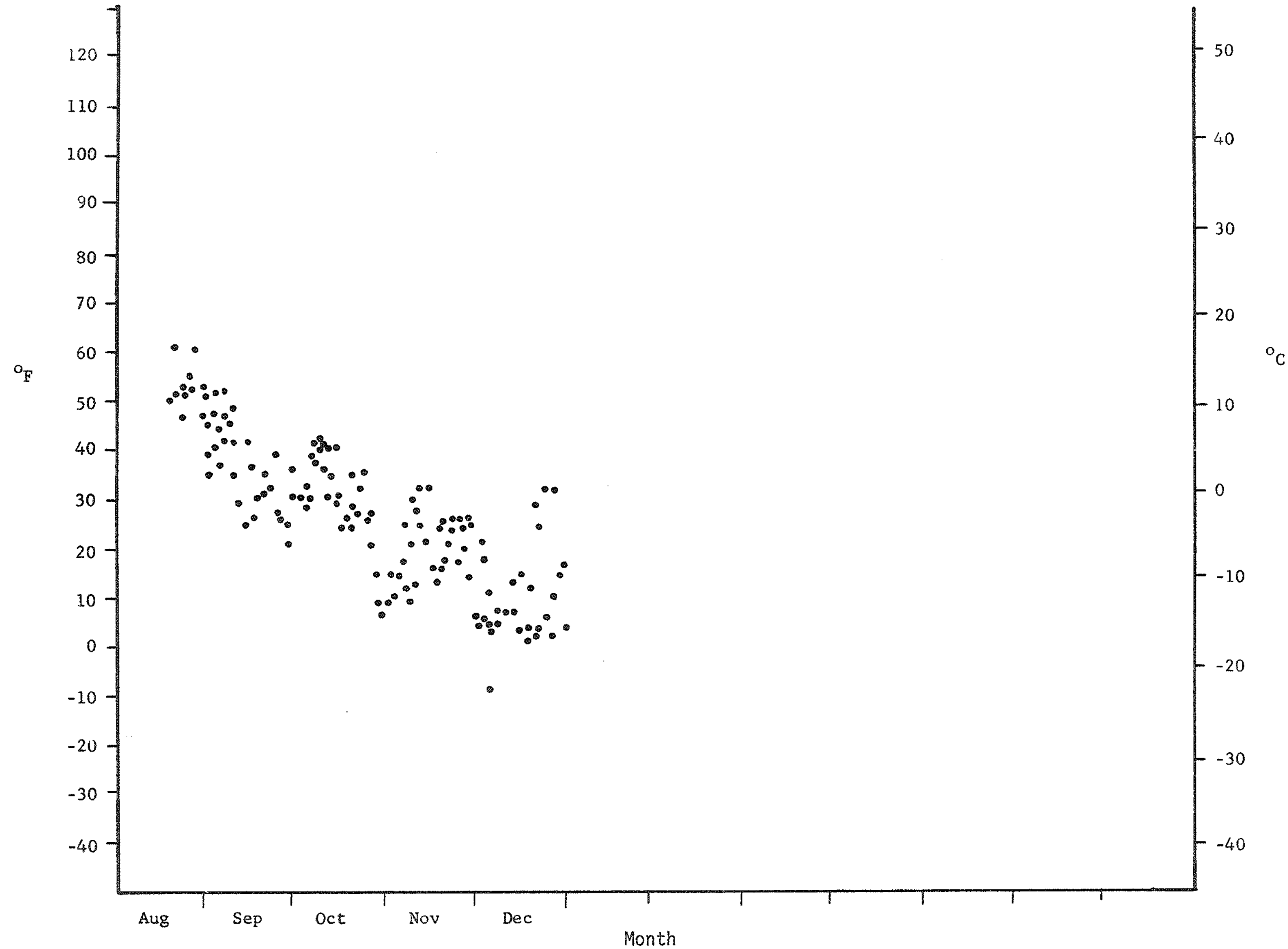


Figure 2. Daily minimum air temperature on northern sites, 1971.

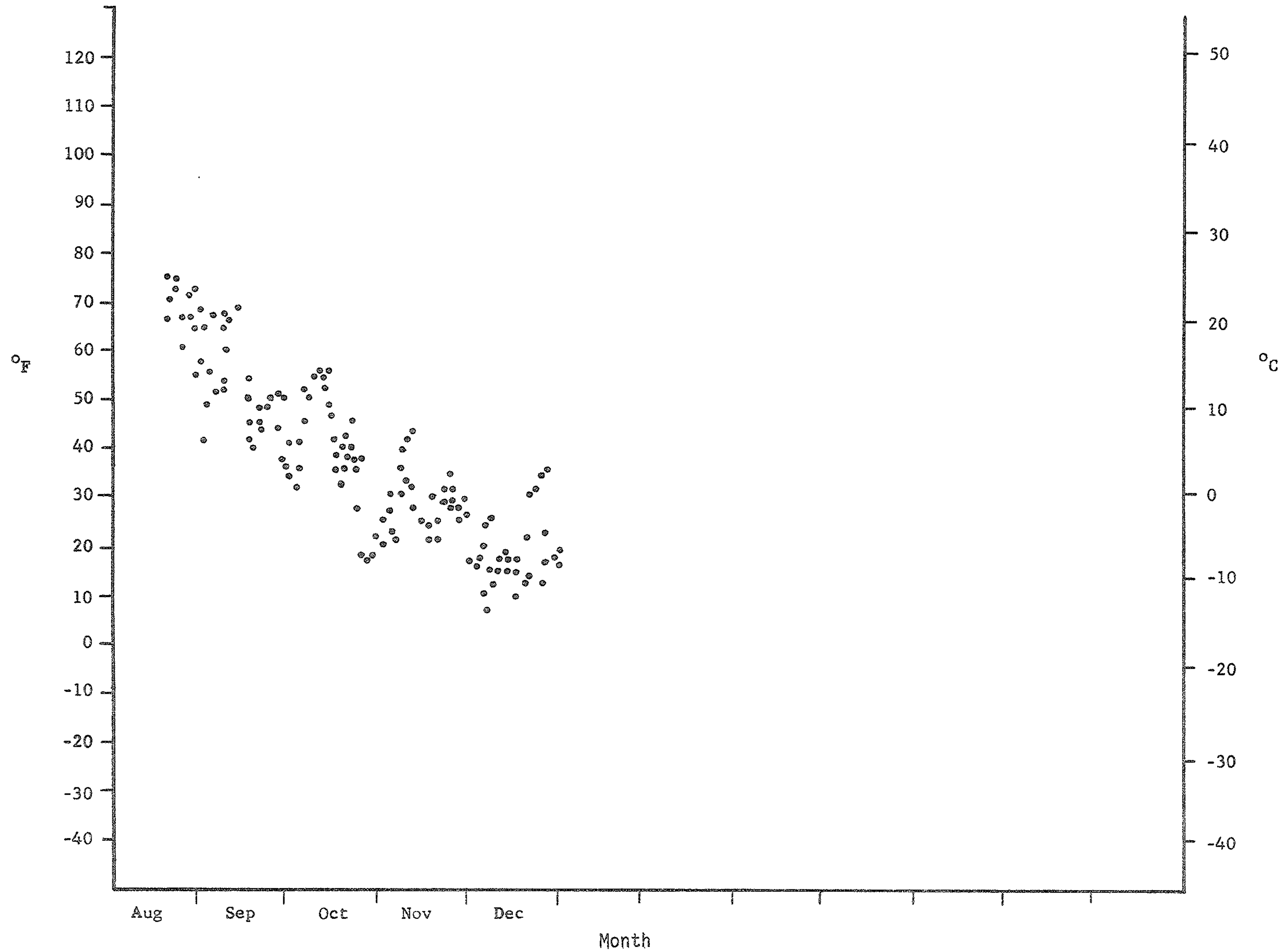


Figure 3. Daily mean air temperature on northern sites, 1971.

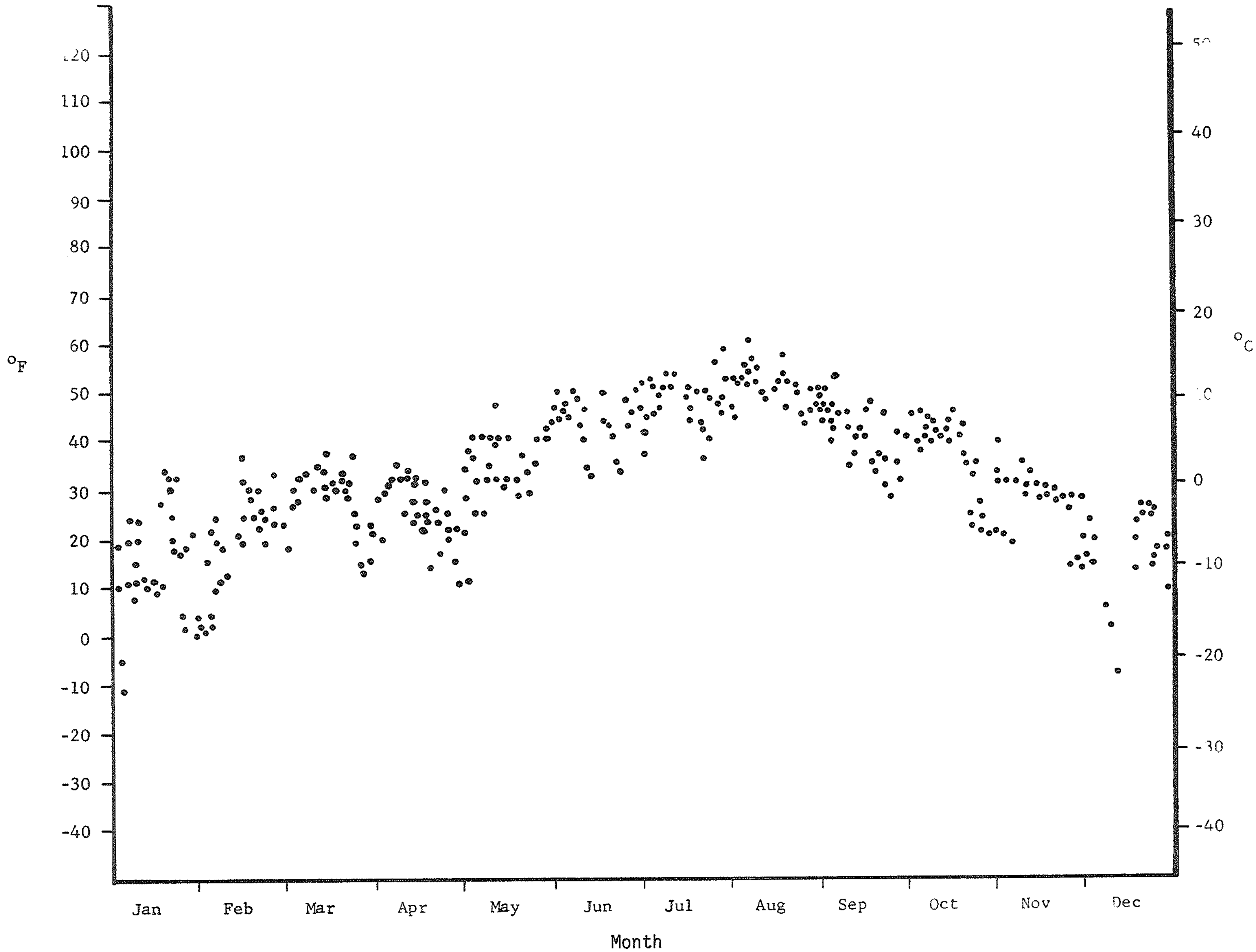


Figure 5. Daily minimum air temperature on northern sites, 1972.

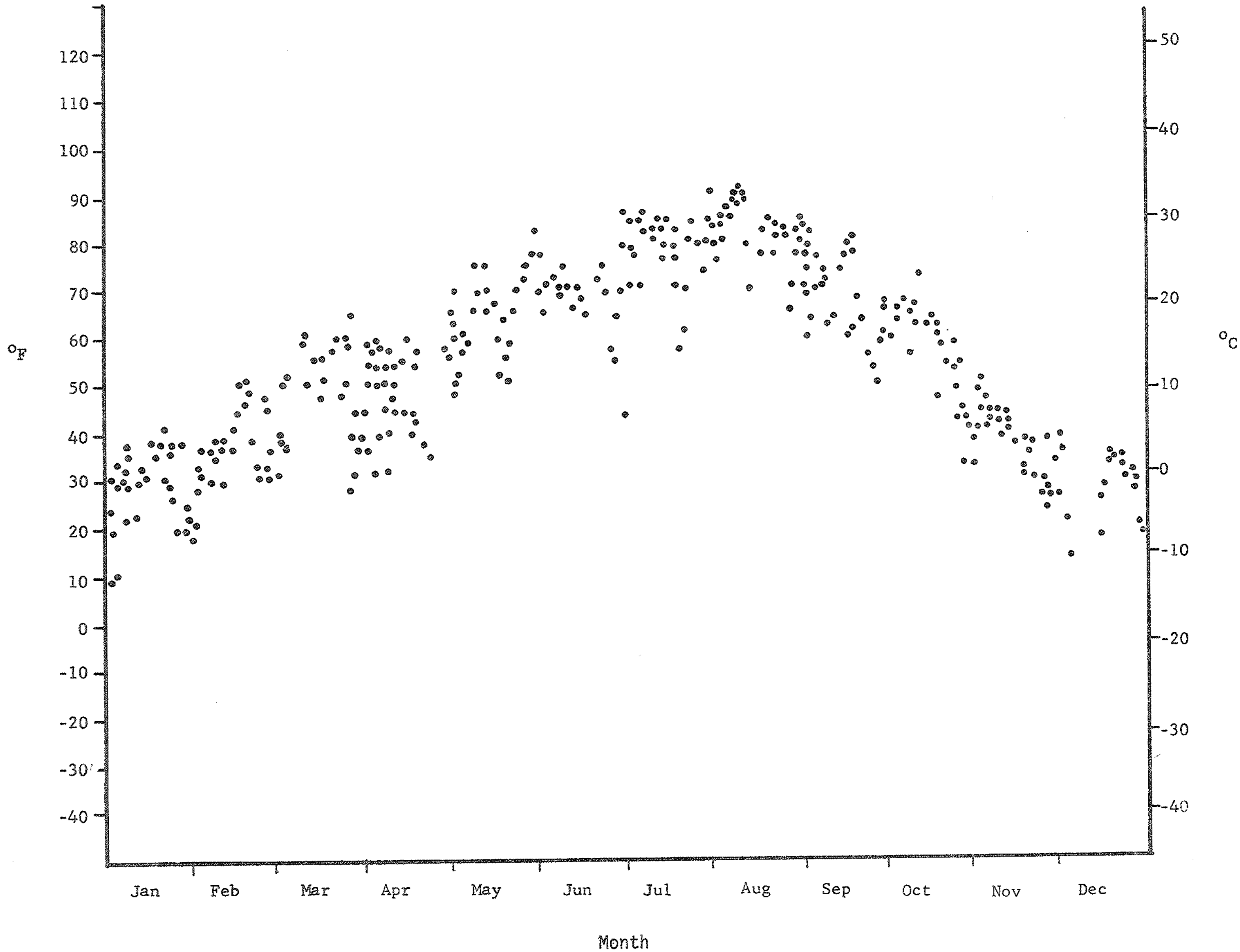


Figure 4. Daily maximum air temperature on northern sites, 1972.

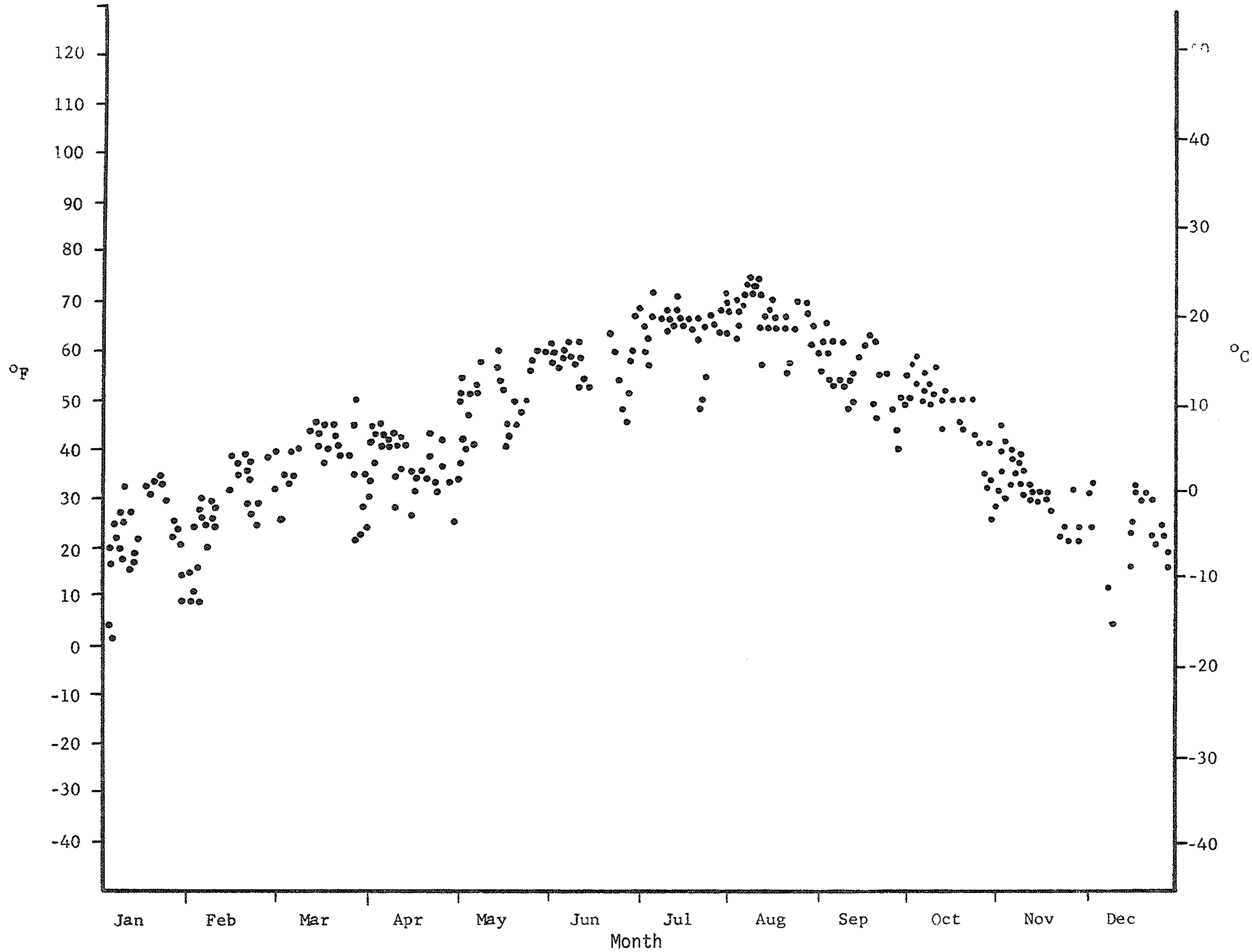


Figure 6. Daily mean air temperature on northern sites, 1971.

Table 2. Monthly air temperature (C) on southern sites

Date	Min.	Max.	Hourly mean	Range of Daily min.	Range of Daily max.	Range of Daily means
Aug 71	0	32	20	0 - 16	20 - 32	17 - 22
Sep 71	-12	32	11	-12 - 6	5 - 32	3 - 20
Oct 71	-19	27	8	-19 - 9	1 - 27	- 3 - 16
Nov 71	-16	16	3	-16 - 3	4 - 16	- 3 - 8
Dec 71	-27	7	2	-27 - 2	-4 - 7	- 8 - 5
Jan 72	-31	9	-3	-31 - 0	-1 - 9	- 9 - 3
Feb 72	-14	18	1	-14 - 2	-5 - 18	-10 - 6
Mar 72	-17	22	5	-17 - 7	2 - 22	- 3 - 12
Apr 72	-13	23	7	-13 - 6	3 - 23	2 - 11
May 72	- 4	31	13	- 4 - 12	14 - 31	5 - 20
Jun 72	1	35	20	1 - 14	19 - 35	13 - 25
Jul 72	3	37	22	3 - 18	21 - 37	14 - 26
Aug 72	2	37	20	2 - 17	22 - 37	15 - 29
Sep 72	- 9	29	12	- 9 - 10	12 - 29	4 - 18
Oct 72	- 9	24	7	- 9 - 8	2 - 24	- 1 - 13
Nov 72	-11	12	2	-11 - 3	-1 - 12	- 4 - 5
Dec 72	-36	9	-8	-36 - 2	-12 - 9	-24 - 12

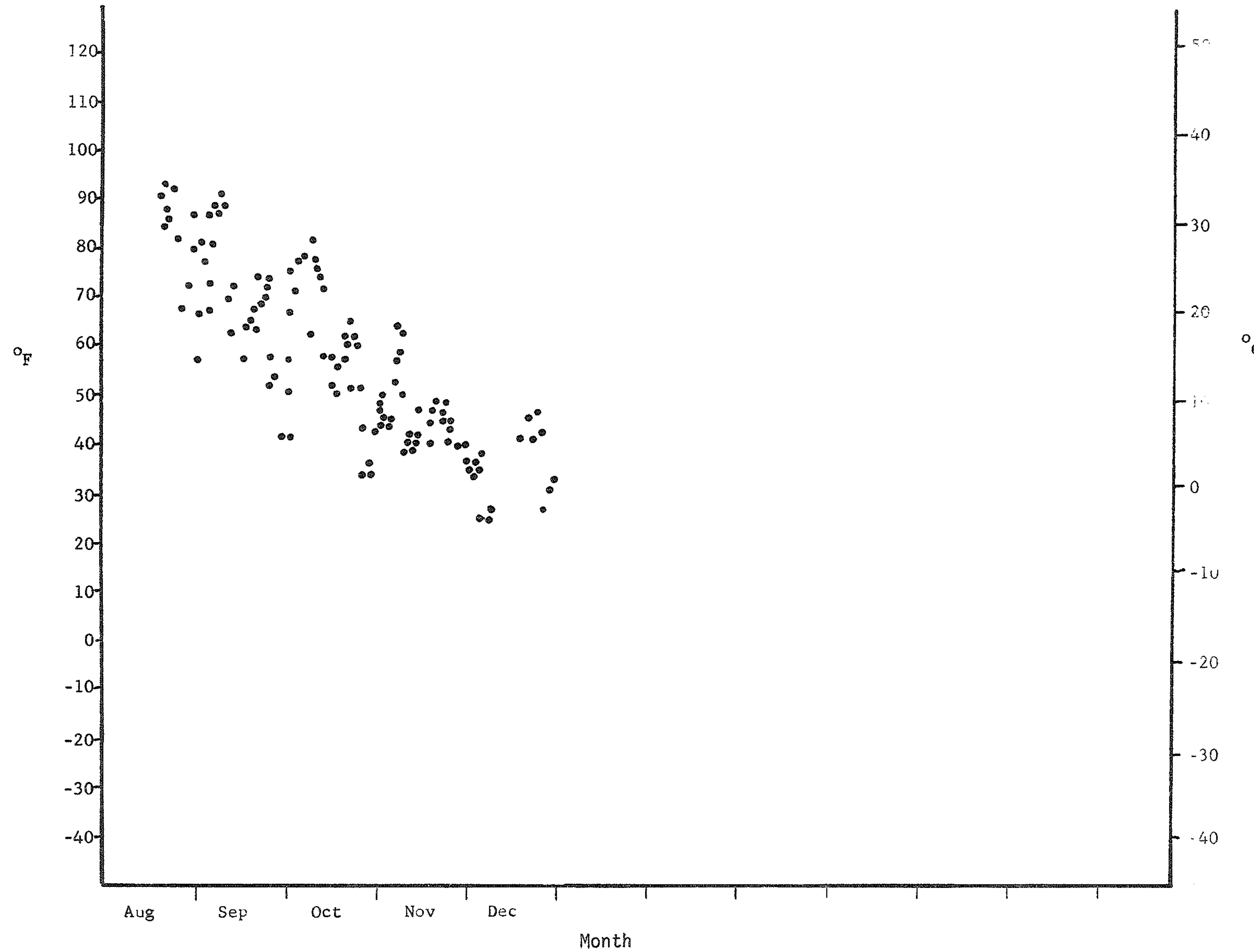


Figure 7. Daily maximum air temperature on southern sites, 1971.

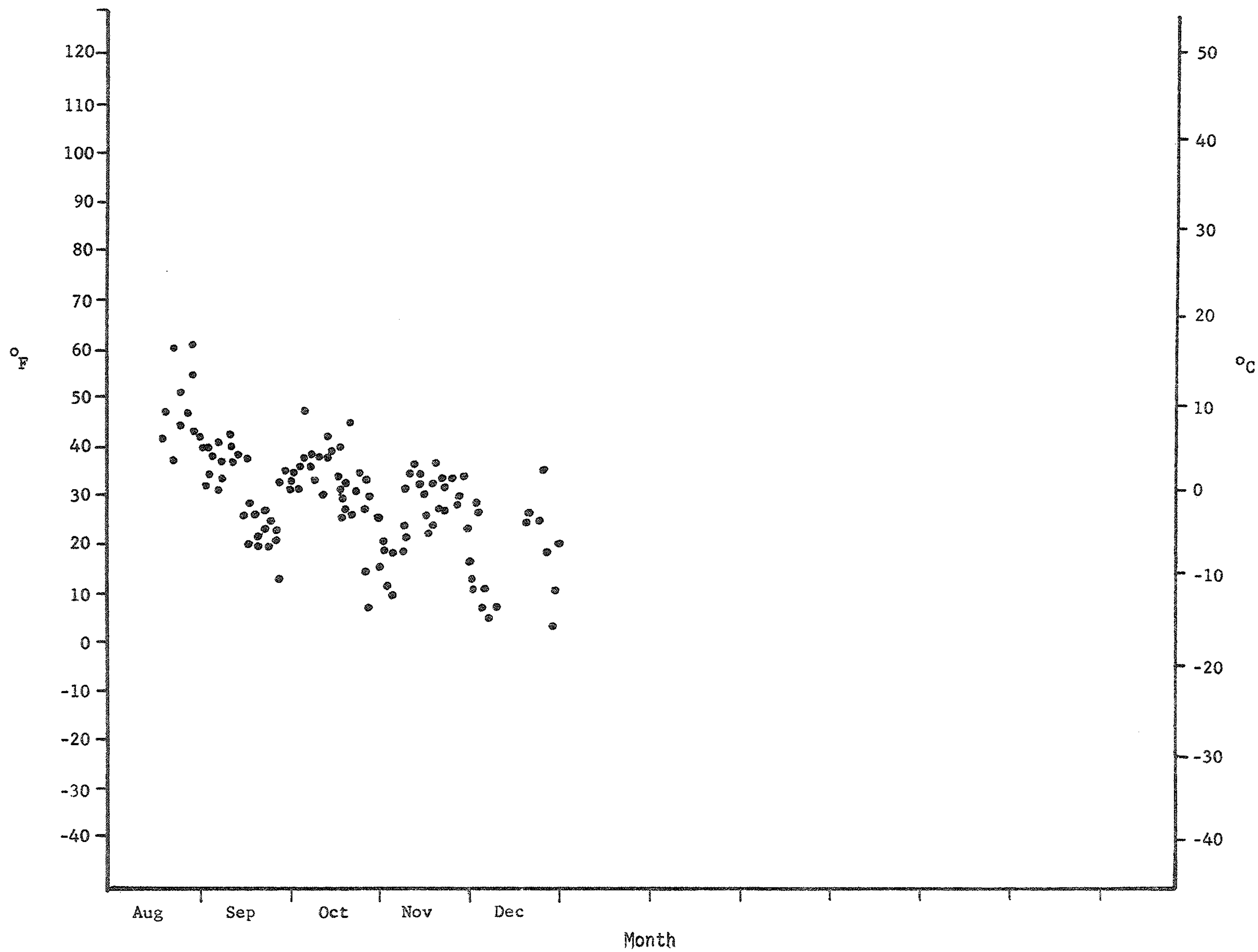


Figure 8. Daily minimum air temperatures on southern sites, 1971.

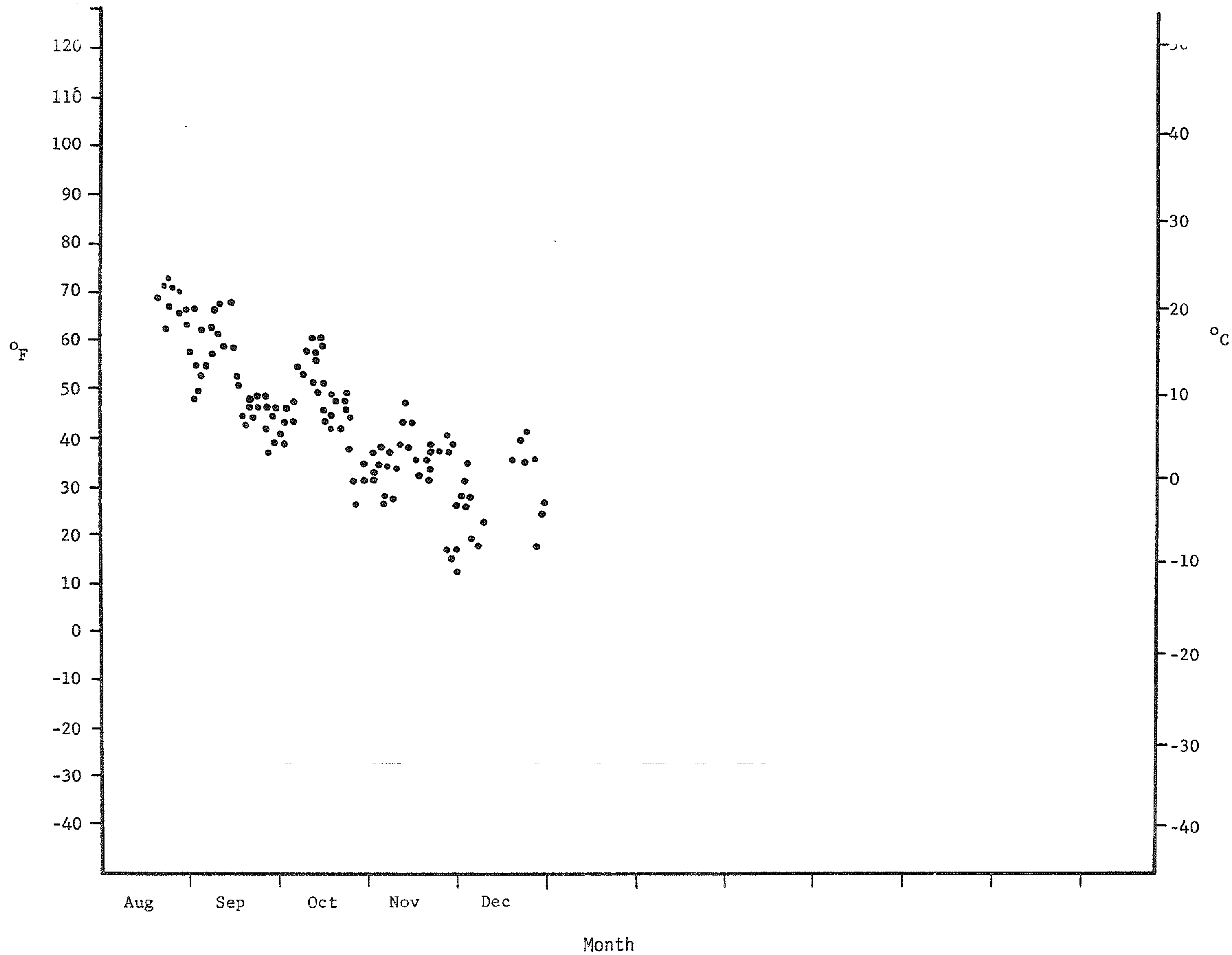


Figure 9. Daily mean air temperature on southern sites, 1971.

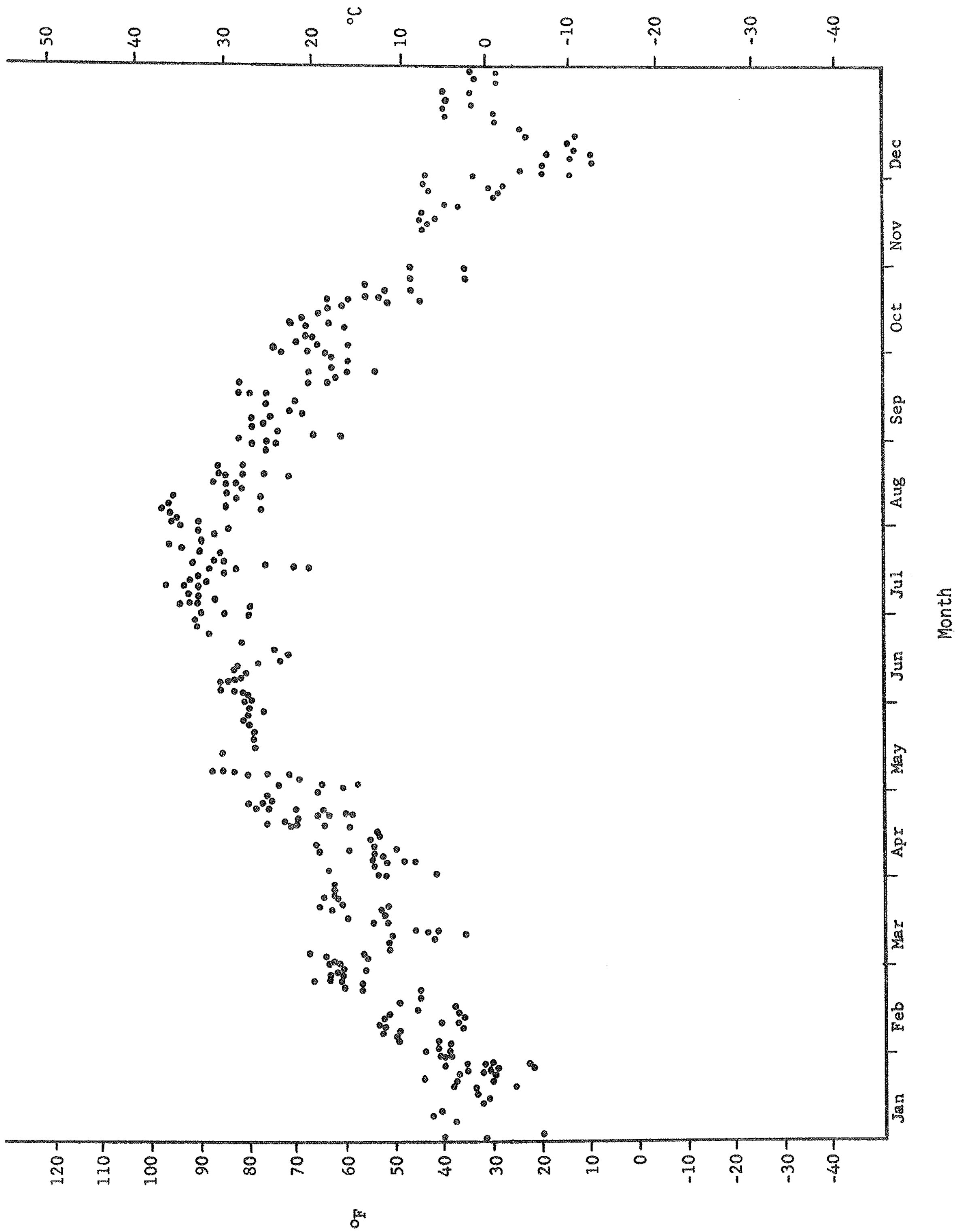


Figure 10. Daily maximum air temperature on southern sites, 1972.

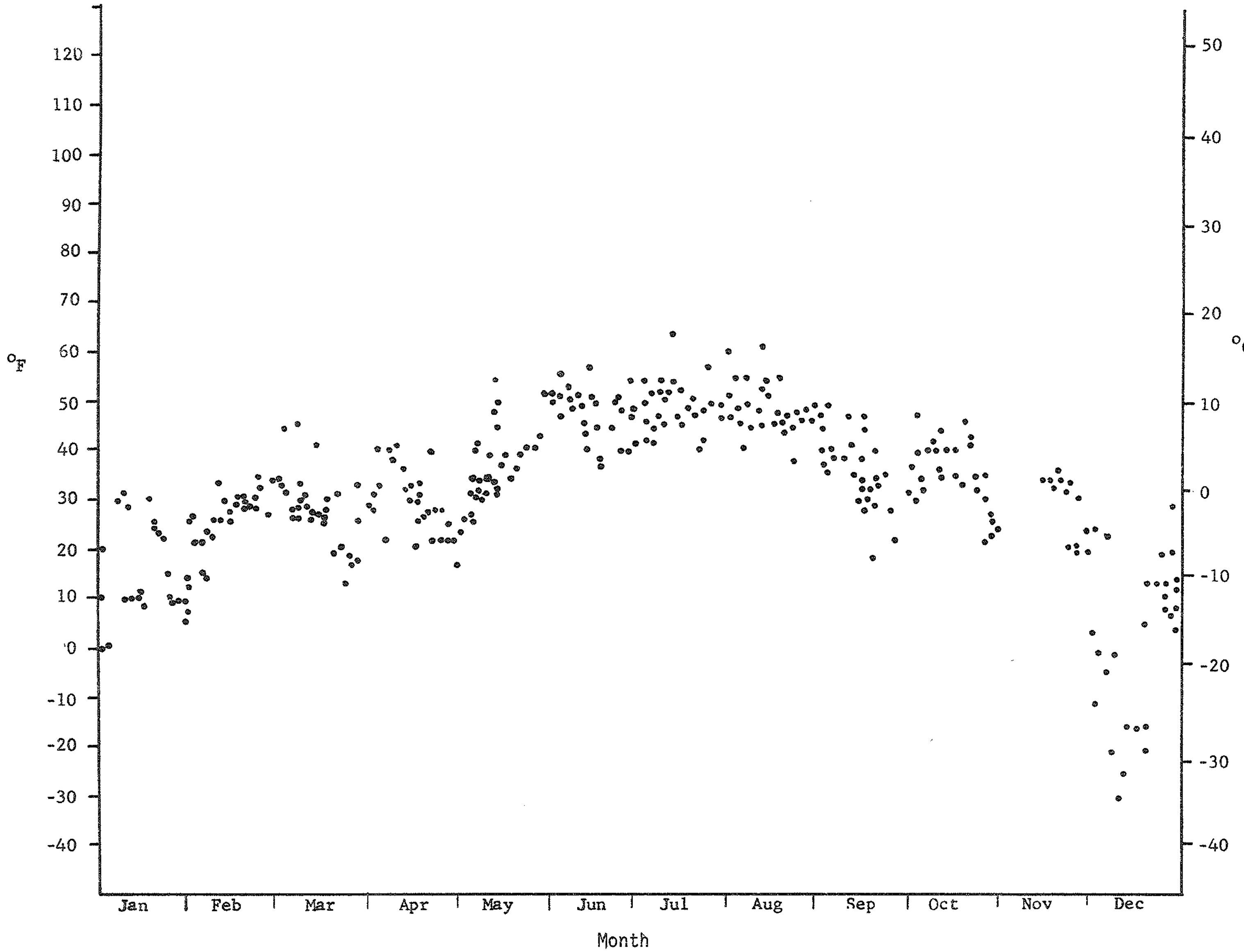


Figure 11. Daily minimum air temperature on southern sites, 1972.

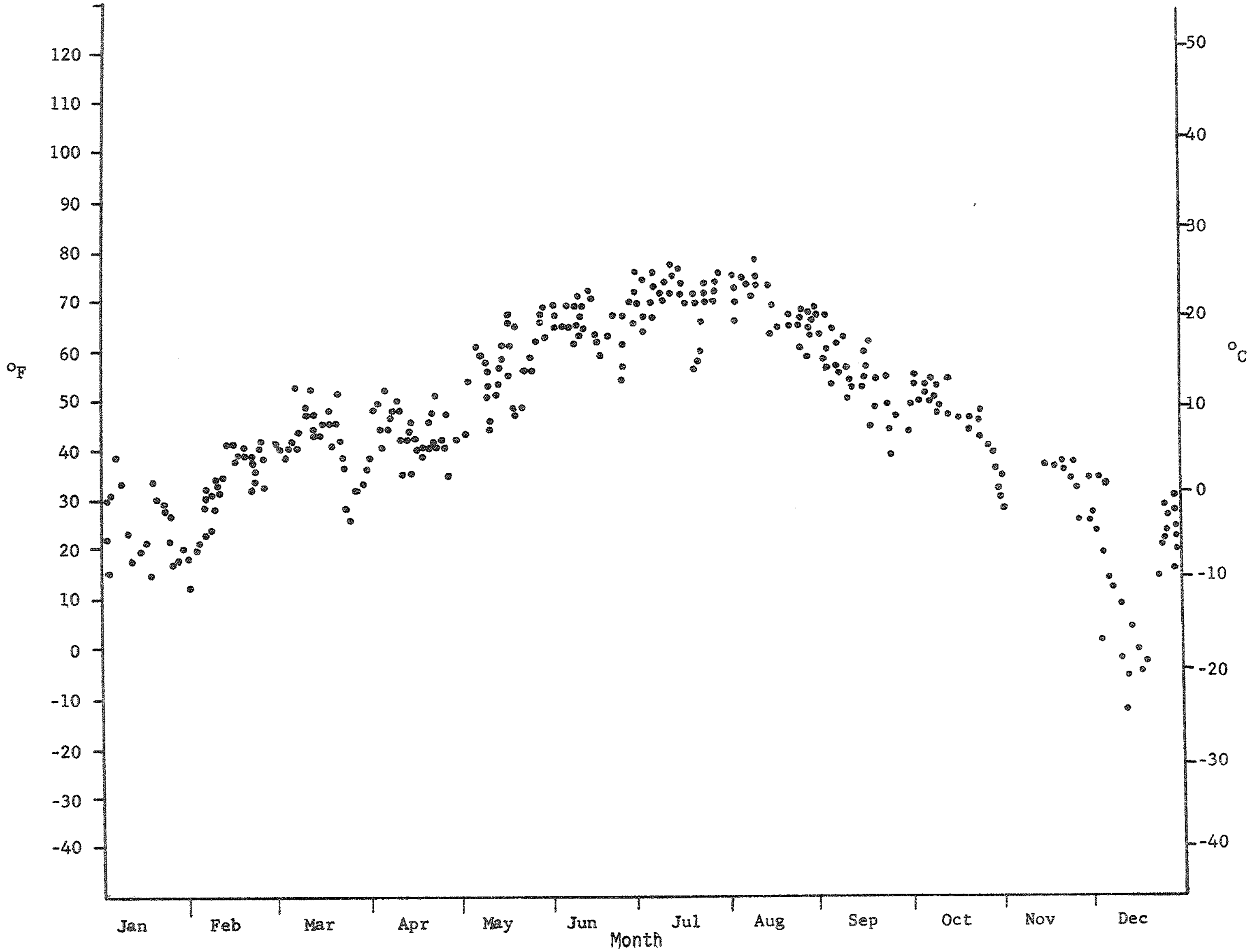


Figure 12. Daily mean air temperature on southern sites, 1972.

A.2. SOLAR RADIATION

Radiation was recorded at Snowville, Utah, not far from the validation sites. Daily integrated values for 1972 are given in Figure 13, with data missing for July, August and the first part of September.

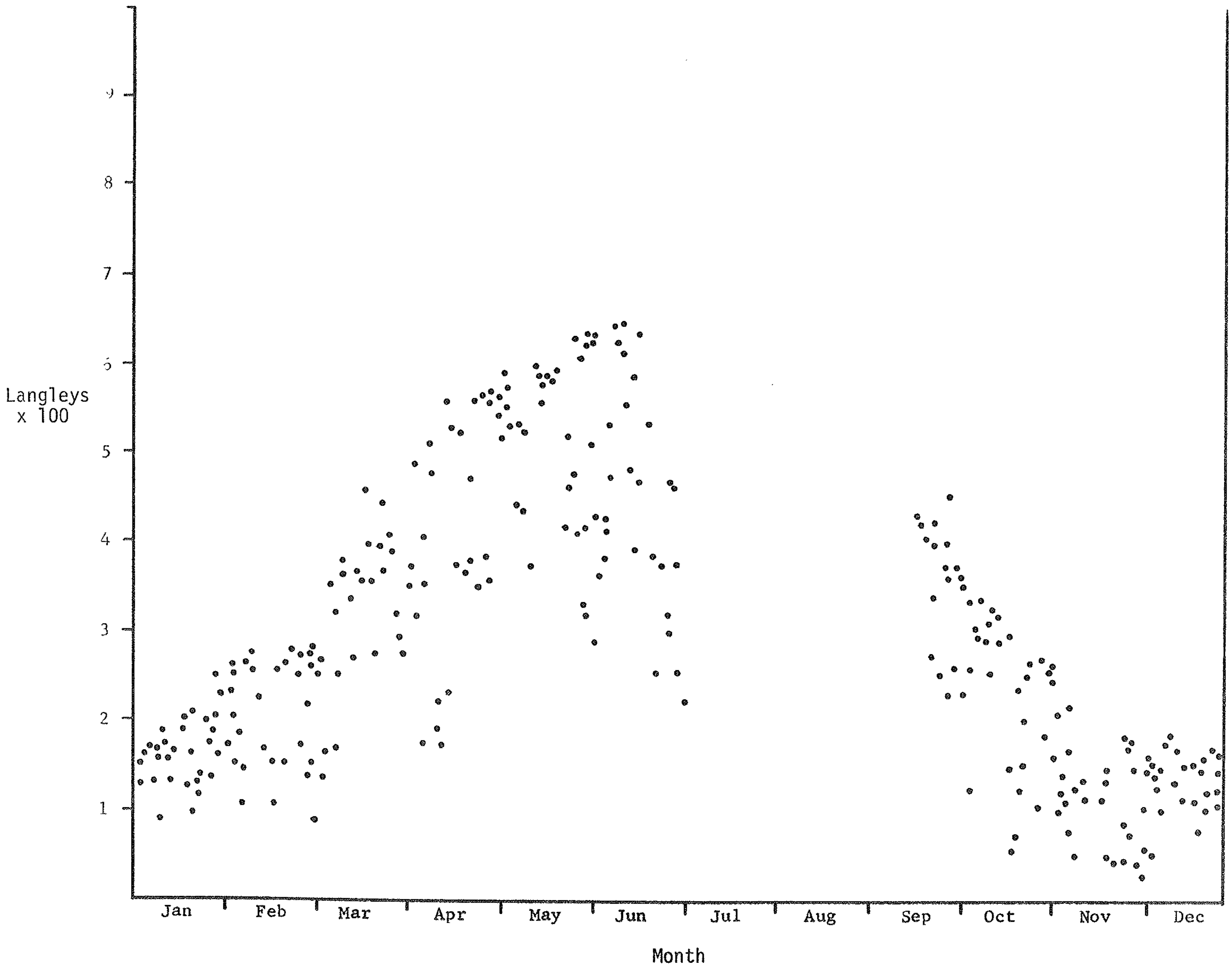


Figure 13. Solar radiation at Snowville, Utah, 1972.

A.3. PRECIPITATION

Precipitation data are reported in Tables 3 and 4 and Figures 14-17. Rainfall events, total precipitation and rate of rainfall are tabled by month from August, 1971, to December, 1972, for the northern (Table 3) and southern sites (Table 4). Individual Figures illustrate weekly precipitation for the two sites for 1971 and 1972.

Table 3. Monthly precipitation on northern sites

Month	Number of Events	Total Rainfall Inches	Total Rainfall mm	Rate of Rainfall In/hr	Rate of Rainfall mm/hr	Snow
Aug 71	2	.15	3.8	.02	.5	
Sep 71	5	1.40	35.6	.06	1.5	
Oct 71	4	.62	15.7	.02	.5	
Nov 71	0	0	0	0	0	
Dec 71		3.50	88.9			Snow
Jan 72		.87	22.1			Snow
Feb 72		2.68	68.1			Snow
Mar 72	4	.62	15.7	.02	.5	
Apr 72	5	.95	24.0	.03	.8	
May 72	4	.36	9.1	.07	1.8	
Jun 72	5	.71	18.0	.02	.5	
Jul 72	3	.67	17.0	.08	2.0	
Aug 72	1	.08	2.0	1.6	40.6	
Sep 72	5	1.54	39.1	.09	2.3	
Oct 72	6	1.87	47.5	.05	1.3	
Nov 72	6	.81	20.6	.03	.8	
Dec 72		4.07	103.4			Snow

Table 4. Monthly precipitation on southern sites

Month	Number of Events	Total Rainfall Inches	Total Rainfall mm	Rate of Rainfall In/hr	Rate of Rainfall mm/hr	Snow
Aug 71	2	.23	5.8	.04	1.0	
Sep 71	3	1.41	35.8	.06	1.5	
Oct 71	2	.5	12.7	.03	.8	
Nov 71	0	0	0	0	0	
Dec 71		.72	18.3			Snow
Jan 72		1.23	31.2			Snow
Feb 72		1.05	26.7			Snow
Mar 72	1	.11	2.8	.06	1.5	
Apr 72	3	.67	17.0	.03	.8	
May 72	4	.15	3.8	.04	1.0	
Jun 72	7	.76	19.3	.13	3.3	
Jul 72	1	.38	9.7	.05	1.3	
Aug 72	3	.34	8.6	.05	1.3	
Sep 72	4	.46	11.7	.03	.8	
Oct 72	5	3.07	78.0	.07	.07	
Nov 72		1.62	41.2			Snow
Dec 72		2.55	64.8			Snow

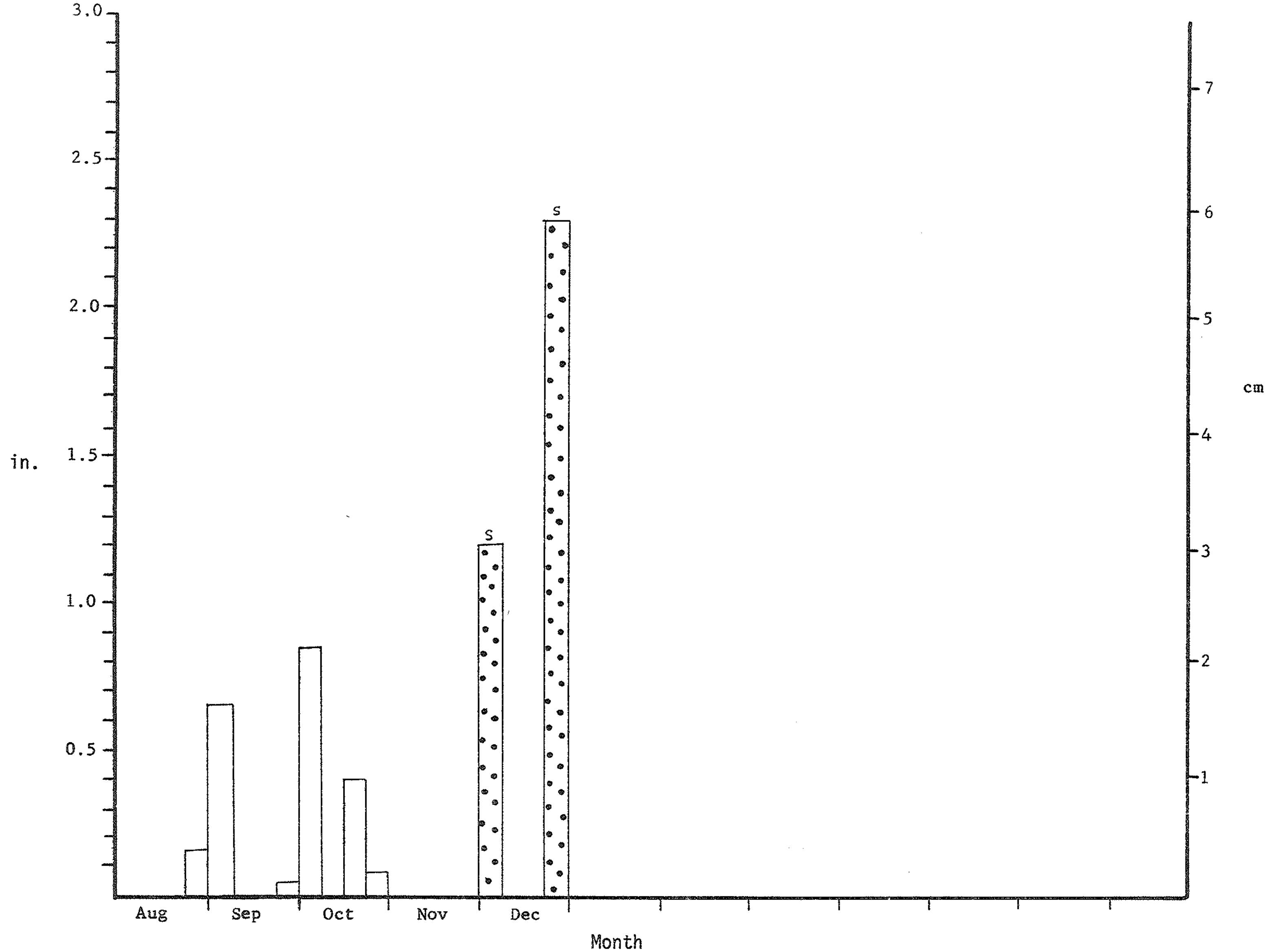


Figure 14. Weekly precipitation on southern sites, 1972.

Figure 15. Weekly precipitation on northern sites, 1972.

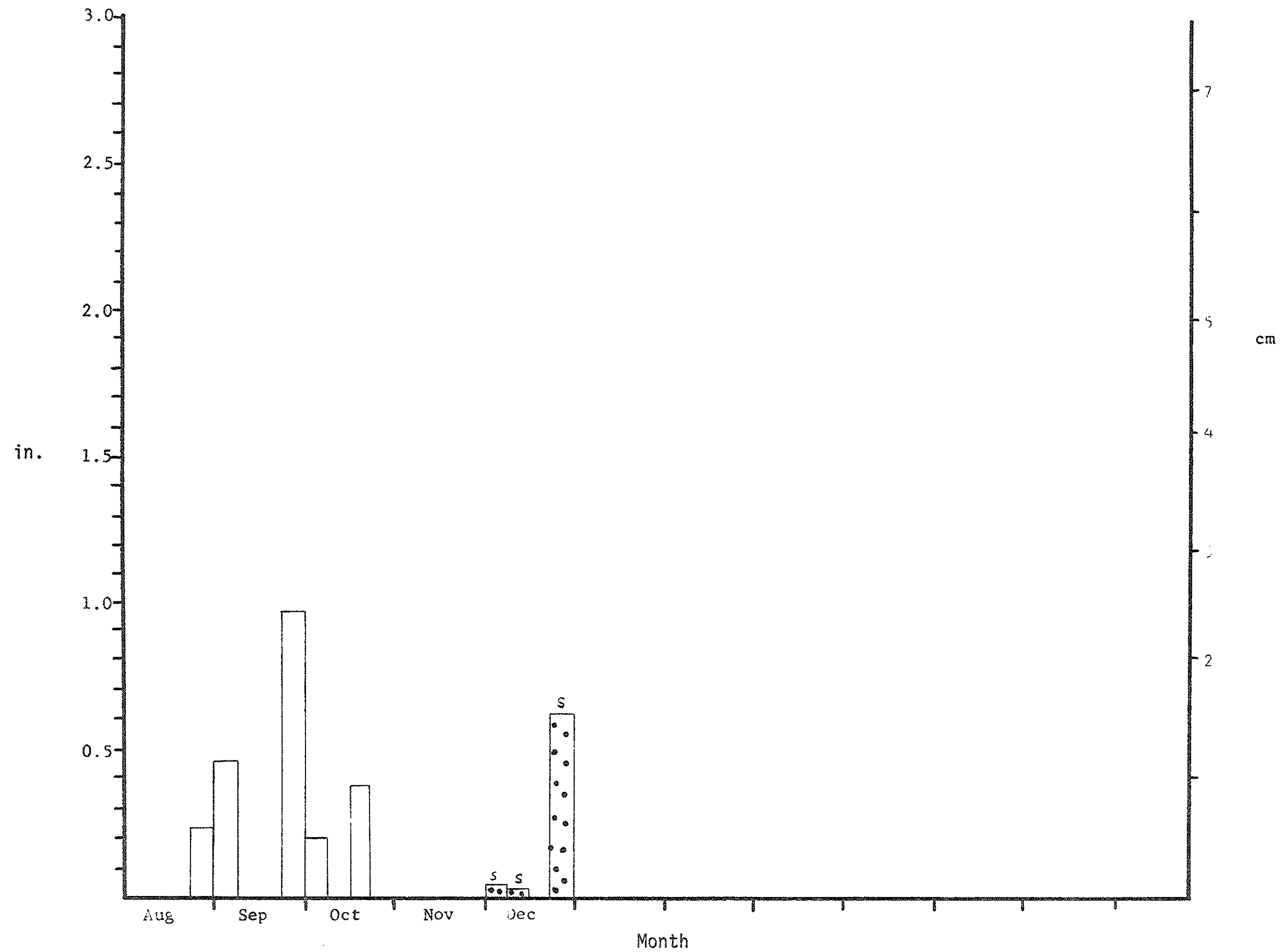


Figure 16. Weekly precipitation on southern sites, 1971.

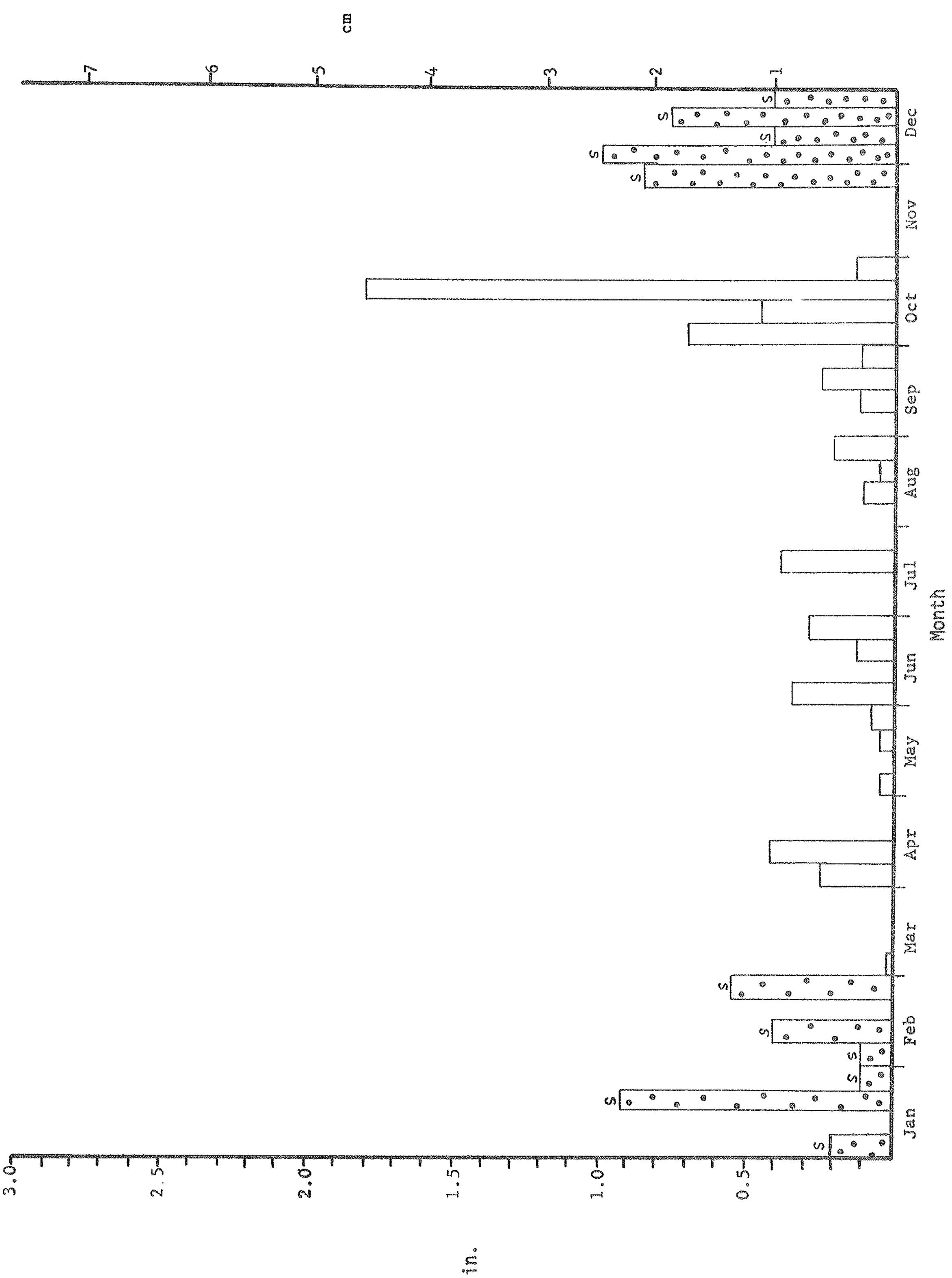


Figure 17. Weekly precipitation on southern sites, 1972.

A.4. RELATIVE HUMIDITY

Percent relative humdiity is shown on a daily mean basis for 1971 and 1972 on the northern (Figures 18 and 19) and southern sites (Figures 20 and 21).

A.5 WIND

Figures 22-25 illustrate mean weekly wind velocity for 1971 and 1972 on the northern (Figures 22 and 23) and southern sites (Figures 24 and 25), as recorded at 2 m above ground level. Wind velocity values at 0.5 m above ground on the southern sites for 1972 are shown in Figure 26.

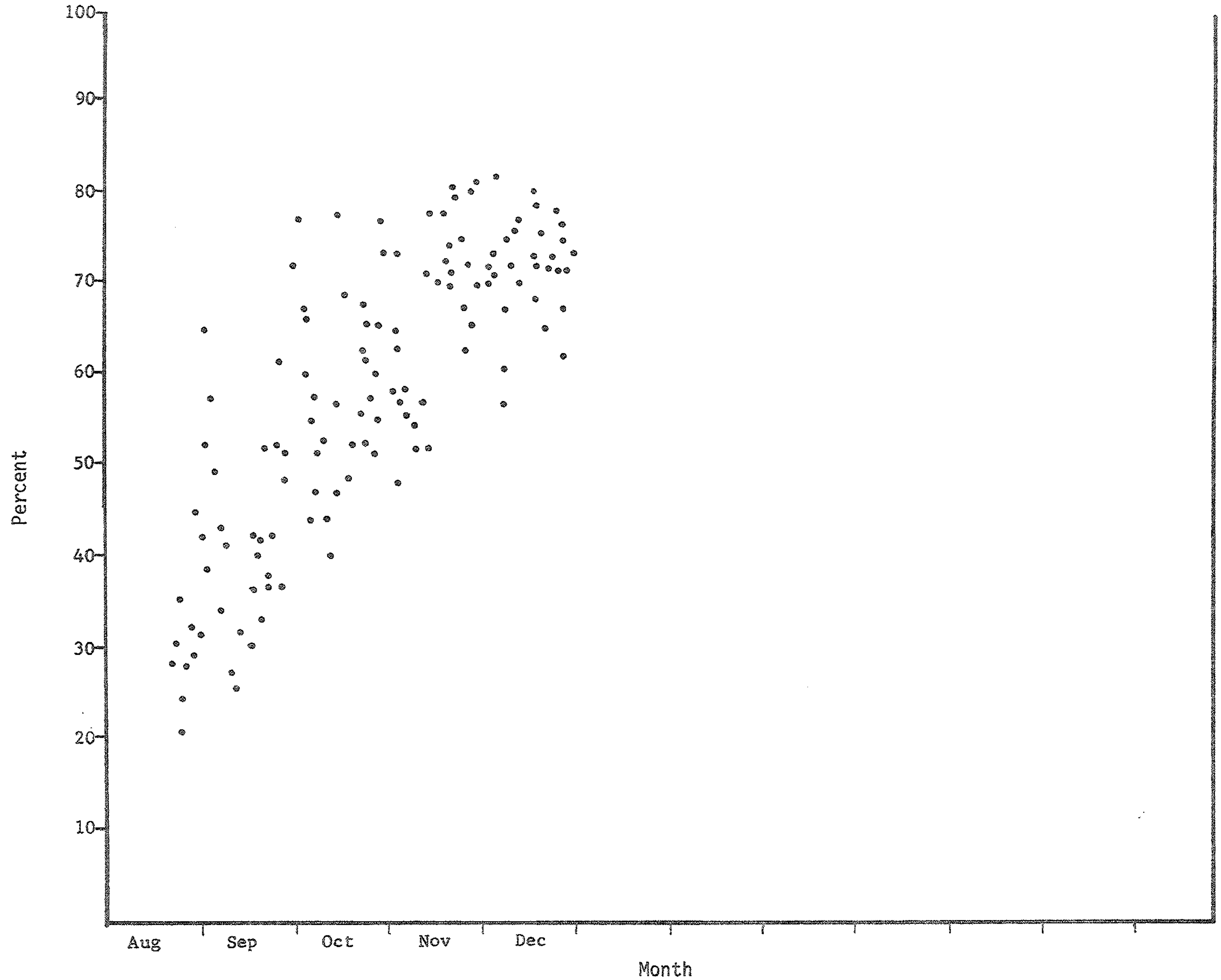


Figure 18. Daily mean relative humidity on northern sites, 1971.

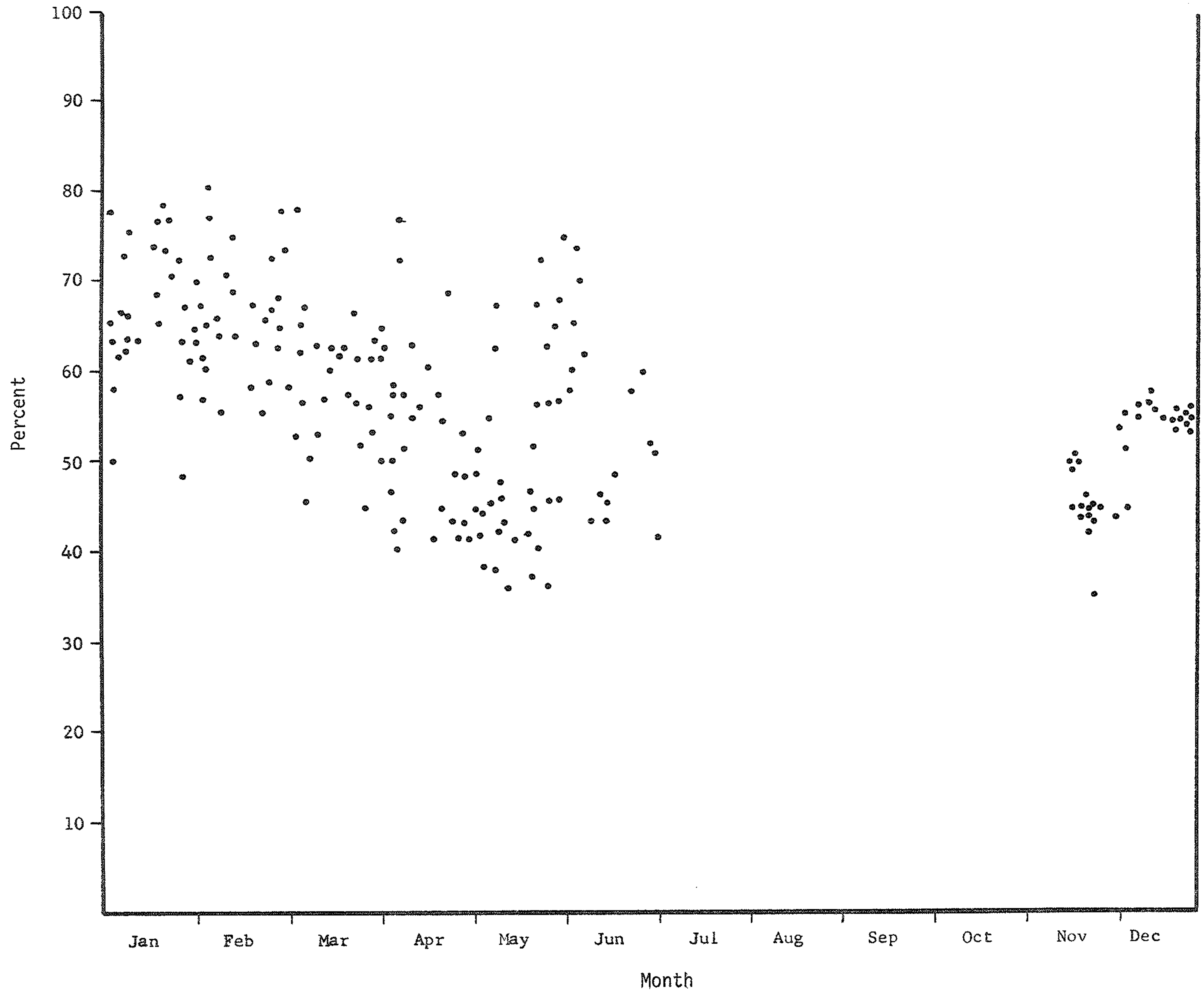


Figure 19. Daily mean relative humidity on northern sites, 1972.

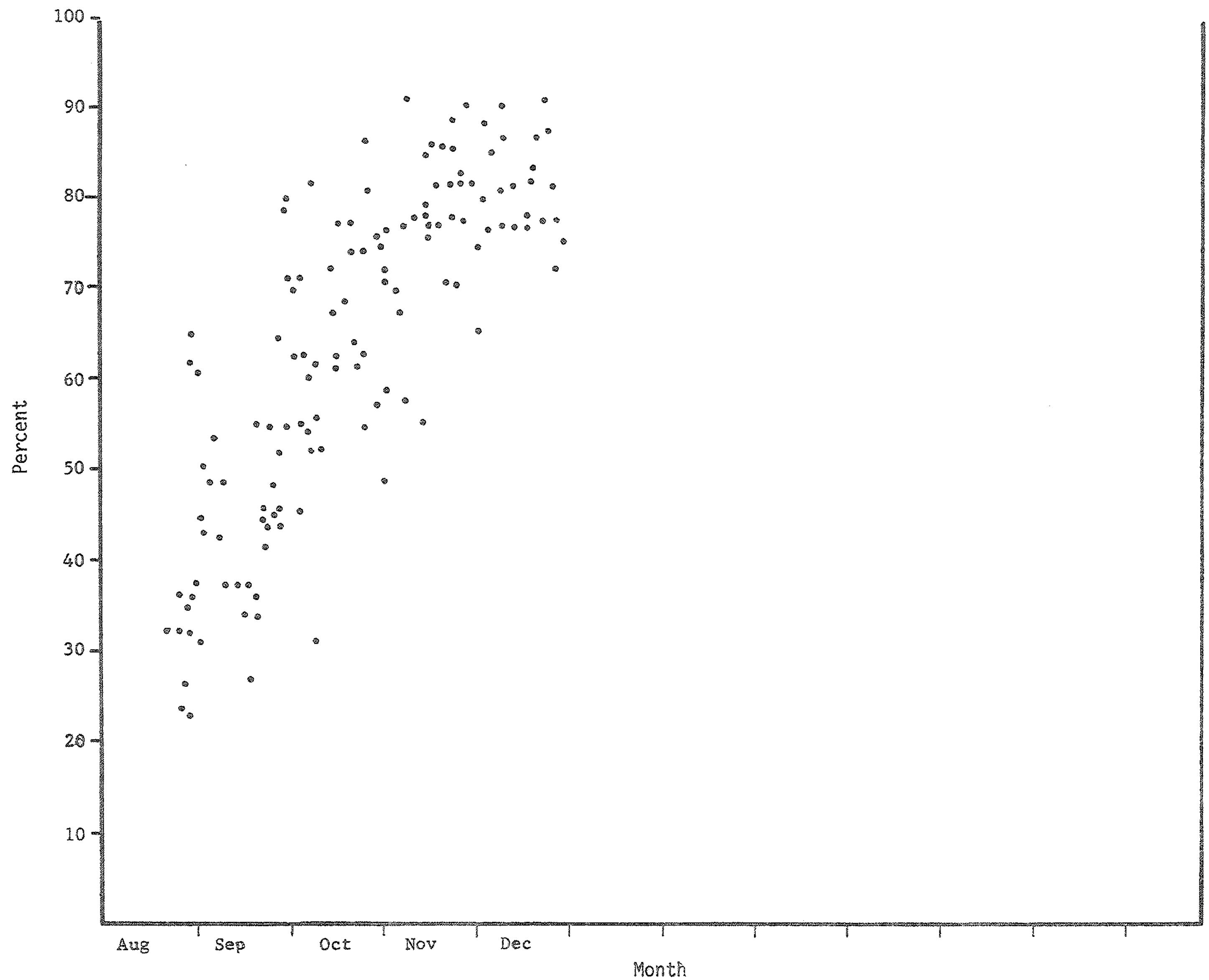


Figure 20. Daily mean relative humdiity on southern sites, 1971.

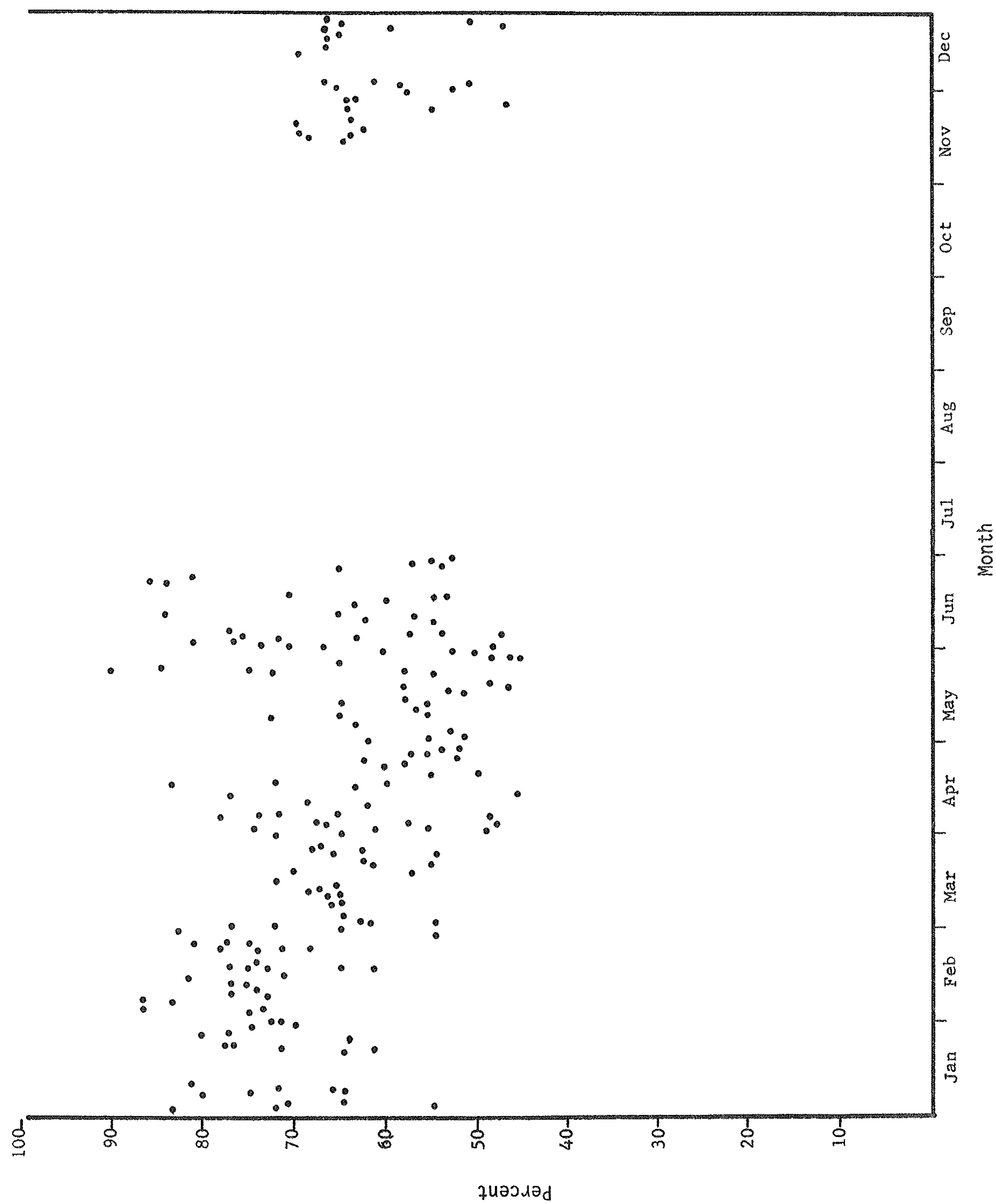


Figure 21. Daily mean relative humidity on southern sites, 1972.

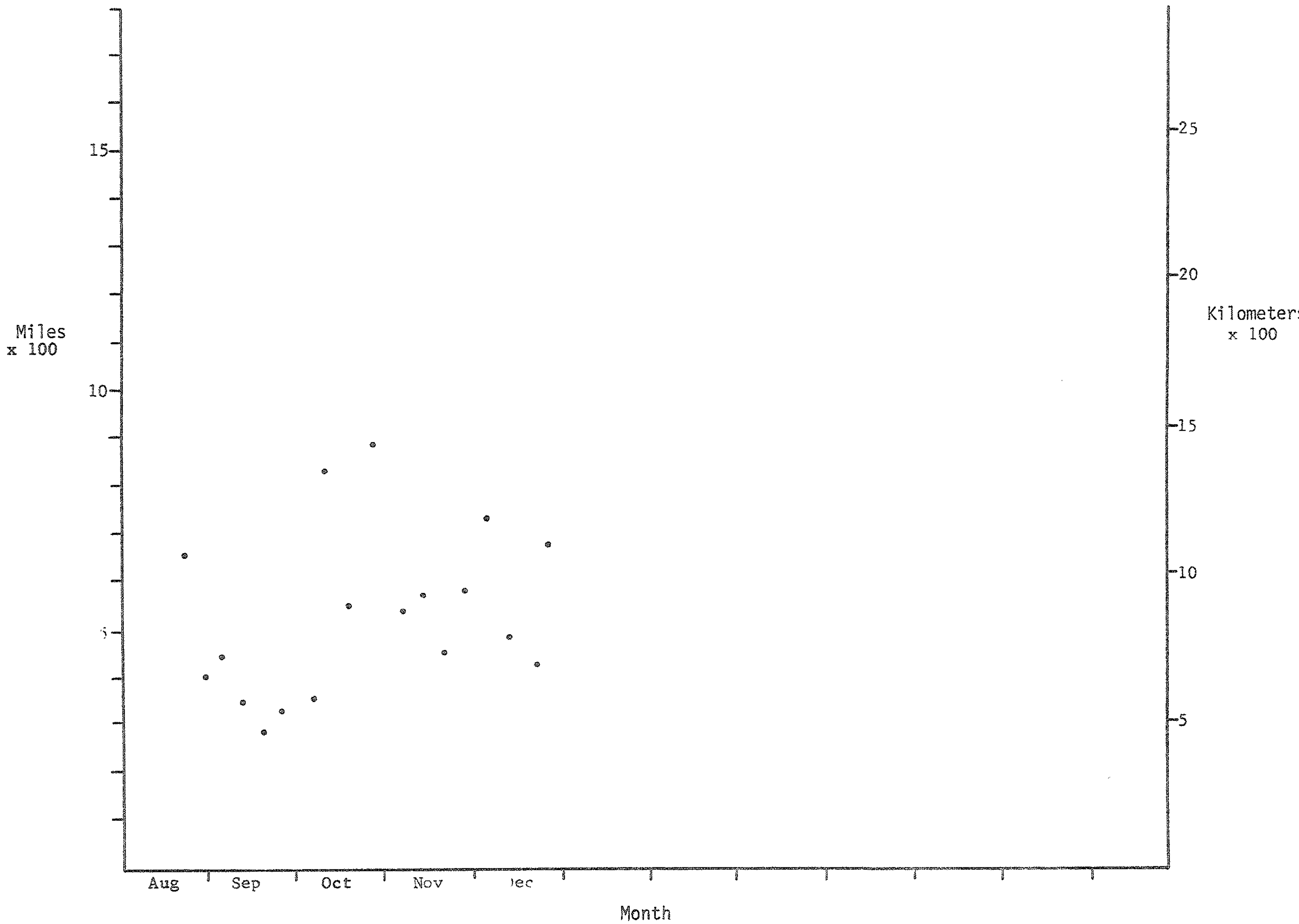


Figure 22. Mean weekly wind velocity (at 2 m) on northern sites, 1971.

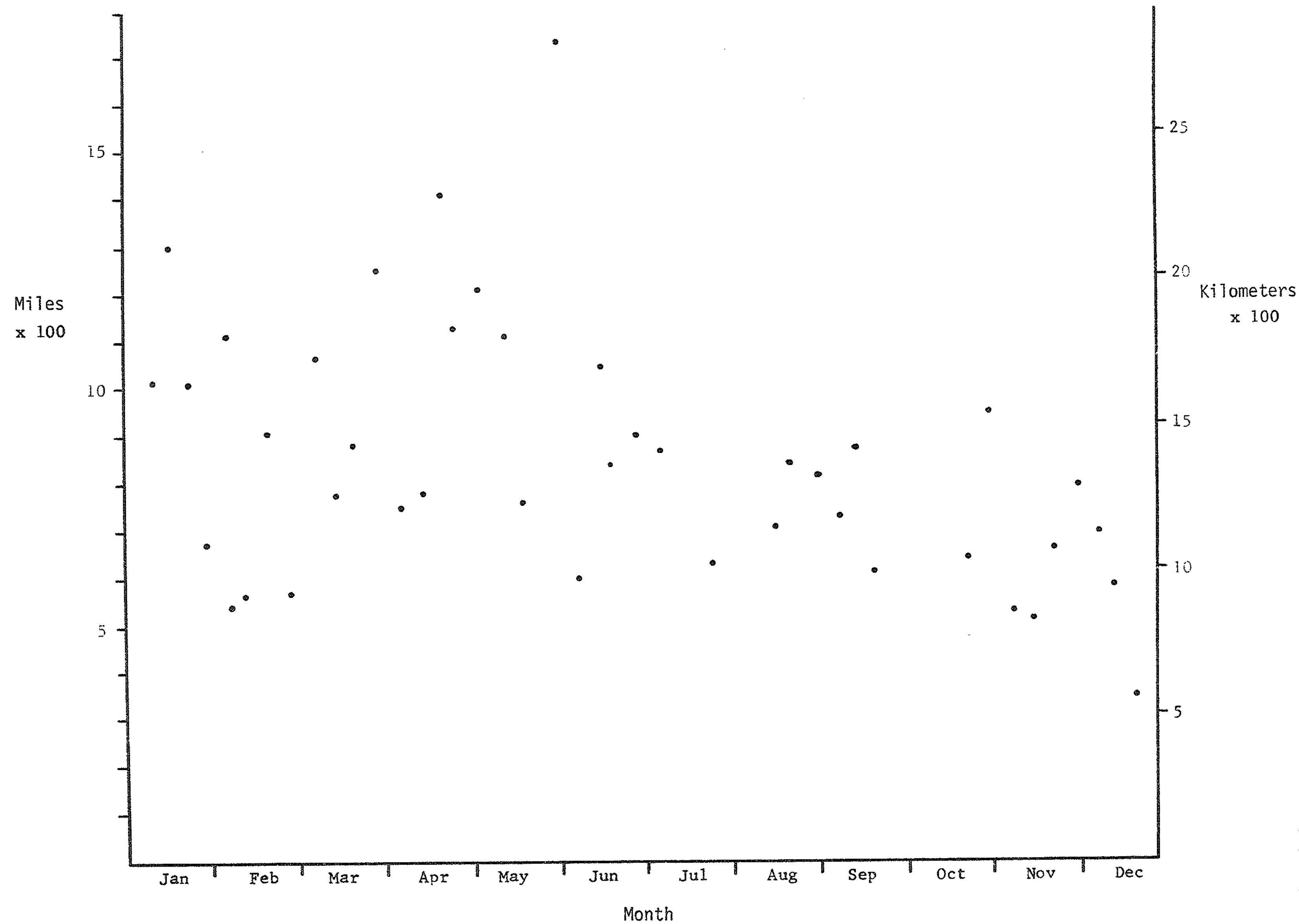


Figure 23. Mean weekly wind velocity (at 2 m) on northern sites, 1972.

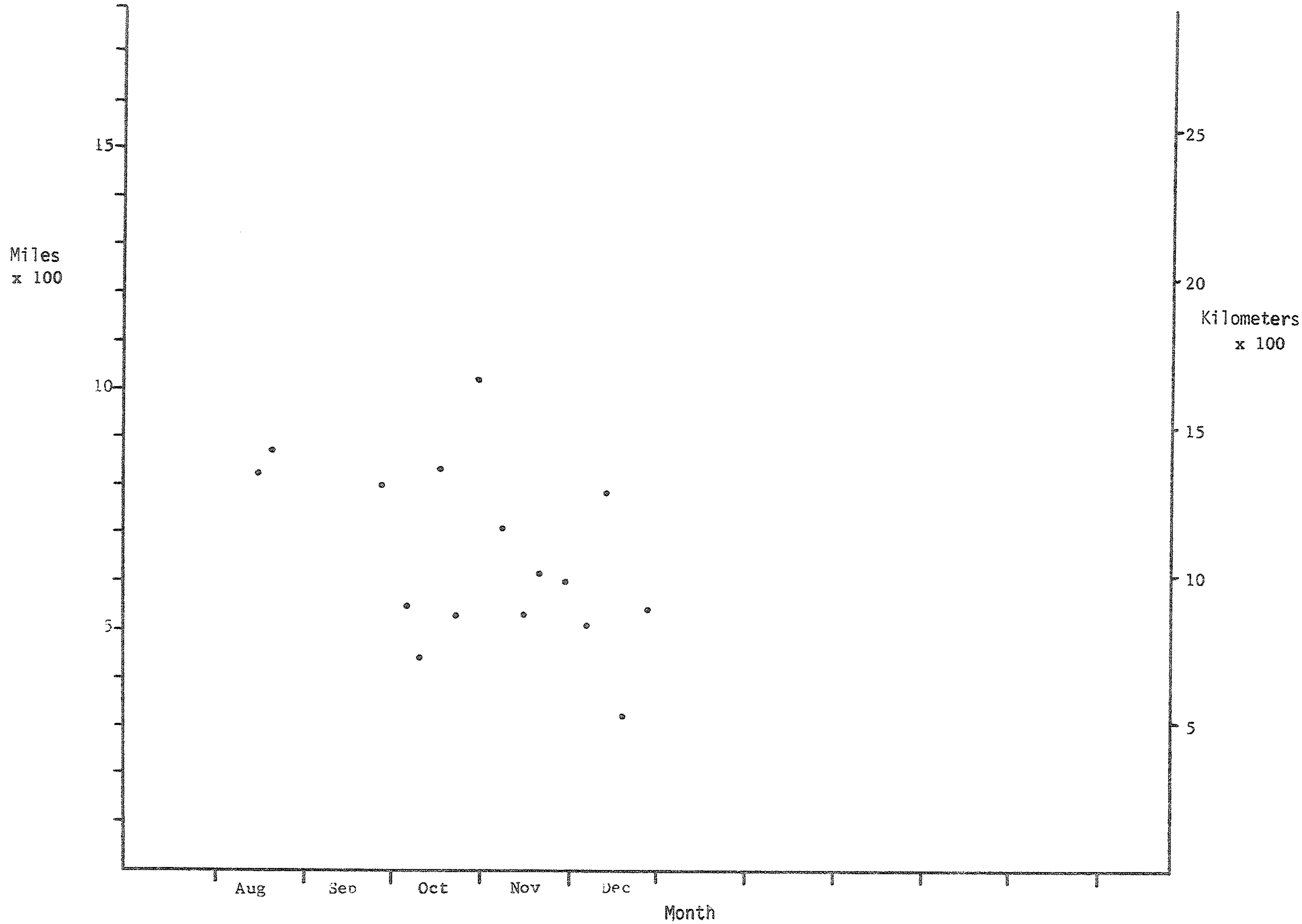


Figure 24. Mean weekly wind velocity (at 2 m) on southern sites, 1971.

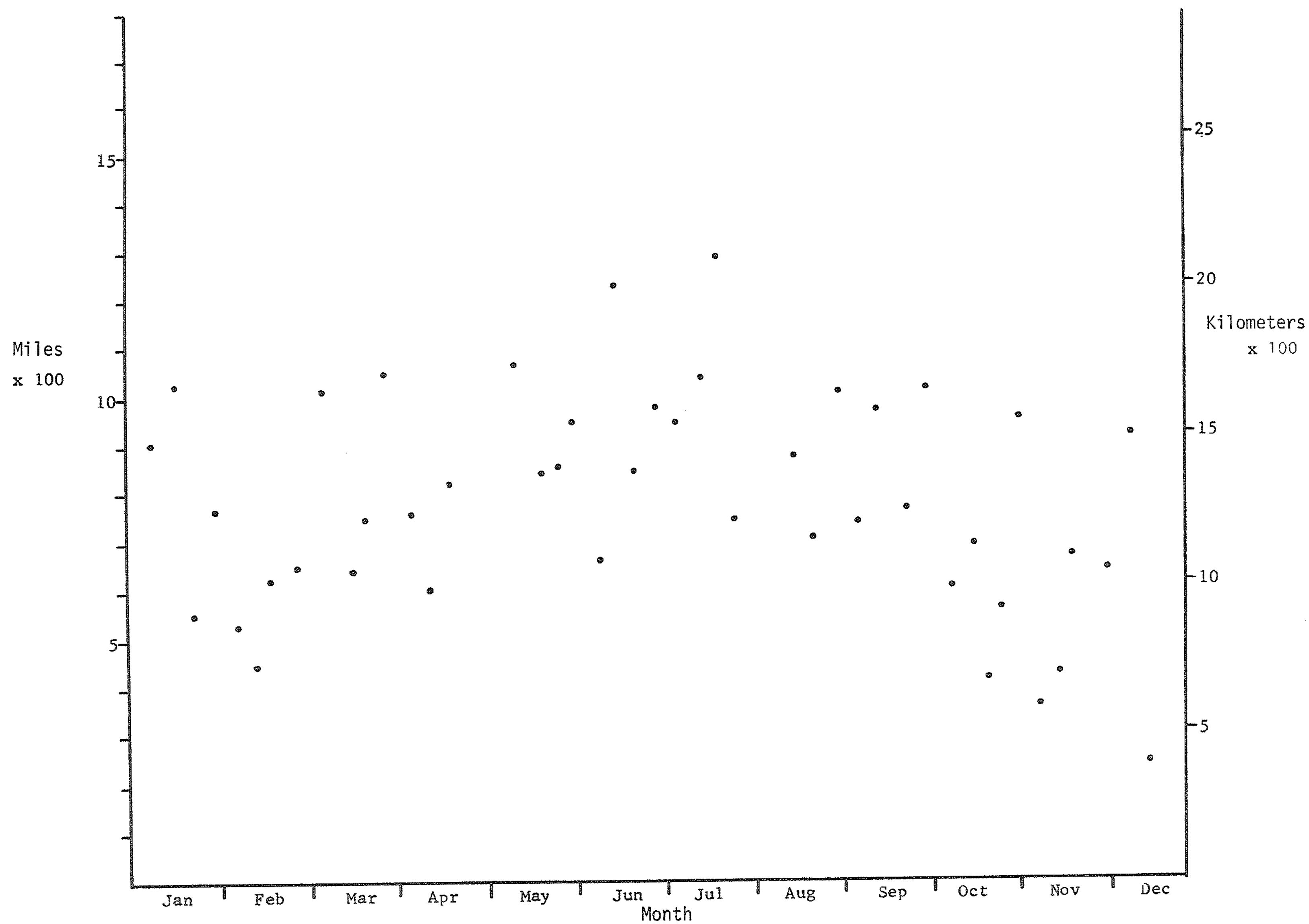


Figure 25. Mean weekly wind velocity (at 2 m) on southern sites, 1972.

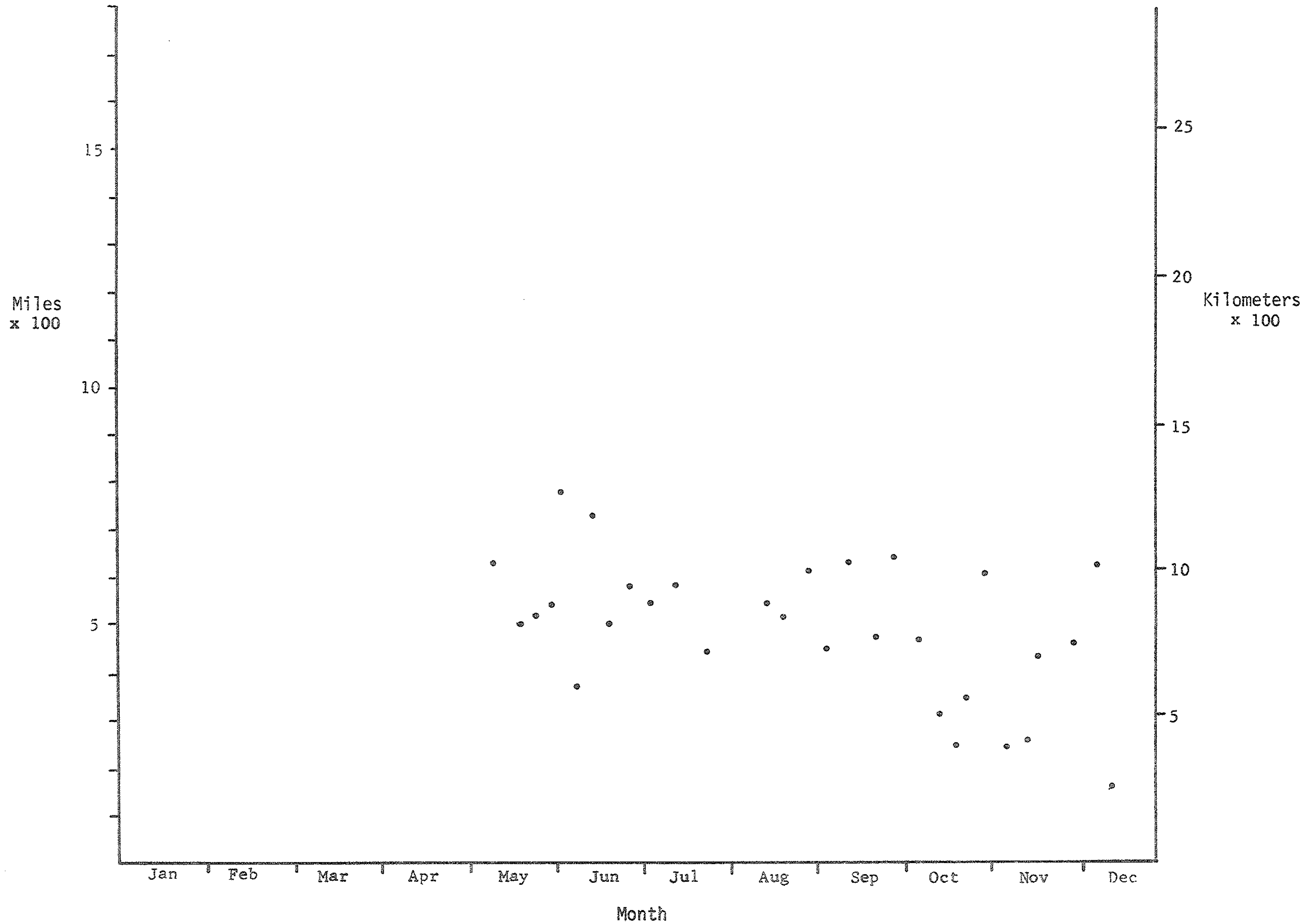


Figure 26. Mean weekly wind velocity (at.5 m) on southern sites, 1972.

A.6. SOIL TEMPERATURE

Maxima, minima, hourly mean, range of daily maxima and minima and range of daily mean soil temperature are presented in Tables 5 (northern sites; 8 months in 1972) and 6 (southern sites; 3 months in 1972) for the soil surface. Graphic presentations of daily maxima and minima at the surface of northern sites for 1972 appear in Figures 27 and 28. Figure 29 depicts soil surface daily mean temperatures on the northern sites for 1972. Figures 30-32 show corresponding data for the southern sites in 1972.

Soil temperatures at several depths on certain dates in 1972 are given in Table 7.

A.7. SOIL MOISTURE

Soil water properties (Table 8) and soil bulk densities (Table 9) are tabled for the southern sites only.

Soil moisture for the southern sites was measured by both the gamma neutron probe techniques. Figures 33-42 illustrate soil water fraction as measured by the gamma probe from July, 1971, to September, 1972. Each Figure represents data for a different depth, ranging from 2.5 cm to 66 cm. Neutron probe recordings of soil water volume (%) are shown in Figures 43-53 from June, 1971, for depths ranging from 31 cm to 183 cm on the southern sites.

Table 5. Monthly soil temperature (C) on surface of northern sites

Month	Min.	Max.	Hourly Mean	Range of Daily Min.	Range of Daily Max.	Range of Daily Means
Apr 72	-7	29	5	-7 - -1	4 - 29	-1 - 12
May 72	-7	46	15	-7 - 10	16 - 46	5 - 22
Jun 72	-1	46	21	-1 - 13	24 - 46	12 - 27
Jul 72	4	46	24	4 - 16	18 - 46	13 - 28
Aug 72	7	46	24	7 - 18	29 - 46	15 - 31
Sep 72	-4	46	15	-4 - 10	10 - 46	4 - 20
Oct 72	-9	35	4	-9 - 7	-1 - 35	-6 - 14
Nov 72	-9	10	-3	-9 - -4	-4 - 10	-5 - 2

Table 6. Monthly soil temperature (C) on surface of southern sites

Month	Min.	Max.	Hourly Mean	Range of Daily Min.	Range of Daily Max.	Range of Daily Means
Apr 72	-15	38	8	-15 - 4	5 - 38	-1 - 14
May 72	-15	46	13	-15 - 10	24 - 46	9 - 25
Jun 72	2	46	20	2 - 26	32 - 46	15 - 28

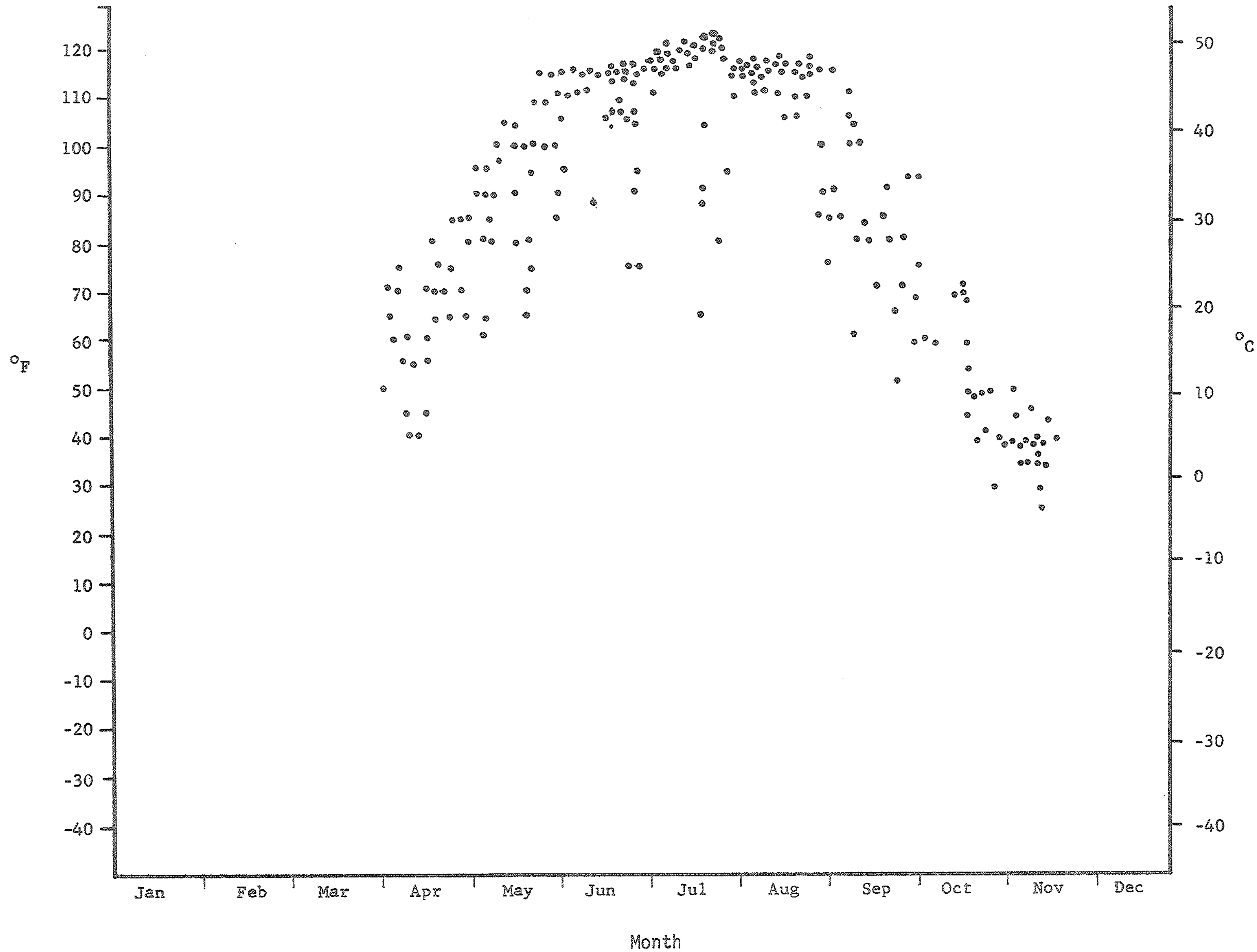


Figure 27. Daily maximum soil surface temperatures on northern sites, 1972.

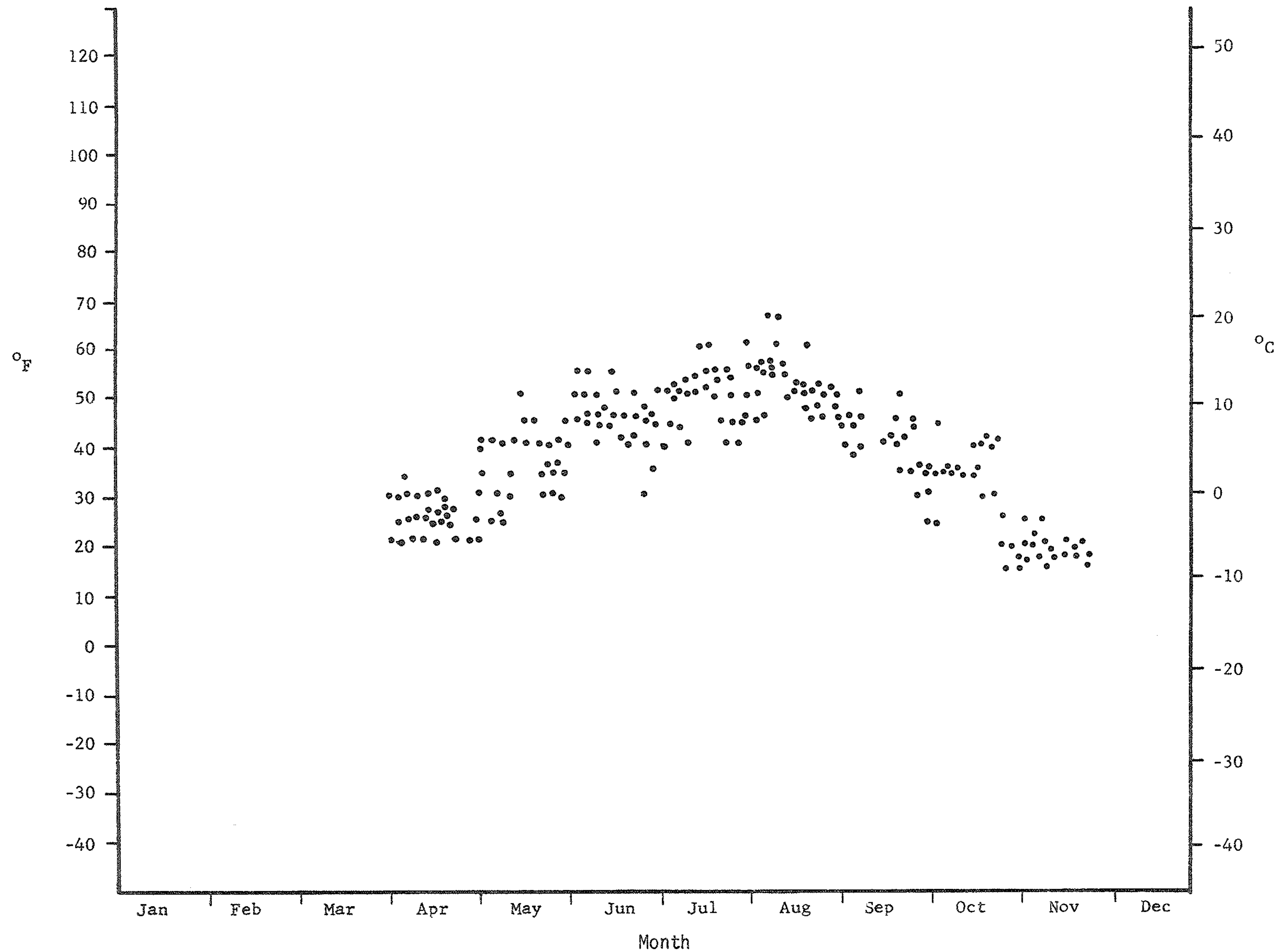


Figure 28. Daily minimum soil surface temperatures on northern sites, 1972.

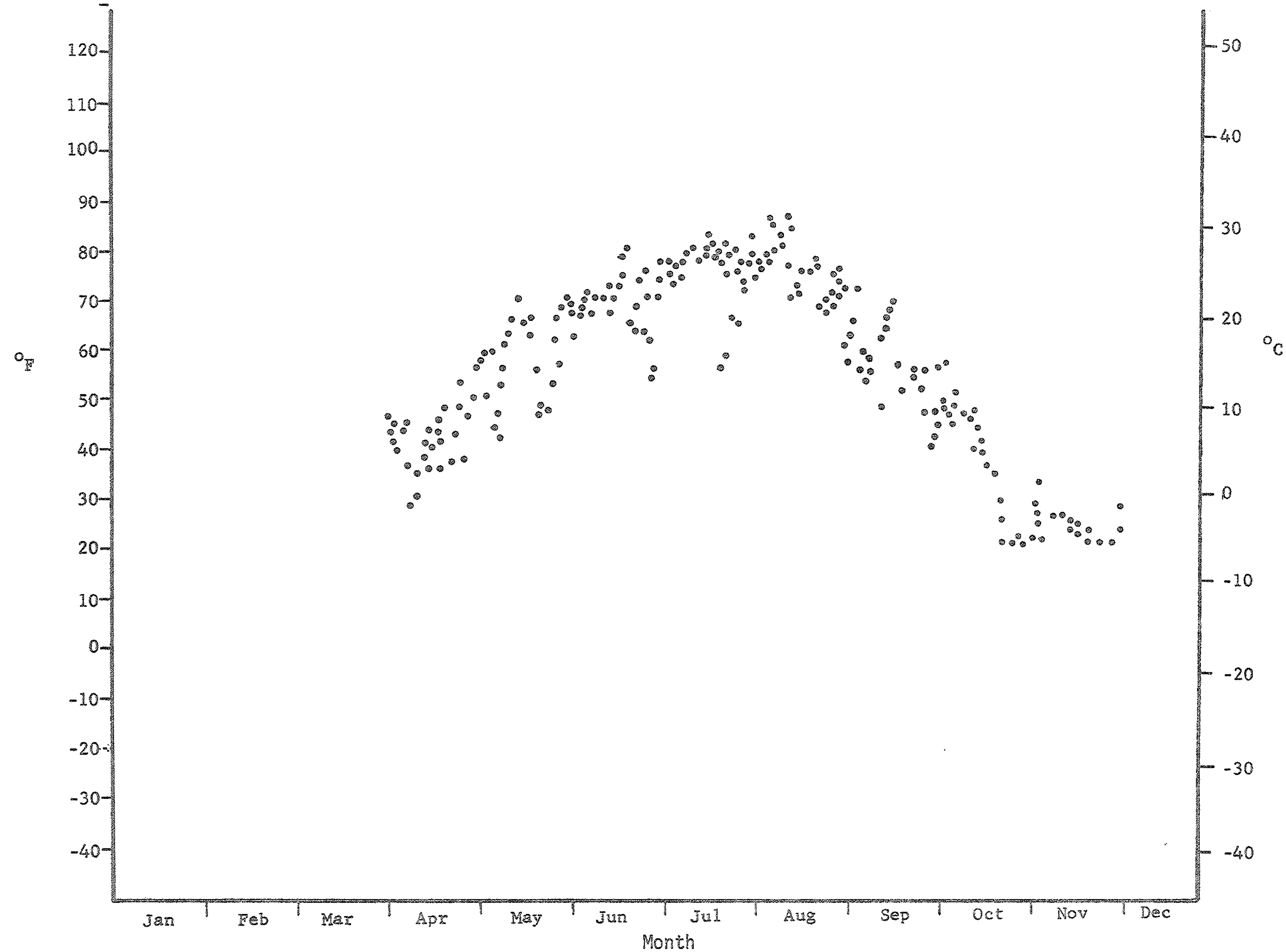


Figure 29. Daily mean soil surface temperatures on northern sites, 1972

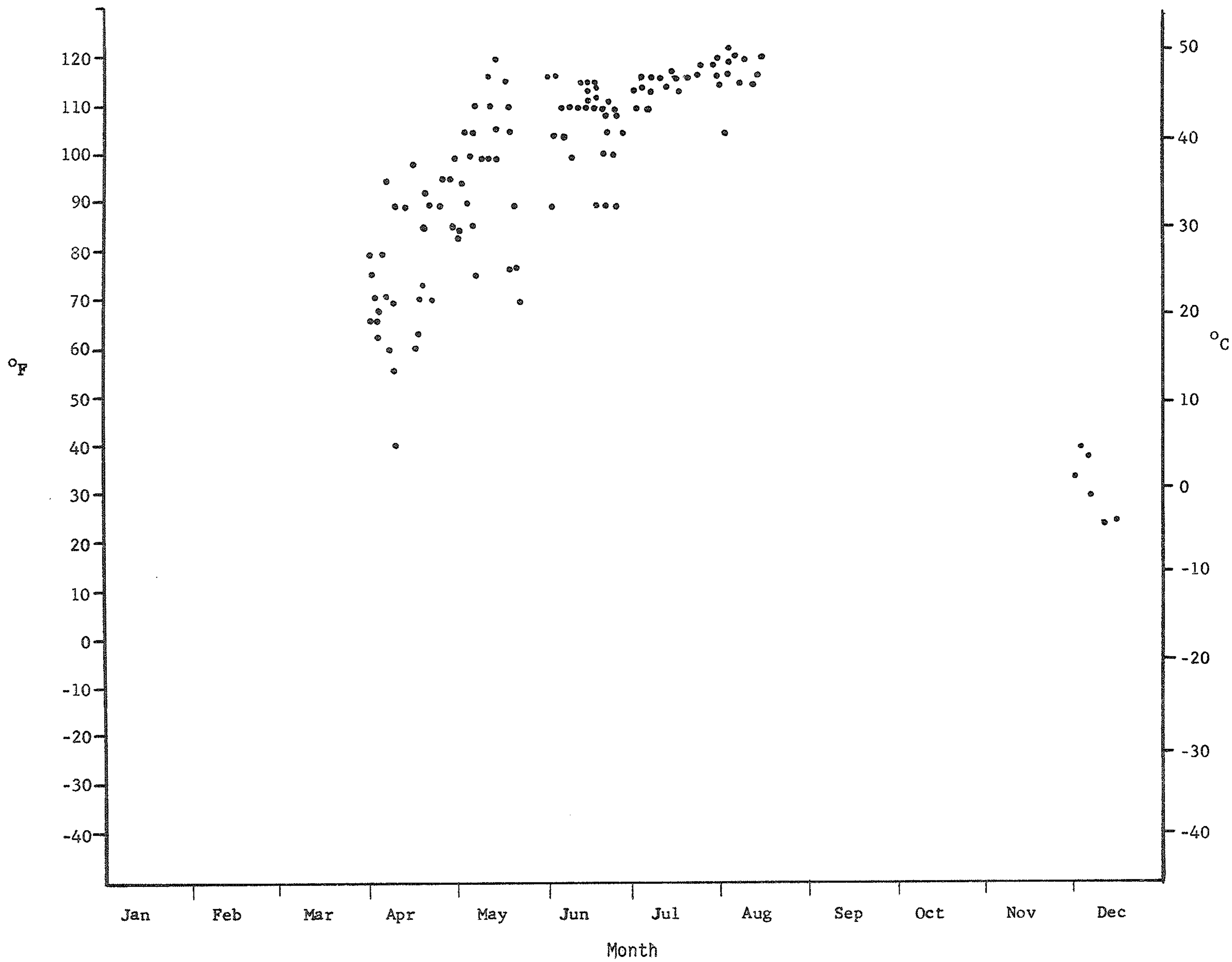


Figure 30. Daily maximum soil surface temperatures on southern sites, 1972.

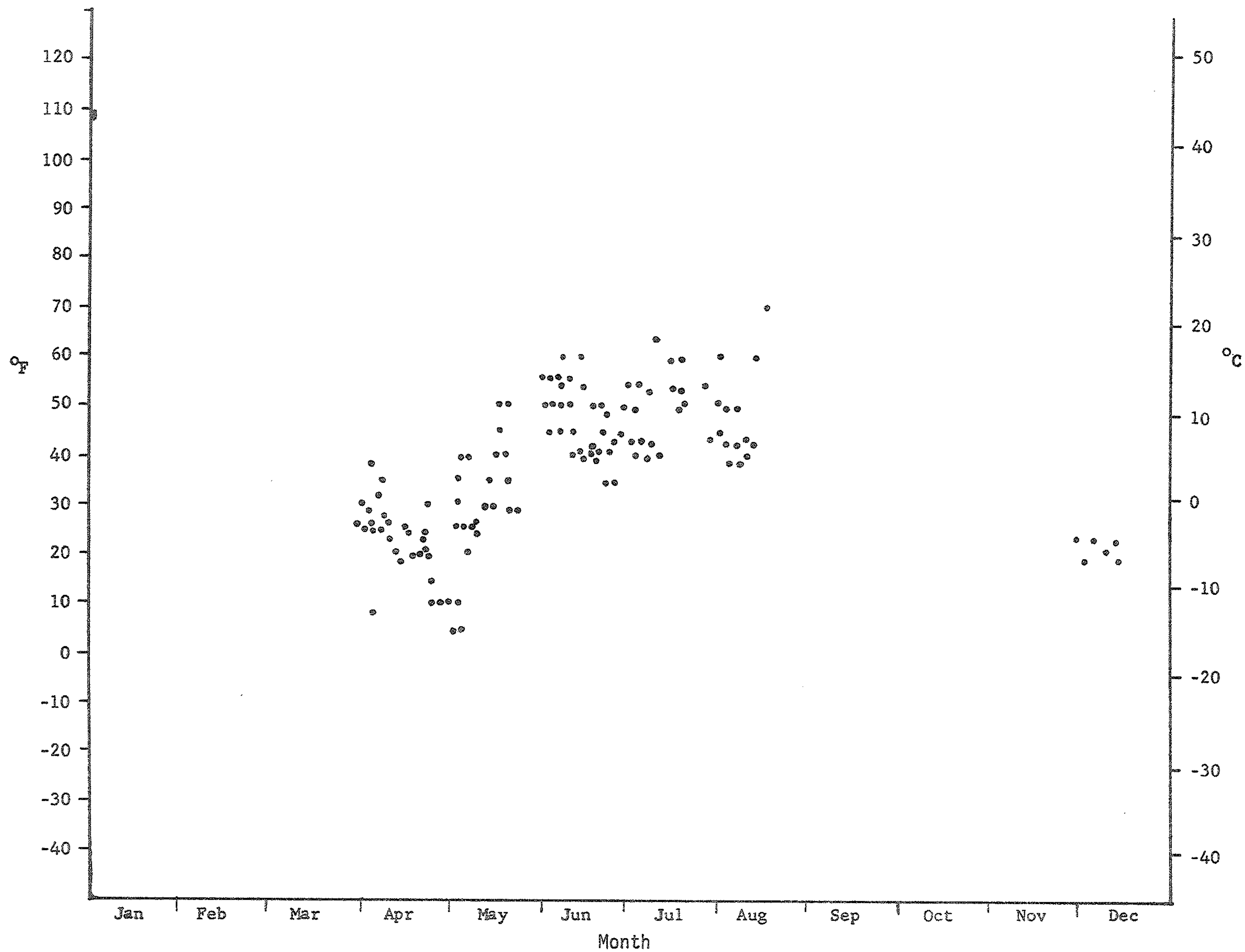


Figure 31. Daily minimum soil surface temperatures on southern sites, 1972.

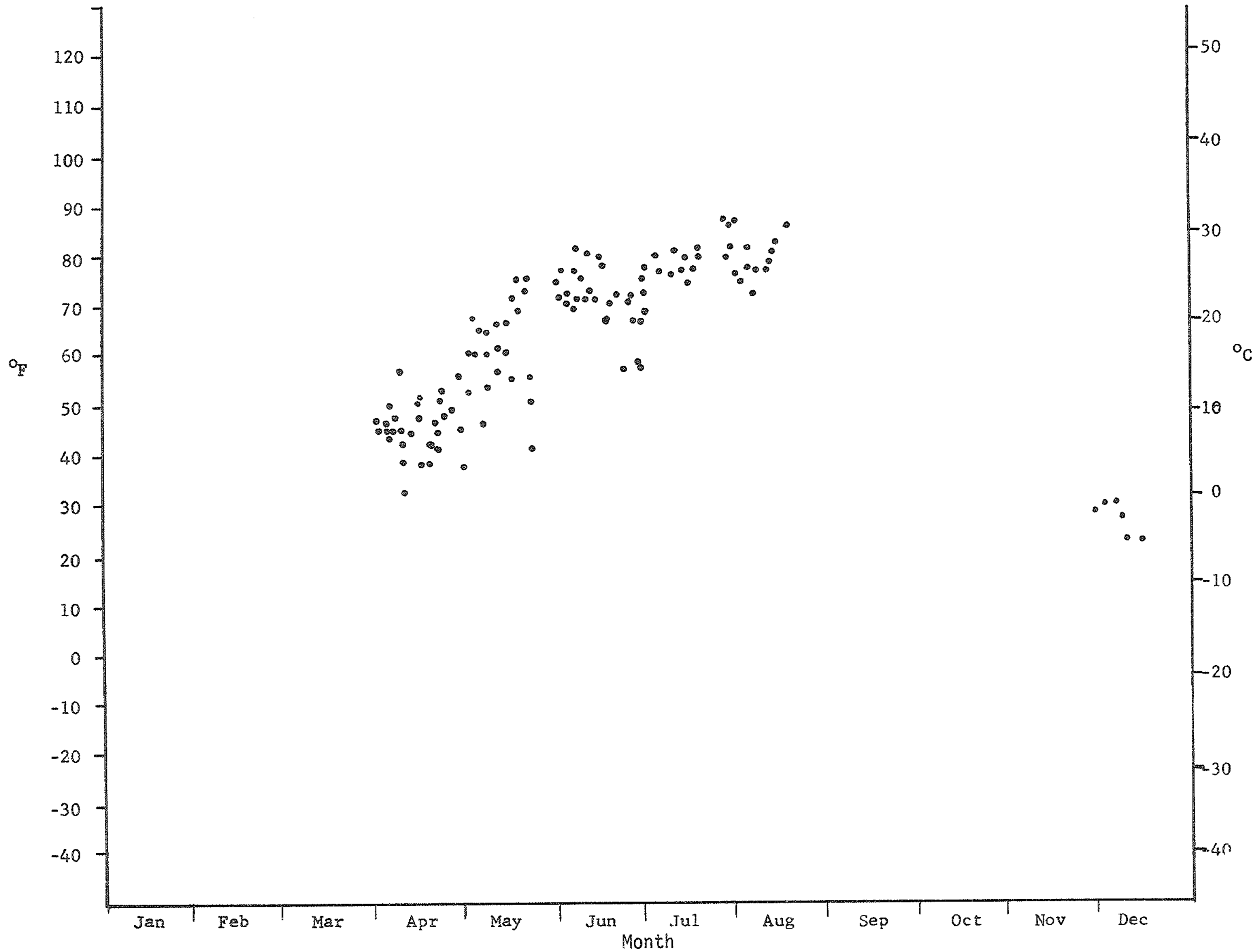


Figure 32. Daily mean soil surface temperatures on southern sites, 1972.

Table 7. Soil temperatures (C) on southern sites

Soil Depth (cm)	Date 12-1-72	12-9-72	12-15-72	12-21-72	12-27-72
1	--	--	2	--	--
3	--	--	2	--	--
7.5	--	--	1	--	--
15	--	--	--	--	--
30	--	1	--	0	--
60	5	7	4	4	4
200	10	12	10	9	9

Table 8. Soil water properties on southern sites

Sample No. 1 - Pressure plate data -- bulk density = 0.87 g/cm^3

Water Content (weight fraction)	Matric Potential (bars)	Total Potential (bars)	Conductivity (cm/min.)
0.48	- .05		4.32 x 10^{-5}
.45			2.70
.42			2.01
.40			1.45
.38			.94
.36	- .33		.29
.33			
.31	- 1.0		
.24	-15.0		

Sample No. 2 - Thermocouple psychrometer sample changer data

Water Content (weight fraction)	Matric Potential (bars)	Total Potential (bars)	Conductivity (cm/min.)
.42		- 7.0	
.33		-14.0	
.27		-3.8 to -4	
.25		9	
.24		-26.5	
.17		-28.0	
.16		-40.5	
.14		-44.0	
.13		-54.0	
.12		-40.0	
.11		-28.2, -33.8	

Table 9. Soil bulk densities on southern sites (sample plot 5)

Neutron Probe Determination		Gamma Probe Determination	
Soil Depth (cm)	pb	Soil Depth (cm)	pb
30	.95	3	.96
46	.80	5	.90
61	1.28	13	.80
76	1.24	20	.92
91	1.22	28	.94
107	1.18	36	.72
122	1.22	43	.77
137	1.28	51	.78
152	1.32	58	.90
168	1.32	66	1.06
183	1.35	74	1.11
198	1.21	81	1.08
		89	1.10
		97	1.15
		104	1.11
		112	1.07
		119	1.12

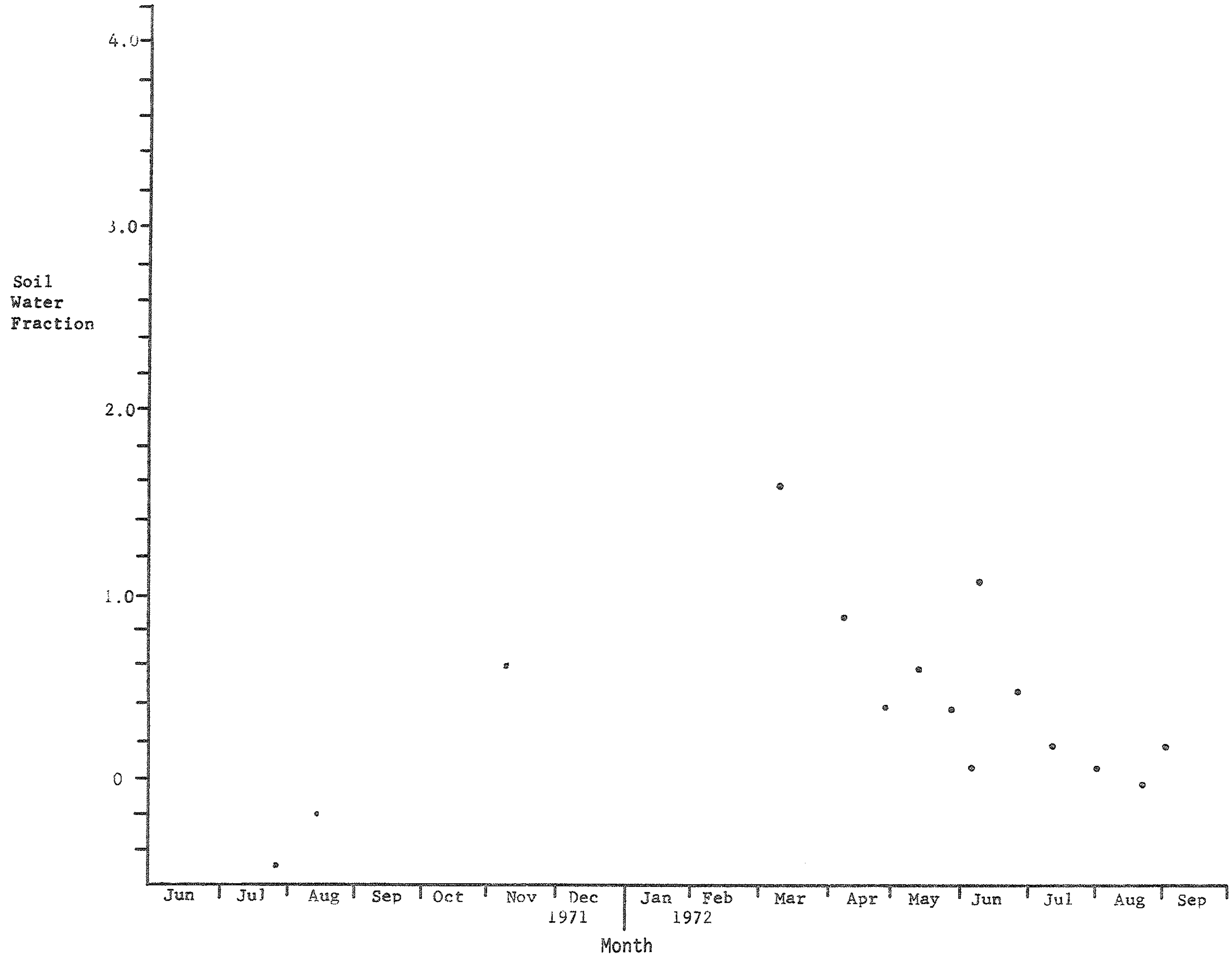


Figure 33. Soil moisture at 2.5 cm depth on southern sites (gamma probe).

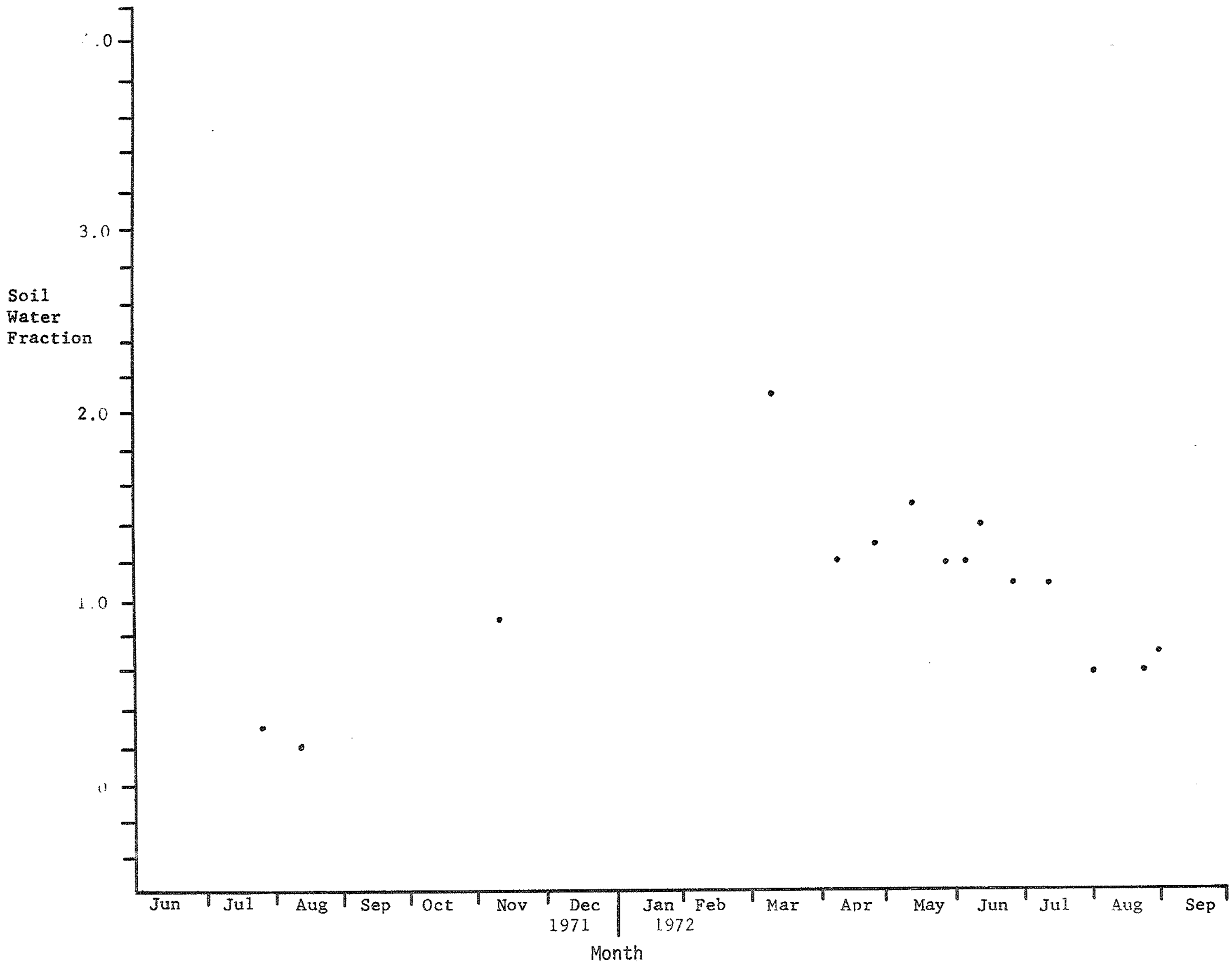


Figure 34. Soil moisture at 5 cm depth on southern sites (gamma probe).

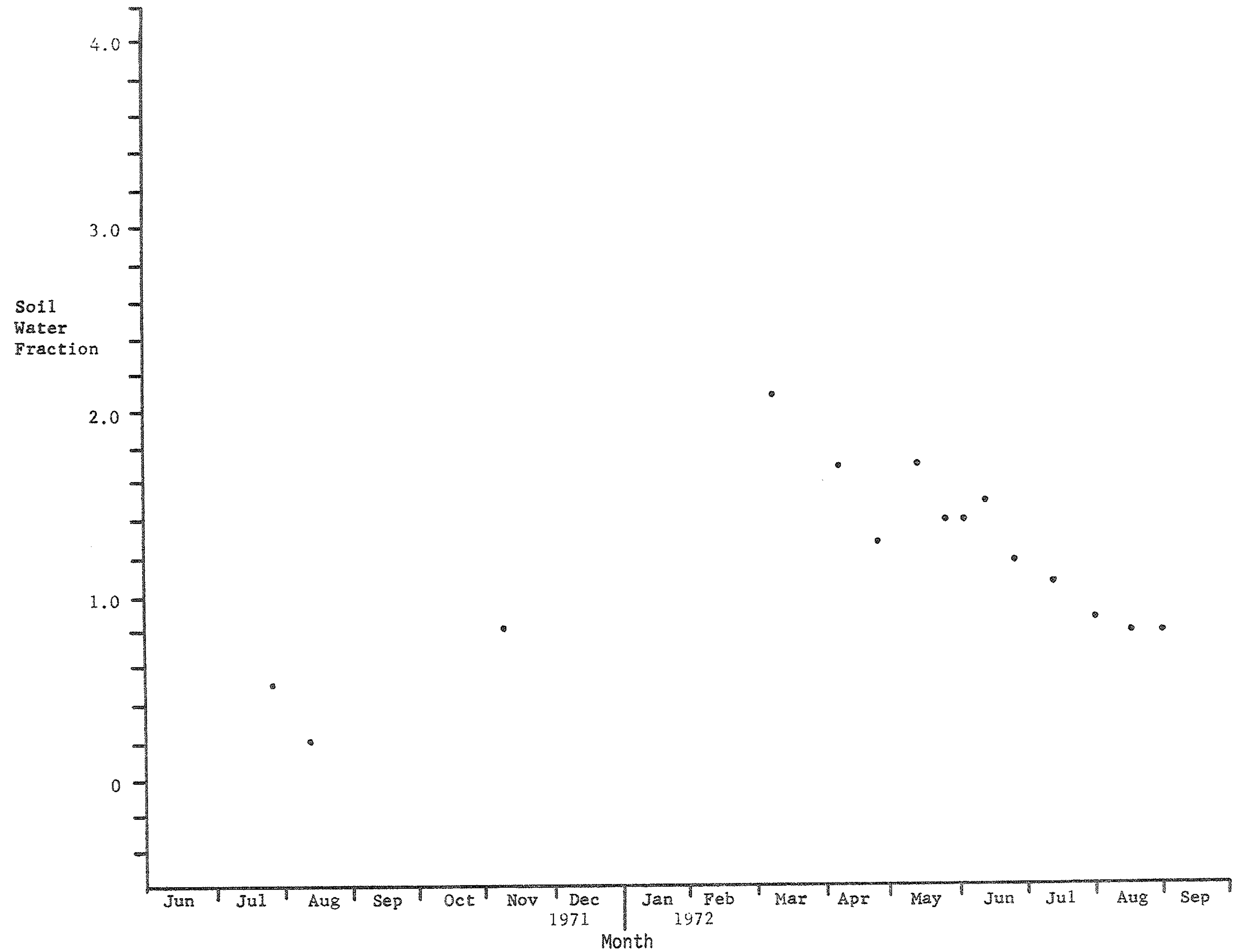


Figure 35. Soil moisture at 13 cm depth on southern sites (gamma probe).

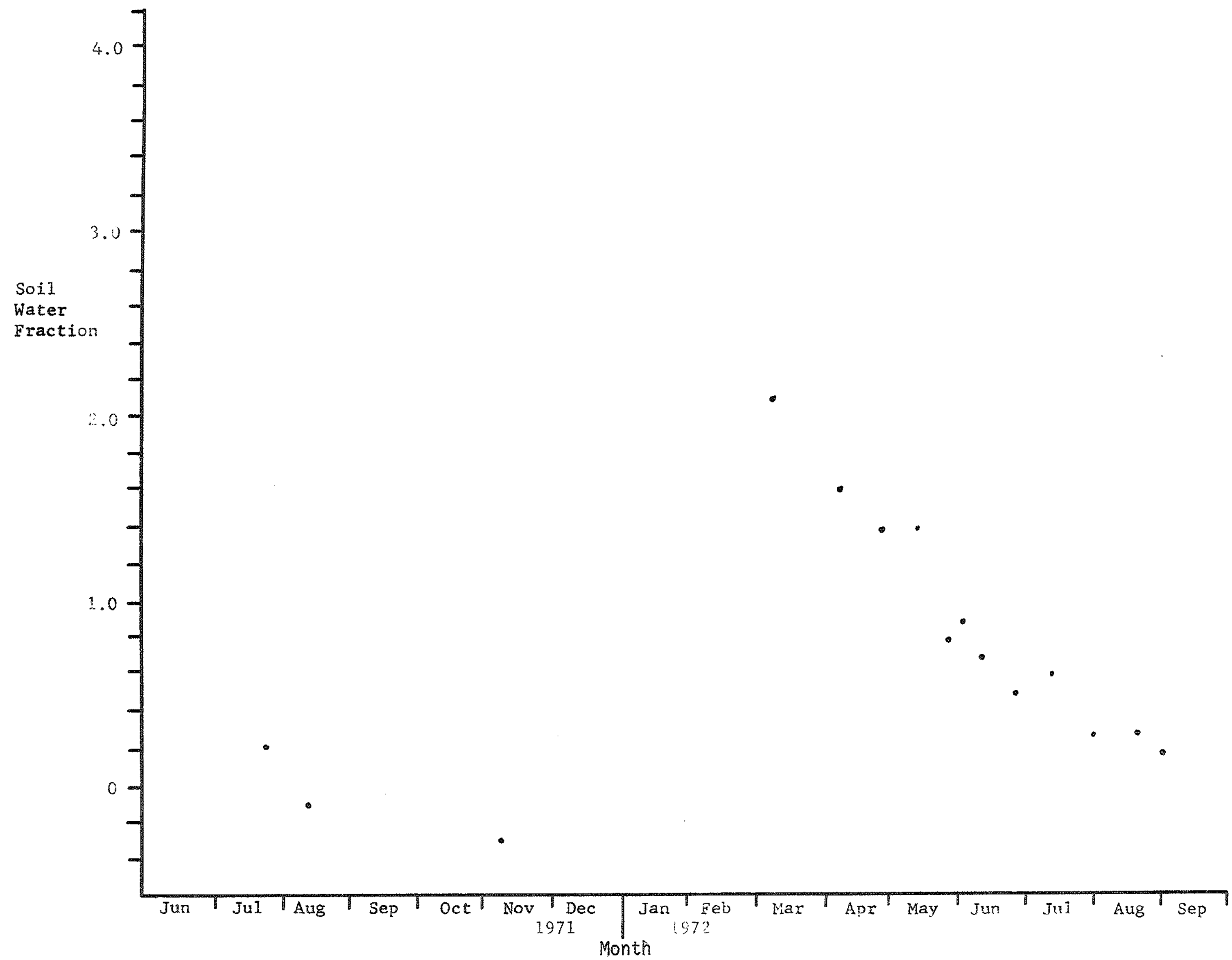


Figure 36. Soil moisture at 20 cm depth on southern sites (gamma probe).

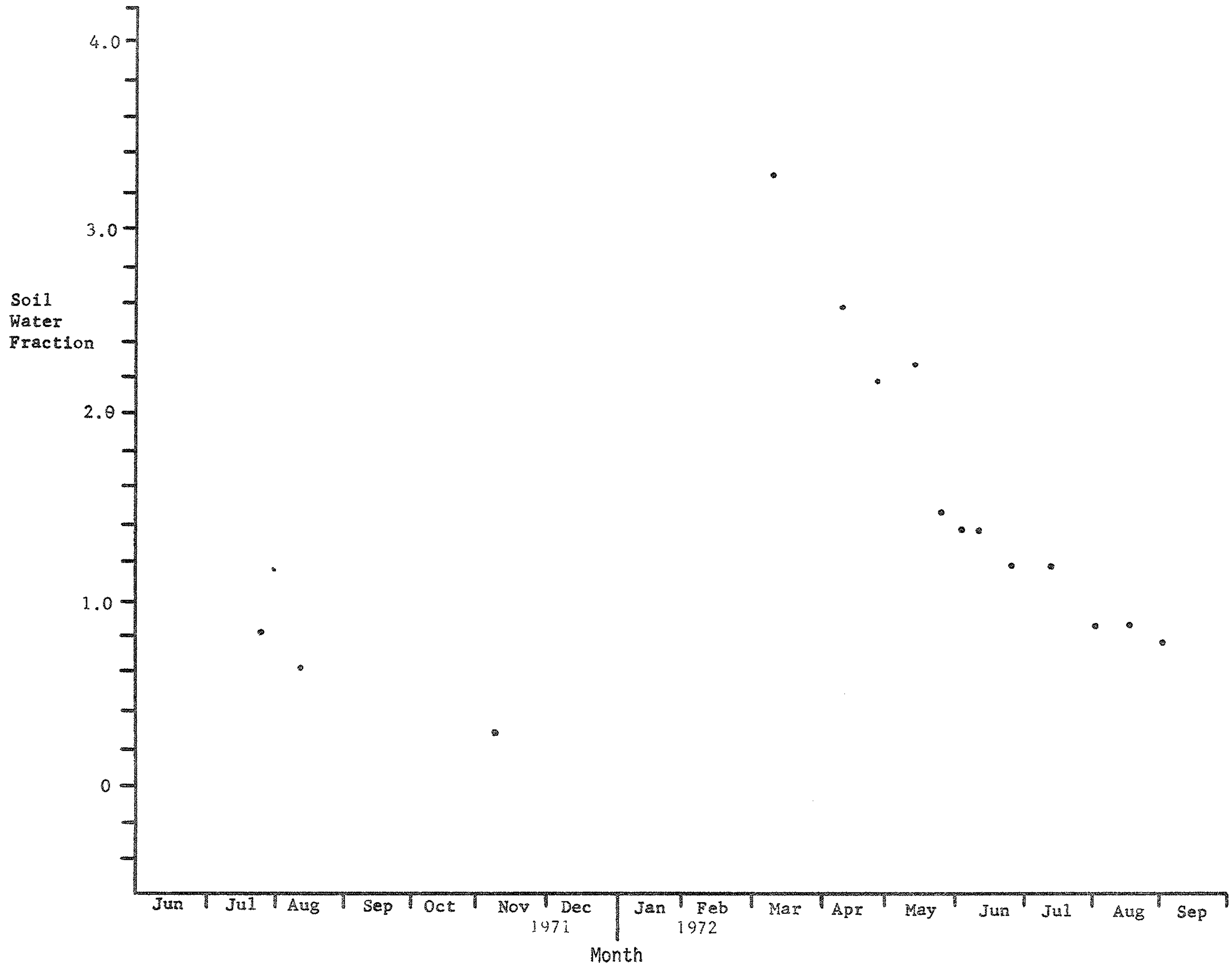


Figure 37. Soil moisture at 2.6 cm depth on southern sites (gamma probe).

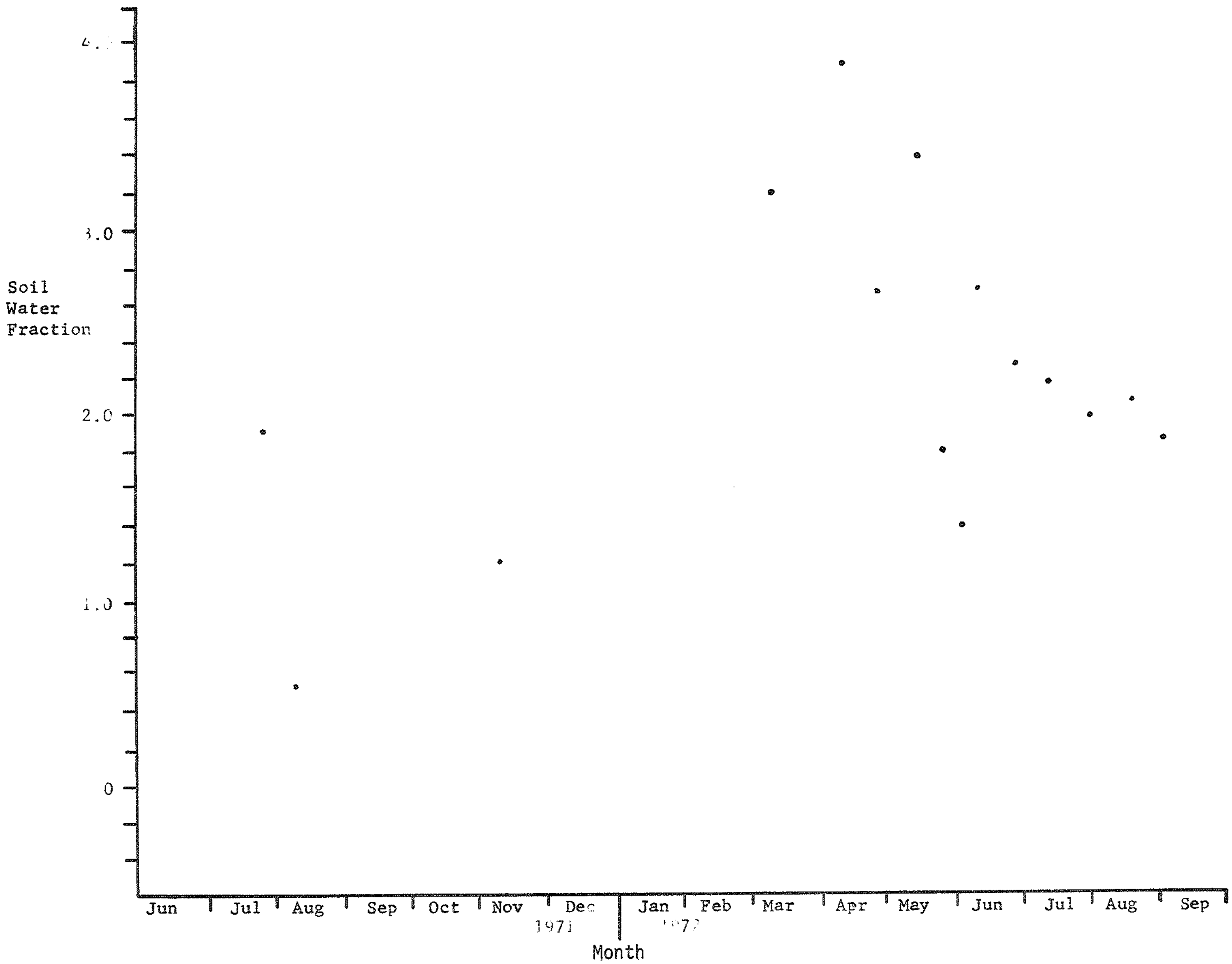


Figure 38. Soil moisture at 36 cm depth on southern sites (gamma probe).

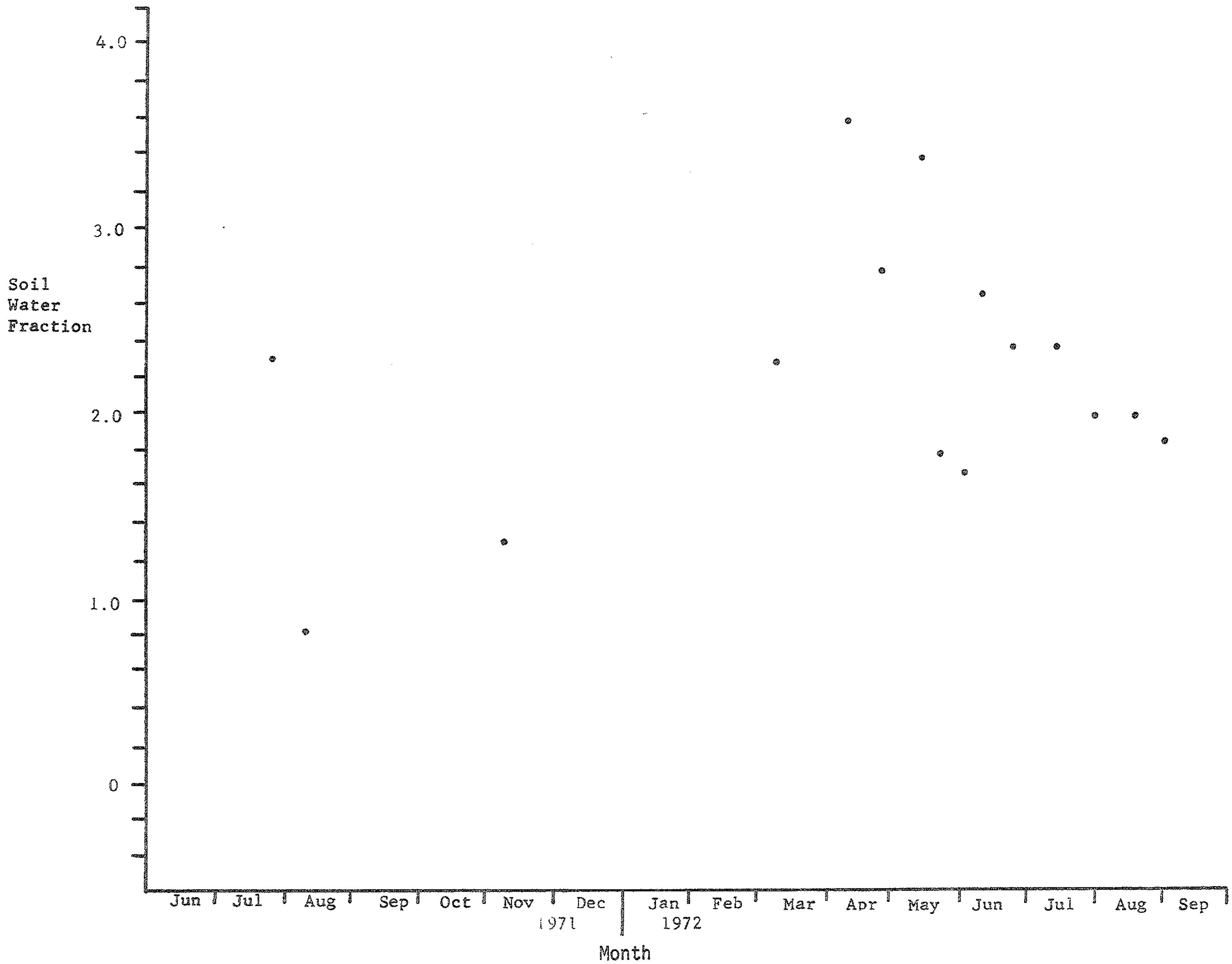


Figure 39. Soil moisture at 43 cm depth on southern sites (gamma probe).

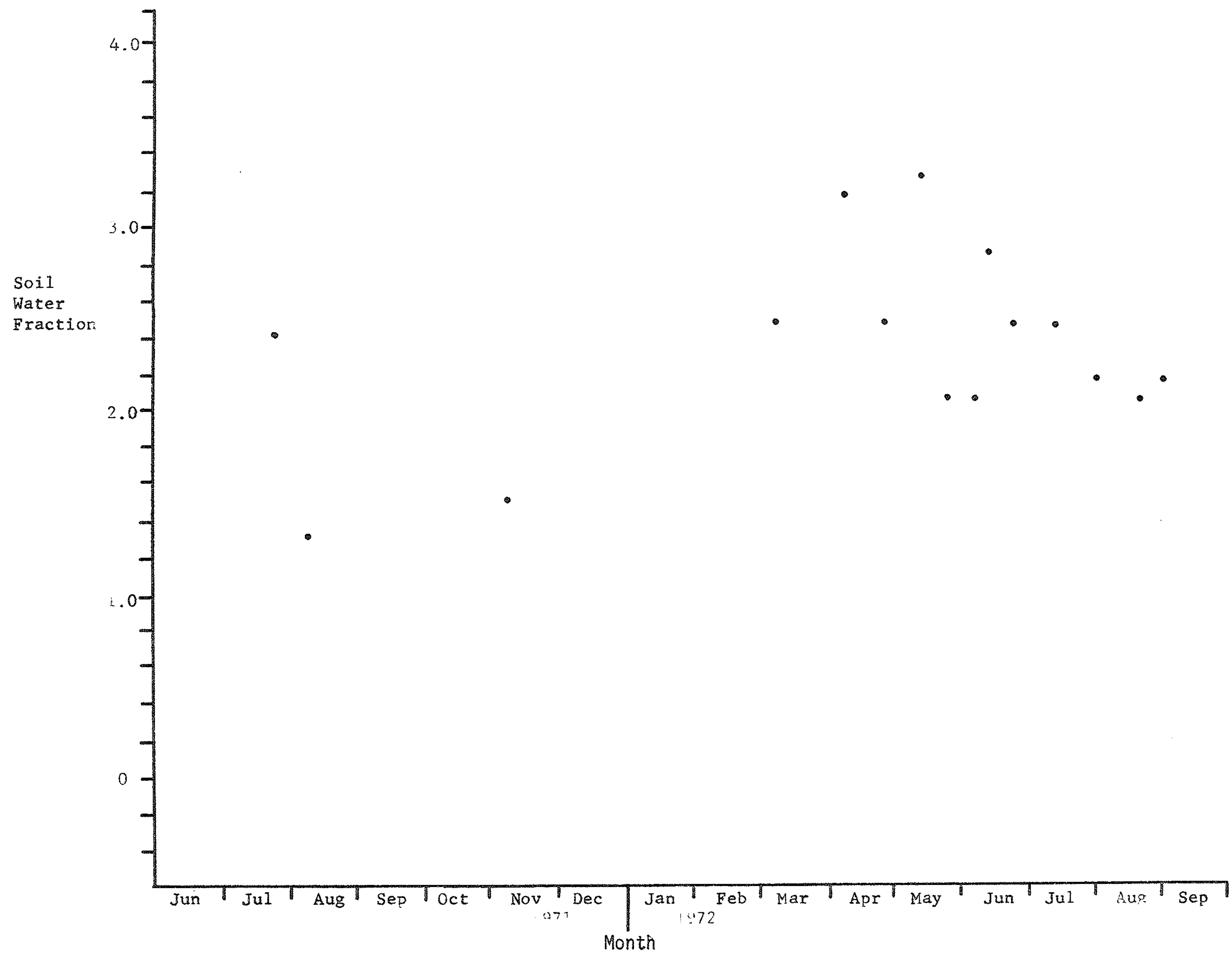


Figure 40. Soil moisture at 51 cm depth on southern sites (gamma probe).

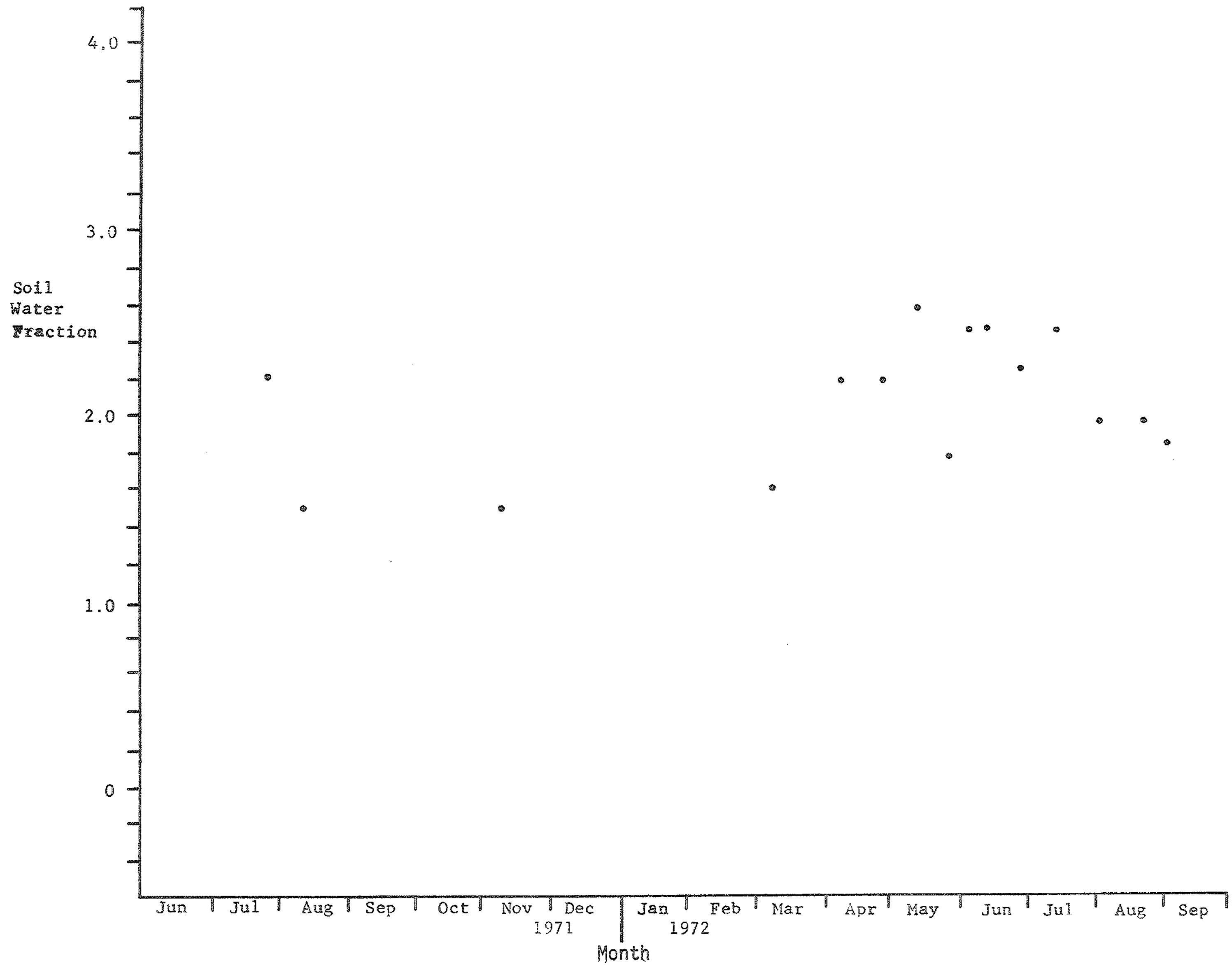


Figure 41. Soil moisture at 58 cm depth on southern sites (gamma probe).

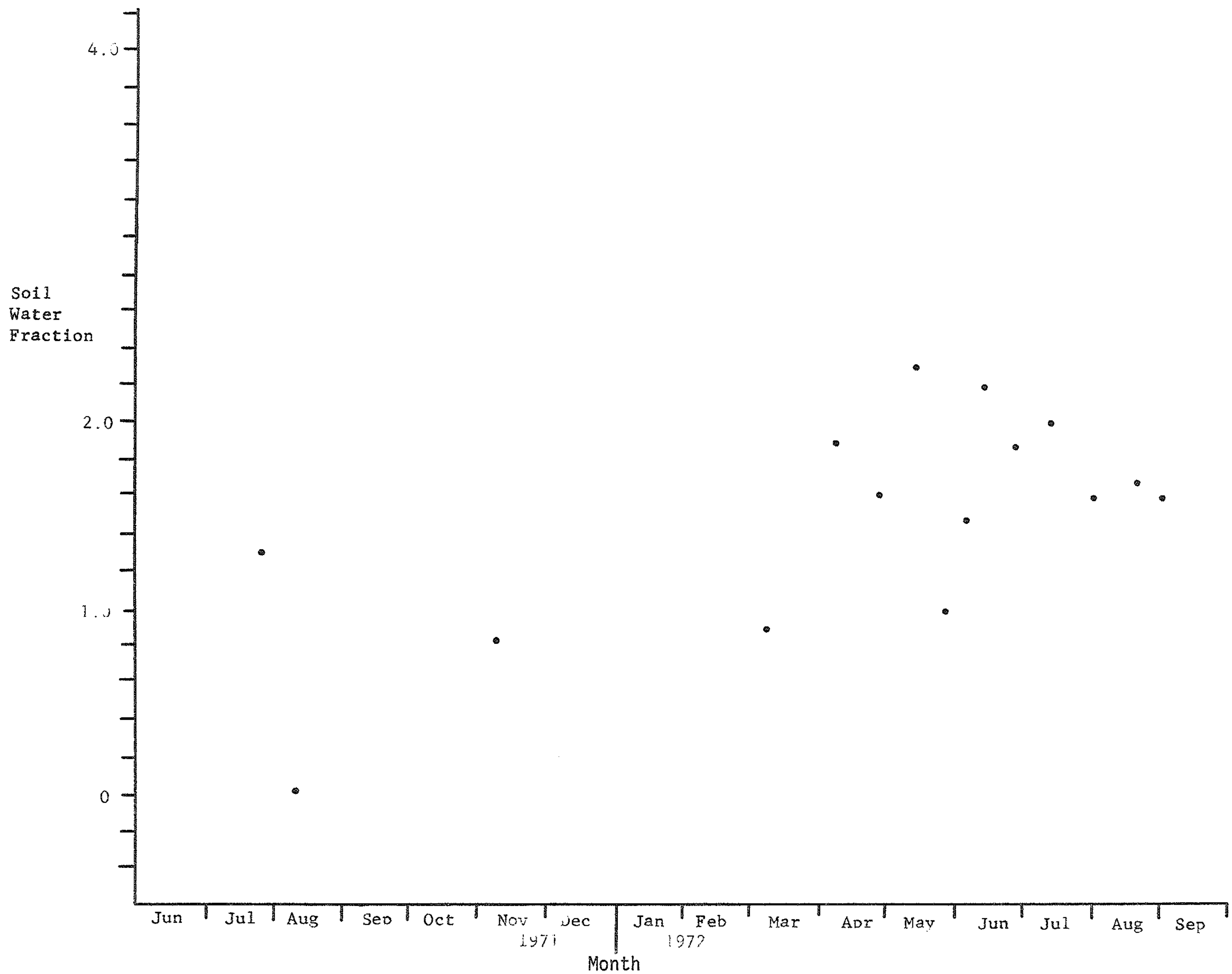


Figure 42. Soil moisture at 66 cm depth on southern sites (gamma probe).

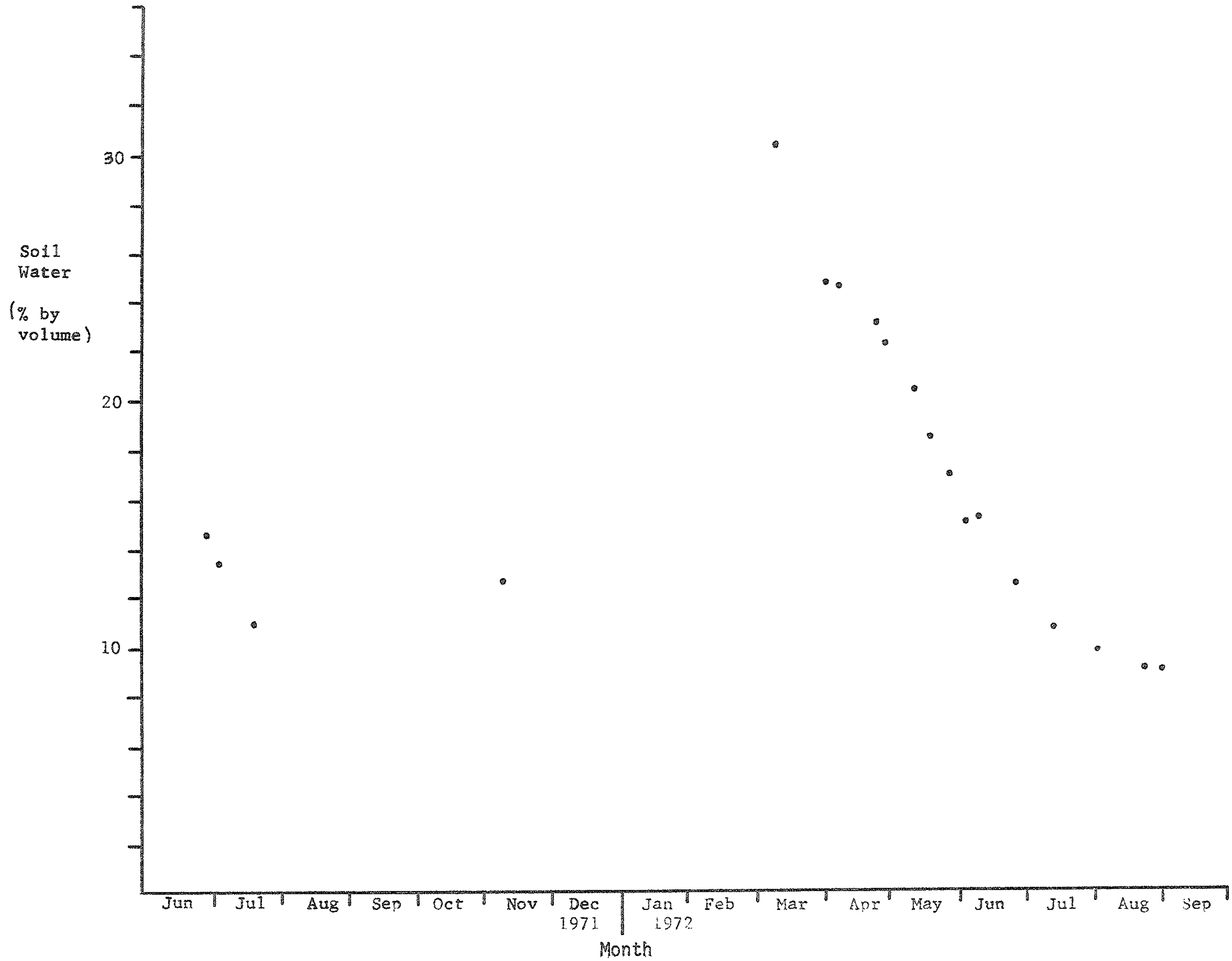


Figure 43. Soil moisture at 31 cm depth on southern sites (neutron probe).

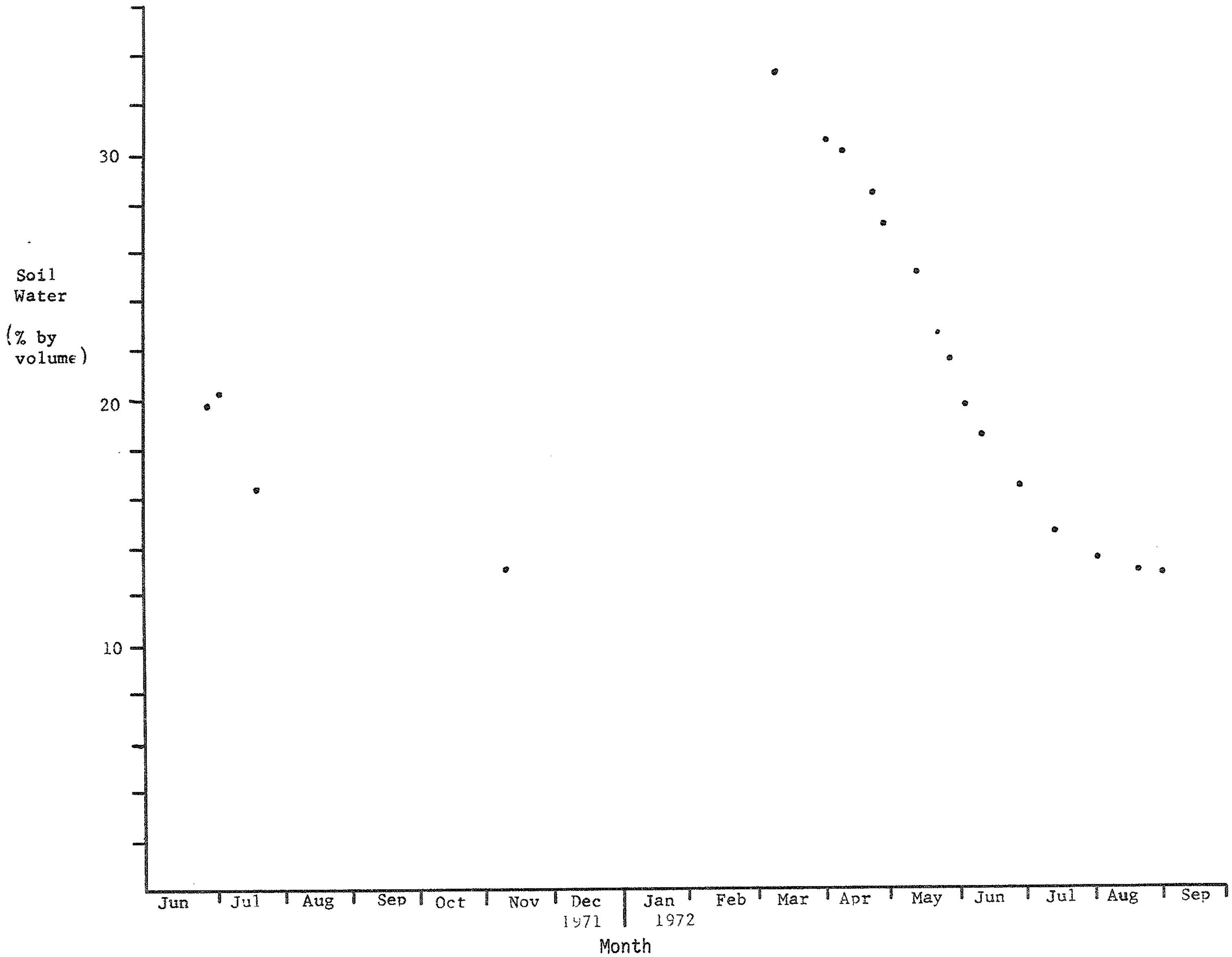


Figure 44. Soil moisture at 46 cm depth on southern sites (neutron probe).

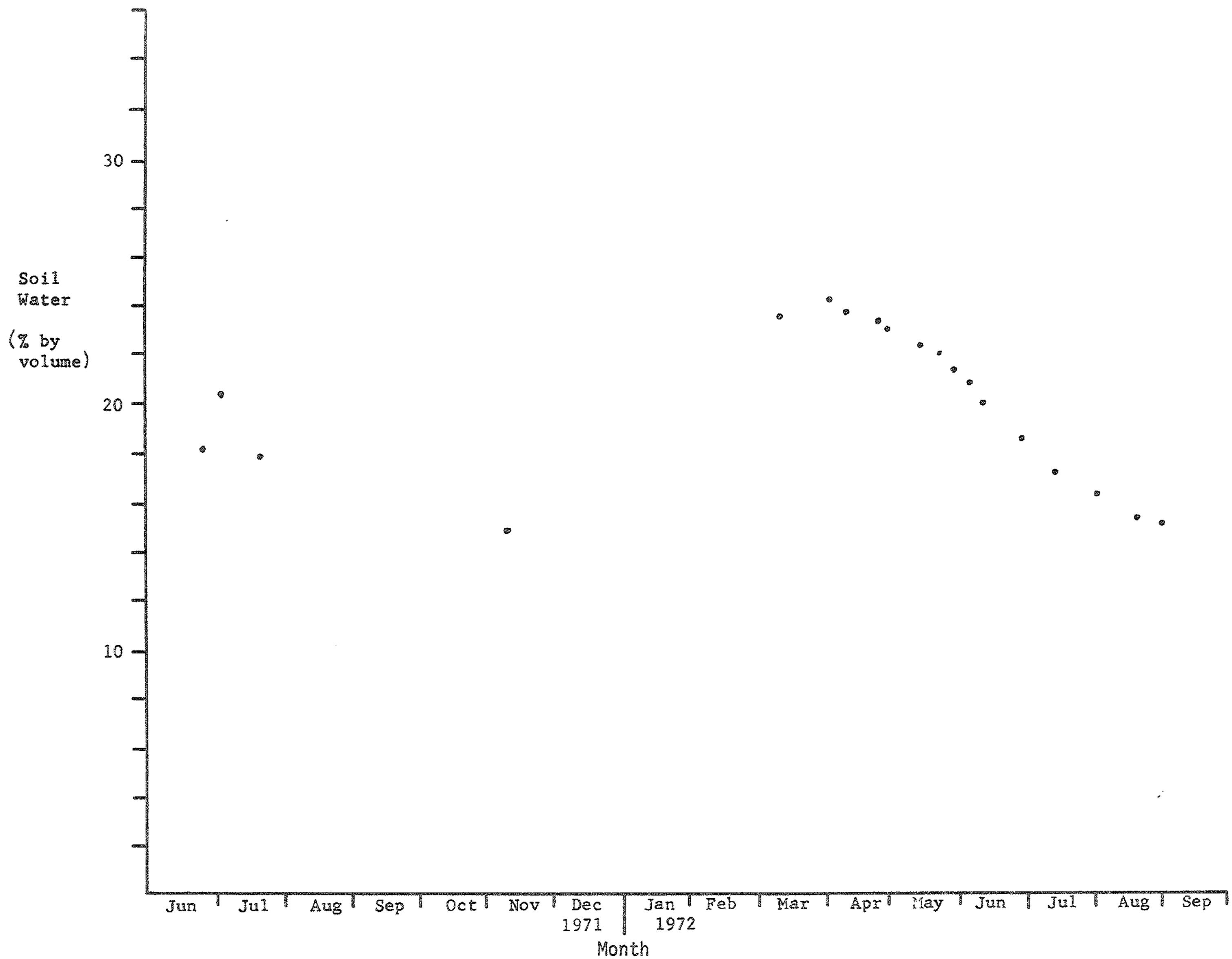


Figure 45. Soil moisture at 61 cm depth on southern sites (neutron probe).

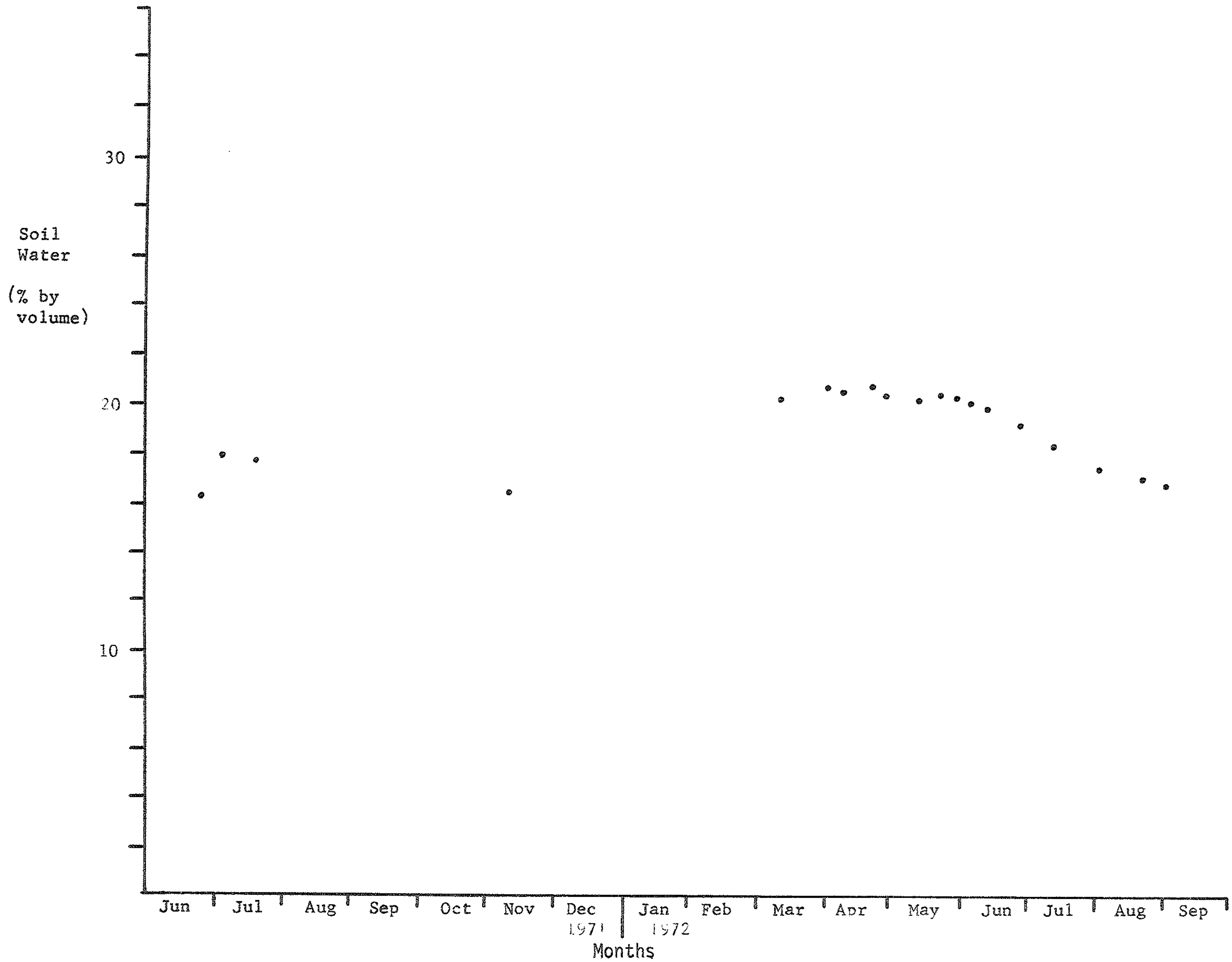


Figure 46. Soil moisture at 76 cm depth on southern sites (neutron probe).

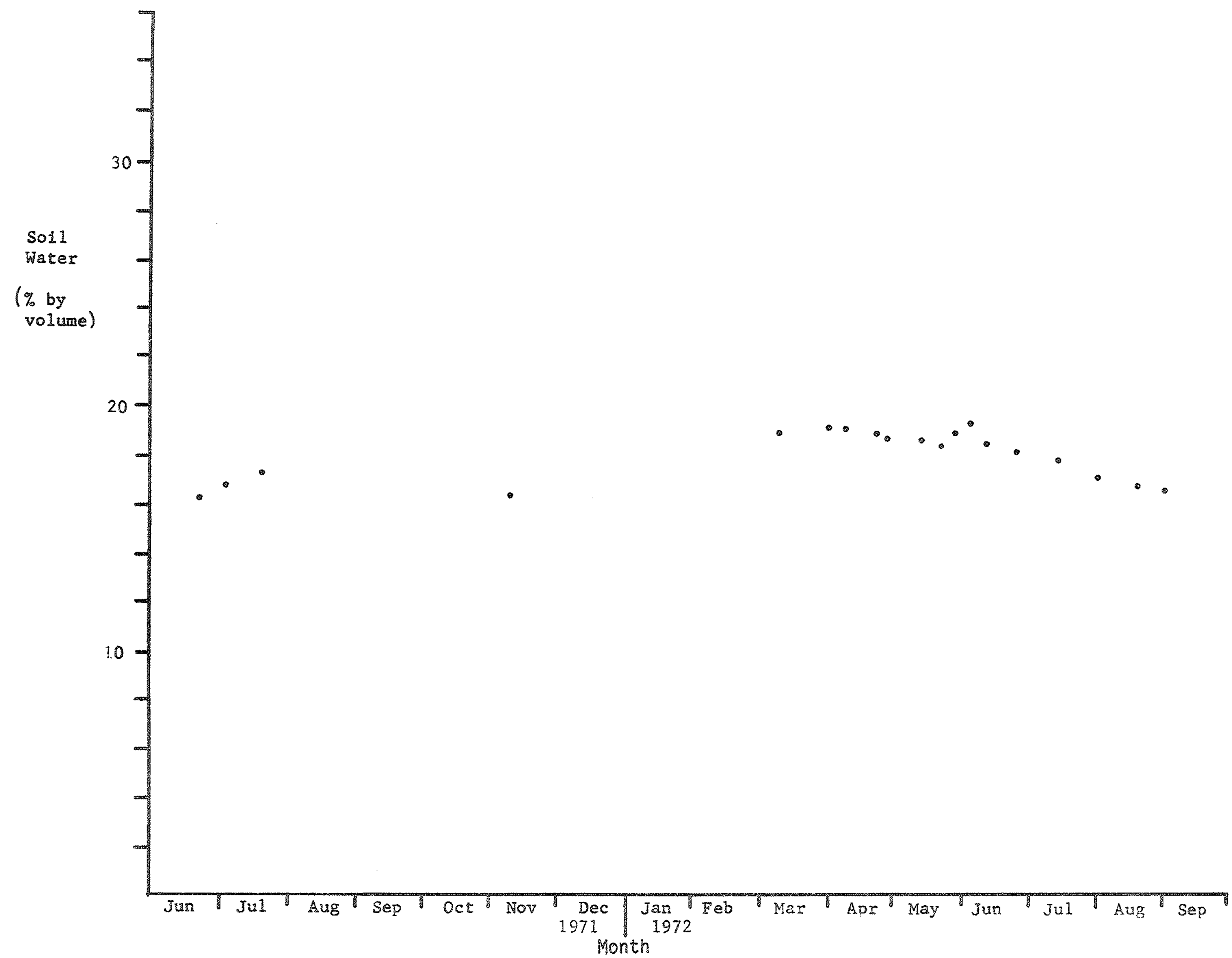


Figure 47. Soil moisture at 91 cm depth on southern sites (neutron probe).

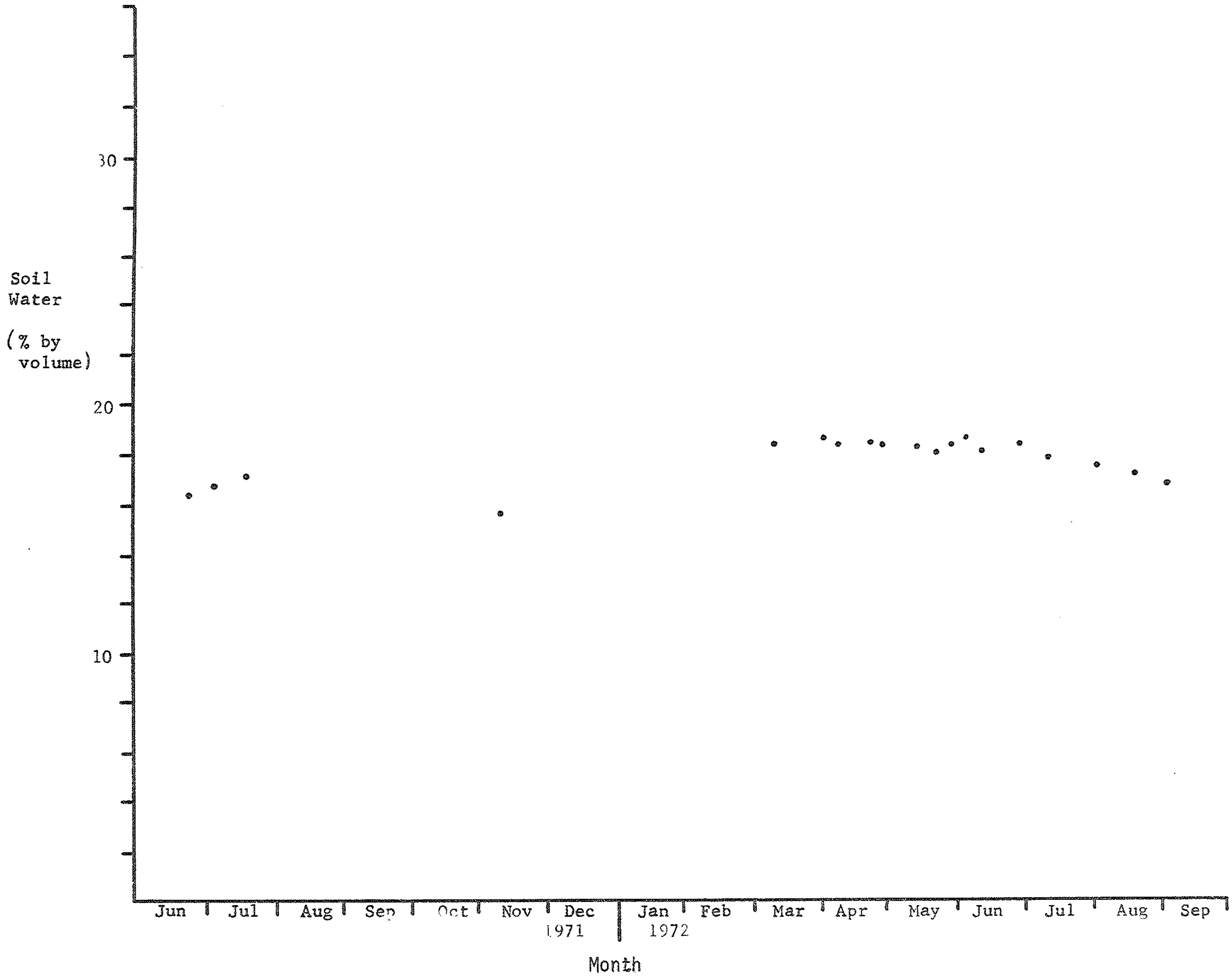


Figure 48. Soil moisture at 107 cm depth on southern sites (neutron probe).

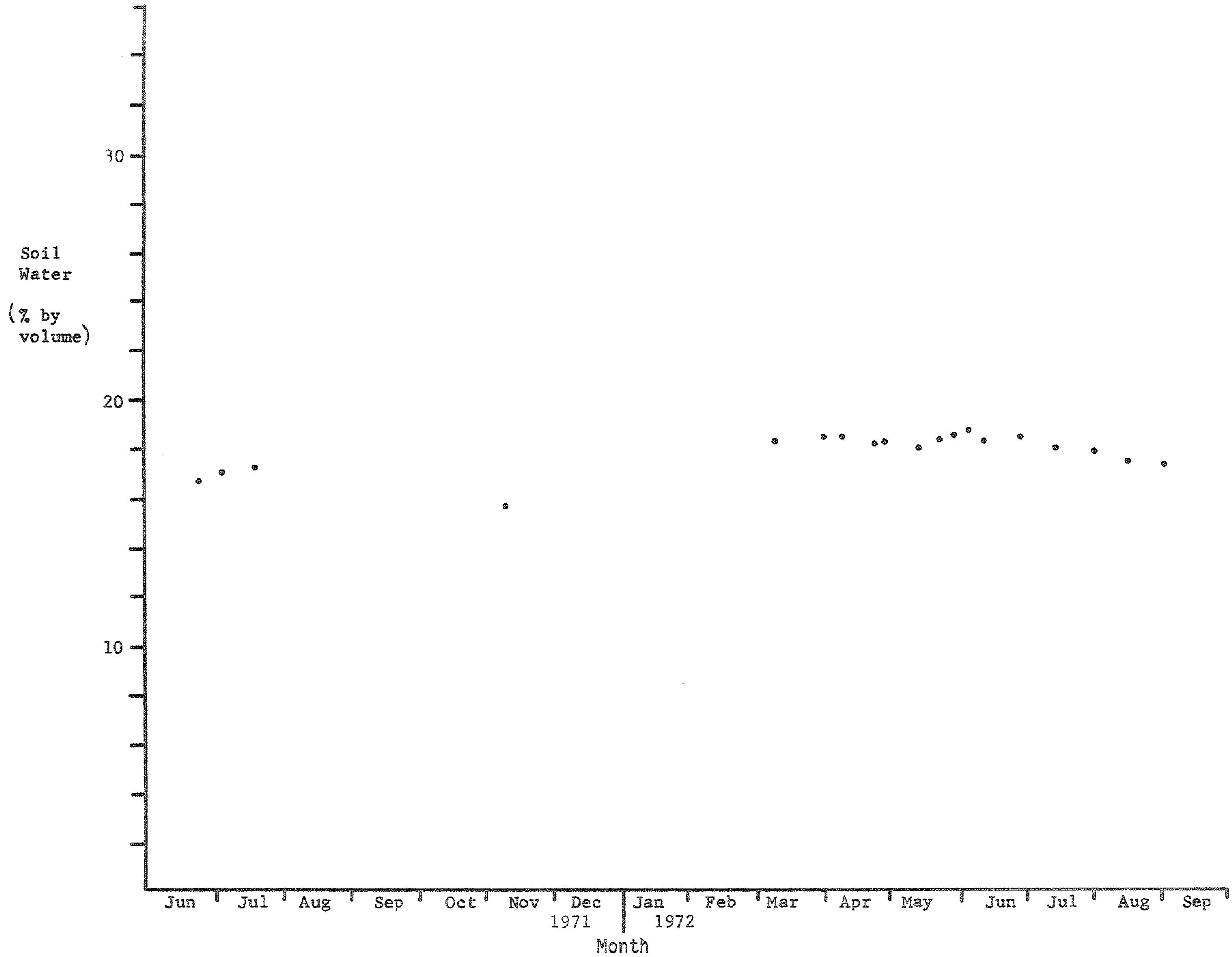


Figure 49. Soil moisture at 122 dm depth on southern sites (neutron probe).

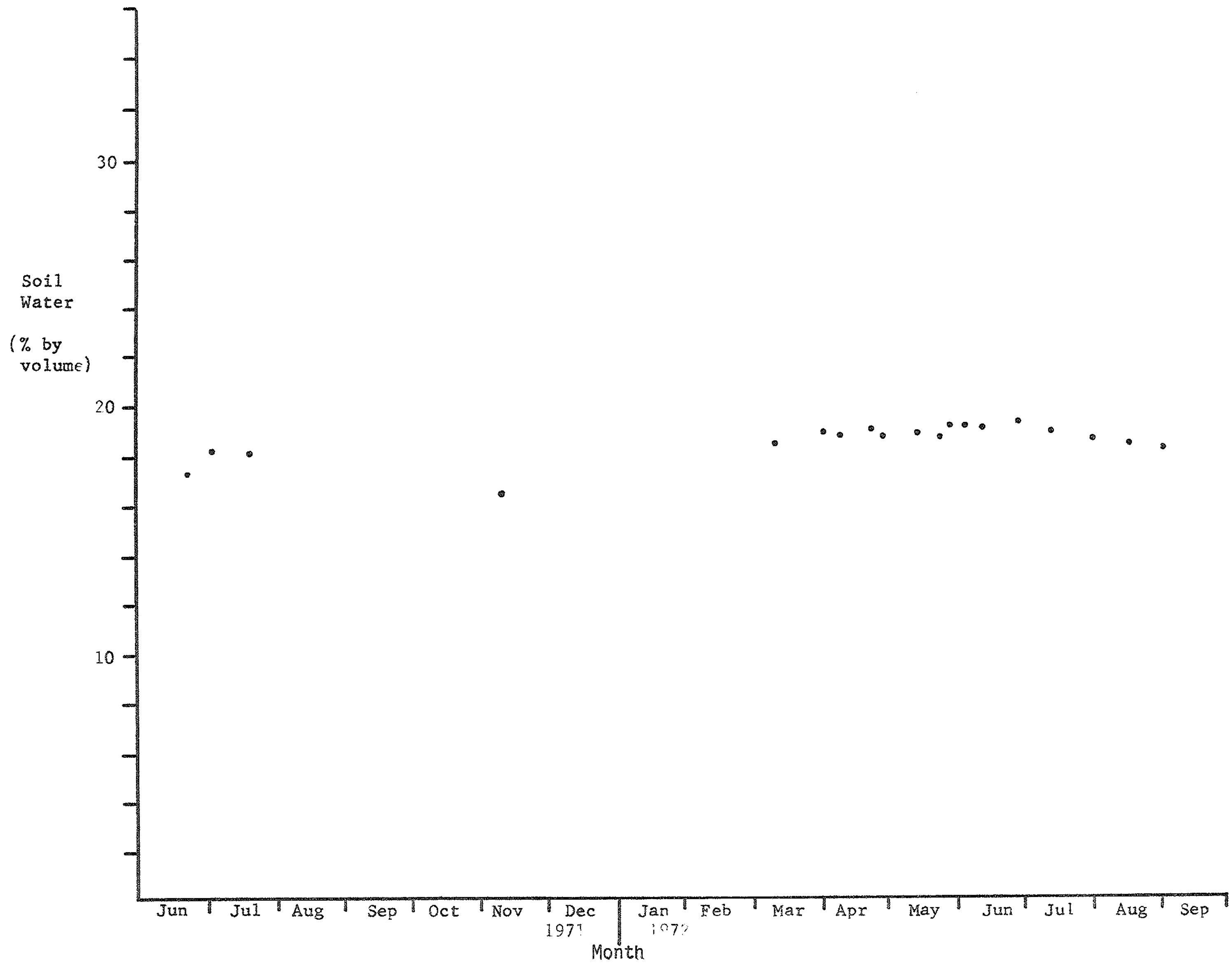


Figure 50. Soil moisture at 137 cm depth on southern sites (neutron probe).

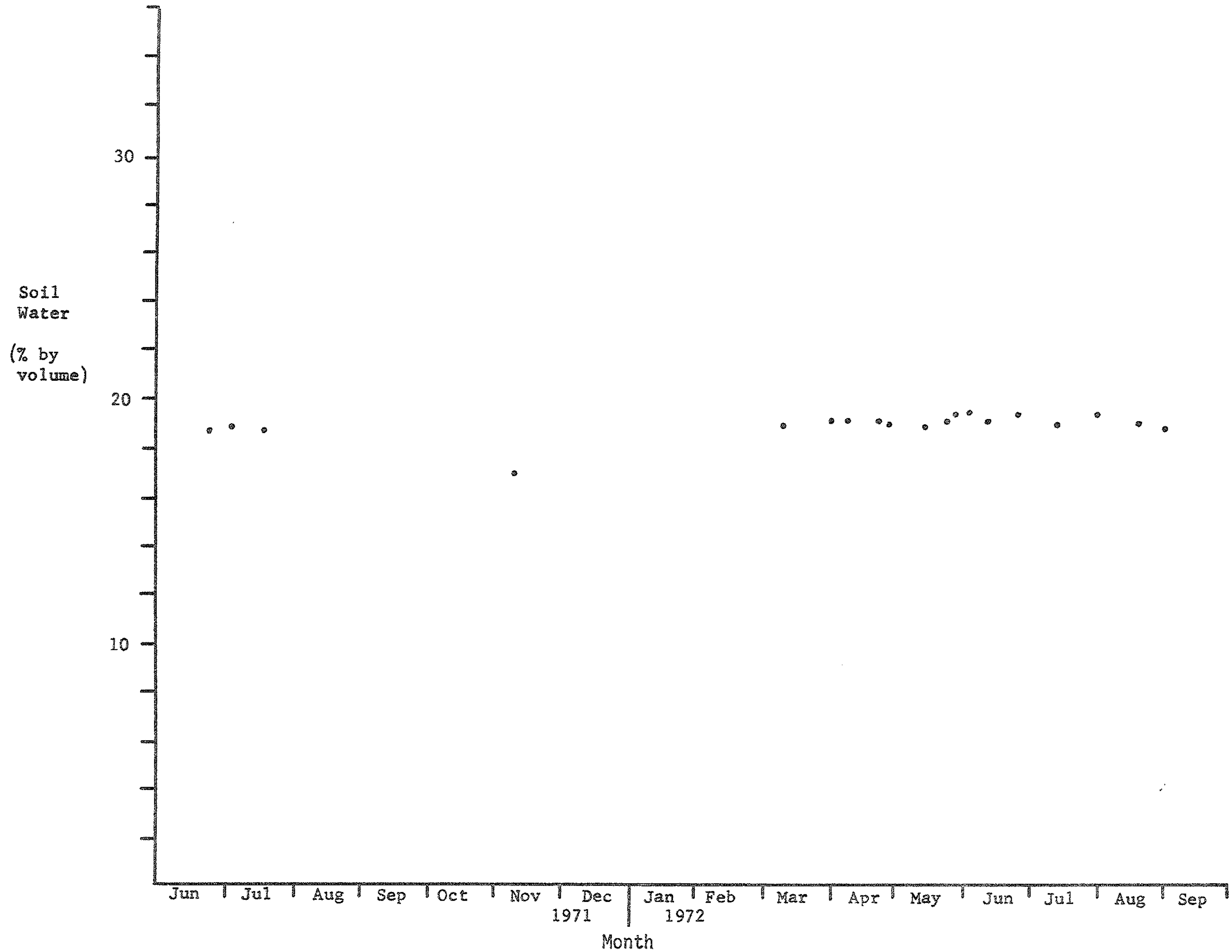


Figure 51. Soil moisture at 152 cm depth on southern sites (neutron probe).

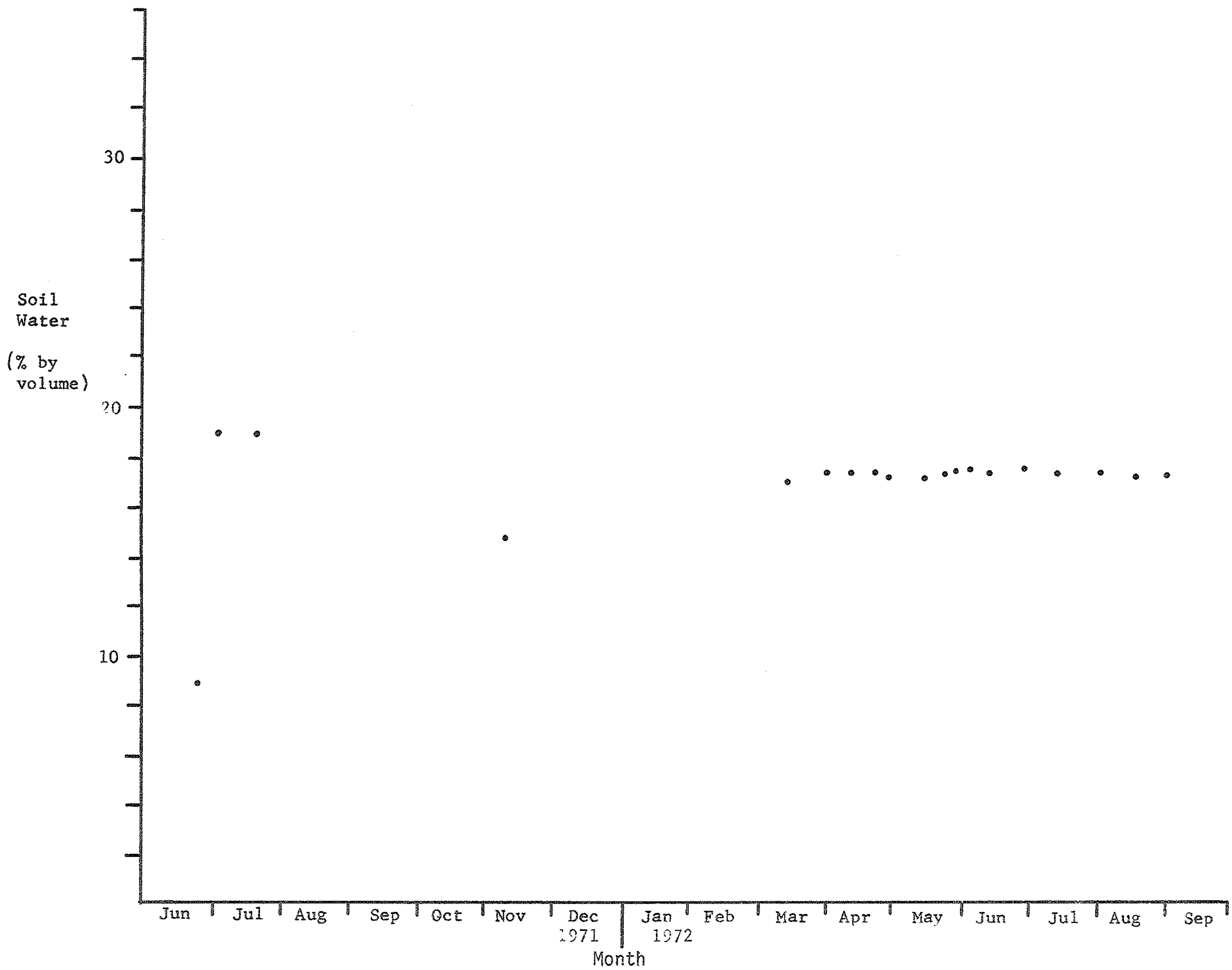


Figure 52. Soil moisture at 169 cm depth on southern sites (neutron probe).

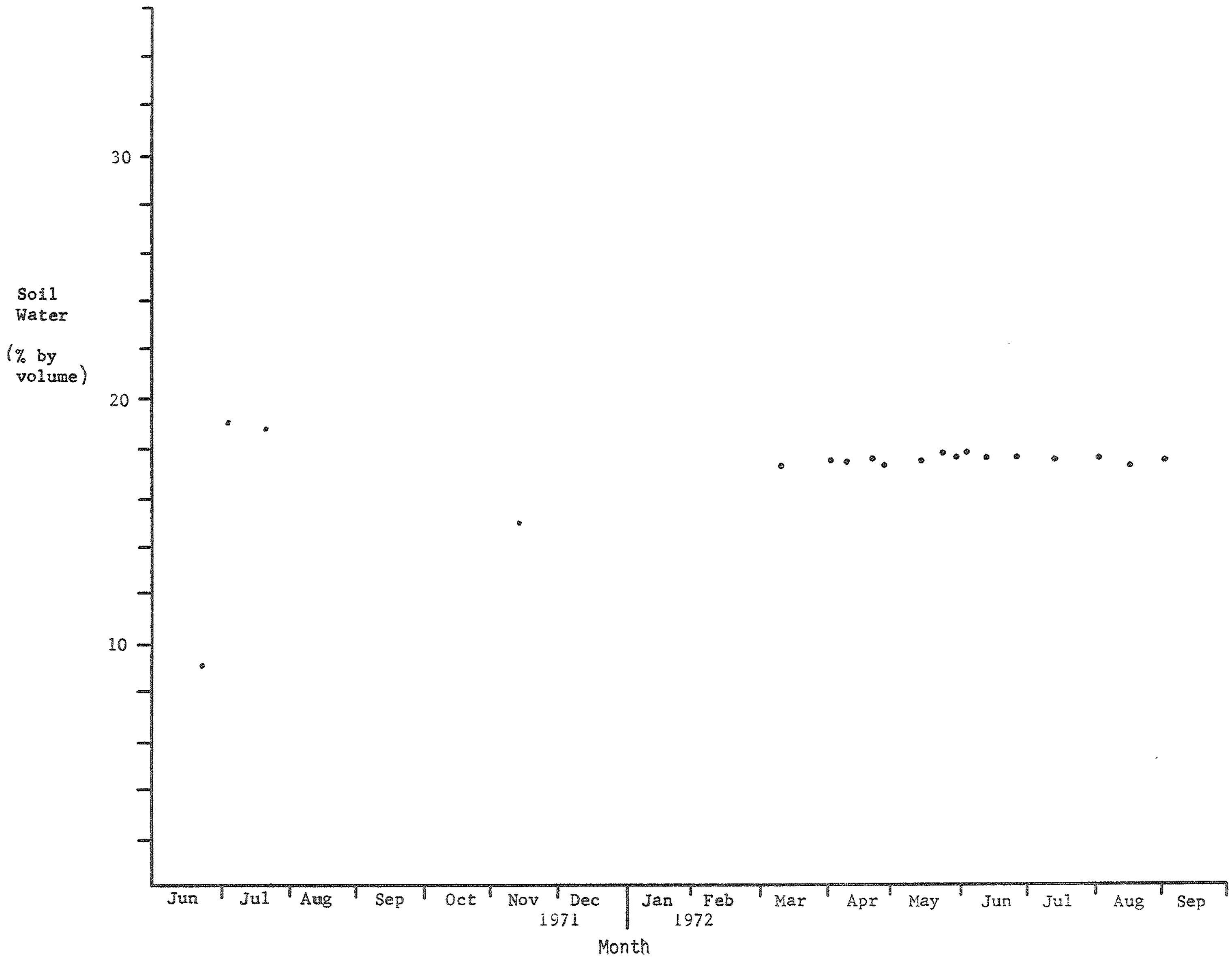


Figure 53. Soil moisture at 183 cm depth on southern sites (neutron probe).

B. PLANTS

INTRODUCTION

This report presents vegetation maps, biomass of above-ground living and dead material by species, and biomass of roots for all four sites. In addition, the plant biomass is further divided into plant parts for each species. Due to similarity in sampling techniques, annuals and perennials are dealt with in the same categories; and litter data are presented here rather than in the soils section.

The original objective of determining biomass on the sites has now been expanded to include measurements of productivity and determinations of factors that influence vegetation structure. The plant studies at Curlew Valley are now moving to meet these expanded objectives.

METHODS

Vegetation maps were prepared for the four sites using aerial photos and qualitative field observations. The maps were used in stratifying the sites for sampling nearly all biotic components.

In 1971, line intercept and quadrat sampling methods were used. The parameters recorded under the 1 cm-wide line intercept technique were (1) extent of species cover except bunchgrasses, (2) height of each plant, (3) basal diameter of bunchgrasses, and (4) basal diameter of shrubs rooted under the line. The line intercept was only used to typify the vegetation on the northern sites. The DSCODES for data collected by this method are A3UBJA1 and 2.

In 1971, 2 x 2 m quadrats were used on shrubs and nested 1 x 1 m quadrats for grasses and annuals. The information collected on the sites included (1) species, (2) density, (3) height, (4) cover, (5) basal area, (6) phenology, and (7) sex. These data typified the live and dead vegetation and were placed under DSCODES A3UBJB3 and 4. Quadrats in like vegetation adjacent to the site were destructively sampled to obtain dry weight biomass(DSCODES A3UBJC1-4). These data were obtained in August and September with 10 samples from each major vegetation type within each of the four sites.

In 1972, only the quadrat method was used However, sample sizes were increased from 10-20 per vegetation type and the nested quadrats were increased from 1 x 1 m to 1 x 2 m.

Litter was collected within each of the quadrats with a 50 x 10 x 15 cm frame which was pushed into the ground. All material within the frame was collected to the depth at which root hairs were encountered (1-3 cm). The litter was separated by immersing it in warm water and pouring the sample through 18 and 45 mesh sieves (1 mm and 354 μ respectively). The litter was then washed in cold water, dried at 20 C for 48 hrs, oven dried at 65 C for 24 hrs, and weighed.

The litter samples were then sorted into (1) large woody stem, (2) small woody and leaf material larger than 2 mm (3) small woody and leaf material smaller than 2 mm, and (4) fecal material.

In 1971, two litter samples were taken within each quadrat. This was increased to eight in 1972. These data are under DSCODES A3UBJD1-4.

Root samples were taken with each litter sample. An 8-cm orchard auger was used to take 20 cm increments of soil to a depth of 60 cm, where soil conditions allowed. The samples were mixed with warm water and poured through a 45 mesh sieve (354μ). The roots were then washed in cold water, air dried at 21 C for 24 hrs, oven dried at 65 C for 24 hrs, and weighed. These data are associated with DSCODES A3UBJE1-4.

In 1972, 100 *Artemisia tridentata* and 300 *Atriplex confertifolia* plants were collected, dried, and data collected on the following parameters: (1) weight of dead wood, (2) weight of woody stems, (3) weight of herbaceous stems, (4) weight of leaves, (5) weight of flowers (6) age, (7) cover, (8) basal area, and (9) height. These data are under DSCODE A3UBJS3.

Agropyron cristatum plants were also collected, dried, separated into old and new growth, and weighed. These data are under DSCODE A3UBJY4.

RESULTS

The northern shrub site (Fig. 1) was divided into three vegetation types (Figs. 2-3). The dominant shrub was *Artemisia tridentata*. *Bromus tectorum* was the predominant understory vegetation. Samples taken on off-site hectares 10, 29, and 31 (Tables 1, 2, and 3) represent the three vegetation types found on the site (Fig. 2).

The northern crested wheat grass site (Fig. 4) was seeded to *Agropyron cristatum* about 30 years ago. Native vegetation reinvaded the site. The result was a more complex plant community than on the shrub site (Figs. 5 and 6). The results of the quadrat analysis on off-site hectares 5, 27, and 28 (Tables 4, 5 and 6) represent the major vegetation types on the site (Figs. 5 and 6).

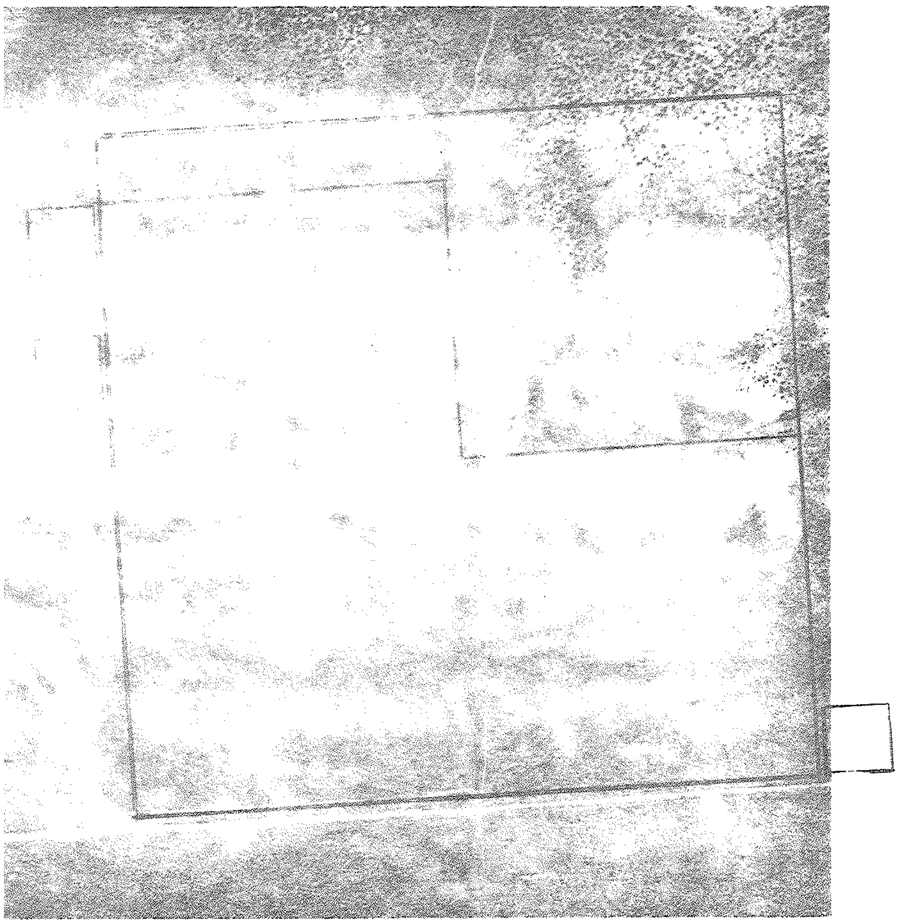


Figure 1. Aerial photo of northern shrub site including off-site destructive sampling areas (small squares).

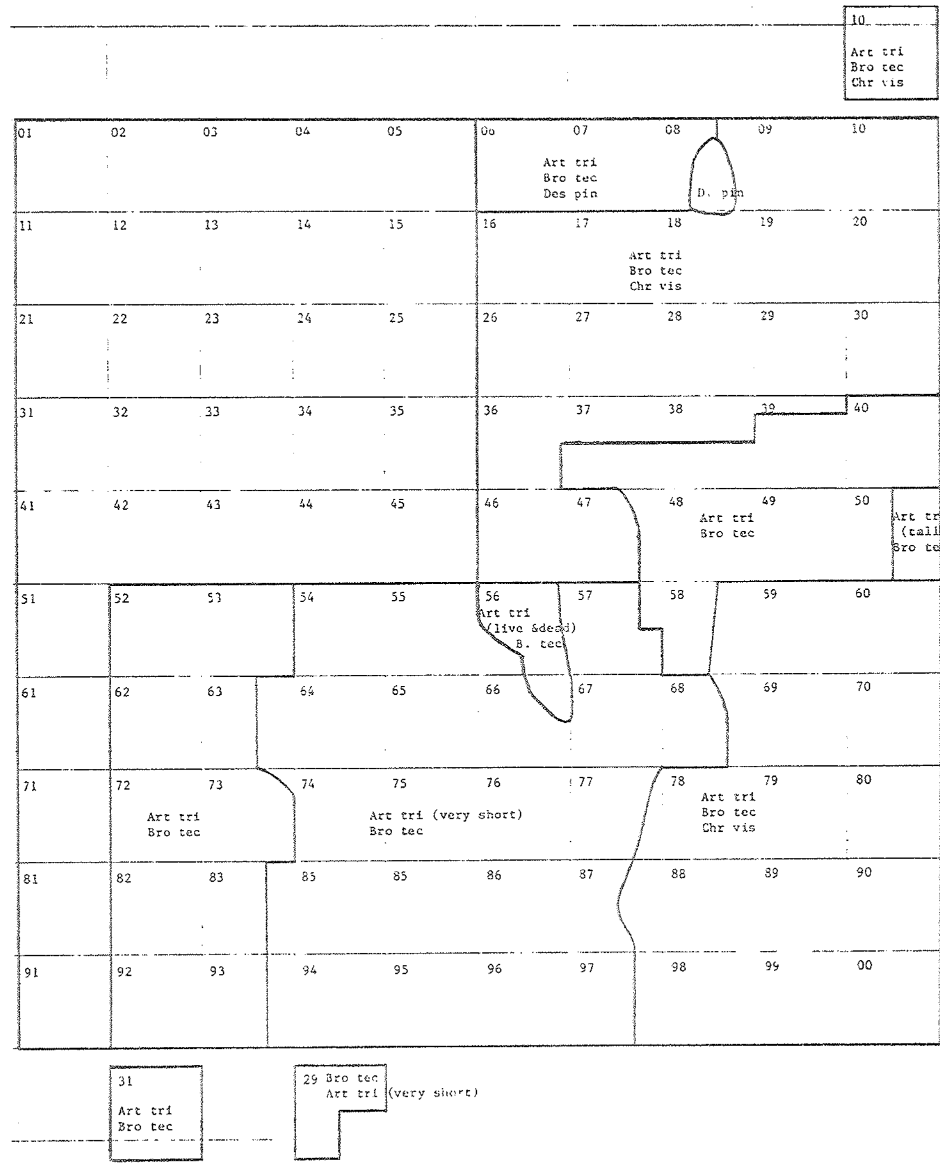


Figure 2. Hectare grid, dominant vegetation, and off-site sampling areas of northern shrub site.

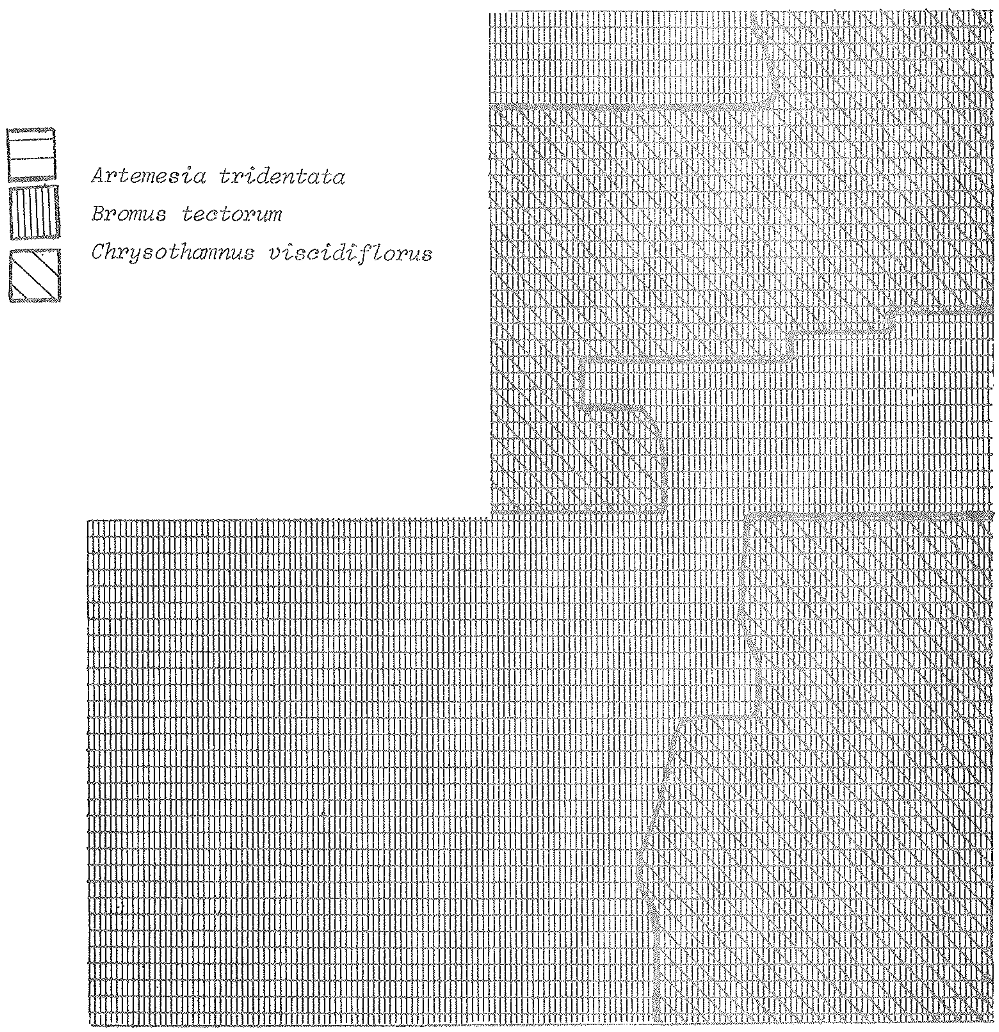


Figure 3. Vegetation types of northern shrub site.

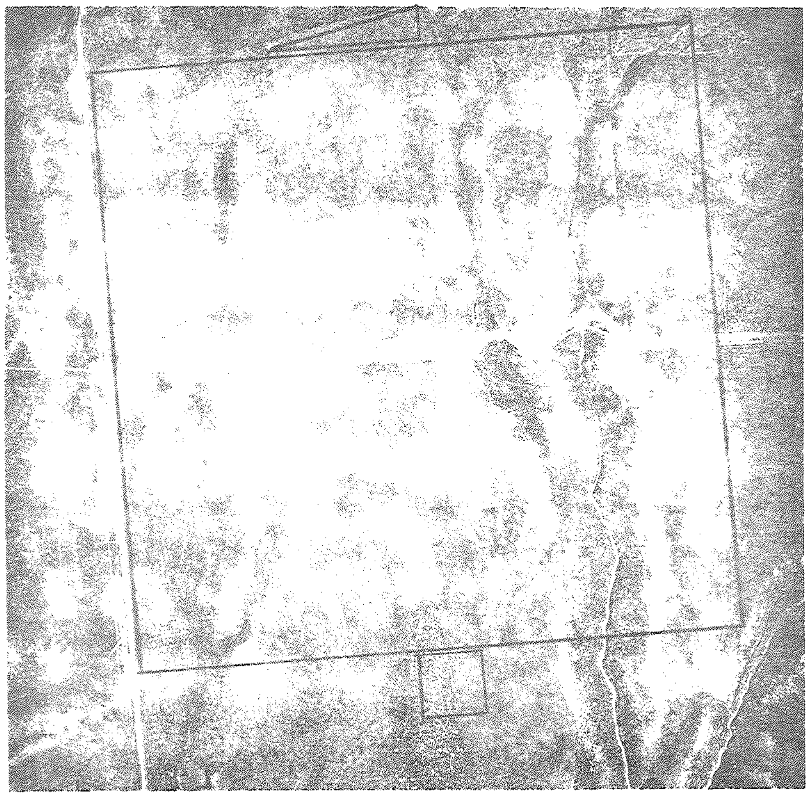


Figure 4. Aerial photo of northern crested wheatgrass site including off-site destructive sampling areas (small plots).

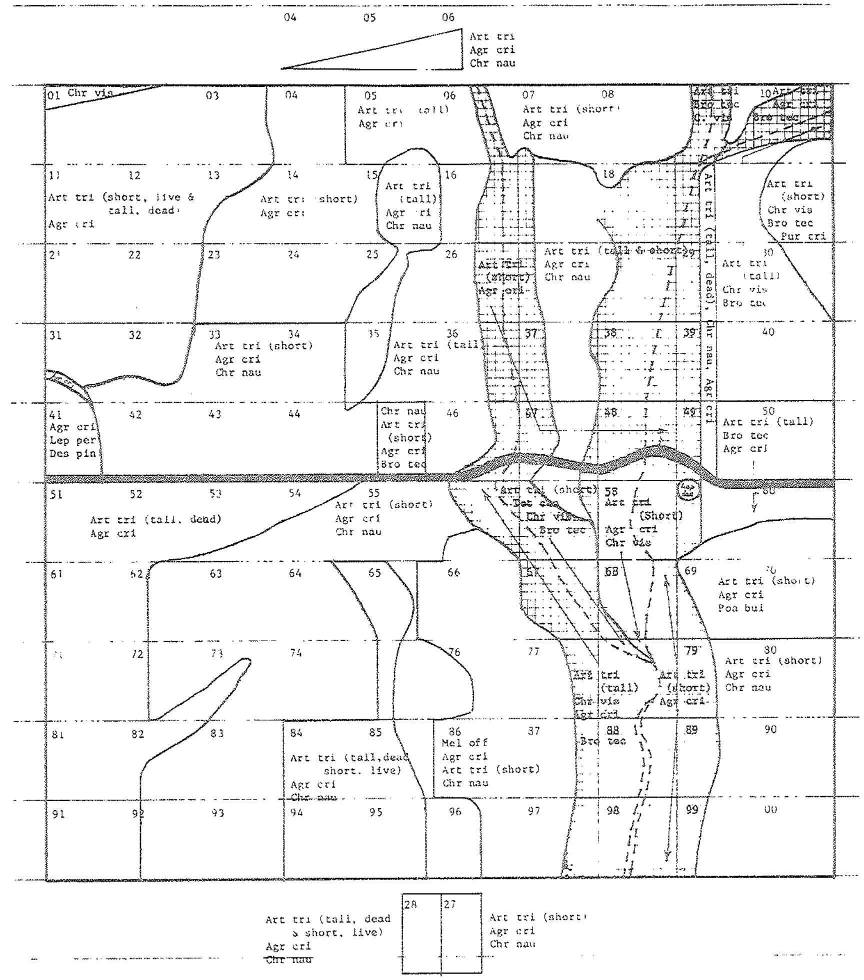


Figure 5. Hectare grid, dominant vegetation and off-site sampling of northern crested wheatgrass site. Area of gullies show in hatching.

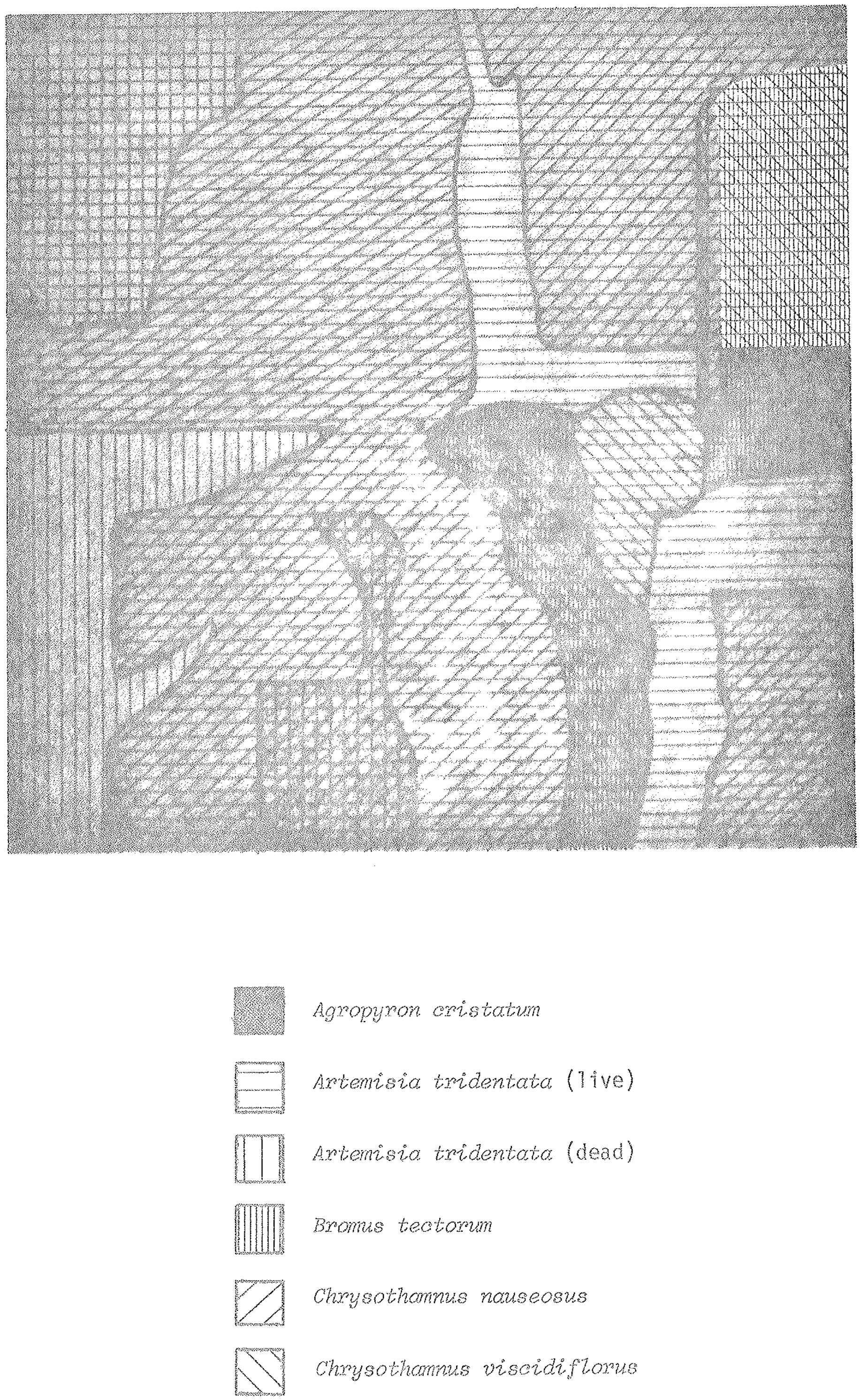


Figure 6. Dominant vegetation on the northern crested wheatgrass site.

Table 1. Quadrat analysis of *Artemisia tridentata*, *Bromus tectorum* and *Chrysothamnus viscidiflorus* community on northern shrub site (sample taken on off-site hectare 10, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area(%)	Biomass (kg/ha)
ARTTRI	.68	1	1744	±421	24	8	65	8	493	141	12	.17	3331
BROTEC		1					31	4					247
CHRVIS	1.03	.9	731	±177	27	10	35	3	59	16			600
STADEA	.15	.6											8820

Table 2. Quadrat analysis of *Artemisia tridentata*, *Bromus tectorum* and *Chrysothamnus viscidiflorus* community on northern shrub site (sample taken on off-site hectare 29, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area(%)	Biomass (kg/ha)
ARTTRI	7.57	1	647	81	56	11	42	1	91	14	49	.42	6,848
BROTEC		.9					30	4					42
GUTSAR	.13	.4	904	39			31	5	28	30	2		35
SITHYS	2.5	.7			10	3	31	3	5	2			118
STADEA	4.05	1											853
Woody litter													626
Leaf litter													4,541
Fecal litter													52
Roots (0-20 cm)									5.16	.76			10,261
Roots (20-40 cm)									3.47	.78			6,901

Table 3. Quadrat analysis of *Artemisia tridentata, Bromus tectorum* and *Chrysothamnus viscidiflorus* community on northern shrub site (sample taken on off-site hectare 31, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1.58	1	1632	315	18	6	65	8	479	148	26	.29	7928
GUTSAR	.45	.8	607	504			24	4	28	15	3		126
SITHYS	.7	.6			5	5	31	4	1	1		.04	8
STADEN	1.33	1											3077

Table 4. Quadrat analysis of *Artemisia tridentata, Agropyron cristatum* and *Chrysothamnus nauseosus* community on crested wheat grass site (sample taken on off-site hectare 5, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1.73	.8	1045	±253	7	± 2	48	± 5	182	±65	18	.11	3155
AGRCRI	6.5	1			60	±21	29	± 4	6	± 2	4	4	409
CHRNAU	.05	.1	450	±947	1	0	30	±63	18	±35	.23	.0005	9
POABUL		.8					38	± 4	48	±71			476
STADEA	.08	.3											29

Table 5. Quadrat analysis of *Artemisia tridentata, Agropyron cristatum* and *Chrysothamnus nauseosus* community on crested wheat grass site (sample taken on off-site hectare 27, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	12	1			154	±45	18	± 3	5	± 2	19	19	565
ARTTRI	.2	.3	1405	±8808	12	±12	64	±34			3	.02	
CHRNAU	1	.6	536	± 313	3	± 1	27	± 9	60	±71	5	.03	596
STADEA	.05	.2											134

Table 6. Quadrat analysis of *Artemisia tridentata, Agropyron cristatum* and *Chrysothamnus nauseosus* community on crested wheat grass site (sample taken on off-site hectare 28, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	6.4	.8			65	±40	36	± 6	6	± 2	4	4	387
ARTTRI	2.2	.8	1804	±1187	41	±25	69	± 7	1399	±814	40	.9	3077
CHRNAU	.2	.2	341	± 596	2	± 3	40	±30	112	±217	.68	.003	224
CHRVIS	1.76	.6	93	± 27	3	± 1	22	± 2	8	± 3	2	.06	145
STADEA	.3	.6											284
Woody litter													1549
Leaf litter													6357
Roots (0-20 cm)													11335
Roots (20-40 cm)													6006

A comparison of the northern sites indicated that the shrub site had more grass as well as more shrub biomass than the grass site (Figs. 7 and 8). This was because cattle used 80-90% of the 1971 grass production on the grass site prior to the quadrat analysis. The shrub site received no grazing in 1971.

The composition of litter was similar on the northern sites. It consisted of standing dead shrubs, shrub leaves and branches, grass parts and dead annuals. There were more dead annuals on the shrub than the grass site. The amount of litter was 6,020 kg/ha on the shrub site and 7,190 kg/ha on the grass site.

The root distribution and biomass of the northern sites was about the same. The roots on the grass site were nearer the surface. At the 40-cm depth they were most nearly equal with 17,162 kg/ha for the shrub site and 17,341 kg/ha for the grass site. No distinction was made between live and dead roots.

The southern shrub site (Fig. 9) had three vegetation types (Figs. 10 and 12). The largest was dominated by *Artemisia tridentata* and *Atriplex confertifolia* with an understory of *Sitanion hystrix* (Art-Atr-Sit type; for species codes see Table 37). The second type consisted of desert annuals (annual type). The predominant one was *Bassia hyssopifolia*. Others included *Halogeton glomerata*, *Descurainia pinnata*, *Salsola kali*, and *Chenopodium album*. There was a lot of dead *Artemisia* present. The third vegetation type consisted of living and dead *Artemisia tridentata* with an understory of *Halogeton glomerata* (Hal-Art type). The results from the quadrat sampling program are presented in Tables 7-23.

In 1971, there was no significant difference between the amount of dead material between the Art-Atr-Sit (Fig. 13) and the Hal-Art (Fig. 14) vegetation types ($P<0.1$). However, the composition of dead material was different. The Hal-Art type had a larger amount of standing dead and fallen wood material as a result of the high mortality of *Artemisia*. The dead material of the Art-Atr-Sit type was mostly fallen leaves and twigs from living shrubs.

Roots found within the Art-Atr-Sit and Hal-Art vegetation showed no significant differences in dispersion or biomass ($P<0.1$). Root biomass decreased sharply below 40 cm. This was probably due to the increase in soluable salt concentrations at about that depth (see Soil section).

Shrub biomass was greater in 1971 (Figs. 13 and 14) than in 1972 (Figs. 15 and 16). This was due to higher precipitation in 1971 (see Abiotic section). The dry conditions during the summer of 1972 resulted in an increase in leaf litter over 1972. Biomass of annuals and biomass changes through summer were only taken in 1972 (Figs. 17, 18 and 19).

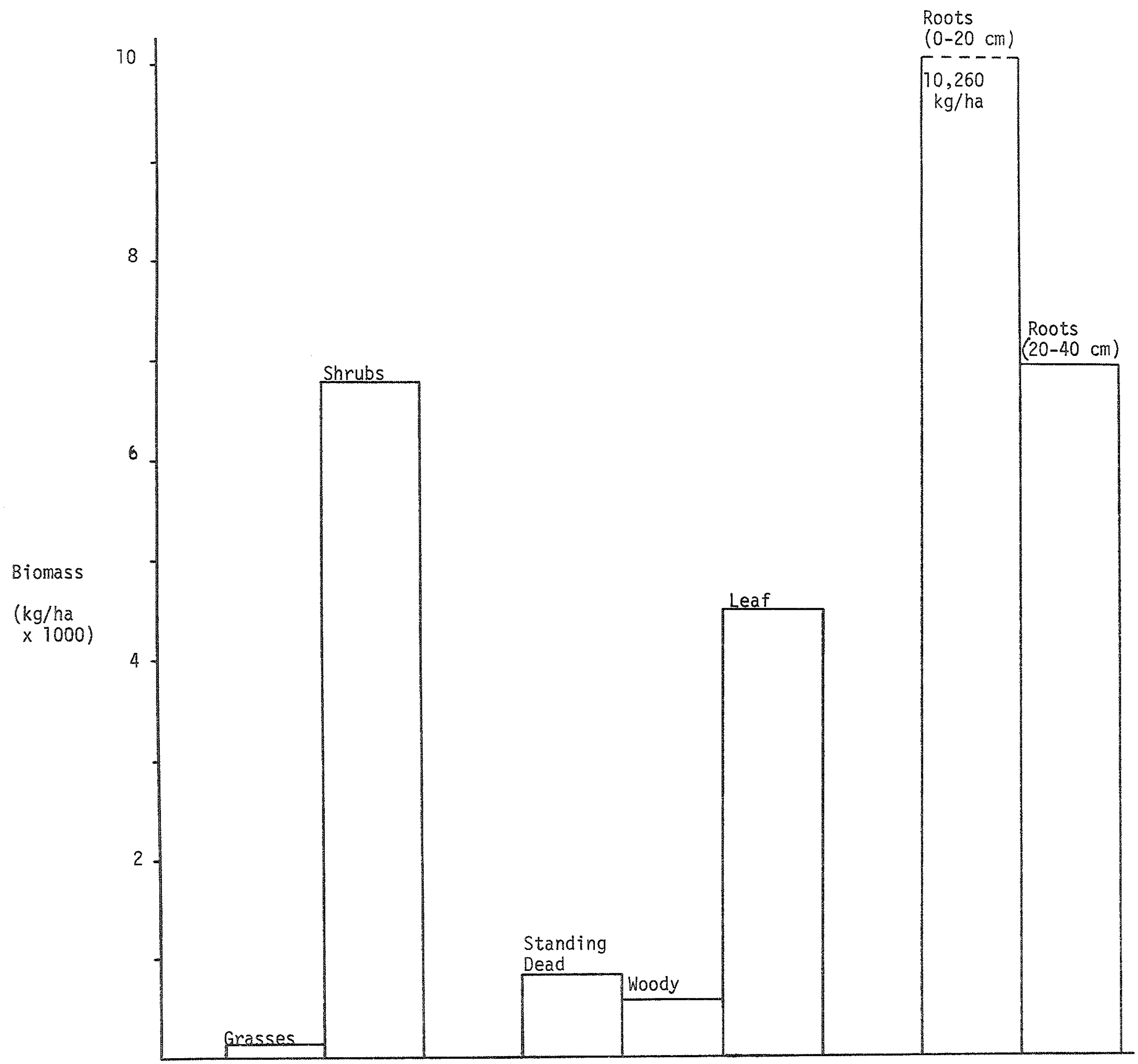


Figure 7. Biomass of plant components, northern shrub site, August 1971.

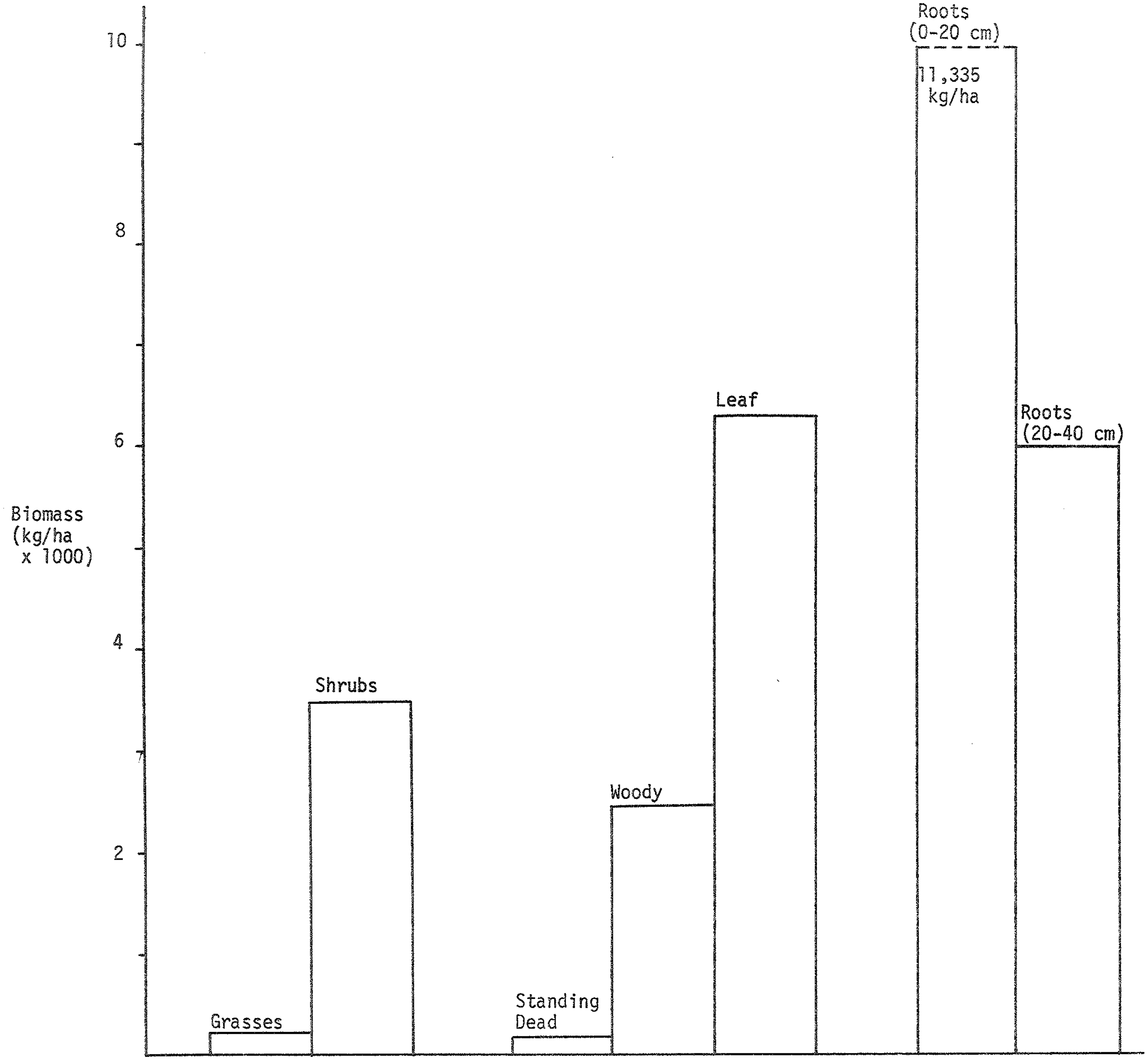


Figure 8. Biomass of plant components, nrothern crested wheat grass site, August 1971.

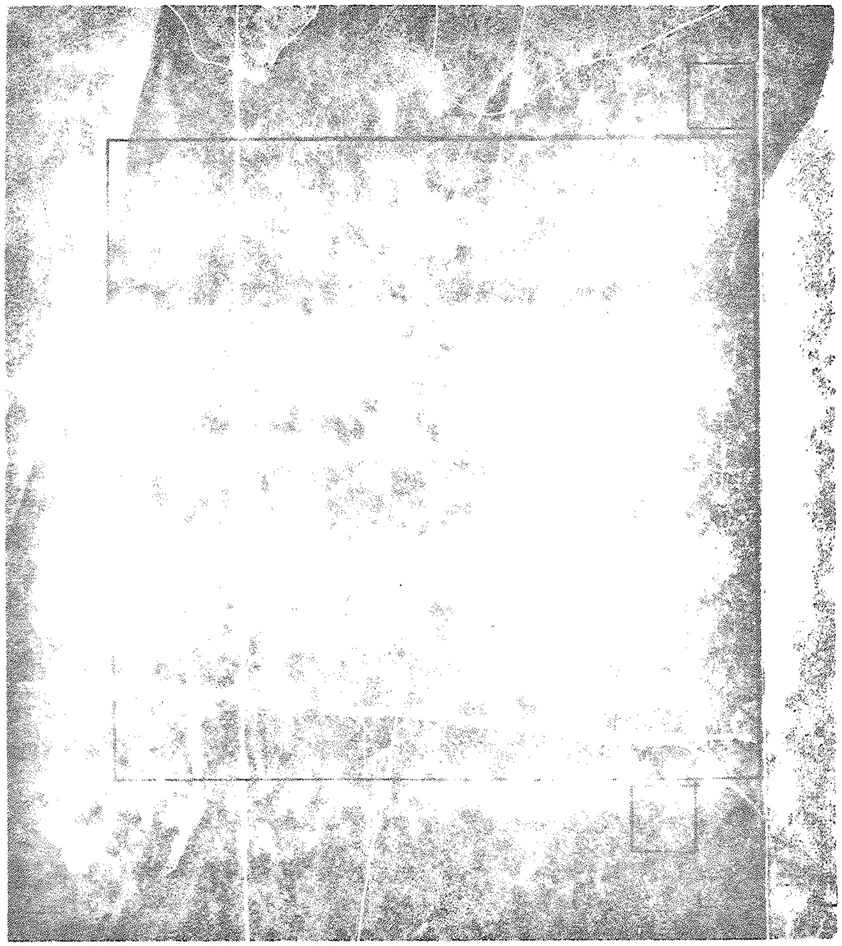


Figure 9. Aerial photo of southern shrub site including off-site destructive sampling areas (small squares).

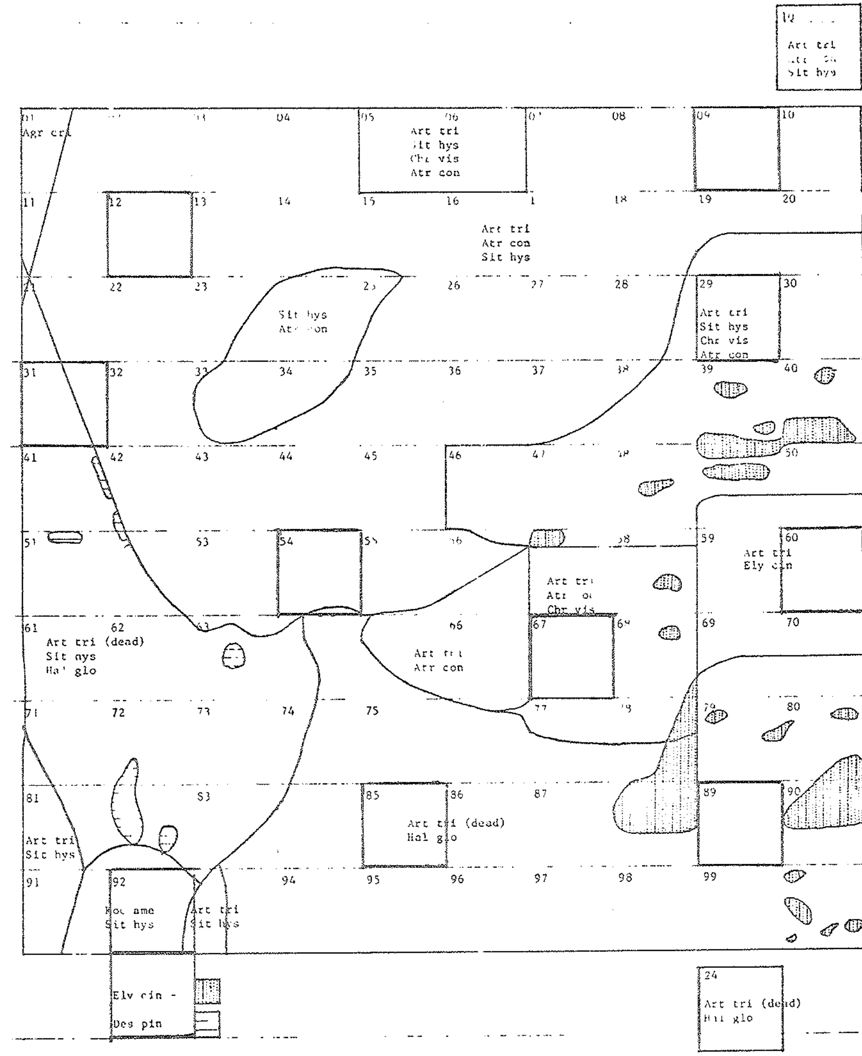


Figure 10. Hectare grid, dominant vegetation and sampling areas, southern shrub site.

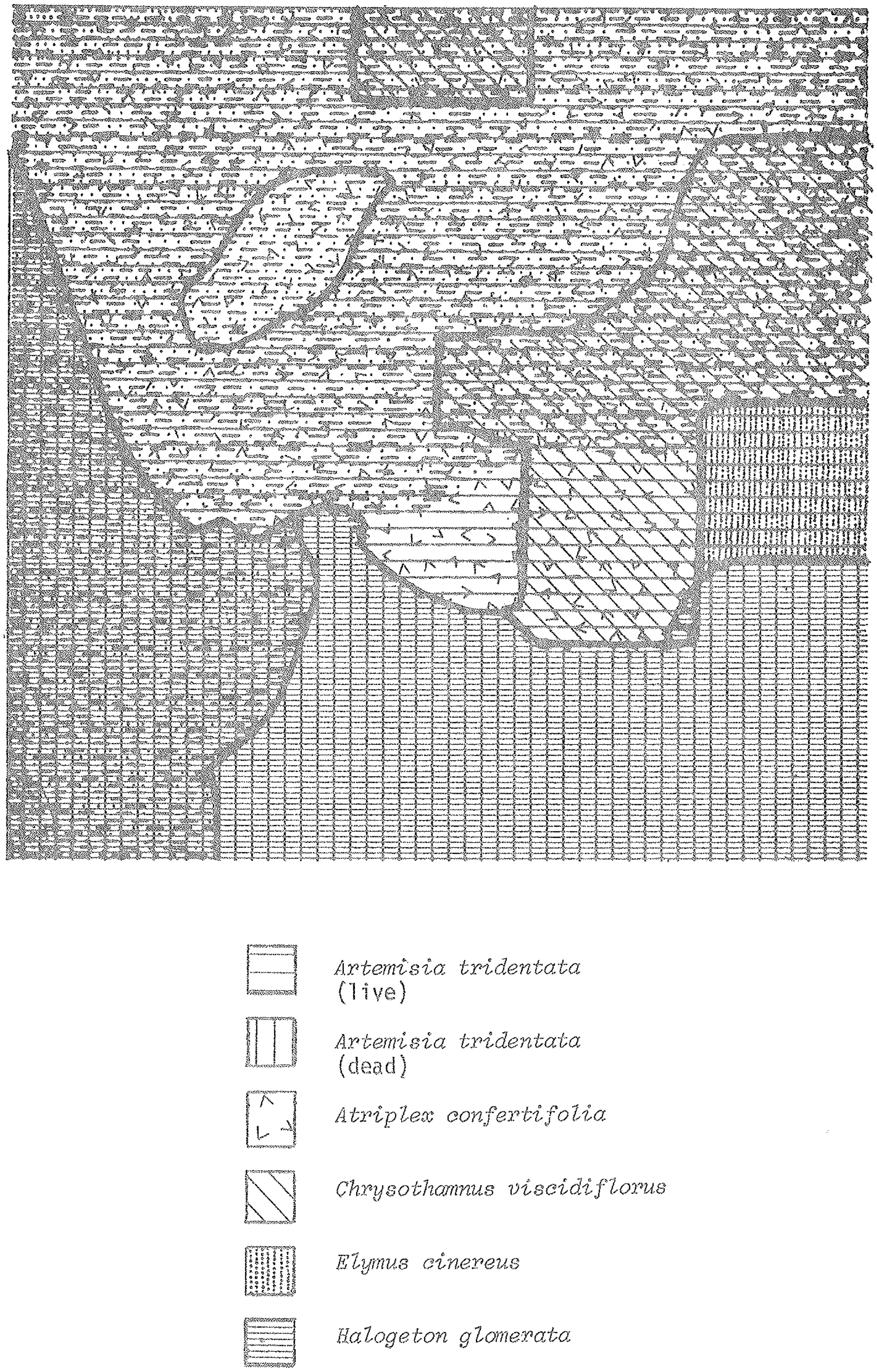


Figure 11. Dominant plants on the southern shrub site.

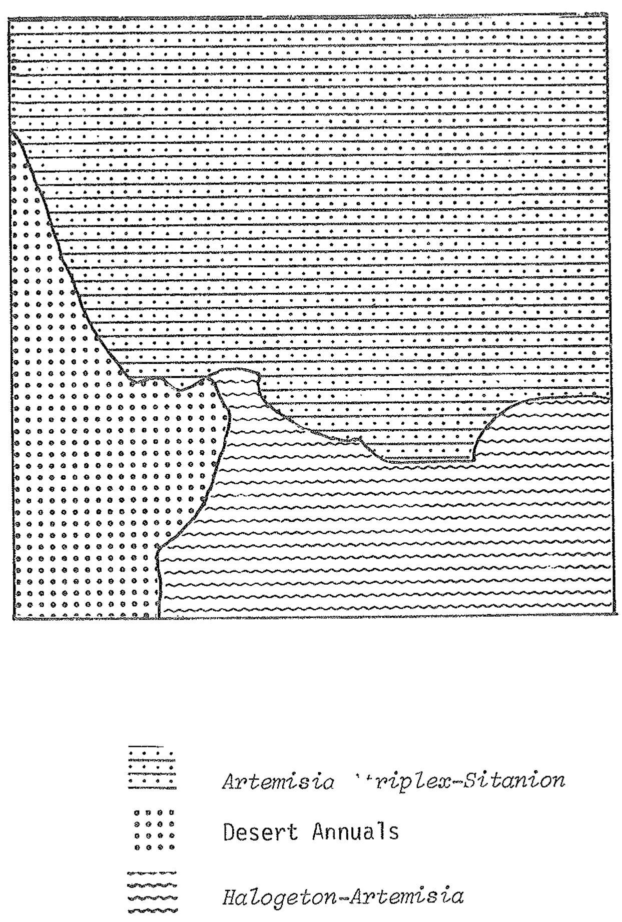


Figure 12. Vegetation map of the major vegetation types on the southern shrub site.

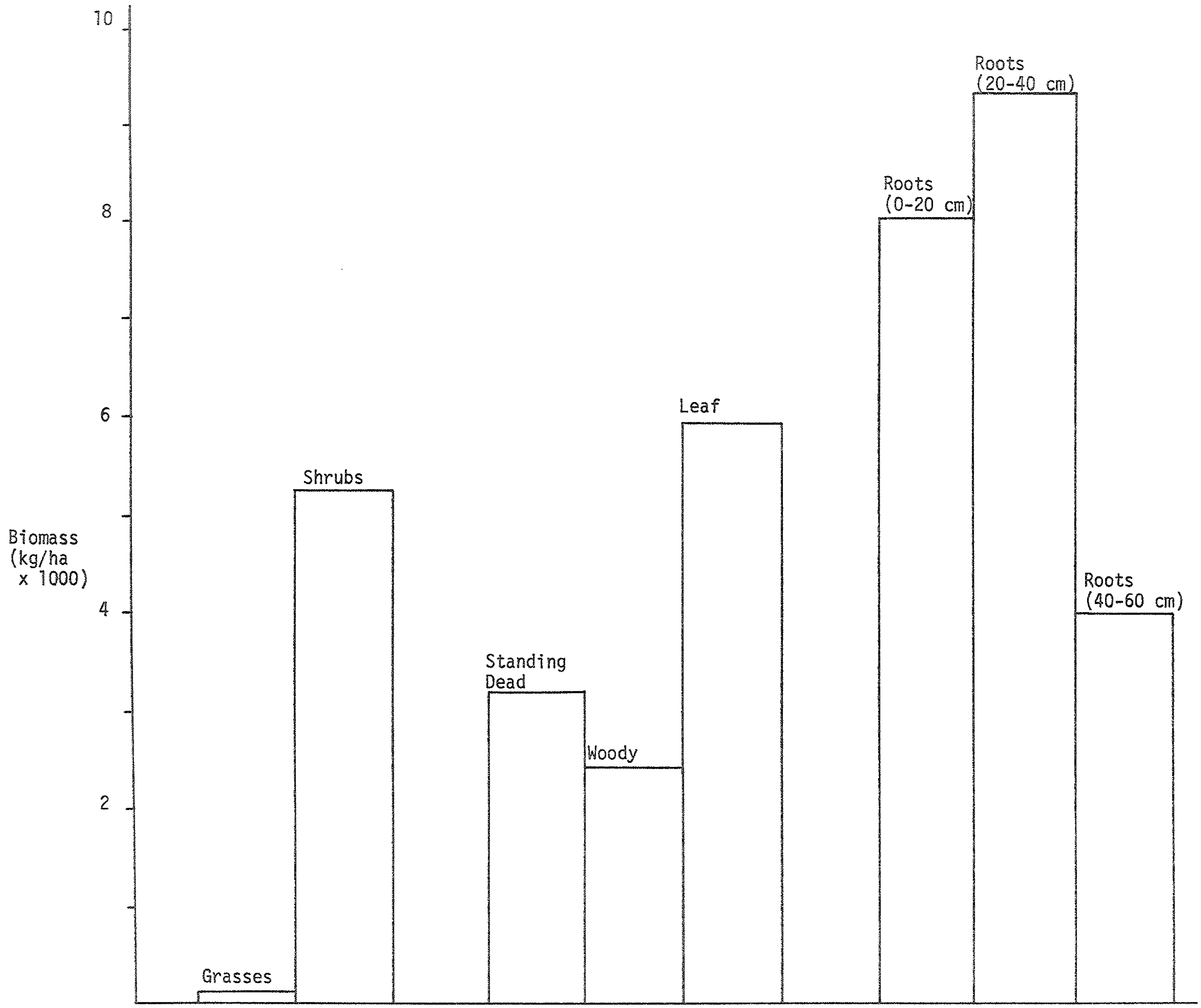


Figure 13. Components of plant biomass in the Art-Atr-Sit vegetation type of shrub site, August 1971.

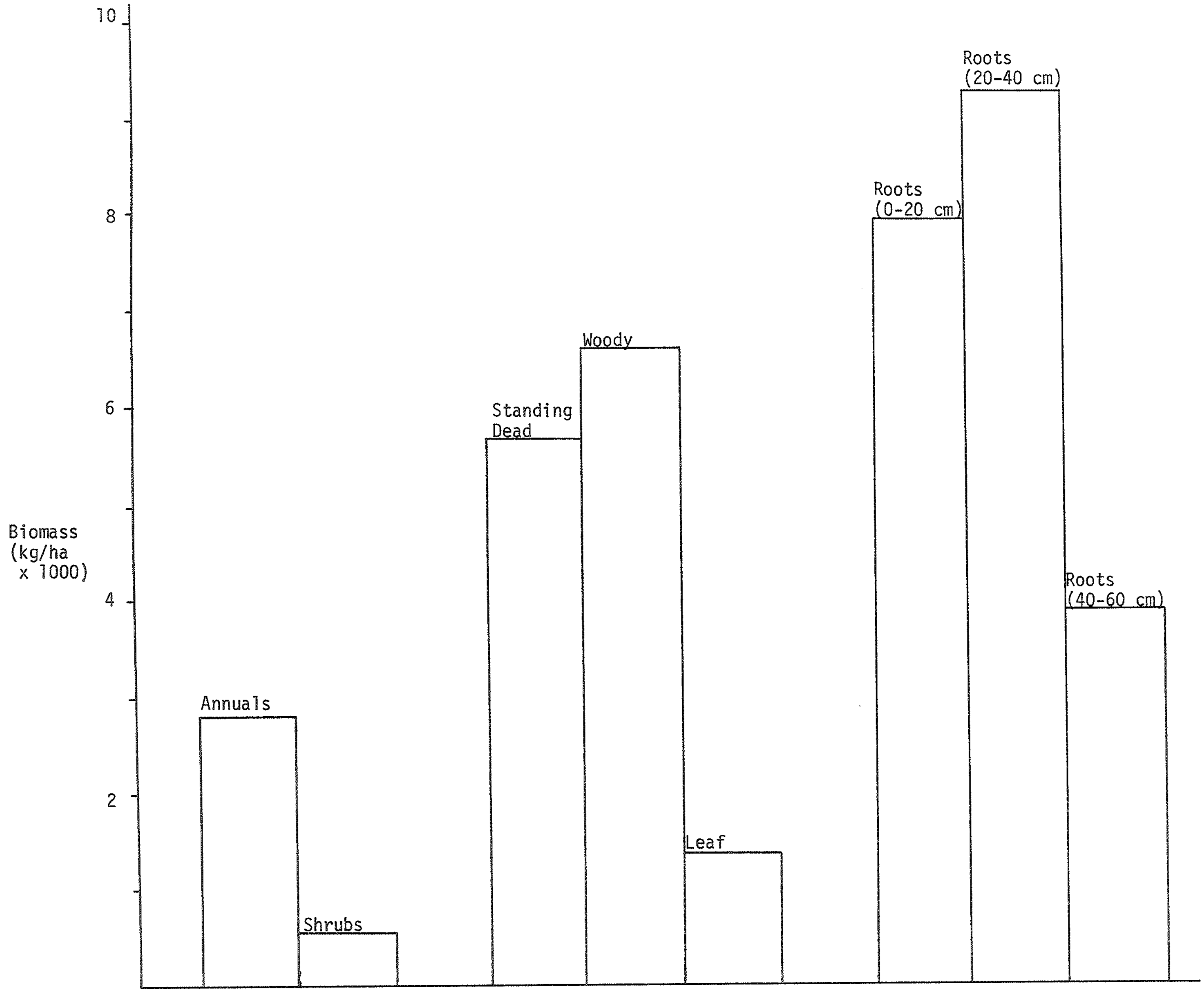


Figure 14. Components of plant biomass in Hal-Art vegetation type of southern shrub site, August 1971.

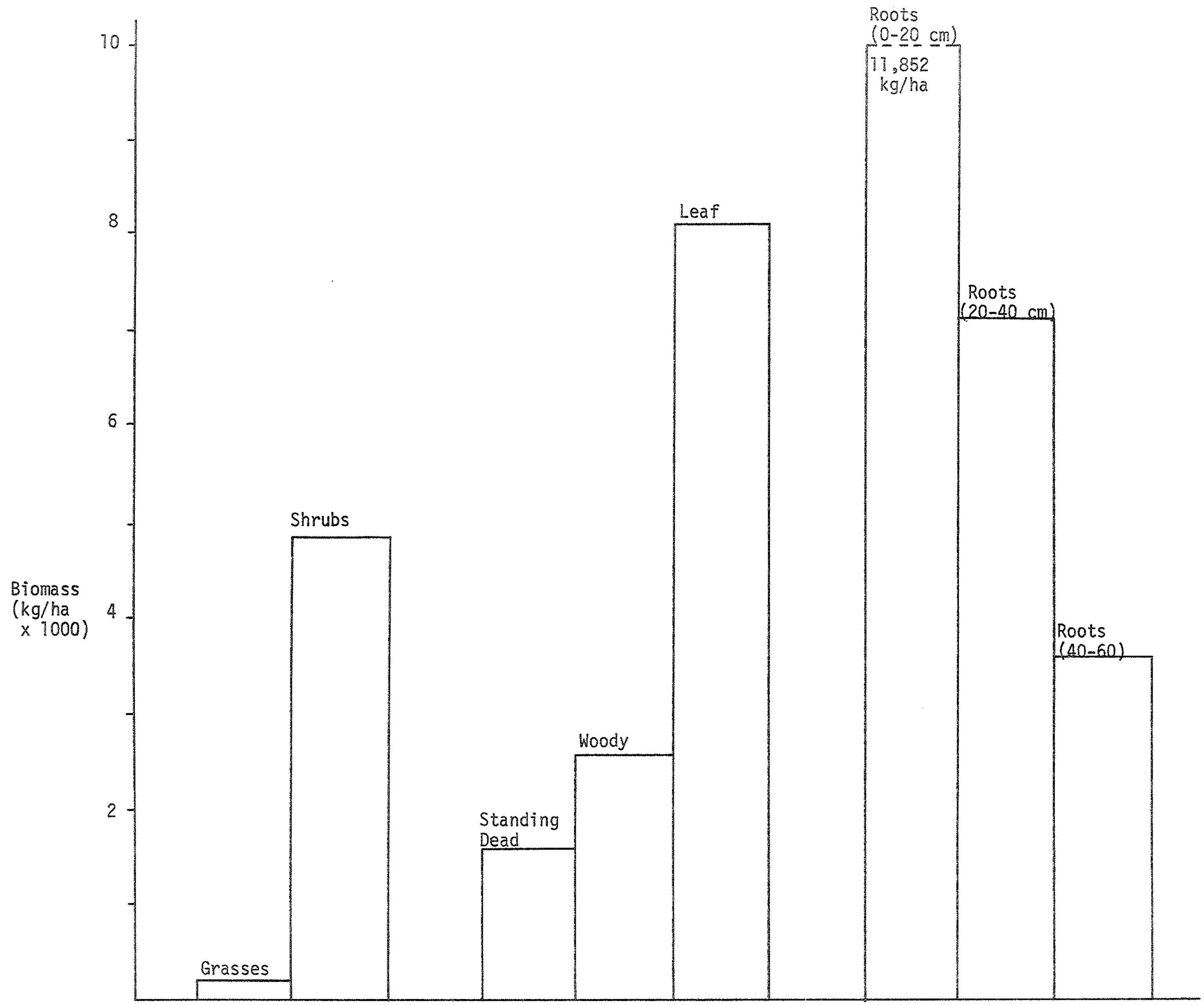


Figure 15. Components of plant biomass in Art-Atr-Sit vegetation type, southern shrub site, August 1972.

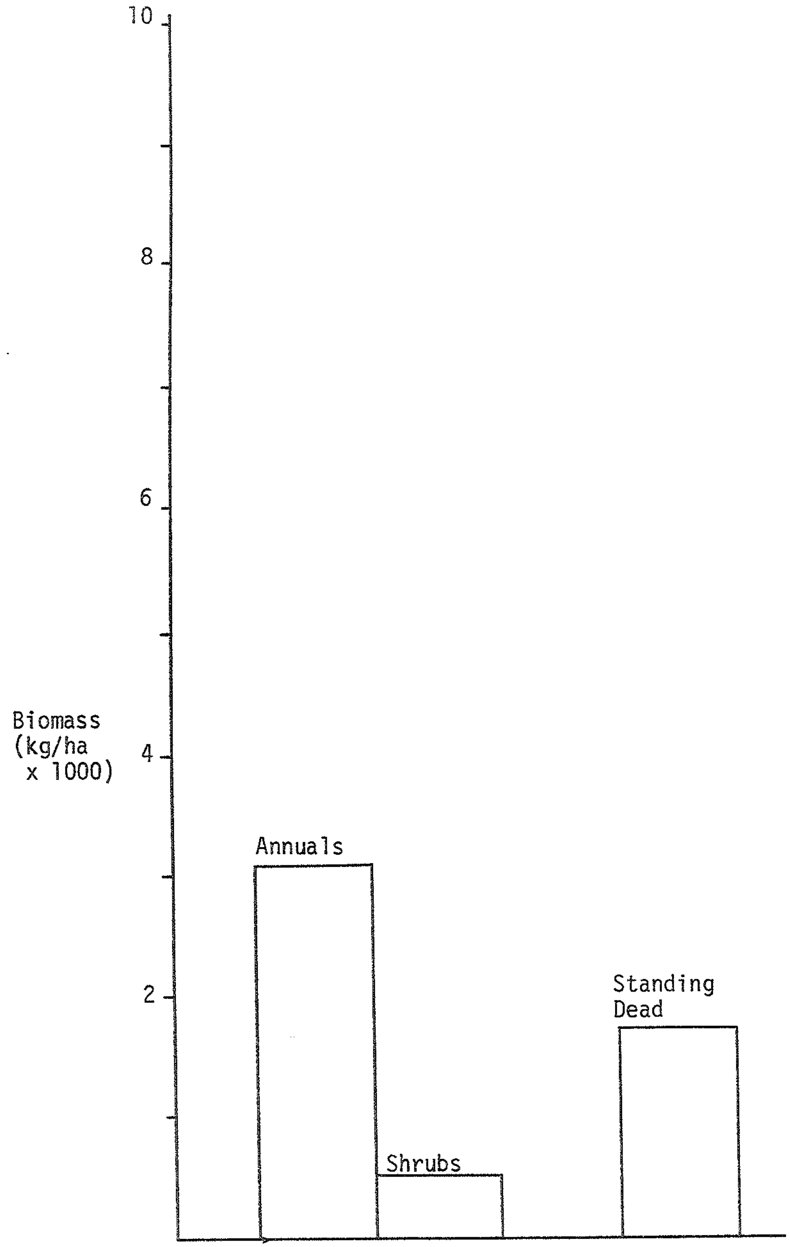


Figure 16. Components of plant biomass in Hal-Art vegetation type, southern shrub site, August 1972.

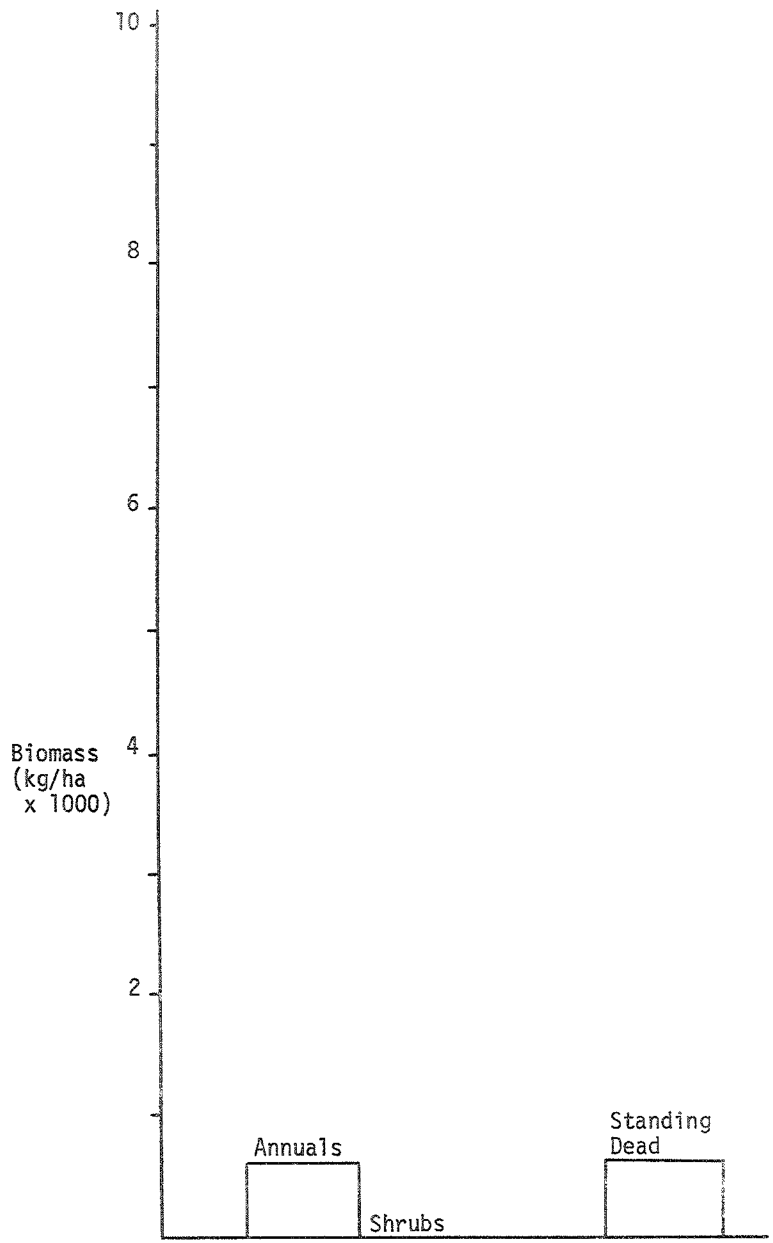


Figure 17. Components of plant biomass in Annuals vegetation type, southern shrub site, August, 1972.

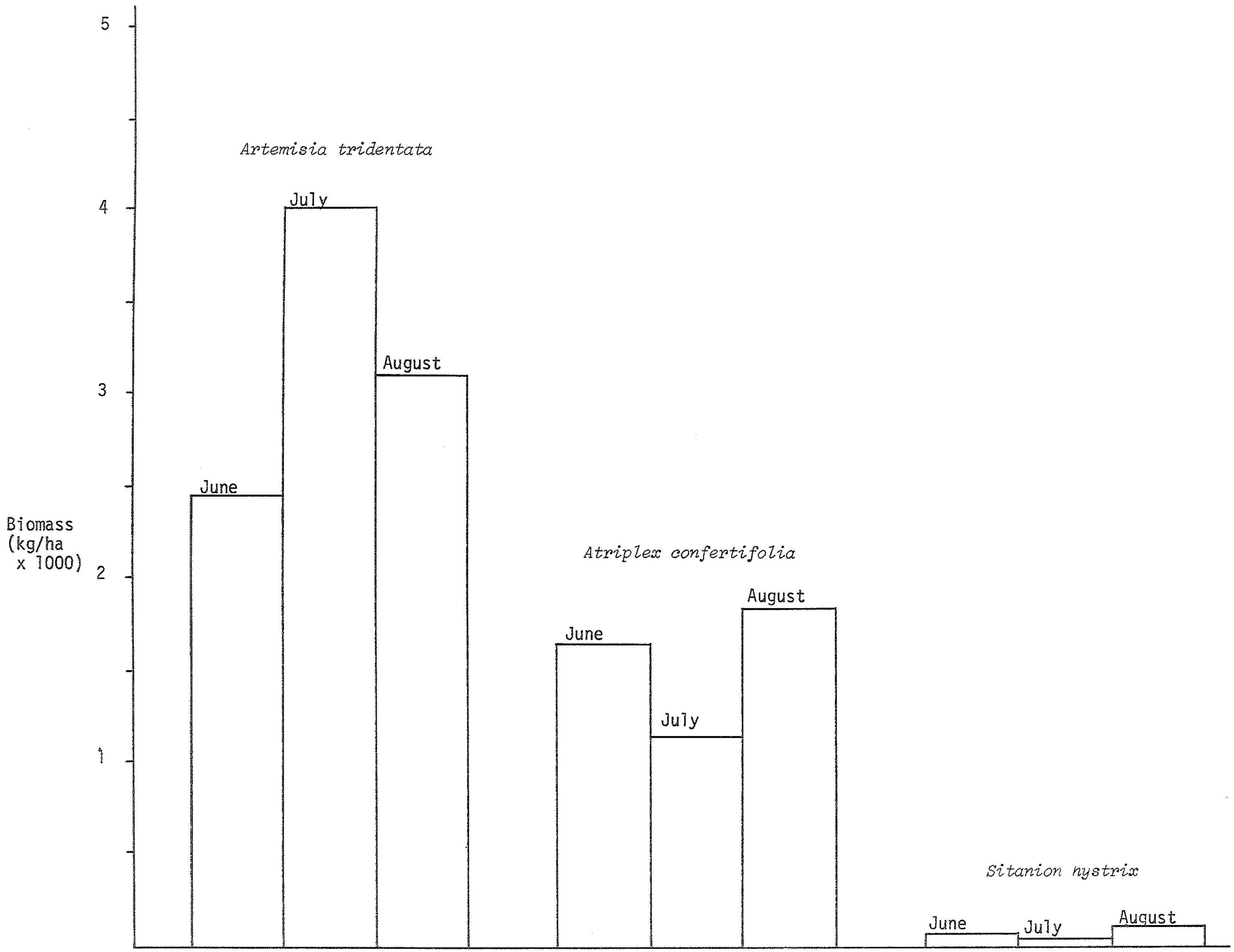


Figure 18. Above ground plant biomass in Art-Atr-Sit vegetation type, southern shrub site, June, July, and August, 1972.

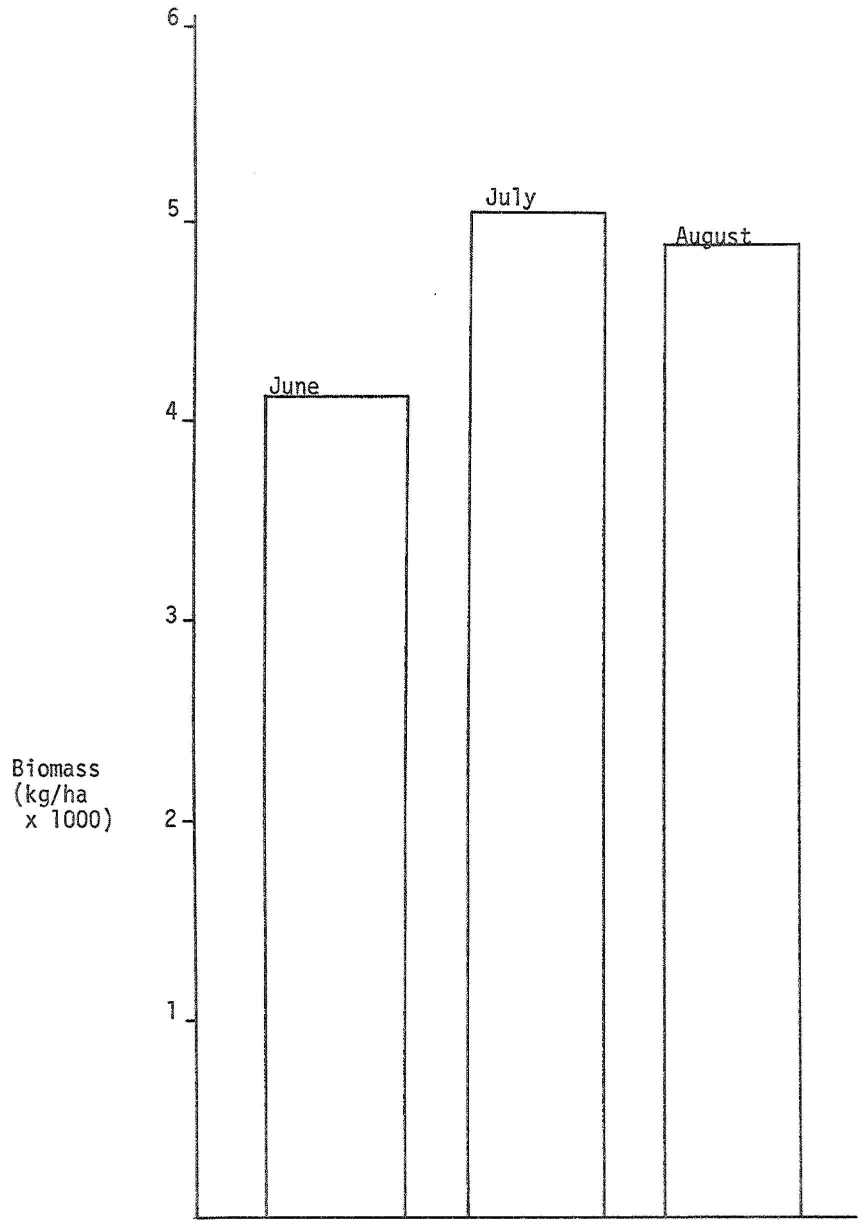


Figure 19. Total above ground biomass in Art-Atr-Sit vegetation type, southern shrub site, June, July, and August, 1972.

Table 7. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on off-site hectare no. 10, August 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1.3	.9	916	±187	11	±3	55	±4	224	±53	12	.15	2911
ATRCON	3.53	1	527	± 92	5	±2	27	±2	69	±14	19	.2	2417
SITHYS	4.5	.9			6	±2	30	±2	21	± 8	.26	.26	95
STADEA	.25	1											3199
Woody litter													2454
Leaf litter													6891
Fecal litter													94
Roots (0-20 cm)													7994
Roots (20-40 cm)													9048
Roots (40-60 cm)													3818

Table 8. Quadrat analysis of Hal-Art vegetation type on the southern shrub site (sample taken on off-site hectare No. 24, August 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.1	.5	2100	±1411	27	±10	87	± 9	566	±168	2	.03	566
HALGLO		1	1911	± 510			46	± 4	144	± 73	55		2879
STADEA	2.3	.9											5630
Woody litter													6504
Leaf litter													1380
Fecal litter													186
Roots (0-20 cm)													6463
Roots (20-40 cm)													7080
Roots (40-60 cm)													2724

Table 9. Quadrat analysis of Art-Atr-Sit vegetation type on the southern shrub site (sample taken on on-site hectare No. 9, June 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.7	.75	264	± 53	17	± 5	56	± 4			7	.48	
ATRCON	2.6	1	99	± 14	7	± 1	27	± 1			10	.72	
CHRVIS	.05	.2	655	±445	22	±21	39	±14			.66	.02	
SITHYS	6.15	1			7	± 1	22	± 1			2	1.68	

Table 10. Quadrat analysis of Art-Atr-Sit vegetation type on the southern shrub site (sample taken on on-site hectare No. 12, July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.39	.7	295	±103	24	±10	59	± 6			5	.4	
ATRCON	2.11	1	98	± 14	6	± 1	29	± 2			8	.56	
CHRVIS	.04	.1	456	±421	13	±10	47	±25			.36	.02	
SITHYS	13.95	1	10	± 18	8	± 1	21	± 1			1	107	

Table 11. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on on-site hectare No. 29, July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.25	.55	303	±104	26	±11	60	±6			3	.28	
ATRCON	2.11	.75	114	± 15	9	± 1	30	±1			10	.76	
CHRVIS	.11	.30	691	±291	16	± 6	46	±8			2	.04	
SITHYS	11.2	1	221	±170	12	± 1	21	±1			1	1.35	

Table 12. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on on-site hectare No. 54 July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.7	.75	346	±84	30	±10	58	±5			10	.84	
ATRCON	1.26	.9	153	±23	11	± 2	32	±2			8	.56	
SITHYS	3.88	1			14	+ 4	20	±1			.56	.56	

Table 13. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on on-site hectare No. 60, July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.69	.8	310	± 70	23	± 7	57	±4			9	.64	
ATRCON	1.1	.8	115	± 24	7	± 2	29	±2			5	.32	
CHRVIS	.31	.6	688	±208	19	± 6	49	±4			4	.12	
ALYCIN	.68	.2			28	±20	33	±3			.19	.19	
SITHYS	1.53	.85			15	± 5	21	±2			.24	.24	

Table 14. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on on-site hectare No. 67, July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.86	.9	380	± 88	27	±7	59	±4			13	.92	
ATRCON	1.33	.2	149	± 28	13	±2	30	±2			8	.68	
CHRVIS	.18	.45	584	±262	19	±7	42	±6			2	.06	
SITHYS	.48	.35			7	±3					.03	.03	

Table 15. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on off-site hectare No. 10, June, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1	.9	791	±117	16	±5	55	±2	248	±48	8	.16	2479
ATRCON	2.94	1	330	± 37	5	±1	31	±1	56	± 8	10	.15	1640
SITHYS	6.83	1			6	±1	19	±1	66	± 7	.42	.42	45

Table 16. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on off-site hectare No. 10, July, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1.55	.9	1033	±156	16	±4	53	±2	256	±55	16	.25	3973
ATRCON	2.6	1	350	± 45	6	±1	28	±2	45	± 7	9	.17	1159
SITHYS	5.73	1			8	±2	18	±1	63	± 8	.49	.49	36
STADEA		1											

Table 17. Quadrat analysis of Art-Atr-Sit vegetation type on southern shrub site (sample taken on off-site hectare No. 10, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	1.46	.9	316	±42	13	±2	54	±2	214	±34	18	.76	3123
ATRCON	3.28	1	86	±11	7	±1	25	±1	52	± 9	11	.88	1710
SITHYS	7.63	1			7	±1	18	±1	1	0	.55	.55	80
STADEA	1.66	1											2568
Woody litter													2570
Leaf litter													8040
Fecal litter													168
Roots (0-20 cm)									5.96	± .40			11852
Roots (20-40 cm)									3.63	± .20			7219
Roots (40-60 cm)									1.72	± .33			3421

Table 18. Quadrat analysis of annuals vegetation type on southern shrub site (sample taken on on-site hectare No. 51, September, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
BASHYS	138.13	.75	697	±1086			19	± 4			5		
CHEALB	.28	.1	11	± 57			15	±32			.006		
DESPIN	9.23	.7	640	± 459			28	± 4			2		
HALGLO	480	.95	5336	±2275			18	± 3			48		
LEPPER	3.45	.4	212	± 221			20	± 4			.42		
SALKAL	9.55	.5	327	± 402			15	± 4			4		
SITHYS	.25	.35			31	±26	14	± 2			.08	.08	

Table 19. Quadrat analysis of annuals vegetation type on southern shrub site (sample taken on on-site hectare No. 52, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
BASHYS	665.03	.9	2247	±1052			14	±2			10		
DESPIN	19.1	.8	353	± 228			24	±2			1		
HALGLO	129.83	.75	2578	±1551			13	0			10		
SALKAL	7.53	.8	539	± 763			11	±1			2		
SITHYS	.48	.35			19	± 9	13	±2			.09	.09	

Table 20. Quadrat analysis of annuals vegetation type on southern shrub site (sample taken on off-site hectare No. 31, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
BASHYS	736.48	.9	4206	±1402			13	±3	97	±30	25		434
DESPIN	29.75	1	650	± 809	25	±158	22	±2	9	± 9	3		49
HALGLO	51	.55	316	± 396			11	±2	32	±36	8		79
SALKAL	17.38	.35	1679	±1994			13	±3	27	±35	3		47
STADEA	.24	.5											684

Table 21. Quadrat analysis of Hal-Art vegetation type on southern shrub site (sample taken on on-site hectare No. 85, September, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.13	.5	1498	± 547	18	± 9	66	±12			3	.02	
BASHYS	1.28	.45	274	± 233			21	± 5			2		
DESPIN	16.8	1	1348	± 585			27	± 2			7		
HALGLO	99.15	1	5150	±2034			30	± 2			44		
SITHYS	.08	.15			14	±12	13	±10			.01	.01	

Table 22. Quadrat analysis of Hal-Art vegetation type on southern shrub site (sample taken on on-site hectare No. 89, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTSEE	5.21	.45									.1		
ARTTRI	.31	.7	1669	± 362	25	±7	63	±8			9	.08	
DESPIN	18.35	1	1144	± 534			29	±2			6		
HALGLO	11.13	.85	2845	±1224			33	±3			18		
SALKAL	27.55	.7	3880	±2016			32	±3			25		

Table 23. Quadrat analysis of Hal-Art vegetation type on southern shrub site (sample taken on off-site hectare No. 24, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
ARTTRI	.15	.4	2754	±1061	26	±13	56	±16	411	±200	4	.04	617
DESPIN	25	.9	2150	± 736			31	± 3	9	± 2	11		40
HALGLO	54.95	1	5775	±1429			30	± 2	568	±493	39		2981
STADEA	.6												1688

Root biomass increased near the soil surface in 1972 relative to 1971. Two factors may have been responsible for this change. The first was that low amounts of rainfall may have stimulated root growth at the surface. The second was that the salt moved upward in the soil profile and forced root growth toward the surface.

The southern crested wheat grass site (Fig. 20) was the most homogeneous site of the four. The seeding was 8 years old -- not sufficient time for much native vegetation to reinvade. The major plants that did invade in portions of the site were *Artemisia tridentata*, *Atriplex confertifolia*, and *Sitanion hystrix* (Figs. 21 and 22). Biomass changes on the southern shrub site from 1971 to 1972 are given in Tables 24 and 25.

The results of the quadrat analysis for the southern grass site are presented in Tables 26-33. Figures 23-25 and Table 34 show the changes in the distribution of biomass through time.

The 1971, grass production was eaten by cattle in the winter and spring of 1972 (see Vertebrates section). Grazing use, coupled with a dry 1972 growing season accounted for the decrease in grass biomass in the summer of 1972.

The large amount of woody litter on this site relative to the type of vegetation present is due to the shrub vegetation that was killed prior to seeding. There were probably no significant changes in the amount of dead woody material between 1971 and 1972.

The root distribution on the grass site changed from 1971 to 1972 just as it did on the southern shrub site. However, there were no significant differences between the root distributions or biomass of the southern sites in 1971 or in 1972 ($P<0.1$)

Work done by M. Caldwell and L. Camp with radioactive carbon tracers indicates that the amount of living root material in a sample of roots taken in a stand of *Atriplex confertifolia* is about 6 to 20% (pers. comm., L. Camp). This work was done about 14 km west of the southern sites.

The *Artemisia tridentata* and *Atriplex confertifolia* shrubs collected on the southern sites served several functions. The first was to establish above-ground components of shrub biomass (Table 35 and Fig. 26). The second was to determine shrub age distribution (Fig. 27). The third function was to develop a predictor for shrub biomass by components from three plant measurements: basal area, size class, and cover (Table 36).

The predictive equations should be of value in monitoring the vegetation through time. Biomass estimates based on the regressions can be made at any future date on the 100 permanent plots that provided the data to develop the equations.

Another use that is to be made of the shrub component data is to develop a predictor of shrub biomass by component from the total biomass of the plant. This will be done in 1973.

During the plant validation work, records have been kept of all the plant species and families seen on the sites (Tables 37 and 38). There were 15 species on the southern sites and about 85 species on the northern sites.

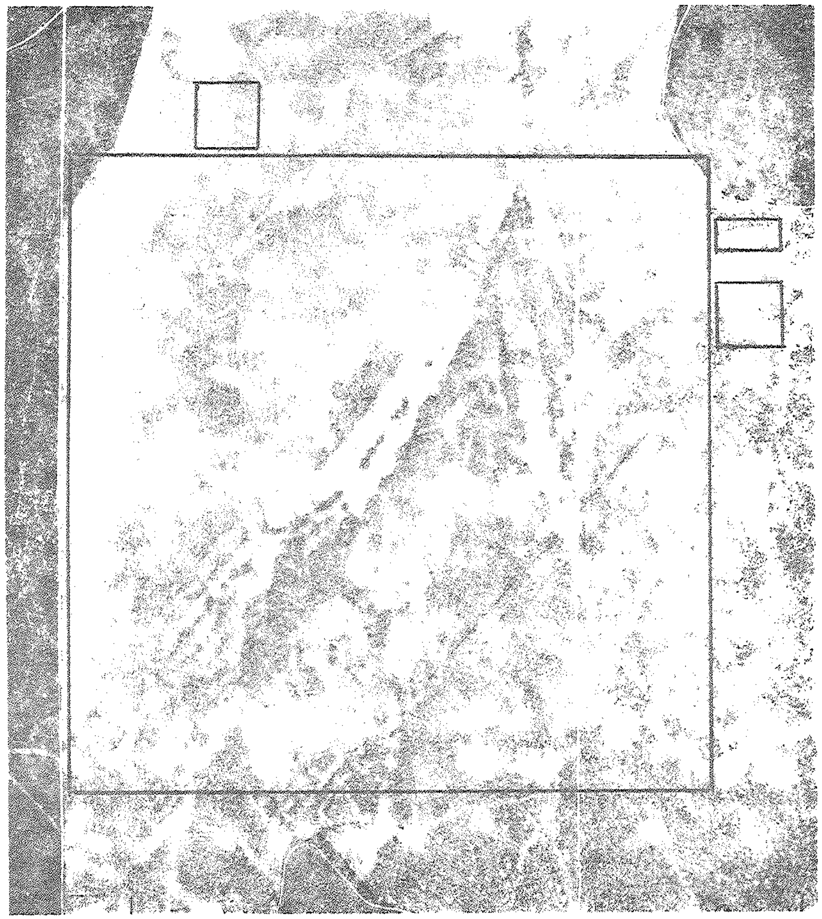


Figure 20. Aerial photo of southern crested wheatgrass site including off-site destructive sampling areas (small plots).

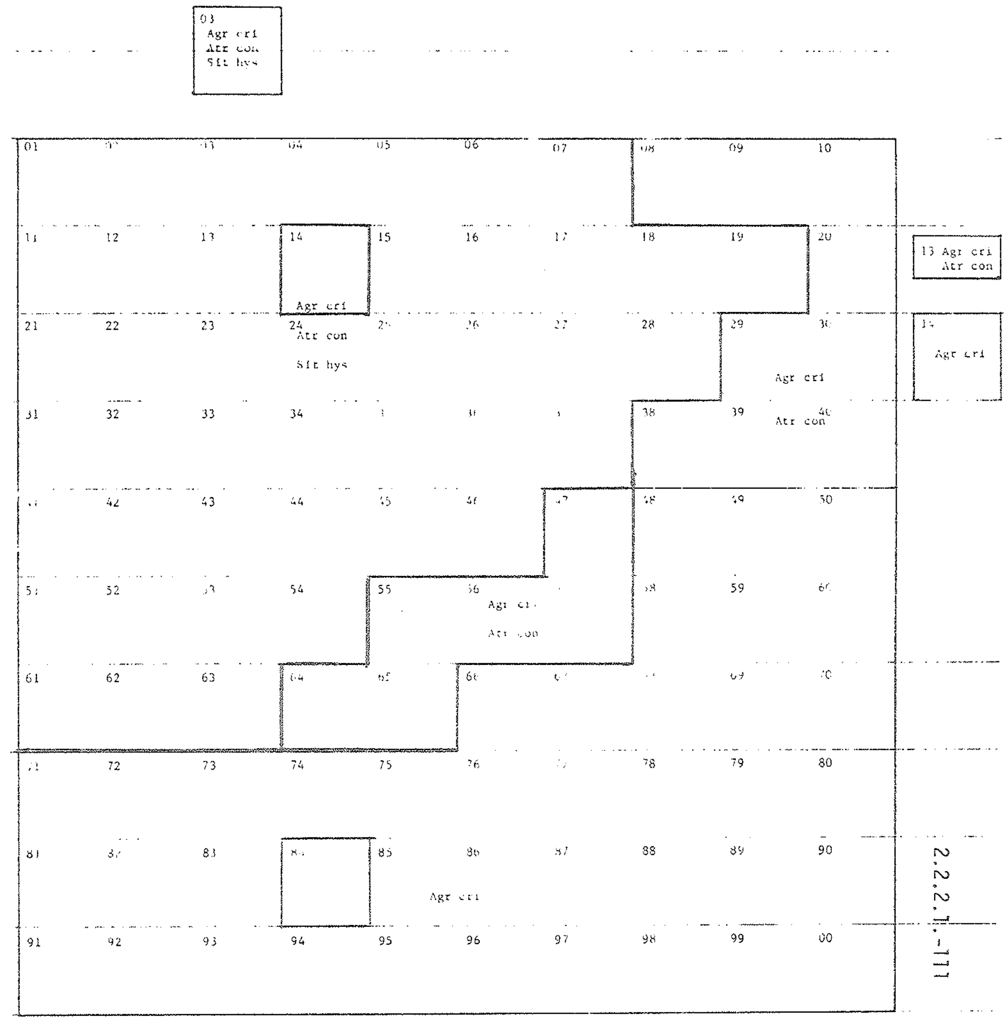


Figure 21. Hectare grid, dominant vegetation of southern sites.

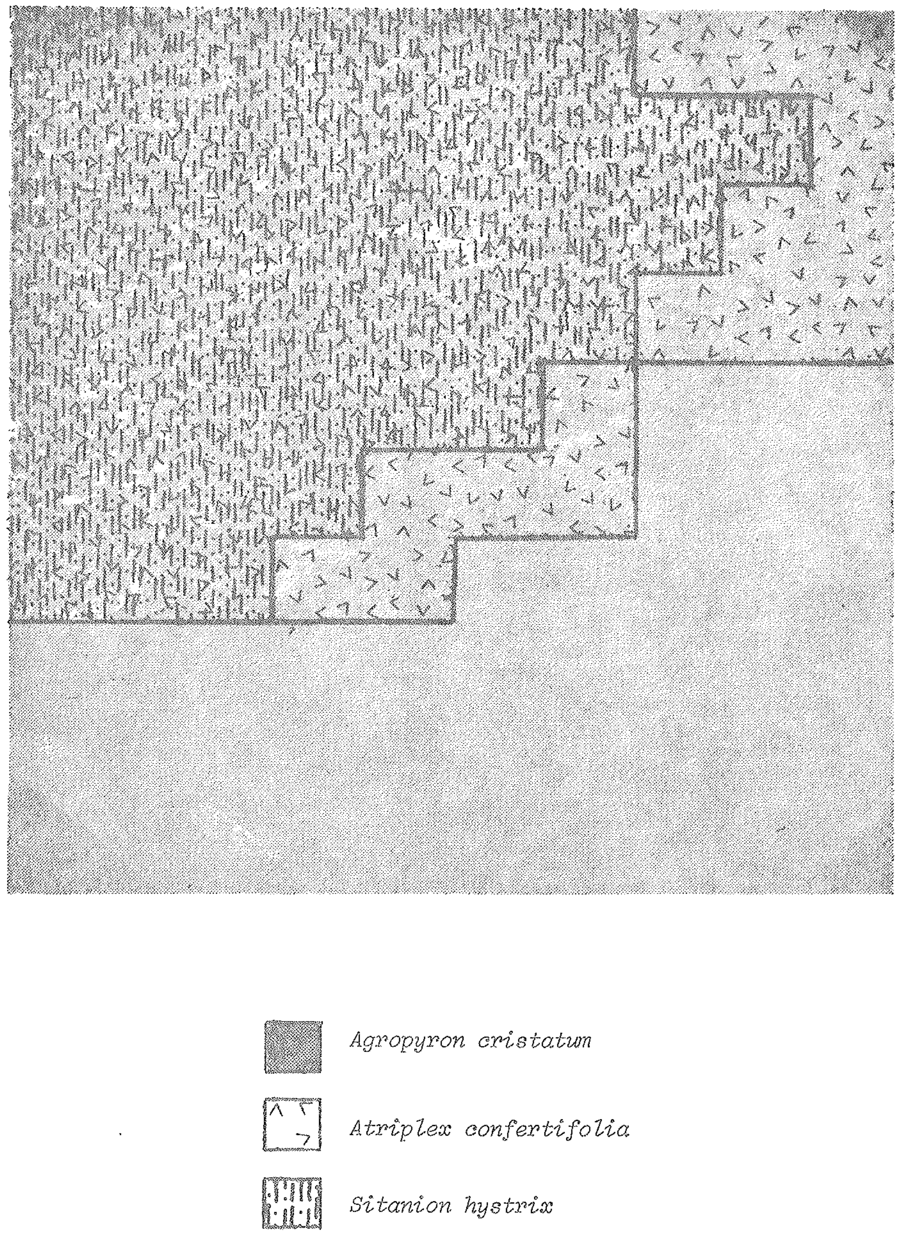


Figure 22. Dominant plants on the southern grass site.

Table 24. Biomass changes in Art-Atr-Sit vegetation type on southern shrub site from 1971 to 1972

Species or Component	Change from August 1971 to August 1972 Cover (%)	Biomass (kg/ha)
ARTTRI	6	+ 212
ATRCON	-8	- 707
SITHYS	.29	- 15
Total	-1.71	- 510
STADEA		- 631
Woody litter		116
Leaf litter		1149
Total		634
Roots (0-20 cm)		3858
Roots (20-40 cm)		- 1829
Roots (40-60 cm)		- 397
Total		1632

Table 25. Biomass changes in Hal-Art vegetation type on southern shrub site from 1971 to 1972

Species or Component	Change from August 1971 to August 1972 Cover (%)	Biomass (kg/ha)
ARTTRI	+ 2	+ 51
HALGLO	-16	+ 102
STADEA		- 3958

Table 26. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 3, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	8	1			38	± 7	58	± 2	17	± 4	3	3.06	1393
ATRCON	2.92	.7	120	±40	2	± 1	21	± 2	11	± 4	3	.08	321
SITHYS	2.3	.8	80	0	11	± 4	31	± 2	8	± 3	.25	.25	187
Woody litter													356.72
Leaf and stem litter													356.72
Fecal litter													14.56
Roots (0-20 cm)													942.61
Roots (20-40 cm)													829.26
Roots (40-60 cm)													447.47

Table 27. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 13, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	9.6	1			45	±6	59	±2	20	±3	4	4.28	1940
SITHYS	4	.4			11	±5	28	±5	3	±4	.42	.42	127
Woody litter													713.96
Leaf&Stem litter													605.66
Fecal litter													17.38
Roots (0-20 cm)													938.64
Roots (20-40 cm)													938.64
Roots (40-60 cm)													423.58

Table 28. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 15, August, 1971)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	11.5	1			41	+8	57	±2	21	± 3	5	4.74	2386
CHRVIS	.72	.2	924	±1184	5	±4	31	±7	59	±88	14	.04	414
Woody litter													7120
Grass litter													4286
Animal fecal litter													305
Roots (0-20 cm)													8511
Roots (20-40 cm)													10043
Roots (40-60 cm)													3699

Table 29. Quadrat analysis of vegetation on southern grass site (sample taken on on-site hectare No. 14, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	12.20 (±2.88)	1			35	±3	25	±1			4	4.32	
ARTTRI	.03	.1	12	±13	1	0	20	0			.0012	.0012	
ATRCON	4.17	1	39	± 4	2	0	20	0			7	.32	
SITHYS	1.17	.75			11	±2	19	0			.01	.01	

Table 30. Quadrat analysis of vegetation on southern grass site (sample taken on on-site hectare No. 84, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	9.2	1			39	±4	23	± 1			4	3.66	
ARTTRI	.06	.2	52	±50	2	±1	24	±11			.12	.12	
ATRCON	1.38	1	26	± 4	2	±2	18	± 1			1.4	.12	
SITHYS	.18	.1			15	±7	17	± 4			.0012	.0012	

Table 31. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 15, June 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	10.3	1			45	±4	25	0	5	± 1	5	5	525
CHRVIS	.04	.1	296	±74	3	±2	23	±10	24	±13	.24	.0022	10

Table 32. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 15, July 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	11.43				50	±3	28	±1	4	±1	6	5.67	504
ARTTRI	.4		111	± 62	1	±1	32	±8	8	±2	.44	.01	32
CHRVIS	.11		388	±213	2	±2	26	±6	12	±7	.43	.002	14

Table 33. Quadrat analysis of vegetation on southern grass site (sample taken on off-site hectare No. 15, August, 1972)

Species	Density (m^2)	Frequency	Cover per Indiv. (cm^2)	90% C.I.	Basal Area per Indiv. (cm^2)	90% C.I.	Height per Indiv. (cm)	90% C.I.	Weight per Indiv. (g)	90% C.I.	Cover (%)	Basal Area (%)	Biomass (kg/ha)
AGRCRI	13.03	1			43	±3	28	±2	6	± .5	6	5.59	723
CHRVIS	.46	.3	204	±86	2	±1	26	±3	17	± 8	2	.06	78
Woody litter													274.6
Grass litter													602.6
Roots (0-20 cm)									6.55	± .37			13,026
Roots (20-40 cm)									3.58	± .36			7119
Roots (40-60 cm)									1.73	± .28			3440

Table 34. Changes in plant biomass on the southern grass site from 1971 to 1972

Species or Component	Change from August 1971 to August 1972 Cover (%)	Biomass (kg/ha)
AGRCRI	+1	-1882
Woody litter		-6256
Grass litter		+1740
Total		-4516
Roots (0-20 cm)		+4515
Roots (20-40 cm)		-2924
Roots (40-60 cm)		- 259
Total		+1332

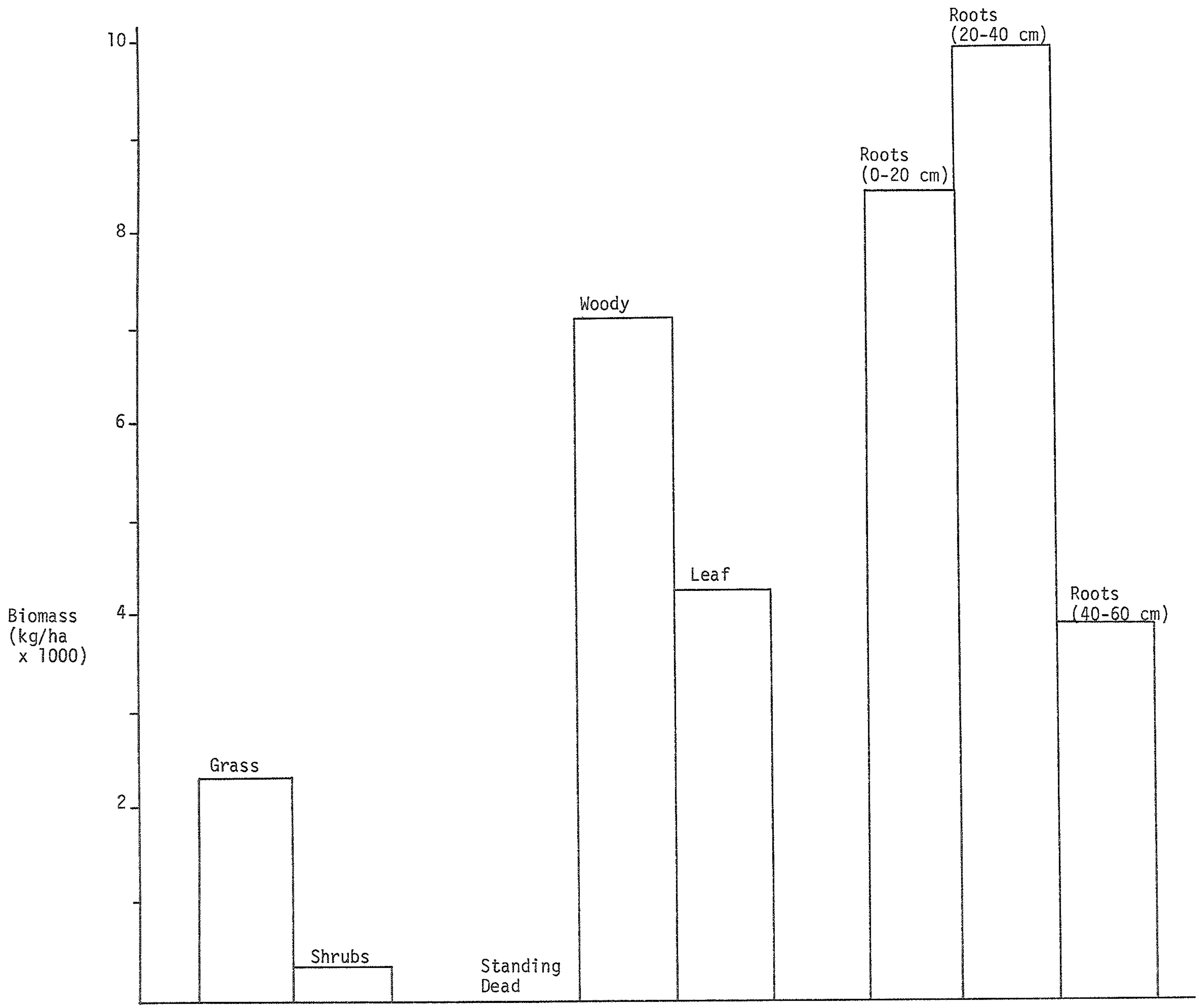


Figure 23. Components of plant biomass, southern grass site, August, 1971.

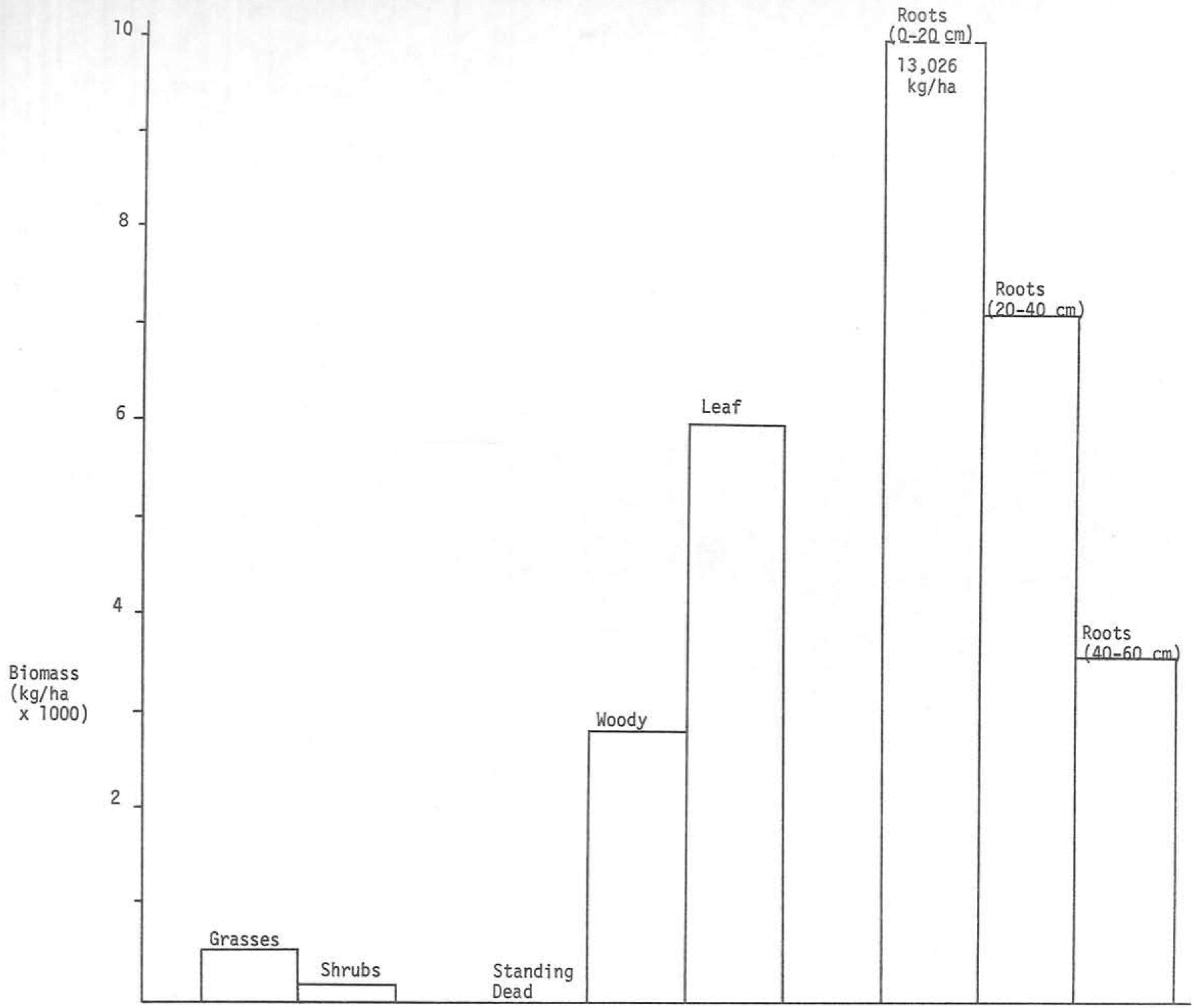


Figure 24. Components of plant biomass on southern grass site, August, 1972.

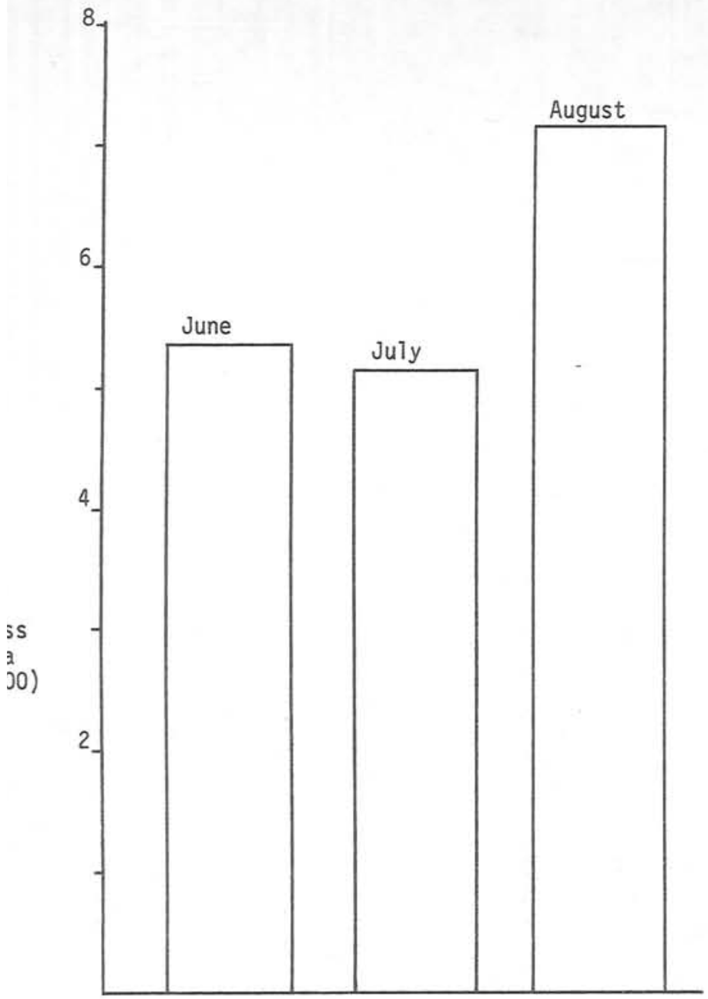


Figure 25. Above ground plant biomass on southern grass site in June, July, and August, 1972.

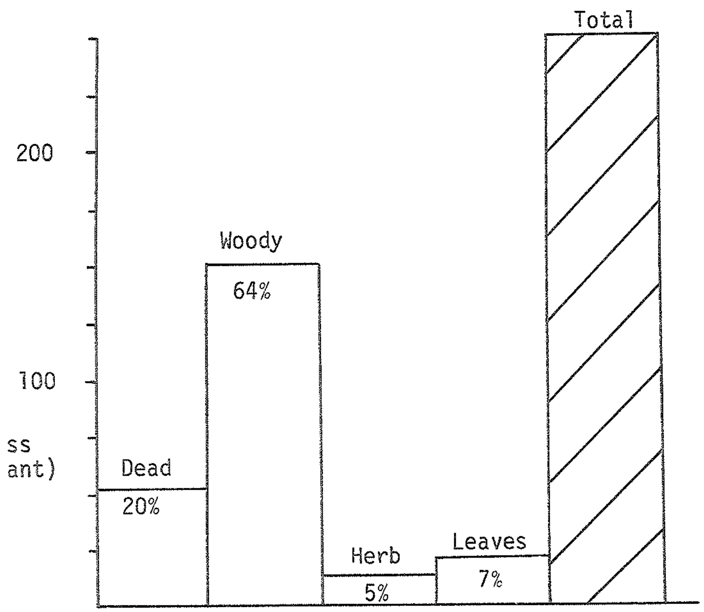
Table 35. Measurements taken from 100 *Artemisia tridentata* and 300 *Atriplex confertifolia* plants in southern shrub site (samples taken from off-site hectare 10, summer, 1972*)

Species	Mean Height (cm)	Mean Cover (cm^2)	Mean Basal Area (cm^2)	Wt. Woody Stems (g)	Wt. Herb. stems (g)	Wt. Leaves (g)	Wt. Inflor-escences (g)	Wt. Dead wood (g)	Total wt. (g)	Mean Age (years)
ARTTRI										
$\bar{x}$ per plant	50.43	1110.12	15.35	163.30	12.94	18.70	2.79	51.12	256.92	19.24
90% C.I.	±2.14	±173.35	±3.14	±28.97	±2.46	±3.66	±.74	±25.64	±52.62	±.99
% of Total				65%	5%	7%	1%	20%	100%	
ATRCON										
$\bar{x}$ per plant	26.10	354.65	5.19	47.10	.97	4.58			54.00	
90% C.I.	±1.09	±35.66	±.63	±5.14	±.26	±.50			±6.44	
% of Total				87%	2%	8%			100%	

*The sum of biomass components accounts for only 97% of the total biomass due to component categories not included in this table.

Artemisia tridentata

Height	50 cm ± 2
Cover	1110 cm^2 ± 173
Basal Area	15 cm^2 ± 3
Age	19 yrs ± 1



Atriplex confertifolia

Height	26 cm ± 1
Cover	355 cm^2 ± 36
Basal Area	5 cm^2 ± 1

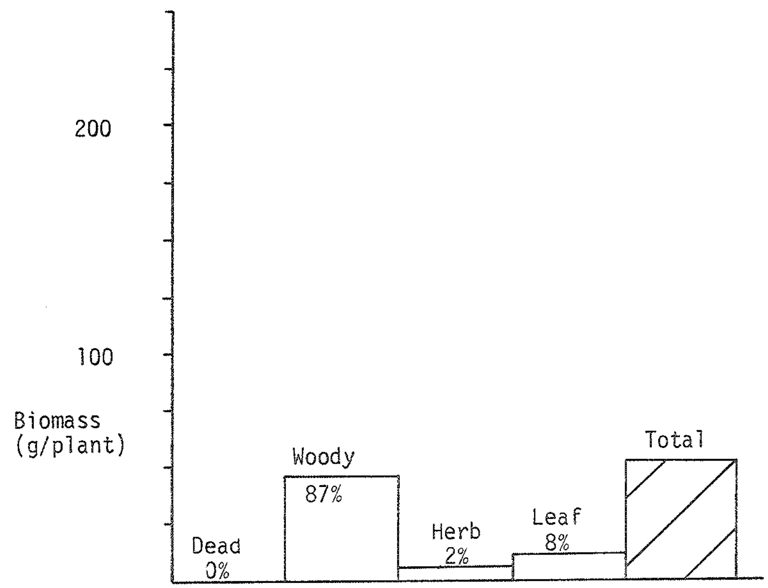


Figure 26. Measurements taken from 100 *Artemisia tridentata* and 300 *Atriplex confertifolia* plants on southern shrub site. (samples taken from off-site hectare 10, summer, 1972).

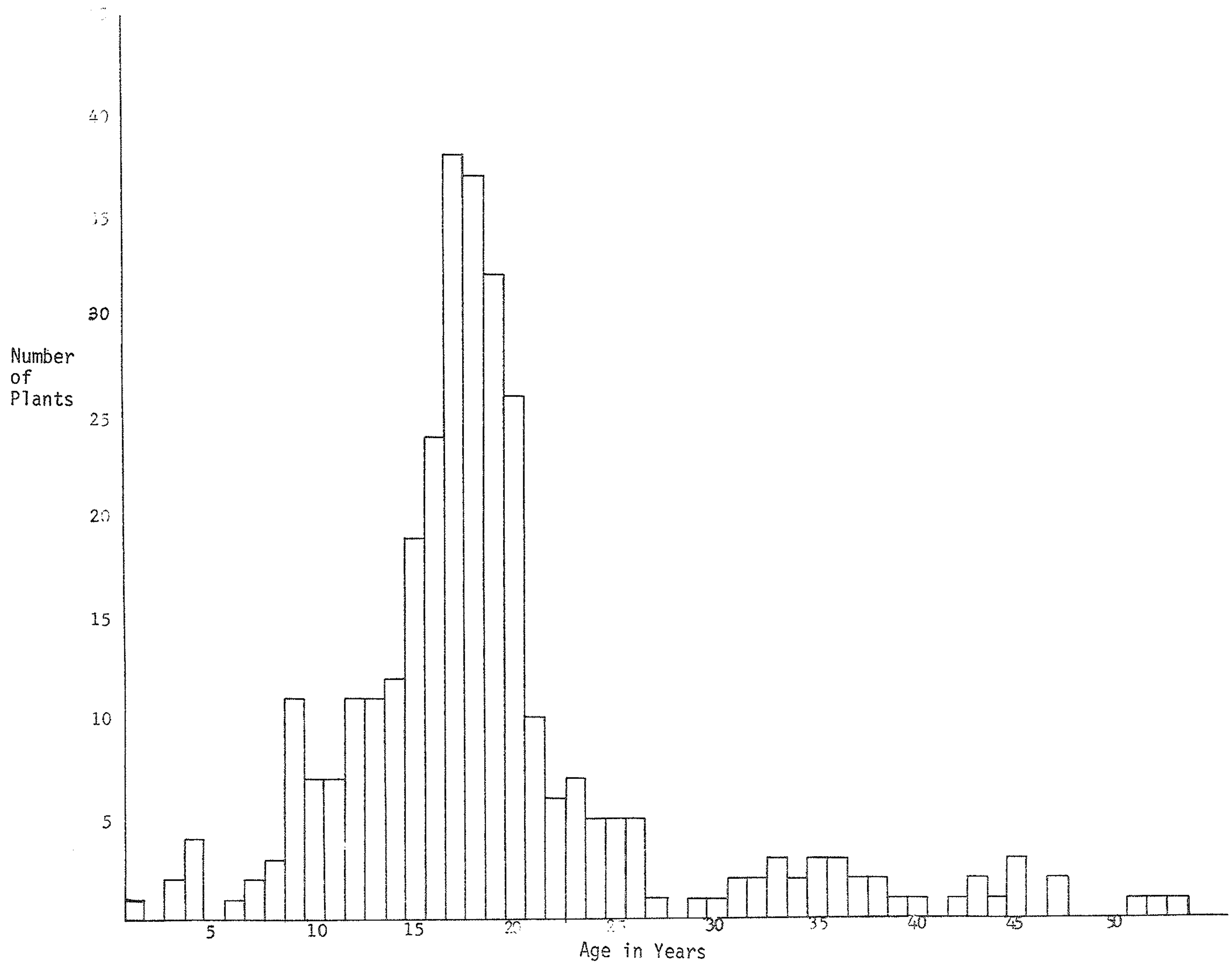


Figure 27. Age distribution of 100 *Artemisia tridentata* plants, southern shrub site (samples taken from off-site hectare 10, summer, 1972.

Table 36. Regression formulae for predicting shrub biomass

		r^2
Artemisia tridentata	$y = 128.8 - 7.787S + .1636C + 5.779B + .1168S^2 + .2976SC + .1205SB + .000004C^2 + .0012CB - .069B^2$	.81
Atriplex confertifolia	$y = 1.834S + .01059C + 1.439B - .04959S^2 + .001894SC + .1671SB + .000007C^2 - .0015CB - .08875B^2 - 3.883$	.89

y = biomass (g)
B = basal area (cm^2)
C = cover (cm^2)
S = site class $\left(\frac{\text{height cm}}{10}\right)$

Table 37. Plant species list and code for Curlew Valley validation sites

Plant	Code Name
Achillea millefolium L.	ACHMIL
Agoseris glauca (Pursh.) Raf.	AGOGLA
Agropyron cristatum (L.) Gaertn.	AGRCRI
Agropyron dasystachyum (Hook.) Scribn.	AGRDAS
Agropyron seedling	AGRSEE
Agropyron smithii Rydb.	AGRSMI
Agropyron spicatum (Pursh.) Scribn & Smith	AGRSPI
Allium acuminatum Hook.	ALLACU
Amelanchier alnifolia Nutt.	AMEALN
Antennaria dimorpha (Nutt.) T. & G.	ANTDIM
Arabis holboellii Horneum.	ARAHOB
Artemisia dead	ARTDEA
Artemisia ludoviciana Nutt.	ARTLUD
Artemisia seedling	ARTSEE
Artemisia tridentata Nutt.	ARTTRI
Aster campestris Nutt.	ASTCAM
Aster chilensis Nees.	ASTCHI
Astragalus beckwithii T. & G.	ASTBEC
Astragalus convallarius Greene	ASTCON
Astragalus purshii Dougl.	ASTPUR
Atriplex confertifolia (Torr. & Frem) Wats.	ARTCON
Balsamorhiza sagittata (Pursh.) Nutt.	BALSAG
Bare ground	BARGRO
Bassia hyssopifolia	BASHYS
Bromus tectorum L.	BROTEC
Calochortus nuttallii T. & G.	CALNUT
Camelina microcarpa Andrz.	CAMMIC
Castilleja chromosa A. Nels.	CASCHR
Castilleja hispida Benth.	CASHIS
Chaenactis douglasii (Hook.) H. & A	CHADOU
Chenopodiaceae seedling	CHESEE
Chenopodium album	CHRDEA
Chrysothamnus dead	CHEALB
Chrysothamnus nauseous (Pall.) Britt	CHRNAU
Chrysothamnus parryi (A. Gray) Greene	CHRPAR
Chrysothamnus viscidiflorus (Hook.) Nutt.	CHRVIS
Cirsium arvense Petr.	CIRUTA
Collinsia parviflora Lindl	COLPAR

Continued

Table 37. Continued

Plant	Code Name
Collomia linearis Nutt.	COLLIN
Comandra umbellata (L.) Nutt.	COMUMB
Cordylanthus ramosus Nutt.	CORRAM
Crepis acuminata Nutt.	CREACU
Cruciferae seedling	CRUSEE
Cymopterus terebinthinus (Hook.) T. & G.	CYMTER
Delphinium nuttallianum Pritz.	DELNUT
Descurainia pinnata (Walt.) Britt.	DESPIN
Descurainia richardsonii (Sweet) Schultz	DESRIC
Elymus cinereus Scribn. & Merrill	ELYCIN
Eriastrum sparsiflorum (Eastw.) Mason	ERISPA
Erigeron caespitosus Nutt.	ERICAE
Erigeron pumilis Nutt.	ERIPUM
Eriogonum microthecum Nutt.	ERIMIC
Eriogonum ovalifolium Nutt.	ERIOVA
Eriogonum umbellatum Torr.	ERIUMB
Erodium cicutarium (L.) L'Her.	EROCIC
Gayophytum ramosissimum Nutt.	GAYRAM
Gilia aggregata (Pursh.) Spreng.	GILAGG
Grass seedling	GRASEE
Gutierrezia sarothrae (Pursh.) Britt. & Rusby	GUTSAR
Hackelia jessicae (McGregor) Brand	HACJES
Halogeton glomerata Meyer	HALGLO
Helianthus annuus L.	HELANN
Hordeum jubatum L.	HORJUB
Hyoscyamus niger L.	HYONIG
Juniperus osteosperma (Torr.) Little	JUNOST
Lactuca serriola L.	LACSER
Lappula redowskii (Hornem.) Greene	LAPRED
Lepidium densiflorum Schrad.	LEPDEN
Lepidium perfoliatum L.	LEPPER
Leptodactylon watsoni (A. Gray) Rydb.	LEPWAT
Linum lewisii Pursh.	LINLEW
Lithospermum ruderale Dougl.	LITRUD
Lomatium triturnatum (Pursh.) Coult. & Rose	LOMTRI
Lupinus sericeus Pursh.	LUPSER
Malcomia africana R. Br.	MALAFR
Microsteris gracilis (Hook.) Greene	MICGRA
Oenothera caespitosa Nutt.	OENCAE
Opuntia polyacantha Haw.	OPUPOL
Orobanche fasciculata Nutt.	OROFAS
Oryzopsis hymenoides (R. & S.) Ricker	ORYHUM
Penstemon cyananthus Hook.	PENCYA
Phlox dead	PHLDEA
Phlox hoodii Rich.	PHLHOO
Phlox longifolia Nutt.	PHLLON
Plantago patagonica Roem. & Schult.	PLAPAT
Poa bulbosa L.	POABUL
Poa dead	POADEA
Poa pratensis L.	POAPRA
Poa secunda Presl.	POASEC
Poa seedling	POASEE

Continued

Table 37. Continued

Plant	Code Name
Polemoniaceae	POLEMO
Polygonum aviculare L.	POLAVI
Polygonum douglasii Greene	POLDOU
Purshia tridentata (Pursh.) DC.	PURTRI
Ranunculus testiculatus Crantz	RANTES
Salsola kali L.	SALKAL
Senecio uintahensis (A. Nels.) Greene	SENUIN
Sisymbrium altissimum L.	SISALT
Sisymbrium linifolium Nutt.	SISLIN
Sitanion hystrix J.G. Smith	SITHYS
Sphaeralcea munroana (Dougl.) Spach.	SPHMUN
Standing dead	STADEA
Stipa comata Trin. & Rupr.	STICOM
Symphoricarpos oreophilus A. Gray	SYMORE
Taraxacum officinale Weber	TAROFF
Tetradymia canescens DC.	TETCAN
Tetradymia dead	TETDEA
Tetradymia spinosa H. & A.	TETSPI
Tragopogon dubius Scop.	TRADUB
Unknown	UNKNOW
Unknown dicotyledoneae	UNKDIC
Unknown monocotyledoneae	UNKMON
Verbena bracteata Lar. & Rodr.	VERBRA
Veronica bilbòba L.	VERBIL
Viola nuttallii Pursh.	VIONUT
Zigadenus paniculatus (Nutt.) Wats.	ZIGPAN

Table 38. Plant families found on Curlew Valley Validation Sites

Apiaceae (Umbelliferae)
Asteraceae (Compositae)
Brassicaceae (Cruciferae)
Cactaceae
Caprifoliaceae
Chenopodiaceae
Cupressaceae
Fabaceae
Geraniaceae
Gramineae
Lilaceae
Linaceae
Malvaceae
Onagraceae
Orobanchaceae
Plantaginaceae
Poaceae (Gramineae)
Polemoniaceae
Polygonaceae
Ranumculaceae
Rosaceae
Scrophulariaceae
Verbenaceae
Violaceae

C. INVERTEBRATES

INTRODUCTION

Invertebrate sampling has been and will remain the most difficult part of the sampling program at Curlew Valley. The primary problems are a lack of adequate techniques and a lack of adequate funding to fully implement the methods that are available. As long as these problems exist the invertebrate sampling will be augmented with qualitative information. Thus, this report contains an annotated list of invertebrates seen on or near the validation sites and insects associated with the major plant species, as well as assessments of invertebrate biomass on the sites.

METHODS

In 1971, an attempt was made to determine invertebrate biomass on the four sites. The technique used was D-Vac evacuation of the major plant species and samples of the ground surface. These data were then to be related to the entire sites through the vegetation analysis. The results of this largely unsuccessful attempt is presented in the results (see DSCODE A3UBJF1&3).

In 1972, only the southern sites were sampled for invertebrates. Three methods were used: (1) diurnal D-Vac evacuation for surface and shrub species, (2) soil removal and analysis following the D-Vac operation to obtain cryptic and subsurface organisms, and (3) operation of pitfall traps within enclosures of specified dimensions. The samples were collected on three vegetation types: (1) *Artemisia, Atriplex,* and *Sitanion;* (2) annuals; and (3) *Agropyron* (see Plants). D-Vac, soil and pitfall samples were taken at random within each vegetation type. During a specific sampling period, eight D-Vac and soil samples were made of each vegetation type, and the pitfall traps were operated for five consecutive days (see DSCODES A3UBJT1, A3UBJV3&4).

A nylon screen cage, .75 x .75 x 1.00 m high, was used for all D-Vac evacuations. The cage was carried against the wind and placed over the predetermined sampling location, and the bottom edges were blocked to prohibit escape of insects. The dominant plant species within the enclosure were recorded. The cage was removed following D-Vac evacuation and a 21.5 x 21.5 x 5 cm deep soil sample was removed to obtain cryptic or surface species not obtained during the D-Vac operation.

Pitfall enclosures consisted of steel flashing 30 cm high placed in a circular pattern of desired dimensions. Pitfall traps of 16.7 cm diameter each were placed within each enclosure. The numbers of pitfalls and enclosure size are detailed in Table 1.

Table 1. Summary of pitfall sampling operation

Dates Operated	VT-1	VT-2	VT-4†	Total Number of Enclosures Operated	Area of Enclosure	Number of Pitfalls
July 3-14	1	2	1	4	18.5 m^2	7
July 17-19*	3	-	3	6	18.5 m^2	12
July 24-28	3	3	3	9	18.5 m^2	12
July 31-Aug 4	3	3	3	9	18.5 m^2	12
August 7-11	3	3	3	9	18.5 m^2	12
August 14-18	3	3	3	9	11.8 m^2	12
August 21-25	3	3	3	9	11.8 m^2	12
Aug 28-Sep 1	3	3	3	9	11.8 m^2	12

* Pitfall operations for July 20 and 21 were destroyed by rain.
† Vegetation type (VT) 1 = Art-Atr-Sit, 2 = Annuals, 4 = Agr.

The D-Vac apparatus was operated within the enclosure for a variable length of time depending on the quantity of enclosed vegetation. Enclosed bare ground was evacuated for no more than 1 minute, while evacuation of enclosures with dense vegetation continued for 6-8 minutes. Except for the initial sampling dates, D-Vac samples were left in the sample net, labeled, and placed in a cool insulated container until the contents could be placed in Berlese-type funnels.

The soil sampler was placed to a depth of 5 cm and the contained soil was removed with a matching utensil. Such samples were also placed with the D-Vac samples until treatment by soil extraction procedures.

Organisms contained within the 17-cm deep pitfall traps were removed by a portable hand vacuum, placed in small jars and cooled until sorted, dried and weighed. Enclosures and traps were removed and reset each Friday during the pitfall studies. The enclosed pitfall traps were covered until Sunday morning, at which time the covers were removed and the pitfalls "activated". Collections were made Monday through Friday from each enclosure between 8 and 11 a.m. Collections were appropriately labeled and placed under refrigeration.

All the samples were processed in the laboratory. Pitfall samples were hand-sorted into appropriate taxomomic units and placed in 95% ethanol for counting and drying.

Twelve of the 24 D-Vac samples collected each sampling day were placed in the 12 Berlese funnels available. The remaining 12 samples were placed at 10-13 C for 40-48 hr, or until treatment of the first samples was complete. Berlese-treated materials were subsequently sorted by hand to enhance accuracy. All samples were placed in 95% ethanol prior to sorting, drying, and counting.

Soil samples were weighed, then treated by a modified Salt and Hollick (1944) flotation technique to remove invertebrates. Organisms obtained by this procedure were placed in 95% ethanol.

Organisms in 95% ethanol, obtained by soil extraction, D-Vac and pitfall, were sorted and counted prior to drying at 45 C. As organic material removed from the specimens via 95% ethanol was negligible in terms of biomass, the use of 95% ethanol was continued as a means of dehydration prior to the drying operation. This procedure was deemed exceptionally effective as sorted specimens preserved in this manner and placed at 45 C for drying first lost weight (evaporation of alcohol), then began to gain weight (presumably as a consequence of absorbing water from the atmosphere). Drying, therefore, was terminated when a weight gain started.

Specimens (either individually or in taxonomic groupings) were taken immediately from the drying oven to be weighed on a Cahn Electrobalance capable of accuracy to 0.0001 mg.

RESULTS, 1971

Invertebrate samples for the northern and southern sites were acquired in June and September, 1971. These data relate specifically to the invertebrates associated with *Atriplex*, *Agropyron*, *Sitanion*, and *Chrysothamnus*, and were acquired by portable D-Vac sampling methods. Approximately 21 plants of each species were sampled during September using a 0.125 m^3 enclosure.

The average dimensions of the plants sampled in 1971 are given in Table 2. The biomass of arthropods on 21 specimens of each plant species are shown in Figures 1 and 2. Tables 3 and 4 indicate, for relative comparison, all biomass data obtained for each site, plant genus-group, and taxon specific to order. Table 5 summarizes the September 11 data of 1971 in terms of estimated g/ha.

Table 2. Average dimensions (in mm) of plants sampled in 1971*

Date of Sample	*Atriplex* So. Grass	*Sitanion* So. Grass	*Agropyron* So. Grass	*Atriplex* So.Shrub	*Sitanion* So. Shrub	*Chrysothamnus* No. Shrub	*Agropyron* No. Shrub	*Agropyron* No. Grass
June	28-23X30	8-40	11-67	29-26X34	7-33	33-32X37	18-27	No sample
Sept	28-26X37	8-35	11-61	32-33X34	10-31	37-34X41	23-70	9-24

*In *Atriplex* and *Chrysothamnus* the first measurement represents height, the second two length and width of crown. In *Sitanion* and *Agropyron* the first measurement represents diameter at base, the second represents height. The data for the June sample are based on 60 plants of each species at each location, while the data for the September sample are based on 21 plants (approx.) of each species at each location.

The most abundant invertebrate fauna was found in association with *Chrysothamnus* on the northern shrub site. The biomass data for this association were two to three times greater than the next most insect-productive, which was *Sitanion* on the southern grass site in June and *Atriplex* on the southern grass site in September. The most significant organisms obtained in June samples were grasshoppers, leafhoppers and hymenoptera (excluding ants) on the northern sites, and leafhoppers, grasshoppers, Coleoptera and spiders on the southern sites, in the sequence presented. The most significant groups collected in September included grasshoppers, ants, Hemiptera, and spiders at the northern sites, and Hemiptera, Coleoptera and spiders at the southern sites, in the order presented. Assuming equal density of all plants sampled, the invertebrate biomass in September approximated 1,501 g/ha on the northern sites and 472 g/ha on the southern sites.

Table 6 summarizes the invertebrates collected from *Artemisia tridentata*. The plants were covered for D-Vac sampling by a variety of enclosure sizes (1.0, 0.5 and 0.25 m) or as in the case of 7/7/71, no enclosure. The foliage area was not taken, so meaningful insect numbers and biomass comparisons per unit were not possible.

Table 3. Biomass of the major invertebrate groups collected in association with *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, June 1971 (data are corrected to facilitate comparison with the 2.6 cubic meter enclosure data reported in Table 4)

Organisms Collected	Biomass (mg)								
	Atriplex So. Grass	*Sitanion* So. Grass	*Agropyron* So. Grass	*Atriplex* So. Shrub	*Sitanion* So. Shrub	*Chrysothamnus* No. Shrub	*Agropyron* No Shrub	Total Biomass	Biomass/3 (Corrected)
Thysanura	0.9	----	1.7	2.1	----	24.3	1.0	30.0	10.0
Orthoptera	----	----	----	----	----	1.1	----	1.1	0.4
Acrididae (Grasshoppers)	51.3	26.0	13.6	42.5	5.6	303.9	97.7	540.6	180.2
Thysanoptera	----	----	----	----	----	----	0.04	0.04	0.01
Hemiptera	2.6	68.7	2.1	43.5	1.3	48.9	10.6	177.7	59.2
Homoptera	10.7	1.2	----	3.7	----	34.8	4.5	54.9	18.3
Cicadellidae	18.1	147.0	34.3	11.6	8.0	173.0	16.1	408.1	136.0
Aphidae	----	----	0.1	----	----	15.2	0.1	15.4	5.1
Coleoptera	62.1	32.6	8.3	14.2	9.3	18.1	0.5	145.1	48.4
Neuroptera	----	----	----	----	----	2.0	----	2.0	0.7
Lepidoptera	1.8	2.0	29.1	0.8	----	22.7	1.0	57.4	19.1
Diptera	22.0	1.4	5.5	10.2	----	13.9	5.9	58.9	19.6
Hymenoptera	3.1	3.1	2.6	2.1	----	120.9	18.5	150.3	50.1
Formicidae	0.3	5.4	0.6	8.6	8.4	34.6	1.8	59.7	19.9
Araneidae	42.2	25.1	16.9	27.3	----	21.3	25.4	158.2	52.7
Acarina	2.9	9.2	5.4	13.7	3.7	0.2	0.1	35.2	11.4
Miscellaneous	1.2	----	2.0	----	----	2.1	1.8	7.1	2.4
Totals	219.2	321.7	122.4	180.1	36.4	836.8	184.9		
Corrected	73.1	107.2	40.8	60.0	12.1	278.9	61.6		

Table 4. Biomass of the major invertebrate groups collected in association with *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, September 11, 1971*

Organisms Collected	Biomass (mg)								
	Atriplex So. Grass	*Sitanion* So. Grass	*Agropyron* So. Grass	*Atriplex* So. Shrub	*Sitanion* So. Shrub	*Chrysothamnus* No. Shrub	*Agropyron* No. Shrub	*Agropyron* No. Grass	Total Biomass
Thysanura	1.1	----	----	2.6	----	----	----	----	3.7
Acrididae (Grasshoppers)	----	----	----	----	----	69.4	----	----	69.4
Thysanoptera	0.02	----	----	----	----	1.0	----	----	1.02
Hemiptera	59.5	----	----	3.8	----	26.5	3.3	----	69.4
Homoptera	----	----	----	----	----	16.0	3.0	----	19.0
Cicadellidae	1.5	----	----	----	----	19.4	5.6	3.3	29.8
Aphidae	----	----	----	----	----	0.15	----	----	0.15
Coleoptera	13.4	----	----	3.7	----	9.9	11.9	----	38.9
Lepidoptera	0.1	----	----	----	1.5	14.2	1.2	----	17.0
Diptera	0.2	----	----	1.2	----	3.3	2.1	0.2	7.0
Hymenoptera	0.002	----	----	----	----	4.4	2.7	0.2	7.3
Formicidae	----	0.5	0.3	3.7	----	41.5	11.9	3.6	61.5
Araneidae	9.2	0.14	----	0.3	2.2	22.0	1.2	7.6	40.6
Acarina	2.3	1.0	0.5	1.7	----	0.2	----	----	5.7
Miscellaneous	3.5	3.5	6.6	3.5	11.7	1.3	1.2	3.9	35.2
Flotation	0.4	1.3	1.5	0.4	0.12	0.5	0.08	----	4.3
Totals	91.1	6.5	8.9	21.1	15.5	229.6	44.3	18.9	

*Data were obtained from a 2.6 m^3 enclosure associated with the plants at each sample site: approx. 21 plants per 0.125 m^3 enclosure

Table 5. Summary of invertebrate biomass collected on 21 *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* plants in Curlew Valley, September 11, 1971, extrapolated to equivalents in g/ha

Site	Plant Associate	Time of Samples	Total m^3 Sampled	Invertebrate Biomass (g/ha)
S. Grass	*Atriplex*	10:15 am	2.6	1,400
S. Grass	*Sitanion*	11:00 am	2.6	260
S. Grass	*Agropyron*	11:45 am	2.6	136
S. Shrub	*Atriplex*	12:30 pm	2.6	32.4
S. Shrub	*Sitanion*	1:45 pm	2.6	240
N. Grass	*Agropyron*	4:45 pm	2.6	29.2
N. Shrub	*Chrysothamnus*	3:15 pm	2.6	353.2
N. Shrub	*Agropyron*	4:00 pm	2.6	680

Table 6. Mean amount of arthropods removed from sagebrush plants on shrub sites, 1971

Taxa		7/7 N. Shrub (sampled without enclosure)	8/25-26 S. Shrub	8/31-9/1 N. Shrub	9/29-10/5 S. Shrub	10/11 N. Shrub
Collembola	# sample present		4	2	7	3
	Animal No.		4	2	21	4
	Animal %		0.1	0.2	2.5	1.3
	Biomass (mg)		0.4	0.2	1.2	0.3
	Biomass %		-	-	0.4	0.4
Thysanura	# sample present			1	1	
	Animal No.			1	11	
	Animal %			0.1	1.3	
	Biomass (mg)			0.1	0.2	
	Biomass %			-	0.1	
Orthoptera	# sample present	1	2	4		
	Animal No.	1	2	5		
	Animal %	0.1	0.1	0.4		
	Biomass (mg)	2.0	25.0	385.6		
	Biomass %	0.1	3.4	60.2		
Isoptera	# sample present		1	1		
	Animal No.		1	1		
	Animal %		0.0	0.1		
	Biomass (mg)		-	0.3		
	Biomass%		-	0.1		
Thysanoptera	# sample present		3	2	6	6
	Animal No.		4	2	14	13
	Animal %		0.1	0.2	1.6	4.1
	Biomass (mg)		6.3	0.2	0.8	0.6
	Biomass %		0.9	-	0.3	0.3
Hemiptera	# sample present	9	6	6	8	10
	Animal No.	109	9	5	14	28
	Animal %	5.9	0.3	0.4	1.6	9.0
	Biomass (mg)	32.5	1.2	24.8	61.9	82.0
	Biomass %	2.1	0.2	3.9	19.4	42.5

Continued

Table 6. Continued

Taxa		7/7 N. Shrub (sampled without enclosure)	8/25-26 S. Shrub	8/31-9/1 N. Shrub	9/29-10/5 S. Shrub	10/11 N. Shrub
Homoptera	# sample present	10	17	20	7	14
	Animal No.	772	199	135	29	29
	Animal %	42.2	6.8	12.1	3.4	9.3
	Biomass (mg)	161.2	29.3	25.2	1.9	7.6
	Biomass%	10.3	4.0	3.9	0.6	3.9
Lepidoptera	# sample present	10	5	7	10	8
	Animal No.	488	11	9	16	13
	Animal %	26.7	0.4	0.8	1.9	4.1
	Biomass (mg)	1221.9	2.5	56.5	8.6	3.6
	Biomass %	78.5	0.3	8.8	2.7	1.9
Diptera	# sample present	3	5	8	3	3
	Animal No.	5	7	12	3	3
	Animal %	0.3	0.2	1.1	0.3	1.0
	Biomass (mg)	0.5	15.8	38.5	0.5	1.3
	Biomass %	0.1	2.2	6.0	0.2	0.7
Coleoptera	# sample present	10	18	16	17	19
	Animal No.	176	167	90	240	87
	Animal %	9.6	5.6	8.1	28.3	27.9
	Biomass (mg)	44.8	554.0	44.5	200.7	57.9
	Biomass %	2.9	76.0	6.9	62.9	30.0
Neuroptera	# sample present			2		
	Animal No.			2		
	Animal %			0.2		
	Biomass (mg)			0.2		
	Biomass %			-		
Hymenoptera	# sample present	10	12	12	10	8
	Animal No.	203	72	72	36	14
	Animal %	11.1	2.4	6.5	4.2	4.5
	Biomass (mg)	65.8	40.4	36.2	28.0	22.4
	Biomass %	4.2	5.6	5.7	8.8	11.6
Pseudo-	# sample present		5	1	5	3
scorpionida	Animal No.		12	1	13	4
	Animal %		0.4	0.1	1.5	1.3
	Biomass (mg)		2.4	0.6	4.1	1.0
	Biomass %		0.3	0.1	1.3	0.5
Scorpionida	# sample present		1			
	Animal No.		1			
	Animal %		-			
	Biomass (mg)		0.1			
	Biomass %		-			
Acarina	# sample present	1	18	19	20	20
	Animal No.	1	2454	719	435	92
	Animal %	0.1	82.3	64.4	51.3	29.5
	Biomass (mg)	-	32.1	9.2	7.1	3.0
	Biomass %	-	4.4	1.5	2.2	1.6
Miscellaneous	# sample present		6	8	5	
	Animal No.		5386	202	5	
	Biomass (mg)		479.9	15.9	5.1	
Total	# sample	10	20	20	20	20
	Animal No.	1829	8369	1318	852	312
	Biomass (mg)	1556.9	1209.1	656.8	324.2	192.9
	# sagebrush plants	28	20	20	20	20
	Biomass mg/sage pl.	55.6	60.46	32.84	16.21	9.65

RESULTS, 1972

In an effort to obtain some information over a 24-hour period, D-Vac and soil samples were taken from 10:00 am July 11 to 10:00 a.m. July 12, 1972, and incorporated in analysis of Art-Atr-Sit and Agr vegetation types. One D-Vac and one soil sample were acquired from predetermined locations within each vegetation type every 2 hours from 8:00 p.m. July 11 through 10:00 a.m. July 12. These data were incorporated with the regular sampling data of July 11. The results are presented in Tables 7 and 8. The limited data in Tables 7 and 8 suggest that the nocturnal samples for D-Vac were about 10-50% of that obtained during morning and afternoon. The data for soil seem to indicate that nocturnal soil samples tend to acquire more specimens and biomass than diurnal samples (at least on the basis of information for the Art-Atr-Sit type).

Table 7. Temporal comparisons of invertebrate density and biomass obtained by D-Vac, July 11-12 in Art-Atr-Sit and Agr vegetation types

Hour	Density (1,000/ha)		Biomass (g/ha)	
	Art Veg Type	Agr Veg Type	Art Veg Type	Agr Veg Type
200	10	0	3	0
400	0	36	0	11
600	18	18	16	16
800	108	0	37	0
1000	18	0	3	0
1300		155		174
1400		204		9
1500	379	76	553	17
1600	84		23	
1700	258		36	
2000	72	18	86	3
2200	54	18	51	16
2400	126	90	237	101

Table 8. Temporal comparisons of invertebrate density and biomass obtained by soil extraction, July 11-12 in Art-Atr-Sit and Agr vegetation types

Hour	Density (1,000/ha)		Biomass (g/ha)	
	Art Veg Type	Agr Veg Type	Art Veg Type	Agr Veg Type
200	200	0	1,020	0
400	0	0	0	0
600	200	0	617	0
800	0	0	0	0
1000	0	0	0	0
1300	-	69	-	7
1400	-	0	-	0
1500	138	0	140	0
1600	138	-	414	
1700	0	-		
2000	0	0	0	0
2200	200	0	149	0
2400	0	0	0	0

A trend existed between the numbers and types of organisms collected by the D-Vac operation in comparison with those obtained via soil extraction when both were compared on per hectare estimates (Tables 9, 10 and 11). For example in Art-Atr-Sit type the number of organisms obtained by D-Vac was nearly three times that of the soil determination, and D-Vac accounted for a greater density estimate on 9 of the 12 sampling dates. Similarly, in Agr type, the density estimate by D-Vac was over 10 times that determined by soil extraction, a condition which was true for all 8 of 8 sampling periods allowing for a comparison. This trend was not true in annuals vegetation type where the D-Vac density estimate was slightly smaller than that determined by soil extraction.

In terms of biomass, however, organisms and estimates obtained by soil extraction were comparable to those obtained by D-Vac, if not more. In annuals type, where biomass of soil-extracted organisms was larger than those obtained by D-Vac in 10 of 11 sampling periods allowing for comparison, the average biomass obtained by soil extraction was nearly 3 times that of the D-Vac. Biomass estimates by D-Vac and soil extraction in Art-Atr-Sit and Agr types were about equal.

The observed differences between D-Vac and soil extraction seemed to indicate that the lighter invertebrates were up in the vegetation and represented a smaller biomass than the heavier invertebrates of the litter and soil.

Density estimates obtained via extrapolated pitfall data (Table 12), seldom exceeded estimates based on D-Vac or soil extraction, but exceeded density estimates obtained by D-Vac on only several of the 27 sampling periods (in all vegetation types). However, biomass determinations based on pitfall data exceeded the estimates based on soil extraction and D-Vac in about 70% of the sampling periods (in all vegetation types) that could be compared. In fact, pitfall biomass estimates sometimes exceeded estimates based on the other procedures two to three-fold or more (Tables 9, 10, 11, and 12).

The accuracy of the pitfall enclosure method depends on the capture of all the live animals within the enclosure. Actually, most of the pitfall data reported here represents a minimum estimate, as few of the nearly 50 taxa examined had become extinct at the end of the 5-day run. Only Tenebrionidae, Carabidae, Formicidae, and Araneidae indicated extinction at the end of 5 days 20% or more of the time they were detected within a given enclosure.

A summarization of density and biomass information for each of the vegetation types by D-Vac, soil extraction, and pitfall is reported in Table 13 for June, July and August, 1972. There was no overlap in populations sampled between D-Vac and the other techniques. The significance of the overlap between soil and pitfall samples was not known

Table 9. Summary of invertebrate biomass and density in Art-Atr-Sit vegetation type as determined by D-Vac and soil extraction, 1972

	Density (1,000/ha)		Biomass (g/ha)	
Date of Sample	D-Vac	Soil	D-Vac	Soil
15 June	222	666	65	51
20 June	3194	99	511	60
27 June	314	200	216	309
5 July	307	50	129	136
11 July	312	125	241	209
18 July	55	160	113	316
25 July	440	125	78	209
1 August	207	125	37	90
8 August	356	75	21	140
15 August	357	300	428	625
22 August	106	125	14	220
29 August	1021	150	632	385
Totals	6891	2200	2485	2750
Averages	574	183	208	229

Table 10. Summary of invertebrate biomass and density in annuals vegetation type as determined by D-Vac and soil extraction, 1972

	Density (1,000/ha)		Biomass (g/ha)	
Date of Sample	D-Vac	Soil	D-Vac	Soil
13 June	622	599	399	1128
20 June	1158	2182	832	2806
27 June	697	----	297	----
5 July	77	100	54	104
11 July	146	100	77	215
18 July	100	160	61	275
25 July	413	25	306	19
1 August	19	125	1	209
8 August	41	600	16	69
15 August	206	325	33	680
22 August	33	125	27	488
29 August	50	100	83	312
Totals	3562	4441	2186	6305
Averages	297	370	182	525

Table 11. Summary of invertebrate biomass and density in Agr vegetation type as determined by D-Vac and soil extraction, 1972

Date of Sample	Density (1,000/ha) D-Vac	Density (1,000/ha) Soil	Biomass (g/ha) D-Vac	Biomass (g/ha) Soil
15 June	516	----	261	----
20 June	394	333	131	80
27 June	124	----	245	----
5 July	310	50	77	41
11 July	151	25	96	4
18 July	40	----	8	----
25 July	633	----	72	----
1 August	384	25	158	410
8 August	2683	75	129	140
15 August	1124	125	53	237
22 August	344	75	26	83
29 August	439	75	30	155
Totals	7142	783	1286	1150
Averages	595	65	107	96

Table 12. Comparison of density and biomass estimates for Art-Atr-Sit, annuals, and Agr vegetation types as determined by pitfall traps*

Week	Density (1,000/ha) *Artemisia*	Density (1,000/ha) *Halogeton*	Density (1,000/ha) *Agropyron*	Biomass (g/ha) *Artemisia*	Biomass (g/ha) *Halogeton*	Biomass (g/ha) *Agropyron*
July 3-14	99	157	65	165	1116	399
July 17-19**	157	---	39	355	---	62
July 24-28	75	200	31	291	672	209
July 31- Aug 4	83	144	26	451	1320	317
Aug 7-11	25	194	60	156	518	267
Aug 14-18	114	167	31	319	1539	162
Aug 21-25	58	58	36	191	250	330
Aug 28- Sep 1	34	55	14	285	1049	246

*Data for Art-Atr-Sit and annuals are less *Nysius*, and data for Agr is less ants.
**Pitfall operations for July 20 and 21 were destroyed by rain, and biomass within enclosures was not obtained. Therefore actual biomass for this period is larger than recorded.

If average monthly values are used for comparison, the greatest invertebrate biomass was to be found in annuals vegetation type, followed by Art-Atr-Sit and Agr. This sequence was indicated by D-Vac, soil extraction and pitfall. The maximum and minumum monthly biomass estimates by D-Vac were 509 g/ha and 302 g/ha, respectively, both in annuals. Similar values for soil were 11 g/ha in Agr and 1,311 g/ha in annuals. Pitfall biomass data consistently indicated the least variance and highest estimates, with a low estimate of 232 g/ha for Agr and a high of 894 g/ha in annuals, with immature *Nysius* excluded.

Density estimates were more variable. Such estimates were highest for Art-Atr-Sit by D-Vac and pitfall procedures, while soil extraction procedures indicated annuals possessed the greatest density. Except for the D-Vac estimates, Agr apparently had the least number of organisms per hectare. Density estimates ranged from 70,000/ha in annuals to 1,243,000/ha in Art-Atr-Sit by D-Vac; 19,000/ha in Agr to 927,000/ha in annuals by soil extraction; and 35,000/ha in Agr to 833,000/ha in Art-Atr-Sit by pitfall.

Table 13. Comparison of density and biomass of invertebrates in the different vegetation types on southern sites, 1972

	Biomass (g/ha)			Density (1,000/ha)		
Month and Method	Art-Atr-Sit	Annuals	Agr	Art-Atr-Sit	Annuals	Agr
June D-Vac	264	509	212	1243	826	345
July D-Vac	140	125	64	281	184	284
August D-Vac	228	32	79	409	70	995
Total Average	211	222	118	644	360	541
June soil	140	1311	27	122	927	111
July soil	218	153	11	115	96	19
August soil	292	640	205	155	255	75
Total Average	217	701	81	131	426	68
July pitfall	467*	894**	232	833*	345**	45†
August pitfall	238	839	258	58	119	35†
Total Average	353	867	245	446	232	40
Grand Average	260	597	148	407	339	216

*Less *Nysius* sp.
**Less immature *Nysius* sp.
†Less Formicidae

Analysis of density and biomass data obtained by D-Vac and soil for the various invertebrate groups are detailed in Tables 14-25 and Figures 3-38. Pitfall data are shown by vegetation-type in Tables 26-31, and by vegetation-type and time in Tables 32-33. The following summarizes the results on the more important taxa.

ACARINA, Phytophagous (Class Arachnida)-mites; insignificant by D-Vac and soil, but apparently and unexpectedly abundant by pitfall. Some rated as phytophagous however, may be immature predaceous forms. To 999,000 and 4.5 g/ha.

ACARINA, Predaceous excluding ticks (Class Arachnida)- primarily rake-legged mites (Caeculidae) of the genus *Caeculus*; have been treated as predators but may feed on fungi (Crossley & Merchant, 1971). Others included "feather-claw" mites of the Teneriffiidae. All vegetation types but predominant in Art-Atr-Sit and Agr. To 2,607,000 and 194 g/ha by D-Vac.

ACRIDIDAE, Phytophagous (Orthoptera)-adults and immature, most *Melanoplus* spp. and immature. Adults to 187,500 g/ha and 3,000/ha (August), and immatures to 3,000 and 232 g/ha (June) by D-Vac. Insignificant by soil and pitfall.

APHIDIDAE, Phytophagous (Homoptera)-wooly aphids; most significant in July. To 80,000 and 3 g/ha by D-Vac.

ARANEIDA, Predaceous (Class Arachnida)-spiders most abundant in Art-Atr-Sit and annuals. To 31,000 and 65 g/ha by pitfall extinction (July), and 29,000 (August) and 71 g/ha by D-Vac (June).

CARABIDAE, Predaceous (Coleoptera)-mostly *Carabus* sp; in all vegetation types but most abundant in annuals. To 300,000 and 378 g/ha in June by soil extraction, and 59,000 and 757 g/ha by pitfall in mid-August.

GRYLLACRIDAE, Phytophagous and scavenger *Ceuthophilus* sp. (Orthoptera)-camel crickets; predominant in annuals and Agr by pitfall, which indicates maximum adult density to 900/ha and biomass to 137 g/ha, immatures to 3,500 and 14 g/ha.

CHELONETHIDA, Predaceous-pseudoscorpions to 9,000 and 3 g/ha by D-Vac analysis, and to 4,600 and about 1 g/ha by pitfall. Rare in D-Vac, common in pitfalls; all vegetation types

CHILOPODA, Predaceous-centipedes insignificant; pitfall estimates to about 200 and less than 1 g/ha.

CHRYSOMELIDAE, Phytophagous (Coleoptera)-mostly minute Halticinae and originally recorded with predaceous Coleoptera; category changed to Tenebrionidae and Curculionidae because of the preponderance of these groups. 1971 studies indicated association with *Agropyron* and *Sitanion* grasses.

CICADELLIDAE, Phytophagous (Homoptera)-2 spp. leafhoppers predominant; about 5-6 species total. In all veg types and most abundant in July and August; to 8,200 and 12 g/ha by pitfall, but 38,000 and 12 g/ha by D-Vac.

COLEOPTERA, Miscellaneous-all beetles other than Tenebrionidae, Carabidae, Curculionidae, Chrysomelidae, and Histeridae. Insignificant in samples; to 3,500 and 2.5 g/ha by pitfall determination.

COLLEMBOLA,-springtails best obtained by Berlese-type funnels and immediately upon return from field. To 14,000 and 3 g/ha in annuals; it may be more significant than indicated.

CYDNIDAE,-(Hemiptera)-burrower bugs principally in annuals by pitfall; to 2,500 and nearly 8 g/ha.

CURCULIONIDAE-weevils = 5-10% of phytophagous Coleoptera and combined with Tenebrionidae as Phytophagous Coleoptera for D-Vac and soil, separate in pitfall. In all vegetation types and to 2,900 and 33 g/ha in Agr early July by pitfall analysis.

DIPTERA, Phytophagous-insignificant by pitfall; all vegetation types; to 38,000 and 20 g/ha in August by D-Vac.

DIPTERA, Predaceous-chiefly mosquitoes and robber flies; to 3,000 and 63 g/ha by D-Vac.

Eremobates sp. (Arachnida:Solpugida)-Predaceous; in all vegetation types and mostly immature; to 4,000 and 131 g/ha in annuals, pitfall (mid-August).

FORMICIDAE, Omnivorous (Hymenoptera)-4-6 spp. ants; predominant in Art-Atr-Sit; to 54,000 and 167 g/ha by D-Vac; to 233,000 and 56 g/ha by soil extraction; and to 69,000 and 64 g/ha by pitfall. All values minimal due to cryptic habits.

Geocoris sp., Predaceous (Hemiptera:Lygaeidae)-abundant in Art-Atr-Sit and annuals, predominant in latter; to 6,400 and 168,000/ha by pitfall, with biomass to 4 g/ha.

HISTERIDAE, (Coleoptera)-found only in annuals by pitfall; to 200 and less than 1 g/ha. Values minimal due to habits.

HEMIPTERA, Phytophagous-principally Pentatomidae, Piesmatidae, and phytophagous Lygaeidae for D-Vac. Predominant in annuals; to 725,000 and 506 g/ha by D-Vac in June. Groups split in pitfall data.

HEMIPTERA, Predaceous-principally Reduviidae, Nabidae, predaceous Lygaeidae, *Zelus* spp., *Nabis* spp., and *Geocoris;* split in pitfall data. Estimates to 500,000 and 963 g/ha by soil extraction; to 3,000 and 8 g/ha by D-Vac.

HYMENOPTERA, other than Formicidae and Mutillidae; principally parasitoids; to 35,000 and 23 g/ha by D-Vac. Larger vespoids and specoids, etc. present in region but absent in samples.

ISOPODA, (Class Crustacea)-Sowbugs present in all vegetation types and estimates to 300 and less than 1 g/ha by pitfall.

IXODIDAE, (parasitic Acarina)-*Dermacentor andersoni;* present by pitfall analysis on one occasion; Art-Atr-Sit mid-August. Estimate to 300 and less than 1 g/ha.

LEPIDOPTERA, principally *Aroga websteri;* mature Lepidoptera to 3,000 and 69 g/ha by D-Vac in late August; immatures to 132,000 and 12 g/ha by D-Vac in June; immatures to 25,000 and 105 g/ha by soil extraction.

Lygaeus, prob. *L. kalmii,* (Hemiptera)-phytophagous small milkweed bugs Art-Atr-Sit and annuals by pitfall; to 3,200 and nearly 16 g/ha early July. All subsequent estimates considerably lower.

Machilis, (Thysanura)-bristletails few in D-Vac and soil, but abundant in all vegetation types by pitfall analysis; to 6,500 and 7 g/ha.

MANTIDAE, Predaceous (Orthoptera) Apterous mantid present in pitfalls at all vegetation types: estimates to 700 and 7 g/ha.

MUTILLIDAE, Predaceous (Hymenoptera)-velvet"ants" present in all vegetation types by pitfall analysis; to 3,300 and 9 g/ha in early July.

Nysius sp., Phytophagous (Hemiptera)-principal phytophagous Hemipteran by D-Vac and soil. Immatures to over 23,000,000 and 7,000 g/ha in annuals first week of July; adults to 59,000 and 40 g/ha in annuals late July. Insignificant in samples by mid-August.

Orius sp., Predaceous (Hemiptera)-minute, and about 200/ha by pitfall analysis on two occasions. Less than 1 g/ha.

PENTATOMIDAE, Phytophagous (Hemiptera)-stink bugs few in D-Vac as phytophagous Hemipteran; estimates to 3,700 and 4.2 g/ha by pitfall analysis, but most estimates less.

REDUVIIDAE, Predaceous (Hemiptera)-few in D-Vac but included among predaceous Hemiptera; mostly *Zelus* spp. To 3,700 and 35 g/ha by pitfall in mid-August, but most estimates less.

SCUTELLERIDAE, Phytophagous (Hemiptera)-to 300 and 63 g/ha on basis of 1 pitfall in late August; absent from D-Vac, soil and other pitfalls.

Stenopelmatus sp., prob. *S. longispina* (Orthoptera)-Jerusalem crickets mostly immature and in all vegetation types; most abundant in Agr; to 2,700 and 239 g/ha by pitfall analysis in July; adults to 300 and 216 g/ha in Agr late August.

TENEBRIONIDAE, Phytophagous (Coleoptera)-considered with Curculionidae as principal phytophagous Coleoptera in D-Vac and soil. Adults to 96,000 and 918 g/ha and immatures to 69,000 and 39 g/ha by pitfall analysis. Genus yet to be determined, but not *Eleodes*; 1 species predominant.

THYSANOPTERA, Phytophagous--principally Phloeothripidae; all vegetation types; to 369,000 and 5 g/ha in Agr early June. Most estimates less than 80,000 and 1 g/ha.

Vaejovis boreus, Predaceous (Scorpionida)-present in all vegetation types. Pitfall analysis indicates density to 900/ha and biomass to 76 g/ha. Three individuals covering 1,300 m^2 with short-wave U.V. light estimated density at 70/ha on July 11 (about 300/ha by pitfall for period July 3-14).

Table 14. Dry weight biomass of invertebrates collected by D-Vac from Art-Atr-Sit, annuals, and Agr vegetation types, Curlew Valley, June 1972

	Biomass (g/ha) (June 13-15)			Biomass (g/ha) (June 20)			Biomass (g/ha) (June 27)		
Organisms Collected	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA									
Machilis									
ACRIDIDAE									
Phytophagous HEMIPTERA	32	375	41	117	506		21	240	5
Predaceous HEMIPTERA									
CICADELLIDAE	.2		3	.2	2			2	
APHIDIDAE									
THYSANIPTERA	.8		5	.6					
LEPIDOPTERA									
TENEBRIONIDAE & CURCULION	3	20	12	45	53	2	74	35	2
CARABIDAE								6	
HYMENOPTERA	.5	23		2		.2		.2	
FORMICIDAE	15		.5	60	3		12		2
Phytophagous DIPTERA	.3		.2	.3			11	5	12
Predaceous DIPTERA									
ARANEIDA	3		2	71	3	2			2
Phytophagous ACARINA						.2			
Predaceous ACARINA	11	.8	3	194	2	17	11	.6	3
Immature ACRIDIDAE			194		232	110	86		219
Immature HEMIPTERA	.2	.2	.2	9	29		.2	8	.3
Immature LEPIDOPTERA	2			12	2		.3	.3	
Total	65.3	399	260.9	511.1	832	131.4	215.5	297.1	245.3

Table 15. Density of invertebrates collected by D-Vac from Art-Atr-Sit, annuals and Agr vegetation types, Curlew Valley, June 1972

Organisms Collected	Biomass (1,000/ha) (June 13-15)			Biomass (1,000/ha) (June 20)			Biomass (1,000/ha) (June 27)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA									
Machilis									
ACRIDIDAE									
Phytophagous HEMIPTERA	15	537	9	94	725		15	345	3
Predaceous HEMIPTERA									
CICADELLIDAE	3		9		6			3	
APHIDIDAE				32					
THYSANOPTERA	66		360	53	3		5	3	
LEPIDOPTERA									
TENEBRIONIDAE & CURCULION	9	15	27	78	60	12	33	17	3
CARABIDAE								14	
HYMENOPTERA	15	35		20		20		9	
FORMICIDAE	26		3	44	3		20		3
Phytophagous DIPTERA	12		3	6			3	3	5
ARANEIDA	3		15	15	20	12		3	3
Phytophagous ACARINA						9			
Predaceous ACARINA	21	35	78	2607	72	338	221	45	78
Immature ACRIDIDAE			3		3	3	3		3
Immature HEMIPTERA	26		9	113	254		9	255	26
Immature LEPIDOPTERA	26			132	12		5	3	
Total	222	622	516	3194	1158	394	314	697	124

Table 16. Dry weight biomass of invertebrates (expressed in grams/hectare) collected by soil extraction from vegetation types, Curlew Valley, June 1972

Organisms Collected	Biomass (g/ha) (June 13-15)			Biomass (g/ha) (June 20)			Biomass (g/ha) (June 27)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA									
Machilis									
Phytophagous HEMIPTERA		770							
Predaceous HEMIPTERA					963				
CICADELLIDAE				11					
APHIDIDAE									
THYSANOPTERA									
LEPIDOPTERA									
TENEBRIONIDAE & CURCULION		288			1304	80	60		
CARABIDAE		50		19	378		87		
HYMENOPTERA									
FORMICIDAE	25				25		56		
Phytophagous DIPTERA									
Predaceous DIPTERA									
ARANEIDA									
Phytophagous ACARINA				30					
Predaceous ACARINA	4	1			1		1		
Immature ACRIDIDAE									
Immature ACARINA									
Immature HEMIPTERA	22	19			135				
Immature LEPIDOPTERA							105		
Total	51	1128		60	2806	80	309		

Table 17. Density of invertebrates collected by soil extraction from three vegetation types, Curlew Valley, June 1972

Organisms Collected	Biomass (1,000/ha) (June 13-15)			Biomass (1,000/ha) (June 20)			Biomass (1,000/ha) (June 27)		
	Art	Annual	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA									
Machilis									
Phytophagous HEMIPTERA		300							
HEMIPTERA									
Predaceous HEMIPTERA					500				
CICADELLIDAE				33					
APHIDIDAE									
THYSANOPTERA									
LEPIDOPTERA									
TENEBRIONIDAE & CURCULION		33			733	333	25		
CARABIDAE		33		33	300		50		
HYMENOPTERA									
FORMICIDAE	33				233		75		
Phytophagous DIPTERA									
Predaceous DIPTERA									
ARANEIDA									
Phytophagous ACARINA				33					
Predaceous ACARINA	133	33			33		25		
Immature ACRIDIDAE									
Immature ACARINA									
Immature HEMIPTERA	500	200			383				
Immature LEPIDOPTERA							25		
Total	666	599		99	2182	333	200		

Table 18. Dry weight biomass collected by D-Vac from three vegetation types, Curlew Valley, July 1972

Organisms Collected	Biomass(g/ha) (July 5)			Biomass(g/ha) (July 11)			Biomass(g/ha) (July 18)			Biomass(g/ha) (July 25)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA			.2	.2	3					1		
Machilis						5						
ACRIDIDAE												
Phytophagous HEMIPTERA	15	41	9	38	21		38	39		12	249	
Predaceous HEMIPTERA												
CICADELLIDAE	1		6	2						5		.8
APHIDIDAE	.2									3		.2
THYSANOPTERA	.2	.2	.5	.3						.2		
LEPIDOPTERA					1	5						50
TENEBRIONIDAE & CURCULION.	2		1	9	1	6	32			11	44	.3
CARABIDAE	3											
HYMENOPTERA	8	12	.2		.2						6	.2
FORMICIDAE	1883		2	3						11	2	2
Phytophagous DIPTERA	.3			.3	14							
Predaceous DIPTERA						63						.8
ARANEIDA			50	.8	.3	15	41	.6	3	15	1	1
Phytophagous ACARINA	.2		1			.5						
Predaceous ACARINA	2	.8	6	12	.5	.6	2		5	11	.5	11
Immature ACRIDIDAE	96			174								
Immature HEMIPTERA	1	.2	.3	.3	36	.8		21		3	3	1
Immature LEPIDOPTERA			1	.8		1				5	.6	5
PSEUDOSCORPIONIDA						.6						
Immature COLEOPTERA										.5		
Total	2011.9	54.2	77.2	240.7	77	97.5	113	60.6	8	77.7	306.1	72.3

Table 19. Dry weight biomass collected by D-Vac from three vegetation types, Curlew Valley, July 1972

Organisms Collected	Biomass(g/ha) (July 5)			Biomass(g/ha) (July 11)			Biomass(g/ha) (July 18)			Biomass(g/ha) (July 25)		
	Art	Annual	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA			5	8	14					9		
Machilis						3						
ACRIDIDAE												
Phytophagous HEMIPTERA	3	30	5	21	30		17	57		15	341	
Predaceous HEMIPTERA												
CICADELLIDAE	20		20	5						14		3
APHIDIDAE	5									80		3
THYSANOPTERA	9	9	33	12						9		3
LEPIDOPTERA					3	3						
TENEBRIONIDAE & CURCULION.	24		3	14	3	17	8			17	20	3
CARABIDAE	9											
HYMENOPTERA	3	3	9		5						8	3
FORMICIDAE	41		3	5						14	3	3
Phytophagous DIPTERA	8			5	3							
Predaceous DIPTERA						3						3
ARANEIDA			3	5	3	3	15	5	5	5	8	9
Phytophagous ACARINA	20		12	8		51				3		
Predaceous ACARINA	83	30	188	186	17	30	15		35	153	17	479
Immature ACRIDIDAE	3			3								
Immature HEMIPTERA	71	5	20	21	68	24		38		94	8	95
Immature LEPIDOPTERA	8		9	9		14				30	8	29
PSEUDOSCORPIONIDA						3						
Immature COLEOPTERA										5		
Total	307	77	310	312	146	151	55	100	40	448	413	633

Table 20. Dry weight biomass of invertebrates collected by soil extraction from three vegetation types, Curlew Valley, July 1972

Organisms Collected	Biomass(g/ha) (July 5)			Biomass(g/ha) (July 11)			Biomass(g/ha) (July 18)			Biomass(g/ha) (July 25)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA												
Machilis												
Phytophagous HEMIPTERA												
Predaceous HEMIPTERA		48		145	193			154		48		
CICADELLIDAE												
APHIDIDAE												
THYSANOPTERA												
LEPIDOPTERA												
TENEBRIONIDAE & CURCULION.	60		37	60			287	121		152		
CARABIDAE	76											
HYMENOPTERA												
FORMICIDAE		56			22		29				19	
Phytophagous DIPTERA												
Predaceous DIPTERA												
ARANEIDA												
Phytophagous ACARINA												
Predaceous ACARINA			4	4		4				4		
Immature ACRIDIDAE												
Immature ACARINA												
Immature HEMIPTERA										5		
Immature LEPIDOPTERA												
Totals	136	104	41	209	215	4	316	275		209	19	

Table 21. Density of invertebrates collected by soil extraction from three vegetation types, Curlew Valley, July 1972

Organisms Collected	Biomass(1,000/ha) (July 5)			Biomass(1,000/ha) (July 11)			Biomass(1,000/ha) (July 18)			Biomass(1,000/ha) (July 25)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA												
Machilis												
Phytophagous HEMIPTERA		25		75	75			80		25		
Predaceous HEMIPTERA												
CICADELLIDAE												
APHIDIDAE												
THYSANOPTERA												
LEPIDOPTERA												
TENEBRIONIDAE & CURCULION.	25		25	25			120	80		50		
CARABIDAE	25											
HYMENOPTERA												
FORMICIDAE		75			25		40				25	
Phytophagous DIPTERA												
Predaceous DIPTERA												
ARANEIDA												
Phytophagous ACARINA												
Predaceous ACARINA			25	25		25				25		
Immature ACRIDIDAE												
Immature ACARINA												
Immature HEMIPTERA										25		
Immature LEPIDOPTERA												
Total	50	100	50	125	100	25	160	160		125	25	

Table 22. Dry weight biomass of invertebrates collected by D-Vac from three vegetation types, Curlew Valley, August 1972

Organisms Collected	Biomass(g/ha) (August 1)			Biomass(g/ha) (August 8)			Biomass(g/ha) (August 15)			Biomass(g/ha) (August 22)			Biomass(g/ha) (August 29)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA															
Machilis			6												
ACRIDIDAE							187,500						77		
Phytophagous HEMIPTERA	2		5	3	3			3		1			17		
Predaceous HEMIPTERA							8								
CICADELLIDAE	2	.2	12	.5			.3		.8				3		.2
APHIDIDAE															
THYSANOPTERA			.6	.3		.5	.3		3			.2	2	.5	.6
LEPIDOPTERA			3									2	69		
TENEBRIONIDAE & CURCUL.	6	.2	27	14	11	2	120	17	3	3		6	18	39	15
CARABIDAE							122	3	11		26		324		6
HYMENOPTERA						.2			.2			.2			
FORMICIDAE	9		1				167	5	1				83		
Phytophagous DIPTERA	1				1	20		.2					.3		
Predaceous DIPTERA											.2				
ARANEIDA			15	1		11	6	.3	9	.5		5	5	40	1
Phytophagous ACARINA				.6		.5									
Predaceous ACARINA	9	.2	3	8	.6	87	3	3	17	8	1	9	17	3	1
Immature ACRIDIDAE			80												
Immature HEMIPTERA	.3	.2	5	.5		6	.2		8			3	6		.5
Immature LEPIDOPTERA	8		.3	.2			1	1		1		.5	2	.3	.8
PSEUDOSCORPIONIDA						2							3		
Misc. HOMOPTERA													6		
	37.3	.8	157.9	28.1	15.6	129.2	187,927.8	32.5	53	13.5	27.2	25.9	632.3	82.8	29.6

Table 23. Density of invertebrates collected by D-Vac from three vegetation types, Curlew Valley August 1972

Organisms Collected	Biomass(1,000/ha) (August 1)			Biomass(1,000/ha) (August 8)			Biomass(1,000/ha) (August 15)			Biomass(1,000/ha) (August 22)			Biomass(1,000/ha) (August 29)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA															
Machilis			5												
ACRIDIDAE							3						3		
Phytophagous HEMIPTERA	3		3	8	5			5		5			30		
Predaceous HEMIPTERA							3								
CICADELLIDAE	9	3	38	3			3		3				9		3
APHIDIDAE															
THYSANOPTERA			84	38	8	66	29	5	221	3		14	84	30	41
LEPIDOPTERA			3									3	3		
TENEBRIONIDAE & CURCUL.	9	8	12	17	3	17	110	15	12	3		20	78	3	5
CARABIDAE							14	3	8		3		29		51
HYMENOPTERA						8			9			3			8
FORMICIDAE	5		3				54	20	3				61		
Phytophagous DIPTERA	3				5	38		3				3	3		
Predaceous DIPTERA											3				
ARANEIDA			26	8		21	24	5	5	3		21	29	3	3
Phytophagous ACARINA				33		32	3			3	3	3			
Predaceous ACARINA	141	3	105	195	20	1713	71	147	375	72	21	89	375	9	41
Immature ACRIDIDAE			3												
Immature HEMIPTERA	20	5	99	51		783	35		485	3	3	183	288		284
Immature LEPIDOPTERA	17		3	3			8	8	3	14		5	17	3	3
PSEUDOSCORPIONIDA						5							9		
Misc. HOMOPTERA													3		
Total	207	19	384	356	41	2683	357	206	1124	106	33	344	1021	50	439

Table 24. Dry weight biomass of invertebrates collected by soil extraction from three vegetation types, Curlew Valley, August 1972

Organisms Collected	Biomass(g/ha) (August 1)			Biomass(g/ha) (August 8)			Biomass(g/ha) (August 15)			Biomass(g/ha) (August 22)			Biomass(g/ha) (August 29)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA															
Machilis															
Phytophagous HEMIPTERA					60										
Predaceous HEMIPTERA															
CICADELLIDAE															
APHIDIDAE															
THYSANOPTERA															
LEPIDOPTERA															
TENEBRIONIDAE & CURCUL.	76	136	410	76	1443	76	608	646	228	62	212	76	158	309	152
CARABIDAE		173		60		60	7			152	272		216		
HYMENOPTERA															
FORMICIDAE															
Phytophagous DIPTERA															
Predaceous DIPTERA															
ARANEIDA					5	4	4	<1	5						
Phytophagous ACARINA				4											
Predaceous ACARINA	14				4		6	1	4	6	4	7	3	3	3
Immature ACRIDIDAE															
Immature ACARINA															
Immature HEMIPTERA								32							
Immature LEPIDOPTERA															
SOLPUGIDA													8		
Total	90	209	410	140	1512	140	625	680	237	220	488	83	385	312	155

Table 25. Density of invertebrates collected by soil extraction from three vegetation types, Curlew Valley, August 1972

Organisms Collected	Biomass(1,000/ha) (August 1)			Biomass(1,000/ha) (August 8)			Biomass(1,000/ha) (August 15)			Biomass(1,000/ha) (August 22)			Biomass(1,000/ha) (August 29)		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
COLLEMBOLA															
Machilis															
Phytophagous HEMIPTERA					25										
Predaceous HEMIPTERA															
CICADELLIDAE															
APHIDIDAE															
THYSANOPTERA															
LEPIDOPTERA															
TENEBRIONIDAE & CURCUL.	25	50	25	25	475	25	200	225	75	25	75	25	75	75	50
CARABIDAE		75		25		25	25			50	25		25		
HYMENOPTERA															
FORMICIDAE															
Phytophagous DIPTERA															
Predaceous DIPTERA															
ARANEIDA					25	25	25	25	25						
Phytophagous ACARINA				25											
Predaceous ACARINA	100				75		50	25	25	50	25	50	25	25	25
Immature ACRIDIDAE															
Immature ACARINA															
Immature HEMIPTERA								50							
Immature LEPIDOPTERA															
SOLPUGIDA													25		
Total	125	125	25	75	600	75	300	325	125	125	125	75	150	100	75

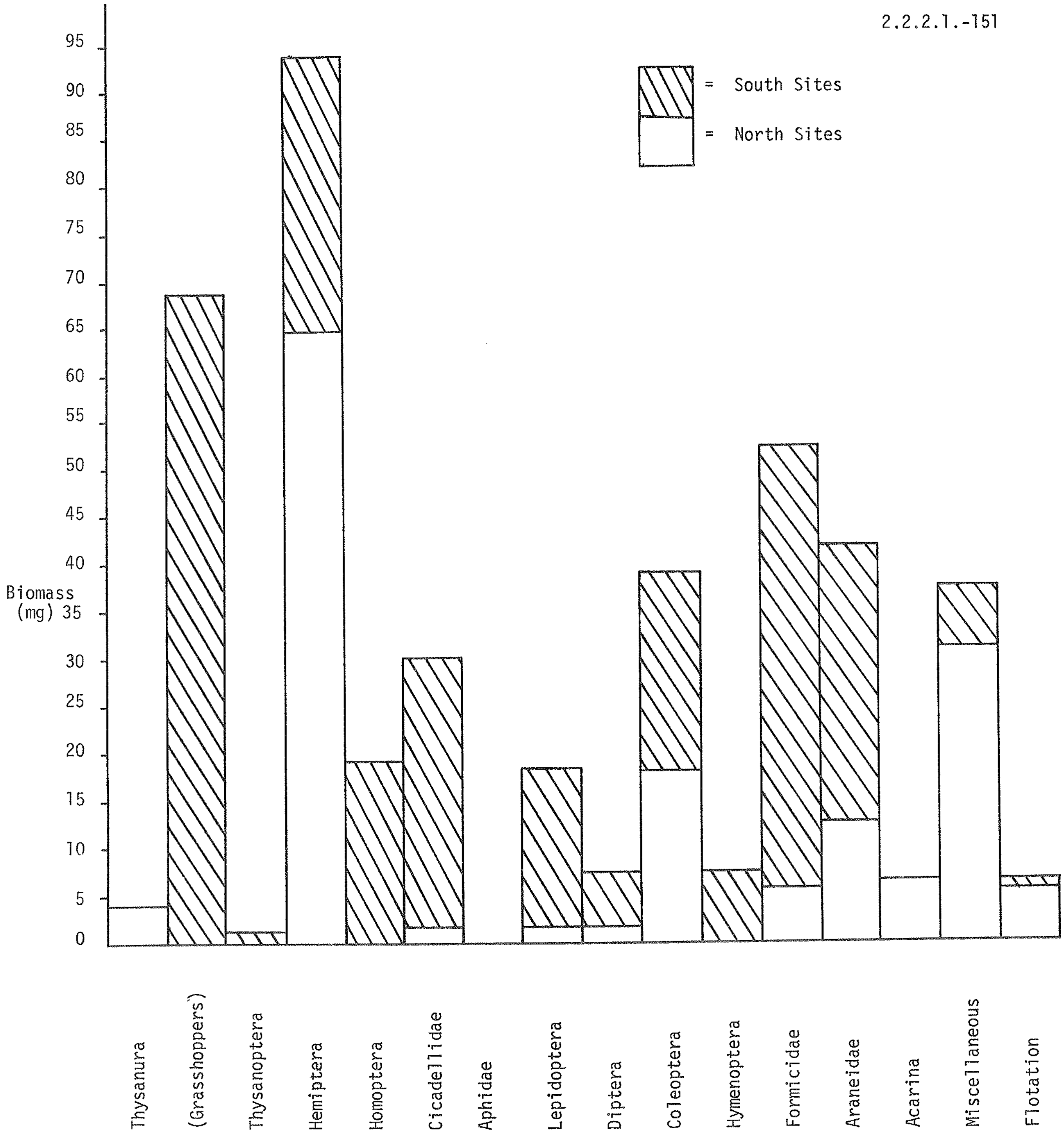


Figure 1. Biomass of the major invertebrate groups collected on 21 plants of *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, September 11, 1971.

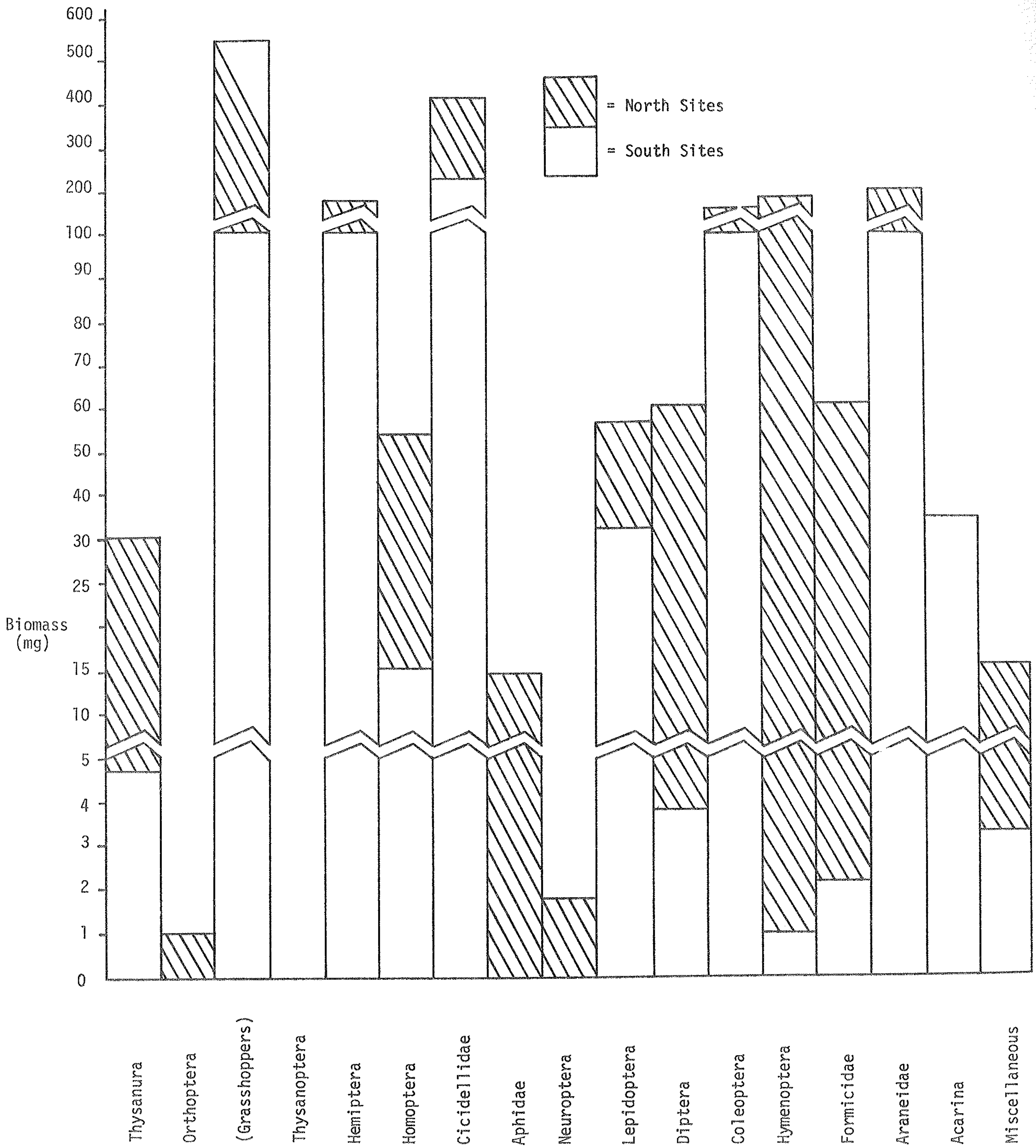


Figure 2. Total invertebrate biomass collected on 21 plants of *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, June 1971.

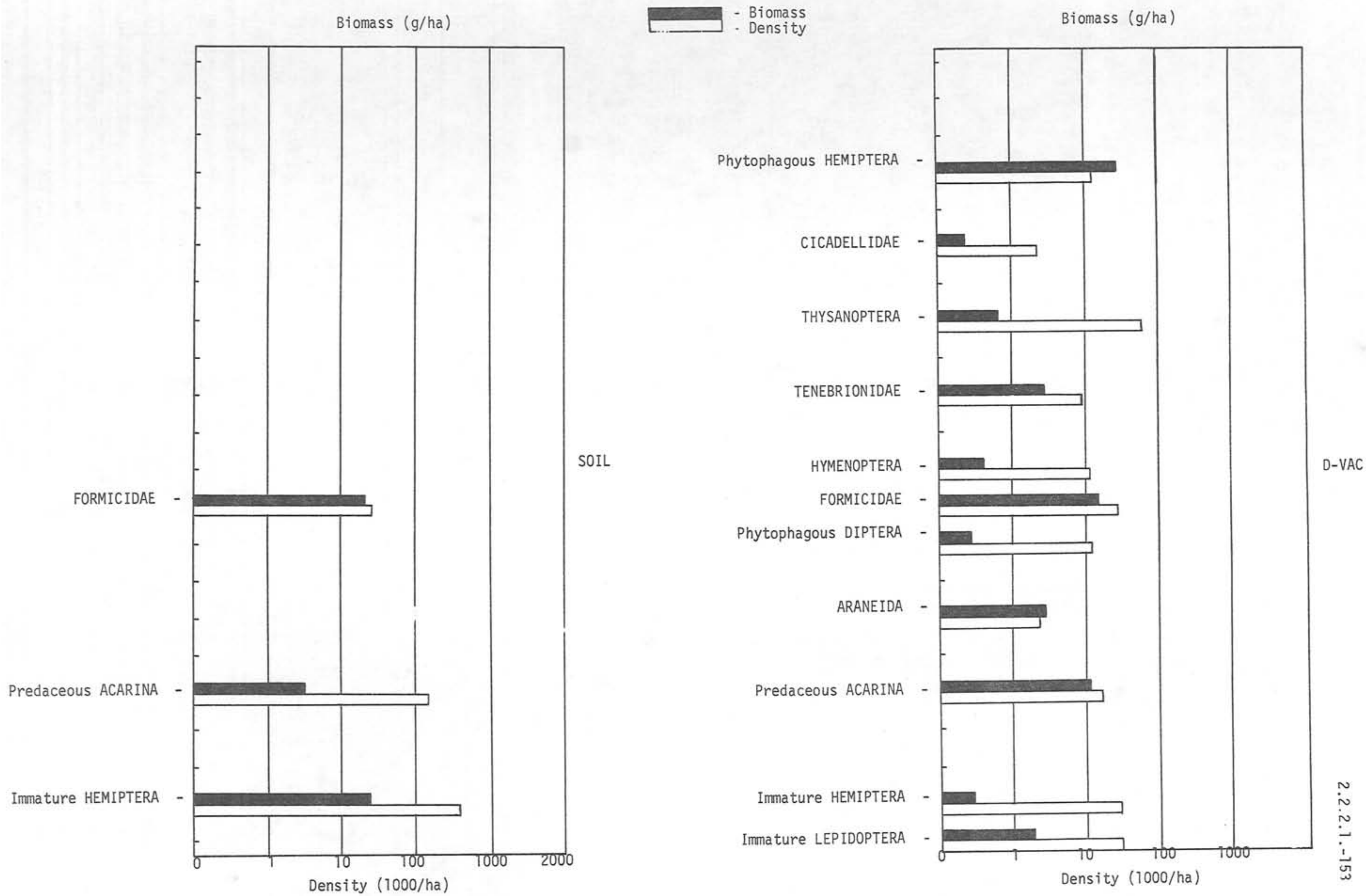


Figure 3. Biomass of invertebrates in Art-Atr-Sit vegetation type by D-Vac and soil extraction, June 15, 1972 (Predominant vegetation: *Atriplex*, *Sitanion*, *Artemisia*)

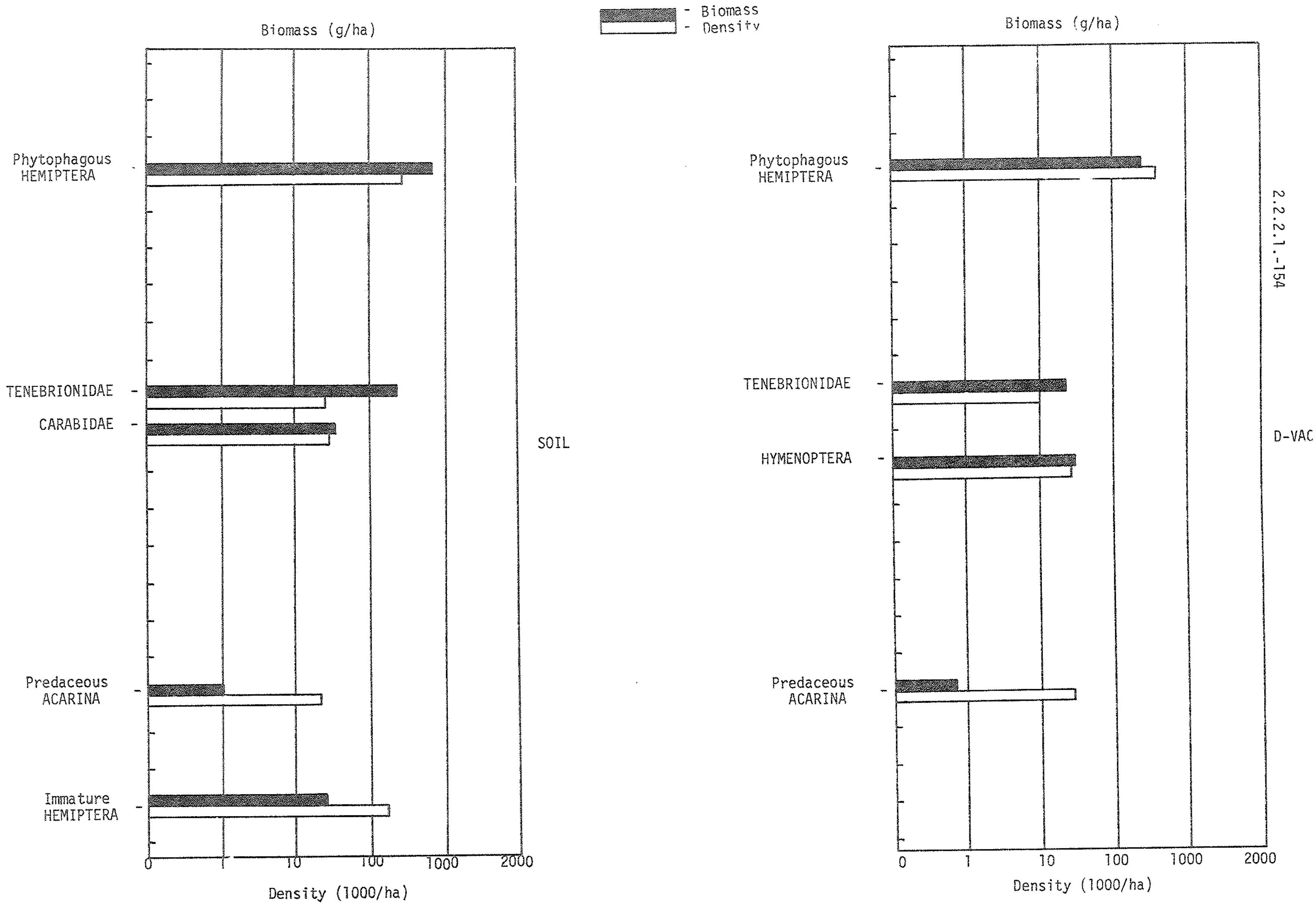


Figure 4. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 13, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Sitanion*)

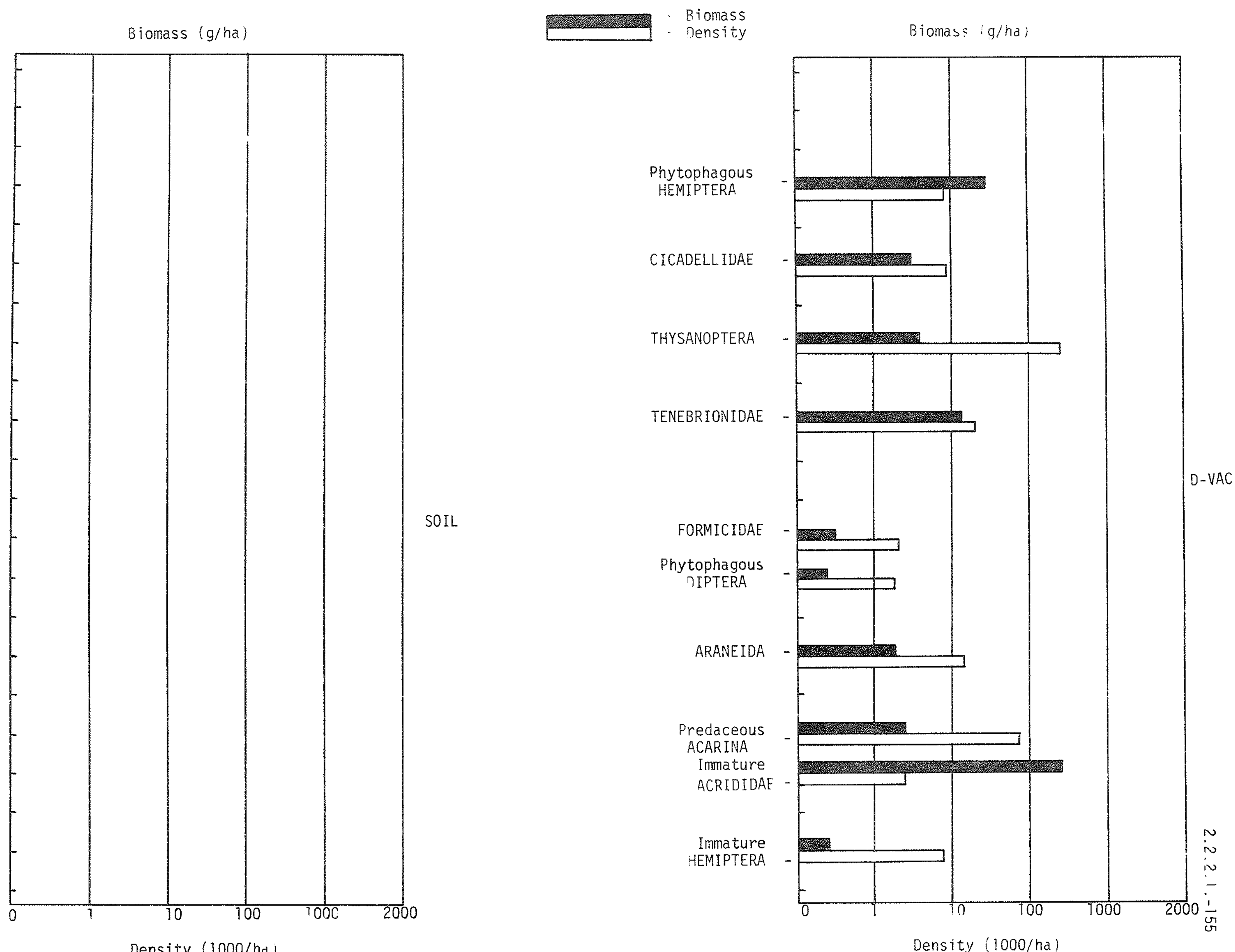


Figure 5. Biomass of invertebrates collected in Agr Vegetation type by D-Vac and soil extraction, June 15, 1972 (Predominant vegetation: *Agropyron*, *Atriplex*, [illegible])

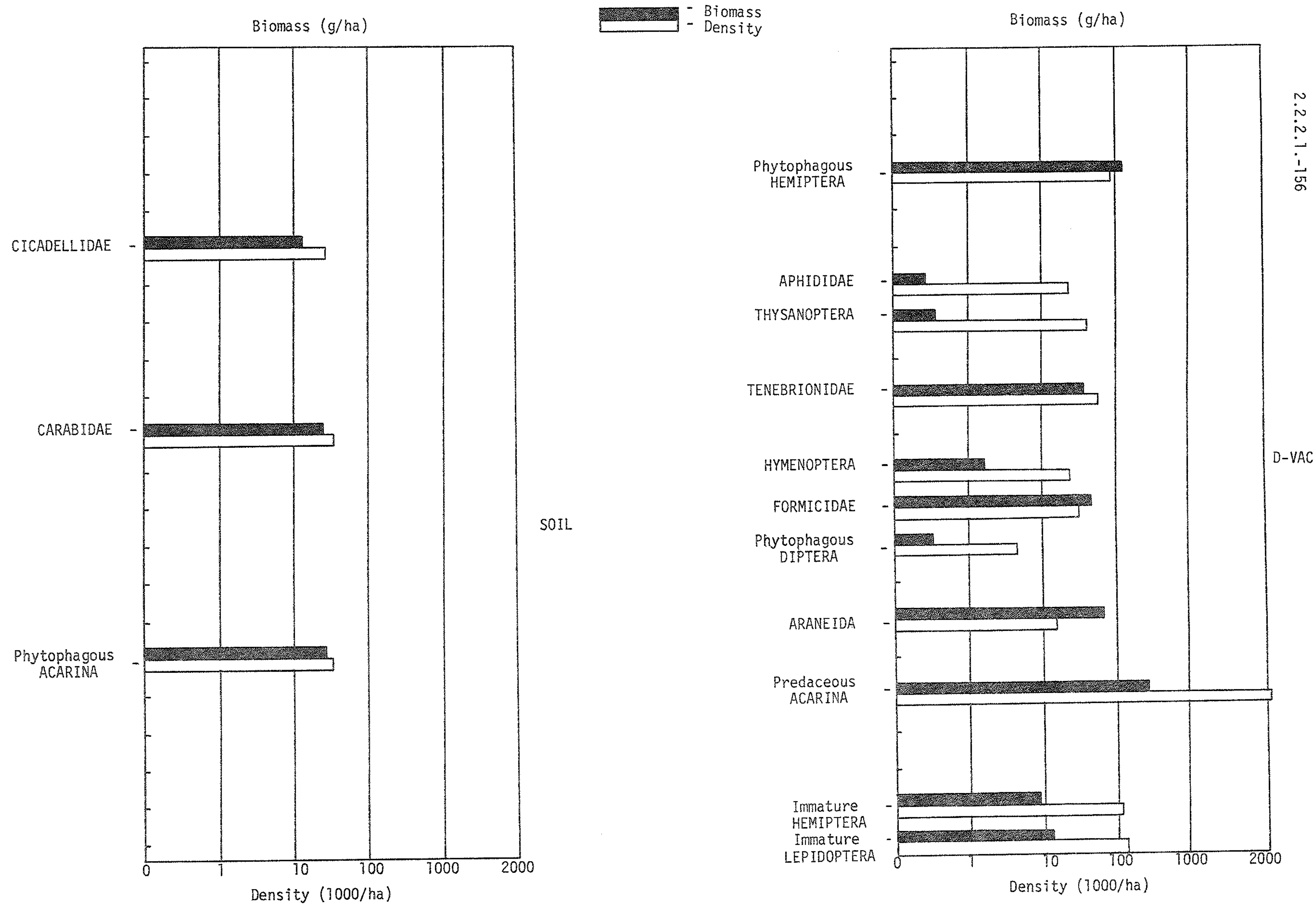


Figure 6. Biomass of invertebrates collected in Art-Atr-Sit vegetation type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Atriplex, Chrysothamus, Artemisia, Sitanion*)

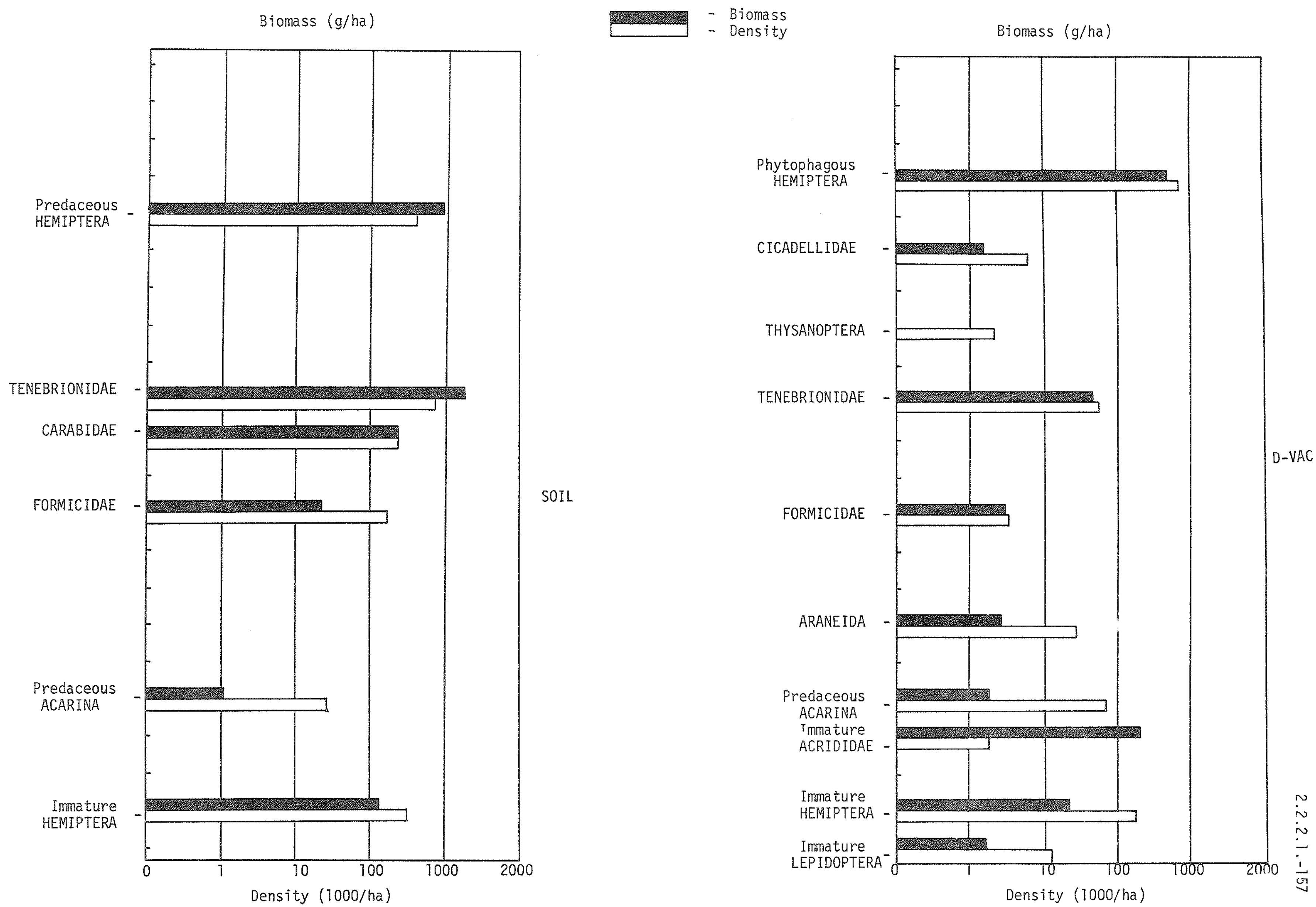


Figure 7. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Halogeton, Bassia, Descurainia, Atriplex, Artemisia, Sitanion*)

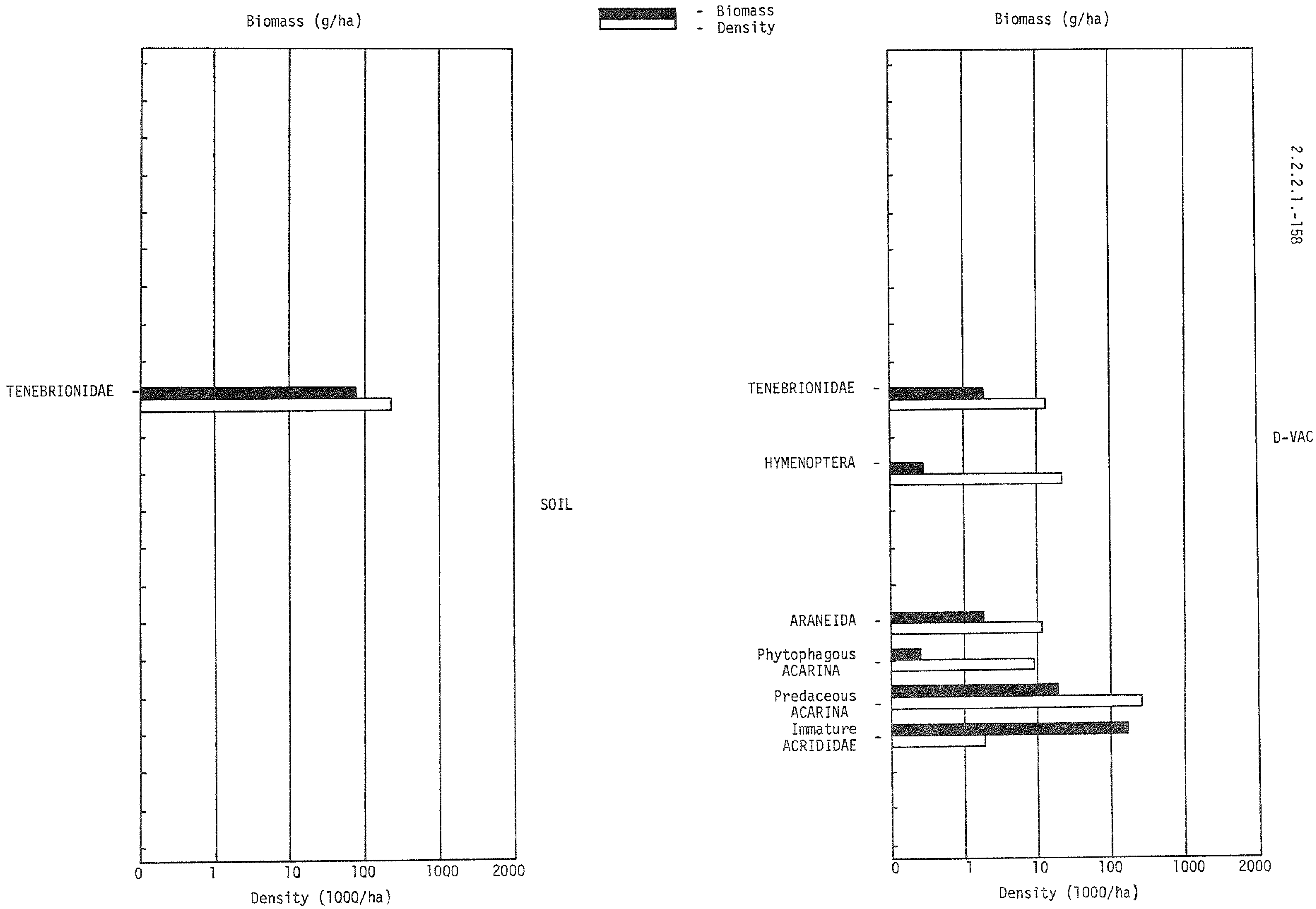


Figure 8. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*)

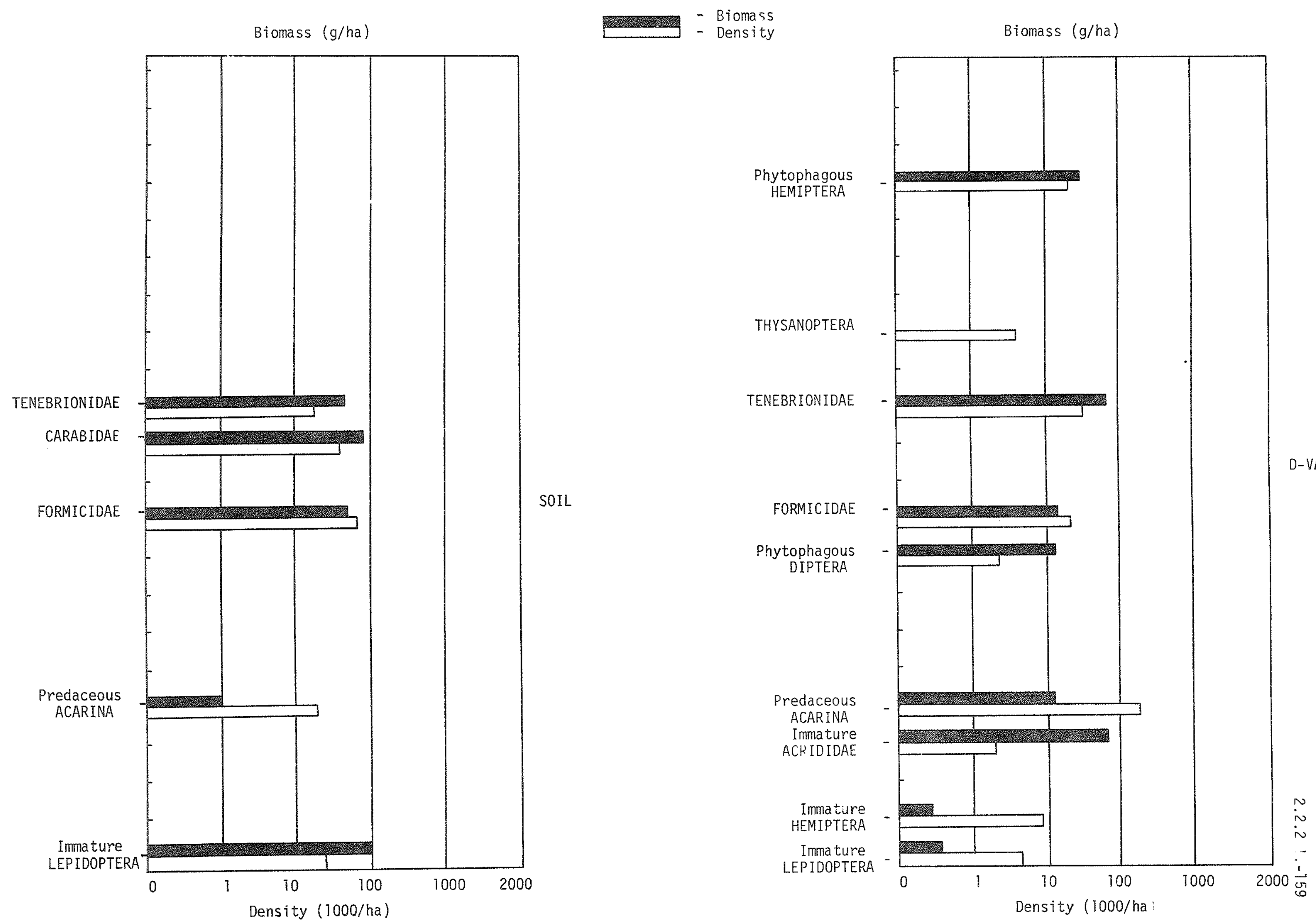


Figure 9. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Artemisia, Atriplex, Sitanion, Halogeton*)

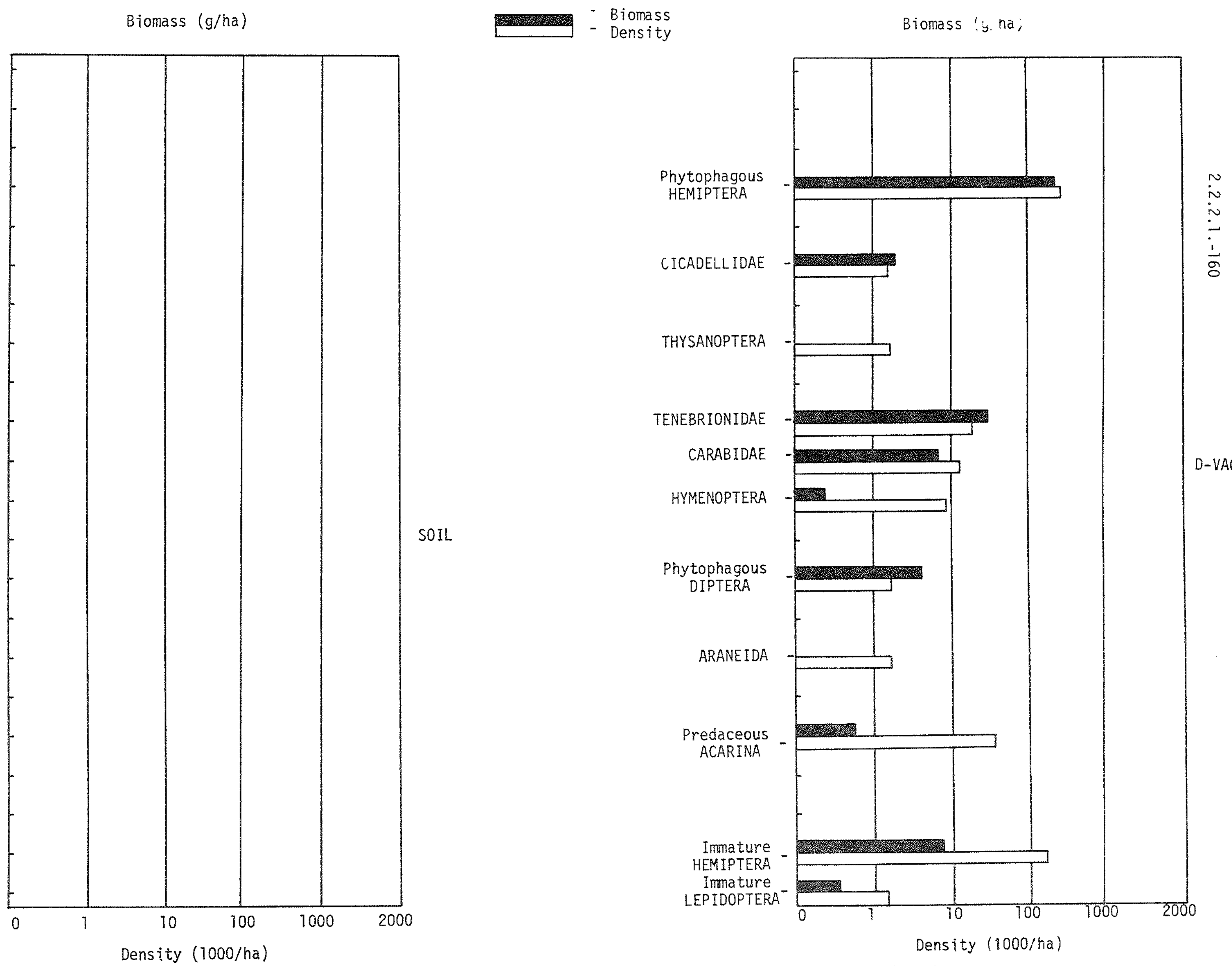


Figure 10. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Halogeton, Salsola, Lepidium, Descurainia*)

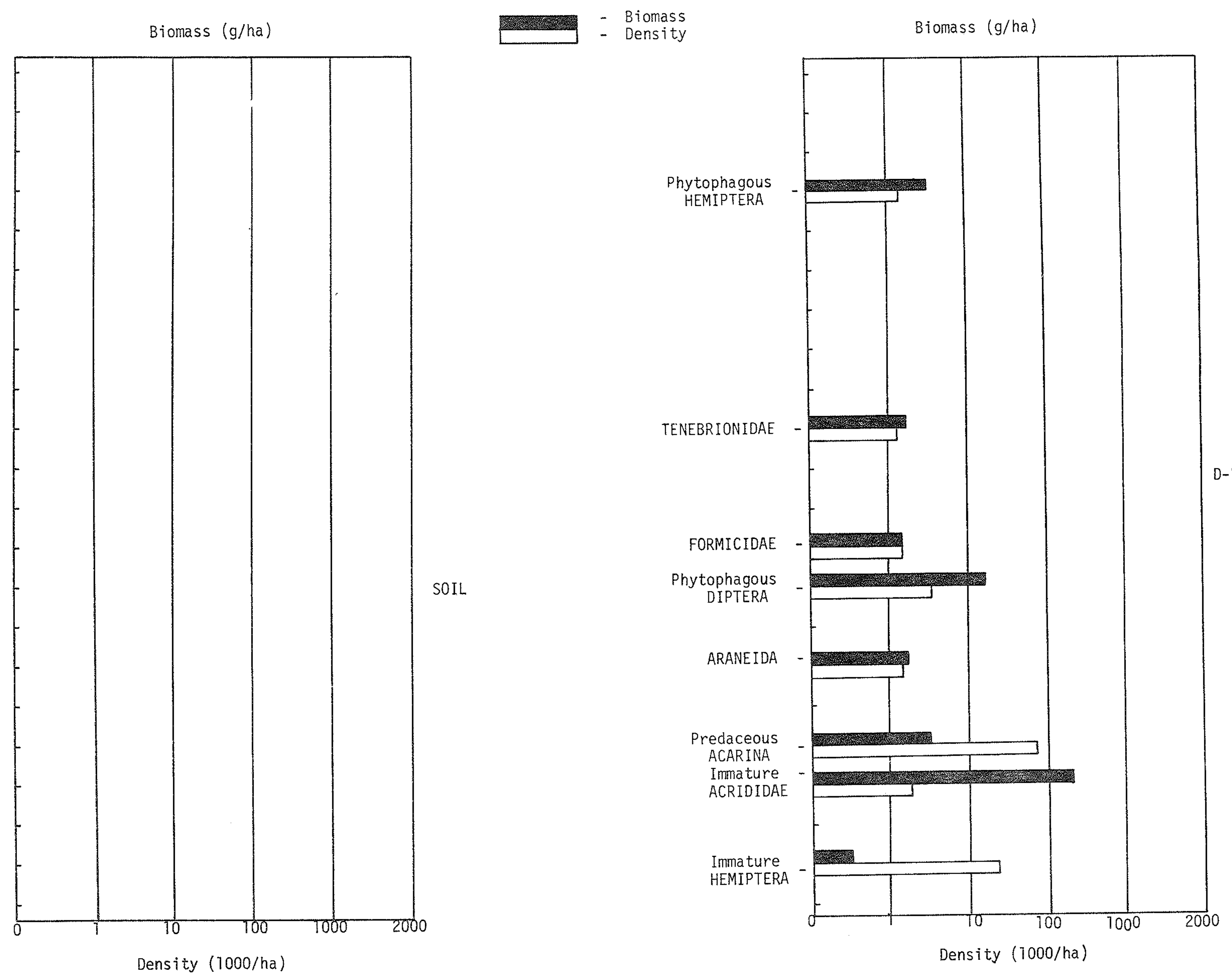


Figure 11. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*, *Sitanion*, *Halogeton*)

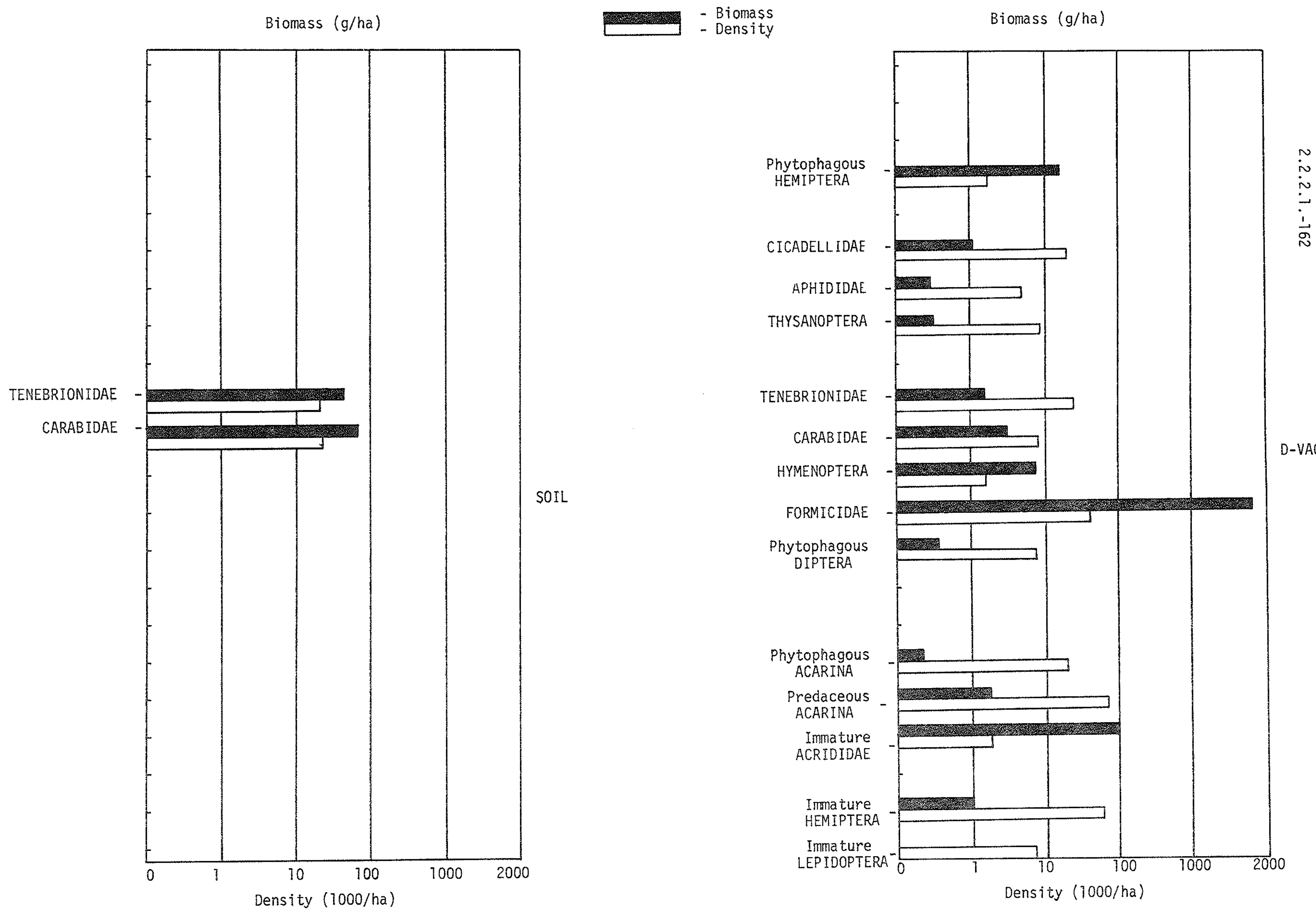


Figure 12. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation: *Atriplex, Artemisia, Sitanion, Chrysothamnus*)

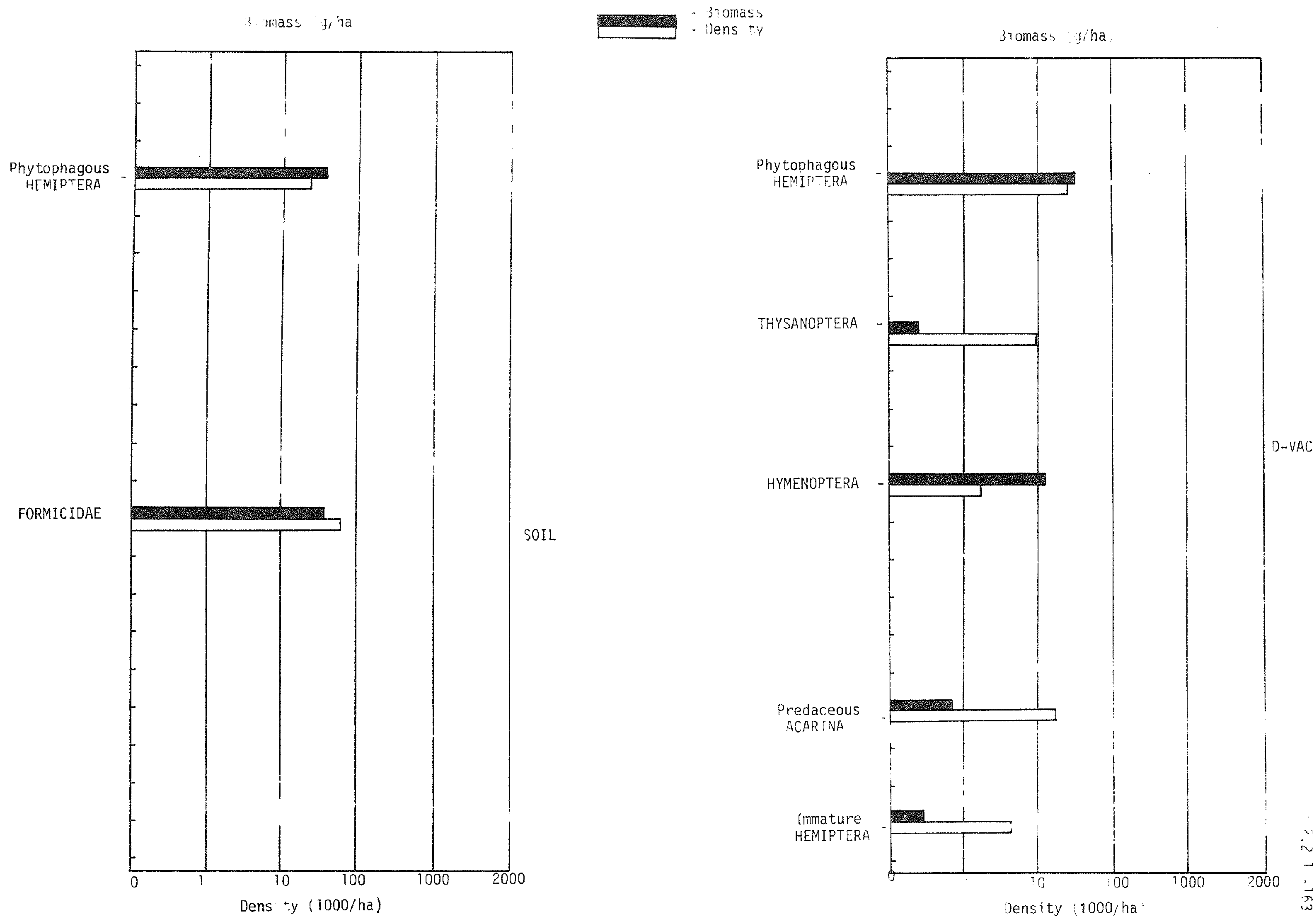


Figure 13 Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation. *la... n, ...)*

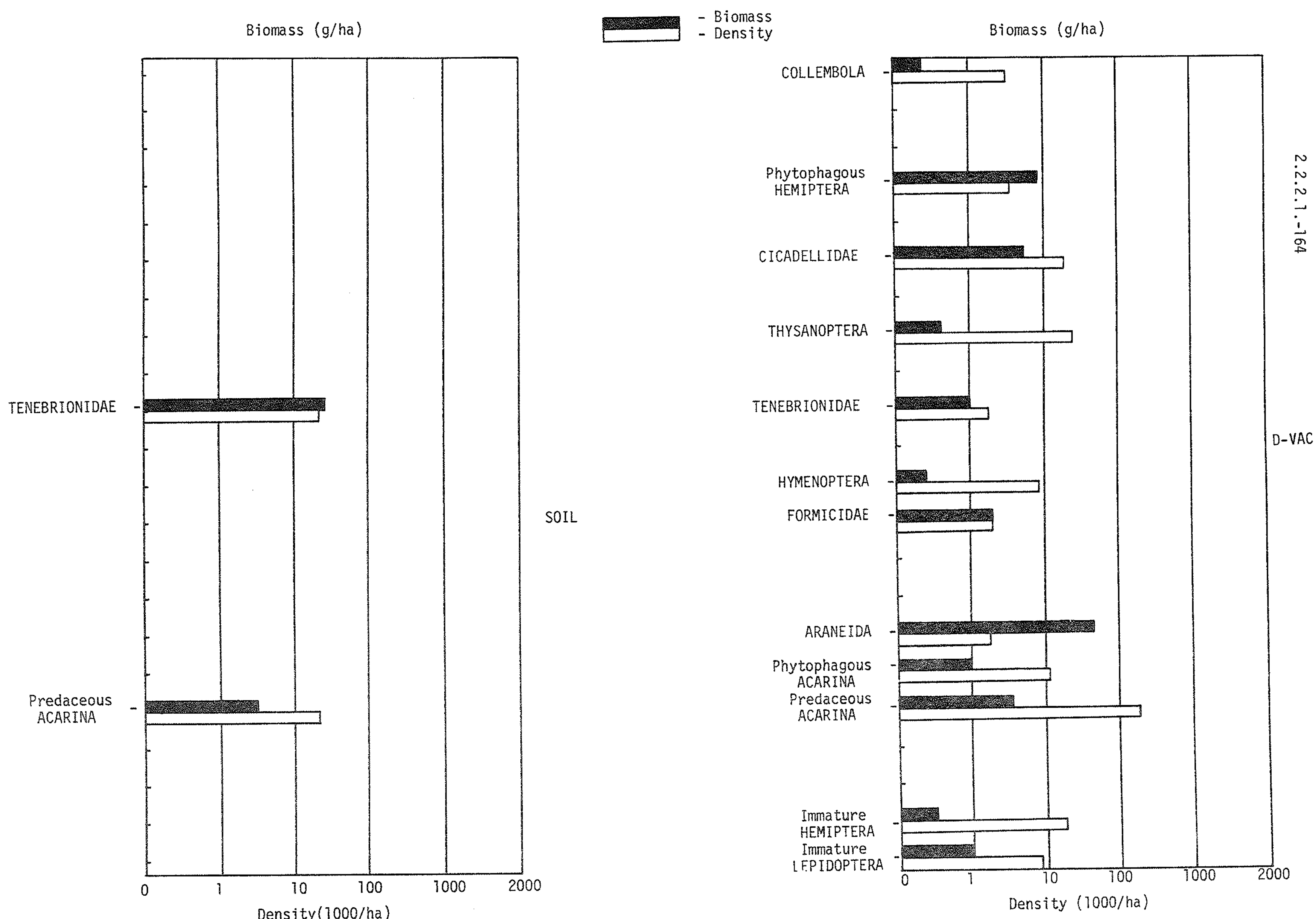


Figure 14. Histogram analysis of invertegrates collected in Agr Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation: *Agropyron, Atriplex*)

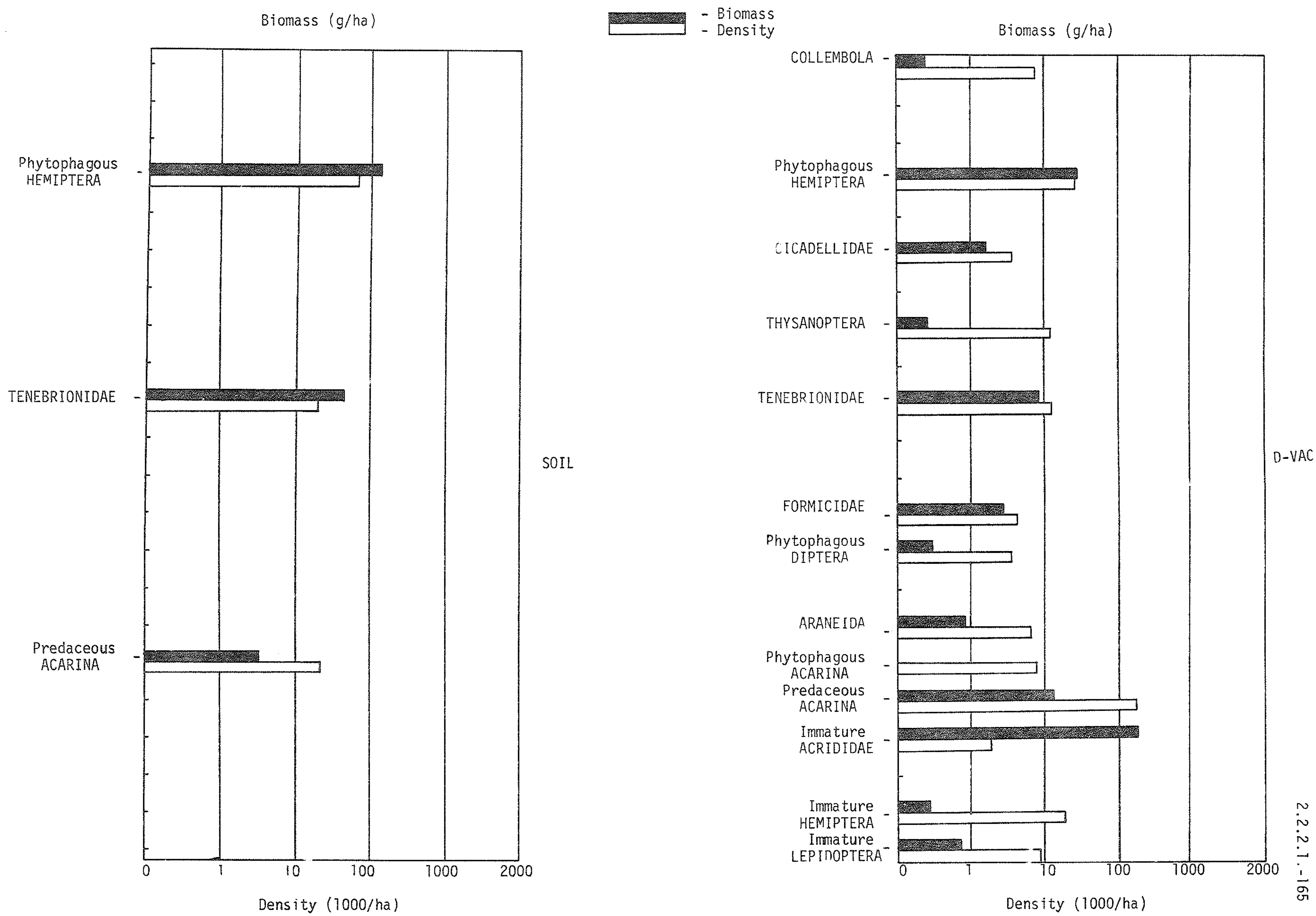


Figure 15. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac or soil extraction, July 11, 1972 (Predominant Vegetation: *Atriplex*, *Artemisia*, *Sitanion*)

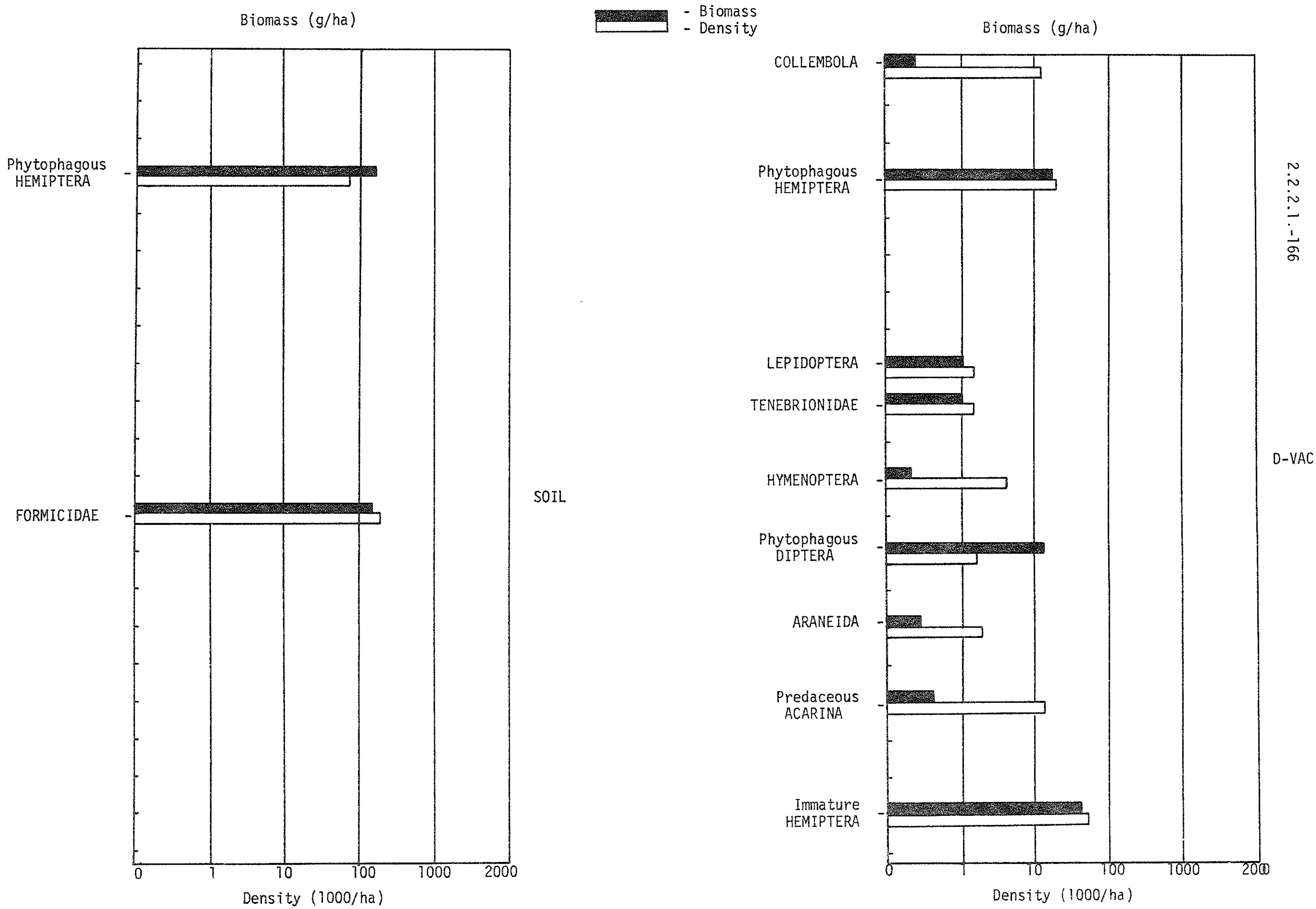


Figure 16. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 11, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Artemisia*)

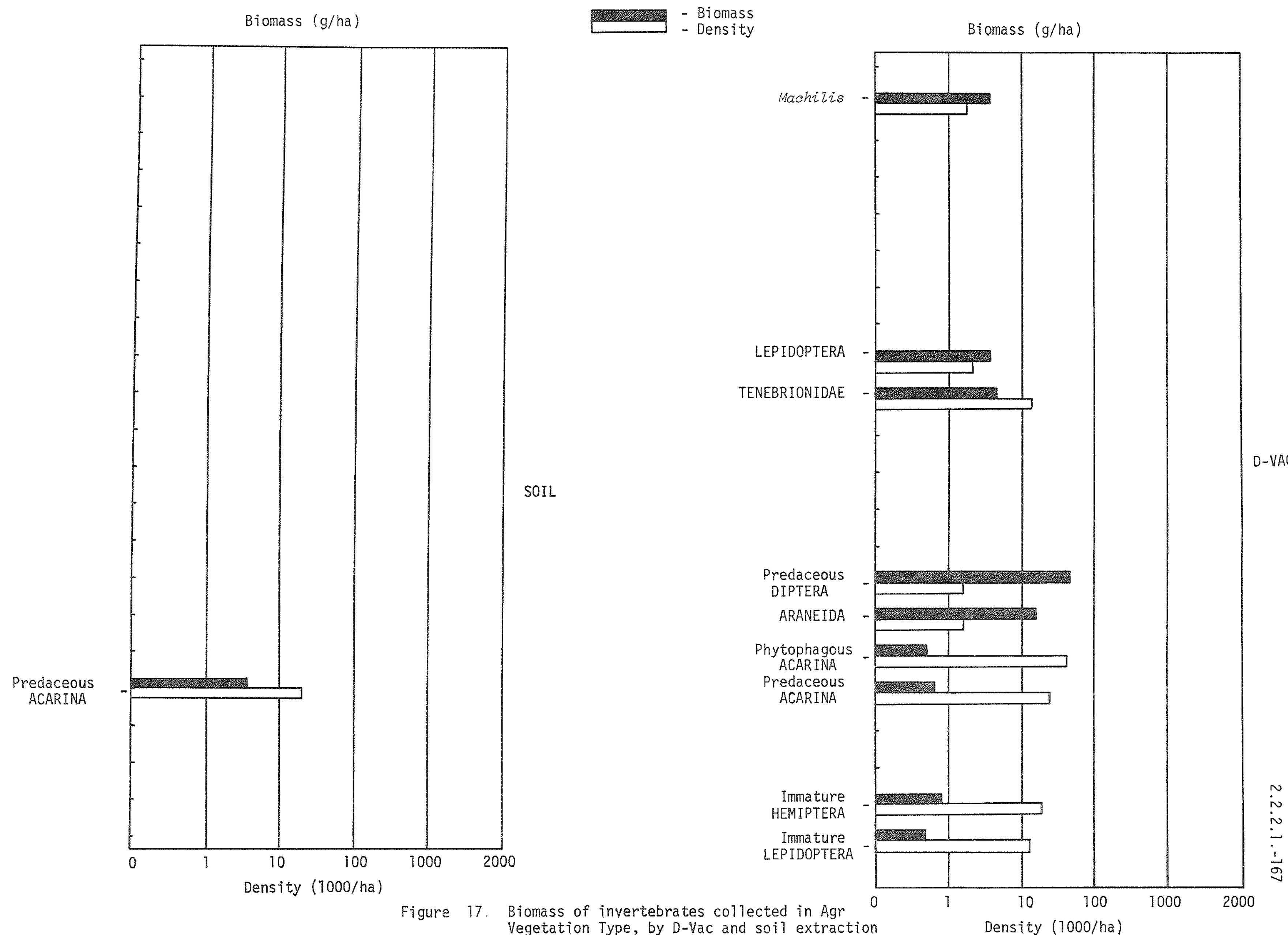


Figure 17. Biomass of invertebrates collected in Agr Vegetation Type, by D-Vac and soil extraction (Predominant Vegetation: *Agropyron, Atriplex*)

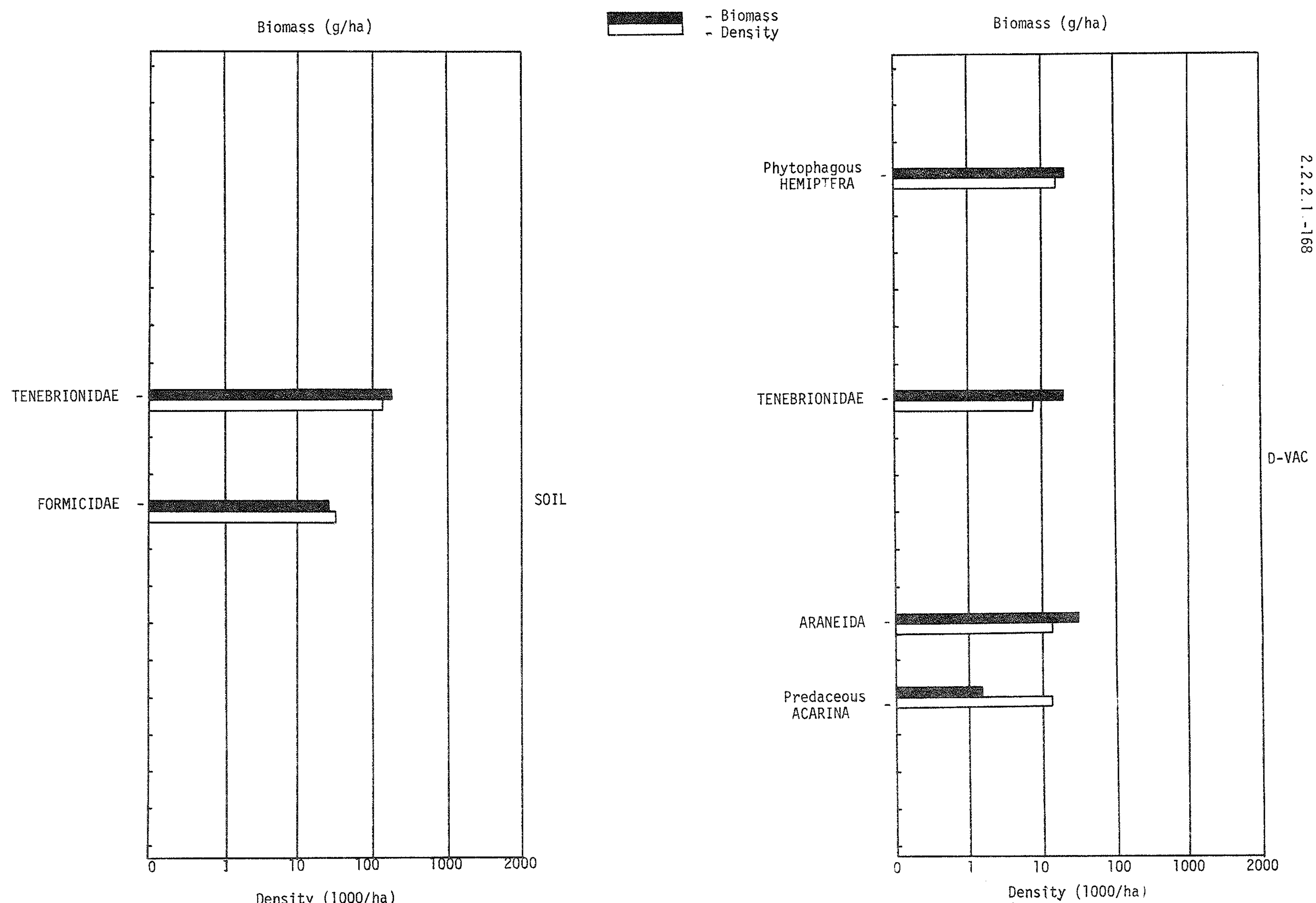


Figure 18. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Atriplex*, dead *Artemisia*, *Artemisia*)

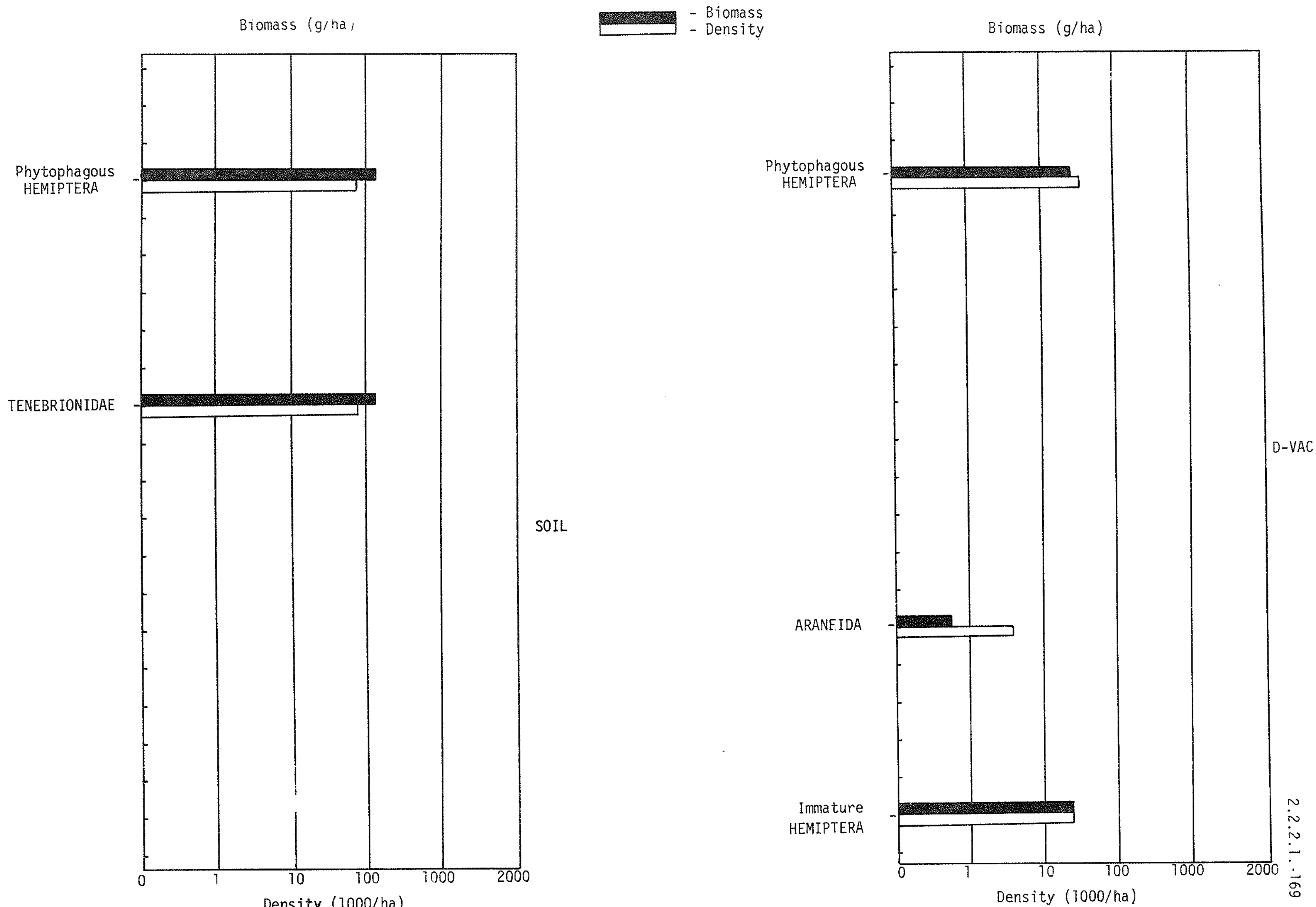


Figure 19. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Bassia* dead)

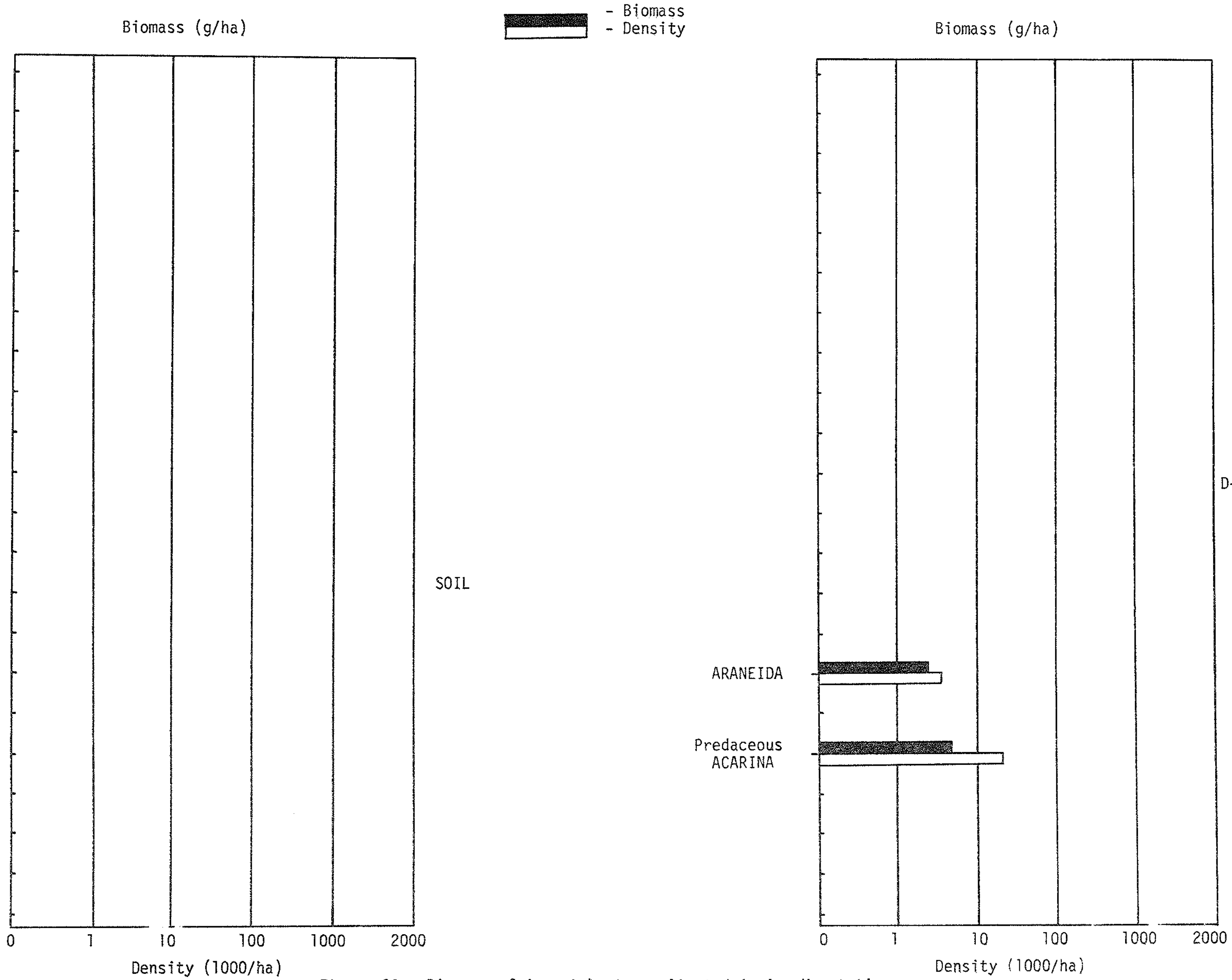


Figure 20. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Agropyron*, *Atri[illegible]x*)

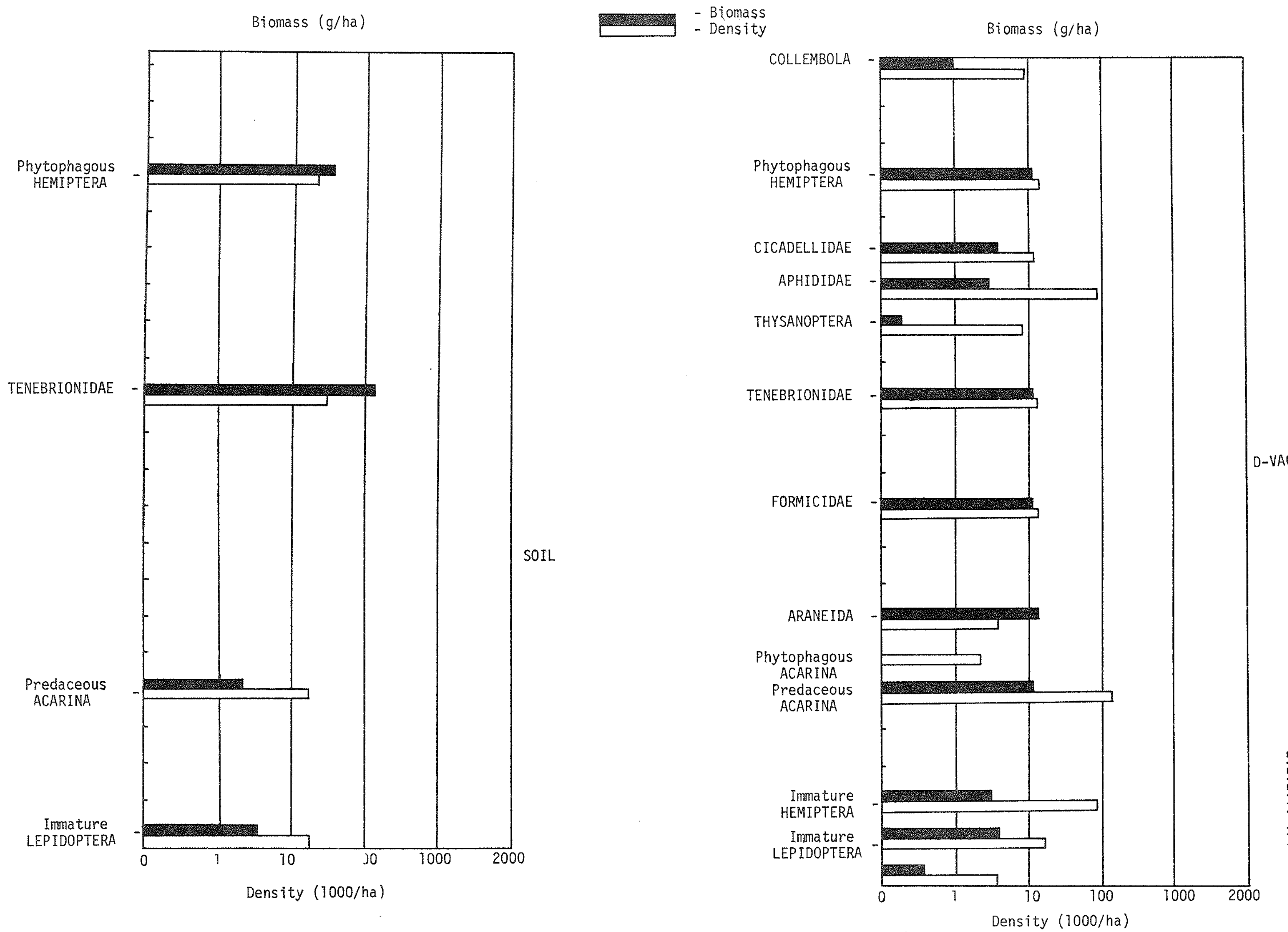


Figure 21. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Atriplex, Artemisia, Sitanion, Chrysothamnus*)

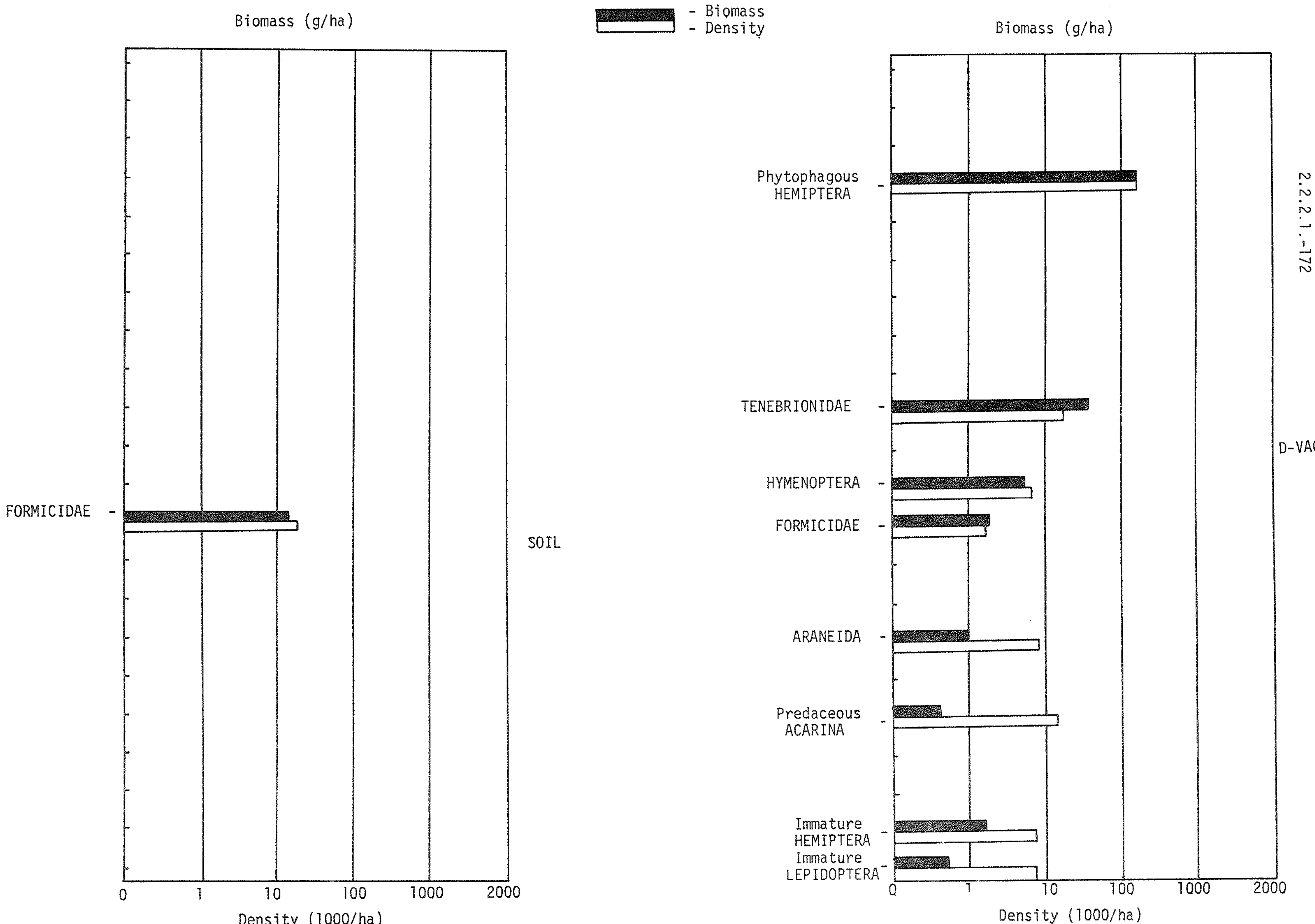


Figure 22. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Halogeton, Sitanion, Descurainia, Descurainia* dead)

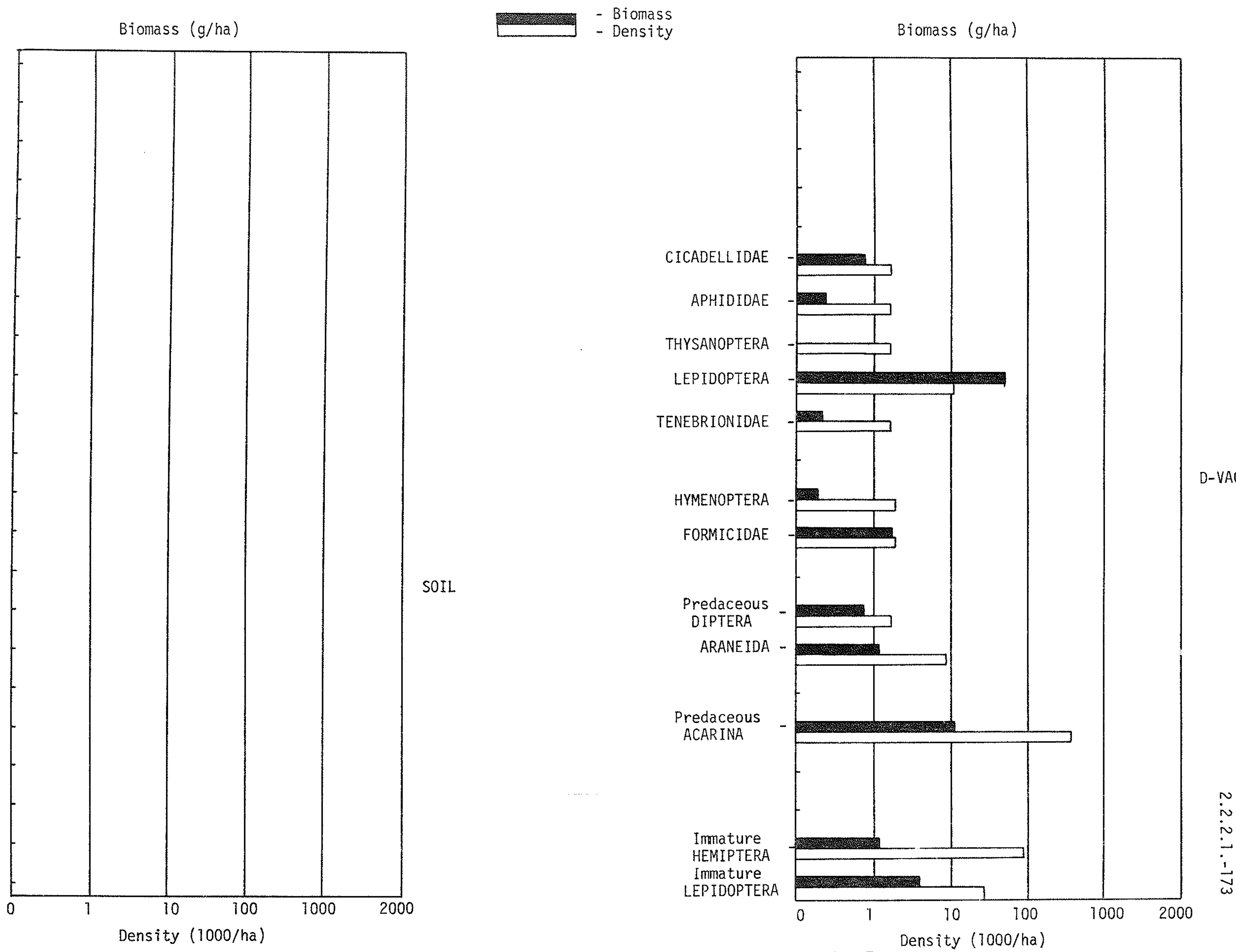


Figure 23. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Artemisia*)

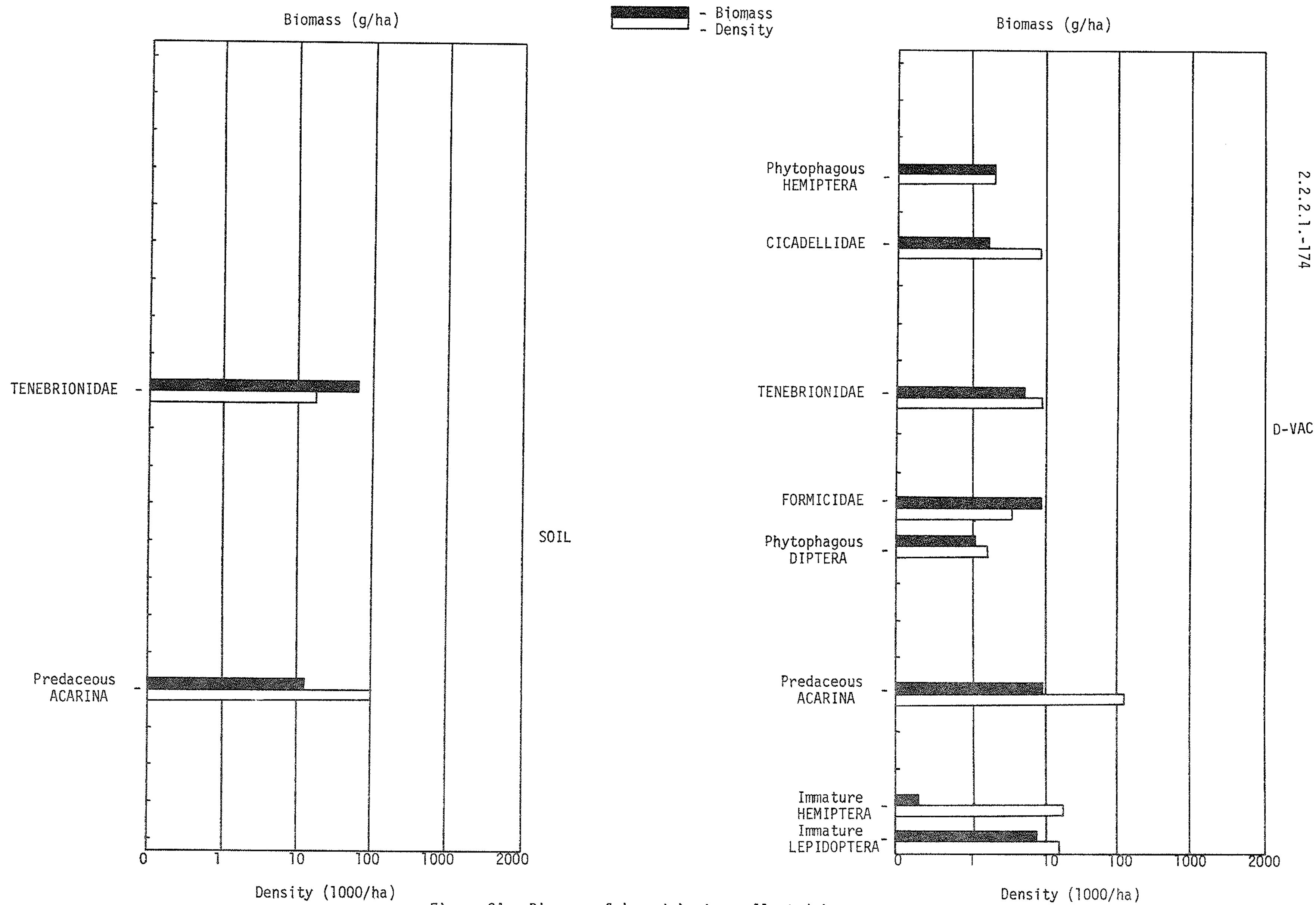


Figure 24. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 1 August, 1972 (Predominant Vegetation: *Artemisia, Sitanion, Atriplex*)

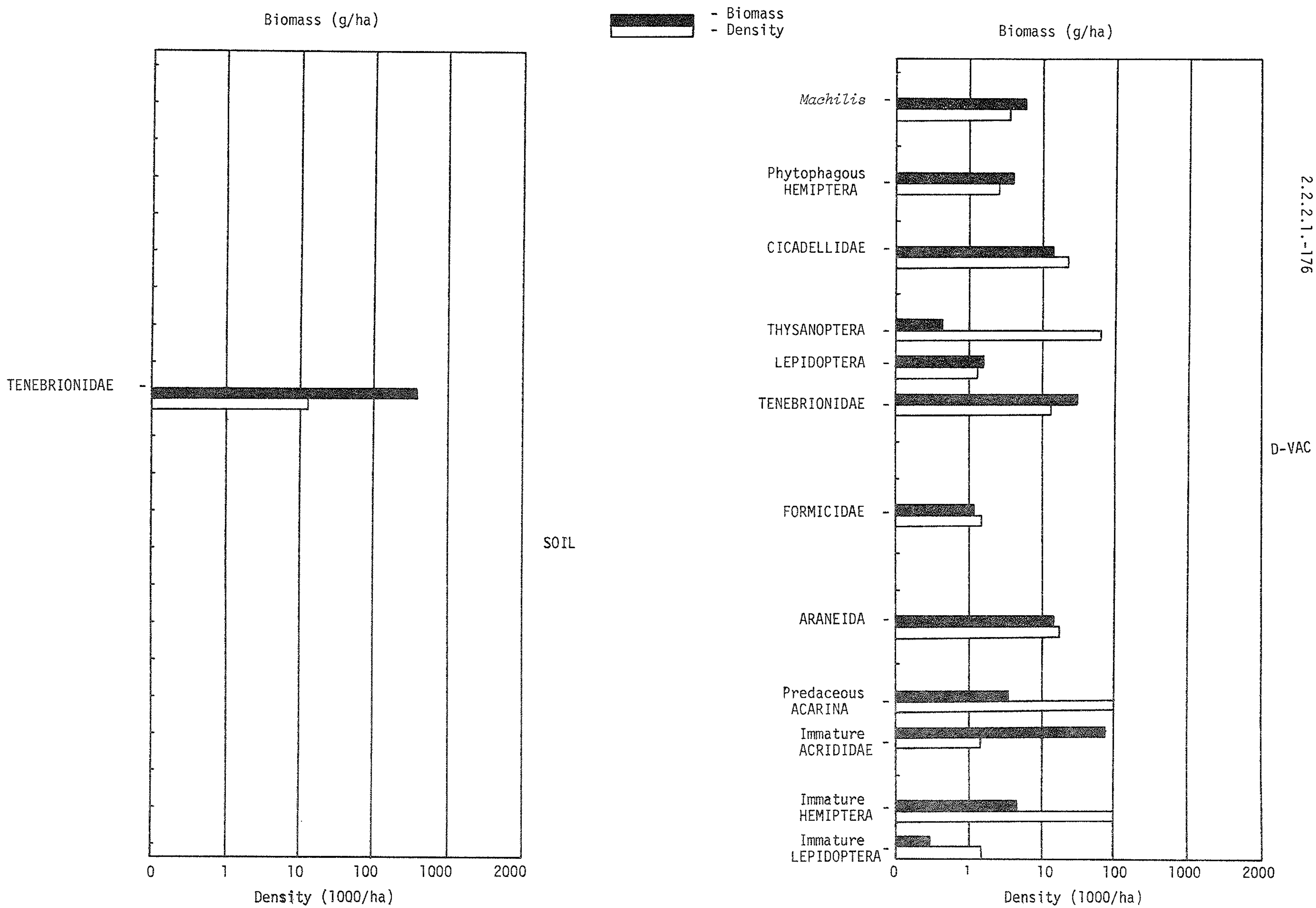


Figure 26. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 1 August, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*, *Halogeton*)

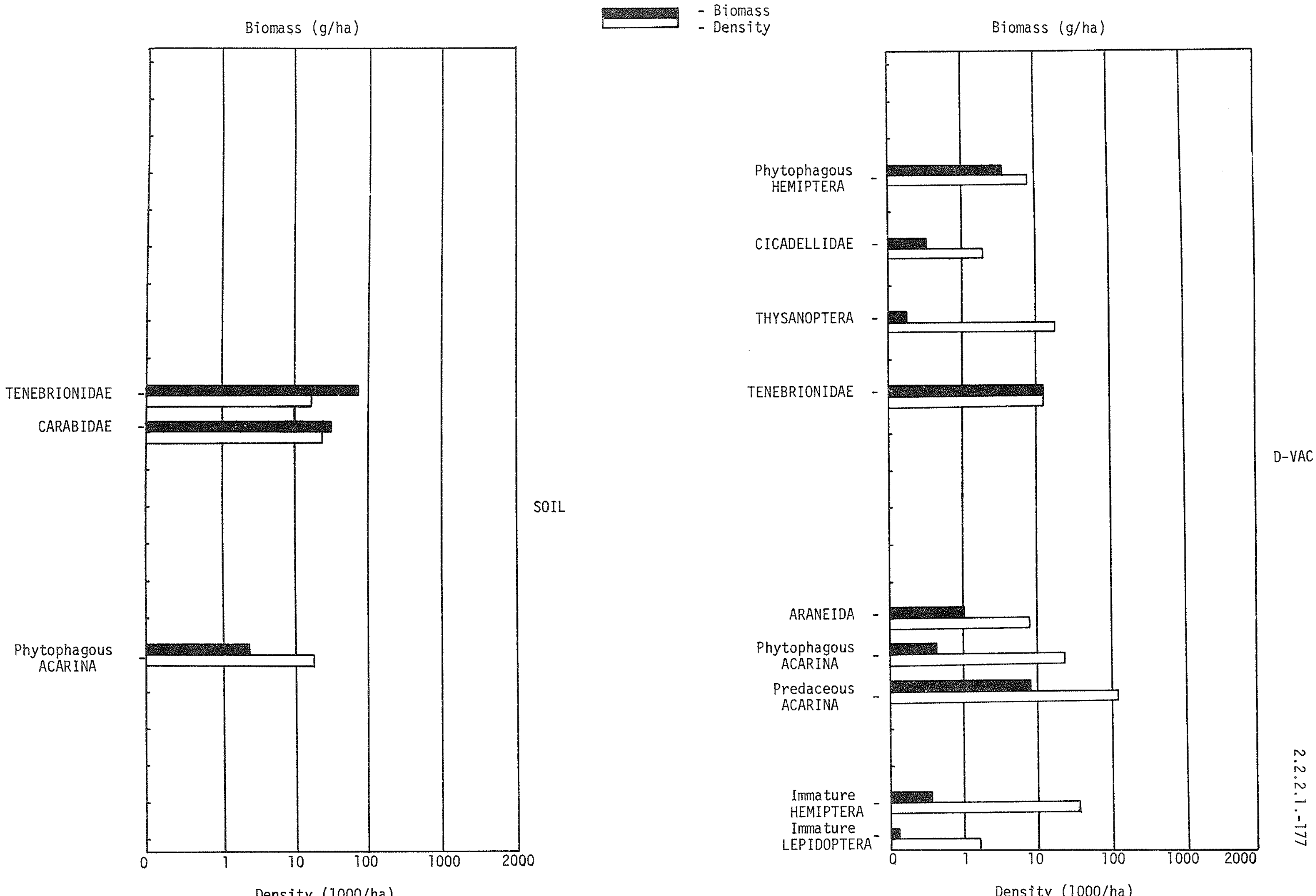


Figure 27. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Sitanion, Artemisia, Atriplex*)

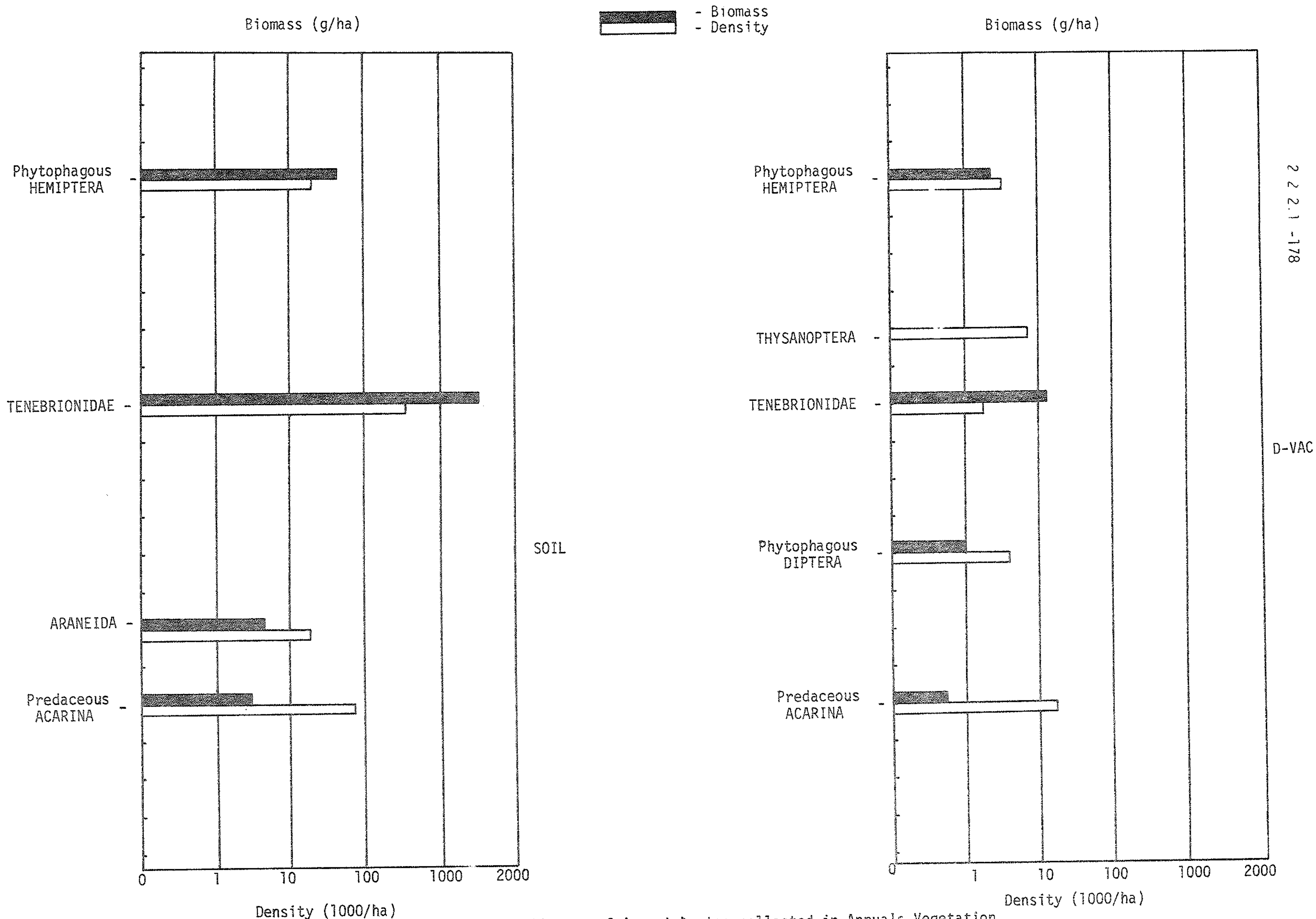


Figure 28. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Descurainia* dead, *Artemisia* dead)

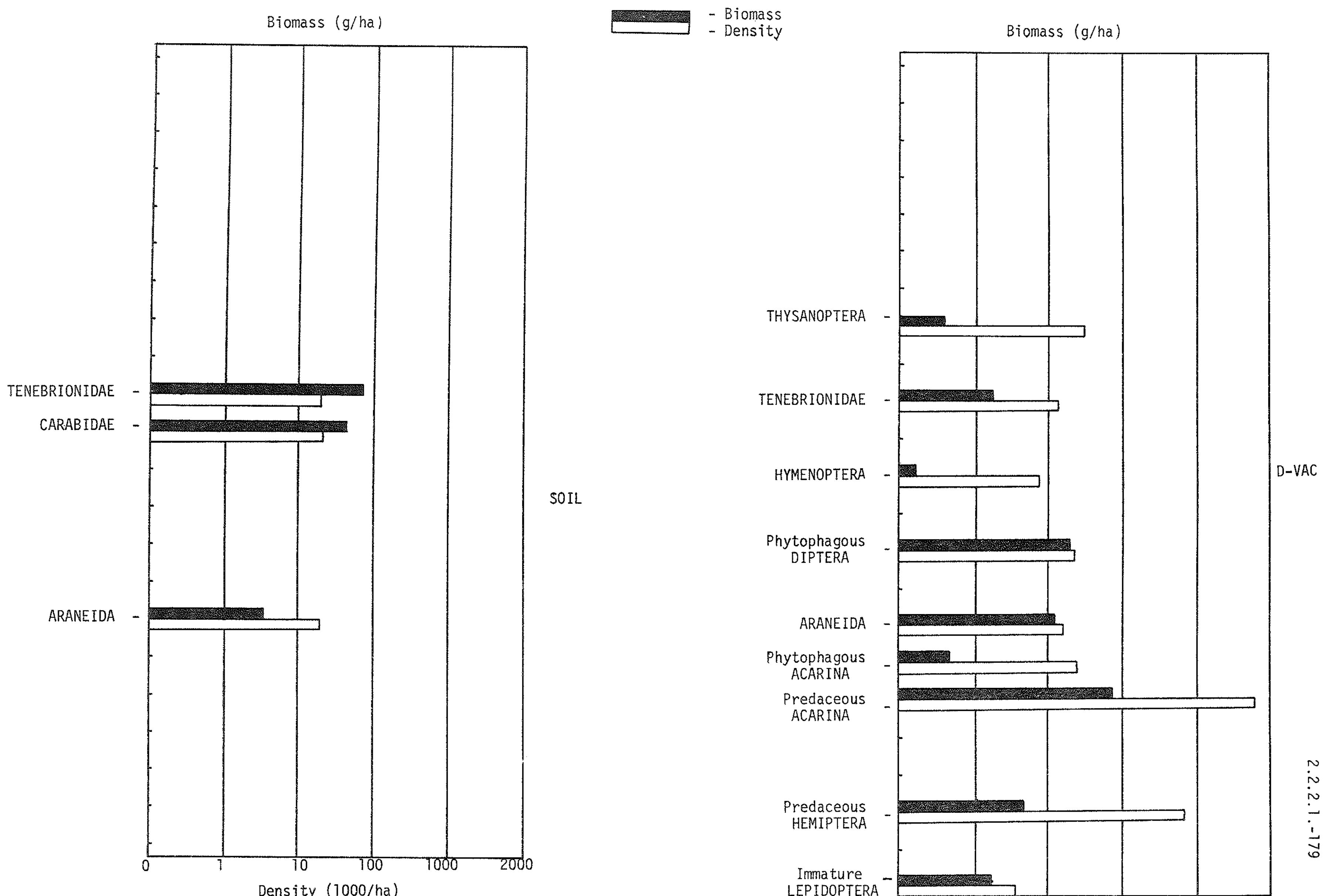


Figure 29. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*, *Chrysothamnus*)

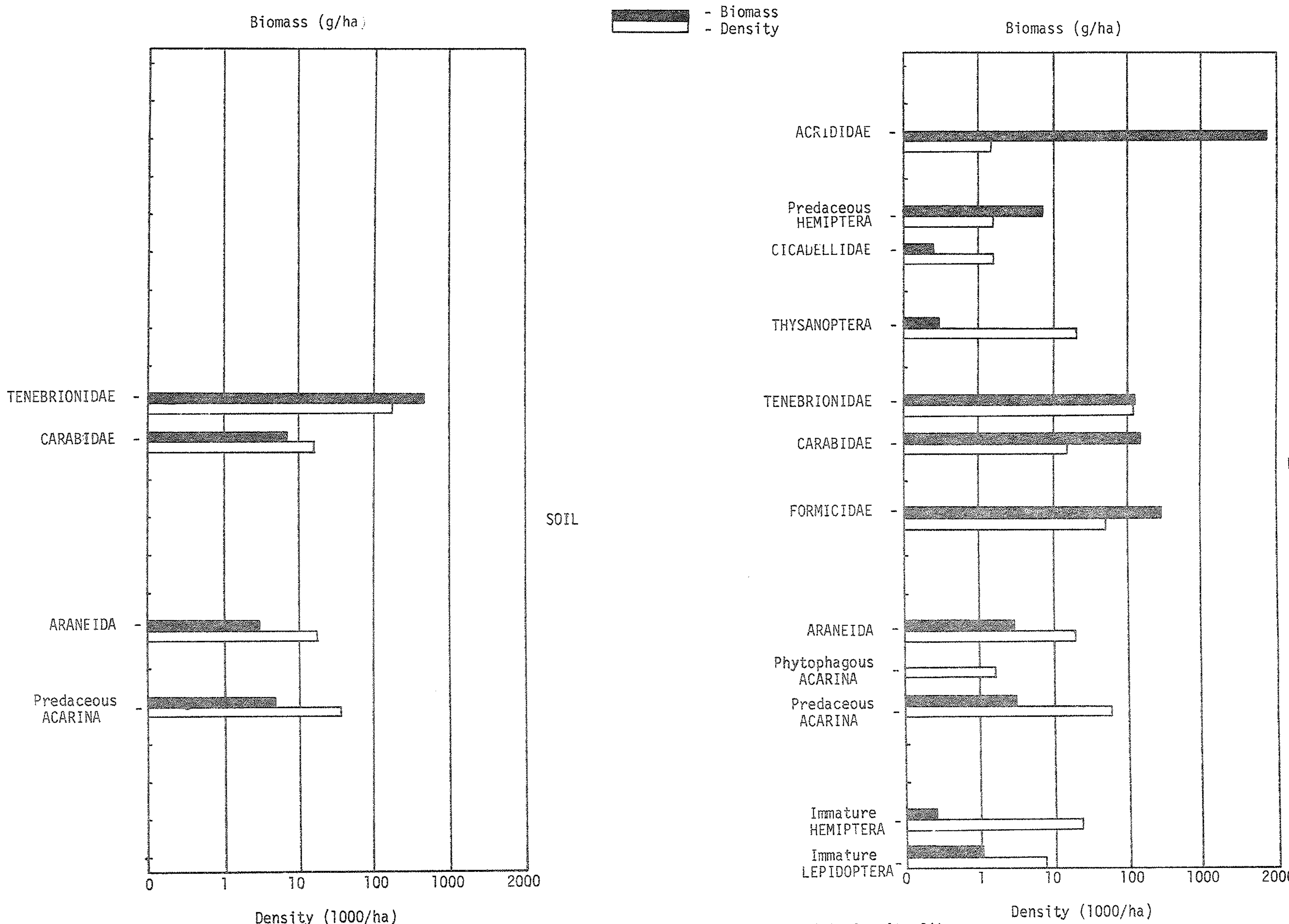


Figure 30. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 15 August, 1972, (Predominant Vegetation: *Atriplex*, *Artemisia* dead *Sitanion*, *Halogeton*, *Chrysothamus*)

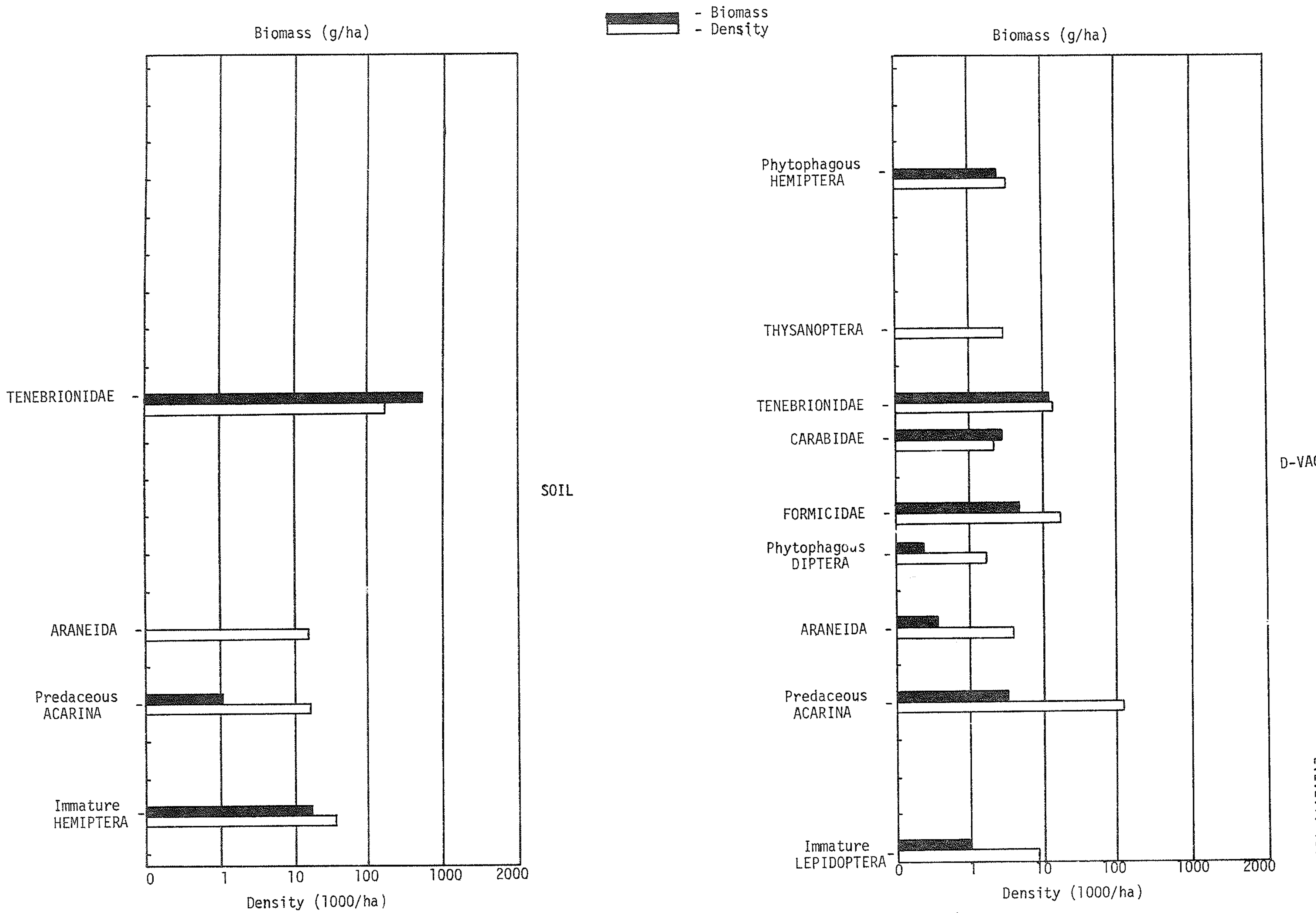


Figure 31. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 15 August, 1972 (Predominant Vegetation: *Halogeton, Bassia, Artemisia* dead, *Sitanion*)

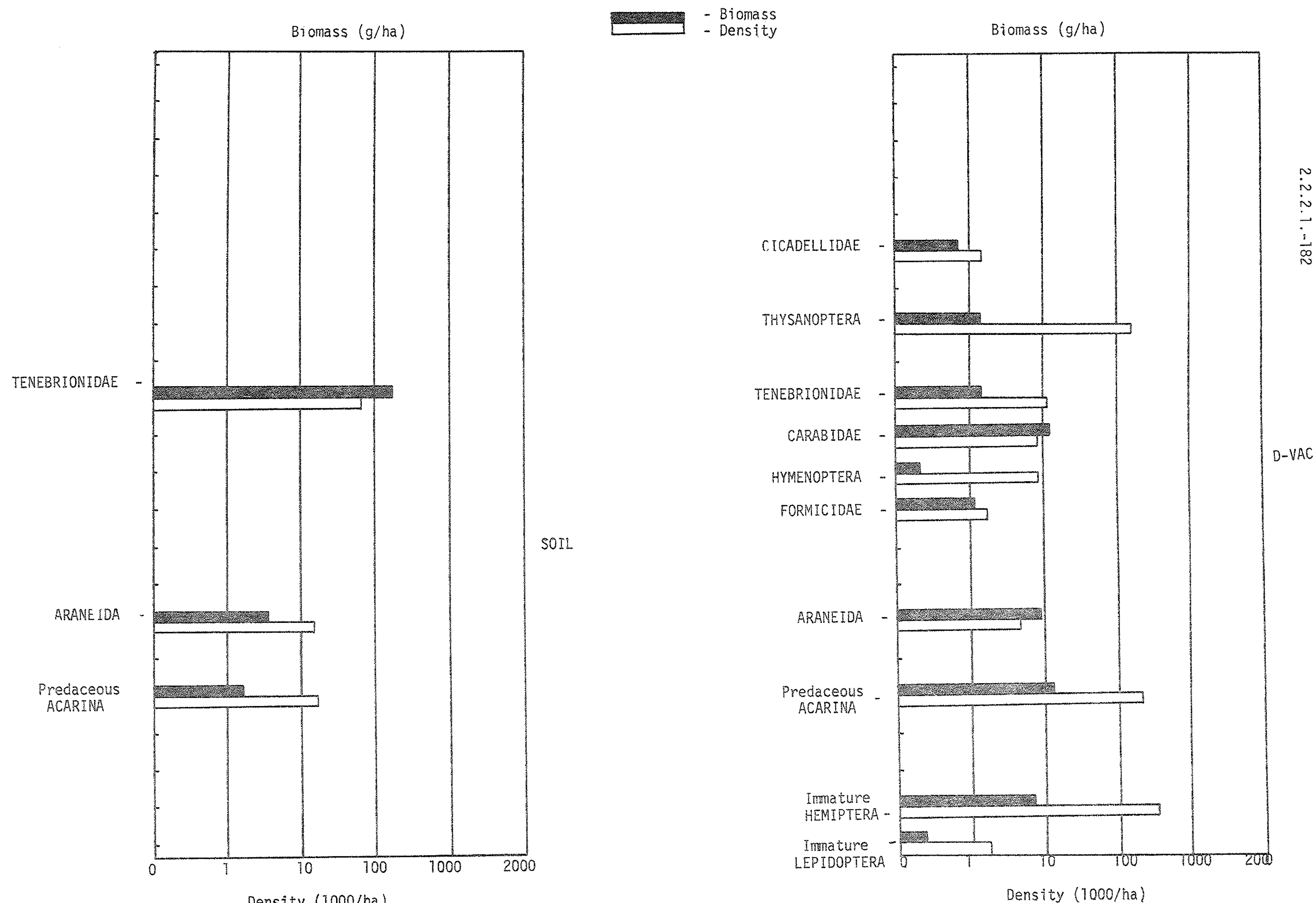


Figure 32. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 25 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Artemisia* dead)

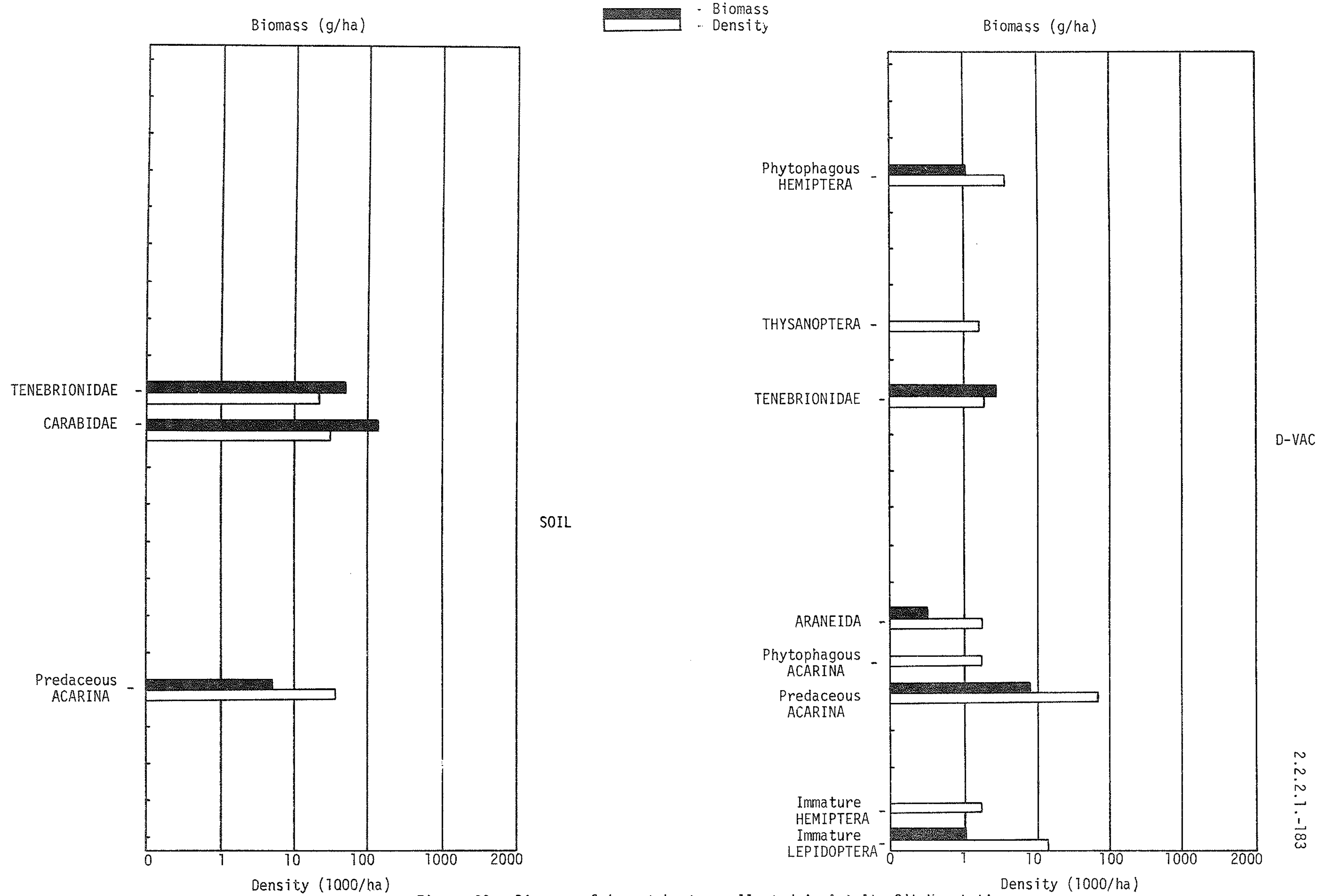


Figure 33. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Artemisia, Atriplex, Sitanion, Chrysothamus, Elymus*)

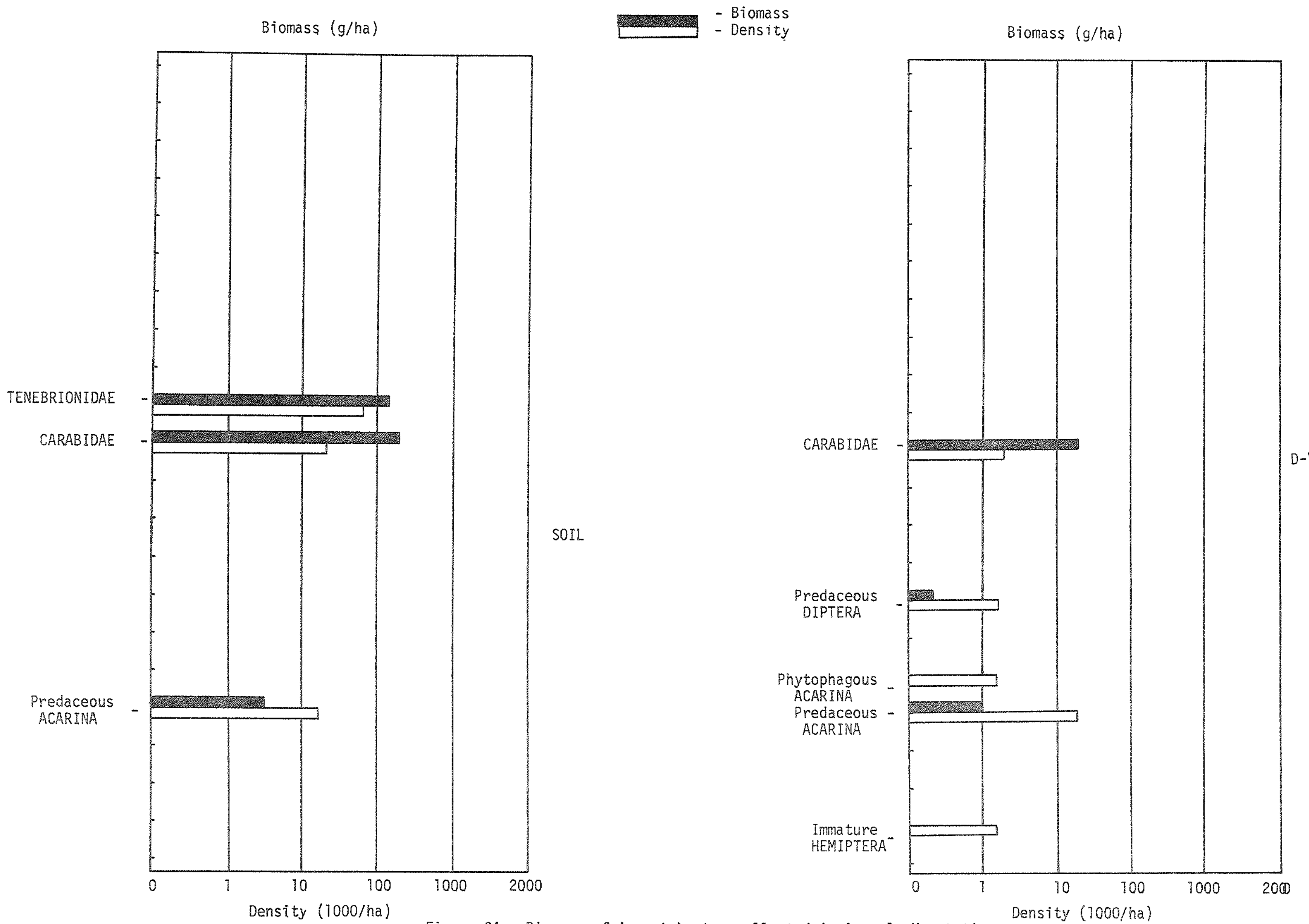


Figure 34. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Halogeton*, *Artemisia* dead, *Bassia*)

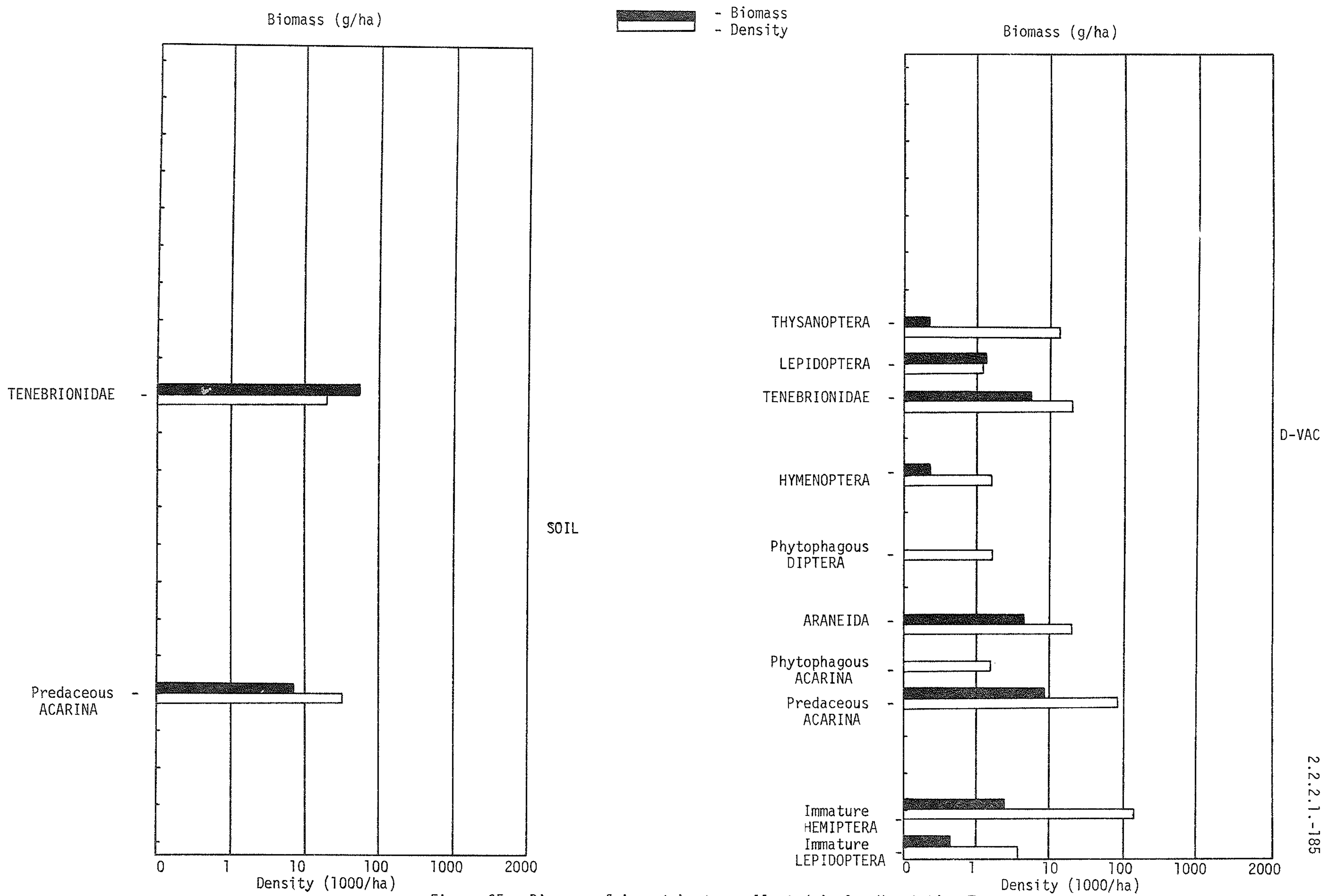


Figure 35. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Artemisia*)

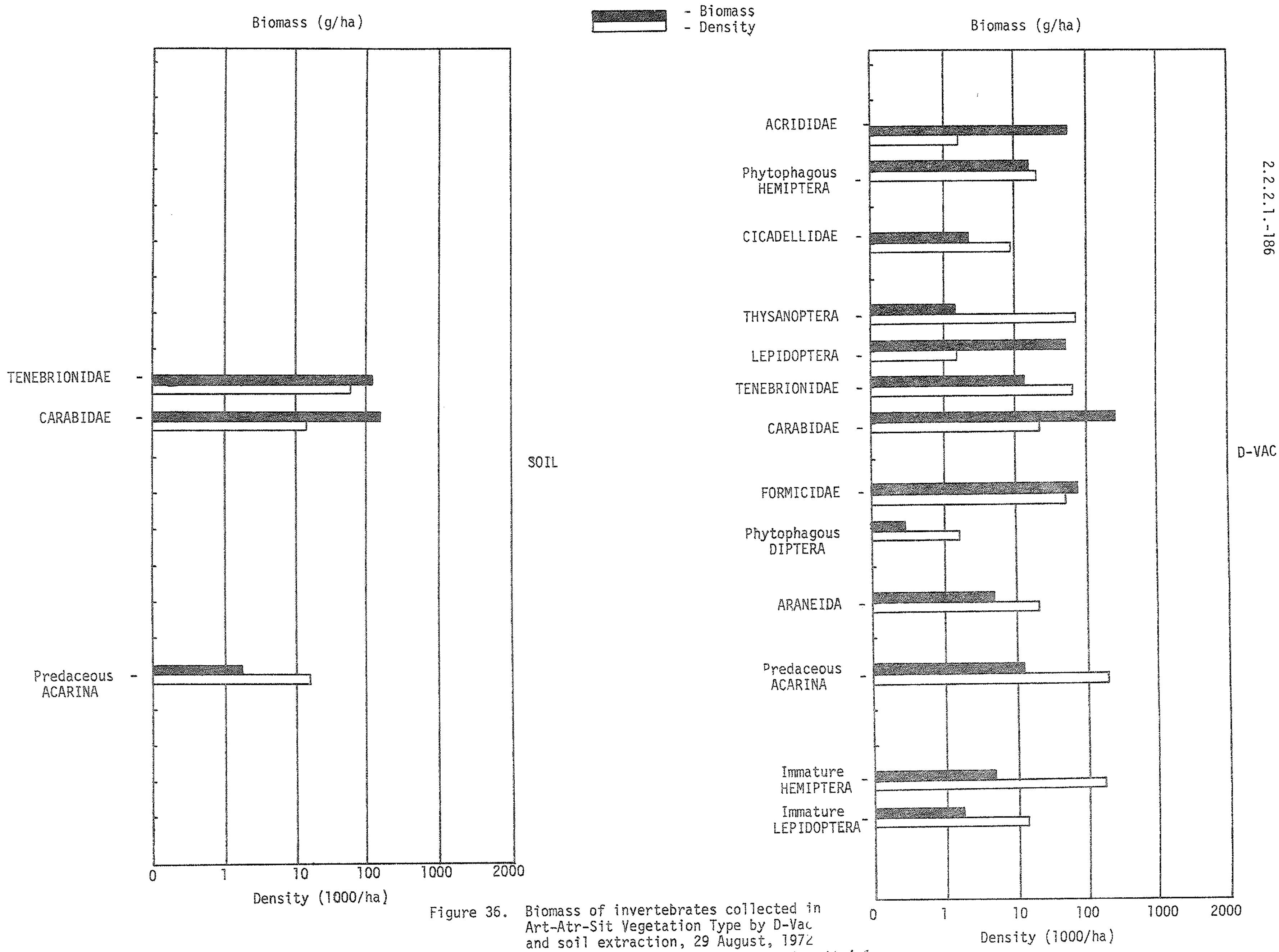


Figure 36. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Artemisia*, *Atriplex*, *Sitanion*, *Chrysothamus*, *Artemisia* dead)

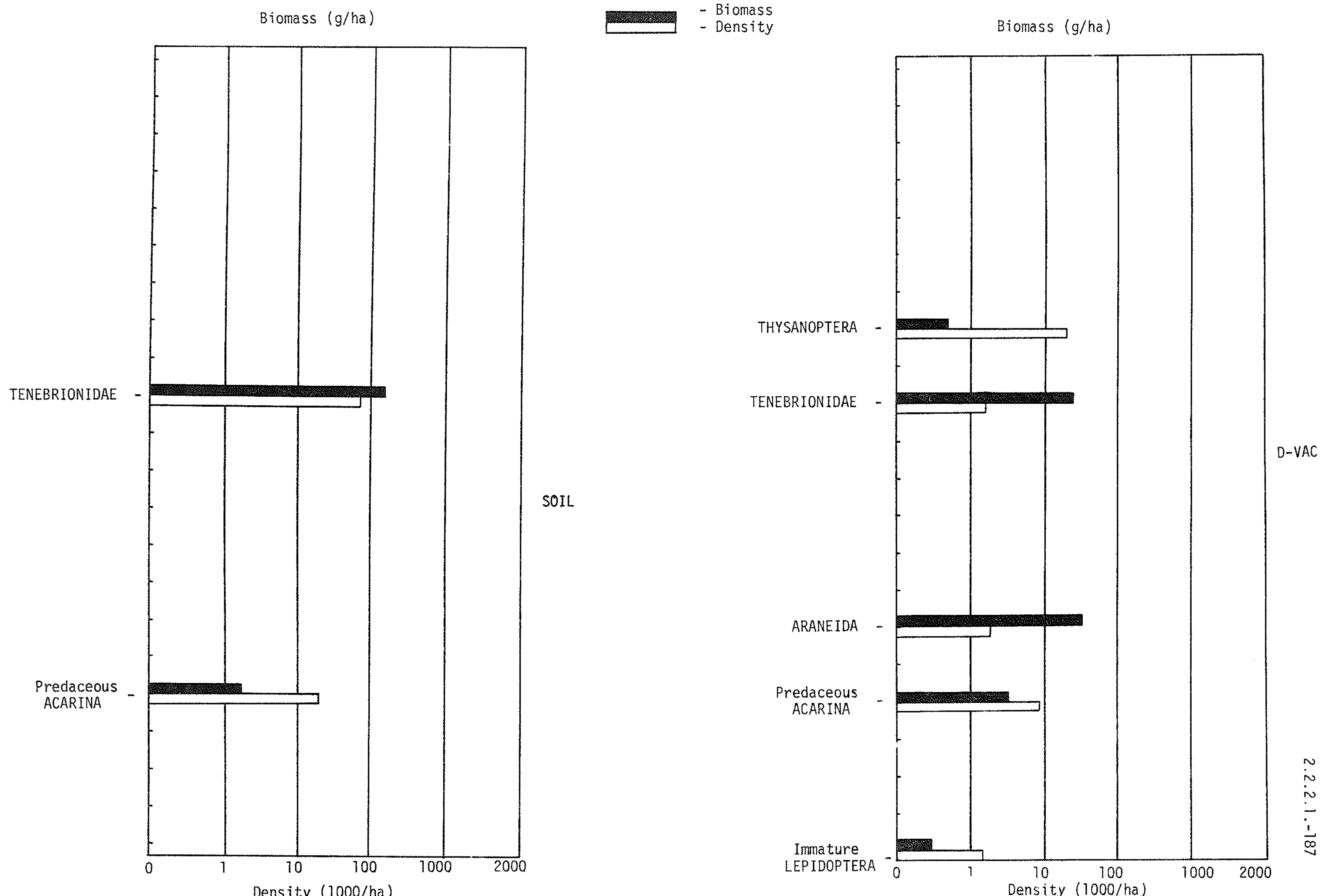


Figure 37. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Halogeton*)

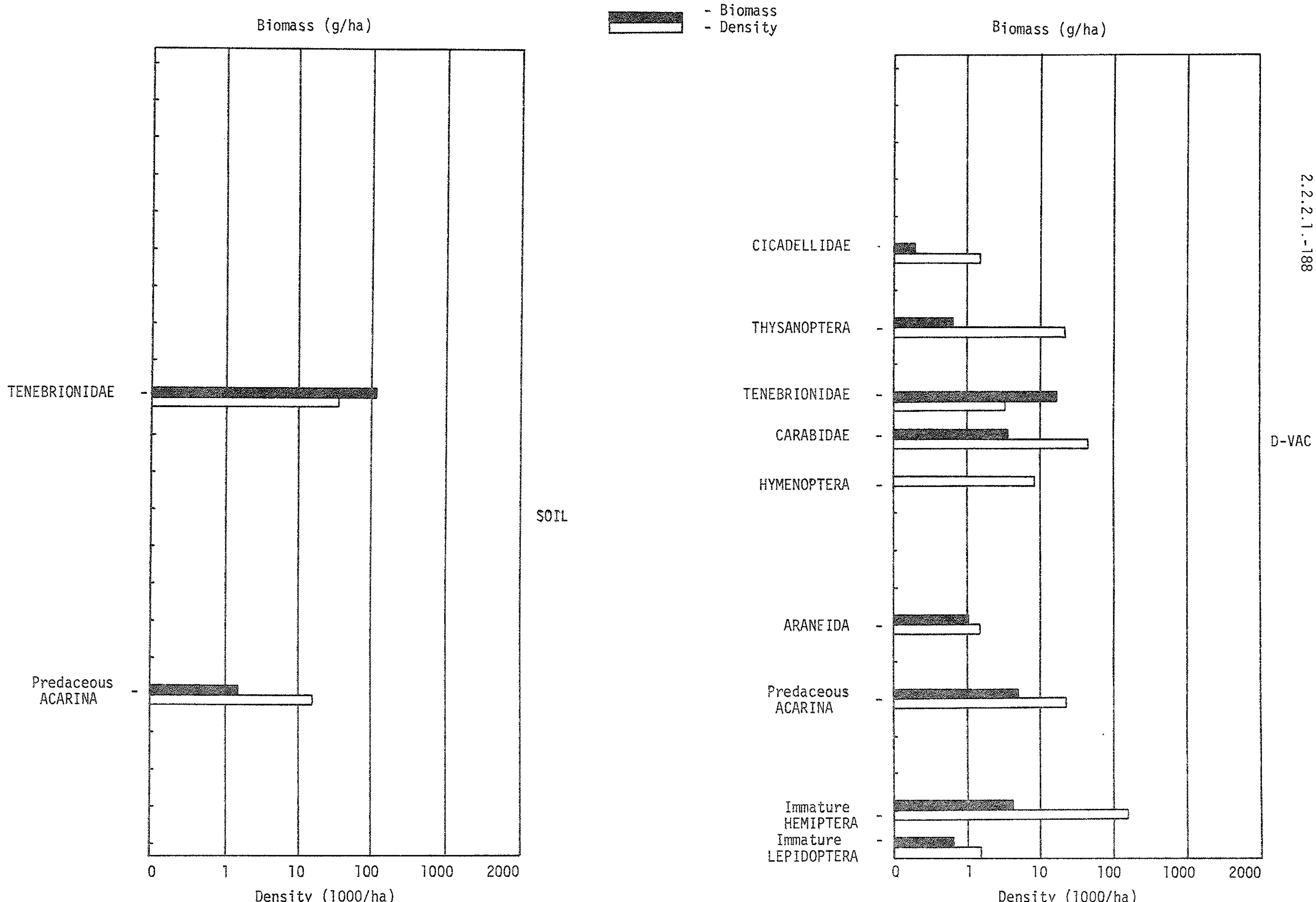


Figure 38. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Chrysothamus*)

Table 26. Estimated biomass of taxa obtained via pitfall enclosures in Art-Atr-Sit vegetation type, Curlew Valley, during July and August 1972

	Biomass (g/ha)							
Taxon	July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 14-18	Aug 21-25	Aug-Sep 28 1
Machilis		3.1	4.6	1.1	1.5	3.8	1.4	1.1
Stenopelmatus								
Ceuthophilus		137.1						
Immature *Stenopelmatus*		85.9	139.0	62.4	.9	76.9	1.3	109.1
Immature *Ceuthophilus*		10.2	1.8	11.9	12.9		.9	24.2
MANTIDAE			11.7		10.7			8.4
Nysius sp.	4.4	4.0	.4	1.2	1.0	.9	.8	.2
Immature *Nysius* sp.	168.0	422.0		.3	2.0			
Lygaeus			.8	.4				
Geocoris sp.	.3	.3	.7	.1				
Immature *Geocoris* sp.								
CICADELLIDAE	3.6	1.6	.9	.8	.1			
Immature CICADELLIDAE	.5		.1				.1	
CARABIDAE	35.9	14.9	1.6	3.0	4.6	87.3	7.2	4.7
Immature CARABIDAE	.2		.1	.4		.7	1.4	1.8
TENEBRIONIDAE	7.3	8.7	62.8	297.3	3.3	31.7	39.5	28.6
Immature TENEBRIONIDAE	.9	.9	.1	.2		1.3	.5	.3
CURCULIONIDAE	15.9	11.4	7.0	14.5	16.7	9.4	7.8	2.6
FORMICIDAE	22.0	17.7	42.1	32.6	24.8	50.1	40.7	63.9
MUTILLIDAE	1.2	.1	1.1	.9		.9	.2	
ARANEIDA	47.0	3.9	4.1	13.0	6.2	27.7	7.9	17.5
Vejovis boreus		26.5					76.2	
Immature *V. boreus*	6.3						3.3	7.0
Eremobates spp.		14.0		1.5		25.2		12.6
Immature *Eremobates*	6.5	5.1	10.1	4.2	11.9	.4	.2	.9
PSEUDOSCORPIONIDA	.5	.1	.1	.2		1.1	.5	1.1
Phytophagous ACARINA	1.7	1.7	.3	.1	.2	.2	.1	.1
Predaceous ACARINA	5.5	2.1	.6	.4	.1	.1	.4	.1
IXODIDAE								
Orius sp.								
PENTATOMIDAE	4.2	2.8	.1	3.2	2.8			
Immature PENTATOMIDAE								
REDUVIIDAE		.6		1.0		.9		
Immature REDUVIIDAE			.4				.6	
CYDNIDAE								
Immature CYDNIDAE								
HISTERIDAE								.7
ISOPODA								
CHILOPODA								
CHRYSOMELIDAE	1.2	2.5	.4	.4				
Misc. COLEOPTERA								
ACRIDIDAE								
SCUTELLERIDAE								
Totals	333.1	777.2	291.0	451.1	155.5	318.6	191.0	284.9
Less Immature *Nysius*	165.0	355.2						

Table 27. Estimated density of taxa obtained via pitfall enclosures in Art-Atr-Sit vegetation type, Curlew Valley, during July and August 1972

Taxon	Density (1,000/ha) July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 14-18	Aug 21-25	Aug-Sep 28 1
Machilis		2.6	3.8	.9	1.3	3.2	1.1	.9
Stenopelmatus								
Ceuthophilus		.2						
Immature *Stenopelmatus*		.7	.9	.5	.2	.3	.3	.5
Immature *Ceuthophilus*		3.5	.9	.9	.7		.4	2.3
MANTIDAE			.7		.4			.3
Nysius sp.	6.5	4.2	.5	.7	1.8	1.7	1.1	.3
Immature *Nysius* sp.	811	1278		.2	2.6			
Lygaeus			.2	.2				
Geocoris sp.	.5	.5	1.1	.2				
Immature *Geocoris* sp.								
CICADELLIDAE	4.4	1.3	3.1	.5	.2			
Immature CICADELLIDAE	1.6		.2				.3	
CARABIDAE	2.7	.9	.2	.2	.4	6.3	.6	.3
Immature CARABIDAE	.5			.2		1.1	.6	1.1
TENEBRIONIDAE	2.2	.9	1.5	6.2	1.1	5.4	2.3	1.1
Immature TENEBRIONIDAE	1.6	1.8	.2	.4		.9	2.6	.6
CURCULIONIDAE	1.1	1.1	.2	2.9	1.5	1.1	4.3	1.7
FORMICIDAE	27.8	53	38.5	46.3	1.9	68.8	31.6	6.3
MUTILLIDAE	1.6	.1	.7	.7		.9	.3	
ARANEIDA	14.2	6.9	6.6	6.0	4.7	9.8	3.6	8.6
Vejovis boreus		.2					.6	
Immature *V. boreus*	.5						.3	.9
Eremobates spp.		.5		.2		.6		.3
Immature *Eremobates*	1.6	.2	1.1	.5		1.4	.6	2.9
PSEUDOSCORPIONIDA	1.1	.7	.4	1.0		4.6	1.7	4.3
Phytophagous ACARINA	31.0	50.8	7.3	3.1	4.6	6.0	2.6	.3
Predaceous ACARINA	.2	24.3	6.7	4.2	1.1	1.1	2.3	1.4
IXODIDAE						.3		
Orius sp.								
PENTATOMIDAE	.5	.3	.2	3.7	.4			
Immature PENTATOMIDAE								
REDUVIIDAE		.2		3.7		.3		
Immature REDUVIIDAE			.2				.3	
CYDNIDAE								
Immature CYDNIDAE								
HISTERIDAE								
ISOPODA								.3
CHILOPODA								
CHRYSOMELIDAE	.5	~1.8	.2	.2				
Misc. COLEOPTERA								
ACRIDIDAE								
SCUTELLERIDAE								
Totals	990.1	1434.7	75.4	83.4	24.9	113.7	57.5	34.4
Less *Nysius*	99.1	156.7						

Table 28. Estimated biomass of taxa obtained via pitfall enclosures in Annuals vegetation type, Curlew Valley, during July and August 1972

	Biomass (g/ha)							
Taxon	July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 14-18	Aug 21-25	Aug-Sep 28 1
Machilis	1.0				.4	.3		.3
Stenopelmatus								
Ceuthophilus				.8		24.3		36.5
Immature *Stenopelmatus*	109.6			106.0		102.1		32.2
Immature *Ceuthophilus*	11.3		4.5	.4		13.9	1.8	1.6
MANTIDAE	5.9				5.4			
Nysius sp.	43.8		39.9	11.3	5.0	1.0	1.8	1.5
Immature *Nysius* sp.	7134		.2	24.0	2.3			
Lygaeus	15.8		.1					
Geocoris sp.	39.9		3.6	1.4	.2		.9	.2
Immature *Geocoris* sp.								
CICADELLIDAE	7.6		.2	.1				
Immature CICADELLIDAE	.3		.1	12.0				
CARABIDAE	672.8		371.5	190.1	76.0	756.9	37.7	236.1
Immature CARABIDAE	.4		.3	.4	.4			1.7
TENEBRIONIDAE	14.6		163.5	917.5	349.3	448.1	101.1	664.5
Immature TENEBRIONIDAE	38.5		1.6	.1	.4	.2	.3	.5
CURCULIONIDAE	3.6		15.4					7.9
FORMICIDAE	3.4		1.0	8.0	2.3	2.3	6.2	.2
MUTILLIDAE	9.1		1.0	.1	.3	.2		
ARANEIDA	64.9		12.4	24.2	27.1	47.8	15.7	59.4
Vejovis boreus	35.9		24.2		24.2			
Immature *V. boreus*					.7			
Eremobates spp.	22.1		29.6	8.0	8.0	125.6	46.6	
Immature *Eremobates*	4.0			4.0	6.7	5.5	17.5	3.0
PSEUDOSCORPIONIDA	.3		.1			.1	.3	.2
Phytophagous ACARINA	4.5		.7	1.4	2.1	.3		
Predaceous ACARINA	2.0		.3	.1	.1	.2		.1
IXODIDAE								
Orius sp.								
PENTATOMIDAE								
Immature PENTATOMIDAE								
REDUVIIDAE			.4	2.9	5.3	5.6	11.7	
Immature REDUVIIDAE	.8			4.6	.7	3.5	5.2	
CYDNIDAE	2.0		.9	.4		1.4	2.7	3.4
Immature CYDNIDAE			.2		.2			
HISTERIDAE							.7	
ISOPODA								
CHILOPODA								
CHRYSOMELIDAE	1.5			2.2	.4			
Misc. COLEOPTERA	.3							
ACRIDIDAE								
SCUTELLERIDAE								
Total	8249.9		671.7	132.0	517.5	1539.3	250.2	1049.3
Less Immature *Nysius*	1115.9							

Table 29. Estimated density of taxa obtained via pitfall enclosures in Annuals vegetation type, Curlew Valley, during July and August 1972

Taxon	Density (1,000/ha)							
	July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 14-18	Aug 21-25	Aug-Sep 28 1
Machilis	.8				.4	.3		.3
Stenopelmatus								
Ceuthophilus				.2		.6		.9
Immature *Stenopelmatus*	.5			.4		1.7		.3
Immature *Ceuthophilus*	.2		1.5	.2		.6	.6	.9
MANTIDAE	.5				.2			
Nysius sp.	6.3		58.7	9.8	8.6	1.4	2.3	.3
Immature *Nysius* sp.	23439		.5	42.1	2.9			
Lygaeus	3.2		.2					
Geocoris sp.	168		6.4	.7	.4		1.4	.3
Immature *Geocoris* sp.								
CICADELLIDAE	3.0		.2	.2				
Immature CICADELLIDAE	.5		.2	.7				
CARABIDAE	51.4		27.5	12.2	5.3	59.4	2.9	16.7
Immature CARABIDAE	10.1		.9	.2	.2		.3	1.7
TENEBRIONIDAE	6.8		53.2	20.4	96.5	72.3	26.1	15.8
Immature TENEBRIONIDAE	68.9		2.9	.2	.7	.3	1.4	.9
CURCULIONIDAE	.3				.7			.3
FORMICIDAE	5.2		1.5	2.6	.9	6.0	4.1	.6
MUTILLIDAE	3.3		.5	.2	.2	.3		
ARANEIDA	31.0		16.2	7.8	8.0	13.8	10.6	9.2
Vejovis boreus	.3		.2		.2			
Immature *V. boreus*					.7			
Eremobates spp.	.3		.4	.2		.3	.6	
Immature *Eremobates*	.8			.2	.4	.9	3.4	1.4
PSEUDOSCORPIONIDA	1.1		.4	.2	.2	.3	1.1	.9
Phytophagous ACARINA	98.8		16.7	38.7	62.2	10.0	.9	.3
Predaceous ACARINA	23.6		11.5	2.9	2.9	3.2	.3	2.9
IXODIDAE								
Orius sp.				.2	.2			
PENTATOMIDAE								
Immature PENTATOMIDAE								
REDUVIIDAE			.2		1.6	1.7		
Immature REDUVIIDAE	.6			2.4	.4	2.0	.3	
CYDNIDAE	.8		.4	.2		.5	1.1	1.4
Immature CYDNIDAE			.2		.2			
HISTERIDAE							.3	
ISOPODA								
CHILOPODA								
CHRYSOMELIDAE	3.5			1.6	.2	.2		
Misc. COLEOPTERA	.3							
SCUTELLERIDAE								
Total	23,929.1		200.4	144.1	194.2	166.6	57.7	55.1
Less Immature *Nysius*	490.1							

Table 30. Estimated biomass of taxa obtained via pitfall enclosures in Agr vegetation type, Curlew Valley, during July and August 1972

	Biomass (g/ha)							
Taxon	July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 12-18	Aug 21-25	Aug-Sep 28 1
Machilis	7.1	5.0	1.5	1.3	4.0	7.6	6.2	3.9
Stenopelmatus								215.7
Ceuthophilus				15.4	14.9		20.0	
Immature *Stenopelmatus*	239.0		110.6	53.0	15.7	4.3	102.9	
Immature *Ceuthophilus*	1.3			7.4	4.4	1.7	1.7	3.7
MANTIDAE		4.2		21.4	5.2			
Nysius sp.		.7	1.1	.6	5.0	.2		
Immature *Nysius* sp.	.6	.4			.3			
Lygaeus								
Geocoris sp.						.3		
Immature *Geocoris* sp.	.2							
CICADELLIDAE	4.6	1.6	8.2	.8	.8			
Immature CICADELLIDAE	3.9		1.4					
CARABIDAE	36.4	17.9	37.6	98.6	30.5	81.1	31.4	14.1
Immature CARABIDAE			.1				1.4	
TENEBRIONIDAE	29.3	9.6	19.4	26.3	99.1	27.2	35.0	1.8
Immature TENEBRIONIDAE		.8	.3		.1	.2	1.0	
CURCULIONIDAE	32.9		.7	24.9				.5
FORMICIDAE	11.2	3.4	10.9	8.5	.6	20.0	1.4	3.2
MUTILLIDAE		.7	1.4		.4	.4		.2
ARANEIDA	23.9	4.5	10.6	20.0	9.1	36.6	43.7	4.1
Vejovis boreus				24.2	24.2			
Immature *V. boreus*			7.5				18.5	
Eremobates spp.		14.8		16.0	8.0			
Immature *Eremobates*	29.4	1.4	8.4	5.1	6.0	.1	1.7	.4
PSEUDOSCORPIONIDA		.1		.1	.1	.1	.3	
Phytophagous ACARINA	.6	.5	.1	.2	.3			
Predaceous ACARINA		.3	.1	.1	.2	.1	.1	.2
IXODIDAE								
Orius sp.								
PENTATOMIDAE					1.4			
Immature PENTATOMIDAE				1.4				
REDUVIIDAE					35.3	.9	1.9	.8
Immature REDUVIIDAE					1.5			
CYDNIDAE					1.3		.7	
Immature CYDNIDAE								
HISTERIDAE							.7	
ISOPODA				.4				
CHILOPODA								.1
CHRYSOMELIDAE		.4						
Misc. COLEOPTERA						.7		
ACRIDIDAE							62.5	
SCUTELLERIDAE								
Total	410.4	65.3	219.9	325.7	268.4	181.5	331.1	248.7

Table 31. Estimated density of taxa obtained via pitfall enclosures in Agr vegetation type, Curlew Valley, July and August 1972

	Density (1,000/ha)							
Taxon	July 3-14	July 17-19	July 24-28	July-Aug 31 4	Aug 7-11	Aug 14-18	Aug 21-25	Aug-Sep 28 1
Machilis	6.5	2.6	1.3	1.5	3.3	6.3	5.2	3.2
Stenopelmatus								.3
Ceuthophilus				.4	.4		.6	
Immature *Stenopelmatus*	1.6		2.7	.2	.2	.9	.9	
Immature *Ceuthophilus*	.5				.2	.3	.3	.3
MANTIDAE		.4		.5	.2			
Nysius sp.		1.3	1.6	.5	7.1	.3		
Immature *Nysius* sp.	1.6	1.3			.4			
Lygaeus								
Geocoris sp.						.6		
Immature *Geocoris* sp.	.5							
CICADELLIDAE	3.8	1.5	4.6	.5	.7			
Immature CICADELLIDAE	8.2		2.7					
CARABIDAE	3.8	.4	2.6	6.4	2.6	5.2	2.6	.9
Immature CARABIDAE			.2				.6	
TENEBRIONIDAE	4.4	3.1	2.7	3.5	24.8	3.4	6.9	.3
Immature TENEBRIONIDAE		1.5	.5		.2	.3	2.3	
CURCULIONIDAE	2.7		.4	1.1				.3
FORMICIDAE	17.4	5.1	17.1	4.0	1.3	40.1	2.6	9.2
MUTILLIDAE		.9	1.5		.4	.6		.3
ARANEIDA	11.4	5.7	4.6	2.7	5.5	7.7	5.5	3.8
Vejovis boreus				.2	.2			
Immature *V. boreus*			.2				.9	
Eremobates spp.		.2		.4	.2			
Immature *Eremobates*	1.6	1.6	.4	.2	.5	.3	1.4	1.1
PSEUDOSCORPIONIDA		1.1		.5	.5	.6	1.4	
Phytophagous ACARINA	8.2	13.7	3.6	4.7	6.4	.3	2.3	.3
Predaceous ACARINA		3.1	1.6	2.4	4.0	3.7	4.0	4.0
IXODIDAE								
Orius sp.				.2				
PENTATOMIDAE					.2			
Immature PENTATOMIDAE				.2				
REDUVIIDAE					.7	.3	.6	.3
Immature REDUVIIDAE					.7			
CYDNIDAE					.5		.3	
Immature CYDNIDAE								
HISTERIDAE							.3	
ISOPODA				.2				
CHILOPODA								.3
CHRYSOMELIDAE		.2				.3		
Misc. COLEOPTERA							.3	
ACRIDIDAE								
SCUTELLERIDAE								
Totals	82.2	43.7	48.3	30.3	61.2	71.2	39.0	24.6
Less Ants	64.8	38.6	31.2	26.3	59.9	31.1	36.4	14.4

Table 32. Estimated density comparisons (1,000/ha) of taxa collected by pitfall enclosures in three vegetation types

Taxon	July 3-14 Art	Annuals	Agr	July 17-19 Art	Annuals	Agr	July 24-28 Art	Annuals	Agr	July 31-August 4 Art	Annuals	Agr
Machilis		.8	6.5	2.6		2.6	3.8		1.3	.9		1.5
Stenopelmatus												
Ceuthophilus				.2							.2	.4
Immature *Stenopelmatus*		.5	1.6	.7			.9		2.7	.5	.4	.2
Immature *Ceuthophilus*		.2	.5	3.5			.9	1.5		.9	.2	
MANTIDAE		.5				.4	.7					.5
Nysius sp.	6.5	6.3		4.2		1.3	.5	58.7	1.6	.7	9.8	.5
Immature *Nysius*	811	23439	1.6	1278		1.3		.5		.2	42.1	
Lygaeus		3.2					.2	.2		.2		
Geocoris sp.	.5	168		.5			1.1	6.4		.2	.7	
Immature *Geocoris* sp.			.5									
CICADELLIDAE	4.4	3.0	3.8	1.3		1.5	3.1	.2	4.6	.5	.2	.5
Immature CICADELLIDAE	1.6	.5	8.2				.2	.2	2.7		.7	
CARABIDAE	2.7	51.4	3.8	.9		.4	.2	27.5	2.6	.2	12.2	6.4
Immature CARABIDAE	.5	10.1						.9	.2	.2	.2	
TENEBRIONIDAE	2.2	6.8	4.4	.9		3.1	1.5	53.2	2.7	6.2	20.4	3.5
Immature TENEBRIONIDAE	1.6	68.9		1.8		1.5	.2	2.9	.5	.4	.2	
CURCULIONIDAE	1.1	.3	2.7	1.1			.2		.4	2.9		1.1
FORMICIDAE	27.8	5.2	17.4	53		5.1	38.5	1.5	17.1	46.3	2.6	4.0
MUTILLIDAE	1.6	3.3		.1		.9	.7	5	1.5	.7	.2	
ARANEIDA	14.2	31.0	11.4	6.9		5.7	6.6	16.2	4.6	6.0	7.8	2.7
Vejovis boreus		.3		.2				.2				.2
Immature *V. boreus*	.5								.2			
Eremobates spp.		.3		.5		.2		.4		2	.2	.4
Immature *Eremobates*	1.6	.8	1.6	.2		1.6	1.1		.4	.5	.2	.2
CHELONETHIDA	1.1	1.1		.7		1.1	.4	4		1.0	.2	.5
Phytophagous ACARINA	31.0	98.8	8.2	50.8		13.7	7.3	16.7	3.6	3.1	38.7	4.7
Predaceous ACARINA	.2	23.6		24.3		3.1	6.7	11.5	1.6	4.2	2.9	2.4
IXODIDAE												
Orius sp.											.2	.2
PENTATOMIDAE	.5			.3			.2			3.7		
Immature PENTATOMIDAE												.2
REDUVIIDAE				.2				.2		3.7		
Immature REDUVIIDAE		.6					.2				2.4	
CYDNIDAE		.8						.4			.2	
Immature CYDNIDAE								.2				
HISTERIDAE												
ISOPODA												.2
CHILOPODA												
CHRYSOMELIDAE	.5	3.5		1.8		.2	.2			.2	1.6	
Misc. COLEOPTERA		.3								.2		
ACRIDIDAE												
SCUTELLERIDAE												
Totals	990	23929	82	1435		44	75	200	48	83	144	30

Table 32. Continued

Taxon	August 7-11 Art	August 7-11 Annuals	August 7-11 Agr	August 14-18 Art	August 14-18 Annuals	August 14-18 Agr	August 21-25 Art	August 21-25 Annuals	August 21-25 Agr	August 28-September 1 Art	August 28-September 1 Annuals	August 28-September 1 Agr
Machilis	1.3	.4	3.3	3.2	.3	6.3	1.1		5.2	.9	.3	3.2
Stenopelmatus												.3
Ceuthophilus			.4		.6				.6		.9	
Immature *Stenopelmatus*	.2		.2	.3	1.7	.9	.3		.9	.5	.3	
Immature *Ceuthophilus*	.7		.2		.6	.3	.4	.6	.3	2.3	.9	.3
MANTIDAE	.4	.2	.2							.3		
Nysius sp.	1.8	8.6	7.1	1.7	1.4	.3	1.1	2.3		.3	.3	
Immature *Nysius* sp.	2.6	2.9	.4									
Lygaeus												
Geocoris sp.		.4				.6		1.4			.3	
Immature *Geocoris* sp.												
CICADELLIDAE	.2		.7									
Immature CICADELLIDAE							.3					
CARABIDAE	.4	5.3	2.6	6.3	59.4	5.2	.6	2.9	2.6	.3	16.7	.9
Immature CARABIDAE		.2		1.1			.6	.3	.6	1.1	1.7	
TENEBRIONIDAE	1.1	96.5	24.8	5.4	72.3	3.4	2.3	26.1	6.9	1.1	15.8	.3
Immature TENEBRIONIDAE		.7	.2	.9	.3	.3	2.6	1.4	2.3	.6	.9	
CURCULIONIDAE	1.5	.7		1.1			4.3			1.7	.3	.3
FORMICIDAE	1.9	.9	1.3	68.8	6.0	40.1	31.6	4.1	2.6	6.3	.6	9.2
MUTILLIDAE		.2	.4	.9	.3	.6	.3					.3
ARANEIDA	4.7	8.0	5.5	9.8	13.8	7.7	3.6	10.6	5.5	8.6	9.2	3.8
Vejovis Boreus		.2	.2				.6					
Immature *V. boreus*		.7					.3		.9	.9		
Eremobates spp.			.2	.6	.3			.6		.3		
Immature *Eremobates*		.4	.5	1.4	.9	.3	.6	3.4	1.4	2.9	1.4	1.1
CHELONETHIDA		.2	.5	4.6	.3	.6	1.7	1.1	1.4	4.3	.9	
Phytophagous ACARINA	4.6	62.2	6.4	6.0	10.0	.3	2.6	.9	2.3	.3	.3	.3
Predaceous ACARINA	1.1	2.9	4.0	1.1	3.2	3.7	2.3	.3	4.0	1.4	2.9	4.0
IXODIDAE				.3								
Orius sp.		.2										
PENTATOMIDAE												
Immature PENTATOMIDAE	.4		.2									
REDUVIIDAE		1.6	.7	.3	1.7	.3			.6			.3
Immature REDUVIIDAE		.4	.7		2.0		.3	.3				
CYDNIDAE			.5		.5			1.1	.3		1.4	
Immature CYDNIDAE		.2										
HISTERIDAE								.3	.3	.3		
ISOPODA												
CHILOPODA												.3
CHRYSOMELIDAE		.2			.2	.3						
Misc. COLEOPTERA												
ACRIDIDAE									.3			
SCUTELLERIDAE												
Totals	25	194	61	114	167	71	58	58	39	34	55	25

Table 33. Estimated biomass comparisons (g/ha) of taxa collected by pitfall enclosures in three vegetation types

Taxon	July 3-14			July 17-19			July 24-28			July 31-August 4		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
Machilis		1.0	7.1	3.1		5.0	4.6		1.5	1.1		1.3
Stenopelmatus												
Ceuthophilus				137.1							.8	15.4
Immature *Stenopelmatus*		109.6	239.0	85.9			139.0		110.6	62.4	106.0	53.0
Immature *Ceuthophilus*		11.3	1.3	10.2			1.8	4.5		11.9	.4	7.4
MANTIDAE		5.9				4.2	11.7					21.4
Nysius sp.	4.4	4.3		4.0		.7	.4	39.9	1.1	1.2	11.3	.6
Immature *Nysius* sp.	168.0	7134	.6	422.0		.4		.2		.3	24.0	
Lygaeus		15.8					.8	.1		.4		
Geocoris sp.	.3	39.9		.3			.7	3.6		.1	1.4	
Immature *Geocoris* sp.			.2									
CICADELLIDAE	3.6	7.6	4.6	1.6		1.6	.9	.2	8.2	.8	.1	.8
Immature CICADELLIDAE	.5	.3	3.9				.1	.1	1.4		12.0	
CARABIDAE	35.9	672.8	36.4	14.9		17.9	1.6	371.5	37.6	3.0	190.1	98.6
Immature CARABIDAE	.2	.4					.1	.3	.1	.4	.4	
TENEBRIONIDAE	7.3	14.6	29.3	8.7		9.6	62.8	163.5	19.4	297.3	917.5	26.3
Immature TENEBRIONIDAE	.9	38.5		.9		.8	.1	1.6	.3	.2	.1	
CURCULIONIDAE	15.9	3.6	32.9	11.4			7.0	15.4	.7	14.5		24.9
FORMICIDAE	22.0	3.4	11.2	17.7		3.4	42.1	1.0	10.9	32.6	8.0	8.5
MUTILLIDAE	1.2	9.1		.1		.7	1.1	1.0	1.4	.9	.1	
ARANEIDA	47.0	64.9	23.9	3.9		4.5	4.1	12.4	10.6	13.0	24.2	20.0
Vejovis boreus		35.9		26.5				24.2				24.2
Immature *V. boreus*	6.3								7.5			
Eremobates spp.		22.1		14.0		14.8		29.6		1.5	8.0	16.0
Immature *Eremobates*	6.5	4.0	29.4	5.1		1.4	10.1		8.4	4.2	4.0	5.1
CHELONETHIDA	.5	.3		.1		.1	.1	.1		.2		.1
Phytophagous ACARINA	1.7	4.5	.6	1.7		.5	.3	.7	.1	.1	1.4	.2
Predaceous ACARINA	5.5	2.0		2.1		.3	.6	.3	.1	.4	.1	.1
IXODIDAE-*Permacentor*												
Orius sp.												
PENTATOMIDAE												
Immature PENTATOMIDAE	4.2			2.8			.1			3.2		
REDUVIIDAE												1.4
Immature REDUVIIDAE				.6				.4		1.0	2.9	
CYDNIDAE		.8					.4				4.6	
Immature CYDNIDAE		2.0						.9			.4	
HISTERIDAE								.2				
ISOPODA												
CHILOPODA												.4
CHRYSOMELIDAE												
Misc. COLEOPTERA	1.2	1.5		2.5		.4	.6			.4	2.2	
ACRIDIDAE		.3										
SCUTELLERIDAE												
Totals	333.1	8249.9	410.4	777.2		65.3	291.0	671.7	219.9	451.1	132.0	325.7

Table 33. Continued

Taxon	August 7-11			August 14-18			August 21-25			August 28-September 1		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr
Machilis	1.5	.4	4.0	3.8	.3	7.6	1.4		6.2	1.1	.3	3.9
Stenopelmatus												215.7
Ceuthophilus			14.9		24.3				20.0		36.5	
Immature *Stenopelmatus*	.9		15.7	76.9	102.1	4.3	1.3		102.9	109.1	32.2	
Immature *Ceuthophilus*	12.9		4.4		13.9	1.7	.9	1.8	1.7	24.2	1.6	3.7
MANTIDAE	10.7	5.4	5.2							8.4		
Nysius sp.	1.0	5.0	5.0	.9	1.0	.2	.8	1.8		.2	1.5	
Immature *Nysius* sp.	2.0	2.3	.3									
Lygaeus												
Geocoris sp.		.2				.3		.9			.2	
Immature *Geocoris* sp.												
CICADELLIDAE	.1		.8									
Immature CICADELLIDAE							.1					
CARABIDAE	4.6	76.0	30.5	87.3	756.9	81.1	7.2	37.7	31.4	4.7	236.1	14.1
Immature CARABIDAE		.4		.7			1.4		1.4	1.8	1.7	
TENEBRIONIDAE	3.3	349.3	99.1	31.7	443.1	27.2	39.5	101.1	35.0	28.6	664.5	1.8
Immature TENEBRIONIDAE		.4	.1	1.3	.2	.2	.5	.3	1.0	.3	.5	
CURCULIONIDAE	16.7			9.4			7.8			2.6	7.9	.5
FORMICIDAE	24.8	2.3	.6	50.1	2.3	20.0	40.7	6.2	1.4	63.9	.2	3.2
MUTILLIDAE		.3	.4	.9	.2	.4	.2					.2
ARANEIDA	6.2	27.1	9.1	27.7	47.8	36.6	7.9	15.7	43.7	17.5	59.4	4.1
Vejovis boreus		24.2	24.2				76.2					
Immature *V. boreus*		.7					3.3		18.5	7.0		
Eremobates spp.		8.0	8.0	25.2	125.6			46.6		12.0		
Immature *Eremobates*	11.9	6.7	6.0	.4	5.5	.1	.2	17.5	1.7	.9	3.0	.4
CHELONETHIDA			.1	1.1	.1	.1	.5	.3	.3	1.1	.2	
Phytophagous ACARINA	.2	2.1	.3	.2	.3		.1			.1		
Predaceous ACARINA	.1	.1	.2	.1	.2	.1	.4		.1	.1	.1	.2
IXODIDAE-*Permacentor*												
Orius sp.												
PENTATOMIDAE												
Immature PENTATOMIDAE	2.8		1.4									
REDUVIIDAE												
Immature REDUVIIDAE		5.3	35.3	.9	5.6	.9		11.7	1.9			.8
CYDNIDAE		.7	1.5		3.5		.6	5.2				
Immature CYDNIDAE			1.3		1.4			2.7	.7		3.4	
HISTERIDAE		.2										
ISOPODA								.7	.7	.7		
CHILOPODA												
CHRYSOMELIDAE												.1'
Misc. COLEOPTERA		.4										
ACRIDIDAE						.7						
SCUTELLERIDAE									62.5			
Total	155.5	517.5	268.4	318.6	1539.3	181.5	191.0	250.2	331.1	284.9	1049.3	284.7

Table 34. Annotated list of invertebrate taxa from Curlew Valley validation sites

Order	Relative Abundance	Habitat	Comments
COLLEMBOLA			
Family PODURIDAE	Abundant		
THYSANURA			
Family MACHILIDAE	Common	Under rocks, Art tri, and other wood stumps, various dead grass clumps	Organic detritus feeders
THYSANOPTERA			
Family PHLOETHRIPIDAE			
Family THRIPIDAE			
Frankliniella occidentalis	Abundant	On Chr vis, Art tri.	Plant feeders
Thrips tabaci	Common	On Chr vis, Art tri, All acc.	Plant feeders
ORTHOPTERA			
Family TETTIGONIIDAE	Scarce		Plant feeders
Family GRYLLACRIDAE			
Sub Family STENOPELMATINAE	Scarce	Under rocks, ground dwelling	
Family ACRIDAE			
Melanoplus sanquinepes	Common	On Chr vis, nau, Art tri, lud.	Plant feeders
Trimerotropis spp.	Common	On Chr vis, nau, Art tri, lud.	Plant feeders
Family GRYLLIDAE			
Gr[illegible]us spp.	Common	On low plants or ground	Omnivorous organ material, plants
Oecan[illegible]hus spp.	Common	On low plants or ground	Omnivorous organ material, plants
Family BLATTIDAE	Common	On litter, debris, grass-sage clumps	Detritus feeders
Family MANTIDAE	Scarce	On the ground, various plants	Predaceous on insects
ISOPTERA			
Family RHINOTERMITIDAE			
Reticulitermes subterranean	Common	On or in Art tri, other wood and stumps	Wood feeder
HEMIPTERA			
Family ANTHOCORIDAE			
Anthocoris melanocerus	Common-Scarce	On Art tri, Chr nau, vis and Sar ver and other plants that have aphids, thrips	Predaceous on aphids, thrips
Anthocoris musculus	Scarce	On Art tri, Chr vis, Sar ver, and Salix various other plants	Predaceous on aphids
[illegible]us tristicolor	Numerous	On Chr vis, Hel ann, Art tri and other plants	Predaceous on thrips, and to some extent aphids

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Family MIRIDAE			
Chlamydatus obliquus	?	?	Plant feeder
Chlamydatus pullus	?	?	Plant feeder
Chlamydatus spp.	Common		
Deraeocoris brevis	Common	On Chr vis, nau and various other plants that have aphids	Predaceous on aphids and thrips
Irbisia brachycerus (Uhler)	Scarce	On Agr cri, Ely cin	Plant feeder
Irbisia brachycerus solani (Heid)	Scarce	On Agr cri, other grasses	Plant feeder
Labops ferrugata	Common		
Labops hesperius	Scarce	On Agr cri	Plant feeder
Leptopterna spp.	Common-Scarce	On Agr cri	Plant feeder
Lygus spp.	Abundant	On Chr vis, nau	Plant feeder on juice mainly
Irbisia pacificus	Common	On Agr cri	Plant feeder
Melanotrichus flavosparsus	Scarce	On Sal kal	Plant feeder
Mimeocapsus minimus	Numerous	On Bas hyp, Atr con	Plant feeder
Orectoderus obliquus	Scarce	?	Plant feeder
Orthotylus flavosparsus	Scarce	On Sal kal	Plant feeder
Phyllopidea picta (Uhler)	Scarce	?	Plant feeder
Phytocoris laevis	Common	?	Plant feeder
Propomiris curtulus	Scarce	?	Plant feeder
Trigonotylus repanda	Scarce	?	Plant feeder
Family REDUVIIDAE			
Sinea confusa	Scarce	On Hel ann, Chr vis, and other plants that attract insects	Predaceous on various insects
Sinea diadena	Scarce	On various plants, also on the ground	Predaceous on various insects
Zetus socius	Scarce	On various plants, also on the ground	Predaceous on various insects
Family COREIDAE			
Leptoglossus clypealis	Scarce	?	Plant feeder
Leptoglossus occidentalis	Scarce	?	Plant feeder
Family CORIZIDAE			
Arhyssus crassus	Scarce	?	Plant feeder
Arhyssus lateralis	Common	?	Plant feeder
Arhyssus tuberculatus (Hambl.)	Scarce	?	Plant feeder
Aufeius impressicellis	Scarce	?	Plant feeder
Liorhyssus hyalinus (Fabr.)	Common	On various grasses and woody plants	Plant feeder

Table 34. Continued

Order	Realtive Abundance	Habitat	Comments
Family CORIMELAENIDAE			
Allocoris entensa	Common	On various grasses, and other plants	Plant feeder
Family SCUTELLERIDAE			
Eurygaster alternatus	Common-Scarce	?	Plant feeder
Homaemus bijugis	Common-Scarce	?	Plant feeder
Family PHYMATIDAE			
Phymata borica	Scarce	On Chr vis, nau, other yellow flowered plants.	Predaceous on other insects
Phymata pennsylvanica	Common	On Chr vis, nau, other yellow flowered plants.	Predaceous on medium-large bees flies, wasps.
Family NABIDAE			
Nabis alternatus	Numerous	On Art tri, Chr vis, nau, Agr cri, smi, and other plants.	Predaceous on other insects.
Family LYGAEIDAE			
Geocoris pallens Stal.	Numerous	On various plants depending on prey species, Art tri, lud, Chr vis, nau, Agr cri, smi, etc.	Predaceous on Cicadellidae, Aphididae, others
Geocoris bullatus (Say)	Scarce-Rare	On various plants depending on prey species.	Predaceous on Cicadellidae, Aphididae, others
Geocoris atricolor Montd.	Scarce	On various plants depending on prey species.	Predaceous on Cicadellidae, Aphididae, others
Lygaeus kalmii	Scarce	On Asc cap	Plant feeder
Nysius ericae Shill.	Abundant	On Atr con, Hal glo, Sal kal	Plant feeder
Nysius spp.	Common	On Atr con, Sal kal, other plants	Plant feeders
Peritrechus saskatchewanensis	Common	On Atr con, Sal kal, other plants, on the ground	Plant feeder
Peritrechus spp.	Common	On Atr con, Sal kal, other plants, and the ground	Plant feeders
Family PENTATOMIDAE			
Chlorochroa sayi	Common	On Art tri, Atr con, Agr cri, smi, other plants	Plant feeder
Carpocoris remotus	Common	?	Plant feeder

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
IOMOPTERA			
Family APHIDIDAE			
Pleotrichophorus acanthovillis	Scarce	On Chr vis, other plants	Plant feeder
Microsiphoniella acophorum (Knowlton-Smith)	Rare	On art tri	Plant feeder
Cavariella aegopodii (Scopoli)	Scarce	On Lom tri, other Umbelliferaes	Plant feeder
Microsiphoniella artemisiae (Gillette)	Numerous	On Art tri	Plant feeder
Obtusicauda artemisiphilum (Knowlton-Allen)	Scarce	On Art tri	Plant feeder
Obtusicauda artemisicola (Williams)	Scarce	On Art tri	Plant feeder
Hayhurst·a atriplicis (Linnaeus)	Scarce	On Che alb	Plant feeder
Sitobion avenau (Fabricus)	Common	On Agr cri, das, smi.	Plant feeder
Brachyungis bonnevillensis (Knowlton)	Common		
Brevicoryne brassicae (L.)	Common-Numerous	On Bas hyp	Plant feeder
Styletaphis canae (Williams)	?	On Art tri	Plant feeder
Brachycaudus cardiui (Linneaus)	Common	On Sal kal	Plant feeder
Styletaphis chrysothamni (Wilson)	Common	On Chr nau	Plant feeder
Obtusicauda coweni (Hunter)	Common	On Art Tri	Plant feeder
Capitophorus Gillette elegani	Scarce	(Caught in flight)	Plant feeder
Pleotrichophorus elongatus (Knowlton)	Scarce	On Chr nau	Plant feeder
Dactynotus escalanti (Knowlton)	Common	On Chr nau south site, Chr vis north site	Plant feeder
Obtusicauda essigi	Rare	On Art tri	Plant feeder
Pseudoepameibaphis essigi	Scarce	On Art tri	Plant feeder
Styletaphis filifoliae (Gillette-Palmer)	Common-Scarce	On Art tri	Plant feeder
Epameibaphis frigidae (Oestlund)	Common-Abundant	On Art tri	Plant feeder
Obtusicauda frigidae (Oestlund)	Rare	On Art tri	Plant feeder
Pseudoepameibaphis glauca (Gillette-Palmer)	Common-Abundant	On Art tri	Plant feeder
Aphis gregalis	Common-Scarce	On Chr vis	Plant feeder
Pleotrichophorus gregarius (Knowlton)	Scarce	On Chr nau	Plant feeder
Aphis helianthi	Common	On Hel ann	Plant feeder
Brachyungis hermistonii (Wilson)	Scarce-Rare	On Art tri	Plant feeder
Pleotrichophorus infrequens (Knowlton-Smith)	Rare	On Art tri	Plant feeder
Flabellomicrosiphum knowltoni	Rare	On Art tri	Plant feeder
Hyperomyzus lactucae (Linneaus)	Scarce	On Lac sca	Plant feeder
Macrosiphoniella ludovicianae (Oestlund)	Scarce	On Art lud	Plant feeder
Aphis maidi-radicis	Scarce	On Hel ann roots	Plant feeder
Aphis lupini	Rare	On Lup ser	Plant feeder
Rhopalosiphum maidis (Fitch)	Common	On Agr cri, smi, spi.	Plant feeder

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Styletaphis minutissima	Common	On Art tri	Plant feeder
Aphis nigragregalis	Rare	On Chr vis, nau	Plant feeder
Obtusicauda spp.	Common	On Art tri	Plant feeders
Aphis oenotherae	Common	On Oen.	Plant feeder
Pleotrichophorus oestlundi (Knowlton)	Common	On Chr nau	Plant feeder
Forda olivacea	Scarce	On Agr cri, smi, spi	Plant feeder
Styletaphis oregonensis (Wilson)	Scarce	On Art tri	Plant feeder
Microsiphoniella oregonensis (Wilson)	Scarce	On Art tri	Plant feeder
Pleotrichophorus packi (Knowlton)	Scarce	On Chr nau	Plant feeder
Myzus persicae (Sulzer)	Scarce-Common	On Sph mun	Plant feeder
Dactynotus pseudobrassicae (Davis)	Scarce-Rare	On Bas hyp, Des pin, Sis alt, lin	Plant feeder
Pleotrichophorus pseudoglandulosus (Palmer)	Scarce	On Art Tri	Plant feeder
Pleotrichophorus pycnorhysus (Knowl-Smith)	Scarce	On Chr vis	Plant feeder
Pleotrichophorus sporadicum (Knowlton)	Rare	On Chr nau	Plant feeder
Brevicoryne symphoricarpi (Thomas)	Scarce	On Ame aln	Plant feeder
Dactynotus taraxaci (Kaltenbach)	Scarce-Rare	On Tar off	Plant feeder
Aphis tetradymia (Knowlton)	Scarce	On Tet can, spi	Plant feeder
Pleotrichophorus tetradymiae (Smith-Kno)	Rare	On Tet can, spi	Plant feeder
Bipersona torticauda (Gillette)	Scarce	On Cir uta, possible other thistles	Plant feeder
Flabellomicrosiphum tridentatae	Rare	On Art tri	Plant feeder
Pseudoepameibaphis tridentatae (Wilson)	Common	On Art tri	Plant feeder
Durocapillata utahensis	Common-Rare	On Chr vis	Plant feeder
Epameibaphis utahensis	Rare	On Art tri	Plant feeder
Pleotrichophorus xerozoous (Knowlton-Smith)	Rare	On Chr nau	Plant feeder
Macrosiphum zerotherum	Rare	On Art tri	Plant feeder
Macrosiphum zerozalphum	Rare	On Ero cic	Plant feeder
Family CICADIDAE			
Okanagana spp.	Scarce	On Art tri	Plant feeders
Platypedia sp.	Common-Scarce	On Art tri	Plant feeders
Family MEMBRACIDAE	Scarce	?	Plant feeder
Family CEROPIDAE	Scarce	On Art tri, Chr vis, par, nau	Plant feeder
Family CICADELLIDAE			
Circulifer tenellus	Common	On Sal kal, and various mustards	Plant feeder
Aceratagallia spp.	Common	On Lup ser, and other Leguminosae	Plant feeders on juice mainly
Empoasca spp.	Scarce	On Lup ser, and other Leguminosae	Plant feeders on juice mainly
Family FULGORIDAE	Scarce	On Art tri, lud, Chr vis, nau, par, other plants	Plant feeders on juice mainly
Family PSYLLIDAE	?	On Art tri, lud and various other plants	Plant feeders on juice mainly
Family COCCIDAE	Scarce	On Atr nut, Agr cri roots	Plant feeders

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Family PSEUDOCOCCIDAE			
Orthezia artemisiae	Scarce	On Art tri, lud	Plant feeder
Phenococcus defectus	Rare	On Art tri, lud	Plant feeder
ryptoripersia tubulata	Rare	On Art tri, lud	Plant feeder
Orthezia artemiseae	Scarce-Rare	On Art tri, lud	Plant feeder
Encyrtidae sp.	Scarce-Rare	On Art tri	Plant feeders
Family CYDNIDAE	Scarce	On mold or root duff, under rocks, also common on various grasses	?
EUROPTERA			
Family CHRYSOPODA			
Chrysopa spp.	Common	On the various plants that have aphids	Predaceous larva, feed on aphids
Family RAPHIDIIDAE	Common-Scarce	On Chr vis, nau, par, Art tri, lud, and other insect attracting plants	Predaceous on small insects
Family HEMEROBIIDAE	Scarce	On Chr nau, Art tri, Jun ost, dark woody areas	Predaceous larva
Family MYMELEONTIDAE	Scarce	Ground dwelling, dig cone shaped pits to trap insect prey, mostly ants	Predaceous on insects
OLEOPTERA			
Family CARABIDAE			
Celia californica	Common	On the ground, under root clumps, rocks, etc.	Predaceous on other insects
(other genera and species)	Common-Numerous	On the ground, under root clumps, rocks, on some of the plants	Predaceous on other insects
Family TENEBRIONIDAE			
Telabis uteana	Common	On the ground, under Art tri, Agr cri clumps, Chr vis, nau plants	Plant feeder but also feeds on other organic matter
Eleodes spp.	Common-Scarce	On the ground, under Art tri, Agr cri clumps, Chr vis nau plants	Plant feeders but also feed on other organic matter
Family CHRYSOMELIDAE			
Monoxia debilis	Common-Numerous	On Chr vis, nau	Plant feeder
noxia erosa	Common-Numerous	On Chr vis, nau	Plant feeder
rirhabda nitidicollis	Common	On Chr vis, nau	Plant feeder
Family CICINDELIDAE	Rare	On the ground or plants depending on prey species	Predaceous on insects
Family SCRABAEIDAE			
Sub Family MELOLONTHINAE			
Phyllophaga spp.	Scarce	Under the ground as larva on plants as adults	Plant feeders as adults, larva are root feeders

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Sub Family SCARABAEINAE			
Aphodius distinctus	Common-Rare	On dung, and the ground	Dung feeder
Aphodius spp.	Common-Rare	On dung, and the ground	Dung feeders
Family STAPHYLINIDAE	Common-Rare	On dung, carrion, decayed plant matter, stones, abandoned bird and mice nests	Predaceous on other insects
Family HISTERIDAE	Rare	On dung, carrion, fungi, and dead plant matter	Predaceous on other insects
Family SILPHIDAE			
Silpha spp.	Rare	Under or on dead animals	Carrion feeders adults and larva
Nicrophorus spp.	Rare	Under or on dead animals	Carrion feeders adults and larva
Family MALACHIIDAE			
Colops bipunctatus	Common	On Chr vis, nau, and other flowered plants	Predaceous on weevil larva and other insects
Family MELOIDAE			
Epicauta ferruginea	Numerous-Common	On Hel ann, Chr vis, nau	Plant feeder as adults but larva feed on grasshopper eggs.
Epicauta maculata	Scarce	On Chr vis, nau	Plant feeder as adults but larva feed on grasshopper eggs.
Epicauta oregona	Scarce	-	Plant feeder as adults but larva feed on grasshopper eggs
Lytta vulnerata	Common	On Chr vis, possible other plants	Plant feeder as adults, larva ?
Nemognatha lurida	Scarce	On Chr vis, nau, Hel ann	?
Nemognatha lutea	Scarce		?
Family ELATERIDAE	Common-Rare	On many flowered plants, under bark, on vegetation in general	Phytophagous adults, larva feed on seeds, roots, etc.
Family COCCINELLIDAE			
Coccinella spp.	Common-Rare	On various grasses and plants depending on prey species	Predaceous larva and adults feed on aphids, scale insects
Hippodamia convergens	Common-Numerous	On various grasses and plants depending on prey species	Predaceous adults and larva, feed on aphids, scale insects
Hyperapis lateralis	Rare	On various grasses and plants depending on prey species	Predaceous adults and larva, feed on aphids, scale insects

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Family DERMESTIDAE			
Dermestes spp.	Rare	On dead plants, roots, other organic matter	Scavengers, feed on dead organic matter
Family CERAMBYCIDAE			
Crossidius intermedius	Common-Rare	On Chr vis, nau other plants	Plant feeders, primarily plants that are dying
Crossidius allgewahri	Common-Rare	On Chr vis, nau, other plants	Plant feeders, primarily plants that are dying
Crossidius pulchellus	Common-Rare	On Chr vis, nau, other plants	Plant feeders, primarily plants that are dying
Crossidius ater	Common-Rare	On Chr vis, nau, other plants	Plant feeders, primarily plants that are dying
Family CURCULIONIDAE			
Hypera postica	Rare	On various Leguminosae	Plant feeder
Sphenophorus spp.	Rare	On various grasses	Plant feeders
LEPIDOPTERA			
Family PAPILIONIDAE			
Papilio spp.	Common-Rare	On various many flowered plants	Nectar feeders as adults, larva feed on Cym ter and other plants
Family PIERIDAE	Common-Rare	?	Adults are nectar feeders, larva feed on Leguminosae and Cruciferous plants
Family NYMPHALIDAE			
Speyeria fritillaries	Common-Rare	On Vio nut as larva, adults on various plants	Adults nectar feeders, larva feed on Vio nut
Speyeria spp.	Rare	On Vio nut as larva, adults on various plants	Adults nectar feeders, larva feed on Vio nut possible other plants
Family LYCAENIDAE			
Sub Family LYCAENINAE	Rare	?	Adults are nectar feeders
Sub Family PLEBEIINAE	Rare	?	Adults are nectar feeders

Table 34. Continued

Order	Realtive Abundance	Habitat	Comments
Family NOCTUIDAE			
Euxoa brocha	Rare	?	Adults are nectar feeders, larva are plant feeders
Euxoa ridingsiana	Common	?	Adults are nectar feeders, larva are plant feeders
Euxoa lactificans	Common	?	Adults are nectar feeders, larva are plant feeders
Euxoa messoria	Scarce	?	Adults are nectar feeders, larva are plant feeders
Euxoa plagigera	Common	?	Adults are nectar feeders, larva are plant feeders
Euxoa oblongistigma	Common	?	Adults are nectar feeders, larva are plant feeders
Euxoa infausta	Rare	?	Adults are nectar feeders, larva are plant feeders
Family GEOMITRIDAE	Rare	On Various shrubs, woody plants	Adults are nectar feeders, larva feed on shrubs
Family PSYCHIDAE			
Aroga websteri	Common	On Art tri, lud, other plants	Adults are nectar feeders larva feed on Sage brush
DIPTERA			
Family CULICIDAE	Numerous-Common	Near moist cool areas, generally around standing water	Adults are nectar or blood feeders depending on sex
Family CHIRONOMIDAE	Common	Near moist cool areas, generally around standing water	Adults are scavengers
Family BOMBYLIDAE	Common	On various many flowered plants	Adults nectar feeders, larva feed on grasshopper eggs, caterpiller and beetle grubs
Family ASILIDAE			
Asilus mesa	Common	On large plants, open areas, depending on prey species	Predaceous on other Diptera, grasshoppers, other insects
Family DOLICHOPODIDAE			
Dolichopus adequatus	Rare	?	Predaceous on small to very small insects
Dolichopus conspectus	Scarce-Rare	On wet grasses, sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects
Dolichopus ramifer	Scarce-Rare	On wet grasses, sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects
Pelastoneurus vagans	Scarce-Rare	On wet grasses, sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects
Sympycnus spp.	Scarce-Rare	On wet grasses, sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Syntormon sp.	Scarce-Rare	On wet grasses, sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects
Thrypticus fraterculus (Whyl)	Scarce-Rare	On wet grasses,sedges, general moist areas (Captured in sweep net)	Predaceous on small to very small insects
Family PHORIDAE			
Megaselida borealis	Rare	On decaying vegetation; adults	?
Family TACHINIDAE			
Plagiprospherysa parvipalpis	Common	?	Larva are parasitic on other insects
Viviania neomexicana	Common	?	Larva are parasitic on Carabidae, other Coleoptera
Voria ruralis	Common	?	Larva are parasitic on moths, probably on Noctuidae
Stomalomyia parvipalis	Common	?	Parasitic
Family CALLIPHORIDAE			
Lucilia sericata	Common	On dead animals	Scavenger, larva feed on dead animals
Family SARACOPHAGIDAE			
Hilarella hilarella	Common	In *Podalonia luctuosa* nest, on cutworms brought in by the wasp	Larva are parasitic on cutworm larva
Senotinia rubriventris	Common	On salt grass, beach grass	Larva are parasitic on *Bicyrtes quadrifasciata*
Taxigriamma heteroneura	Common-Scarce	?	Larva are parasitic on cut worm larva
Sarcophaga kellyi	Common		Larva are parasitic on grasshoppers
Sarcophaga opifera	Common	?	Larva are parasitic on grasshoppers probably *Melanoplus* genus
Sarcophaga planifrons	Common	?	Larva are parasitic on grasshoppers
Sarcophaga therminieri	Common	In grass habitats	Larva are parasitic on grasshoppers
Microchaetina valida	Common-Scarce	?	Larva are parasitic ?
Family MUSCIDAE			
Stomoxys sp.	Common-Scarce	On or around cattle, horses, breed in very wet grass clumps, fresh horse dung	Adults omnivorous organic juice and blood feeders
Haematobia sp.	Common-Scarce	On or around fresh cow dung, lay eggs on same	?

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Musca sp.	Common-Scarce	On decayed plants, other decayed matter	Omnivorous organic matter, fluids
Family ANTHOMYIIDAE			
Hylemyia cilicrura	Scarce	?	?
Egle cinerella	Scarce	?	?
Sub Family SCATOPHAGINAE			
Scatophaga steroraria	Scarce	On or around horses, cattle	?
Family STRATIOMYIDAE			
Hedriodiscus truquii (Bellardi)	Scarce	On Chr vis, nau, breeds in water	Nectar feeding adults
Nemotelus communis	Scarce	On Chr vis, nau, breeds in very shallow standing water	Nectar feeding adults
Nemotelus canadensis	Scarce	On Chr vis, nau, breeds in very shallow standing water	Nectar feeding adults
Odontomyia inaequalis	Scarce	On Chr vis, nau, breeds in high saline water	Nectar feeding adults
Family TABANIDAE			
Chrysops aestuans	Scarce	On Chr vis, nau, breeds around water areas, also found around animals	Blood sucking, feeds on deer, other animals
Chrysops discalis	Scarce	On Chr vis, nau, breeds around water areas, also found around rabbits.	Blood sucking, feeds on rabbit other animals
Chrysops mitis	Scarce	? breeds around water areas	Probably blood sucking ?
Tabanus productus	Scarce	On or around cattle, horses, other animals	Adult females are blood sucking
Tabanus stonei	Scarce	On or around cattle, horses, other animals	Adult females are blood sucking
HYMENOPTERA			
Family ICHNEUMONIDAE	Abundant		All are parasitic on other wasps, insects
Family BRACONIDAE (25 spp.)	Abundant (Especially at S. site)	Around various flowered plants	Parasitic on insects
Family POMPILIDAE	Abundant	On Ach lan, other plants that may harbor spiders	Parasitic on spiders
Family SPHECIDAE			
Podalonia spp.	Abundant	On various plants depending on prey, Noctuidae	Predaceous on Noctuidae
Ammophila spp.	Numerous	On various plants depending on prey, Pieridae and other Lepidoptera	Predaceous on Pieridae and other specific Lepidoptera
Chlorionini spp.	Common	On various plants or the ground depending on prey species, Acridae, Gryllacridae, Orthoptera	Predaceous on various Orthoptera

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Sceliphronini spp.	Common	On various plants that harbor spiders	Predaceous on spiders
Larrini spp.	Common	On various plants that harbor spiders	Predaceous on spiders
Astatini spp.	Scarce	On various plants that harbor Pentatomidae, Lygaeidae	Predaceous on Pentatomidae, Lygaeidae
Oxybelus spp.	Scarce	On or generally around Ach lan	Predaceous on small flies
Cercerini spp.	Abundant	On various plants, and the ground	Predaceous on adult Bup-restid Curculionidae, Tenebrionidae
Philanthus spp.	Abundant	On various plants that attract Aphidae	Predaceous on small bees
Crabroninae spp.	Abundant	On various plants and other organic material that attract Diptera	Predaceous on Diptera, some sp. predaceous on small wasps
Family APIDAE			
Apis spp.	Abundant	On various many-flowered plants	Nectar, and pollen feeders
Bombus (10 spp.)	Numerous-Abundant	On various many-flowered plants	Nectar, and pollen feeders
Family ANTHOPHIDAE			
Svastra spp.	Common	On Hel ann	?
Tetralonia spp.	Common	?	?
Diadasia spp.	Numerous	1 sp. on Hel ann, 1 on cactus 2-3 on Malvacea	?
Nomada spp.	Numerous	?	Parasitic on *Andrena*
Melecta spp.	Rare	?	Parasitic on *Anthophora*
Triepolus spp.	Common	?	Parasitic on Anthrophor-idae
Epeolus spp.	Scarce	?	Parasitic on *Colletes*
Ceratina spp.	Common	?	?
Anthophora spp.	Numerous	?	?
Melissodes spp.	Abundant	?	?
Neolarra sp.	Scarce	?	Parasitic on *Perdita*
Family MEGACHILIDAE			
Anthocopa spp.	Rare	?	?
Stelis spp.	Rare	?	Parasitic on *Osmiinae*
Coelioxys spp.	Common	?	Parasitic on *Megachile*
Ashmeadiella spp.	Numerous	?	?
Osmia spp.	Common	?	?
Megachile spp.	Numerous	?	?
Dioxys	Rare	?	Parasitic on *Ashmeadiella*, *Anthidiinae*
Hoplitis spp.	Scarce	?	?
Anthidium spp.	Common	?	?

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Family COLLITIDAE			
Colletes spp.	Abundant-Very Abundant	On Various Compositae	Nectar, pollen feeders
Hylaeus spp.	Abundant	?	Nectar, pollen feeders
Family HALICTIDAE			
Halictus spp.	Abundant-Very Abundant	?	Nectar, pollen feeders
Dialictus spp.	Abundant-Very Abundant	?	Nectar, pollen feeders
Sphecodes spp.	Common	?	Parasitic on Halictinae
Agapostemon spp.	Numerous	?	Nectar, pollen feeders
Evylaeus spp.	Numerous	?	Nectar, pollen feeders
Lasioglossnn spp.	Numerous	?	Nectar, pollen feeders
Family ANDRENIDAE			
Adrena spp.	Abundant-Very Abundant	On Cruciferae, Salix during the spring, very abundant	Nectar, pollen feeders
Nomadopsis spp.	Abundant	?	Nectar, pollen feeders
Perdita	Abundant-Very Abundant	On Chr vis, nau, very abundant	Nectar, pollen feeders
Family VESPIDAE			
Sub Family POLISTINAE			
Polistes fuscatus	Abundant	?	Predaceous on Lepidoptera
Sub Family EUMENINAE (25-30 spp.)	Abundant	? Most common at the N. site	Predaceous on Lepidoptera
Family CYNIPIDAE (2-3 spp.)	Common	?	Some insect parasitism and plant gall formation
Family TIPHIIDAE (10 spp.)	Common	?	Parasitic on Scarabaeidae, other Coleoptera
Family SCOLIIDAE (3-4 spp.)	Scarce	On various flowered plants	Parasitic on Scrabaeidae
Family MUTILLIDAE	Common-Scarce	On the ground or various flowers	Parasitic on aleate wasps, bees, certain flies
Family CHRYSIDIDAE	Numerous-Abundant	?	Parasitic on aleate wasps, other insects
Family CHALCIDOIEA (150 spp.)	Abundant-Very Abundant (Especially on the S. site)	On various small composites, Tar off and others (Adults do seek a nectar food source)	Parasitic on various Lepidoptera, Coleoptera, Diptera
Family TENTHREDINIDAE (4 spp.)	Rare	On Salix spp.	External plant feeders
Family PROCTOTRUPIDAE			
Proctotrupes sp.	Common	?	A possible parasite ?

Table 34. Continued

Order	Realtive Abundance	Habitat	Comments
Family FORMICIDAE			
Aphaenogaster subterranea valida	?	?	?
Crematogaster mormonum	?	?	?
Formica cinerea var. *neocinerea*	Common	In and on the ground in sage brush and foothill areas	Omnivorous
Formica fusca Linneaus	"	"	"
Formica fusca var. *neorufibarbis*	"	"	"
Formica fusca var. *subaenescens*	"	"	"
Formica integroides planipilis	"	"	"
Formica manni	"	"	"
Formica neoclara	"	"	"
Formica neogagates	"	"	"
Formica neorufibarbis	"	"	"
Formica obscuripes	"	"	"
Formica obtusopolosa	"	"	"
Formica oreas	"	"	"
Formica oreas comptula	"	"	"
Formica planipilis	"	"	"
Formica pruinosa	"	"	"
Formica rasilis densiventris	"	"	"
Formica sanguinea puberula	"	"	"
Formica subnitens	"	"	"
Formica subpolita var. *camponoticept*	"	"	"
Formica whymperi	"	"	"
Lasius alienus americanus	"	In and on the ground in lower foothill sage brush areas	"
Lasius nigre	"	and Jun ost woody areas of the north site	"
Lasius var. *americanus*	"	"	"
Lasius var. *sitkaensis*	"	"	"
Lasius nevadensis	"	"	"
Lasius nitens	"	"	"
Manica americana	?	?	Probably omnivorous
Manica lobifrons	?	?	"
Manica monticola	?	?	"
Pogonomyrmex occidentalis (Cresson)	Abundant-V. Abund.	On or in the ground in dry arid open areas	Plant seed gatherers
Solenopsis molesta (Say)	?	On or in the ground in dry areas	Probably omnivorous
Solenopsis molesta validiuscula	?	"	"
Stenemma sp.	?	?	?
Tapinoma sessile (Say)	?	?	?

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
SCORPIONIDA			
Family VEJOVIDAE			
Vejovis boreus	Common	On or under Art tri dead clumps, live Art tri clumps, litter piles, dead limbs	Predaceous on insects
SOLPUGIDA			
Eremobates sp.	Scarce	On dry arid areas under rocks, cracks in limbs, litter piles etc, dirt	Predaceous on insects
CHELONETHIDA			
Dactylochelifer silvestris	Scarce	On or in dry or mossy duff below Jun ost, Art tri, Chr vis, nau	Predaceous on insects
Dinocheirus dorsalis (Banks)	Scarce	On or in Art tri duff	"
Haplocheifer philipi (Chamberlin)	Scarce	On or in dry or mossy duff, or Art tri duff	"
Hesperochernes utahensis	Scarce	On or in Jun ost duff	"
Lamprochernes lavipalpis	Rare	?	"
Microbism confusum	Scarce	On sage brush fragments, dead leaves	"
Syarinus obscurus (Banks)	Scarce	On or near horse dung	"
PHALANGIDA	Scarce	?	"
ARANEIDA			
Family ARANEIDAE			
Araneus gemmoides	Scarce	In areas where circular webs would be effective, (Orb-weaver)	"
Argiope trifasciata (Forskal)	Common	In areas where circular webs would be effective, (Orb-weavers)	"
Family DICTYNIDAE			
Dictyna idahoana	Common	In areas where a irregular web would be effective, cracks, crevices, or the tips of various plants	"
Family CLUBIONIDAE			
Micaria foxi	Common-Numerous	In flat tubular silk sac in rolled leaves or crevices of Chr vis, nau, other plants	"
Family THOMISIDAE			
Thanatus formicinus	Scarce	On Chr vis, nau and other many-flowered plants	Predaceous on bees, flies, other insects that come to flowers
Xysticus montanensis	Common	On Chr vis, nau, and other many-flowered plants	"
Family THERIDIIDAE			
Euryopis sp.	Scarce	On Chr vis, nau and other plants	Predaceous on insects

Table 34. Continued

Order	Relative Abundance	Habitat	Comments
Family SALTICIDAE			
Phidippus apacheanus	Common	On the ground, or various plants that may harbor prey, (Jumping spider)	Predaceous on insects
Salticus peckhamae	Common	On the ground, or various plants that may harbor prey, (Jumping spider)	Predaceous on insects
Gertschia sp.	Scarce	On the ground, or various plants that may harbor prey, (Jumping spider)	Predaceous on insects
ACARINA			
Family CAECULIDAE			
Caeculus spp.	Common	On various types of plants, and the ground	Predaceous ??
Family TENERIFFIIDAE	Common	On various types of plants, and the ground	Predaceous ??
Family IXODIDAE			
Dermacentor andersoni	Common	On various animals	Blood feeding
CHILOPODA	Rare	?	Predaceous
ISOPODA	Rare	On various types of vegetation	Omnivorous

Table 35. Insects associated with major plant species on southern validation sites, Curlew Valley

ARTEMISIA TRIDENTATA

Plant Feeding (foliage): *Melanoplus sanquinepes*, *Trimerotropis* spp. Ceropidae sp., *Aroga websteri*, *Apterona crenulella*

Plant Feeding (Sap - Juice): *Frankliniella occidentalis*, *Thrips tabaci*, *Chlorochroa sayi* (some cell damage), *Microsiphoniella acophorum* (Knowlton-Smith), *M. artemisia* (Gillette), *M. oregonensis* (Wilson), *Obtusicauda artemisiphilum* (Knowlton-Allen), *O. artemisicola* (Williams), *O. frigidae* (Oestlund), *O. cowehi*, *O. essigi*, *Styletaphis canae* (Williams), *S. filifoliae* (Gillette-Palmer), *S. minutissima*, *S. oregonensis* (Wilson), *Pseudoepameibaphis essigi*, *P. glauca* (Gillette-Palmer), *P. tridentatae*, *Eupameibaphis frigidae* (Oestlund), *E. utahensis*, *Brachyungis hermistonii* (Wilson), *Pleotrichiphorus infrequens* (Knowlton-Smith), *P. pseudoglandulosus* (Palmer), *Flabellomicrosiphum knowltoni*, *F. tridentatae*, *Macrosiphum zerotherum*, *Orthezia artemisae*, *Phenococcus defectus*, *Cryptoripersia tubulata* Fulgoridae spp., Psyllidae spp., Encyrtidae spp.

Plant Feeding (Roots): Pseudococcidae sp., Okanagana spp. larva, Platypedia sp. larva.

Pollinators: Wind pollination primarily

Artemisia (Dead): Machilidae spp., *Reticultitermes subterranean*

Predaceous on Other Insects: *Vejovis boreus*, around the base of large clumps; *Nabis alternatus*, *Anthocoris melanocerus*, *A. musculus*, *Orius tristicolor*, *Geocoris pallens* s Stal., Raphidiidae sp., various Araneida spp.

ATRIPLEX CONFERTIFOLIA

Plant Feeding (foliage): Acridae spp., Coleoptera spp.

Plant Feeding (Sap - Juice): *Chlorochroa sayi* (some cell damage), *Nysius ericae* Shill., *Nysius* spp., *Peritrechus saskatchewansis*, *Peritrechus* spp. (this group may possibly feed on seed also), Cicadellidae spp.

Plant Feeding (Roots): Coleoptera spp., possible Scrabaeidae larva.

Pollinators: Wind pollination primarily

Atriplex (Dead): Thysanura sp., Acarina spp. ??

Predaceous on Other Insects: various Araneida spp., Saracophagidae spp., Astatini spp., Acarina spp.

CHRYSOTHAMMUS VISCIDIFLORUS

Plant Feeding (foilage): *Melanoplus sanquinepes*, *Trimerotropis* spp., *Monoxia debilis*, *erosa*, *Trirhabda hitidicollis*, *Epicauta maculata* (Adults), *Lytta vulnerata* (Adults), *Nemognatha lurida* (Adults), *Apterona crenulella*

Plant Feeding (Sap - Juice - Nectar): *Frankliniella occidentalis*, *Thrips tabaci*, *Lygus* spp., *Pleotrichophorus acanthovillis*, *P. pychnorhysus* (Knowlton-Smith), *Aphis gregalis*, *Styletaphis minutissima*, *Durocapillata utahensis*, Fulgoridae sp., Ceropidae sp., *Hedriodiscus truquii* (Bellardi), *Nemotelus communis*, *N. canadensis*, *Odontomyia inaequalis*, *Apis* spp., *Bombus* spp., *Perdita* sp.

Predaceous on Other Insects: *Phymata borica*, *P. pennsylvanica*, *Nabis alternatus*, *Deraeocoris brevis*, *Anthocoris melanocerus*, *A. musculus*, *Orius tristicolor*, *Sinea confusa*, Raphidiidae sp., Chrysopoda sp., *Colops bipunctatus*, *Micaria foxi*, Salticidae spp., *Xysticus montanensis*, *Thanatus formicinus*, Ichneumonidae (Parasitic), Braconidae (Parasitic).

Chrysothammus (Dead): *Crossidius intermedius*, *Crossidius allgewahri*, *Crossidius pulchellus*, *Crossidius ater*, all feed on dying plants.

Table 35. Continued

Pollinators: *Eucerceris superba, Podalomia luctuosa, Philanthus multimaculata, Prionyx canadensis, Ammophila cleopatra, Cerceris conifrons, Geron* sp., *Phthiria sulphurea, Mythicomyia* sp., *Phoecilanthrax lutzi, dissoptus, fulgida, Habitus ligatrs, Dialictus* spp., *Hylacus sterensi*

SITANION HYSTRIX

Plant Feeding (Foliage): Acridae (*Melanoplus* sp., *Trimerotropis* sp.), Coleoptera spp. (Others)

Plant Feeding (Sap - Juice): *Irbisia brachycerus solani* (Heid)?, *Labops hesperius, Liorhyssus hyalinus*, Cicadellidae spp., (Others).

Pollinators: Wind pollination primarily

Predaceous on Other Insects: Various Acraneidae spp., Acarina spp., Coleoptera spp.

HALOGETON GLOMERATA

Plant Feeding (Foliage): *Corizagrotis auxilaris* (not found by the author but reported in low numbers).

Plant Feeding (Sap - Juice): *Nysius ericae* Schill., *Circulifer tenellus, Lygus* spp.

Pollinators: Wind pollination primarily.

Predaceous on Other Insects: *Nabid alternatus*, Reduviidae sp.

BASSIA HYSSOPIFOLIA

Plant Feeding (Foliage): *Corizagrotis auxiliaris* (not found by the author but reported in low numbers)

Plant Feeding (Sap - Juice): *Brevicoryne brassicae* (L), *Dactynotus pseudobrassicae, Adrena* spp., *Mimeocapsus minimus*, Pentatomidae spp.

Pollinators: Wind pollination primarily

SALSOLA KALI

Plant Feeding (Foliage): Pieridae spp. (larva)

Plant Feeding (Sap - Juice): *Nysius ericae* Shill., *Nysius* spp., *Peritrechus saskatchewanensis* , *Brachycaudis cardiui* (L), *Circulifer tenellus, Melanotrichus flavosparsus, Chlamydatus pullus*.

Pollinators: Wind primarily; *Nomadopsis scutellanis, Dialictus* sp.

Predaceous on Other Insects: Reduviidae spp., various Araneida.

DESCURAINIA PINNATA

Plant Feeding (Foliage): *Plutella xylostella* (a small amount), Noctuidae spp., *Corizagrotis auxilaris* (not found by author but reported in small numbers)

Plant Feeding (Sap - Juice - Nectar): *Dactynotus pseudobrassicae, Circulifer tenellus, Adrena* spp., *Meleanotrichus* spp., *Trigonotylus* spp., *Nysius ericae*.

Pollinators: *Andrena piperi, A. scurra, Halictus tripartitus, H. ligatus, Dialictus* spp.

Predaceous on Other Insects: *Nabis alternatus, Geocoris pallens*.

Table 35. Continued

AGROPYRON CRISTATUM

Plant Feeding (Foliage): *Melanoplus* sp., *Trimerotropis* sp., *Telabis* sp., *Eleodes* sp., Some plant feeding but also other organic matter.

Plant Feeding (Sap - Juice): Thysanoptera spp., *Chlorochroa say* (some cell damage), *Rhopalosiphum maidis* (Fitch), *Forda olivacea, Irbisia brachycerus* (Uhler), *I. pacificus* (Uhler) *I. brachycerus solani* (Heid). *Labops hesperius, L. Ferrugata.* Cicadellidae spp.

Plant Feeding (Roots): *Forda olivacea,* Coccidae spp. to some extent, *Eleodes* sp. larva, Lepidoptera spp. larva.

Pollinators: Wind pollination primarily.

Agropyron cristatum (Dead): Collembola sp., Acarina spp., Machilidae sp.

Predaceous on Other Insects: *Nabis alternatus, Geocoris pallens, Cocinella sp.,* Araneida spp.

D. VERTEBRATES

1. REPTILES AND AMPHIBIANS

A decision was made not to sample reptiles and amphibians since so few are found on the sites.

2. BIRDS

Introduction

Avian validation studies on the northern and southern sites were initiated in July, 1971. The primary objective was to determine the population density and biomass for each species on a seasonal basis.

Methods

The Emlen (1971) method of line transects was used on all the sites since the beginning. Sampling trips were initiated one-half hour after sunrise and were usually completed within 2 hours. In 1971 the transect routes were different each day, but subjectively chosen to traverse the various vegetation types within the sites. During the 1972 breeding season, however, identical transect routes crossing all vegetation types were followed each day. This procedure allowed for more uniformity of transect counts between observers. Vegetational zones were crossed at right angles rather than followed.

Both right angle and radial distances were determined for each bird detected on either side of the transect line. Detections included sightings of any bird sitting on the plot or unseen vocalizing birds whose locations could be closely approximated. Birds that were first seen flying were omitted unless their approximate flushing distance could be determined.

In 1971 distances were recorded laterally to a point 125 m from the transect line. During the summer of 1972 the transect strips included distances laterally to 75 m. This disparity between transect widths does not alter or bias population estimates derived from the Emlen method. Range-finders were used during the summer of 1972 to accurately determine distances of less than 30 m.

In 1972 the census technique of mapping singing males (Williamson, 1964) was conducted on the north shrub site. Two 12-ha plots were selected and gridded at 50 m intervals. These plots were usually censused from 10 - 12 AM during the period from

June 6-30. The location of nests also helped confirm the presence of territories. Brewer's sparrows call from the tops of shrubs when observers approach the nest. This behavior was useful in determining the number of territories within a plot, even though a nest was not found. At the end of the breeding season the total number of territories were determined from composite maps of each plot. Only the Brewer's sparrow had a high breeding density and sufficiently small territories to be accurately censused by this method.

The total biomass of each species per site was based on body weights of birds collected in 1971. Many birds were collected with mist nets, but elusive species were collected by shooting. Most birds were weighed, sexed, aged, banded, and released, while the sexually monomorphic species, not in breeding condition, were dissected to obtain these data.

Data collected on frequent visits to nests were used to determine nest success and nest productivity.

Data Set A3UBJG1-4 applies to the data on birds.

Results

Emlen's line transect technique requires a frequency distribution of right angle flushing or sighting distances for each species. Theoretically, the point of inflection of this curve represents the maximum lateral distance from the transect line within which all birds will be seen. This proximal strip of 100% coverage is different for each species and may vary with sex, age and the time of day or season. Separate frequency distributions were made for most species for the June and July-August periods. These two periods of time, based on nesting data and behavioral changes, represent the nesting and post-nesting seasons. During the post-nesting season adults generally become more conspicuous and immature birds function behaviorally as adults.

Because few sightings were recorded in June for sage sparrows and in July - August for vesper sparrows, flushing distances for these species were tallied as a whole for the summer (Table 1). Brewer's sparrow densities were high enough that individual distributions could be made for each site. The complete coverage strip for this species differs, not only with the season, but also with change in vegetation types on the sites. Horned lark flushing distances were grouped for the entire summer, since this species had probably completed its nesting activity in early June. The southern sites were tallied separately, but both distributions indicated the same lateral distance of the complete coverage strip.

Table 1. Frequency distributions of birds flushing at various right angle detection distances from June-August 1972

	Distance (m)																
	0 - 2.74	3.05 - 5.79	6.10 - 8.84	9.14 - 11.89	12.17 - 14.94	15.24 - 17.89	18.29 - 21.03	21.34 - 24.08	24.38 - 27.13	27.43 - 30.18	30.78 - 33.53	33.83 - 36.58	36.88 - 39.62	39.93 - 42.67	42.98 - 45.72	46.02 - 48.77	49.07 - 75.29
Vesper sparrow																	
Northern grass																	
June-Aug.	27	24	17	11	11	8	7	4	5	5	8	3	3	2	1	0	2
Sage sparrow																	
No. and So. shrub																	
June-Aug.	17	24	14	16	12	13	14	11	10	10	6	3	4	0	4	0	3
Brewer's sparrow																	
Northern shrub																	
June	51	36	25	30	26	29	15	15	12	14	8	6	4	2	4	3	7
July-Aug.	118	97	74	79	73	62	47	61	28	30	7	17	17	13	16	5	20
Northern grass																	
June	37	29	19	22	10	17	23	4	10	10	3	0	0	1	4	1	5
July-Aug.	163	108	106	102	79	72	70	63	45	51	30	21	17	14	16	5	41
Southern shrub																	
June	17	20	13	13	10	10	7	9	1	3	0	2	2	2	1	1	6
July-Aug.	18	40	32	32	25	18	20	16	13	12	7	10	12	6	10	1	10
Horned lark																	
Southern grass																	
June-Aug.	67	62	56	74	57	56	45	32	32	15	14	16	15	10	10	5	26
Southern shrub																	
June-Aug.	51	46	42	40	42	31	29	24	25	15	14	8	12	11	3	2	26
S. thrasher																	
Both northern sites and southern shrub																	
June	9	6	5	6	12	5	10	11	4	2	3	4	5	0	1	0	8
July-Aug.	60	21	15	32	291	27	25	30	18	25	15	27	24	10	28	3	38

Sage thrasher sighting distances were separated into nesting and post-nesting periods, but since sightings were not numerous, data from all three sites on which this species occurred were included in one frequency distribution. The vertical lines in Table 1 indicate the estimated distance on each side of the transect line within which 100% of the birds will be seen.

Population estimates were based on the number of birds detected within this proximal strip of assumed 100% coverage. The number of birds within this proximal strip was extrapolated to estimate densities on the 100-hectare sites. Final monthly estimates for each site were simply the mean of all estimates from daily censuses within that month.

Several species occurred in such small numbers that frequency distributions could not accurately determine a proximal strip of complete coverage. These species (e.g. mourning dove, loggerhead shrike, western meadowlark, and black-billed magpie) are large, mobile birds, which were commonly seen at distances greater than 75 m from the transect line. Since mourning doves and meadowlarks nested on some sites, their areas of activity were probably confined and a 100% coverage strip of 75 m was assigned to these species. The density estimates were again derived by extrapolating to 100 hectares as described above. Individual loggerhead shrikes and magpies, however, may range over long distances during any census trip. Therefore, the line transect technique was inappropriate and population estimates were the mean number of birds seen per census trip, regardless of right angle sighting distances.

Density estimates are shown in Tables 2-5. The winter months (e.g. January, February and March) were grouped into one time period, since during the winter months few bird species used any of the sites. Only horned larks consistently appeared on the southern sites. Census trips averaged about one per month during the winter and the appearance of irregular visitors and early or late migrants during these counts may have given unrealistic density estimates for some species.

Many different species were observed on or over the sites during the course of this study. Some of these species were only seen once (e.g. during migration) and many were irregular visitors that nested off-site. A list of those species that may be expected to be seen on the sites, but whose irregular occurrence makes density estimates impractical is given in Tables 6 and 7.

Density estimates for 1971 are based on proximal 100% coverage strips determined from data collected for that year (Table 8). Western meadowlark densities were based on a 100% coverage strip of 125 m. The information collected in 1972 was considered to be more accurate, since a greater quantity of data was collected during this year.

Table 2. Avian densities on the northern shrub site derived from transect counts (birds/100 ha)——DSCODE A3UBJG1

Species	Jan Feb Mar 71	Jan Feb Mar 72	Apr 71	Apr 72	May 71	May 72	June 71	June 72	July 71	July 72	Aug 71	Aug 72	Sept 71	Sept 72	Oct Nov Dec 71	Oct Nov Dec 72
Mourning Dove	-	-	-	2	-	5	-	3	29	6	28	6	7	-	0	-
Blk.-b. Magpie	-	-	-	0	-	2	-	0	1	0	0	1	1	-	4	-
Sage Thrasher	-	-	-	0	-	16	-	13	6	22	15	29	2	-	0	-
L. Shrike	-	-	-	0	-	1	-	1	2	3	3	4	0	-	1	-
W. Meadowlark	-	-	-	7	-	10	-	10	13	11	8	9	13	-	14	-
Sage Sparrow	-	-	-	0	-	2	-	6	7	7	12	10	16	-	2	-
Brewer's Sp.	-	-	-	0	-	148	-	162	168	231	153	139	51	-	0	-
Total	-	-	-	9	-	184	-	194	226	289	219	206	90	-	19	-
Number of counts	0	0	0	1	0	2	0	10	6	12	8	10	3	0	2	0

Table 3. Avian densities on the northern grass site derived from transect counts (birds/100 ha)——DSCODE A3UBJG2

Species	Jan Feb Mar 71	Jan Feb Mar 72	Apr 71	Apr 72	May 71	May 72	June 71	June 72	July 71	July 72	Aug 71	Aug 72	Sept 71	Sept 72	Oct Nov Dec 71	Oct Nov Dec 72
Gray Flycatcher	-	0	-	0	-	0	-	3	1	3	1	3	0	-	0	-
Horned Lark	-	9	-	5	-	0	-	0	3	0	6	0	18	-	26	-
Sage Thrasher	-	0	-	3	-	10	-	6	17	9	5	12	0	-	0	-
L. Shrike	-	0	-	0	-	0	-	0	0	0	2	0	0	-	0	-
W. Meadowlark	-	7	-	3	-	3	-	5	5	3	5	4	8	-	7	-
Vesper Sparrow	-	0	-	6	-	6	-	44	12	27	9	16	0	-	0	-
Brewer's Sp.	-	0	-	0	-	105	-	172	83	232	56	156	23	-	0	-
Total	-	16	-	17	-	124	-	230	121	274	84	191	49	-	33	-
Number of counts	0	1	0	3	0	1	0	6	6	11	8	10	2	0	2	0

Table 4. Avian densities on the southern shrub site derived from transect counts (birds/100 ha)——DSCODE A3UBJG3

Species	Jan Feb Mar 71	Jan Feb Mar 72	Apr 71	Apr 72	May 71	May 72	June 71	June 72	July 71	July 72	Aug 71	Aug 72	Sept 71	Sept 72	Oct Nov Dec 71	Oct Nov Dec 72
Sage Thrasher	-	0	-	7	-	17	-	23	10	22	14	16	0	8	0	0
Horned Lark	-	108	-	54	-	52	-	115	27	81	41	51	24	20	20	27
Sage Sparrow	-	21	-	7	-	22	-	15	5	13	16	16	9	14	7	0
Brewer's Sp.	-	0	-	5	-	76	-	69	59	73	50	31	14	10	0	0
Total	-	129	-	73	-	167	-	222	101	189	121	114	47	52	27	27
Number of counts	0	1	0	3	0	3	0	8	4	10	8	10	3	2	2	2

Table 5. Avian densities on the southern grass site derived from transect counts (birds/100 ha)——DSCODE A3UBJG4

Species	Jan Feb Mar 71	72	Apr 71	72	May 71	72	June 71	72	July 71	72	Aug 71	72	Sept 71	72	Oct Nov Dec 71	72
Horned Lark	-	-	-	90	-	135	-	60	182	111	198	118	41	9	41	45
Total	-	-	-	90	-	135	-	60	182	111	198	118	41	9	41	45
Number of counts	0	0	0	2	0	2	0	7	4	10	8	7	2	1	2	2

Table 6. Avian species seen occassionally on transect counts but of insufficient number to estimate

Northern Shrub	Northern Grass
Red-tailed Hawk	Turkey Vulture
Swainson's Hawk	Cooper's Hawk
Ferruginous Hawk	Swainson's Hawk
Marsh Hawk	Prairie Falcon
Sparrow Hawk	Sparrow Hawk
Ring-necked Pheasant	Sharp-tailed Grouse
Long-eared Owl	Ring-necked Pheasant
Poorwill	Mourning Dove
Common Nighthawk	Long-eared Owl
Red-shafted Flicker	Short-eared Owl
Gray Flycatcher	Common Nighthawk
Bank Swallow	Violet-green Swallow
Pinyon Jay	Rough-winged Swallow
Common Raven	Cliff Swallow
Plain Titmouse	Pinyon Jay
Mockingbird	Common Raven
Robin	Robin
Red-winged Blackbird	Red-winged Blackbird
Brewer's Blackbird	Bullock's Oriole
Scott's Oriole	Brewer's Blackbird
Bullock's Oriole	Lark Bunting
Brown-headed Cowbird	House Finch
Western Tanager	Pine Siskin
House Finch	American Goldfinch
Green-tailed Towhee	
Grasshopper Sparrow	
Vesper Sparrow	
Black-throated Sparrow	
Chipping Sparrow	
White-crowned Sparrow	

Table 7. Avian species seen occassionally on transect counts but of insufficient number to estimate

Southern Shrub	Southern Grass
Swainson's Hawk	Marsh Hawk
Rough-legged Hawk	Sparrow Hawk
Golden Eagle	Mourning Dove
Marsh Hawk	Short-eared Owl
Long-billed Curlew	Common Raven
Mourning Dove	Sage Thrasher
Short-eared Owl	Loggerhead Shrike
Common Nighthawk	W. Meadowlark
Say's Phoebe	Sage Sparrow
Violet-green Swallow	
Tree Swallow	
Barn Swallow	
Cliff Swallow	
Pinyon Jay	
Common Raven	
Loggerhead Shrike	
W. Meadowlark	
Vesper Sparrow	
Chipping Sparrow	

Table 8. Frequency distribution of birds flushing at various right angle detection distances from June-August 1971

	Distance (m)											
Species	0- 2.74	3.05- 5.79	6.10- 8.84	9.14-11.89	12.17-14.94	15.24-17.89	18.29-21.03	21.34-24.08	24.38-27.13	27.43-30.18	30.48+	60.96+
Brewer's Sparrow	79	79	70	87	116	124	111	112	53	62	171	71
Horned Lark	36	45	63	71	102	115	91	105	21	44	210	538
Sage Sparrow	10	9	8	14	7	10	3	4	0	4	16	2
Vesper Sparrow	7	3	1	6	1	0	1	1	1	3	3	8
Sage Thrasher	10	4	8	16	14	11	3	8	4	9	27	82
Meadow-lark	11	8	3	8	8	6	6	10	1	12	37	104
Mourning Dove	7	6	2	0	1	4	0	2	0	0	4	13

Biomass estimates are given in Tables 9-12. These estimates were calculated by multiplying the monthly population estimates by the mean dry weight of each species as given in Table 13.

Territorial mapping (Williamson, 1964) was done on two 12-ha plots gridded within the northern sage site. This site was chosen for this mapping technique because it offered a large number of breeding birds and the most homogeneous vegetation of the three sites on which birds nested. Unfortunately, only the Brewer's sparrow had sufficiently small territories and nesting densities high enough to allow for a projected estimate on a 100 ha basis.

New maps of the plots were carried into the field each day and the locations of all individuals were plotted. Particular attention was given to simultaneously singing males, the location of nests and plotting the locations of characteristic behavior patterns which were exhibited in the vicinity of the nests. These factors were most valuable in determining, from seasonal composite maps, the number of territories present.

One plot contained 13 territories and the other contained eight territories. Very local situations within both plots had high nesting densities. The average size of each territory, when both plots were combined, was 1.14 ha per pair. The nesting density, on a 100 ha site, would then be 89 pairs or 178 individuals. This compares quite favorably with the line transect estimate for June, which was 162 birds/100 ha. These results indicated that Emlen's line transect technique was accurate when applied during the Brewer's sparrow nesting period. Perhaps this method will become more accurate as more sighting distances are compiled for other species.

Data on nest success and productivity are summarized in Table 14. Nests of all species were very difficult to locate and several species (e.g. western meadowlark, horned lark and sage sparrow) are not represented in this Table. It is believed horned larks had probably completed nesting when intensive sampling began in early June.

Some Brewer's sparrows still had young in the nest until mid-July, but most young had fledged by the end of June. This species did not renest if the first clutch was successful. The actual nesting period for the Brewer's sparrow is from the last week in May until mid-July.

Only five sage thrasher nests were found and three of these still had eggs in the nest in mid-July. These July nests, most likely, represent second broods with the nesting activities terminating early in August.

Table 9. Avian biomass on northern shrub site (dry weight in kg/100 ha)——DSCODE A3UBJG1

Species	Jan Feb Mar 71	72	Apr 71	72	May 71	72	June 71	72	July 71	72	Aug 71	72	Sept 71	72	Oct Nov Dec 71	72
Mourning Dove	-	-	-	.07	-	.17	-	.1	.98	.2	.95	.2	.24	-	0	-
Blk -b. Magpie	-	-	-	0	-	.09	-	0	.05	.09	0	.14	.05	-	.09	-
Sage Thrasher	-	-	-	0	-	.19	-	.15	.07	.26	.18	34	.02	-	0	-
L. Shrike	-	-	-	0	-	.02	-	.02	.03	.04	.04	.06	0	-	.02	-
W. Meadowlark	-	-	-	.2	-	.29	-	.29	.38	.32	.23	.26	.38	-	.4	-
Sage Sparrow	-	-	-	0	-	.01	-	.03	.04	.04	.06	.05	.08	-	.01	-
Brewer's Sp.	-	-	-	0	-	.47	-	.51	.53	73	.48	.44	.16	-	0	-
Total	-	-	-	.27	-	1.24	-	1.1	2.08	1.68	1.94	1.35	93	-	.52	-

Table 10. Avian biomass on northern grass site (dry weight in kg/100 ha)——DSCODE A3UBJG2

Species	Jan Feb Mar 71	72	Apr 71	72	May 71	72	June 71	72	July 71	72	Aug 71	72	Sept 71	72	Oct Nov Dec 71	72
Gray Flycatcher	-	0	-	0	-	0	-	.01	Tr	.01	Tr	.01	0	-	0	-
Horned Lark	-	.08	-	.04	-	0	-	0	.02	0	.05	0	.15	-	.22	-
Sage Thrasher	-	0	-	.04	-	.12	-	.07	.2	.11	.06	.14	0	-	0	-
L. Shrike	-	0	-	0	-	0	-	0	0	0	Tr	0	0	-	0	-
W. Meadowlark	-	.2	-	.09	-	.09	-	.14	.14	.09	.14	.11	.23	-	.2	-
Vesper Sparrow	-	0	-	.05	-	.05	-	.32	.09	.2	.07	.12	0	-	0	-
Brewer's Sp.	-	0	-	0	-	.33	-	.54	.26	.73	.18	.49	.07	-	0	-
Total	-	.28	-	.22	-	.59	-	1.08	.71	1.14	.5	.87	.45	-	.42	-

Table 11. Avian biomass on southern shrub site (dry weight in kg/100 ha)——DSCODE A3UBJG3

Species	Jan Feb Mar 71	72	Apr 71	72	May 71	72	June 71	72	July 71	72	Aug 71	72	Sept 71	72	Oct Nov Dec 71	72
Sage Thrasher	-	0	-	.08	-	.2	-	.27	.12	.26	.17	.19	0	.09	0	0
Horned Lark	-	.9	-	.45	-	.44	-	.96	.23	.69	.34	.43	.2	.17	.17	.23
Sage Sparrow	-	.11	-	.04	-	.11	-	.08	.03	.07	.08	.08	.05	.07	.04	0
Brewer's Sparrow	-	0	-	.02	-	.24	-	.22	.19	.23	.16	.1	.05	.03	0	0
Total	-	1.01	-	.59	-	.99	-	1.53	.57	1.25	.75	.8	.3	.36	.21	.23

Table 12. Avian biomass on southern grass site (dry weight in kg/100 ha)——DSCODE A3UBJG4

Species	Jan Feb Mar 71	Jan Feb Mar 72	Apr 71	Apr 72	May 71	May 72	June 71	June 72	July 71	July 72	Aug 71	Aug 72	Sept 71	Sept 72	Oct Nov Dec 71	Oct Nov Dec 72
Horned Lark	-	0	-	.75	-	1.13	-	.5	1.52	.93	1.56	.99	.34	.08	.34	.39
Total	-	0	-	.75	-	1.13	-	.5	1.52	.93	1.56	.99	.34	.08	.34	.39

Table 13. Sex age and average weights of the more common species of birds on the sites during the summer, 1971*

Species	Number	Sex	Age	Weight	Est. Dry Weight (g)
Horned Lark	28	M	Ad.	29.6	8.88
" "	15	F	Ad.	28.0	8.4
" "	42	?	Imm.	26.8	8.04
" "	85	All	---	27.9	8.37
Brewer's Sparrow	10	M	Ad.	10.6	3.18
" "	3	F	Ad.	9.5	2.85
" "	10	?	Imm.	10.8	3.24
" "	23	All	---	10.5	3.15
Mourning Dove	12	M	Ad.	115.4	34.62
" "	10	F	Ad.	109.8	32.94
" "	22	All	Ad.	112.9	33.87
Meadowlark	8	M	Ad.	103.8	31.14
"	3	F	Ad.	76.8	23.04
"	11	All	Ad.	95.9	28.77
Sage Sparrow	3	M	Ad.	18.2	5.46
" "	3	?	Imm.	16.7	5.01
" "	6	All	---	17.4	5.22
Vesper Sparrow	4	All	---	24.2	7.26
Sage Thrasher	2	F	Ad.	39.3	11.79
Blk.-b. Magpie				156.0	46.8

*Note: Most birds were shot; however, a few others (especially horned larks) were netted, banded and released. Other weights were taken either from the literature or from museum specimens. Dry weights are based on the assumption of 70% water content.

Table 14. Nest success and productivity on the sites, 1972

	Successful Nests	Unsuccessful Nests	Young Fledged/Nest (all nests included)
Northern Shrub			
Brewer's Sparrow	17	5	2.5
Sage Thrasher	1	1	2.0
Mourning Dove	7	0	2.0
Northern Grass			
Brewer's Sparrow	10	0	3.1
Vesper Sparrow	2	0	3.0
Gray Flycatcher	1	0	4.0
Southern Shrub			
Brewer's Sparrow	4	1	2.0
Sage Thrasher	3	0	3.3
C. Nighthawk	1	0	2.0

Very few mourning doves were seen on the sites in June, but many flew over the areas during the morning transect counts. Six of the seven mourning dove nests on the north shrub site were discovered in July. These are probably second or third nestings and this species most likely nested elsewhere earlier in the summer.

Line transect methods of estimating densities of passerines involved many variables, i.e. weather, time of day or season, inter-observer variability, inconspicuousness of birds and the screening effect of different vegetation types. Some of these variables were at least partially eliminated. All counts were done during the same time each day under favorable weather conditions (e.g. non-raining sky and wind velocity less than 10 m.p.h.). During July and August, early morning temperatures became quite warm before transect counts could be completed. Field notes indicate that this marked increase in temperature obviously decreased the number of birds detected during the latter part of these transects. It was impossible to circumvent this problem. Seasonal differences in conspicuousness, caused by behavioral mechanisms, were compensated for by changes in the widths of the 100% coverage strips. Most species became more conspicuous after the nesting season and the result was 100% coverage strips that extend to greater distances (Table 1).

Table 15. Observer variability in population density estimates on the sites of the more common avian species - 1972 ($\bar{x}$ = mean value)

Species	June Olson	June Powers	June $\bar{x}$	July Olson	July Powers	July $\bar{x}$	August Olson	August Powers	August $\bar{x}$
Northern Shrub									
Brewer's Sp.	160	164	162	262	200	231	152	128	139
Sage Sparrow	9	4	6	9	6	7	11	9	10
S. Thrasher	6	20	13	20	25	22	25	32	29
W. Meadowlark	11	8	10	9	12	11	10	8	9
Northern Grass									
Brewer's Sp.	150	193	172	221	243	232	159	153	156
Vesper Sp.	49	33	44	29	23	27	16	16	16
S. Thrasher	5	7	6	6	13	9	11	14	12
W. Meadowlark	8	3	5	2	3	3	2	5	4
Southern Shrub									
Brewer's Sp.	64	74	69	71	75	73	30	32	31
Sage Sparrow	18	12	15	13	13	13	17	16	17
S. Thrasher	19	27	23	22	23	22	16	16	16
Horned Lark	115	--	115	70	92	81	56	46	51
Southern Grass									
Horned Lark	60	--	60	117	105	111	118	--	118

Inter-observer variability was reduced as much as was possible. Both observers, in the summer of 1972, recorded data in exactly the same manner (e.g. distances were measured with rangefinders, transect routes were identical, etc.). Field experience in 1971 proved to be invaluable as a guideline for correct procedures for 1972 research. Inter-observer variability might be credited to each individual's sensory acuity or the marked change in activity of birds on some days. Table 15 represents each observer's monthly density estimate for the more common species.

Several species, i.e. vesper sparrow, sage sparrow and horned larks, characteristically run away from observers without being seen. Horned larks run on the ground and flush at long distances from the transect line, but vesper and sage sparrows seldom flush. This factor may result in population densities for vesper and sage sparrows that are considerably underestimated. Extreme secrecy of vesper sparrows, during the post-breeding season, resulted in density estimates that were lower than during the nesting season.

Conspicuousness of a species is related not only to behavioral characteristics, but also to the screening effects of different vegetation types. When many sightings can be recorded, as with Brewer's sparrows, the screening effect of vegetation will be detected and corrected for, by the change in widths of the proximal 100% coverage strips (Table 1).

D. 3 RODENTS

Introduction

The research design calls for an initial inventory of rodent species on each validation site and periodic estimates of density and biomass of these species. This was begun in August, 1971, and continued in August, 1972. It was felt that a post-breeding sample at this time of year would give the most useful information possible with the manpower and budgetary constraints of the program. This report contains an inventory of the species, estimates of their biomass, and data on population structure on all four sites.

Methods

Small mammal populations were sampled by live-trapping with 7.6 x 7.6 x 25.4 cm (3 x 3 x 10 in) Sherman livetraps baited with peanut butter and rolled oats. Traps were distributed in a 12 x 12 grid, two traps per station at 15-m intervals. Bedding material was provided to reduce trap mortality when nighttime temperatures approached freezing. Traps were set at 3:00-5:00 p.m. and checked at 8:00-10:00 a.m.; the traps were left inactive during mid-day hours. In most cases each grid was run for five consecutive nights.

All animals were toe-clipped for identification, removing not more than one toe from each front foot and two toes from each hind foot. Data, including species, sex, age, sexual condition, and weight in g, were recorded in the field on computer-compatible forms. Age determinations were subjective judgements based upon size, weight and appearance, separating animals into three age classes, juvenile, subadult and adult.

In all cases sampling grids were placed such that a complete numbered hectare was located in the lower left of the grid as shown in Figures 1-4. The grid location is identified by the number of this hectare.

During 1971 we sampled each of the northern sites and the south shrub site with two trapping grids. The south grass was sampled by only one grid. During the 1972 season, only one grid was sampled on each of the northern sites. We increased our effort on our southern sites, sampling three grids on the shrub and two grids on the grass.

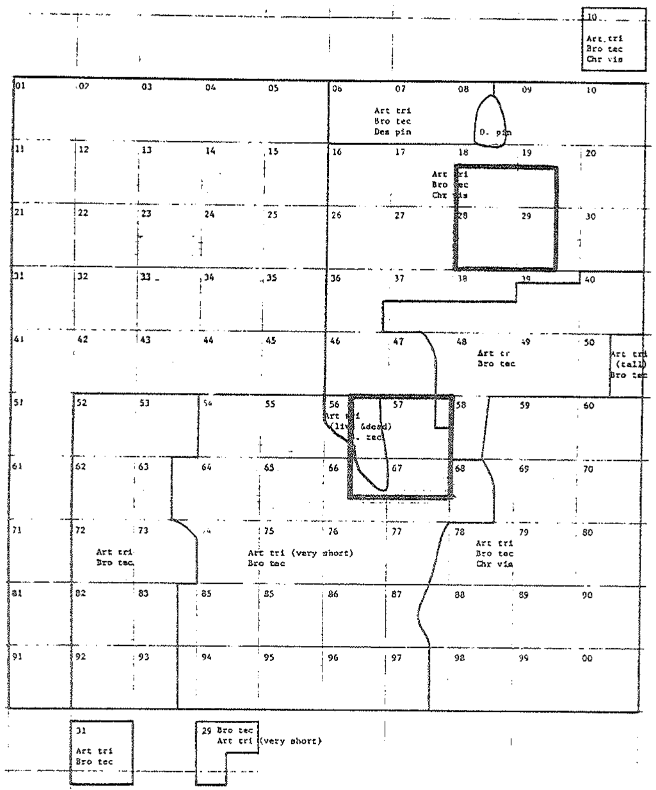


Figure 1. Location of 12 x 12 trapping grids on northern shrub site.

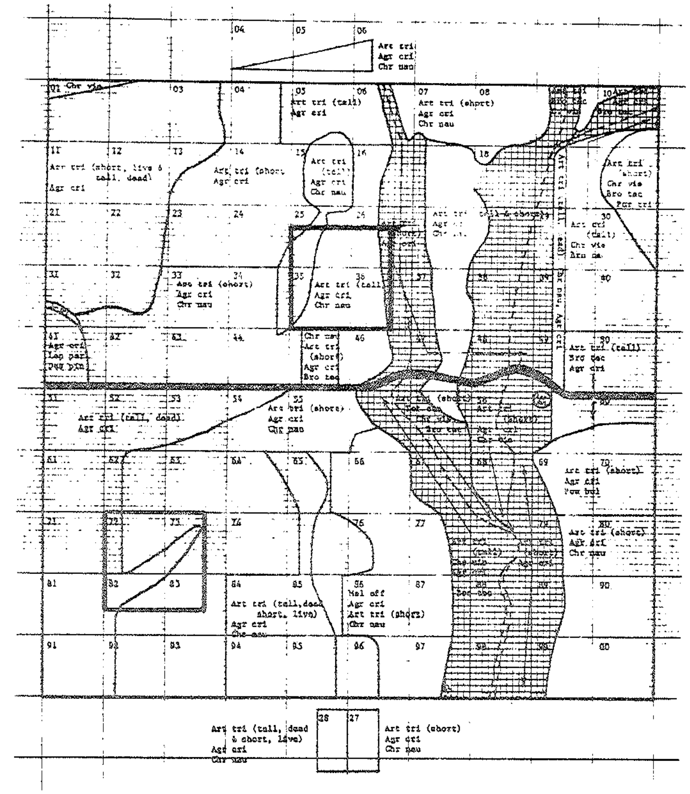


Figure 2. Location of 12 x 12 trapping grids on northern grass site.

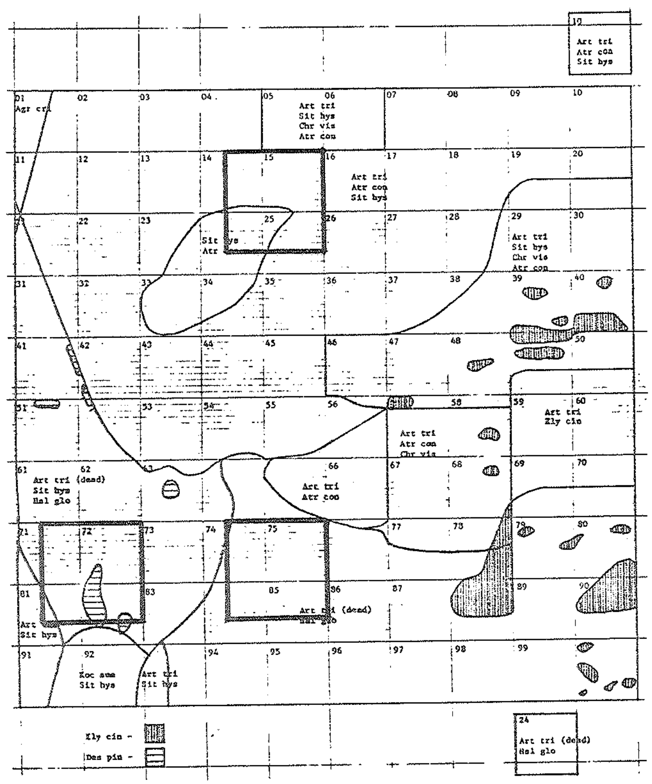


Figure 3. Location of 12 x 12 trapping grids on the southern shrub site.

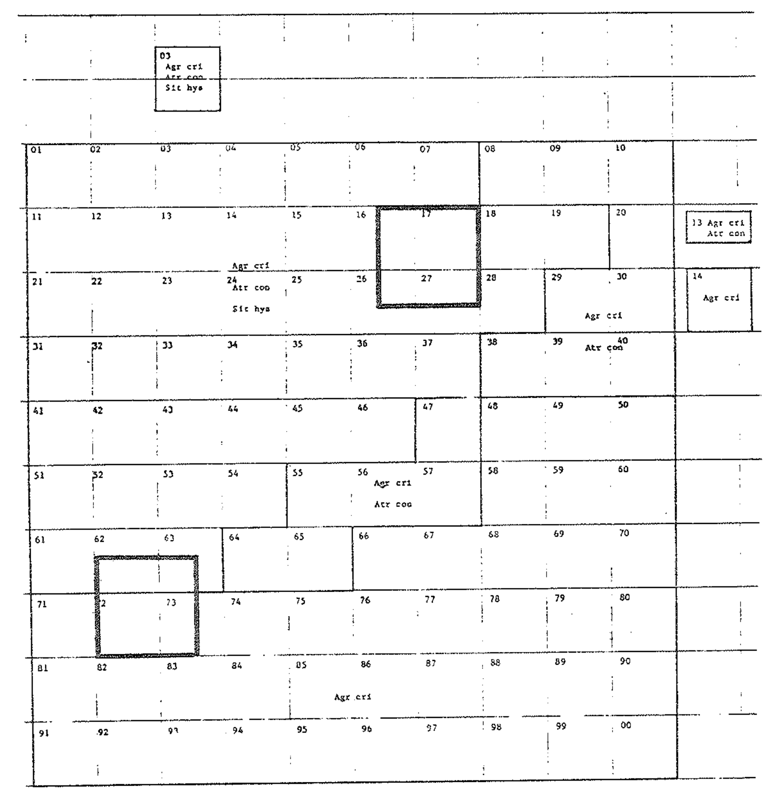


Figure 4. Location of 12 x 12 trapping grid on the southern grass site.

Home range

Home range estimates were made for each animal captured at three or more locations using the elliptical method proposed by Jennrich and Turner (1969). This method was chosen as it has high statistical stability and is free of sample size bias (Turner et al., 1971). Also, as Stumpf and Mohr (1962) have shown, home ranges of small mammals tend to be linear rather than circular. This being the case, a home range area calculated on the basis of an elliptical shape more probably approximates reality than one that assumes circularity.

When sufficient individual home ranges for a species were obtained, these were pooled according to the Jennrich and Turner (1969) formula to form a common estimate of home range area. Because of the relatively short sampling period, many animals had too few captures for Jennrich and Turner home range area estimates to be made. For these animals (those captured at two or more locations) the distance between successive captures, the mean of this distance, and the maximum distance between captures, were calculated as in Brant (1962).

In order to approximate Jennrich and Turner home range estimates, a multiple regression formula was developed relating home range area to these other movement parameters. The equation chosen,

$$Y = 0.078 + 0.098x^2 \quad (r^2 = .65)$$

predicts home range from the square of the distance between successive captures (Figure 5). In cases where only a few Jennrich and Turner estimates could be made directly, the rest were approximated by the regression technique and both types of estimate combined to provide a pooled home range area for the species. These cases are indicated by a single asterisk in the home range column of population Tables.

In cases where no Jennrich and Turner estimates could be made, the regression method alone was used. The mean of these regression estimates was then used as a pooled home range area for the species. These cases are indicated by a double asterisk in the home range column.

In most cases we determined a pooled home range area for each species using one of the above methods. The sample grid was then expanded by the diameter of a circle of the area of the pooled home range to estimate the area actually sampled. This is as described by Turner et al. (1971).

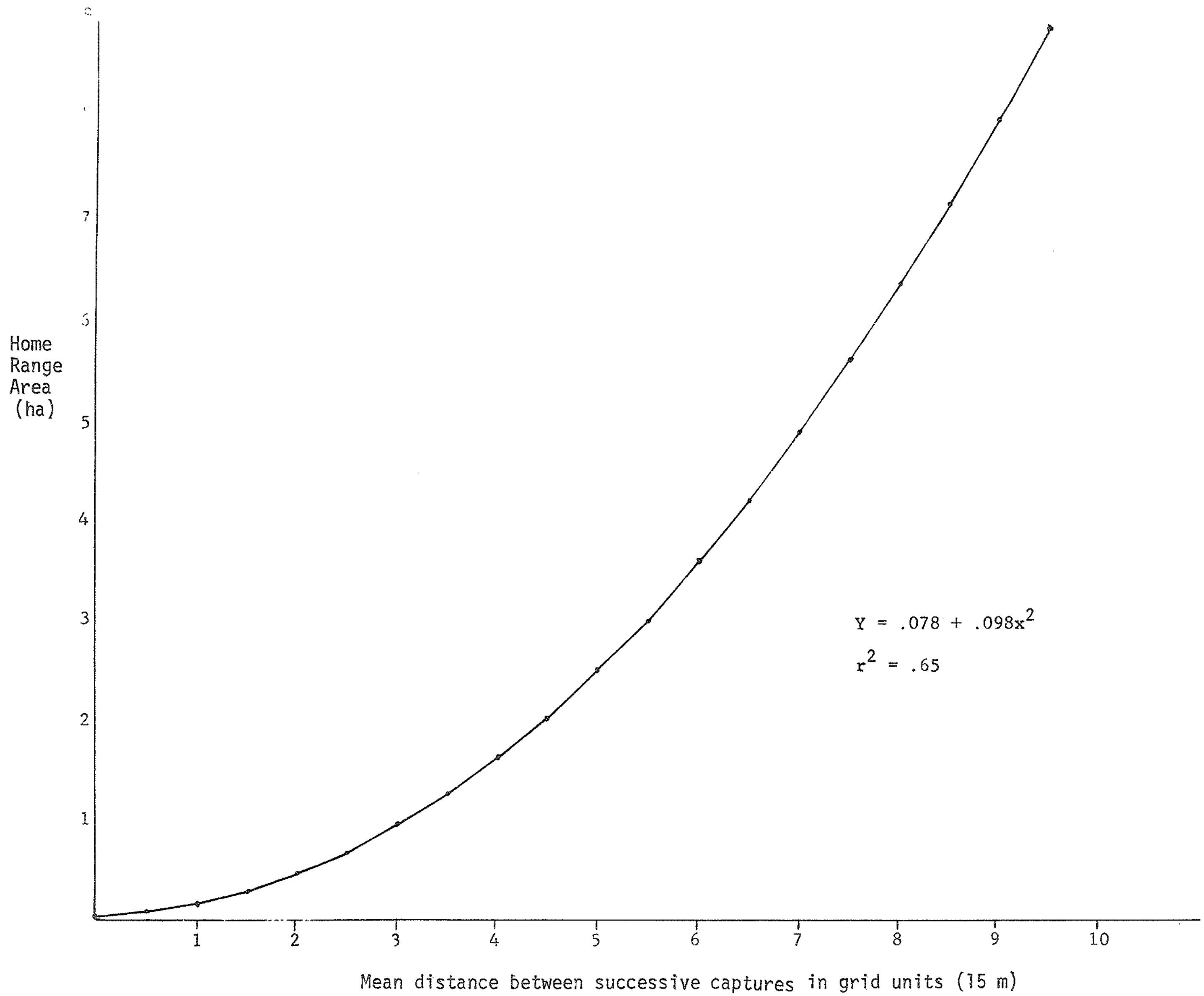


Figure 5. Regression equation for predicting home range area from movement data.

In a few cases these two methods were not feasible as animals were captured at only one point, so no movement data were available. When this was the case, the grid was expanded by the distance between traps as an approximation of the area sampled. A triple asterisk in the home range column indicates this method was used.

Density estimates

Because this report is intended to supercede the 1971 report, all estimates that appeared in that report have been revised and are presented here. There is considerable discrepancy between these estimates and those in the 1971 report because of improvements in methodology in 1972.

It was decided that the Schnabel (1938) method be used as modified by Overton(1965) to allow for known reduction of population size. This estimator uses a basic Lincoln Index but in effect averages a series of daily estimates. This estimate is then adjusted upwards to allow for known mortality. An advantage is that confidence limits are easily calculated from a table devised by Chapman (1948) and discussed by Hanson (1967). In most cases density estimates are based on this method.

Although in some cases the Schnabel estimate was somewhat below the actual number of animals captured, these estimates were still used in estimating density. This was because in all cases the actual number of animals captured was within the bounds of the 95% confidence limits on the Schnabel estimate, and the discrepancy was never large. The difference is possibly due to the effects of mortality, immigration and emigration during the trapping period.

In the few cases where no other estimator is possible, the actual number of animals captured is used as the basis of density estimates. These cases are obvious in the tables that follow.

Density estimates are calculated by dividing the population estimate by the adjusted sample area determined from home range and movement figures.

Biomass

All biomass estimates are given in g of dry weight. Animals were weighed to the nearest g when captured. Mean weights were calculated for each species in a sample. A 70% water content was assumed in converting these means to dry weight.

The mean weight figure for each species in a sample was converted to dry weight and multiplied by the computed density estimate to yield a biomass per ha figure.

As stated above, 95% confidence limits were determined for the Schnabel estimates using the table developed by Chapman (1948) and discussed by Hanson (1967). In some cases our sample values fell outside the range of Chapman's table; in such cases confidence limits were approximated by extrapolation.

Confidence limits are given only for the estimated population within the area sampled. Limits are not given for the density and biomass estimates themselves as these are both based on estimates of home range area for which we have no error estimate. An approximation could be obtained by dividing the upper and lower limits given by the estimated area sampled.

DSCODES for this study are A3UBJH1-4.

Results

The results are presented in tabular form for each site. Sample years are presented separately. The six-letter species code used in the collection of data is used in all tables for brevity. A list of all rodent species observed on the sites to date and their codes is found in Table 16.

The apparent discrepancy in number of animals between the sex and age ratio tables and the other tables for a sample is due to the fact that sex and age data are not available for all individuals because of escapes, etc. The sex and age ratios include only those animals for which these data are available.

An asterisk in the Pooled Home Range column indicates that the estimate is the result of pooling estimates based on both the Jennrich and Turner (1969) formula and the regression equation; a double asterisk indicates that the estimate is based on the regression equation alone; a triple asterisk indicates that the area sampled is based on the arbitrary expansion of the grid by the intertrap distance.

The northern shrub site was sampled by trapping grids located in two different hectares (Fig. 1). Both hectares were sampled in 1971; only one was sampled in 1972. (A3UBJH1).

Hectare 28 is located in an area of tall *Artemisia tridentata* at low to medium density with mixed grass and forbs. This vegetation type predominates in the northern portion of the shrub site. Results of the 1971 and 1972 samples are presented in Tables 17-21.

Hectare 57 is located in an area of low, scrubby *Artemisia tridentata*. This area was cultivated at one time and consequently the vegetation differs considerably in physiognomy from the northern portion of the site. Hectare 57 was sampled in 1971 only. Results of this sample are presented in Tables 22 and 23.

Table 16. Rodent species observed on Curlew Valley Validation Sites

Species	Species Code	N. Shrub	N. Grass	S. Shrub	S. Grass
Spermophilus towsendii	SPETOW			x	x
Eutamias minimus	EUTMIN	x	x	x	x
Perognathus parvus	PERPAR	x	x	x	x
Dipodomys microps	DIPMIC			x	x
Dipodomys ordii	DIPORD	x		x	
Reithrodontomys megalotis	REIMEG			x	x
Peromyscus maniculatus	PERMAN	x	x	x	x
Peromyscus truei	PERTRU		x		
Onychomys leucogaster	ONYLEU	x	x	x	
Lagarus curtatus	LAGCUR	x	x	x	

Table 17. Species, sex, and age structure of rodents on northern shrub site (hectare 28, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	65	37	28	43	13	32	20
PERPAR	57	31	26	46	2	23	32
EUTMIN	5	4	1	20	0	3	2
ONYLEU	4	1	3	75	2	1	1

Table 18. Estimated population numbers, density, and biomass on northern shrub site (hectare 28, 1971)

Species	Number Captured	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	66	5	63	49-75	.49	5.95	10.59	4.7	49.73
PERPAR	57	4	60	35-76	.26	4.95	12.12	5	60.6
EUTMIN	6	0	-	-	***	3.24	1.85	8.6	13.59
ONYLEU	4	0	7	2-21	.68**	6.66	1.05	5.1	5.36
Total									129.28

*See text for explanation of asterisks.

Table 19. Species, sex and age structure of rodents on northern shrub site (hectare 28, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	31	20	11	33	0	13	17
PERPAR	67	30	37	55	0	14	53
EUTMIN	13	7	6	46	0	0	13
ONYLEU	1	1	0	0	0	0	1
LAGCUR	1	0	1	100	0	0	1

Table 20. Estimated population numbers, density, and biomass on northern shrub site (hectare 28, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	31	2	37	23- 57	.74	6.86	5.39	4.7	25.33
PERPAR	67	0	80	65-100	.32	5.24	15.27	5.1	77.83
EUTMIN	14	0	31	8.5- 91	.21**	4.7	6.6	9.3	61.38
ONYLEU	1	0	-	-	.18*	4.53	.22	5.9	1.3
LAGCUR	1	0	-	-	***	3.24	.31	5.1	1.58
Total									167.42

*See text for explanation of asterisks

Table 21. Changes in estimated rodent density and biomass on northern shrub site (hectare 28, 1971-1972)

Species	No Captured 1971	No Captured 1972	Change in Captures 1971-1972	Estimated Density 1971 (no/ha)	Estimated Density 1972 (no/ha)	Change in Density 1971-1972	Estimated Biomass 1971 (g/ha)	Estimated Biomass 1972 (g/ha)	Change in Biomass 1971-1972
PERMAN	66	31	-35	10.59	5.39	-5.2	49.73	25.33	-24.4
PERPAR	57	67	+10	12.12	15.27	-3.15	60.60	77.83	+17.23
EUTMIN	6	14	- 8	1.85	6.6	+4.75	13.59	61.38	+47.79
ONYLEU	4	1	- 3	1.05	.22	- .83	5.36	1.3	- 4.06
LAGCUR	0	1	+ 1	-	.31	+ .31	-	1.58	+ 1.58
Total							129.28	167.42	+38.14

Table 22. Species, sex, and age structure of rodents on northern shrub site (hectare 57, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	70	40	30	43	14	28	28
PERPAR	45	27	18	40	12	15	18
EUTMIN	21	15	6	29	0	4	17
ONYLEU	3	1	2	67	1	1	1
LAGCUR	1	1	0	0	0	0	1
DIPORD	1	0	1	100	1	0	0

Table 23. Estimated population numbers, density, and biomass on northern shrub site (hectare 57, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	71	13	65	52-77	.41	5.63	11.54	4.5	51.93
PERPAR	45	1	54	38-72	.52*	6.07	8.90	4.8	42.72
EUTMIN	24	4	32	17-52	.95*	7.56	4.23	8.7	36.8
ONYLEU	3	0	--	--	.47**	5.87	.51	5.4	2.75
LAGCUR	1	0	--	--	***	3.24	.31	4.2	1.3
DIPORD	1	1	--	--	***	3.24	.31	10.8	3.35
Total									138.85

*See text for explanation of asterisks.

The northern grass site was also sampled by trapping grids located in two different hectares (Fig. 2). Both were sampled in 1971; only one was sampled in 1972 (A3UBJH2).

Hectare 35 is an area of *Chrysothamnus viscidiflorus*, *Artemisia tridentata* and *Agropyron cristatum*. This grid also sampled a portion of a large ravine or gully. Hectare 35 was sampled only in 1971. The results of that sample are presented in Tables 24 and 25.

Hectare 72 is located in an area of tall, dead *Artemisia tridentata* and relatively open areas of *Agropyron cristatum*. During the 1971 sample this area had been grazed heavily and had extensive areas of bare ground; the 1972 sample immediately preceded grazing and consequently the area was much more lush with *Agropyron cristatum* filling the previously bare areas. Results of the 1971 and 1972 samples are presented in Tables 26 - 30.

The southern shrub site was sampled by trapping grids located in three different hectares, representing three distinct vegetation types (Fig. 3). Two of these grids were sampled in both 1971 and 1972; the third was sampled in 1972 only (A3UBJH3).

Hectare 15 is located in a native shrub community consisting of *Artemisia tridentata, Atriplex confertifolia* and occasional *Chrysothamnus viscidiflorus*. The native grass *Sitanion hystrix* is common in this area also. This grid was sampled in both 1971 and 1972. Results of these samples are given in Tables 31-35.

Table 24. Species, sex, and age structure of rodents on northern grass site (hectare 35, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	74	29	45	61	7	42	25
PERPAR	31	16	15	48	3	16	12
EUTMIN	35	26	9	26	0	7	28
LAGCUR	4	1	3	75	1	0	3
ONYLEU	1	1	0	0	0	0	1
PERTRU	1	1	0	0	0	0	1

Table 25. Estimated population numbers, density, and biomass on northern grass site (hectare 35, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	76	9	70	56-79	.82	7.14	9.8	4.5	44.1
PERPAR	33	1	32	28-92	.42	5.67	5.64	4.7	26.51
EUTMIN	35	0	53	22-42	2.12*	10.84	4.89	8.6	42.05
LAGCUR	4	2	--	--	***	3.24	1.23	5.7	5.99
ONYLEU	1	0	--	--	1.06**	3.18	.31	6.5	2.02
PERTRU	1	0	--	--	.57**	6.26	.16	4.2	.67
Total									121.34

*See text for explanation of asterisks

Table 26. Species, sex, and age structure of rodents on northern grass site (hectare 72, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	39	19	20	51	2	23	14
PERPAR	10	3	7	70	0	1	9
EUTMIN	9	7	2	22	0	1	8

Table 27. Estimated population numbers, density, and biomass on northern grass site (hectare 72, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	41	10	38	28-50	.73	6.83	5.57	3.9	23.4
PERPAR	10	0	10	7-15	.29	5.1	1.96	4.7	9.21
EUTMIN	10	0	16	4-60	4.6*	16.57	.97	9.3	9.02
Total									41.63

*See text for explanation of asterisks.

Table 28. Species, sex, and age structure of rodents on northern grass site (hectare 72, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	32	18	14	44	2	8	22
PERPAR	24	15	9	38	1	10	13
EUTMIN	16	8	8	50	0	0	16
LAGCUR	5	0	5	100	0	3	2
ONYLEU	3	1	2	67	0	2	1

Table 29. Estimated population numbers, density, and biomass on northern grass site (hectare 72, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	33	1	35	26-87	1.11*	8.06	4.34	5.1	22.13
PERPAR	24	0	31	16-63	.27*	5	6.2	4.7	29.14
EUTMIN	18	0	29	11-62	.61	6.41	4.52	9.6	43.39
LAGCUR	5	0	--	--	.18**	4.53	1.1	5.4	5.94
ONYLEU	3	0	--	--	***	3.24	.93	6.2	5.77
Total									106.37

Table 30. Changes in estimated rodent density and biomass on northern grass site (hectare 72, 1971-1972)

Species	No. Captured 1971	No. Captured 1972	Change in Captures 1971-1972	Estimated Density 1971 (no/ha)	Estimated Density 1972 (no/ha)	Change in Densitv 1971-1972	Estimated Biomass 1971 (g/ha)	Estimated Biomass 1972 (g/ha)	Change in Biomass 1971-1972
PERMAN	41	33	- 8	5.57	4.34	-1.23	23.4	22.13	- 1.27
PERPAR	10	24	+14	1.96	6.2	+4.24	9.21	29.14	+19.93
EUTMIN	10	18	+ 8	.97	4.52	+3.55	9.02	43.39	+34.37
LAGCUR	0	5	+ 5	--	1.1	+1.1	--	5.94	+ 5.94
ONYLEU	0	3	+ 3	--	.93	+ .93	--	5.77	+ 5.77
Total							41.63	106.37	+64.74

Table 31. Species, sex, and age structure of rodents on southern shrub site (hectare 15, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	7	4	3	43	0	2	5
PERPAR	3	2	1	33	0	0	3
EUTMIN	4	2	2	50	0	0	4
ONYLEU	1	1	0	0	1	0	0
DIPMIC	2	2	0	0	0	0	2

Table 32. Estimated population numbers, density, and biomass on southern site (hectare 15, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	7	0	6	3-10	.87	7.3	.82	6.2	5.08
PERPAR	3	0	--	--	3.7**	14.6	.21	6.3	1.32
EUTMIN	5	0	--	--	.96**	7.59	.53	8.9	4.72
ONYLEU	1	0	--	--	.57**	6.26	.16	5.6	8.48
DIPMIC	2	0	--	--	***	3.24	.62	16.2	10.04
Total									29.64

*See text for explanation of asterisks.

Table 33. Species, sex, and age structure of rodents on southern shrub site (hectare 15, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	13	11	2	15	1	7	5
PERPAR	33	11	22	67	2	12	19
EUTMIN	15	8	7	47	0	1	14
DIPMIC	12	2	10	80	0	3	7

Table 34. Estimated population numbers, density, and biomass on southern shrub site (hectare 15, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	13	7	19	14-26	1.27*	8.54	2.22	4.2	9.32
PERPAR	44	12	42	34-52	.65	6.54	6.42	4.7	30.17
EUTMIN	15	2	25	10-55	1.08*	7.97	3.14	8.4	26.38
DIPMIC	10	2	12	5-24	.61	6.41	1.87	17.6	15.31
Total									81.18

*See text for explanation of asterisks.

Table 35. Changes in estimated rodent density and biomass on southern shrub site (hectare 15, 1971-1972)

Species	No.Captured 1971	No.Captured 1972	Change in Captures 1971-1972	Estimated Density 1971 (no/ha)	Estimated Density 1972 (no/ha)	Change in Density 1971-1972	Estimated Biomass 1971 (g/ha)	Estimated Biomass 1972 (g/ha)	Change in Biomass 1971-1972
PERMAN	7	13	+ 6	.82	2.22	+1.4	5.08	9.32	+ 4.24
PERPAR	3	44	+41	.21	6.42	+6.21	1.32	30.17	+28.85
EUTMIN	5	15	+10	.53	3.14	+2.61	4.72	26.38	+21.66
ONYLEU	1	0	- 1	.16	--	- .16	8.48	--	- 8.48
DIPMIC	2	10	+ 8	.62	1.87	+1.25	10.04	15.31	+ 5.27

Hectare 72 is located in an area that has been disturbed sometime in the past and now consists primarily of an annual chenopod community. *Bassia hyssopifolia, Salsola kali* and *Halogeton glomerata* are the dominant species with occasional patches of the mustards *Lepidium perfoliatum* and *Descurainia pinnata*. Virtually no shrub cover is present though the remains of an *Artemisia tridentata* community is present as standing dead and litter. This grid was sampled in 1972 only. Results of this sample are presented in Tables 36-37.

Hectare 75 is located in a vegetation type somewhat intermediate between the two described above. *Artemisia tridentata* is the predominant shrub but appears to be dying out as most individuals are dead or unhealthy. We did, however, observe some seedlings of this species in the area this year. *Halogeton glomerata* is present in this area in large, dense stands. There are occasional patches of *Salsola kali*. This area was sampled both in 1971 and 1972. Results of both samples are presented in Tables 38-42.

The southern grass site was sampled by trapping grids located in two different hectares (Fig. 4). This site was a single vegetation type. It consists of a fairly uniform stand of *Agropyron cristatum*.

Hectare 17 was sampled only in 1972. Results of this sample are presented in Tables 43 and 44. Hectare 72 was sampled in both years. These results are presented in Tables 45-49 (A3UBJH4).

Table 36. Species, sex, and age structure of rodents on southern shrub site (hectare 72, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	18	10	8	46	0	2	16
PERPAR	11	9	2	25	0	0	11
DIPORD	8	6	2	18	0	0	8

Table 37. Estimated population numbers, density, and biomass on southern shrub site (hectare 72, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	18	4	19	13-27	.47	5.87	3.24	5	16.2
PERPAR	11	1	12	7-19	.39*	5.54	2.17	5	10.85
EUTMIN	1	0	--	--	***	3.24	.31	8 4	2.6
DIPORD	8	0	5	3-9	.41*	5.63	.89	14.7	13.08
Total									42.73

*See text for explanation of asterisks.

Table 38. Species, sex, and age structure of rodents on southern shrub site (hectare 75, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	24	15	9	38	3	10	11
PERPAR	2	2	0	0	2	0	0
EUTMIN	13	5	8	62	1	3	9

Table 39. Estimated population numbers, density, and biomass on southern shrub site (hectare 75, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	25	0	22	16-31	1.99	10.51	2.09	5.4	11.29
PERPAR	2	0	--	--	***	3.24	.62	4.1	2.54
EUTMIN	13	0	28	6-111	3.37**	13.85	2.02	8.7	17.57
Total									31.4

Table 40. Species, sex, and age structure of rodents on southern shrub site (hectare 75, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	55	35	20	36	0	36	19
PERPAR	11	7	4	36	0	3	0
EUTMIN	15	7	8	53	0	0	15
ONYLEU	1	1	0	0	0	0	1
DIPMIC	1	0	1	100	0	0	1
DIPORD	18	8	10	56	0	1	17
REIMEG	3	2	1	33	0	0	3

Table 41. Estimated population numbers, density, and biomass on southern shrub site (hectare 75, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	56	3	56	43-66	.49	5.99	9.38	4.1	38.46
PERPAR	11	0	10	6-16	.22*	4.75	2.11	4.7	9.92
EUTMIN	16	0	19	10-31	1.76*	9.90	1.92	8.6	16.51
ONYLEU	1	0	--	--	***	3.24	.31	7.2	2.23
DIPMIC	1	0	--	--	***	3.24	.31	20.4	6.32
DIPORD	19	2	17	11-12	.48*	5.93	2.87	13.5	38.75
REIMEG	3	0	--	--	***	3.24	.93	1.8	1.67
Total									113.86

*See text for explanation of asterisks.

Table 42. Changes in estimated rodent density and biomass on southern shrub site (hectare 75, 1971-1972)

Species	No. Captured 1971	No. Captured 1972	Change in Captures 1971-1972	Estimated Density 1971 (no/ha)	Estimated Density 1972 (no/ha)	Change in Density 1972	Estimated Biomass 1971 (g/ha)	Estimated Biomass 1972 (g/ha)	Change in Biomass 1971-1972
PERMAN	25	56	+31	2.09	9.38	+7.29	11.29	38.46	+27.17
PERPAR	2	11	+ 9	.62	2.11	+1.49	2.54	9.92	+ 7.38
EUTMIN	3	16	+13	2.02	1.92	- .1	17.57	16.51	- 1.06
ONYLEU	0	1	+ 1	--	.31	+ .31	--	2.23	+ 2.23
DIPMIC	0	1	+ 1	--	.31	+ .31	--	6.32	+ 6.32
DIPORD	0	19	+19	--	2.87	+2.87	--	38.75	+38.75
REIMEG	0	3	+ 3	--	.93	+ .93	--	1.67	+ 1.67
Total							31.4	113.86	+82.46

Table 43. Species, sex, and age structure of rodents on southern grass site (hectare 17, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	8	3	5	63	0	2	6
PERPAR	18	11	7	39	0	9	9
REIMEG	5	2	3	60	0	2	3

Table 44. Estimated population numbers, density, and biomass on southern grass site (hectare 17, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	8	0	8	4-12	.72*	6.8	1.18	4.5	5.31
PERPAR	18	1	18	11-27	.54*	6.15	2.93	4.1	11.89
REIMEG	5	0	8	1-42	.57**	6.26	1.28	2.3	2.94
Total									20.14

*See text for explanation of asterisks.

Table 45. Species, sex, and age structure of rodents on southern grass site (hectare 72, 1971)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	5	5	0	0	0	2	3
PERPAR	7	5	2	29	2	4	1
DIPMIC	1	0	1	100	0	0	1

Table 46. Estimated population numbers, density, and biomass on southern grass site (hectare 72, 1971)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	5	0	--	--	1.65**	9.61	.52	5.7	2.96
PERPAR	8	0	--	--	.27**	5.00	1.6	4.8	7.68
DIPMIC	1	0	--	--	***	3.24	.31	15	4.65
Total									15.29

Table 47. Species, sex, and age structure of rodents on southern grass site (hectare 72, 1972)

Species	Number	Males	Females	% Female	Juvenile	Subadult	Adult
PERMAN	11	8	3	27	1	8	2
PERPAR	24	11	13	54	1	6	17
DIPMIC	4	1	3	75	0	2	2
REIMEG	2	1	1	50	0	1	1

Table 48. Estimated population numbers, density, and biomass on southern grass site (hectare 72, 1972)

Species	Number	Number Dead	Schnabel Estimate	Schnabel 95% Confidence Limits	Pooled Home Range (ha)	Area Sampled (ha)	Estimated Density (no/ha)	Mean Dry Weight (g)	Estimated Biomass (g/ha)
PERMAN	11	0	12	5-24	.55*	6.18	1.94	3.8	7.37
PERPAR	27	4	28	15-35	.31*	5.18	5.41	4.5	24.3
DIPMIC	4	0	--	--	***	3.24	1.23	12.6	15.5
REIMEG	2	0	--	--	***	3.24	.62	2.3	1.43
Total									48.6

*See text for explanation of asterisks.

Table 49. Changes in estimated rodent density and biomass on southern grass site (hectare 72, 1971-1972)

Species	No. Captured 1971	No. Captured 1972	Change in Captures 1971-1972	Estimated Density 1971 (no/ha)	Estimated Density 1972 (no/ha)	Change in Density 1971-1972	Estimated Biomass 1971 (g/ha)	Estimated Biomass 1972 (g/ha)	Change in Biomass 1971-1972
PERMAN	5	11	+ 6	.52	1.94	+1.42	2.96	7.37	+ 4.41
PERPAR	8	27	+21	1.6	5.41	+3.81	7.68	24.3	+16.62
DIPMIC	1	4	+ 3	.31	1.23	+ .92	4.65	15.5	+10.85
REIMEG	0	2	+ 2	--	.62	+ .62	--	1.43	+ 1.43
Total							15.29	48.6	+33.31

Besides those species mentioned in Tables 17-49, the Townsend's ground squirrel, *Spermophilus townsendii*, occurs around the southern validation sites. The species was first noticed in early summer, 1972. Its short period of above-ground activity and probable low density allowed it to remain undetected during 1971. We have not yet attempted a density estimate but plan to begin in 1973. This estimate will most likely be based on a count of active burrow systems found on the site.

Regarding the other rodents, we hope to expand our effort beyond the post-breeding samples that were taken in 1971 and 1972. During these years we restricted ourselves to such samples as it was felt that they would provide the most information possible within the budgetary constraints of the program. The size and diversity of the Curlew Valley Validation Sites is such that we are severely limited in our ability to sample each site adequately. Replication has been impossible.

We began de-emphasizing the northern two sites in 1972 in order to increase our sampling intensity in the south. This allowed us to sample the three distinct vegetation types on the south shrub site and to sample two grids on the south grass. We plan to continue the de-emphasis on the north in order that we cover the south more adequately through time. We will begin a pre-breeding sampling program in April, 1973, on the south shrub site

The work to date indicates a general increase in rodent densities and biomass from 1971 to 1972. Figure 6 indicates the nature of these changes with the two most important species, *Peromyscus maniculatus* and *Perognathus parvus*. *Peromyscus* has, on the other hand, increased in density in all areas sampled.

Figure 7 shows that, even though there was a decrease in *Peromyscus* density on the northern sites, the increase in other species more than compensated for this loss and there was a net increase in total rodent biomass on all of the sites.

An examination os the data in Figures 6 and 7 and Tables 17-49 makes it obvious that there is a large amount of variation in species composition and density between samples taken in different areas. These differences may be ascribed to differing vegetation type.

This relationship between the rodent population and the vegetative community is illustrated in Figures 8 and 9. Figure 8 is a map of the vegetation types we have defined on the south shrub. Figure 9 is a graph showing the species composition and their densities in samples taken within each of these three vegetation types. Points of particular interest are the inversion in relative abundance of *Peromyscus* and *Perognathus* between the *Artemisia/Artiplex* community and the others. *Perognathus* is predominant only in the *Artemisia/Atriplex* community. Also, there is a nearly complete inversion in species of *Dipodomys* between the *Artemisia/Atriplex* community and the others. *D. microps* is the only species of *Dipodomys* present in the native shrub type; *D. ordii* is the predominant species in the other two types.

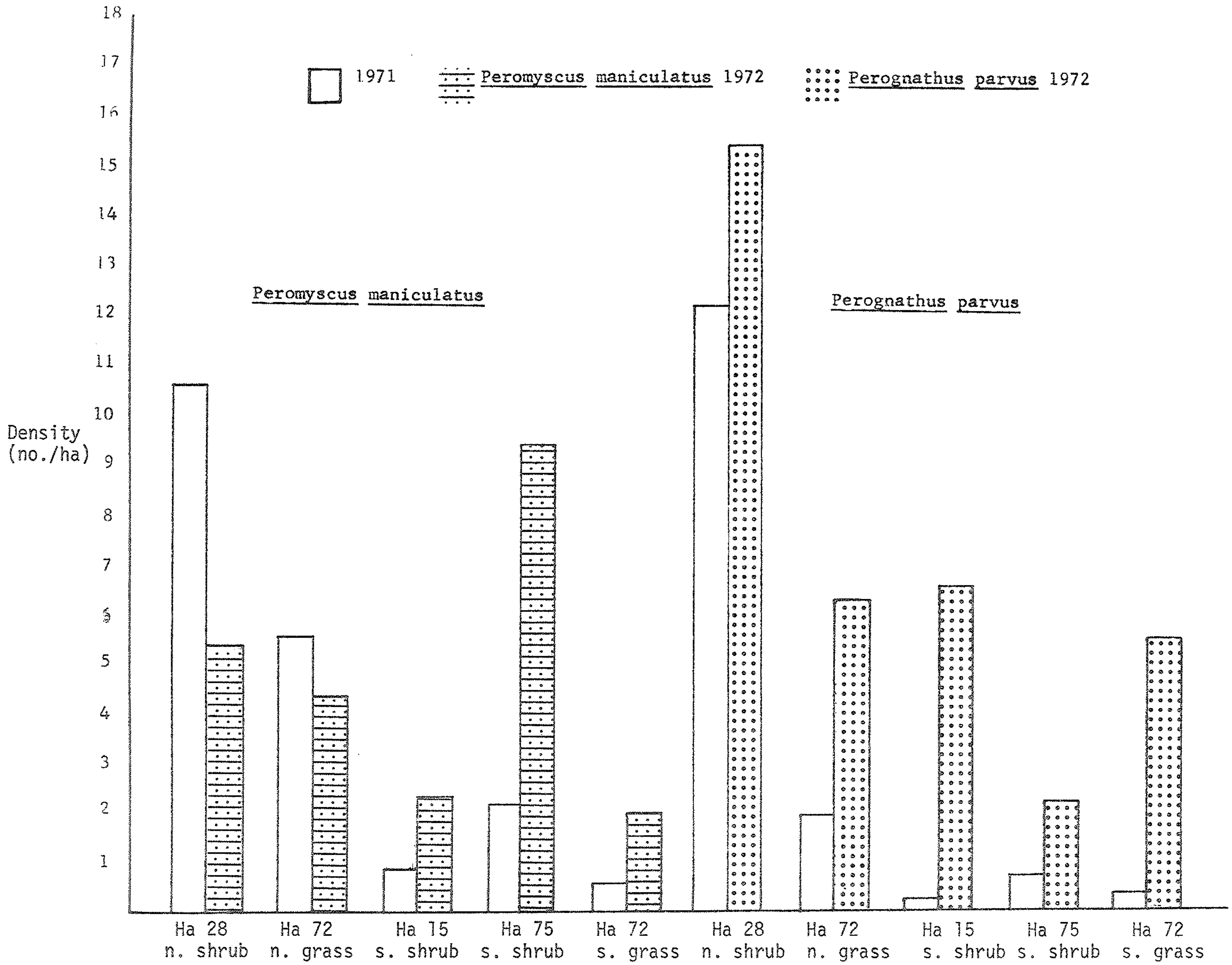


Figure 6. Changes in estimated density of two rodent species on Curlew Valley Validation Sites, 1971-1972.

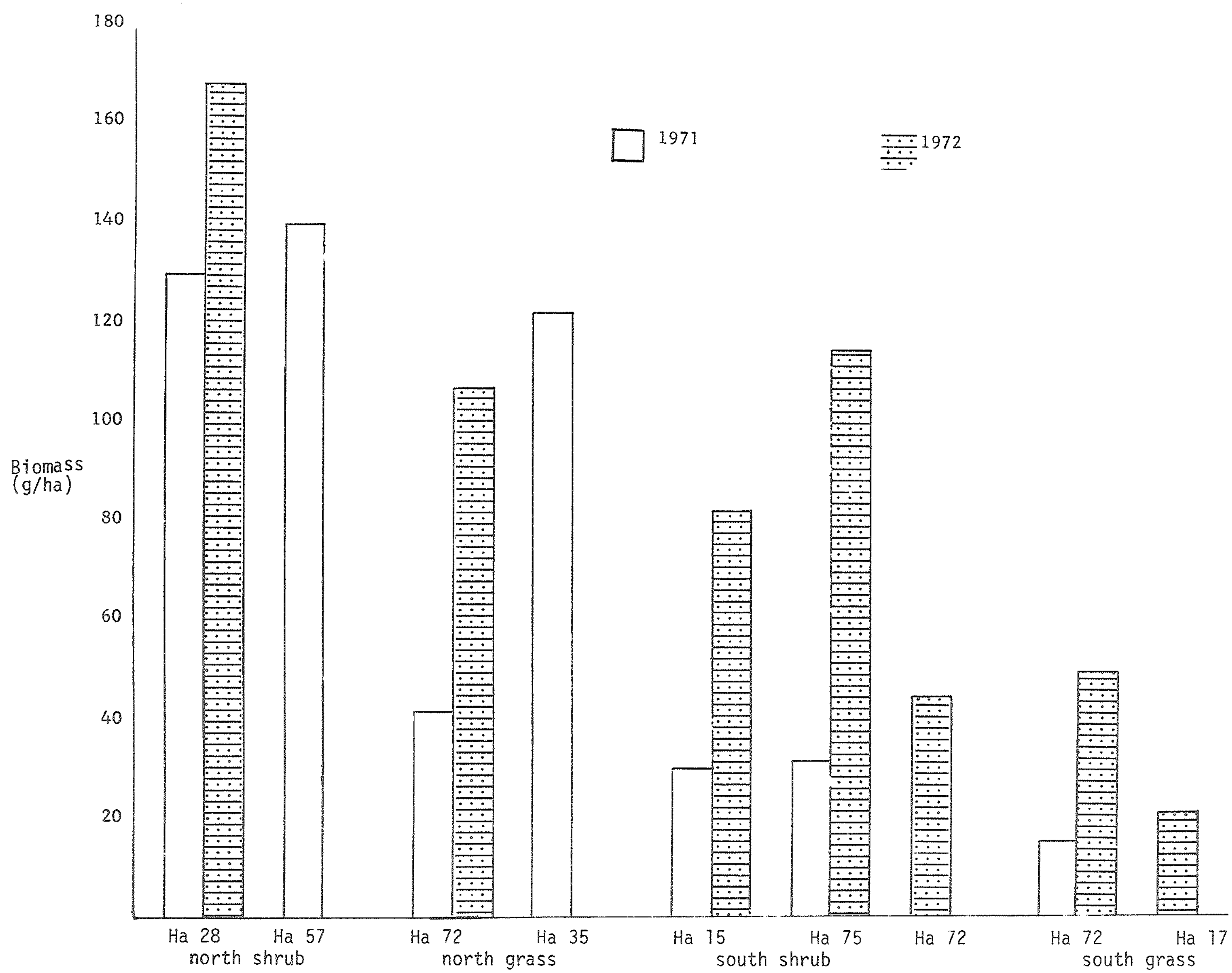


Figure 7. Changes in total estimated rodent biomass on Curlew Valley Validation Sites, 1971-1972.

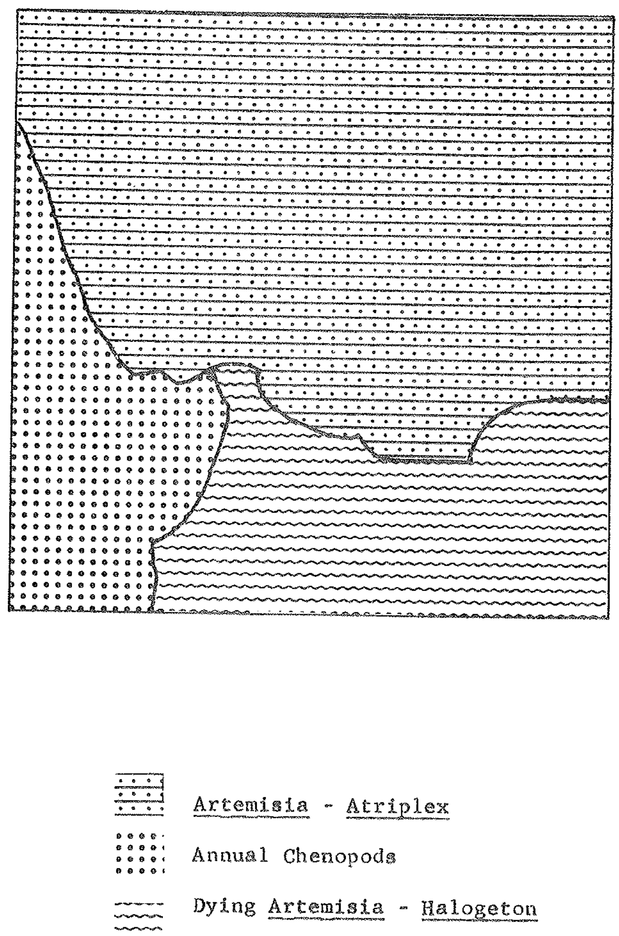


Figure 8. Vegetation map showing defined vegetation types on southern shrub site.

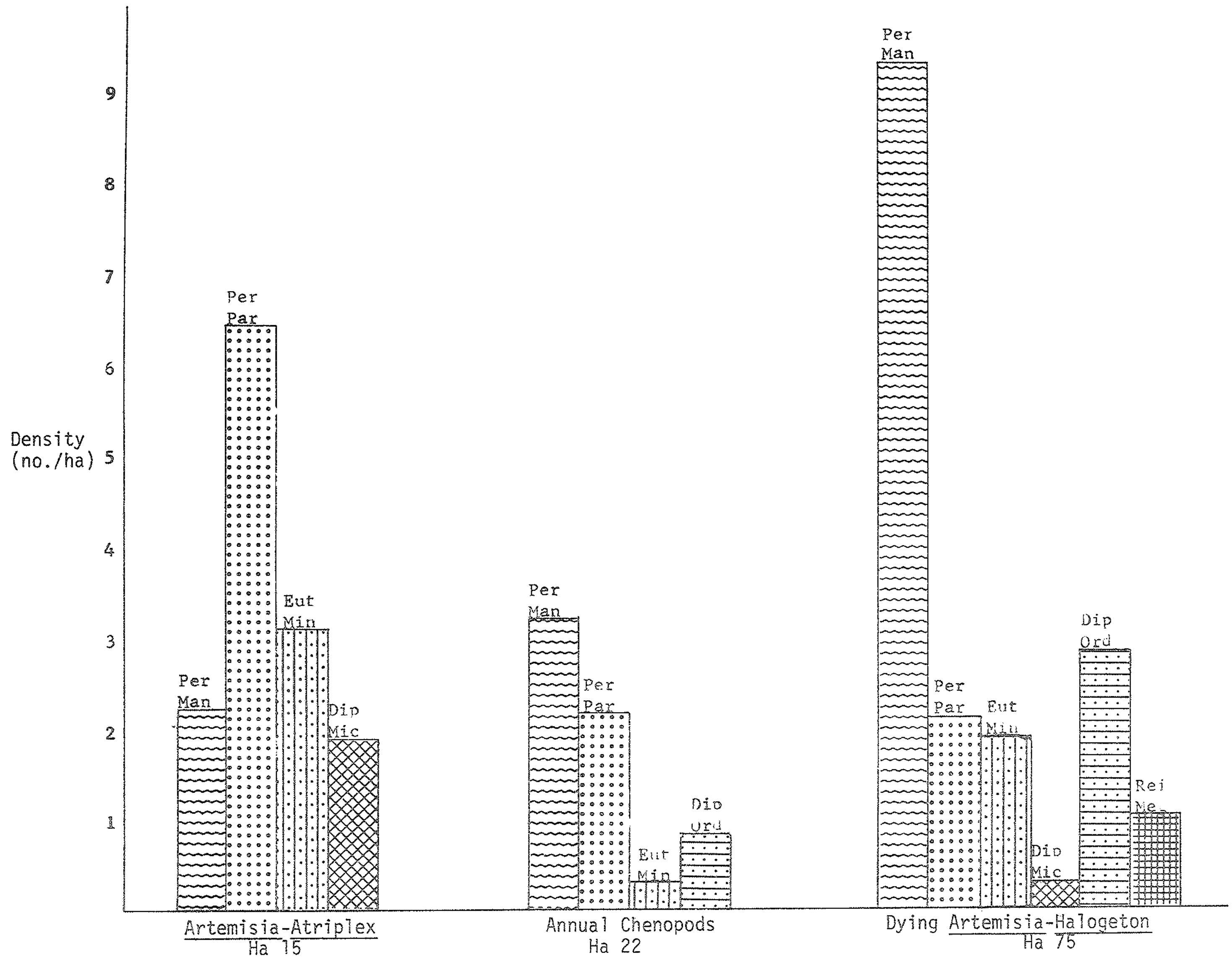


Figure 9. Estimated rodent density by species in three vegetation types, south shrub site, 1972.

These vegetational relationships are most likely due to differing cover and food requirements of the various species. For instance, Johnson (1961) demonstrated the differing food habits of *Dipodomys microps* and *D. ordii*. *D. microps* relied heavily on *Atriplex confertifolia* while *D. ordii* subsisted on a variety of plants including *Halogeton* and various mustards. Further, Johnson found that the distribution of *D. microps* closely paralleled that of *A. confertifolia*. These findings are borne out by our own data as indicated above.

In addition, the distribution of *Perognathus parvus* on the south shrub site somewhat follows the findings of Rosenzweig (1973) that *Perognathus* sp. avoids open areas free of shrub cover.

At the moment we are unable to do more than speculate as to these relationships as we have no food habits or cover preference data for rodents in these areas. We hope to be able to do a certain amount of work along this line in 1973.

There are certain problems of methodology yet to be solved; some of these will probably evade solution for a long time. All estimates presented here are really "best guesses" and are continually subject to reinterpretation.

One of the basic problems is failure to meet the requisite assumptions for the various estimators in use. Nearly all of the Lincoln Index-type estimators have as their basic assumption equal catchability; in other words, randomness of capture. There is evidence that there are behavioral differences between animals in response to traps that may negate the assumption of randomness. This had been well substantiated in the literature (Young, Nees, and Emlen, 1952; Geis, 1955; Balph, 1968; Crowcroft and Jeffers, 1961; Huber, 1962; and others) and is indicated in the results of this study. It appears that this differential trap-response may be a species-specific trait.

In an effort to test the assumption of randomness we plotted frequency of capture curves for each of the species *Peromyscus maniculatus*, *Perognathus parvus* and *Eutamias minimus*. If there were a neutral response to traps, one would expect these curves to fit a Poisson distribution (Young, Nees, and Emlen, 1952; Geis, 1955; Crowcroft and Jeffers, 1961; and Huber, 1962). A truncated Poisson distribution was fitted to each curve using the method of Cohen (1960) to estimate λ. The goodness of fit was then tested using both the Chi-square and the Kolmogorov-Smirnov test. Results of this are shown in Figures 10-12.

The curve based on the pooled *Peromyscus maniculatus* data is significantly different from the Poisson ($P < .05$) with both the Chi-squared and the Kolmogorov-Smirnov test (Fig. 10). This indicates the failure of the assumption of randomness in *Peromyscus* due to the possible development of either trap avoidance or a trap habit by some individuals.

A similar test conducted on the pooled *Perognathus parvus* data was not so conclusive. The Chi-square test rejected the hypothesis that there was no difference between the frequency of capture curve and the Poisson ($P < .05$), but the Kolmogorov-Smirnov test failed to reject (Fig. 11). We interpret this as indicating a degree of differential trap response though not as pronounced as in *Peromyscus*.

The frequency of capture curve constructed from the pooled *Eutamias minimus* data failed to show a significant difference from the Poisson using both tests (Fig. 12). This may be interpreted as indicating that perhaps the assumption of randomness is being met in this species.

Other methodological problems involve density and home range determinations. We feel that perhaps the best method so far available for determining home range area is the Jennrich and Turner (1969) elliptical method (Turner et al., 1971). The basic problem with this, or any other method, is that at least three capture points are needed to compute an area. With our present 5-day sampling program we are necessarily limited in the number of individual home ranges we can calculate. Many animals will only be captured once or twice during a 5-day program. A remedy would be to increase the length of the sample period. In addition, a longer sampling period would increase the problems of mortality, emigration and immigration. We have made an attempt to increase the number of individual home ranges on which we can base our pooled estimate by approximating them through a regression technique. This is not the best answer but we feel that it is a reasonable compromise.

Another question deals with the value of the multiple-trap (two-trap) stations we presently employ in our trapping grid. The present design requires 288 traps/grid which makes the installation and removal of a grid a rather cumbersome task. If we were to reduce the trapping grid to single trap stations it would even become possible to leave certain trap grids installed through the entire summer. This would make periodic sampling less of a chore. The value of a periodic sample is obvious.

The prime question now is whether the increased efficiency of double-trap stations offsets the added cost of such a design This is a difficult question to answer definitely as many factors must be considered In high density situations it is logical to think that multiple-trap stations are desirable as they do help ensure that open traps are always available to animals. The advantages of multiple-trap stations are not restricted to such high-density situations, however. The increased probability of capture that is gained with an increase in the number of traps at a station may be of great value in obtaining an adequate sample under low density conditions. In this case a double-door trap may suffice.

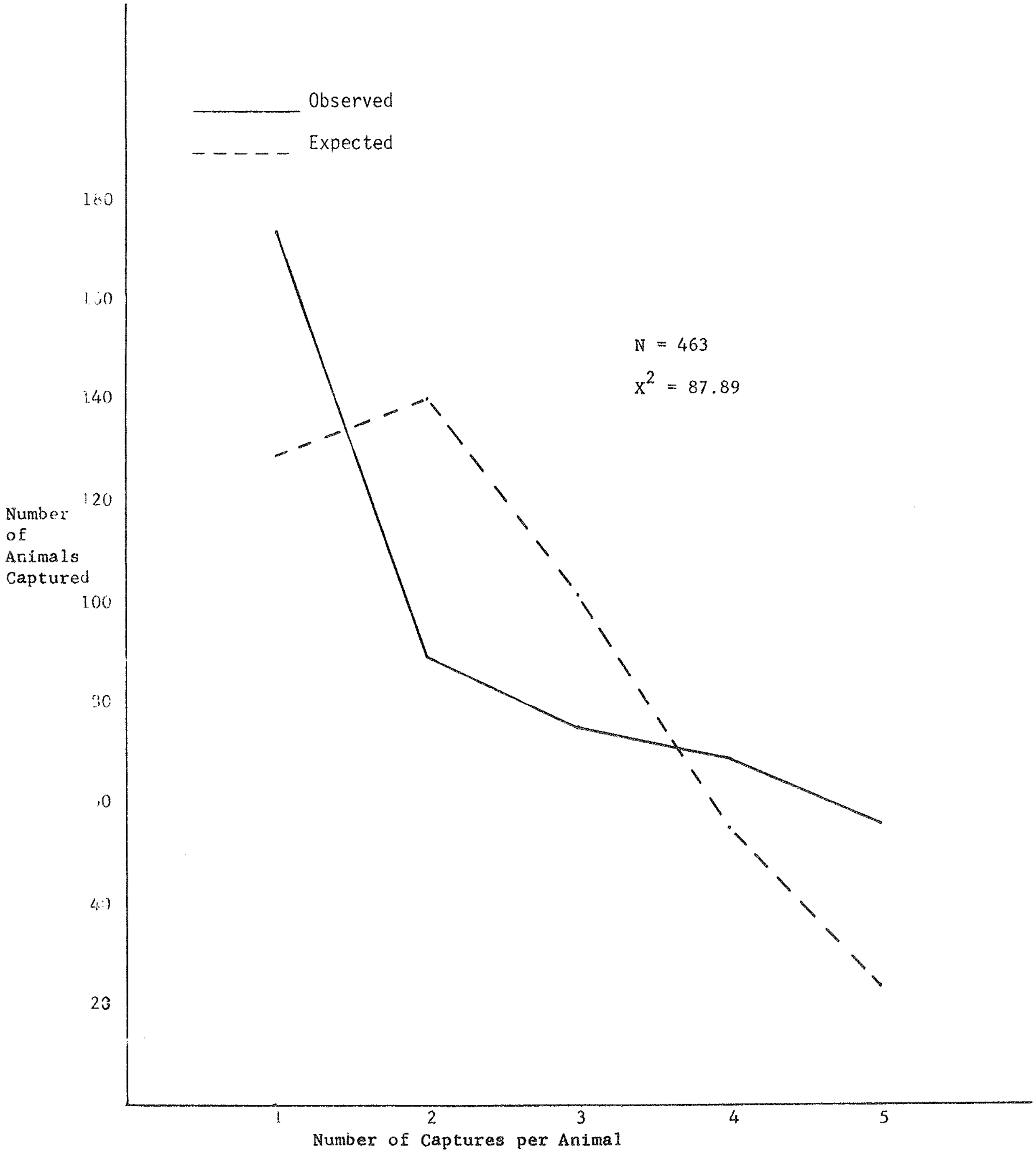


Figure 10. Comparison of *Peromyscus maniculatus* frequency of capture curve with Poisson distribution

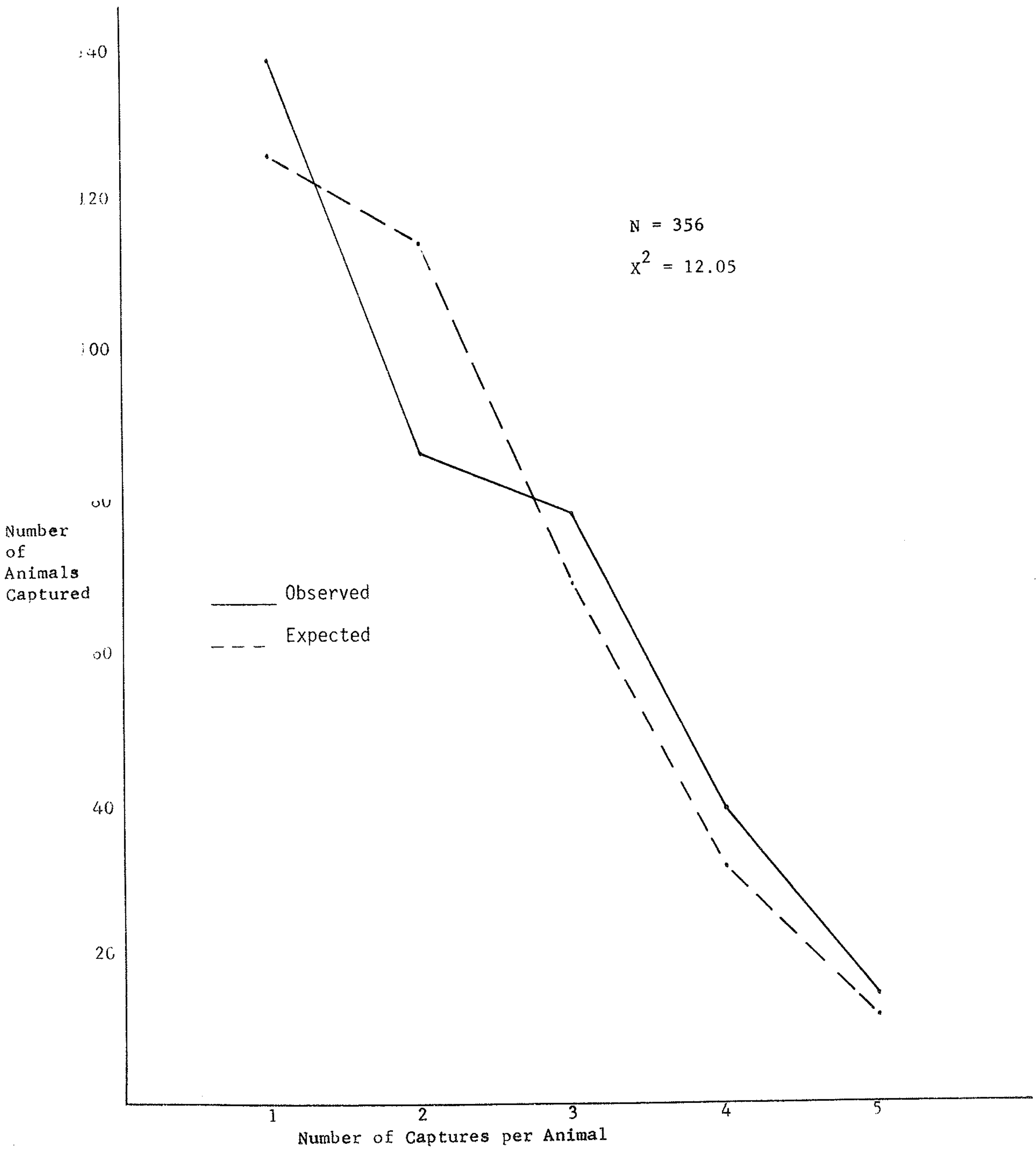


Figure 11. Comparison of *Perognathus parvus* frequency of capture curve with Poisson distribution.

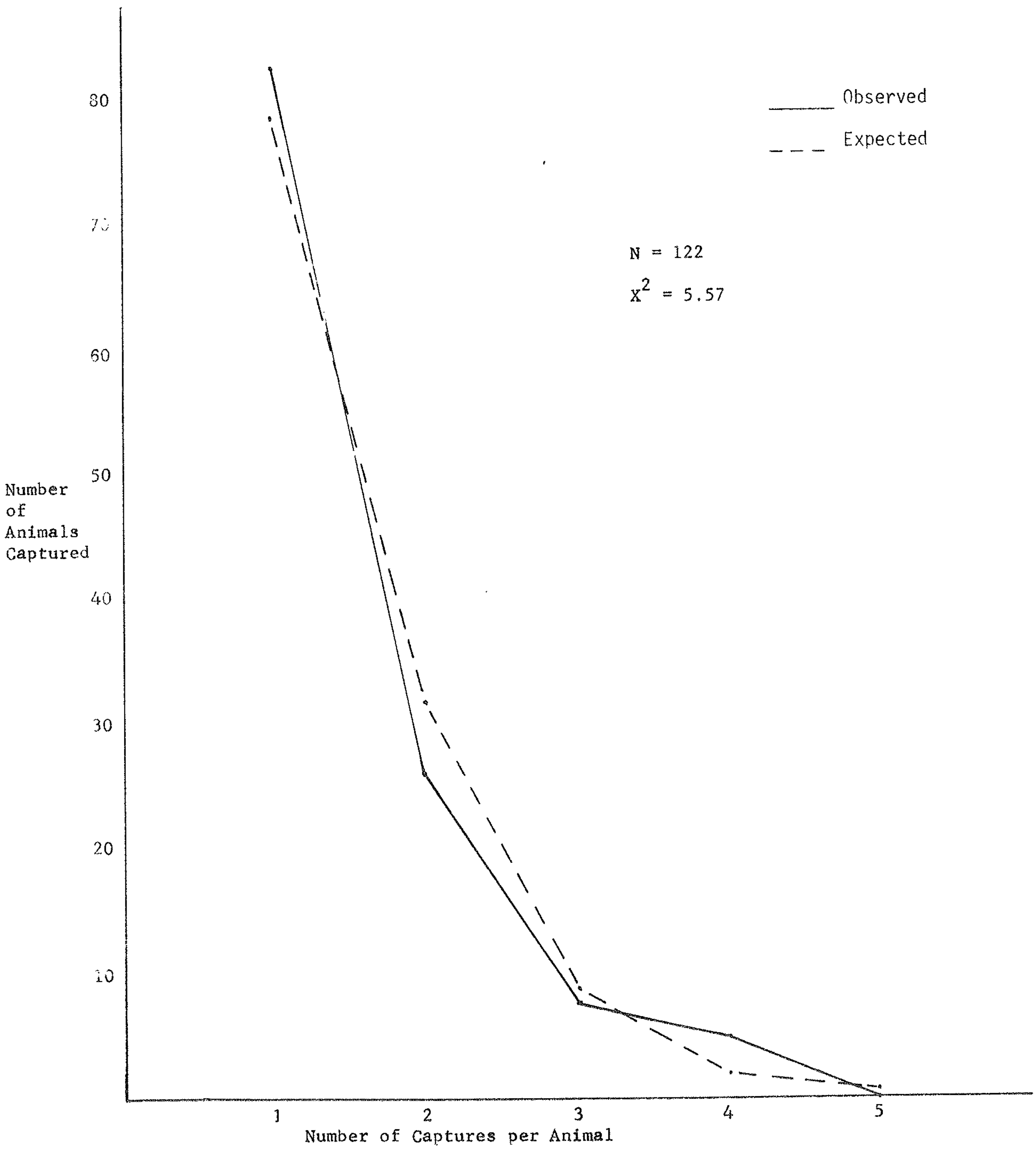


Figure 12. Comparison of *Eutamias minimus* frequency of capture curve with Poisson distribution.

Our validation work to date has resulted in a low rate of double captures. We feel, therefore, that the greatest value gained from our present two-trap design is in the increased probability of capture provided by the two trap entrances. One way to reduce the effort required to operate our present design would be to switch to a double-door trap such as a Havahart. Our work has, in fact, shown that these traps are more efficient than single door Sherman traps; this difference may be attributed to the difference in number of entrances (Balph, 1971; Anderson and Balph, 1972). This would be a reasonable answer were it not for the expense of converting to this type of trap. Also, Havahart traps have some serious disadvantages; they are not as sturdy as Sherman box traps, are difficult to set, and are rather sensitive to wind and rain.

We suggest that these various factors be considered when designing a sampling program. Once a trapping design is selected we then recommend that cumulative capture curves be plotted as a guide to proper length of sampling period. This will allow the trapping program to be run just long enough to obtain the required data.

It is obvious that a trap sampling is of necessity a compromise between many conflicting factors. We must weigh the cost of multiple-trap grids and lengthy sampling periods against the values gained from each in order to arrive at a reasonable sampling system that provides adequate data within the constraints of our budget.

D. 4 LAGOMORPHS

Introduction

Blacktail jackrabbits, *Lepus californicus*, are the most important lagomorph on the sites. Two others, cottontail rabbits (*Sylvilagus nuttalli*) and pygmy rabbits (*S. idahoensis*), also occur, but they are patchily distributed and not very abundant. The jackrabbit is the only lagomorph we have censused to date. This report contains a census of jackrabbit density on the northern sites and the southern shrub site.

Methods

The sampling method used was basically that described by Balph (1971). Each site was divided into two segments, measuring approximately 500 x 100 m and separated by a road. Twenty observers were spaced at intervals around the perimeter, stationed either on foot, on 4-m wooden towers, or on top of trucks, depending upon terrain and visibility. Observers counted all animals seen leaving the area. Those observers watching the dividing road monitored net movement of animals between the two segments of the site. These observers maintained this position from the start of the first drive until the drive line passed them on the second drive.

The drive line consisted of 30 drivers at even spacing across the 500-m width of the drive area. The drive line moved through the site, making as much disturbance as possible. Each driver was required to count only those animals that ran through the line to the rear between the driver on their right and themselves.

Total jackrabbit numbers were easily calculated from the drive data (DSCODE A3UBJI1). Biomass was estimated by assuming a mean live weight of 2,100 g per jackrabbit, based upon 9 years of data from Curlew Valley (L.C. Stoddart, unpublished data). These were converted to dry weight by assuming a 70% live weight water content.

Results

Both northern sites and the south shrub were censused in 1971. Because of the cost and effort of conducting a census, only the south shrub site was censused in 1972. The south grass site has not been censused by drive count because jackrabbit use of that site is confined to nocturnal hours.

Results of these censuses are presented in Table 50 and by graphic comparison in Figure 13.

Table 50. Density and estimated biomass of jackrabbits on Curlew Valley Validation Sites, 1971 and 1972

Site	Area	No. Counted 1971	No. Counted 1972	Change 1971-1972	No./Ha 1971	No./Ha 1972	Change 1971-1972	Biomass (kg/ha) 1971	Biomass (kg/ha) 1972	Change 1971-1972
North shrub	70	182	--	--	2.6	--	--	1.64	--	--
North grass	100	102	--	--	1.02	--	--	.64	--	--
South shrub	100	300	55	-245	3	.55	-2.45	1.89	.35	-1.54
South grass	100	0	0	--	0	0	--	0	0	--

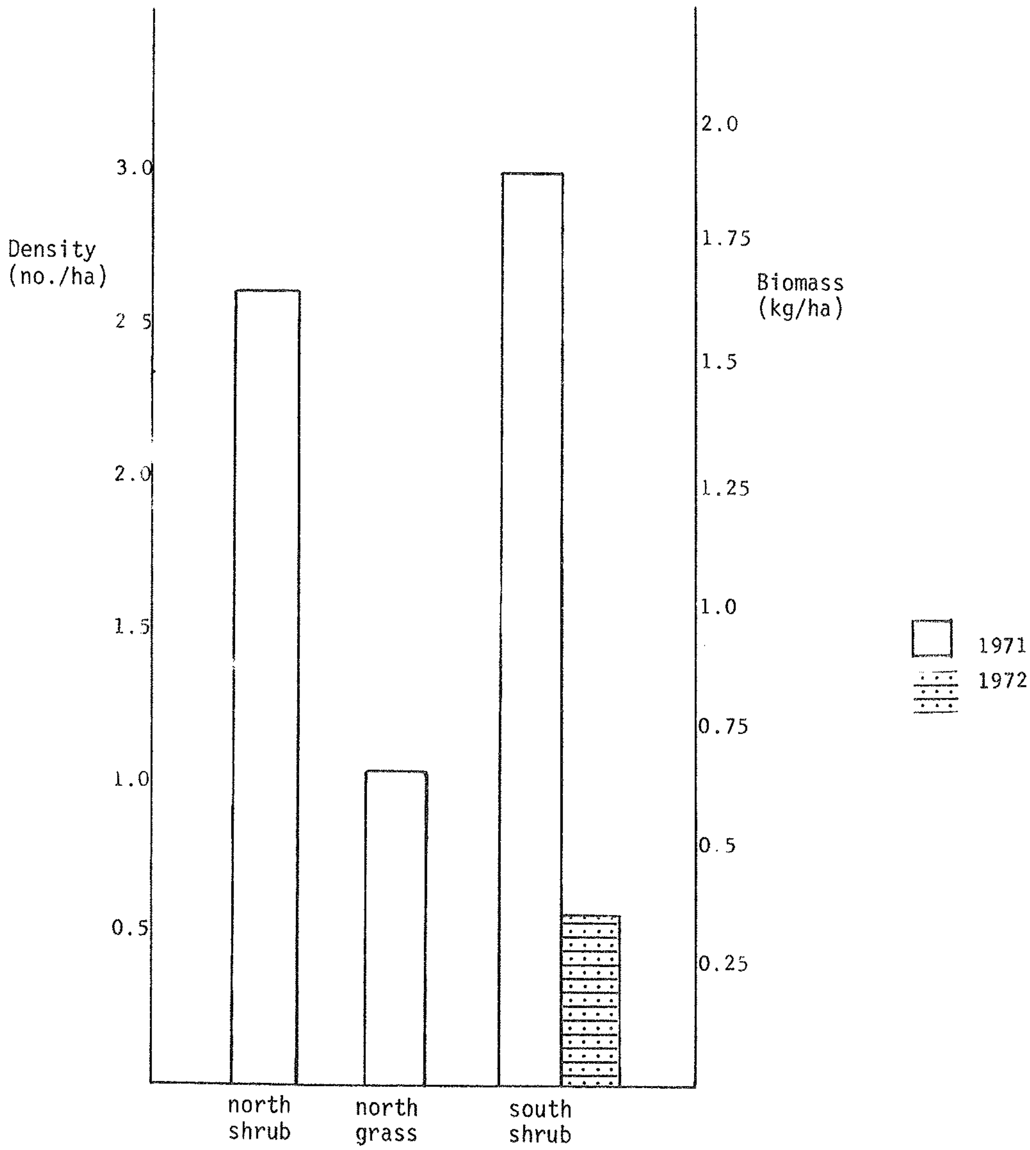


Figure 13. Estimated jackrabbit density and biomass on Curlew Valley Validation Sites, 1971 and 1972.

Jackrabbits were an extremely important member of the herbivorous consumer community. They were present year round and were capable of removing a large amount of vegetation, particularly at times of population highs.

Jackrabbit densities and resultant biomass were very high at the time of the 1971 census. The jackrabbit population fell sharply in 1972, and this was manifested in a very low rabbit count on the sites (Fig. 13).

This population decline appeared to be general throughout Curlew Valley. A square-mile area in another part of the valley was censused at the same time in both 1971 and 1972 as part of a long-term jackrabbit population study. A similar decline was observed in these censuses as well as in a line transect index conducted throughout the valley (L.C. Stoddart, personal communication).

This change in population level was not unexpected. Rabbit populations had been increasing in recent years and were expected to reach a peak and decline. A variety of factors probably contributed to this decline when it occurred:

1. Reproduction in 1972 was evidently down as compared with previous years. L.C. Stoddart (personal communication) has indicated that only an average of 2.5 litters/female were produced versus as many as five litters/female in the past.
2. Juvenile survival may have been lower than normal in 1972. There was a high coyote/rabbit ratio this year and this has been shown to be well correlated with rabbit mortality (Stoddart, 1972).
3. Disease may have played a role in the decline. We found a number of freshly dead rabbits (primarily juveniles) during the spring and summer. These animals exhibited no sign of predation. Three dead animals were collected for autopsy; of these, tularemia was isolated in two, the third being too badly decomposed for a determination (L.C. Stoddart, personal communication).
4. 1972 was a relatively dry year and these drought conditions may have had an adverse effect on the food supply as well as on the rabbits themselves.

All of these factors may be and probably are interrelated; which factor was most responsible is not known at this time. What is known is that the jackrabbit population in Curlew Valley has declined sharply.

D. 5 CATTLE

Introduction

Five-hundred cooperator-owned Hereford cows graze in the area of the southern sites for approximately two and one-half months each winter (15 Nov.-30 Jan.). The actual use of the sites may vary greatly from year to year depending upon the availability of snow as a source of dietary water for the animals (Conway Perry, personal communication).

Our efforts in validation work during 1971 and 1972 were directed toward quantifying cattle grazing use of the southern sites. We hoped to compute an energy budget and energy consumption rate for cattle on the site by using original and published data on biomass, activities, and energy expenditures of grazing cattle. This report covers our attempts to accomplish the following:

1. To quantify days of grazing use by cows on the southern sites.
2. To determine animal biomass changes during the grazing period.
3. To quantify daily activities of grazing cows.
4. To calculate an estimate of daily energy consumption by cows using the site.

Methods

A group of 23 pregnant, grade Hereford cows belonging to cooperator C.H. Steed were selected from the herd of 500 for biomass determinations in 1971. These cows were tagged and weighed individually on 15 November 1971, and were immediately trucked to the Snowville seeding and released. The remainder of the cattle (477 head, belonging to seven other cooperators) were moved to the seeding the following day. The 23 head were again weighed on 21 January 1972, the day following their removal from the seeding. A change in the livestock management routine in 1972 prevented animal biomass determinations during the 1972-73 grazing season that year. Cattle were placed in the area on 23 November in 1972.

Observations of numbers of cattle occupying the sites were made on 23 days spaced irregularly throughout the 1971-72 grazing period and on 17 days spaced at 4-day intervals during the 1972-73 period. These observations consisted of counting the number of cows occupying the grass type and shrub type at 7:00 a.m., 12:00 noon and 3:00 p.m. daily in 1971, and at dawn, 9:00 a.m. 12:00 noon, 3:00 p.m., and dusk in 1972. These values were then averaged across days to give a mean daily occupancy for the two sites as a whole. Observation times were selected on the basis of other research in the vicinity (Benthon Smith, unpublished) indicating that grazing activities began about 7 a.m. each morning and ceased at about 6 p.m. each evening.

Daily distance traveled was computed for individual animals on 15 occasions during the grazing period. Animals were observed during a 24-hour period and their movements were plotted on aerial photographs. Distance traveled was then determined through measurements on the photograph. Other daily activities such as time spent grazing, ruminating, standing, and lying were recorded.

Energy consumption by the grazing cows was calculated according to the method outlined by Cook (1970). Briefly, this method involves the summation of net energy expenditures for various physiological and behavioral functions (maintenance, gestation, locomotion, tissue growth or loss, etc.) of animals of known body weight. Through assumptions of appropriate coefficients for transformation of net energy to metabolizable energy to digestible energy, and further assuming a coefficient for digestibility of gross energy, total gross energy removed per hectare can be calculated indirectly. Calculations and assumptions are illustrated below:

Energy Component and Assumptions	References
Digestible energy (DE) = $\frac{\text{Metabolizable Energy (ME)}}{0.8}$	(Brody, 1945)

1. Maintenance Energy Requirement

$$\text{M.E.} = \frac{81 \times W_{kg}^{.75}}{f_1} + \frac{\text{expenditures for travel + grazing + ruminating + standing}}{f_1}$$

Assumptions:

a.	net energy (NE) for basal metabolism = $81 \times W_{kg}^{.75}$	(Blaxter, 1962)
b.	efficiency factor $f_1 = \frac{NE}{ME} = 0.80$	(Blaxter, 1962)
c.	travel component = 45.18 kcal/100 kg body weight/ 1 km travel	(Brody, 1945)
d.	grazing component = 0.54 kcal/hr/kg	(Graham, 1964)
e.	ruminating component 0.24/kcal/hr/kg	(Graham, 1964)
f.	standing component 0.34/kcal/hr/kg	(Graham, 1964)
g.	maintenance of body temperature = 16.0 kcal/degree-F day below animals' critical temperature of 7° F.	(Young, 1971)

2. Tissue gain or loss

$$ME_{(gain)} = \frac{\text{retained (or lost) energy}}{f_2}$$

Assumptions:

a. retained (lost) energy per kg body weight change = 4190 kcal (Garrett et al., 1959)

b. f_2 = efficiency factor of $\frac{NE}{ME}$ for gain = 0.42 (Blaxter, 1962)

3. Pregnancy

$$ME_{pregnancy} = \frac{\text{Fetus Energy}}{f_3} + \frac{\text{Increased Basal Metabolic Rate}}{f_1}$$

Assumptions:

a. Calving date March 1

b. Average birth weight of calves = 32 kg (Cook, 1970)

c. Fetal growth = 90% during last 8 weeks of gestation (Brody, 1945)

d. Fetal growth during grazing period = 4 kg

e. Composition of fetus:

18.9% protein = 0.76 kg protein = 4,320 kcal
3.3% fat = 0.13 kg fat = 1,235 kcal

f. Maternal tissue growth = 50% during last 8 weeks of gestation (Brody, 1945)

g. Maternal tissue growth during grazing period = 4 kg (Brody, 1945)

h. Composition of maternal tissue:

12.2% protein = 0.5 kg protein = 2,850 kcal
0.92% fat = 0.04 kg fat = 405 kcal

i. Total energy retained in fetus and maternal tissues during grazing period = 4,320 + 1,235 + 2,850 + 405 = 8,800 kcal

j. Daily energy retention = 8,800/66 days = 133 kcal/day

k. Efficiency factor f_3 of fetal growth = 0.40 (Blaxter, 1962)

l. Increased basal metabolism = $81 \times 8^{.75}$ = 386 kcal/day

Results

Biomass fluctuations of cattle during the first year's grazing period are shown in Table 51. An average daily weight loss of 0.136 kg per head was observed.

Table 51. Body weight changes of cattle during a 66-day grazing period, 1971-72

Date	Mean Weight (kg)	S.E.	N.
11-15-71	345		23
1-21-72	336		23

Cattle usage of the southern sites was highly variable, and apparently dependent upon prevailing weather conditions. During the initial year, there was a time lapse of 20 days between introduction of cattle into the area (15 November) and initiation of any appreciable grazing use on the sites (6 December). By 6 December, there was apparently sufficient snow on the ground that animals were no longer dependent upon developed water for meeting their daily water requirements. They tended to use the sites in increasing numbers throughout the remainder of the grazing period (Table 52). During 1972-73, grazing use of the sites began immediately after the cattle were introduced into the seeding, but the rate of use was considerably less than during the initial year. The grassland site received appreciably more grazing use than did the sagebrush shrub site in both years (Table 52).

Daily grazing activities and their energy costs are summarized in Table 53.

Table 52. Grazing use (number of cattle) on the southern Curlew Valley sites

Date	Grass Site		Shrub Site	
	1971-72	1972-73	1971-72	1972-73
Nov. 24	----	55.2	----	10.6
28	----	43.8	----	9.2
Dec. 2	----	45.0	----	4.2
6	24.7	28.8	0.0	2.6
7	16.0	----	0.0	----
8	30.6	----	17.4	----
9	19.0	----	10.0	----
10	----	4.4	----	0.0
11	23.0	----	12.3	----
15	65.0	16.6	29.5	3.4
16	56.0	----	13.0	----
17	63.0	----	29.7	----
18	----	47.8	----	2.8
21	6.5	----	7.0	----
22	87.0	10.0	30.3	2.4
23	81.8	----	22.3	----
26	----	25.8	----	2.2
29	49.7	----	21.3	----
30	----	5.8	----	1.4
Jan. 4	----	9.0	----	0.0
6	14.0	----	61.3	----
8	58.7	0.0	19.3	0.0
11	136.0	----	52.7	----

Continued

Table 52. Continued

Date	Grass Site 1971-72	Grass Site 1972-73	Shrub Site 1971-72	Shrub Site 1972-73
Jan. 12	----	0.0	----	0.0
15	90.7	----	7.0	----
16	----	0.0	----	0.0
20	----	0.0	----	1.4
24	----	0.0	----	0.0
29	----	8.8	----	20.0
Mean daily occupancy	55.0	17.7	22.2	3.5

Table 53. Daily activities and energy expenditures by 340 kg cows on and near the southern sites

Activity	Quantity 1971-72	Quantity 1972-73	Unit Energy Cost	Total Energy Cost 1971-72	Total Energy Cost 1972-73
Grazing (hours)	9.08	9.45	0.54 kcal/hr/kg	1667	1735
Standing (hours)	1.46	1.67	0.34 kcal/hr/kg	169	193
Ruminating (hours)	0.67[a]	8.93	0.24 kcal/hr/kg	55	729
Walking (km)	5.21	6.26	0.45 kcal/km/kg	800	958
Maintenance of body temp.[b]	0.51	1.00	16.00 kcal/degree-F day of sub-critical temperature	8	16
Total Net Energy Expenditure (NE/0.8):				2699	3631
Total Metabolizable Energy Expenditure (ME/0.8):				3374	4539

[a]Daylight observations only.

[b]Number of degree-F days below animal's critical temperature of 7 F prorated over entire grazing season.

The total daily energy budget (metabolizable energy) for the average cow grazing the area was then calculated as:

	1971-72	1972-73
A. Maintenance		
1) Basal Metabolism:[1]	6414 kcal	6414 kcal
2) Activity of maintenance and maintenance of body temperature during periods of cold stress (Table 3)	3374	4539
	3374	4539
B. Tissue Loss:[1]	-1357	-1357
C. Pregnancy:[1]	816	816
D. Calculated total daily ME consumption	9247	10412
E. Calculated daily digestible energy consumption:	11558	13015

[1]Assumed to be similar for both years in absence of original data for 1972-73.

Assuming that the major component in the diet of these cattle was crested wheatgrass, and that the digestion coefficient for gross energy in mature crested wheatgrass is 65% (Mitchell, 1969), daily per animal consumption of energy on the southern sites was approximately 17,782 kcal and 20,023 kcal in 1971-72 and 1972-73, respectively. Under these assumptions, 35% of the daily consumption or 6,239 kcal and 7,008 kcal would be returned to the site as feces during the two respective years of the study.

Considering that the 2 km^2 southern sites sustained an average daily grazing use of 77.2 animals per day in 1971-72 and 25.7 animals per day in 1972-73 (Table 52), and the duration of grazing on the site during the two respective years was 46 and 69 days, the total number of cow days of grazing use was 3551 for 1971-72 and 1773 for 1972-73. Seasonal gross energy consumption on a unit land area basis was calculated to be 315,719 kcal/ha and 177,504 kcal/ha for the two years investigated.

The results are stored under DSCODES A3UBJR3&4.

Blaxter (1962) reported that most attempts to calculate energy needs for animals under natural conditions have met with little success, due to the highly variable and largely unquantifiable nature of environmental stress. Our calculated average daily metabolizable energy requirement (9.8 Mcal) agrees rather closely with the recommendation of 10.3 Mcal daily for maintenance of 350 kg pregnant cows (N.A.S., 1970), considering that our cows were losing weight and were often under acute environmental stress.

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E. CALORIMETRY AND CHEMICAL ANALYSIS

Samples of organic matter have yet to be processed.

F. SOIL

1. PHYSICAL AND CHEMICAL PROPERTIES

Introduction

A soil survey was conducted on all four sites in Curlew Valley. The survey included standard soil descriptions and chemical analyses. All data on the physical and chemical properties of soils are associated with DSCODE A3UBJQ1-4.

Results, North Sites

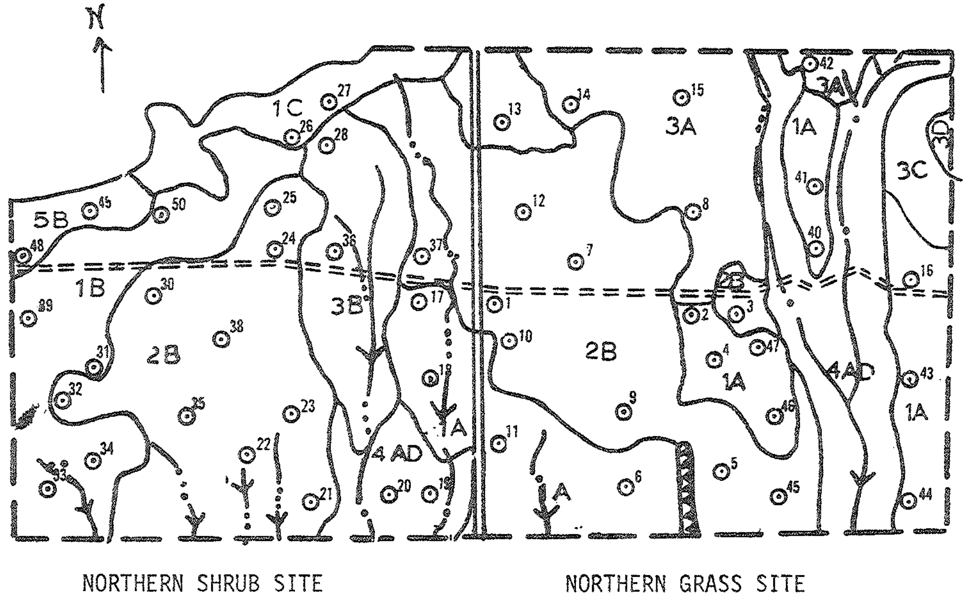
The northern sites are characterized by rolling topography with deep dissection and severe sheet and gully erosion. The upper levels of Lake Bonneville lie within the sites and at least two distinctly different geologic materials are encountered. The lower-lying rocks are of the Salt Lake Formation; the upper material is much harder. The differences in geology and historic lake levels complicate the soil patterns.

Other than differences in coarse fragments, there appears to be little difference in the gross physical characteristics of the soils except at location 15 (Fig. 1). There, a lime cemented hard pan was encountered at 93 cm which would inhibit root penetration. Particle size distribution is difficult to measure because some samples do not disperse with the usual laboratory methods.

Parleys and Bingham soils are characteristic of soils on lake terraces in the 35 to 40 cm rainfall belt. They have dark-colored surface soils and lime is leached to about 50 cm. The reaction of these soils is about neutral in the surface, increasing to about pH 8 at 50 cm where the lime zone is encountered. Parleys soils show about 3 ppm boron below 68 cm. Bingham shows less than 1 ppm boron throughout. Chemical analyses are presented in Tables 1-3.

Kearns soils are similar to Parleys and Bingham except Kearns lacks the clay increase in the subsoil which is present in Parleys and Bingham, and Kearns is calcareous below 23 cm.

Wheelon soils are calcareous throughout. The reaction, salt content and boron are all high. Gypsum is very high in the lower part of the soil. The electrical conductivity at 30 cm is 16 millimhos/cm and indicates a salt problem. Wheelon soils are those mapped in the severely eroded areas in complex with Kearns. Wheelon soils on this site are similar to the soils in the south site.



LEGEND

SOIL SYMBOL	SOIL MAPPING UNIT
1A	Parleys silt loam, 1 to 3% slopes
1B	Parleys silt loam, 3 5o 6% slopes
1C	Parleys clay loam, 6 to 15%
2B	Kearns-Wheelon Complex, 3 to 6% slopes
3A	Binham loam, 1 to 3% slopes
4AD	Severely eroded soils and soil material, 1 to 30% slopes
3C	Bingham loam, 1 to 3% slopes
3D	Unclassified, steep and stony
5B	Obray silty clay loam, 3 to 6% slopes

OTHER SYMBOLS

Soil Location

Deep active intermittent stream channels
Shallow intermittent stream channels
Escarpment

Figure 1. Soil map of Curlew Valley northern sites. Scale: 32 mm = 1 k.

The soil descriptions are given below (see soil map, Fig. 1). Parleys silt loam, 1-3% slope (1A) -- The northern sites consist of about 80% Parleys silt loam with inclusions of Kearns and Wheelon silt loam. Parleys silt loam is a deep dark-colored, well-drained, medium-textured soil. They are formed in lake sediments that have been modified by wind action on old terraces at about 1,500 m above sea level.

A description of a typical profile of Parleys silt loam, taken at location no. 6 (Fig. 1) follows:

Profile	Depth (cm)	
A11	0-05 0-13	Grayish brown (10YR 5/2) silt loam, dark brown (10YR 3/3) moist; moderate thick granular structure; noncalcareous; slightly hard. friable, slightly sticky and slightly plastic.
A12	13-30	Grayish brown (10YR 5/2) heavy silt loam, dark brown (10YR 3/3) moist; weak medium prismatic structure, noncalcareous; slightly hard, friable, slightly sticky and moderately smooth abrupt boundary.
B2t	30-50	Light brownish gray(10YR 6/2) light silty clay loam, dark grayish brown (10YR 4/2) moist; strong medium subangular blocky structure, permeated with cicada casts, very compact. Hard, friable, sticky and plastic; numerous fine roots; noncalcareous; clear wavy boundary.
B3Ca	50-68	Very pale brown (10YR 7/2) heavy silt loam, grayish brown (10YR 5/2) moist; strong medium subangular blocky structure. Highly permeated with cicada casts; very compact in places. Many fine roots around cicada casts; strongly caclareous, but interior of cicada casts generally noncalcareous; hard, friable, slightly sticky and plastic.
Cla	68-93	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2), moist, weak medium subangular blocky structure, some cicada activity, very compact, strongly calcareous; hard, friable, slightly sticky and moderately plastic.
C1	95-130	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2) moist; massive, hard, friable, slightly sticky and moderately plastic.
C2	130-185	White (2.5Y 8/2) silt loam, light brownish gray (2.5Y 6/2) moist; massive, slightlv hard, friable, slightly sticky and slightly plastic.

The inclusions in this mapping unit consist of Kearns silt loam, a dark soil that is similar to Parleys silt loam but lacks the B2t subsoil characteristics, and Wheelon soil loam, a deep, light-colored, strongly calcareous soil. This mapping unit occurs in five separate areas mainly in the crested wheat site.

Parleys silt loam, 3-6% slope (1B, Fig. 1) -- This soil is all located on one body in the extreme western part of the unseeded area where the vegetation consists of a thick growth of big sagebrush.

The Parleys soil in this unit is similar to the Parleys silt loam, 1-3% slopes, but the inclusions consist mainly of a soil with a finer textured (silty clay) subsoil (B2t).

Parleys clay loam, 6-15% slopes (1C, Fig. 1) -- This soil is located in a narrow irregular area along the north border of the unseeded area. It occurs at the base of a steeply sloping hill. The surface has a scattering of angular cobble and gravel washed from the steeper areas above. The surface soil has been eroded and is only 10-15 cm thick in most places. The subsoil (B2t) is a heavy clay loam. The vegetation is mainly big sagebrush with a scattering of juniper trees.

Kearns-Wheelon soils, 3-6% slopes (2B, Fig. 1) -- This unit consists of about 50% Kearns silt loam and 30% Wheelon silt loam, with about 15% inclusions of Parleys silt loam, and 5% other soils.

This complex is extensive in both northern sites. It occurs on somewhat uneven gently sloping lake terraces. Erosion is active in these areas.

A description of typical profile of Kearns silt loam taken at location no. 38 follows:

Profile	Depth(cm)	
A11	0- 10	Grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate thick platy structure breaking to moderate fine granular; very slightly hard, very friable, slightly sticky and slightly plastic, many fine roots, noncalcareous.
A12	10- 23	Grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic, many fine roots, noncalcareous.
B2	23- 33	Light brownish (10YR 6/2) heavy loam or silt, dark grayish brown (10YR 4/2) moist; moderate medium subangular blocky structure with some cicada casts; hard, friable, slightly sticky and slightly plastic, few fine roots, slightly to moderately calcareous.
Cca1	33- 70	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2) moist; weak to moderate subangular blocky with moderate cicada activity; hard, friable, slightly sticky and slightly plastic; very strongly calcareous.
Cca@	70-115	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2) moist; massive, slightly hard, very friable, very slightly sticky and very slightly plastic; very strongly calcareous.
C1	115-128	Light gray (10YR 7/2) fine sandy loam, brown (10YR 5/3) moist; massive, slightly hard, very friable, nonsticky and nonplastic; moderately calcareous.
C2	128-165	Light gray (10YR 7/2) loamy fine sand, brown (10YR 5/3) moist; single grain; loose; nonsticky and nonplastic, moderately calcareous.

A typical description of Wheelon silt loam taken at location no. 22 follows:

A11	0- 4	Light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; strong medium platy structure, visicular; slightly hard, friable, slightly sticky and slightly plastic; abundant fine roots, moderately calcareous
A12	4- 13	Greyish brown (10YR 5/2) silt loam, dark brown (10YR 3/3) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic, abundant fine roots, moderately calcareous.

B2t	13- 15	Light brownish gray (10YR 6/2) silty clay loam, grayish brown (10YR 5/2) moist; moderate medium subangular blocky structure; hard, firm, moderately calcareous. Clay at this depth is unusual for the Wheelon series.
B3Ca	15- 30	White (10YR 8/2) heavy silt loam or light silty clay loam, light brownish gray (10YR 6/2) moist; moderate medium subangular blocky structure, hard, friable, slightly sticky and slightly plastic, very strongly calcareous.
Cca	30- 55	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2) moist; massive; hard, friable, slightly sticky and slightly plastic, very strongly calcareous.
C1	55-100	White (10YR 8/2) silt loam, light brownish gray (10YR 6/2) moist; massive; slightly hard, friable, slightly sticky and slightly plastic, contains gypsum seams, strongly calcareous.
C2	100-165	Pale brown (10YR 6/2) loamy sand, brown (10YR 5/3) moist, single grain, loose, very friable, nonsticky and nonplastic, moderately calcareous.

The major inclusion in this mapping unit consists of Parley silt loam. In places this soil differs from the typical Parleys silt loam in that it is calcareous throughout the profile. A description of the calcareous variant made at location no. 12 follows:

A11	0- 10	Light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; weak medium platy structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; moderately calcareous.
A12	10- 20	Light brownish gray (10YR 6/2) silt loam, dark grayish brown (10YR 4/2) moist; moderate fine granular structure; slightly hard, very friable, slightly sticky and slightly plastic; abundant fine roots; moderately calcareous.
B2t	20- 30	Light gray (10YR 7/2) silty clay loam, grayish brown (10YR 5/2) moist; strong medium subangular blocky structure, permeated with cicada casts; very hard, firm, sticky and plastic (some mixing of darker surface by cicada in this horizon).
B3Ca	30- 43	Very pale brown (10YR 7/3) silty clay loam, brown (10YR 5/3) moist; strong medium subangular blocky structure, firm in places, many cicada casts; very hard, firm, sticky, and plastic, few fine roots; strongly caclareous.
Cca	43- 68	Light gray (10YR 7/2) silt loam, light brownish gray (10YR 6/2) moist; moderate medium subangular blocky structure permeated with cicada casts, firm in places; hard friable, slightly sticky and slightly plastic.
C1	68-190	Light gray (2.5Y 7/2) silt loam, light brownish gray (2.5Y 6/2) moist; few cicada casts, massive, hard, friable, slightly sticky and slightly plastic.

Bingham loam, 1-3% slopes (3A) -- This mapping unit consists of about 80% Bingham loam with inclusion of gravelly and cobbly alluvium along intermittent stream channels. The soils are dark colored, moderately deep, medium textured over very gravelly sand.

This unit occurs on gently sloping deltaic terraces of Lake Bonneville, mostly at or near its highest level.

A description of typical profile of Bingham loam, taken at location no. 36 follows:

A11	0- 10	Grayish brown (10YR 5/2) loam, dark brown (10YR 3/3) moist; moderate medium platy breaking to moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic; abundant fine roots; noncalcareous.
A12	10- 20	Brown (10YR 5/3) loam, dark brown (10YR 3/3) moist; strong fine granular structure; slightly hard, friable, slightly sticky and slightly plastic, many fine roots, noncalcareous.
B2t	20- 45	Brown (10YR 5/3) gravelly clay loam, dark brown (10YR 3/3) moist; strong medium subangular blocky structure; very hard, friable, sticky and plastic, noncalcareous; few fine roots.
Cca	45- 85	Pale brown (10YR 6/3) very gravelly sandy loam (gravel mainly fine), brown (10YR 4/3) moist; strongly coated with lime on underside, massive; slightly hard, very friable, nonsticky and nonplastic; abundant fine roots.
C1	85-108	Light gray (10YR 7/2) sandy loam, brown (10YR 5/3) moist; massive; slightly hard, very friable, nonsticky and nonplastic.
C2	108-130	Pale brown (10YR 6/3) sandy loam, dark brown (10YR 4/3) moist; massive; slightly hard, friable, nonsticky and nonplastic.

A second profile described at location no. 15 follows.

A11	0- 10	Dark grayish brown (10YR 4/2) loam, very dark grayish brown (10YR 3/2) moist; moderate thick platy structure; slightly hard, friable, slightly sticky and slightly plastic; abundant fine roots; noncalcareous.
A12	10- 20	Dark grayish brown (10YR 4/2) loam very dark grayish brown (10YR 3/20) moist; moderate fine granular structure; slightly hard, friable, slightly sticky and slightly plastic, abundant fine roots, noncalcareous.
B2t	20- 45	Dark brown (10YR 6/3) very gravelly clay loam, dark brown (10YR 4/3) moist; moderate medium subangular blocky structure, hard, friable, slightly sticky and slightly plastic, abundant fine roots, noncalcareous.
Cca	73- 93	Pale brown (10YR 6/3) very gravelly sand, brown (10YR 5/3) moist; massive to simple grain; loose nonsticky and nonplastic; lime occurs in seams, pebbles coated with lime, abundant roots.
Ccm	93-113	Very pale brown (10YR 8/3) strongly cemented hard pan, depth to pan in bottom of pit ranged from 93 to 100 cm in thickness. Thickness of pan was not determined.

This soil differs from no. 36 in that it is underlain by a strongly-cemented pan at depth ranging from 93 to 113 cm.

The Bingham soils occur in two separate areas, one in the north central part of the grass site and the second one in the north central part of the shrub site.

Severely eroded soils and soil material, 1-3% slope (4AD, Fig. 1) -- This mapping unit consists of undifferentiated, severely eroded soils of the Bingham,Parleys, Kearns, and Wheelon Series, and of small areas of recent alluvial soils.

The largest area of this mapping unit is in the eastern part of the crested wheat grass site. The area consists of two V-shaped drainageways with steep side slopes and deep active gullies in the bottom. A second small area is in the southeast part of the shrub site.

Obray silty clay loam, 3-6% slope (5B, Fig. 1) -- This mapping unit consists of deep, dark colored fine-textured soils that have a thin surface horizon (A1) and a thick strongly developed columnar subsoil horizon (B2t).

It is located in a small area in the extreme northwest part of the shrub site. The vegetation is a thick growth of Juniper with western wheatgrass, prickly pear, snake weed, partially dead big sage brush and scattered bitterbrush in small open areas.

Table 1. Soil analysis of northern sites

Lab. No.	Location	Depth cm	me/100 g Gyp.	CEC	EK	ES	% ESP	SP	OC	N	$CaCO_3$	ppm P	B
71-3173	CNS #6	0- 13	0	21.4	2.5	0.4	1.9	43	1.6	.15	-----	35	.1
3174	Parleys	13- 30	0	22.3	2.2	0.5	2.2	43	1.1	.13	-----	11	.4
3175		30- 50	0	20.1	1.5	0.7	3.5	41	.6	.08	-----	.4	.4
3176		50- 68	0	16.9	1.1	1.4	8.3	39	.4	.06	14.9	.2	1.3
3177		68- 93	0	16.1	1.0	3.1	19.3	42	.4	.06	26.8	1.2	3.0
3178		93-130	0	17.1	1.2	6.0	35.1	39	.3	.05	27.0	.4	2.8
3179		130-160	0	18.9	1.1	6.8	36.0	77	.3	.04	24.9	.2	1.8
3180		160-185	0	21.1	1.3	7.7	36.5	60	.2	.04	16.8	1.0	2.6
3181	CNS #15	0- 10	0	18.4	1.7	0.5	2.7	35	1.1	.11	-----	19	0
3182	Bingham	10- 20	0	19.1	1.9	0.5	2.6	40	1.0	.11	-----	15	.3
3183	w/pan	20- 45	0	19.2	1.7	0.5	2.6	38	.8	.09	-----	10	.3
3184		45- 73	0	18.4	1.4	0.6	3.3	38	.5	.07	0.2	2.2	.2
3185		73- 93	0	17.6	1.0	0.7	4.0	28	.3	.04	1.4	1.2	.1
3186		93- +	0	12.7	0.8	0.8	6.3	36	.5	.06	21.8	3.4	0
3187	CN #22	0- 4	0	21.3	1.8	0.7	3.3	35	1.0	.12	4.6	17	.4
3188	Wheelon	4- 13	0	21.4	2.1	1.6	7.5	38	1.0	.11	4.4	3.6	.2
3189		13- 15	0	20.4	2.3	4.8	23.5	49	.9	.09	14.0	2.0	1.0
3190		15- 30	0	18.4	1.9	6.1	33.2	55	.8	.09	39.1	3.6	10.4
3191		30- 55	0	18.8	1.7	8.6	45.7	46	.4	.05	29.8	2.2	7.5
3192		55-100	0	20.9	1.1	7.0	33.5	55	.4	.05	17.4	2.2	.9
3193		100-125	97.2	20.2	1.0	4.9	24.3	64	.3	.03	9.1	3.2	.6
3194		125-165	14.0	13.6	0.6	2.9	21.3	38	.1	.02	4.7	1.6	.2
3195	CN #36	0- 10	0	20.6	2.4	0.4	1.9	37	1.4	.14	-----	32	.2
3196	Bingham	10- 20	0	21.3	2.4	0.4	1.9	40	1.0	.11	-----	16	.2
3197		20- 45	0	21.1	1.8	0.4	1.9	38	.6	.08	-----	.8	.4
3198		45- 85	0	14.8	0.7	0.4	2.7	48	.6	.06	1.5	1.2	.1
3199		85-108	0	17.0	0.6	0.5	2.9	37	.3	04	18.0	.2	.4
3200		108-130	0	17.7	0.9	0.7	4.0	37	.2	.03	9.8	0	.1
3201	CN #38	0- 10	0	19.7	2.0	0.3	1.5	40	1.1	.12	-----	10	.2
3202	Kearns	10- 23	0	33.3	2.9	0.4	1.2	42	1.0	.11	-----	2.6	.4
3203		23- 33	0	32.3	1.8	0.3	0.9	46	.8	.12	1.0	1.2	.7
3204		33- 70	0	24.2	1.0	1.5	6.2	46	.5	.06	30.3	.2	1.1
3205		70-115	0	28.5	0.8	5.0	17.5	55	.3	.04	18.9	0	1.3
3206		115-128	0	27.5	0.7	5.0	18.2	53	.1	.02	10.6	0	.5
3207		128-165	0	21.5	0.8	4.9	22.8	43	.1	.02	7.3	0	.9
3208	CN #49	0- 3	---	54.9	---	0.6	1.1	65	---	---	-----	----	---
3209		10- 20	0	49.1	1.6	2 6	5.3	67	.7	.08	0.2	0	.3

Table 2. Soil analysis of northern sites

Lab No.	Location	Depth (cm)	>2mm	1/3	15	Sand 2-.05 (%)	Silt .05-.002 (%)	Clay .005 (%)	HYDROMETER Texture	#1	#2	#3	#5	#6	Total Sand (%)
71-3173	CNS #6	0- 13		25.1	11.8	29	54	17	Silt Loam	.7	1.7	1.9	8.1	15.3	27.7
3174	Parleys	13- 30		25.2	12.5	28	53	19	Silt Loam	.2	1.2	1.7	7.8	14.1	25.0
3175		30- 50		29.1	12.1	29	55	16	Silt Loam	0	.3	.6	5.8	17.0	23.7
3176		50- 68		28.5	12.6	33	54	13	Silt Loam	.4	1.3	1.1	6.1	23.2	32.1
3177		68- 93		32.8	13.7	31	52	17	Silt Loam	**--	---	---	---	----	----
3178		93-130		36.6	13.4	32	54	14	Silt Loam	--	---	---	---	----	----
3179		130-160		53.8	15.7	22	65	13	Silt Loam	--	---	---	---	----	----
3180		160-185		48.1	15.9	21	66	13	Silt Loam	--	---	---	---	----	----
3181	CNS #15	0- 10		22.1	10.0	35	46	19	Loam	2.9	4.4	3.6	9.3	11.9	32.1
3182	Bingham	10- 20	17.3	21.7	10.4	36	45	19	Loam	3.0	4.4	3.9	9.9	12.2	33.4
3183	w/pan	20- 45	11.2	21.8	10.6	36	44	20	Loam	3.7	5.3	4.1	9.8	12.9	35.8
3184		45- 73	22.2	22.4	9.9	42	39	19	Loam	6.2	8.1	5.6	10.2	10.2	40.3
3185		73- 93	53.2	13.1	8.4	76	12	12	Sandy Loam	17.6	26.4	12.7	,14.5	7.6	78.8
3186		93- +	29.1	15.9	7.1	79	15	6	Loamy Sand	23.9	24.6	11.1	13.4	8.3	81.3
3187	CN #22	0- 04		26.1	11.9	21	60	19	Silt Loam	.4	.9	1.3	7.3	16.9	26.8
3188	Wheelon	4- 13		25.2	12.2	22	57	21	Silt Loam	.2	1.0	1.4	7.4	15.8	25.8
3189		13- 15		32.2	15.6	18	63	19	Silt Loam	.3	.8	1.1	5.5	8.8	16.5
3190		15- 30		38.1	17.0	8	62	30	Silty Clay Loam	--	---	---	---	----	----
3191		30- 55		37.6	16.1	15	61	24	Silt Loam	--	---	---	---	----	----
3192		55-100		47.0	16.1	18	65	17	Silt Loam	.1	.4	.7	3.7	12.4	17.3
3193		100-125		52.7	17.7	*(30	63	7	Silt Loam)	--	---	3.6	---	----	----
3194		125-165		14.5	7.6	*(46	50	4	Silt Loma)	.1	2.1		5.8	31.6	43.2
3195	CN #36	0- 10	11.4	21.4	11.0	43	38	19	Loam	4.8	7.2	5.3	12.7	13.0	43.0
3196	Bingham	10- 20	17.6	21.8	11.9	39	42	19	Loam	3.0	4.7	4.0	11.3	13.6	36.6
3197		20- 45	23.8	23.9	11.8	43	37	20	Loam	7.1	8.3	5.7	12.5	10.3	43.9
3198		45- 85	85.9	----	----	81	11	8	Loamy Sand	---	---	---	----	----	----
3199		85-108	5.1	20.7	9.5	61	31	8	Sandy Loam	---	---	---	----	----	----
3200		108-130	6.3	22.6	10.1	53	38	9	Sandy Loam	---	---	---	----	----	----
3201	CN #38	0- 10		20.6	11.3	36	46	18	Loam	0	1.2	3.5	17.3	18.0	40.0
3202	Kearns	10- 23		20.8	11.3	49	36	15	Loam	.3	2.8	5.0	21.9	20.6	50.6
3203		23- 33		22.8	11.7	46	39	15	Loam	.7	2.9	4.8	22.2	19.6	50.2
3204		33- 70		36.4	15.4	36	50	14	Loam	---	---	---	----	----	----
3205		70-115		37.3	13.0	37	55	8	Silt Loam	---	---	---	----	----	----
3206		115-128		26.2	11.0	42	53	5	Silt Loam	---	---	---	----	----	----
3207		128-165		14.2	8.5	80	16	4	Loamy Sand	.1	2.4	12.0	39.1	25.7	79.2
3208	CN #49	0- 3	15.3	----	----	19	59	22	Silt Loam	---	---	---	----	----	----
3209		10- 20		45.3	23.6	23	45	32	Clay Loam	---	---	---	----	----	----

*High in gypsum

**Undispersed clay

Table 3. Soil analysis of northern sites

Lab. No.	Location	Depth cm	pH	TSS	EC_c	ODOC	N	$CaCO_3$	CEC	EK	ES	ESP	SP	1/3	15	P	GYP	P	S	Si	Cl	Text
3173	CNS#6	0- 13	7.3	.04	.6	1.57	.15		21.4	2.5	0.4	1.9	42.6	25.1	11.8	35.4	0	.1	29	54	17	SiL
74	Parleys	13- 30	7.2	.04	.4	1.05	.13		22.3	2.2	0.5	2.2	43.3	25.2	12.5	11	0	.4	28	53	19	SiL
75		30- 50	7.5	.05	.5	.55	.08		20.1	1.5	0.7	3.5	40.9	29.1	12.1	.4	0	.4	29	55	16	SiL
76		50- 68	8.1	.05	.7	.37	.06		16.9	1.1	1.4	8.3	38./	28.5	12.6	.2	0	1.3	33	54	13	SiL
77		68- 93	8.5	.07	1.2	.38	.06		16.2	1.0	3.1	19.3	42.1	32.8	13.7	1.2	0	3.0	31	52	17	SiL
78		93-130	8.8	.08	1.2	.32	.05		17.1	1.2	6.0	35.1	49.4	36.6	13.4	.4	0	2.8	32	54	14	SiL
79		130-160	9.0	.08	1.0	.29	.04		18.9	1.1	6.8	36.0	76.9	53.8	15.7	.2	0	1.8	22	65	13	SiL
80		160-185	8.-	.08	1.1	.22	.04		21.1	1.3	7.7	36.5	59.8	48.1	15.9	1.0	0	2.6	21	66	13	SiL
81	CNS#15	0- 10	7.1	.04	.4	1.09	.11		18.4	1.7	0.5	2.7	35.1	22.1	10.0	19	0	0	35	46	19	L
82	Bingham	10- 20	7.2	.04	.4	1.03	.11		19.1	1.9	0.5	2.6	40.2	21.7	10.4	15	0	.3	36	45	19	L
83		20- 45	7.1	.04	.4	.77	.09		19.2	1.7	0.5	2.6	38.2	21.8	10.6	10	0	.3	36	44	20	L
84		45- 73	7.4	.04	.3	.49	.07		18.4	1.4	0.6	3.3	38.1	22.4	9.9	2.2	0	.2	42	39	19	L
85		73- 93	8.0	.04	.4	.28	.04		17.6	1.0	0.7	4.0	28.1	13.1	8.4	1.2	0	.05	76	12	12	SL
86		93- +	8.2	<.03	.5	.50	.06		12.7	0.8	0.8	6.3	35.9	15.9	7.1	3.4	0	0	79	15	6	LS
87	CN#22	0- 4	7.9	.05	.4	1.04	.12		21.3	1.8	0.7	3.3	35.0	26.1	11.9	17	0	.4	21	60	19	SiL
88	Wheelon	4- 13	8.0	.05	.5	1.00	.11		21.4	2.1	1.6	7.5	37.7	25.2	12.2	3.6	0	.2	22	57	21	SiL
89		13- 15	8.3	.15	1.9	.85	.09		20.4	2.3	4.8	23.5	48.5	32.2	15.6	2.0	0	1.9	18	63	19	SiL
90		15- 30	8.2	.40	7.3	.84	.09		18.4	1.9	6.1	33.2	54.9	38.1	17.0	3.6	0	10.4	8	62	30	SiCL
91		30- 55	8.3	.55	16.0	.42	.05		18.8	1.7	8.6	45.7	45.6	37.6	16.1	2.2	0	7.5	15	61	24	SiL
92		55-100	8.1	.60	17.0	.39	.05		20.9	1.1	7.0	33.5	54.7	47.0	16.1	2.2	0	.9	18	65	17	SiL
93		100-125	7.9	.65	21.0	.27	.03		20.2	1.0	4.9	24.3	64.1	52.7	17.7	3.2	97.2	.6				
94		125-165	7.9	.45	14.0	.12	.02		13.6	0.6	2.9	21.3	37.6	14.5	7.6	1.6	14.0	.2				
95	CN#36	0- 10	7.2	.05	.9	1.42	.14		20.6	2.4	0.4	1.9	37.3	21.4	11.0	32	0	.2	43	38	19	L
96	Bingham	10- 20	7.2	.04	.4	1.04	.11		21.3	2.4	0.4	1.9	39.6	21.8	11.9	16	0	.2	39	42	19	L
97		20- 45	7.1	.05	.4	.64	.08		21.1	1.8	0.4	1.9	38.0	23.9	11.8	.8	0	.4	43	37	20	L
98		45- 85	7.9	<.03	.3	.56	.06		14.8	0.7	0.4	2.7	48.1			1.2	0	.1	81	11	8	LS
99		85-108	8.3	.03	.4	.29	.04		17.0	0.6	0.5	2.9	36.6	20.7	9.5	.2	0	.4	61	31	8	SL
3200		108-130	8.3	.03	.4	.15	.03		17.7	0.9	0.7	4.0	37.0	22.6	10.1	0	0	.1	53	38	9	SL
01	CN#38	0- 10	7.6	.04	.4	1.06	.12		19.7	2.0	0.3	1.5	40.0	20.6	11.3	10.3	0	.2	36	46	18	L
02	Kearns	10- 23	7.7	.04	.4	1.01	.11			2.9	0.4		41.6	20.8	11.3	2.6	0	.4	49	36	15	L
03		23- 33	7.8	.05	.4	.83	.12			1.8	0.3		45.6	22.8	11.7	1.2	0	.7	46	39	15	L
04		33- 70	8.5	.03	.4	.52	.06			1.0	1.5		46.0	36.4	15.4	.2	0	1.1	36	50	14	L
05		70-115	9.0	.05	.7	.25	.04			0.8	5.0		54.6	37.3	13.0	0	0	1.3	37	55	8	SiL
06		115-128	8.9	.07	1.1	.13	.02			0.7	5.0		53.4	26.2	11.0	0	0	.5	42	53	5	SiL
07		128-165	9.0	.07	1.5	.09	.02			0.8	4.9		43.4	14.2	8.5	0	0	.9	80	16	4	LS
08	CN#49	0- 3	7.7	.10	.5	1.25					0.6		64.5						19	59	22	SiL
09		10- 20	7.3	.10	7	.65	.08			1.6	2.6		66.6	45.3	33.6	0	0	.3	23	45	32	CL

Results, South Sites

The southern sites are on a smooth and nearly level valley plain. The parent soil material is Lacustrine and Eolian sediments. The soils are uniform in many properties. This includes texture, cation exchange capacity, boron, salt, and lime distribution.

The average thickness of the A horizons is 11.2 cm with a range of 10-15 cm. The B horizons average 24.4 cm in thickness with a range of 5-36 cm. The CCa horizons average 43 cm and have a range of 36-56 cm.

The increase of total soluable salts, calcium carbonate and exchangeable sodium at the 25-41 cm depth probably inhibits root development of some plants.

A description of the Thiokol silt loam at location no. 13 follows. Location no. 11 is similar (see soil map, Fig. 2). Chemical analyses are presented in Table 4.

Profile	Depth(cm)	
A_1P	0- 08	Light gray (2.5Y 7/2) silt loam, dark grayish brown (2.5Y 4/2) moist; aggregate, grayish brown (~2.5Y 5/2) moist crushed; strong thin platy structure breaking to moderate fine granular; slightly hard, friable, slightly sticky and plastic; plentiful fine roots; visicular pores; strongly calcareous; moderately alkaline (pH 8.1).
A_{12}	8- 15	Light gray (2.5Y 7/2) silt loam, grayish brown (10YR 5/2) moist; moderate thin platy structure breaking to moderate fine granular; slightly hard, friable slightly sticky and plastic; plentiful fine roots; strongly calcareous; moderately alkaline (pH 8.0).
B_2	15- 28	Light gray (10YR 7/2) silt loam, grayish brown (10YR 5/2) moist; weak subangular blocky structure breaking to moderate to weak fine granular; slightly hard, friable, slightly sticky and plastic; plentiful fine roots; many fine pores; strongly calcareous; moderately alkaline (pH 8.0).
C_1Ca	28- 48	White (10YR 8/1) silt loam, very pale brown (10YR 7/3) moist; strong subangular blocky structure; compact hard, friable, slightly sticky and plastic; few fine roots; few medium fine pores; very strongly calcareous; moderately alkaline (pH 8.0); strongly saline (.60% T.S.S.).
CCa	48- 79	White (10YR 8/1) silt loam, very pale brown (10YR 7/3) moist; horizontal bedding breaking to medium and fine angular and subangular blocky structure; compact, hard, friable, slightly sticky and slightly plastic; mat of fine brown roots concentrated along horizontal bedding plains; few medium and fine pores; strongly calcareous; mildly alkaline (pH 7.6); strongly saline (1.2% T.S.S.).
CCa	79-102	White (2.5Y 8/0) silt loam, light gray (2.5Y 7/2) moist; coarse prismatic cleavage breaking to medium prisms and angular blocks; few fine roots along aggregate surfaces; strongly calcareous; moderately alkaline (pH 2.9); strongly saline (1.2% T.S.S.).
C	102-229	White (5Y 7/1) silt loam, light gray (5Y 6/1) moist; massive, breaking into medium angular blocks; strongly caclareous; mildly alkaline (pH 7.7); strongly saline (1.5% T.S.S.).

The Thiokol silt loam at location no. 14 also represents locations 17, 18, 19 and 20, except the thickness of the A and B horizons in this pedon is about 8 cm less than the average for all observations within the study area.

Profile	Depth (cm)	
A_{11}	0- 10	Light gray (2.5Y 7/2) silt loam, grayish brown (2.5Y 5/2) moist; strong thin platy structure breaking to strong fine granular; slightly hard, friable, slightly sticky and plastic; many fine roots; many visicular pores moderately calcareous; moderately alkaline (pH 8.0).
B_{21}	10- 18	Light gray (10YR 7/2) silty clay loam; grayish brown (10YR 5/2) moist; moderate, thin platy structure breaking to strong fine granular; slightly hard, friable, sticky and plastic; many fine roots; common medium and fine pores, moderately calcareous; mildly alkaline (pH 7.8).
B_{22}	18- 28	Light gray (2.5Y 7/2) heavy silt loam, grayish brown (2.5Y 5/2) moist; weak, medium subangular, blocky structure; slightly hard, friable, slightly sticky and plastic, many fine roots; common fine and few medium pores; moderately calcareous; mildly alkaline (pH 7.6).
C_1Ca	28- 41	White (2.5Y 8/2) silt loam, light brownish gray (2.5Y 6/2) moist; weak subangular, blocky structure; slightly hard, friable, slightly sticky and plastic; many fine roots; common fine pores; strongly calcareous; neutral (pH 2.3).
C_2Ca	41- 58	White (2.5Y 8/0) silt loam, light gray (2.5Y 7/2) moist; strong, medium subangular, blocky structure, with numerous angular cicada casts; compact, hard, firm, slightly plastic and slightly sticky; fine roots along aggregate surfaces; very strongly calcareous, mildly alkaline (pH 7.4); strongly saline (.65% T.S.S.).
C_3Ca	58- 81	Similar to above but less compact, and has fewer fine roots along cleavage planes; strongly calcareous; mildly alkaline (pH 7.8); strongly saline (.8% T.S.S.).
C_4Ca	81- 97	About one-half of this horizon was loose and soft, appeared to have been worked by rodents, the other half was moderately compact with medium to fine prismatic cleavages, breaking readily to medium platy. Strong brown mottles on aggregate surfaces. Strongly calcareous; mildly alkaline (pH 7.7); strongly saline (1.0% T.S.S.).
C_5Ca	97-107	White (5Y 8/1) silt loam, light gray (5Y 7/2) moist; weak to moderate prismatic cleavage breaking into course angular blocks; fine roots along cleavage plane surfaces; strongly calcareous; mildly alkaline (pH 7.8); strongly saline (1.0% T.S.S.).
C_6	107-244	Light gray (5Y 7/2) silt loam, gray (5Y 6/1) moist; many medium distinct yellowish red (10YR 5/6) mottles; weak prismatic cleavage breaking to course plates; few fine roots along aggregate surfaces; strongly calcareous; mildly alkaline (pH 7.7); strongly saline (1.2% T.S.S.).

Location no. 22 is representative of many of the other sampling locations except the thickness of the A and B horizons is less.

A	0- 10	Light brownish gray (2.5Y 6/2) silt loam, dark grayish brown (2.5Y 4/2) moist; strong thin platy structure; slightly hard, friable, slightly sticky and plastic; moderately calcareous; moderately alkaline (pH 8.1).
B	10- 15	Light brownish gray (10YR 6/2) heavy silt loam, dark grayish brown (10YR 4/2) moist; strong thin platy structure breaking to strong fine granular; soft, friable, slightly sticky and plastic; many fine roots and many fine visicular pores; moderately calcareous; moderately alkaline (pH 7.9).

B	15- 25	Light brownish gray (10YR 6/2) silt loam, grayish brown (10YR 5/2) moist; weak medium subangular blocky structure; soft, friable, slightly sticky and plastic; strongly calcareous; mildly alkaline (pH 7.8); slightly saline (.15% T.S.S.).
C_1Ca	25- 46	White (10YR 8/2) silt loam, light brownish gray (2.5Y 6/2) moist; moderate medium subangular blocky structure with numerous hard rounded cicada casts; hard, firm, slightly sticky and slightly plastic; many fine and medium roots along aggregate surfaces; very strongly calcareous; mildly alkaline (pH 7.8); strongly saline (.70% T.S.S.).
C_2Ca	46- 66	Pale brown (10YR 6/3) silt loam, brown (10YR 5/3) moist;moderate fine subangular blocky to massive; part of horizon soft and loose and partly compact, soft areas contain mats of fine brown roots; strongly calcareous; mildly alkaline (pH 7.8); strongly saline (.90% T.S.S.).
C_3Ca	66- 89	White (2.5Y 8/2) silt loam, light gray (2.5Y 7/2) moist; coarse platy breaking to angular blocky; hard, firm, slightly sticky and plastic; very strongly calcareous; moderately alkaline (pH 7.9); strongly saline (.80% T.S.S.).
C_4	89-211	Light gray (5Y 7/2) silt loam, light olive gray (5Y 6/2) moist; weak medium prismatic breaking to moderate medium angular blocky; hard, firm, slightly sticky and plastic; strongly calcareous; moderately alkaline (pH 7.9); strongly saline (1.2% T.S.S.).

Table 4. Soil analysis at three sampling locations on southern sites, Curlew Valley

Depth (cm)	NO_3-N ppm	pH	TSS (%)	EC_c mmho/cm	OC (%)	N (%)	$CaCO_3$ (%)	CEK me/100g	EK me/100g	ES me/100g	ESP (%)	SP (%)	P ppm	1/3bar H_2O (%)	15bar H_2O (%)	MA_h S (%)	MA_h Si (%)	MA_h C (%)	B ppm
Location No. 13																			
0- 08	31.8	8.1	0.1	2.2	2.1	0.2	26.8	20.6	4.6	2.7	13	43	31	28.6	13.5	24	58	18	1.0
8- 15	14.8	8.0	0.1	1.9	1.4	0.1	17.9	17.5	2.7	1.6	9	40	12	29.3	13.0	22	61	17	.6
15- 28	1.8	8.0	0.1	1.4	1.1	0.1	27.5	17.1	5.9	1.6	9	49	1.8	32.7	14.8	23	53	24	1.2
28- 48	10.5	8.0	0.6	15.0	1.0	0.1	41.3	16.9	2.5	4.7	28	62	2.0	41.8	15.6	14	62	24	1.6
48- 79	10.0	7.6	1.2	32.0	1.2	0.1	37.5	17.8	2.1	6.1	34	65	2.9	43.6	18.8	49	34	17	4.3
79-102	1.8	7.9	1.2	27.0	0.4	0.1	34.0	15.9	1.8	6.5	40	77	2.5	64.9	16.7	1	71	28	5.7
102-122	1.5	7.8	1.4	30.0	0.4	0.1	21.6	15.3	1.6	0.9	6	55	3.3	45.3	14.0	1	75	24	6.2
122-147	-	7.7	1.4	34.0	0.3	0.0	20.5	16.3	1.7	6.5	40	50	3.5	43.8	13.4	6	71	23	7.0
147-178	-	7.7	1.4	36.0	0.3	0.0	22.8	13.3	1.2	4.1	31	49	5.3	43.0	12.3	11	67	22	6.0
178-203	-	7.6	1.6	42.0	0.3	0.1	22.8	14.3	1.4	5.2	36	49	8.6	40.9	13.5	11	64	25	5.7
203-229	-	7.6	1.6	39.0	0.4	0.1	21.6	15.3	1.6	5.9	39	51	6.9	40.5	13.6	54	28	18	5.0
Location No. 14																			
0-1.3	2.3	7.5	0.1	1.4	2.4	0.2	18.9	16.6	3.6	.6	3	45	37	37.6	13.1	20	46	34	1.0
1.3-2.5	2.0	8.1	0.1	.9	1.7	0.9	19.3	16.9	4.4	1.2	7	39	41	30.9	12.9	17	64	19	1.4
2.5- 10	3.3	8.0	0.1	.9	1.4	0.4	11.8	17.5	5.3	.8	5	35	21	29.0	13.0	10	62	28	1.0
10- 18	9.0	7.8	0.1	1.1	1.1	0.1	9.9	20.4	5.4	1.0	5	37	14	28.7	14.7	11	63	26	.7
18- 28	1.1	7.6	0.1	2.4	0.9	0.1	11.9	20.5	4.6	2.0	10	47	6.9	30.9	17.2	12	64	24	.6
28- 41	0.8	7.3	0.3	6.4	0.8	0.1	33.9	15.4	3.4	2.0	13	53	7.3	36.8	15.4	6	69	26	.9
41- 58	0.6	7.4	0.7	15.2	0.7	0.1	42.1	15.2	2.6	4.5	29	59	5.7	40.4	14.6	4	71	25	.9
58- 81	0.6	7.6	0.8	27.0	0.8	0.1	30.4	17.5	2.3	13.0	74	57	2.0	37.1	14.7	43	41	16	3.0
81- 97	1.1	7.6	1.0	28.0	0.6	0.1	27.1	17.5	2.4	9.0	51	57	7.1	43.1	14.6	21	55	24	4.6
81- 97*	0.9	7.8	1.0	26.0	0.6	0.1	39.1	16.6	1.8	8.9	54	77	2.5	55.2	15.6	19	57	24	3.9
97-107	0.8	7.8	1.0	24.0	0.5	0.1	39.2	15.2	1.6	8.7	57	70	2.5	54.9	13.8	8	70	22	3.7
107-137	.	7.6	1.0	33.0	0.4	0.1	22.1	15.4	1.6	8.2	53	57	2.9	40.8	13.2	8	73	19	4.4
137-157	.	7.8	1.2	33.0	0.2	0.0	19.9	15.3	1.8	6.9	45	52	4.5	46.1	13.4	10	71	19	4.6
157-188	.	7.8	1.2	30.0	0.3	0.0	23.7	14.0	1.5	8.2	59	50	5.1	40.1	12.3	3	75	22	4.3
188-218	.	7.7	1.6	36.0	0.3	0.0	23.5	14.0	1.5	6.2	44	53	7.9	38.7	12.8	4	72	24	4.0
218-244	.	7.6	1.2	39.0	0.3	0.0	21.1	15.0	1.5	6.2	41	50	9.3	39.8	12.7	5	73	22	3.8
Location No. 22																			
0- 10	14.5	8.1	0.1	4	2.1	0.2	14.0	16.3	5.1	1.9	41	12	44	28.0	12.1	16	60	24	0.7
10- 15	10.8	7.9	0.1	2	1.0	0.1	11.9	18.8	4.0	0.8	5	4	50	27.6	16.5	17	55	28	0
15- 25	1.8	7.8	0.2	4	1.0	0.1	22.8	16.5	4.0	1.6	4	10	59	29.1	16.4	18	59	23	0.3
25- 46	0.6	7.8	0.7	16	0.6	0.1	42.6	14.1	2.5	4.2	4	30	66	46.7	15.2	7	70	23	1.5
46- 66	1.0	7.8	0.9	24	0.7	0.1	36.8	15.6	2.0	5.0	4	32	72	46.9	16.4	34	48	18	2.5
66- 66*	1.0	7.6	1.0	26	1.0	0.1	34.6	16.3	2.1	3.7	3	23	75	47.6	17.8	50	35	15	2.7
66- 89	2.3	7.9	0.8	23	0.6	0.1	40.8	16.1	1.8	5.4	3	34	74	56.8	14.5	14	66	20	3.3
89-112	2.0	7.9	0.9	20	0.3	0.1	24.7	16.0	1.6	4.0	3	25	63	42.9	13.7	8	72	20	3.8
112-137	-	7.9	1.2	26	0.2	0.0	20.7	16.5	1.8	4.3	4	26	56	39.2	13.4	8	72	20	4.2
137-163	-	7,8	1.4	31	0.3	0.0	25.7	15.2	1.4	3.5	6	23	52	41.5	13.0	5	75	20	4.1
163-188	-	7.9	1.2	33	0.3	0.1	23.8	15.4	1.4	1.9	8	12	59	39.2	13.6	8	71	21	4.1
188-211	-	7.7	1.4	35	0.3	0.1	24.4	15.7	1.5	0.9	11	6	57	37.2	13.9	15	67	18	4.1

*Loose

F. 2 LITTER

Estimates of litter biomass are in the Plant section due to similarity in sampling techniques

F. 3 LICHENS

INTRODUCTION

The objectives of this study are to produce a catalog of the lichens present at the Curlew Valley Validation Sites and to estimate the biomass of lichens present. Since nitrogen economy is probably of great significance on the desert, it is especially important that a record of nitrogen-fixing species and, where possible, their biomass, be obtained. Lichens and mosses are excellent micro-climate indicators and lichens are also air pollution indicators; since the deserts of the world will be used more and more in such ways as could drastically alter micro-climate factors and/or cause extensive air pollution, a carefully constructed catalog of the lichens should be produced as soon as possible.

METHODS

Collections of lichens were made and were prepared for herbarium mounting. Tentatively identified specimens were taken to Boulder and Denver and compared with specimens in the lichen herbaria there. Dr. Sam Shushan at Boulder and Dr. Roger Anderson at Denver assisted with the identification; Dr. Shushan also provided generously of his curator experience in demonstrating methods of mounting and curating superior to the methods previously used at the Ricks College Herbarium. Duplicate specimens have been make; Art Holmgren at Utah State University has indicated an interest in beginning a lichen herbarium at USU and specimens will be sent to him if he should do this.

To measure biomass of soil lichens, four random samples of soil were collected at the south validation sites, just north of the northwest corner of the grass enclosure. All of the soil to the depth of 2 or 3 cm over an area of exactly $1m^2$ was placed in a container. Each sample of fresh soil weighed about 4-5 kg. The soil was placed on a fine screen and the lichens washed free from the soil particles; the finer soil passed readily through the screen while the lichens, other organic matter and much of the soil were held. Lichens, being heavier than water, were readily separated from litter and other coarse organic matter by flotation. A second washing resulted in most of the soil being separated from the lichens. Excess water was drained off and the moist mixture of lichens and soil was thoroughly mixed and weighed. Five small samples of exactly 100 mg moist weight were than taken from each of the four original samples, which at this time weighed approximately 35 g moist weight each, and examined under a dissecting microscope where forceps were used to separate all of the remaining soil from the lichens. After washing thoroughly in petri dishes under the dissecting microscopes, the lichen subsamples were oven dried and weighed. From these subsamples, the dry weights of the four original samples were calculated.

Two transects were run in order to calculate percent cover of lichens, one just north of thenorth boundary marker at the south sites and the other just north of the north boundary marker at the north sites. Both transects included plots in the crested wheatgrass and in the shrub sites. At intervals of 15 m, estimates of cover for each of several lichen "types" were made and recorded and a collection of the lichens present was taken for identification later in the herbarium at Ricks College. At the south sites, 17 plots were included in the transect; at the north sites, 35 plots were included.

RESULTS

Specimens of ten species of lichens have been deposited in the Ricks College Herbarium and 17 other species have been identified and will be deposited. One additional species collected at the north sites has been deposited in the Denver University Lichen Herbarium. The 28 species are listed in Table 5. The DSCODE for this study is A3UBJ02.

Table 5. Species of lichens collected in Curlew Valley

**Collema tenax,* very abundant soil lichen, south sites.
**Dermatocarpon lachneum,* abundant soil lichen, south sites.
**Fulgensia fulgens,* relatively abundant soil lichen, all sites.
**Lecanora lentigera,* soil lichen, south sites.
**Xanthoria polycarpa,* very abundant bark lichen on *Artemisia* and other shrubs, all sites.
**Thrombium epigaeum,* rare soil lichen, south sites; identification not confirmed.
Thrombium mongolicum, rare rock lichen, north sites; identified by Roger Anderson and deposited in University of Denver lichen herbarium.
**Lecidea russellii,* soil lichen commonly growing on soil accumulation in rock crevices, found at all sites.
**Diploschistes scruposus,* soil lichen, south sites.
**Stereocaulon microscopicum,* rare soil lichen, south sites; identification not confirmed.
**Lecanora piniperda* f. *nigrescens,* common bark lichen found on greasewood, *Atriplex confertifolia*, and *Artemisia tridentata,* at all sites.
Lecidea atrobrunnea, relatively abundant rock lichen, north sites.
Lecidea decipiens, relatively abundant soil lichen, south sites.
Caloplaca pyracea, rock lichen, north sites.
Caloplaca spp. rock lichen, gray apothecia, north sites.
Lecanora peltata, rock lichen, identified by Roger Anderson, north sites.
Lecanora melanophthalma, common rock lichen, north sites.
Lecanora atra, rock lichen, north sites.
Lecanora spp. rock lichen, north sites.
Lecanora spp. Aspicilia group, rock lichen, north sites.
Lacanora spp. rock lichen, north sites.
Acarospora smaragdula, roch lichen, north sites; both the regular *smaragdula* and the *strigata* type occur, the latter being more common.
Staurothele spp. probably *S. catalepta,* rock lichen, north sites.
Parmelia chlorochroa, soil lichen, north sites (There is some question about this.)
Acarospora chlorophana, rock lichen, north sites.
Caloplaca citrina, rock lichen, north sites.
Caloplaca spp. rock lichen, north sites; possibly *C. approximata.*
Parmelia spp. gray rock lichen, north sites.

* The species marked with the asterisk are processed and deposited in the herbarium at Ricks College; in most cases, duplicate specimens are available.

By far the most abundant lichen at the south sites is *Collema tenax*; 32.4% of the soil in the south shrub site was covered with this lichen according to our transect adjacent to the site, which appears to be typical of the south sagebrush area. *C. tenax* is a nitrogen-fixing lichen having a species of *Nostoc* as its phycobiont. The plots along the transect that lay adjacent to the south crested wheatgrass site were almost free of lichens. *C. tenax* occurred in one of the 35 plots along the transect adjacent to the north sites; this was in the north crested wheatgrass area and percent cover of *C. tenax* in this plot was 10%. This species was therefore found in three of the four validation sites; the south shrub, south crested wheatgrass and north crested wheatgrass sites. It is almost certainly present in the north shrub site too.

Moss protonemata and young moss gametophytes covered 27.0% of the soil in the south sagebrush site and *Dermatocarpon lachneum* 21.2%. *Fulgensia fulgens* covered 6.4% and the cover of *Lecidea decipiens* probably approached 0.1%; the cover of all other species combined was probably less than 0.1%. The biomass, dry weight, of all lichens at the south sagebrush site was 219 ± 22.7 kg/ha; we estimate that over 90% of this was due to *Collema tenax* with most of the remainder due to *D. lachneum*. The mosses float and no attempt was made to separate moss matter from the litter and other floating organic matter.

Although it is well established that many, if not most, gelatinous lichens are capable of nitrogen fixation (Henriksson, 1951, 1957, 1961; Bond and Scott, 1955; Scott, 1956), rates of nitrogen fixation which occur in nature are not known. If the *C. tenax* on the soil at the south site fixes nitrogen as rapidly as *C. tenax* phycobiont does in the laboratory, about 13 kg/ha available nitrogen could be fixed in a 6-week period (Henriksson, 1957). It appears as though denitrification takes place very rapidly in the desert, so that even large amounts of nitrogen fixation may for practical purposes be insignificant unless something is done to reduce the rate of denitrification -- such as applying irrigation water. Nevertheless, here is an area where much research is needed. At the legume laboratory at Uppsala University's agricultural college in Ultuna, Sweden, Bjalve and others, obtained rates of nitrogen fixation in sterile sand inoculated with the *Collema tenax* phycobiont as high as in soil containing the usual non-symbiotic nitrogen fixers such as *Azotobacter* (Henriksson 1961).

Time ran out before a good picture of lichen cover was obtained or biomass estimated at the north sites. The latter is more difficult to evaluate lichenologically because (1) there are more species there, (2), the crustose species which are present are more difficult to identify than the foliose species present on the south sites, and (3) the terrain creates further difficulties with rocks present on over 30% of the plots and shrubs on most of the plots, and with very little bare ground on some plots whereas other plots are 100% bare ground. *Acarospora smaragdula* covered an average of 34.5% of the rock surface in the 10 plots in which it occurred; since rocks covered about 12% of the ground surface along the transect, about 3.8% of the ground surface was covered with this species. Another 1.4% of the ground surface was covered with *Fulgensia fulgens*. The black bark lichens, crustose lichens of the *Lecanora piniperda* type, covered 6% of the bark of shrubs along the transect; *Xanthoria polycarpa* covered

more than 0.1% of the bark despite the fact that it was completely absent in one section of the transect. *X. polycarpa* was especially abundant, both on the north and on the south sites, on dead stems and twigs of *Atriplex* and *Artemisia*. On all sites, however, the cause of death seemed to have an important bearing on the presence of *Xanthoria*. Where the brush had been railed, *Xanthoria* was abundant; where the brush seemed to have been killed by 2, 4, 5-T or other herbicide, there was no *Xanthoria* and very little *Lecanora*. It is easy to understand how the herbicides would kill the lichens along with the shrubs, but it is difficult to explain why the lichens had not become reestablished on the dead shrubs, especially since they ordinarily colonize a twig or branch only after it has died. It would be interesting to study a history of the range management on the north sites to see just how closely the absence of *Xanthoria* coincides with herbicide treated areas, and also the length of time available for recolonization since any brush killing treatments were carried out.

A very abundant lichen collected just a few miles north of the north validation sites, and also in the vicinity of Locomotive Springs and Spring Bay southeast of the south validation sites is *Caloplaca elegans*. It is undoubtedly present and probably very abundant, perhaps even more abundant than *Acarospora smaragdula*, on the north sites, even though it has not yet been reported from the north sites in this study. *Lecanora rubina* is also undoubtedly present and probably very abundant. *L. rubina, L. malanopthalma* and *C. elegans* are probably good indicators of air pollution. A student at Ricks College this fall, Michael Hansen, has measured increased rates of respiration in the two *Lecanoras* when they are exposed to sulfur dioxide fumes from a furnace specially built on the desert west of Rexburg; another student, Suzanne Pearson, has observed chemical alterations in cystine and cysteine directly proportional to the distance between the same furnace and the site where *L. melanopthalma* was growing. More detailed descriptions of the lichen community would be highly desirable in the Curlew Valley area in order that changes due to air pollution might better be assessed. Undoubtedly, microclimatic changes could also be evaluated better if the lichen vegetation were better known (see Pearson 1969, 1970).

Collections were made of *Candelariella vitellina* and *C. xanthostigma* on a rock very close to the north sites. The richness of the lichen flora at the north sites is not surprising; however, the abundance of lichens, especially *Collema tenax*, at the south site is remarkable.

F. 4 ALGAL CRUSTS

Introduction

Soil algae may form extensive photosynthesizing areas in hot, cold, and polar desert areas or in other extreme environments with respect to salinity or pH where no other chlorophyllous plants are evident. In arid and semi-arid areas, their importance has been noted in soil stabilization, the restriction of water penetration and evaporation, the reclamation of salty land, and as primary colonizers of barren ground. They are resistant to desiccation and to extreme soil temperatures, including diurnal freeze-thaw cycles. They are also fore-runners to subsequent establishment on soil surfaces of mosses and subsequent seedplants (Booth, 1941; Lynn and Brock, 1969).

A recent review has indicated that desert soil crusts and associated diaphanous materials provide ecological niches where environmental factors are much less restrictive than in the surrounding soil (Cameron and Blank, 1966). The abundance and diversity of populations built up in these microniches and their algal components are an important source of organic matter (e.g., Fltecher and Martin, 1948; Lund, 1962; Shields and Durell, 1964). It has been found that some soil crusts and some of the algal isolates from arid regions have the ability to fix atmospheric nitrogen (Cameron and Fuller, 1960; Mayland et al., 1966).

Since algae constitute a significant portion of the biomass of the lichen association, both free-living algae and lichen masses were recorded as algal crusts in this report. This was required due to the difficulty in quantitatively separating the free-living algal material from the lichen association and higher plant debris. In addition, the technique of estimating algal biomass was dependent on chlorophyll per unit surface area and did not distinguish between chlorophyll of algal-fungal associations and free-living algae.

This report deals with three aspects of algal crusts:

1. A technique to estimate biomass of algal crusts on desert soils.
2. The determination of biomass of surface algal crusts at the Curlew Valley southern validation sites.
3. The determination of the percentage of soil coverage by algae and algal crusts in relation to types of higher vegetation present at the Curlew Valley southern validation sites.

Technique development

A method for the determination of chlorophyll *a* in the presence of phaeophytin *a* (Method 602 C) is presented in Standard Methods for the Examination of Water and Wastewater, 13th edition, 1971. The major advantage claimed for this method is that it is possible to use it in situations where samples may contain large quantities of physiologically inactive green pigments whose source is the decomposing parts of higher plants or partially degraded algal materials. The technique of analysis is dependent upon the distinction between

phaeophytin *a* and chlorophyll *a*, which have absorption peaks in the same regions of the spectrum. It is known that acidification of chlorophyll *a* solutions results in a lowering of optical density at 665mμ, while solutions of phaeophytin *a* show no reduction when thus treated. It then becomes possible to read mixed solutions of chlorophyll *a* and phaeophytin *a* before acidification and obtain accurate measurement of chlorophyll *a* alone. It may also be necessary to read such solutions at 750mμ to adjust for turbidity of the solution.

To test this method of determination of chlorophyll and to correlate it with biomass of algal crusts, a number of experiments were conducted in the laboratory.

Experiment 1. Examination of algal mats grown on agar surfaces.

The first step in the conduct of the experiment was the establishment of an algal crust composed of genera obtained from the validation sites. The predominant organisms in this simulated desert algal crust were *Trentepholia*, *Oscillatoria*, *Phormidium* and *Scytonema*.

The medium chosen for the culturing of the algal mat was Bristol's solution fortified with 5% soil extract and solidified by addition of 1.5% agar (see RM 72-1, p. 63). Cultures of this and all succeeding experiments were grown under continuous light of approximately 500 to 100 ft.c. at a temperature of 25 ± 3 C for a period of 3 to 5 weeks following inoculation.

After the mat had reached a density roughly comparable to that observed on desert soils in the field, samples of known surface area (obtained by excision with a sharp scalpel using a 22 mm x 22 mm cover glass as a template) were removed and allowed to air dry in the laboratory for a period of at least 24 hr. The agar surface did not adhere to the mat material (verified by microscopic examination) and allowed the removal of a sample consisting primarily of algal material alone, with the possible exception of perhaps 1% or less of the biomass obtained being composed of either fungi or bacteria (estimated by microscopic examination). Following the drying period, the samples were either weighed and subsequently ashed to determine biomass, or extracted according to the following procedures.

Air dried samples were placed in porcelain crucibles, weighed, and the crucibles containing the algal mat material heated to a cherry red for 5 minutes over an open flame. The crucibles were placed in a desiccator and allowed to return to room temperature and then reweighed. The difference in weight following ignition from that of the air dried material was recorded as biomass.

Chlorophyll determination was made in the following manner.

a. The air dried algal crust was homogenized in 10 ml of 90% acetone and extracted in the dark at 5 C for 24 hr.
b. The extract was cleared of debris by centrifuging in a clinical centrifuge spinning at full speed for 3-5 min.

c. Solvent and contained chlorophyll were decanted to a spectrophotometer tube and read at 655 mμ and 750 mμ before and after acidifying with one drop of concentrated HCl.

d. The 750 mμ readings were subtracted from the 655 mμ readings in both reading sets.

e. The corrected 665 mμ readings were then used to calculate the concentration of chlorophyll in the sample accurding to the following equation:

$$C = \frac{26.73\ (665_b - 665_a) \times V}{A}$$

where 665_b and 665_a are the optical densities of the 90% acetone extract before and after acidification, respectively; V = volume of the extract in ml; and A = substrate area in square centimeters.

Chlorophyll values appeared quite consistent, indicating reasonable consistency of sample size and homogeneity of the algal mat. Biomass values were also acceptable on the basis of these criteria (Table 6).

It is, however, necessary that the relationship of chlorophyll content to biomass hold for increased sample sizes in order for it to be suitable for field application.

Experiment 2. Determination of the relationship of chlorophyll content to biomass values obtained from samples of increasing size.

To determine whether a linear relationship between biomass and chlorophyll exists for the algae of desert soil crusts, the preceding experiment was repeated using a series of increasingly large samples. The methodology of the experiment was identical to that of the preceding experiment with the exception that a greater number of samples were removed from the mat.

Referring to Table 7 it can be seen that a strong correlation exists between biomass and chlorophyll and that both values correlate with the size of area sampled. It would thus appear that if a given area of algal mat is analyzed for chlorophyll content that the biomass of the area sampled can be determined if interference from attached debris does not interfere with the analysis.

Experiment 3. Effect of soil and plant debris on determination of biomass and chlorophyll of desert soil crusts.

Two types of culture media were prepared. The first consisted of a simple slurry of desert soil collected from the validation site which was autoclaved and allowed to come to a solid but quite moist condition. The second type of culture media was prepared as above, except for the addition of a thin layer of Bristol's

solution fortified with 5% soil extract prepared from the same soil and solidified with 1.0% agar. Three types of samples, all representing the same surface area (4.84 cm^2) were removed from the soil and agar surfaces.

One set of samples consisting of algal crust and attached soil and plant debris was assayed for biomass and chlorophyll with little attempt at separation of the algal crust from the attached soil and debris. A second set of samples, also from the soil surface medium,was carefully washed to remove as much attached soil and debris as possible without loss of any algal material. The third set of samples was obtained from the agar surface slurry and was quite free of contaminating material which might be expected to contribute to biomass (verified by microscipic examination). Samples were all handled as previously described and analyzed for both chlorophyll and biomass as per previous methodology.

Values of biomass and chlorophyll *a* obtained from the various types of samples are shown in Table 8. As can be seen, the presence of even "small" amounts of attached non-algal material greatly affects the values obtained for biomass; however, chlorophyll *a* values tend to be quite constant regardless of contamination by non-algal components and show good correlation with biomass of cleanly-harvested algal material.

In addition it appears that attached soil and plant debris have no effect on the values for chlorophyll by the method employed.

Table 6. Biomass of agar-grown algal mat compared to chlorophyll *a* content.

Sample		Biomass* (mg)		Chlorophyll *a** ($mg \times 10^{-3}$)
1		2.1		3.4
2		1.9		3.6
3		2.4		3.6
4		2.0		3.9
	Average	2.1	Average	3.6

*All values are for sample areas of 4.84 cm^2.

Table 7. Biomass and chlorophyll *a* content of algal crusts of increasingly large areas

Crust Area (cm^2)	Biomass (mg)	Chlorophyll *a* ($mg \times 10^{-3}$)	$\frac{\text{Chlorophyll } a}{\text{Biomass (mg)}} \times 10^{-3}$
4.84	28	3.8	1.36
"	26	3.5	1.35
"	20	3.6	1.80
9.68	49	7.9	1.61
"	46	7.6	1.55
"	48	7.4	1.54
19.36	90	15.0	1.67
"	85	14.4	1.69
"	86	14.5	1.69
		Average	1.58

Table 8. Comparison of biomass and chlorophyll *a* values obtained from 484 mm^2 area of algal crusts

Biomass (mg) (uncleaned crusts)	Chlorophyll *a* (mg x 10^{-3}) (uncleaned crusts)	Biomass (mg) (cleaned crusts)	Chlorophyll *a* (mg x 10^{-3}) (cleaned crusts)	Biomass (mg) (agar crust)	Chlorophyll *a* (mg x 10^{-3}) (agar crust)
238	4.6	58	5.0	30	4.5
249	4.9	76	5.3	35	4.9
230	5.2	60	4.6	35	5.1
220	4.7	64	4.3	37	4.7
160	4.5	75	4.8	32	5.8
Averages					
222	4.7	65	4.8	35	4.8

The results of the experiments strongly indicate that estimation of algal biomass of desert soil-algae crusts is greatly dependent upon the freeness of the sample from other contaminating substances, if determinations are made on the basis of ashing. In addition, it is apparent that even if crusts are carefully cleaned of debris, sufficient non-algal material remains which greatly influences the results obtained by ashing.

Chlorophyll values obtained by the method described appear to be quite unaffected by the presence of non-algal materials present in samples and seem to be quite consistent for comparable algal crusts, at least for the soil types used and cultural conditions employed.

Methods to determine biomass and cover

Samples were removed from the southern sites for subsequent laboratory evaluation. Such samples were taken at 1 m intervals along 100 m transects on both sites. Evaluation was carried out in regard to quantification of biomass values, on an area basis. Samples were harvested by means of a stainless steel cork borer of known diameter and the surface area of the sample calculated. All data gathered were from the upper 1 cm of soil surface unless otherwise indicated.

Samples of known algal surface area were homogenized in 90% acetone and extracted in the dark for 24 hrs. Following extraction the supernatant was cleared of debris by centrifugation or by filtration through glass-fiber filters. The supernatant was then decanted to a spectrophotometer tube and read at 665mμ before and after acidifying with one drip of conc. HCl. The 750mμ readings were subtracted from the 665mμ readings in both pre- and post-acidified solutions to account for turbidity. In every case in which samples were filtered, the 750mμ readings were found to be stable before and after acidificaiton. THis portion of the technique will be omitted in the future. The corrected 665mμ readings were used to calculate the concentration of chlorophyll in the sample according to the following equation:

$$C = \frac{26.73\ (665_b - 750_b)\ X\ (665_a - 750_a)\ X\ V}{A}$$

Where 665_a and 665_b and 750_a and 750_b = O.D. of the acetone extract at the indicated wave lengths before and after acidification. V = volume in l of extracting solution, and A - the area in m^2 represented by the sample. C = chlorophyll *a* in mg/m^2.

The methods are associated with DSCODE'S A3UBJ11 and A3ULA04.

Results

Analysis of the data indicates that no correlation exists between the type of vascular vegetation present and the extent or nature of the cryptomatic crust (Table 9). However, the crested wheat grass site surveyed yielded a more homogeneous cover with regard to algal flora than did the shrub site which was rich in both algal and lichen cryptogams. Algal biomass in the crested wheat site was also much less variable than in the shrub site examined.

Visual examination in the field indicated an average of 71% algal cover for the shrub site and 80% for the crested wheat grass site. Biomass values for the shrub site ranged from a dry weight of 95.7 kg/ha to 239 kg/ha and averaged 159 kg/ha. It should be pointed out that these data were collected in July, a period at which algal biomass values would be expected to approach their yearly minimum due to the very dry conditions which prevailed. A standing crop of soil algae will be conducted in the winter and spring of 1973 -- periods during which it is assumed that algal standing crop will be near maximum for these sites.

The southern sites were found to contain the following genera: *Astasia*, *Cholorella*, *Chlorococcum*, *Nostoc*, *Oscillatoria*, *Phormidium*, *Scytonema*, and *Tolypothrix*.

Table 9. Biomass and cover of algal crusts on southern validation sites

Zone Number	Vegetation Type	Hectare Number	Algal Cover (%)	Algal Biomass (kg/ha)
1*	*AGR CRI***	12		
	ATR CON	14-15	80	96
	SIT HYS	33-34		
		44		
	AGR CRI	09		
2*	*ATR CON*	38-39	80	96
		55-56		
		64-65		
		58		
3*	*AGR CRI*	72	80	97
		77		
		84-85		
4	*AGR CRI*	01	80	97
	ART TRI			
5	*ATR CON*	05-06	82	144
	CHR VIS			
	SIT HYS			
	ART TRI	09-10		
6	*ATR CON*	12-13	74	144
	SIT HYS	25-26		
7	*ATR CON*	24-33	61	192
	SIT HYS			
	ART TRI			
8	*ATR CON*	29-30	73	191
	CHR VIS	47-48		
	SIT HYS			
	ART TRI(dead)	41-51-52	73	96
9	*SIT HYS*			
	ART TRI	56-66-65	78	169
10	*ATR CON*			
	ART TRI	57-58		
11	*ATR CON*	67-68	78	216
	CHR VIS			
12	*ART TRI*	59-60	80	167
	ELY CIN			
13	*ART TRI*(dead)	86-87	41	96
	HAL GLO	94-95		
14	*ART TRI*	81-91	67	96
	SIT HYS			
15	*SIT HYS*	91-92	70	239

*Zones 1-3 are located in the southern crested wheat grass site while zones 4-15 are located in the southern validation shrub site.

**Abbreviations used as indicated below:

AGR CRI=Agropyron cristatum
ART TRI=Artemisia tridentata
ATR CON=Atriplex confertifolia
CHR VIS=Chrysothamnus viscidiflorus
ELY CIN=Elymus cinereus
HAL GLO=Halogeton glomerata
SIT HYS=Sitanion hystrix

F. 5 MICROORGANISMS

The validation program at Curlew Valley treated migroorganisms a little differently than it did other organisms. This was because biomass of microbes *per se* has less biological significance than their activity. Therefore, a decision was made to include the determination of microbial activity rate in the soil. THis was done on both the northern and southern sites by different investigations.

Introduction; southern sites

An attempt was made on the southern sites to characterize microbial activity through the soil profile and season of year. In addition a determination was made of soil nutrient pools and fluxes, especially those of nitrogen (DSCODE A3UBJK1).

Methods; southern sites

Early samples were taken at four locations on or near the southern sites. Three were in native vegetation and one was in crested wheat grass. Sample station 1 was at soil survey location no. 21. The dominant vegetation was shadscale. Sample station no. 2 was at soil survey location no. 15 where the dominant vegetation was sagebrush. Sample station no. 3 was at soil survey location no. 22; dominant vegetation was crested wheat grass. Sample station no. 4 was at soil survey location no. 14, characterized by shadscale vegetation. The physical and chemical properties at the sample stations are reported in Table 1 on page 2.2.2.1.-77 of RM 72-1.

At each station samples were taken with an auger at the 0-3, 5-20, 40-50, 70-80, 110-130 cm depths. The samples were placed in sterile whirl-a-pak bags, marked for identification, and stored in a refrigerator at 3 C until tested. Prior to analysis, the entire sample was mixed thoroughly with a mortar and pestle, returned to the bag, and the desired amount weighed for testing.

Beginning in March,1972, the samples were taken at different areas than before and were collected under or between specific plant species (Table 10). Only the surface 8 cm of soil were taken. The samples were handled as described above.

Table 10. Location and description of microbial sampling areas on southern sites, 1972

Date	Designation	Location	Vegetation
March	3-SU	Shrub site	Under sage brush
March	3-SF	Shrub site	Sage brush interspace
March	4-AgU	Grass site	Under crested wheat
March	4-AgF	Grass site	Crested wheat interspace
March	4-AtV	Grass site	Under shadscale
March	4-AtF	Grass site	Shadscale interspace
March	3-RU	Shrub site	Under rabbit brush
March	3-RF	Shrub site	Rabbit brush interspace
March	3-AtU	Shrub site	Under shadscale
March	3-AtF	Shrub site	Shadscale interspace
May-Nov	3-I abcde	Soil location no. 15	Nonspecific interspace
May-Nov	3-T abcde	Soil location no. 15	Under sage brush
May-Nov	3-C abcde	Soil location no. 15	Under sage brush
May-Nov	41-I abcde	Soil location no. 22	Nonspecific interspace
May-Nov	41-B abcde	Soil location no. 22	Under shadscale
May-Nov	4-I abcde	Soil location no. 13	Nonspecific interspace
May-Nov	4-A abcde	Soil location no. 13	Under crested wheat
May-Nov	4-C abcde	Soil location no. 13	Under shadscale

The determination of microbial numbers (DSCODE A3UBJJ5) was made by placing 1 g of each sample in a 250 ml screw-cap Erlenmeyer flask containing 99 ml sterile distilled water to give a 1:100 dilution. After vigorous shaking, further dilutions of 10^{-3}, 10^{-4}, 10^{-5} and/or 10^{-6} as desired, were made in screw-cap tubes containing 9 ml sterile distilled water. Five plates were made for each dilution. Plates with 10^{-2} and 10^{-3} and 10^{-4} dilutions were poured with Martin's Medium for the enumeration of fungi. Plates with 10^{-4}, 10^{-5}, and/or 10^{-6} dilutions were poured with Soil Extract Agar for the enumeration of bacteria and streptomycetes.

After thorough mixing, the agar was allowed to harden, and the plates were incubated at 22 C. The plates were stacked and inverted during incubation time. The fungal plates were counted after 5 days; the bacterial colonies on the soil extract agar plates were counted after 5 days, and the streptomycetes on the same plates between 7 and 14 days.

For microaerophilic plate counts, soil dilutions of 10^{-3} and 10^{-4} were plated with Brewer's Anaerobic Agar (Difco). The solidified plates were placed upright in large desiccator jars The desiccators contained a small amount of 0.5M sulfuric acid in a water reservoir below to obtain a less than saturated water vapor atmosphere. The lid was placed on the jars with a sealant and the jars evacuated. Nitrogen was then allowed to fill the jar from a nitrogen tank. This process was repeated three times. After 14 days the plates were removed and counted.

All microbial counts are reported on an over-dry soil weight basis. Methods for the preparation of soil extract agar and Martin's medium were described on pages 2.2.2.1.-76, 79 of RM 72-1.

The Curlew Valley validation site report of 1971 research, RM 72-1 (Balph, 1972) also describes techniques employed to measure soil respiration (p. 79.), phosphatase activity (p. 79), proteolytic activity (p. 80), dehydrogenase activity (p. 81), soil pH (p. 81), ammonium nitrogen (p. 81), total nitrogen (p. 82), nitrate nitrogen (p. 82), nitrate nitrogen (p. 82), organic carbon (p. 82), and soil moisture content (p. 84). Nitrification potential was measured by a percolation method, using a perfusion apparatus as described by Collins and Sims (1956). Nitrate was determined with the 4-methylumbelliferous method (Skujins, 1964).

Soil water potential was measured using a Wescor, Inc., Model MJ55 psychrometric microvoltmeter with a Model C-51 Sample Chamber Psychrometer (Instruction Manual, C-51 sample Chamber Psychrometer, Wescor, Inc., Logan, Utah). Calibration of the psychrometer was done according to Wiebe et al. (1971).

Results, southern sites:

Streptomycete numbers, aerobic bacteria numbers, fungi propagule numbers, and microaerophile numbers are given in Tables 2,3,4, and 5, respectively, on pp. 85-88 of RM 72-1 (Balph, 1972). Numbers of microorganisms found in the March, 1972, samples are shown in Table 11.

It is evident that there are about an equal number of streptomycetes and bacteria in these soils. Most of the streptomycetes are located in the 5 - 20 cm layer, whereas bacteria fluctuate about evenly between 0 - 3 and 5 - 20 cm depths. These numbers decrease considerably with increase in soil depth, reaching numbers below 10,000/g, which is extremely low for natural soils.

Numbers of streptomycetes for soil samples of March, 1972, ranged from 8.6×10^{-6} to 190 X 10-6 Numbers of streptomycetes were always somewhat higher than numbers of aerobic bacteria. Except for soil sample 4Aa (under crested wheat), all the samples taken under the plants had higher numbers than those taken from interspaces between plants.

Fungal numbers, likewise, were higher in soils from under plants than in soils from interspaces. These numbers varied from 12,000 - 387,000.

Anaerobic bacterial counts ranged from 80,000 - 1,120,000 and were generally higher in soils from under plants than in soils from interspaces

Dehydrogenase activity (A3UBJJ4) representing total biological activity is reported for samples taken through the soil profile from 1969 - 1971 in Table 6 of RM 72-1, p. 95 (Balph, 1972). Table 12 of the present report shows dehydrogenase activity for surface soils sampled in 1972. It is evident that most of the activity was located in the top 3 cm layer, with generally negligible rates below.

The dehydrogenase results for March, 1972, indicated that the highest activity was in soils from under shadscale. The next highest activity was under the base of rabbit brush. The lowest activity of 0.61 mg formazan was in the interspaces between shadscale. All activities were lower in soils from the interspaces than in soils from under the plants.

The highest dehydrogenase activity in May 10, 1972, samples was found in 4-I interspace between crested wheat, grass site, location no. 13. The highest activity in June 2, 1972, samples was in 4-A under crested wheat, grass site, location no. B. The lowest activity in both May 10 and June 2 samples was in 3-I, interspace, grass site, location no. 15. The activity remained about the same from May to June except for the 4-A samples in which June activity was about 50 percent higher than May activity. The values for different samples taken from each area were generally in close agreement.

June 15, 1972 samples showed essentially the same amounts of activity the May and June 2 samples. Activity in 4-A was the same as in May rather than high as on June 2.

The highest dehydrogenase activity on July 7 and 13, 1972, was found in 4-A under crested wheat, grass site. The lowest activity on July 7 and 13, as in May and June, was found in 3-I interspace, shrub site. July 27 samples showed an overall increase in activity, with highest activity at 4-I, interspace, crested wheat, and 3-T, under sage brush, shrub site.

August 5, 1972, samples indicated a decrease in activity, with highest values again in 4-A samples. September 29 samples showed an increase in activity, with 1.76 mg formazan formed from 4-A samples. October samples showed a decrease in activity from a high of 1.4 mg formazan from 3-C, under shadscale, shrub site, on October 6, to a high of 1.03 mg from 3-T on October 15. The lowest activity on October 15 was 0.40 mg formazan formed from 3-I.

Proteolytic activity (DSCODE A3USQ02) represented the ability of soil to degrade proteinaceous matter. Tbe protein hydrolysis values for 1970, 71, expressed as percent gelatin hydrolyzed under experimental conditions, are shown in Table 7 of RM 72-1, p. 95. Proteolytic activity, like dehydrogenase activity, was higher by about one order of magnitude in the top 3 cm layer than in the rest of the soil, based on 1972 surface samples (Table 13).

Table 11. Numbers of microorganisms in soils of southern sites, March, 1972

Sample	Aerobic Bacteria (no/g dry soil)	Streptomycetes (no/g dry soil)	Fungi (no/g dry soil)	Anaerobic Bacteria	
				Sample	No/g dry soil
3-SU	65,400,000	72,900,000	445,000	3-SU	576,000
3-SF	21,800,000	42,700,000	16,900	3-SF	1,070,000
4-AgU	90,800,000	97,800,000	33,300	4-AgU	333,000
4-AgF	101,600,000	116,000,000	81,700	4-AgF	114,000
4-AtU	196,000,000	211,000,000	57,100	4-AtU	460,000
4-AtF	81,300,000	93,800,000	22,300	4-AtF	385,000
3-RU	181,000,000	192,000,000	39,900	3-RU	1,320,000
3-RF	36,900,000	46,700,000	26,000	3-RF	86,900
3-AtU	14,000,000	18,200,000	20,000	3-AtU	467,000
3-AtF	9,410,000	11,400,000	13,200	3-AtF	548,000

Table 12. Dehydrogenase activity in top 8 cm of soil on southern sites

Sample	mg Formazan Formed 27 March 72
3-SU	1.04
3-SF	.66
4-AgU	1.20
4-AgF	.98
4-AtU	1.78
4-AtE	1.21
3-RU	1.41
3-RF	.82
3-AtU	1.02
3-AtF	.61

Sample	mg Formazan Formed		
	10 May 72	2 June 72	15 June 72
4-I	1.07	.95	1.07
4-A	.95	1.42	.97
4-I	.89		
4-B	1.00		
3-I	.502	.50	.63
3-C	1.02	1.03	1.10
3-T	1.04	.96	1.05

Sample	mg Formazan Formed			
	7 July, 72	13 July, 72	27 July, 72	5 August, 72
3-Ca	.64	.65	1.26	.85
b	.60	1.29	1.07	.94
3-Ia	.34	.79	.70	.48
b	.36	.48	.77	.49
3-Ta	.40	1.37	.92	.95
b	.68	.69	1.43	.81
4-Aa	.76	1.13	.98	1.07
b	1.04	1.39	.91	1.40
4-Ia	.58	1.40	1.06	.65
b	.66	.93	1.44	.96

Sample	mg Formazan Formed 29 September, 72
3-C	.46
3-I	.90
3-T	.66
4-A	1.76
4-I	1.28

Sample	mg Formazan Formed		
	6 October, 72	15 October, 72	19 October, 72
3-C	1.4	.98	---
3-I	.66	.40	1.19
3-T	.84	1.03	---
4-A	---	.80	1.04
4-C	.90	---	---
4-I	.94	.72	.90

Table 12. Continued

Sample	mg Formazan Formed 1 November, 72	mg Formazan Formed 6 November, 72
3-C	1.74	----
3-AC	----	1.28
3-I	.62	.68
3-AT	----	.96
3-T	.88	----

4-A	1.48	----
4-AC	----	.91
4-I	1.24	.90

Table 13. Proteolytic activity in top 8 cm of soil on southern sites

Sample	% Hydrolysis 27 March, 72
3-SU	36
3-SF	17
4-AgU	33
4-AgF	30
4-AtU	35
4-AtF	20
3-RU	35
3-RF	19
3-AtU	16
3-AtF	20

Sample	% Hydrolysis 10 May, 72
41-B	32
41-I	27.4
4-I	29.2
4-A	28.0
3-C	33.4
3-T	34.6
3-I	18.8

Sample	% Hydrolysis 2 June, 72	15 June, 72	21 June, 72	29 June, 72
3-Ca	23	13	35	44
3-Cb	23	4	35	33
3-Ta	7	33	21	36
3-Tb	39	42	25	36
3-Ia	7	7	9	11
3-Ib	24	24	21	24
4-Aa	39	42	33	23
4-Ab	5	44	26	23
4-Ia	7	29	25	23
4-Ib	2	26	26	43

Table 13. Continued

Sample	% Hydrolysis 7 July, 72	13 July, 72	27 July, 72
3-Ca	42.5	41.0	36.0
3-Cb	43.0	37.0	33.0
3-Ta	15.0	25.0	36.0
3-Tb	29.0	29.0	29.0
3-Ia	13.0	28.0	10.0
3-Ib	17.0	17.0	22.0
4-Aa	31.0	33.0	37.0
4-Ab	39.5	36.0	37.0
4-Ia	31.5	31.0	36.0
4-Ib	26.0	20.0	38.0

Sample	% Hydrolysis 5 August, 72	Sample	% Hydrolysis 29 September, 73
3-Ca	38	3-C	14
b	42	3-I	29
3-Ia	10	3-T	23.4
b	26	4-A	48
3-Ta	33	4-I	39
b	41		
4-Aa	36		
b	40		
4-Ia	28		
b	28		

Sample	% Hydrolysis 6 October, 72	15 October, 72	19 October, 72
3-C	45	43	
3-T	13	18	43
3-T	33	41	
4-A	--	42	47
4-C	44	--	--
4-I	42	38	35

Sample	% Hydrolysis 1 November, 72	6 November, 72
3-C	62	
3-AC		45
3-I	25	22
3-A		44
3-T	46	
4-A	60	
4-AC		46
4-I	49	36

Proteolytic and dehydrogenase activity followed similar patterns in these soils. Proteolytic activity in May 10, 1972, like dehydrogenase activity, was highest in samples 4-I, 41-B, 3-T, and 3-C, and lowest in 3-I.

The highest activity in June, July and August was in samples from under shadscale on the shrub site, and from under crested wheat on the grass site. In September, activity was greatest in samples from under crested wheat, grass site, but was lowest in samples from under shadscale, shrub site. However, the differences between species was not highly significant.

Phosphatase activity values in absence of bacteriostatic agent (A3UBJJ2) and in presence of toluene (A3UBJJ3) are shown in Table 8 and 9 of RM 72-1 (p. 97) for 1970 and 71, and in Tables 14 and 15 for 1972. The activity is not restricted to the surface layer. Often the deeper soil layers have higher values. Phosphatase activity showed little difference among 1972 samples, except that there was very low activity in the soils from under sage brush. Activity was generally highest in the interspace areas rather than under the plants, with the exception of 4-Ia, interspace crested wheat, grass site, location no. 13. Phosphatase activity for May 10 was highest in samples from interspaces, shrub site location no. 15. Activity was reduced by 1/2 in all other samples.

Soil respiration values (A3UBJJ1) are shown in Table 10 of RM 72-1 (p. 101) for 1970- 71, and in Table 16 for 1972. These values decrease with increasing soil depth. The values at 5-20 cm are 1/2 those at 0-3 cm, and become even smaller at greater depths.

The amounts of ammonium (ppm), nitrate (ppm), total inorganic nitrogen (ppm), organic nitrogen (percent), and total nitrogen are shown in Table 11 of RM 72-1, p. 102 (DSCODE A3USQ01). Seasonal changes in soil nitrogen are shown in Figure 2 for ammonium, Figure 3 for nitrate, and Figure 4 for total nitrogen.

Soil organic carbon (A3USQ01) values are also shown in Table 11 of RM 72-1, p. 102. Seasonal changes in soil organic carbon content are shown in Figure 5.

Table 14. Phosphatase activity in absence of microbial inhibitor in top 8 cm of soil on southern sites

Sample	μmoles β-naphthol/g soil 27 March, 1972
3-SU	.20
3-SF	.76
4-AgU	.46
4-AgF	.44
4-AtU	.58
4-AtF	.70
3-RU	.60
3-RF	1.02
3-AtU	.66
3-AtF	.90

Table 14. Continued

Sample	µmoles β-naphthol/g soil 10 May, 1972
3-C	.47
3-I	.84
3-T	.39
4-A	.55
4-I	.57
41-I	.42
41-B	.70

Table 15. Phosphatase activity in presence of microbial inhibitor in top 8 cm of soil on southern sites

Sample	µmoles β-naphthol/g soil 27 March, 1972
3-SU	.10
3-SF	.64
4-AgU	.34
4-AgF	.27
4-AtU	.40
4-AtF	.56
3-RU	.38
3-RF	.80
3-AtU	.52
3-AtF	.70

Sample	µmoles β-naphthol/g soil 10 May, 1972
3-C	.33
3-I	.70
3-T	.24
4-A	.37
4-I	.38
41-I	.34
41-B	.50

Table 16. Rate of CO_2 evolution in top 8 cm of soil on southern sites

	CO_2 in µmoles/g/min							
Sample	-Bars	2 June 72	-Bars	15 June 72	- Bars	21 June 72	-Bars	29 June 72
3-Ca	-1.5	38.6	-3.8	13.6	-5.3	17.6	-3.4	37.6
b	-1.4	33.2	-4.3	13.9	-4.7	37.4	-3.6	21.2
3-Ia	-0.6	40.8	-4.6	7.0	-5.4	23.0	-1.7	20.8
b	-0.8	18.2	-4.1	20.6	-6.2	35.0	-2.1	19.1
3-Ta	-1.9	53.6	-4.3	33.2	-3.4	31.4	-2.5	29.6
b	-2.2	48.8	-4.3	37.9	-4.4	44.6	-2.2	72.4
4-Aa	-1.1	49.2	-4.4	37.4	-4.1	53.7	-4.1	65.3
b	-1.5	49.2	-5.1	59.9	-4.2	45.0	-1.6	55.5
4-Ia	-1.7	50.6	-4.2	49.6	-4.3	51.5	-2.6	52.0
b	-2.3	50.2	-4.9	46.1	-5.5	57.5	-2.2	66.6

Continued

Table 16. Continued

Sample	-Bars	7 July 72	-Bars	13 July 72	-Bars	27 July 72
3-Ca	-6.9	47.0	-3.4	42.6	-6.7	34.4
b	-5.8	49.2	-3.8	68.0	-8.6	17.2
3-Ia	-5.7	24.8	-4.9	44.8	-6.5	18.8
b	-5.7	38.2	-5.4	44.0	-7.0	23.4
3-Ta	-3.3	30.6	-4.2	32.4	-5.4	45.4
b	-3.8	39.4	-6.2	68.4	-6.1	49.6
4-Aa	-0.9	60.6	-4.7	66.6	-6.0	42.8
b	-4.2	60.2	-6.0	58.2	-5.5	43.6
4-Ia	-0.7	50.4	-6.5	31.4	-4.7	36.2
b	-4.1	61.0	-8.0	59.0	-7.4	66.0

	CO_2 evolved, µmoles/g/min			
Sample	-Bars	5 August 72	-Bars	29 September 72
3-Ca	-2.7	10.6	-0.6	12.0
b	-3.2	21.2	-0.2	10.6
3-Ia	-1.2	18.6	-1.8	11.4
b	-1.4	9.2	-2.2	14.2
3-Ta	-4.4	37.6	-10.4	47.4
b	-4.8	28.8	-12.6	47.4
4-Aa	-2.8	38.6	-6.2	40.0
b	-10.6	39.4	-6.3	55.0
4-Ia	-6.3	18.6	-2.8	26.6
b	-6.8	38.2	-2.5	32.4

	CO_2 evolved, µmoles g/min					
Sample	6 October 72	-Bars	15 October 72	-Bars	19 October 72	-Bars
3-C	36	-6.9	26	-5.3	---	---
3-I	25	-6.7	9	-6.0	24	-8.5
3-T	24	-9.0	26	-9.5	---	---
4-C	37	-7.5	---	----	---	---
4-I	31	-8.5	22	-8.5	12	-8.0
4-A	--	----	22	-8.5	33	-11.0

	CO_2 evolved, µmoles/g/min			
Sample	1 November 72	-Bars	6 November 72	-Bars
3-C	38	-6.5	---	---
3-AC	---	---	41	-9.5
3-I	11	-4.5	9	-9.0
3-T	16	-11.5	---	---
3-AT	---	---	31	-9.5
4-A	26	-11.5	---	---
4-AC	---	---	32	-9.0
4-I	14	-12.5	4	-6.4

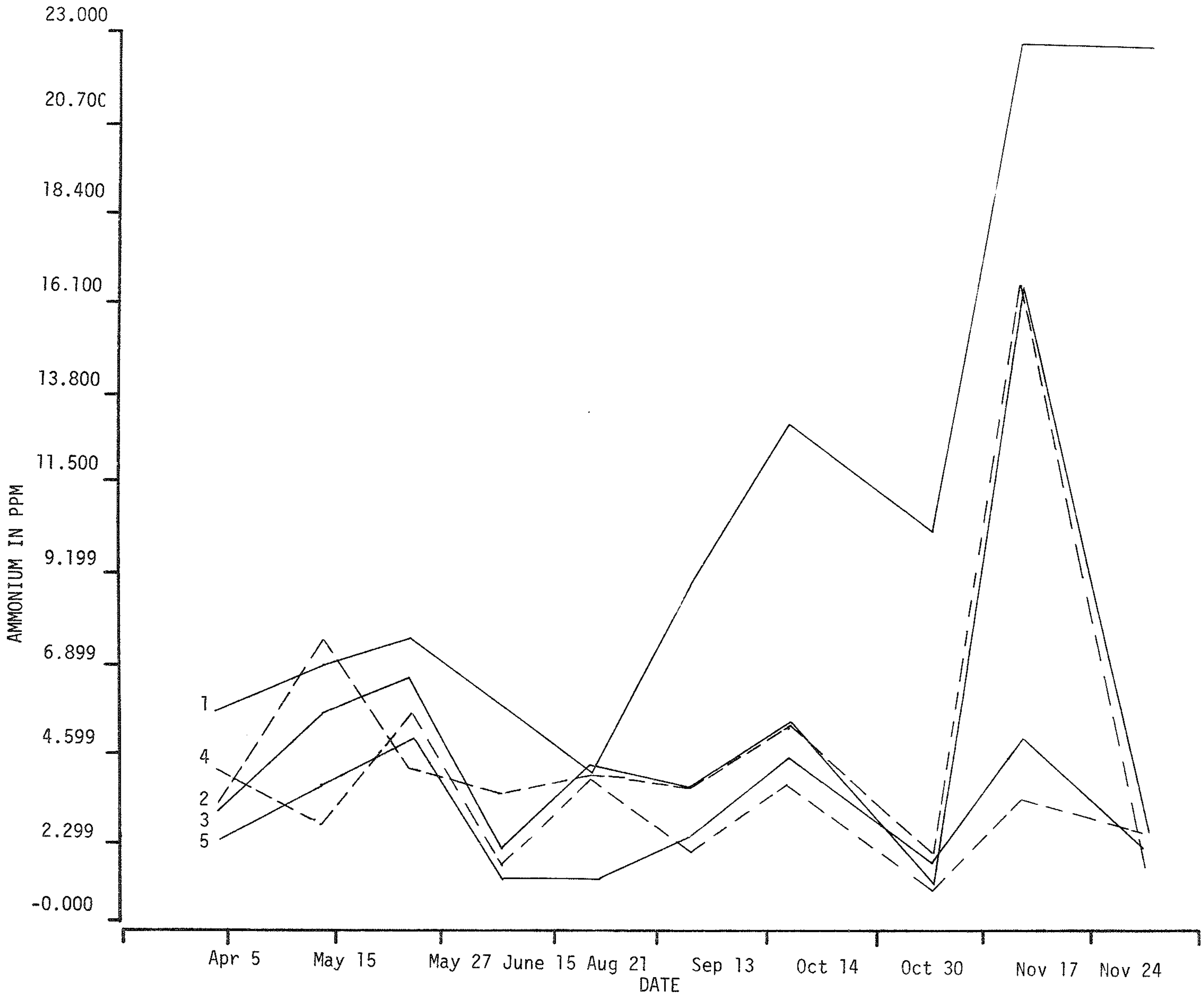


Figure 2. Seasonal changes in mean ammonium at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

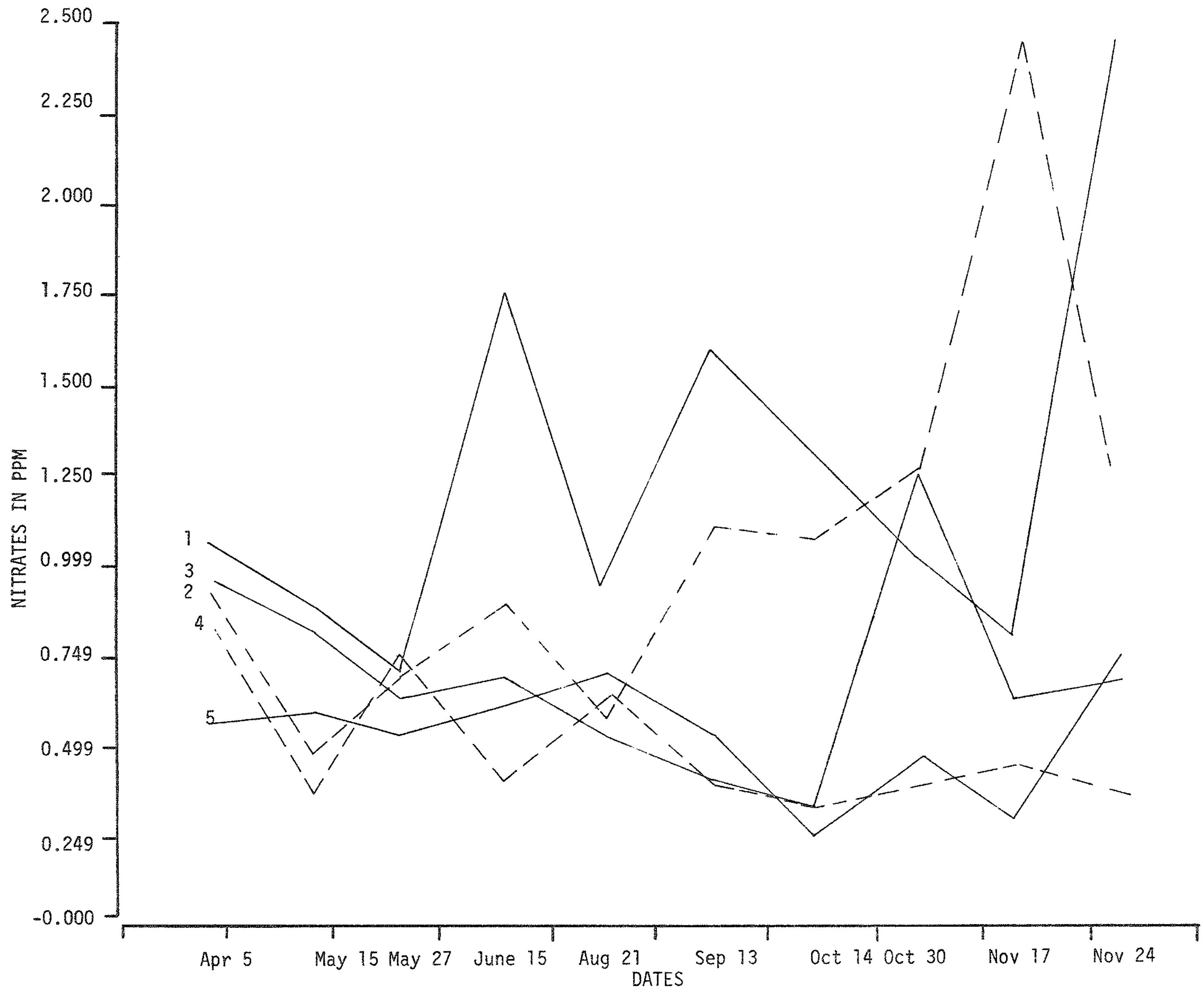


Figure 3. Seasonal changes in mean nitrates at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

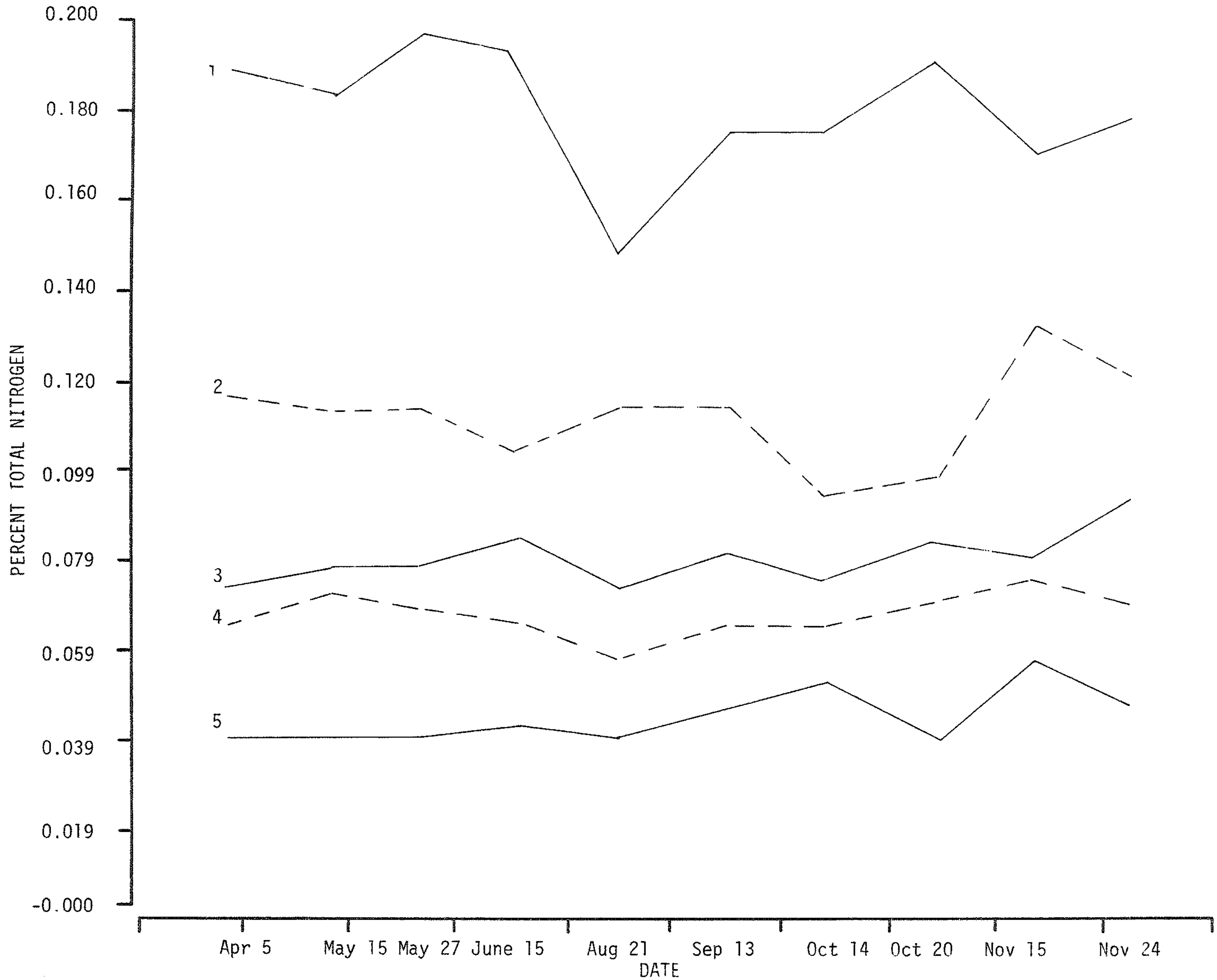


Figure 4. Seasonal changes in mean nitrogen at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

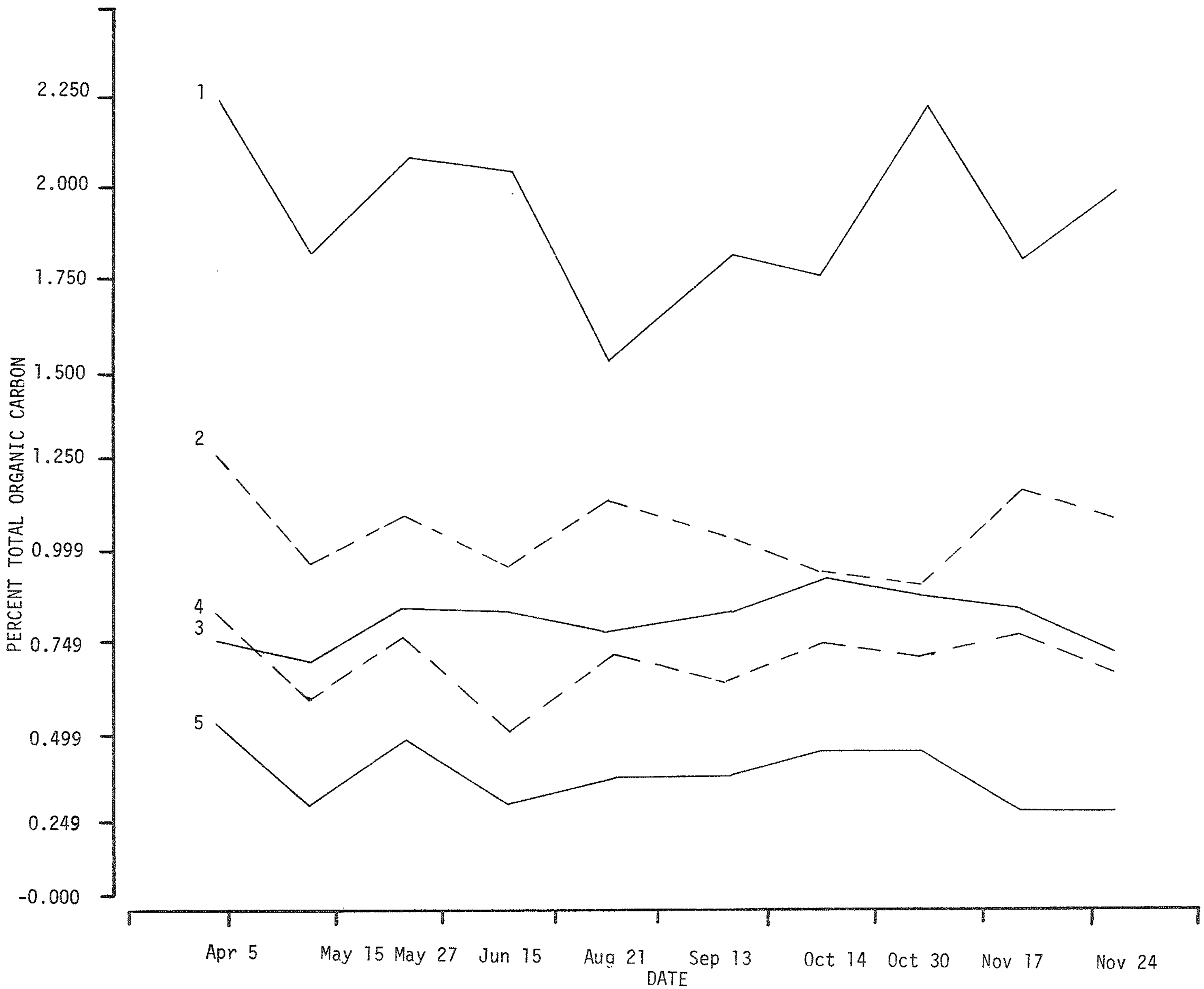


Figure 5. Seasonal changes in mean organic carbon at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

The Carbon-Nitrogen ratio values indicate the carbon availability for nitrogen immobilizatior (see Table 12, RM-72, p. 114). The values all lie between 6 and 12, which is low. No seasonal correlation is now evident, but there appears to be a correlative trend between the C/N ratio and depth in the profile. The average C/N value decreased by 1 - 3 units from the surface to 5 - 20 cm depth, then remained stable to 1 m depth, when it increased considerably in some cases.

The pH values (A3UBJJ6) of collected soils are shown in Table 13 of RM 72-1, p. 115, for 1969 and 1971, and in Table 17 for 1972. These values were determined in a 1:1 water suspension and were therefore essentially different from those shown on p. 77 of RM 72-1, which were determined in a soil paste.

Soil moisture for samples collected from the southern sites in 1972 are shown in Table 18. Samples taken at the base of sage brush, shrub site,had the highest percent moisture of all the samples taken in the months of June and July. In August, September, and October, the highest moisture content was found in samples from the crested wheatgrass site.

Table 17. Sample pH values in top 8 cm of soil on southern sites, 1972

Sample	2 June 1972	15 June, 72	21 June 72	29 June 72
3-Ca	8.55	9.80	9.08	9.05
b	8.90	9.52	8.89	9.33
3-Ia	8.18	8.90	8.55	8.95
b	8.30	9.08	8.64	8.98
3-Ta	8.18	9.12	8.61	8.98
b	8.22	8.80	8.41	8.70
4-Aa	8.49	9.10	8.48	8.65
b	8.51	9.09	8.39	8.78
4-Ia	8.85	9.20	8.60	9.13
b	8.48	8.90	8.51	8.99

Sample	7 July 72	13 July 72	27 July 72
3-Ca	8.88	9.07	8.85
b	8.90	8.33	9.18
3-Ia	8.68	8.75	8.99
b	8.52	8.77	9.13
3-Ta	8.72	9.15	8.72
b	8.62	8.35	8.62
4-Aa	8.55	8.53	8.58
b	8.72	8.68	8.65
4-Ia	8.87	8.88	8.98
b	8.73	9.18	9.02

Table 17. Continued

Sample	5 August 72	29 September 72
3-Ca	8.88	8.99
b	9.00	
3-Ia	8.47	9.12
b	8.50	
3-Ta	8.48	9.22
b	8.28	
4-Aa	8.47	9.31
b	8.40	
4-Ia	8.72	9.21
b	8.68	

Sample	6 October 72	15 October 72	19 October 72
3-C	9.45	8.75	
3-I	8.83	9.15	8.82
3-T	8.69	8.81	
4-A	----	8.75	8.47
4-C	8.68	----	
4-I	8.91	8.98	9.22

Sample	pH
	1 November, 1972
3-C	8.83
3-I	8.96
3-T	8.57
4-A	8.65
4-I	9.05
	6 November, 1972
3-AC	8.43
3-I	8.22
3-AT	8.45
4-AC	8.32
4-I	8.71

Table 18. Moisture content through soil profile on southern sites in 1972

	Percent Moisture			
Sample	2 June, 72	15, June 72	21 June 72	29 June 72
3-Ca	3.84	3.09	3.62	2.55
b	4.17	3.41	3.41	3.19
3-Ia	1.31	2.46	1.22	2.04
b	3.30	2.55	1.93	2.46
3-Ta	4.27	4.05	2.55	2.14
b	1.62	4.05	2.88	2.35
4-Aa	0.60	3.30	3.19	1.72
b	3.30	3.51	2.88	2.46
4-Ia	1.93	2.77	2.65	1.72
b	3.19	2.77	2.77	1.62

Table 18. Continued

Sample	Percent Moisture 7 July 72	13 July 72	27 July 72
3-Ca	3.95	2.14	1.72
b	4.27	2.46	1.01
3-Ia	3.95	2.04	2.46
b	2.77	2.14	2.88
3-Ta	5.93	2.88	5.48
b	4.71	3.62	3.84
4-Aa	2.88	1.83	0.40
b	2.65	2.04	0.40
4-Ia	2.88	1.83	3.30
b	2.65	2.46	3.09

Sample	5 August, 72	29 September, 72
3-Ca	2.46	7.70
b	2.77	---
3-Ia	2.35	5.40
b	2.35	---
3-Ta	2.77	4.10
b	2.77	---
4-Aa	4.38	5.20
b	3.95	---
4-Ia	2.98	5.20
b	2.88	---

Sample	6 October 72	15 October 72	19 October 72
3-C	12.1	14.2	----
3-I	14.3	10.6	12.1
3-T	8.2	11.8	----
4-A	----	16.4	26.5
4-C	24.2	----	----
4-I	20.5	14.5	10.4

Sample	1 November 72
3-C	25.8
3-I	15.1
3-T	19.2
4-A	19.3
4-I	11.5

	6 November 72
3-AC	25
3-I	15
3-AT	19
4-AC	23
4 I	11

The plate counts show that there are severalfold more streptomycetes than bacteria in these soils.

The numbers of aerobic bacteria decrease with increasing depth in the profile. However, the highest number is often found not in the surface 3 cm where most of the algal and lichen activities are located, but rather at 5 - 20 cm, reaching $>10^7$/g. The numbers may decrease to 10^4/g at 1.2 m. The surface layer may contain an average of 2 x 10^6 aerobes/g. The numbers in the surface layer may increase during the rainy spring and fall periods, indicating higher zymogenous activity. Generally, there are 2 - 4-fold more streptomycetes than aerobic bacteria in the profiles. Their highest numbers are found in the 5-20 cm depth. More bacteria are found in the crested wheatgrass site than in the shrub site.

Fungal propagule numbers exhibit a pattern similar to that of streptomycetes in the soil profile, and their numbers vary from several hundred to 10^5/g. Considering their relative size, however, their biomass may exceed that of bacteria by about 10^4. Anaerobic bacteria are found throughout the profile, and their numbers vary from several hundred to 250,000/g. The highest numbers are found at 5 to 20 cm. Their numbers and distribution indicate that there are many anaerobic microsites in the soil surface layers. They allow anaerobic processes, including denitrification, to take place.

Determination of dehydrogenase activity was based on the ability of soil to oxidize triphenyltetrazolium chloride to the respective formazan. It represents the "total biological activity". The surface 3 cm layer always had the highest activity. The 5 - 20 cm layer had some activity, while deeper layers had only traces of measurable activity. Activity in 1972 samples from the shrub site showed an increase from July 7 to July 27. Activity showed a decrease in August 5 samples and a further decrease in September 29 samples. October samples indicated an activity increase.

Activity in samples from the crested wheatgrass site was low in the first week of July, higher in the second week, low again in the third week, and highest in the last week. Activity in September samples was even higher than in samples taken the last week of July. Activity in October samples was only 1/2 that in September 29 samples. The week-to-week fluctuations between samples are related to changes in soil moisture. Samples were collected after each rainfall.

Proteolytic activity showed the potential of soil to degrade introduced proteinaceous material. The determination was based on the rate of gelatin hydrolysis and the results were reported as percent hydrolysis after 20 hours incubation.

Proteolytic activity, like dehydrogenase activity, was about 10 times greater in the surface 3 cm layer than in the rest of the profile. It dropped off rapidly, often to zero at the 70 - 80 and 110- 130 cm depths. Proteolytic activity is not represented by one specific enzyme. It is a composite activity of many extracellular enzymes and proteolytic microorganisms, depending on the analytical method used. The bacterial proteolytic extra-

cellular enzymes are relatively heat stable, and one would expect that the proteolysis would take place at a wide temperature range.

Bacterial proteolytic enzymes are active at pH values up to 9, suggesting that their activity is not limited by the pH values of desert soils.

We found that only 56% of maximum protein added to soil is decomposed with prolonged incubation. It is possible that some of the added protein is sorbed onto or within the clay particles. Almost all decomposition of proteinaceous material occurs in the top layer of soil. In 1972 samples, proteolytic activity was higher in July than in June. Correlation with dehydrogenase activity was apparent from site to site and from date to date. There was a slight decrease in proteolytic as well as in dehydrogenase activity in August samples. The activity was much lower in September samples from the shrub site, but was greater in samples from the grass site.

Determination of phosphatase activity was based on the hydrolysis of naphthylophosphate and was reported as μmole of β-naphthyl per gram of soil after 16.5 hours of incubation. The greatest activity was often at 5 - 20 cm and 40 - 50 cm. In the September 1971 samples activity at 70 - 80 cm was even greater than in the surface layer at all stations except location no 1. In almost all cases, the 1.2 m depth showed the lowest activity. There are reports in the literature (Skujins, 1967) that phosphatase activity is inversely proportional to available phosphate in soils. Phosphatase activity, unlike other enzymatic activities, is not concentrated in the surface layer of Curlew Valley soils. Phosphatase activity is inversely related to phosphate amounts in these soils.

The phosphatase activity was measured in the presence and absence of a microbial inhibitor, to assess the contribution of microorganisms and accumulated extracellular enzymes to the total phosphatase activity.

Distribution of soil respiration values (CO_2 release) show the same pattern as the other biological activities: CO_2 release from the surface 3 cm is several times greater than from the rest of the profile. Respiration values in June 1972 were highest in samples from the shrub site, 3-T; and from the grass site, 4-A and 4-I. CO_2 evolution increased slightly from June to July, with highest values in 4-A, 4-I, 3-T, and 3-C samples.

There was a decrease in CO_2 in August and September samples. Samples 4-A and 3-T remained the most active. On all dates sampled, the lowest values were from 3-I samples (shrub site, interspace) and from 3-C samples (shrub site, under shadscale).

Ammonium - nitrogen values fluctuated between 0.7 - 104 ppm. Maximum values were evident in October and November samples in the surface 3 cm layer. During early summer, there was a considerable amount of NH_4^+ - N present which might have been due to the presence of active microflora. In early spring and in summer there was considerably

less NH_4^+ - N than in October and November. During the winter the NH_4^+ -N concentration decreased to an average of 5 ppm. A pronounced increase (from 1.5 - 8 ppm) was evident throughout the rest of the profile in the spring. Below 5 cm, the ammonium-nitrogen values were generally low and never reached values above 10 ppm. Our preliminary experiments indicated that much of the ammonium present in soils in late spring and in the fall was lost by volatilization due to the high pH values and desiccation of soils.

Nitrate-nitrogen values fluctuated between 2 - <1 ppm. These values were lower than what one might expect in cultivated soils. As a rule, the highest values (1 ppm and above) were found in the surface 0 - 3 cm and 5 - 20 cm. Although the nitrate concentration occasionally doubled in October and November, there was no correlation with ammonia fluctuations.

The total inorganic nitrogen (ammonium N and nitrate N) contributed only a small fraction (<1%) to the total nitrogen content of the soils.

The organic nitrogen content varied between 0.30 - 0.04%. Values were highest in the surface 3 cm (ave. 0.12%) and gradually decreased with increasing soil depth. The lowest values were at 1.2 m.

An increase of about 0.05% in organic nitrogen was evident during April and May in the surface layer. A similar increase was noticeable in some cases in October and November. The added nitrogen was lost during the summer or winter months. The seasonal variation was only slightly reflected in the 5 - 20 cm level, and not at all in the deeper profile.

Ammonium and total organic nitrogen values showed significant seasonal variations. It appeared that some of the nitrogen-containing soil organic matter, especially in the surface 3 cm layer, was rapidly decomposed during the wet fall months. Not more than 10% of the released ammonium - N appeared as nitrate. It is unlikely that it would have been immobilized in soil organic matter, because there was no excess carbohydrate material. Ammonium may have been fixed by soil clays, however, as shown by a parallel study (Skujins, 1972,73). Alternatively, the ammonium may have been nitrified, thus becoming mobile, and again denitrified by anaerobic organisms at a different microsite. In this manner the increase in the nitrate concentration in soils would have been limited as shown by chemical analytical techniques. Finally, it is possible that ammonium was lost by volatilization, which would have been enhanced by the high soil pH values. It appeared that leaching of any of the nitrogen components to the deeper strata was of no importance in the soils, as fluctuations in soil moisture were detected maximally to about 50 cm.

Organic carbon decreased gradually through the profile. It averaged 2% in the surface layer, 1% at 5 - 20 cm, and 0.3% or less at 1.2 m. An increase of about 0.5% in organic carbon was evident during April and May in the surface layer. A similar increase occurred in some cases in October and November. The added carbon was lost during the summer or winter months. The seasonal variation was slight at 5 - 20 cm, and did not occur at deeper levels.

The carbon-nitrogen ratio values generally were low, indicating that no carbohydrate material was available for further nitrogen immobilization. Somewhat higher C/N values were found in the top 3 cm and below 1 m depth.

The pH values in 1:1 water suspension fluctuated from 8.1 - 8.9. These high soil pH values may have affected the chemical behavior and biological activities in these soils uniquely. For example, volatilization of ammonia may have been an important factor in the nitrogen budget.

The examination of biological activities characterizing the biological status of the soils and the determination of nitrogen pools and fluxes in these soils has demonstrated that the biological activities were concentrated in the top 3 cm layer. Significant activity was occasionally found in the 5 - 20 cm layer, especially in the crested wheat site It may be assumed that the biological activity was more evenly distributed through the top 20 cm layer immediately upon seeding to crested wheat. However, the biological activity characteristics were reverting to the pre-cultivation situation. The location of the majority of biological activities in the top 3 cm layer has been also demonstrated in a parallel study (Skujins, 1972) with nitrification, ammonification, and N-fixing potentials.

Although considerable increase in N content (Δ = 0.05 - 0.1%) took place in these soils, especially in the surface layer during the wet and relatively warm periods, much of this N subsequently disappeared and could not be traced by conventional methods. Of the 500 ppm of nitrogen lost, only a mean of about 30 ppm appeared as ammonium.

It is suggested here that upon decomposition and ammonification of organic matter containing the fixed N in the surface layer during the biologically active period, the released NH_4^+ volatilized as ammonia before it could become nitrified. This process was enhanced by soil pH > 8 and by the lengthy dry periods even during the rainy seasons.

The organic carbon pools and fluxes were apparently intimately associated with organic nitrogen pools and processes. Although there appeared to be excess nitrogen in the soils, no excess carbon was available to immobilize it.

It was shown by comparing soils sampled directly under the canopy of plants with samples taken from between the plants that activity was significantly higher in soils under canopy (Table 19 and 20). It should be noted however, that the nitrogen fixation under the canopy was negligible compared with that in the bare areas (Skujins, 1973).

Attempts to correlate dehydrogenase activity with other biological parameters in cultivated and well irrigated soils generally have not been successful (Skujins, 1967). In arid soils, however, where the biological activities are associated with certain properties of distinct soil horizons and where the activities change by orders of magnitude in their vertical distribution, the dehydrogenase activity appears to be a useful criterion for the characterization of soil biological status and for the prediction of several biological activities.

The three-year averages of dehydrogenase activity, proteolytic activity, soil respiration and nitrification potential are shown in Table 21. The correlation indices (r^2) of dehydrogenase activity with preteolytic activity, nitrification potential, and soil respiration in the Curlew Valley soils are shown in Table 22.

Table 19. Comparison of some bioligical activities in soils of the southern sites by means of averages for July through September, 1972

Sample	Dehydrogenase mg Formazan	Proteolysis % Hydrolysis	CO_2 Evolution µ moles/g/min
3-C	.92	40	31
3-I	.56	26	25
3-T	.91	23	43
4-A	1.09	40	51
4-I	.96	33	42

Table 20. Comparison of dehydrogenase activity (mg Formazan formed) between Curlew, Rock Valley (Nevada), and Silverbell (Arizona) validation site soils, by means of averages for August 2 - September 26, 1972

Sample Curlew*	Dehydrogenase	Sample Silverbell	Dehydrogenase	Sample Rock Valley	Dehydrogenase
3-C	.92	P.V.	.68	Kr.	.87
3-I	.56	open	.16		---
3-T	.91	Cr.	.41	Cr.	1.00
4-A	1.09	Fr.	.71	Fr	.84
4-I	.96	open	.17	Bare	.14

*Curlew Valley sample designations do not correspond to the same species found in Arizona and Rock Valley except 3-I (open or bare area).

Note:
Silverbell, Arizona and Rock Valley, Nevada, samples are described in Skujins, 1973, RM 73-35.

Table 21. Some biological activities in soils of the southern sites, 1969-1971

Soil Location	Sampling Depth (cm)	Respiration μmCO_2/g/min	Proteolysis % Hydrolysis	Nitrification Potential μgNO_3^-/g/Day	Dehydrogenase mg Formazan
14	0- 03	48.7	39.7	13.6	1.92
	5- 20	16.7	6.2	1.9	0.18
	40- 50	16.0	4.3	1.1	0.04
	70- 80	12.8	4.1	1.6	0.01
	110-130	10.0	1.6		0.01
15	0- 03	40.3	37.3	8.0	1.17
	5- 20	19.2	5.0	1.5	0.17
	40- 50	13.4	3.8	1.4	0.02
	70- 80	15.1	1.1	1.1	0.03
	110-130	7.7	0.9		0.01
21	0- 03	29.3	33.4	8.0	2.71
	5- 20	11.9	7.6	4.1	0.45
	40- 50	10.5	5.5	1.2	0.02
	70- 80	9.2	2.6	1.6	0.02
	110-130	7.8	1.5		0.05
22	0- 03	42.6	35.0	18.4	1.75
	5- 20	14.5	13.5	1.5	0.29
	40- 50	15.3	6.6	1.6	0.07
	70- 80	10.5	2.5	1.3	0.03
	110-130	7.7	1.1		Trace

Table 22. Correlation indices (r^2) for dehydrogenase activity with several soil activities in soils of the southern sites

$$r = \frac{\Sigma xy}{\sqrt{(\Sigma x^2)\ (\Sigma y^2)}}$$

Sampling Date	May 27, 70				Aug. 21, 70				Oct. 30, 71				April 5, 71				Sept. 13, 71				Oct. 14, 71			
Soil Location No.	14	15	21	22	14	15	21	22	14	15	21	22	14	15	21	22	14	15	21	22	14	15	21	22
												r^2 Values												
Proteolysis	.98	.99	.97	.99	.98	.99	.96	.99	.99	.98	.98	.96		.98	.93		.998	.998	.92	.87	.99	.90	.99	.998
Nitrification									.98			.999					.997	.98	.99	.99	.998	.99	.99	.999
Respiration					.94	.89	.99	.997	.95	.96	.97	.97		.96	.89	.84								

Nitrification potential is the ability of soil to change ammonium ion to nitrate ion. It was measrued *in vitro* in "ideal" moisture and aeration conditions. The results showed that the potential was about one order of magnitude higher in the top 3 cm layer than in the rest of the soil (Skujins, 1973).

It was evident that an assay of dehydrogenase activity may be used to predict the proteolytic, nitrifying and respiratory activities in these soils.

Of other activities measured, the dehydorgenase activity did not correlate with microbial numbers. As a rule, more organisms were found in the 5 - 20 cm layer than in the surface 3 cm layer. Neigher did dehydorgenade correlate with phosphatase, which showed scattered activity values throughout the profiles.

Introduction; northern sites

On the northern sites an attempt was made to measure microbial biomass, ATP content, and CO_2 evolution rates. In addition, three methods of predicting microbial activity from laboratory measurements were evaluated. In this section of the report microbial activity includes total microorganisms, bacteria, actinomycetes, and fungi.

Methods; northern sites

Soil samples were taken bimonthly for 12 months at eight sampling locations on the northern sites. At each location, composite core samples were taken to a depth of 10 cm using sterile sputum collecting tubes.

During the winter months, when the ground was frozen, a small hand trowel was used to collect the samples. Each specimen was placed in a sterile Whirl-a-pack bag (Nasco) and marked for identification. Measurements were taken immediately upon return to the laboratory whenever possible, or stored at 4 C until tests could be conducted.

Each sample was assayed for total number of microorganisms, numbers of bacteria, actinomycetes, and fungi. Dilutions of 10^{-3},10^{-4},10^{-5}, and 10^{-6} were prepared from an original 10^{-2} dilution which consisted of 1 g of soil in 99 ml of sterile tap water. Plates with 10^{-3} and 10^{-4} dilutions were poured with Martin's medium (Martin , 1950) for the enumeration of fungi. Surface plates of soil extract agar (Allen, 1957) and modified casitone glucose agar (Peltier et al., 1965) were spread with 10^{-5} and 10^{-6} dilutions for the enumeration of total microorganisms, bacteria, and actinomycetes.

All plates were incubated at 23 C and placed in the dark. The fungal plates were counted after 7 days and the total microorganisms, bacteria, and actinomycetes were counted after 5 days, and after 7 days. All counts were made on a Spencer Darkfield Quebec Colony Counter. Microbial numbers were calculated per g of oven dried soil.

Exactly 10.0 g of each soil sample were placed into weighing bottles. The bottle containing the soil were then placed into a Univect drying oven set at 110 C. After 24 hr the samples were removed, allowed to cool, and reweighed (Skujins, 1972). The amount of weight loss was calculated as the number of g of water per 100 g of soil.

Crucibles containing exactly 10.0 g of each soil sample were placed in a Thermolyne type A1500 furnace set at 550 C. After 2 hr, including warm-up time, the samples were removed, allowed to cool in a desiccator, and reweighed (Skujins, 1972). The amount of weight loss was calculated as the number of g of organic material per 100 g of soil. Each sample was corrected for the percent moisture.

The pH values of the soil samples were determined by placing 10 g of soil in a 50 ml beaker and adding 10 ml of freshly boiled distilled H_2O. The suspension was stirred several times during the next 30 minutes and the clay particles allowed to settle out for about 1 hr (Black, 1965). The pH was read by inserting the glass electrode of Sargent Model LS pH meter into the clear supernatant solution.

A micro-diffusion method of Elkan and Moore (1962) was modified and used in this study. Exactly 30.0 g of seived soil from each sampling location were added to Erlenmeyer flasks containing a 25 ml center well. Then 2.0 ml of 1N NaOH (prepared from freshly boiled distilled H_2O) was added to the center wells. Each flask was stoppered and incubated at 23 C in the light for approximately 20 hr depending upon the activity of the soil.

At the end of the incubation period 2.0 ml of saturated $BaCl_2$ were added to the center well and the contents swirled, restoppered and incubated for an additional 45 minutes. From the mixture of NaOH and Na_2CO_3 the carbonate was quantitatively precipitated as $BaCO_3$, leaving free $NaOH_2$ in solution which was titrated with standard HCl to the phenolphthalein end-point. Bromphenol blue was then added, and the mixture titrated to a yellow color, representing the excess of acid necessary for rapid solution of the precipitated $BaCO_3$. Once all the precipitate had dissolved the solution was back-titrated with standard NaOH until the indicator just turned blue. The amount of HCl used in the second half of the titration, corrected for the NaOH used in the back titration, represented the carbonate present.

For ATP extraction, 2.0 g of sieved soil was added to a 250 ml boiling flask. Then 25 ml of a boiling solution of ethanol (95%) and Tris buffer (0.025 M, pH 7.75) in a 1:1 ratio was added. The flask was then placed on a high vacuum-type rotating evaporator

(Rinco Model VE-1000-B) and partially submerged in a 55 C water bath. After 5 minutes, the contents of the flask were brought to a final volume of 25.0 ml with ice-cold Tris buffer. The soil extract was then centrifuged for 10 min, at 10,000 x G,to remove the soil particles. Five ml aliquots of the supernatant were dispensed in test tubes, capped, and either placed in an ice-bath for an immediate assay or frozen at -20 C.

For ATP analysis, 1.8 ml of the standard or soil extract-ATP solution was pipetted into a standard glass liquid scintillation counting vial. At zero time, 0.2 ml of the reconstituted enzyme extract was added, the mixture shaken by hand for 5 seconds, and then placed on the elevator of a liquid scintillation counter (Packard Tri-Carb, Model 2002). Then, 11.0 seconds after the addition of the enzyme, the vial was lowered into the counting chamber. The first 6-second count began 18.5 seconds after the enzyme addition. An 11.0 second delay between counts allows for the data printout. Each assay recorded for 11 sequential counting periods, giving a total reaction time of approximately 3 minutes.

A series of ATP standard concentrations per liter (5 μg, 10 μg, 25 μg, 50μg, and 100 μg) were assayed each time a new vial of the enzyme preparation was rehydrated. Standard curves were plotted on log-log paper and unknown values determined by these curves.

Results; northern sites

The incubation time for the CO_2 evolution rate determination was dependent upon the microbial activity of the soil. Throughout most of the year the CO_2 determination was conducted over a 20 hr incubation. This time was decreased during periods of greater microbial activity i.e., late fall and spring months.

A similar study was applied to a soil profile (Table 23). A low level of residual CO_2 was observed throughout the top 10 centimeters (10-11%). The 10 to 50 centimeter depth contained a greater percentage of residual CO_2 than the upper levels (26-31%). The biological CO_2 was calculated by subtracting the residual CO_2 from the total CO_2.

Table 23. Soil profile showing CO_2 activity of raw and sterile soil incubated for 20 hr (CO_2 expressed as milliequivalents x 10^5 per dry g soil per hr)

Depth (cm)	Total CO_2	Residual CO_2	Percent Residual	Biological CO_2
0- 2	8.30	0.85	10.2	7.45
2-10	7.74	0.86	11.1	6.68
10-20	3.63	1.07	19.5	2.56
20-30	3.43	1.07	31.2	2.36
30-50	3.15	0.84	26.7	2.31

The luminescence of standard ATP concentrations of 5 to 100 μg ATP per liter decayed exponentially over a 3- min reaction time (Fig. 6). Higher concentrations such as 100 μg ATP per liter did not start exponential decay until nearly 2 minutes reaction time had elapsed. During the interval of exponential decay the luminescence is directly proportional to the ATP concentration (Fig. 7). If the ATP levels in the soil were high, the 3-min readings were used to calculate the standard curves. With lower soil ATP, the reaction time was 1.5 min. No residual ATP was detected after sterilization of soils.

ATP concentrations per g of soil were highest in the top 2 cm of soil profile (Table 24). Routine bimonthly samples were 10 cm composite core samples, and thus contained most of the biological activity found in the soil profile (50-70%).

Table 24. Soil profile of physical and biological parameters: Figures are mean values of 3 profiles taken at different dates, and all biological parameters expressed per dry g soil

Depth (cm)	Total Microorganisms (x 10^{-5}/g)	Bacteria (x 10^{-5}/g)	Actinomycetes (x 10^{-5}/g)	Fungus (x 10^{-3}/g)	Moisture (%)	pH	Organic Matter (%)	CO_2 Evolution (meq x 10^5/g/hr)	ATP Concentration (μg x 10^2/g)
0- 2	81.6	70.8	10.8	19.9	14.1	8.0	2.6	5.51	38.20
2-10	143.2	115.3	27.9	55.8	19.1	8.0	3.5	5.96	19.63
10-20	92.8	61.2	31.6	24.9	18.1	8.0	2.6	3.17	8.84
20-30	60.3	40.7	19.6	16.7	18.1	7.8	3.5	2.34	8.17
30-50	61.5	36.3	25.2	11.2	16.9	8.0	3.3	2.41	8.70

The monthly soil samples were placed into 3 groups based on the predominant vegetative type. Locations no. 1 through 4 were on the sage brush site at hectare no. 58, 57, 36, and 49, respectively. Location no. 6 through 8 were on the crested wheat grass site at hectare no. 43, 54, and 53 respectively. Location no. 5 was also on the grass site at hectare no. 41 but was in a more pure stand of crested wheatgrass than location no. 6 through 8.

All activity parameters were expressed as mean monthly readings of the combined sampling locations within each group. The mean CO_2 evolution rates and the mean number of total microorganisms over the 12 months were calculated for each of the 3 sampling groups (Table 25). The results indicated that greater productivity occurred on the more recently manipulated area (location no. 5).

Total microorganisms ranged from a low of 38 x 10^5 per dry g of soil in July of 1971 (Figure 8a) to a high of 220 x 10^5 per dry g soil in January of 1972 (Figure 9a). The peak months for the microbial populations were January through April and the low counts occurred in July, August, and September. Bacteria comprised the majority of the total microbial population (70-93%). Actinomycetes followed a similar annual pattern as the bacteria but the % of Actinomycetes increased from a low of 7 to 10 percent in January to a high of 20-30 percent during the dry summer season. The fungal population ranged from a low of 17 x 10^3 per dry g soil during July (Figure 10b) to a high of 108 x 10^3 in March (Figure 8b).

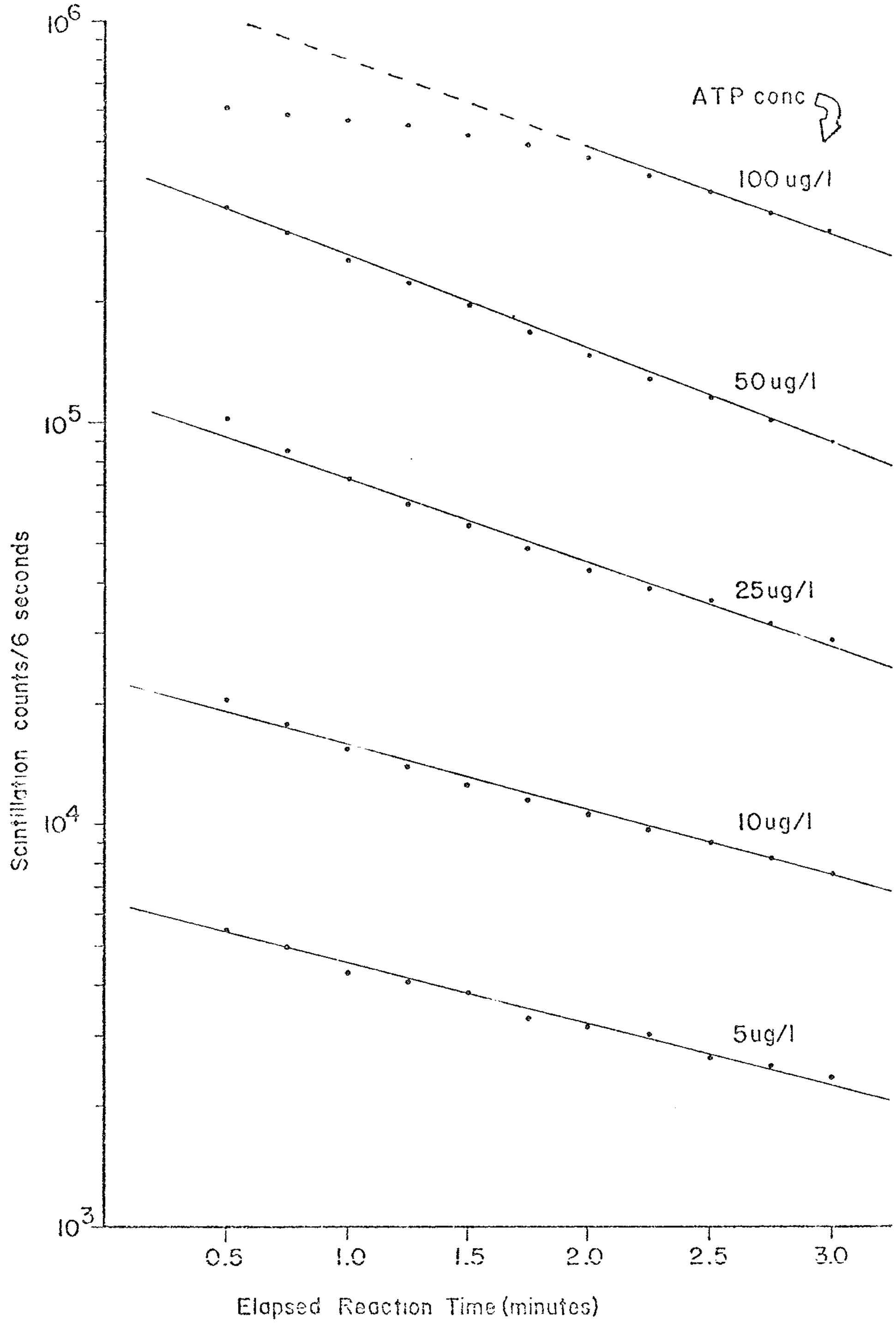


Figure 6. Luminescence decay curves of ATP standard concentrations with reaction time.

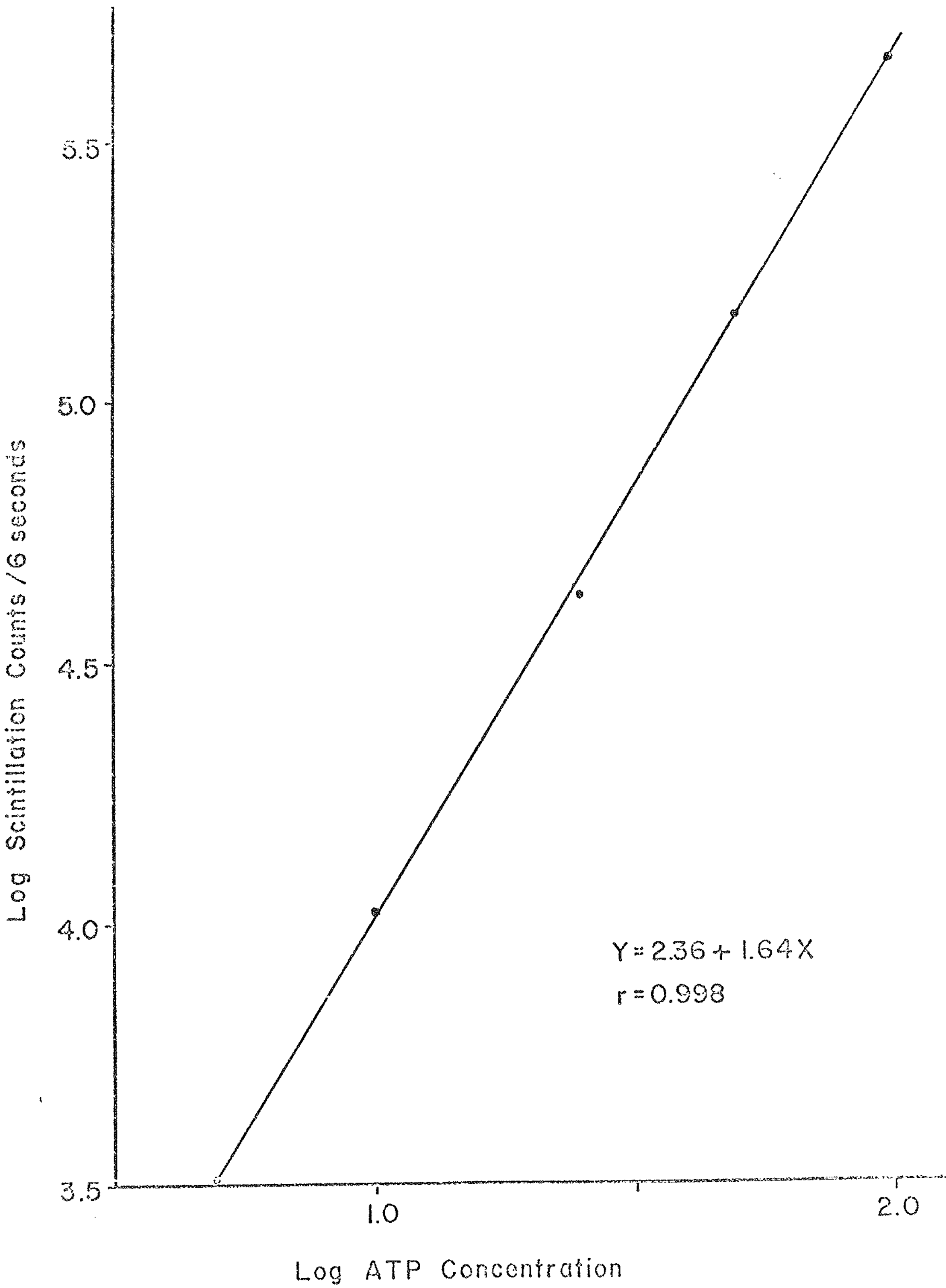


Figure 7. Standard curve for light emission versus ATP concentration at an elapsed reaction of 3.0 minutes.

Soil moisture ranged from a low of 1% w/w in July (Figure 10b) to a high of 29% in January. CO_2 evolution followed a very similar pattern. May through August were the low periods with the lowest in June (Figure 9c). The high readings varied between the 3 groups. February had the high readings for the sage site (Figure 10c), while the high for the grass-shrub area was in January (Figure 8c). The grass area reached its peak CO_2 production in December (Figure 9c).

Soil ATP concentration determinations were not conducted for the month of July due to lack of samples. October and November produced the samples with the greatest concentrations of ATP (Figures 10c, 8c, 9c) while the January samples contained the lowest levels

The mean monthly temperature and the total monthly precipitation values have been added to each of the pertinent Figures to aid in the interpretation of the activity parameters and the significance of the soil moisture (Figures 10d, 8d, 8d).

The relationships between all parameters in Figures 8, 9 and 10 were determined by calculating their correlation coefficients (r). When ATP was correlated with the other eight parameters, nearly all r values were less than 0.3 with the exception of ATP:Total precipitation in the grass sampling group (r=.5224) CO_2 was significantly related to: (i) total microorganisms (r range =.4162 to 5818), (ii) bacteria (r range -.4906 to 0.6201), and (iii) fungi (r range = 0.4507), but not to (iv) actinomycetes (r range = .1204 to 0.1256). The greatest degree of correlation found to an activity parameter was between CO_2 and soil moisture (r range = 0.8827 to 0.9574) and between CO_2 and mean monthly temperature (r range - 0.7592 to 0.8722).

Plate count results were consistent with those reported for the southern sites by Skujins (1972). He reported 10^6 to 10^7 bacteria plus streptomycetes per dry g soil and 10^4 to 10^5 fungi. Total microorganisms ranged from 3.8×10^6 to 2.2×10^7 per dry g soil in this study. In both studies the greatest numbers of microorganisms were found in the 5 to 20 cm depth. The similarity of results in two studies in 2 separate, but similar, areas confirms the usefulness of the plate count technique in spite of its drawbacks.

According to Brock (1966), bacterial numbers must be at least 10^6 per g before concluding that they are making any significant contribution to an ecosystem. Thus, the microbial population may be considered as having the potential of being an actively participating portion of the total soil biomass. Bacterial populations are generally higher in grasslands due to the greater root density (Alexander, 1961). This trend was also observed in this study, with the greatest mean microbial counts in the heaviest grass cover (location no. 5) and the lowest counts in the sage brush site (Table 25). The high microbial counts observed in January and February were apparently due to the incubation effect of the snow cover and the solar radiation.

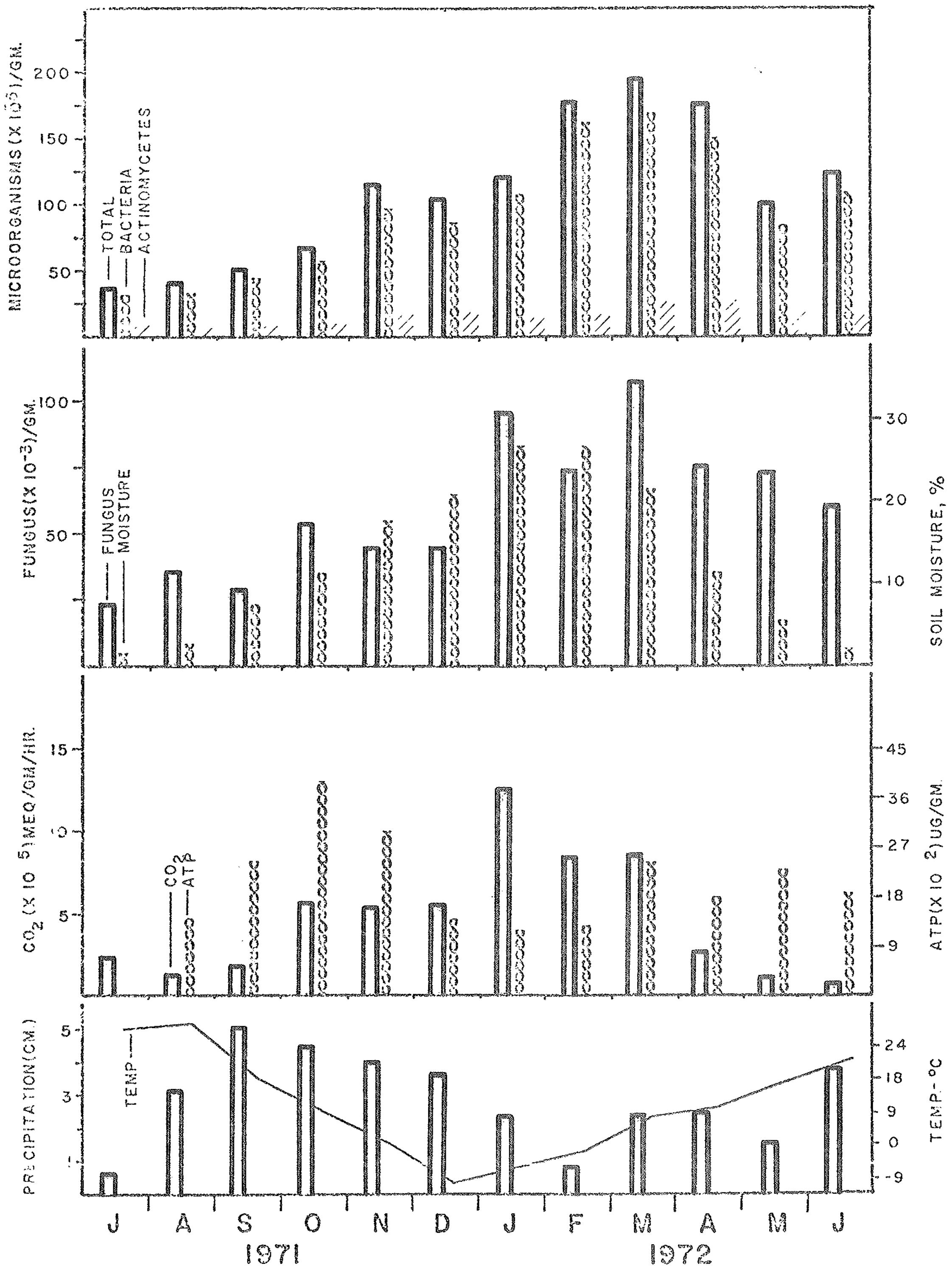


Figure 8. Biological and physical parameters monitered during a 12-month period in the grass-shrub sampling group (location no. 6-8). Soil values expressed per dry gram soil.

Figure 8a. Total bacteria, actinomycetes and fungi.

Figure 8b. Fungus population and total soil moisture.

Figure 8c. Soil CO_2 evolution rates and ATP concentrations.

Figure 8d. Total monthly precipitation and mean monthly temperature for Curlew Valley

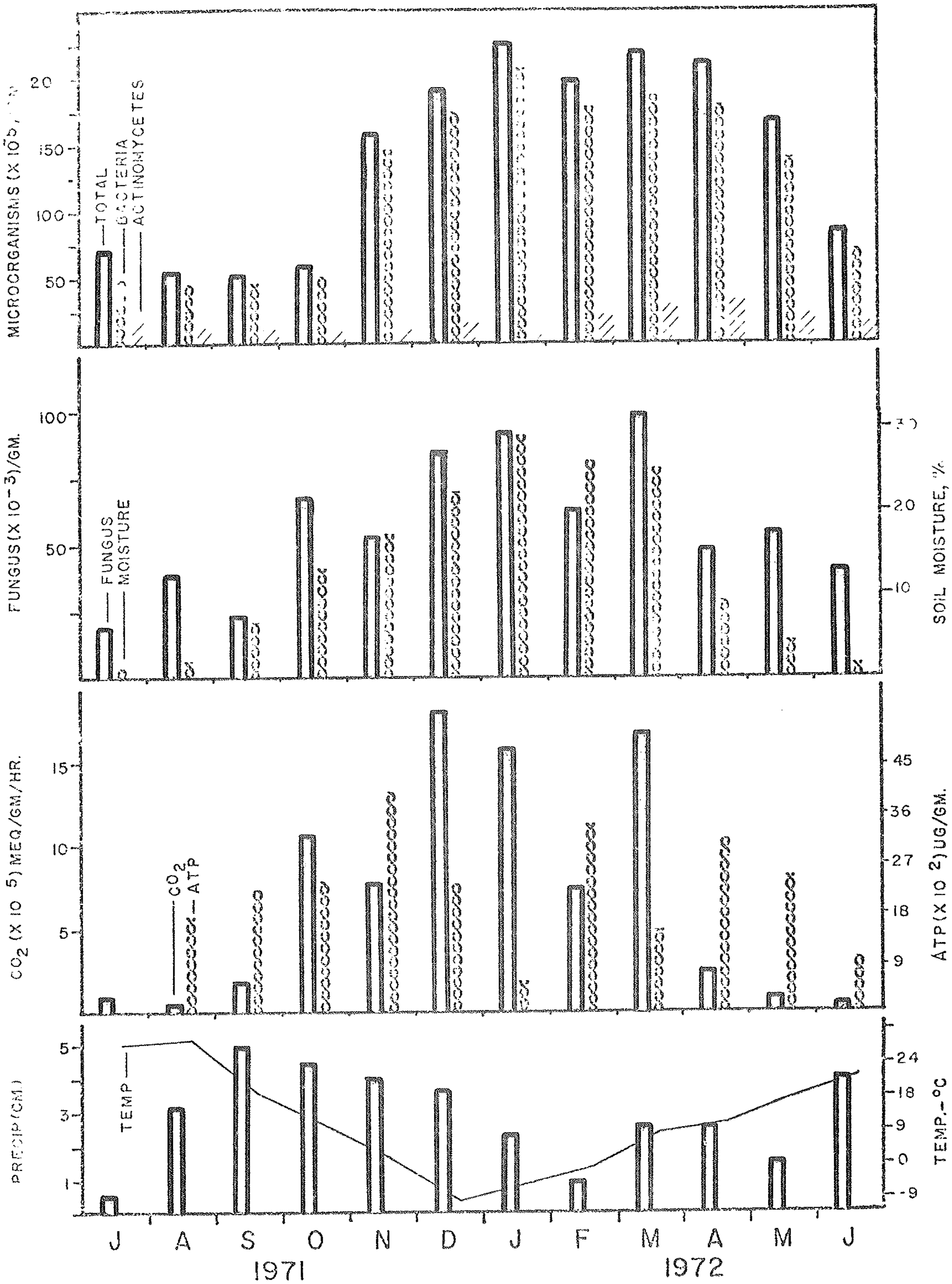


Figure 9. Biological and physical parameters monitered during a 12-month period in grass (location no. 5). Soil values expressed per dry gram soil.

Figure 9a. Total bacteria, actinomycetes and fungi.

Figure 9b. Fungus population and total soil moisture.

Figure 9c. Soil CO_2 evolution rates and ATP concentrations.

Figure 9d. Total monthly precipitation and mean monthly temperature for Curlew Valley

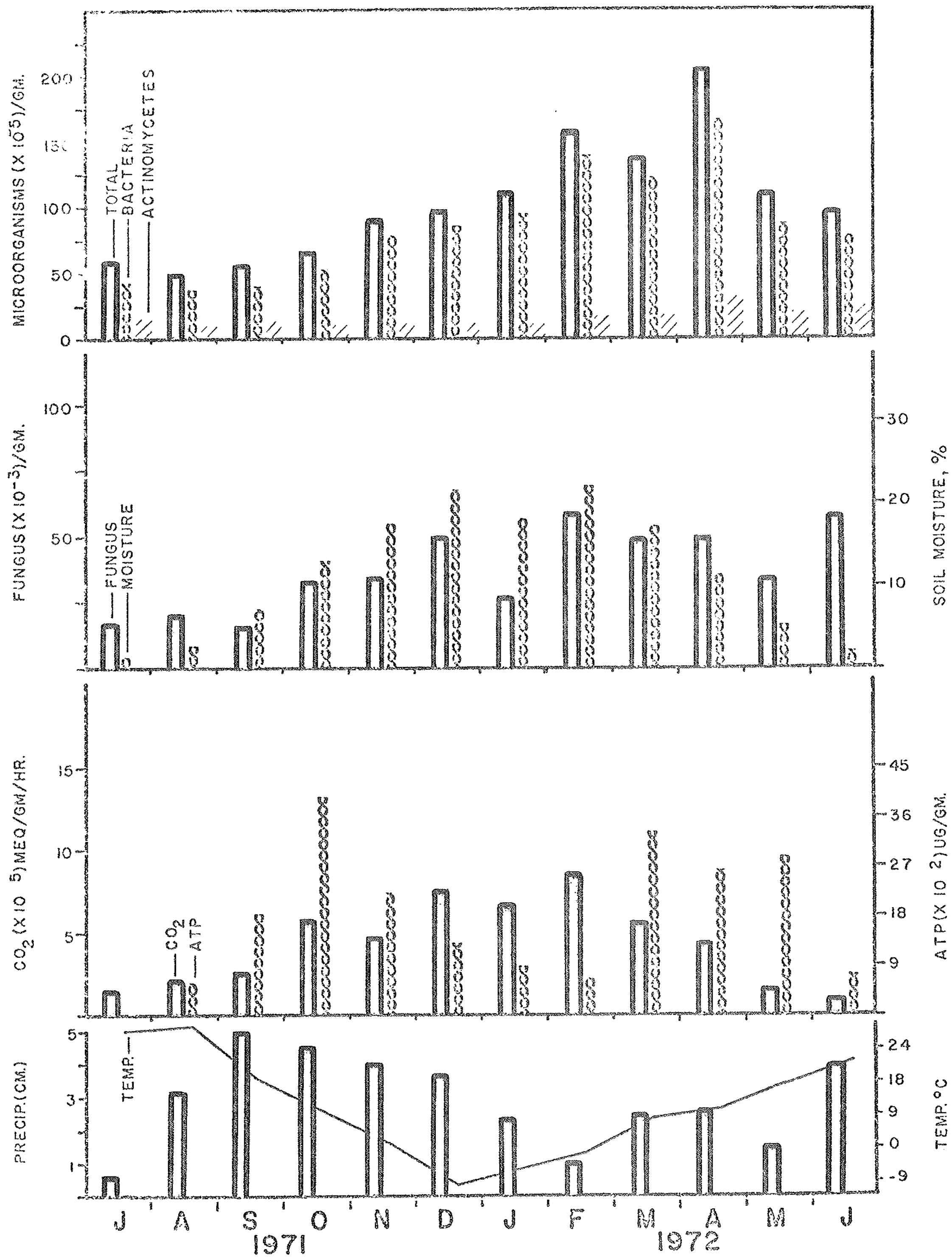


Figure 10. Biological and physical parameters monitered during a 12-month period on the sage brush site (location no. 1-4). Soil values expressed per dry gram soil.

Figure 10a. Total bacteria, actinomycetes and fungi.

Figure 10b. Fungus population and total soil moisture.

Figure 10c. Soil CO_2 evolution rates and ATP concentrations.

Figure 10d. Total monthly precipitation and mean monthly temperature for Curlew Valley (Malad Airport). From U.S. Dept. of

Table 25. Comparison of mean CO_2 evolution rates and mean total microorganism concentrations in 3 sampling groups on the north sites over a 12 month period: CO_2 expressed as meq x 10^5/dry g soil/hr and total microorganisms x 10^{-5}/dry g soil.

Soil Sampling Groups	Activity Parameter	Months of the year beginning with July 1971 and ending with June 1972												
		J	A	S	O	N	D	J	F	M	A	M	J	Mean
Shrub	CO_2	1.6	2.0	2.3	5.8	4.7	7.4	6.9	8.4	5.6	4.2	1.5	0.9	4.3
	Total Microorganisms	55	50	52	59	91	98	110	157	137	194	111	96	101
Mixed Grass and Shrub	CO_2	2.4	1.3	1.7	5.7	5.3	5.4	12.6	8.4	8.4	2.5	1.2	1.0	4.7
	Total Microorganisms	39	40	52	68	116	105	122	179	194	179	202	126	119
Grass	CO_2	0.9	0.6	2.0	10.5	7.7	18.0	15.8	7.4	16.7	2.3	0.8	0.5	6.9
	Total Microorganisms	69	56	50	59	154	190	221	196	216	211	167	85	140

It is apparent from these studies that a considerable portion of the microbial flora in the desert soil exists in a minimally respiring or dormant state. The determined CO_2 evolution rates from the soil were five to eight times lower than rates calculated from the number of bacteria in the soil. This comparison was based on the assumption that the plate counts represented the actual number of microorganisms in the soil. Also in support of a dormant existence was the fact that the ATP per viable cell in the same soil profile was many times greater than that calculated from total number of microorganisms determined by plate counts.

The relationship between microbial numbers and CO_2 evolution has not been fully resolved. In the desert soil, bacteria must be primarily in an inactive or dormant phase and thus rarely would one expect the CO_2 production to be directly proportional to the size of the viable population. This assumption was supported by the parameter correlation. The range of correlation coefficients found between CO_2 and total microorganisms over a 12-month period was only 0.4162 to 0.5818. This poor correlation may be due to several factors, the most important being that respiration rates are related to metabolic activity and biomass rather than numbers.

When CO_2 evolution rates were correlated with biomass as determined by soil ATP, the correlation coefficients were even lower, 0.0424 to 0.1557. These correlations were determined over a 12-month period. When the same correlation was computed for the soil profiles in Table 24, the r value was 0.7984. A possible explanation for this discrepency was that the soil profiles were collected in the spring when the microbial population was probably in a more active state giving a more direct relationship between biomass and respiration.

The ATP assay proved to be reliable and extremely sensitive, but not specific for microbial ATP. If soil animals, plant root material, and fungal and actinomycetal spores and hyphae could either be counted or removed from the soil, the assay could be used as a measure of microbial biomass and reveal better correlations to soil respiration and microbial numbers. In a study such as this where the soil was to be treated as a "Black Box" and only its contributions to the desert biome considered, soil ATP determinations were of great value as measures of total soil biomass. Carbon dioxide evolution rates and soil plate counts were found to be more indicative of the soil microbial population and showed a greater correlation to the environmental parameters, i.e., soil moisture, total precipitation, and mean monthly temperature.

The crested wheatgrass area (location no. 5) consistently contained greater levels of biological activity and was located in the most recently manipulated area. The mixed crested wheatgrass-shrub area (locations no. 6-8) was more active than the sage brush area (locations no 1-4) which was in its natural state. Thus, it is apparent that clearing and reseeding not only increased the primary production useful to livestock, but also increased the rates of energy flow within the desert floor.

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ABSTRACT

Various abiotic and biological measurements were made on a 46.1 ha (113.9 acres) validation site in Rock Valley, Nye County, Nevada, during 1972. Abiotic measurements included wind speed and direction, air temperature, insolation, rainfall, soil temperatures, soil moisture contents, and selected physicochemical attributes of soils. Biological measurements included estimates of standing crops of annual and perennial plants, together with state changes associated with production of new tissue during the spring of 1971; periodic estimates of the relative abundances of various ground- and shrub-swelling arthropods; and estimates of densities and biomasses of selected species of vertebrates.

Mean monthly air temperatures rose steadily from around 5 C in January to about 30 C in July. Temperatures in April, however, were somewhat lower than those of March. Between mid-summer and the end of the year mean monthly air temperatures fell smoothly to around 5 C in December. Mean monthly temperatures measured 244 cm above the ground were somewhat higher (2-5 C) than those measured at 15 cm during the first half of the year. Mean temperatures at 30 cm (both in shrubs and in the open) were intermediate. During the last half of the year the highest mean temperatures were generally measured at 15 cm in the open. Differences in air temperatures measured under varying circumstances were more pronounced when mean monthly maxima and minima were compared. Weekly incident solar energy rose from around 2000 cal/cm^2 early in the year to about 6000 cal/cm^2 in early June. Solar energy then fell to year-end values of around 1700 cal/cm^2 per week. The annual total was 190,000 cal/cm^2. Hardly any rain fell during the first five months of 1972. A light rain in April (ca. 2 mm) had no observable effect on soil moisture at 15 and 30 cm. About 20 mm fell in June, but again soils did not respond significantly. Between August and December almost 100 mm of rainfall were recorded, about two-thirds of this in October and November. Total annual rainfall (average of 5 stations) was 114 mm. Corresponding rainfall for 1971 was 104 mm. Rainfall recorded at each of 5 stations was generally similar, though in September one station recorded only 38-55% of that registered at the other stations. In terms of general rainfall and temperature experience, 1972 exhibited a much warmer spring than 1971, less summer precipitation, and much more fall and winter rainfall. January of 1972 was particularly cold. Mean monthly relative humidity fell from around 45% in January to about 15% in July. Then, with the rains of August-November, mean humidities rose abruptly to roughly 65% in November and declined to about 50% at year's end. Mean monthly soil temperatures rose from around 8 C in January to roughly 30 C in July, and then fell smoothly to about 12 C in November. During the spring, measurements near the surface (3 and 15 cm) were somewhat higher than those at greater depths (30 and 45 cm). During the fall this relationship was reversed. Measurements made in the open were quite similar to those made beneath shrubs. Similarly, differences between stations were slight. Mean monthly soil temperature maxima at 3 and 15 cm were

always higher than means at greater depths. Mean temperature minima were generally higher at 30 and 45 cm. Soils were near saturation in January and February ($\geq$12% moisture by weight), but dried steadily throughout the spring. By May, soil moisture tensions were around -40 bars or less (roughly equivalent to 3-4% moisture content by weight). June rainfall did not have obvious effects on moisture levels measured at 15 and 30 cm. Soil moistures at 15 cm increased following the August rains, dried out, and then were saturated by the rains of October and November. Moisture levels at 30 cm did not generally begin to increase until October and November.

Soil profiles in the vicinity of shrubs (as opposed to bare areas) exhibit aeolian deposits as an A_1 horizon, which also contain higher levels of organic matter and nutrients. In fact, an important generalization is that local geographic differences in soils are less pronounced than differences between soils between shrub clumps and that of bare areas. Soils of the validation site are underlain by a massive and strongly-cemented caliche layer (at depths of 30 to 70 cm). This layer is virtually impervious to plant roots and restricts the movement of moisture to greater depths.

The validation site was divided into six reasonably homogeneous zones of vegetation, ranging in extent from 1.41 to 21.21 ha. The vegatation of these zones differs in species composition and the relative abundance of major perennials. In all zones eight shrubs compose from 94-97% of the perennial populations: *Ambrosia dumosa, Ephedra nevadensis, Eurotia lanata, Grayia spinosa, Krameria parvifolia, Larrea divaricata, Lycium andersonii,* and *L. pallidum.* *Ambrosia dumosa* is the most common species in all zones. During the spring of 1972 the validation site was estimated to sustain about 5 million annuals (ca. 11/m^2). Estimated average density in 1971 was about 7.8/m^2. Although the overall density in 1972 was higher, annuals were much smaller and standing crops during the spring were lower than in the preceding year. Production of winter annuals was estimated to range from 1.63 to 5.65 kg/ha, depending upon the zone of reference. The overall site mean was 3.2 kg/ha (cf. 4.9 kg/ha in 1971). Of the 1972 total, about 1.89 kg/ha (59%) was attributable to just six annual species: *Bromus rubens, Chaenactis carphoclinia, C. fremontii, Chorizanthe rigida, Festuca octoflora* and *Phacelia vallis-mortae.* Approximately this same roster accounted for about 75% of the 1971 annuals production. Survival of annuals during 1972 was lower than in 1971, presumably because of the lack of spring rains in 1972.

Total coverage on a site-wide basis for nine perennials is about 20%. About 400,000 perennials occur on the validation site (ca. 8672/ha), and around 10% of these are entirely dead. Of the living shrubs, proportions of dead tissue have been estimated to range from as low as 26% (*Lycium pallidum*) to as high as 68.6% (*Larrea divaricata*). Overall, the ratio of above-ground standing dead to living plant material is estimated as about 5:4. Total live above-ground standing crop on the site is estimated at around 41,363 kg (ca. 897 kg/ha). Root biomass has been estimated as roughly 873 kg/ha,

which suggests a total standing crop of approximately 1770 kg/ha for the site as a whole. The largest contributors to standing crop are *Larrea divaricata* and *Lycium andersonii*. On a site-wide basis production of new above-ground tissue (shoots, leaves, flowers, fruits) by perennials in 1972 was estimated at about 183 kg/ha, ca. 11% greater than the revised 1971 estimate of 157 kg/ha. In both years new leaves made up most of the net net production--76% in 1971 and 63% in 1972. The increased production in 1972 was largely attributable to new leaves and stems produced by *Ambrosia dumosa* and fruit production by *Grayia spinosa*. Production estimates for six other species were remarkably similar for both years. Production by winter annuals was about 1.7% of that by perennials in 1972 (cf. 3.1% in 1971--based on revised production estimates). Shrub diversity on the validation site was estimated both as $\hat{H}$ (0.903) and $\hat{H}'$ (2.084), with a relative diversity of 0.69. Perennials generally leafed out two weeks or so later in 1972 than in 1971 because of the particularly cold weather during late January 1972. However, the warmer air temperatures during February and March promoted rapid flower development and most shrubs flowered two weeks to a month earlier in 1972 than in 1971.

Arthropods were sampled regularly by pitfalls and by vacuuming shrubs during 1972. Work began on March 6 and was contined until late September. A total of 11,200 trap-nights were registered in the course of pitfall trapping and 1096 shrubs (*Larrea divaricata, Ambrosia dumosa, Lycium andersonii, Ephedra nevadensis, Krameria parvifolia,* et al.) were vacuumed. Almost 200 kinds of arthropods were taken by D-Vac. Ground-dwelling species exhibited about the same abundances as observed in 1971, or showed modest increases. Shrub-dwelling species showed general increases in apparent densities. Species commonly taken by traps were camel crickets (*Ceuthophilus fossor*), tenebrionid beetles (e.g., *Araeoschizus sulcicollis, Centrioptera muricata, Cryptoglossa verrucosa, Edrotes orbus, Triorophus laevis, Trogloderus costatus*), spiders (*Appolophanes texanus, Marpissa californica, Psilochorus utahensis, Syspira eclectica*), solpugids, scorpions (*Hadrurus arizonensis, Vejovis* sp.), and isopods (*Venezillo arizonicus*). Absolute densities of 12 species of tenebrionids were estimated from capture-recapture data, and associated dry weight biomass values were calculated for six species. Estimated densities ranged from around 100/ha or less (*Auchmobius subboreus, Coniobiosoma elongatum, Eleodes armata, Metoponium convexicolle*) to 100/ha or more (*Edrotes orbus* in 1972, *Trogloderus costatus*). Combined dry weight biomass of six species was about 342 g/ha in 1971 and 542 g/ha in 1972. The time of first appearance and maximum abundance of adult tenebrionids was generally 4-6 weeks earlier in 1972 than in the previous year, a phenomenon apparently related to warmer spring temperatures and associated advances in shrub phenology. The local distributions of some of the tenebrionids were highly correlated with soil texture. *Edrotes orbus* prefers coarse soils while *Cryptoglossa, Trogloderus, Centrioptera* and *Triorophus* are most common in areas of fine sandy soil. The acridid *Bootettix punctata*, an obligate feeder on *Larrea*, is the most abundant of the chewing defoliators in Rock Valley. Pseudococcids are important

sap-consuming arthropods--sustaining some of the highest densities observed on the site. They extract more sap than used and excrete the excess as honey-dew. Membracids are abundant sap-consuming forms on *Larrea*. Larval lepidopterans constitute an important functional assemblage in Rock Valley and are responsible for most of the conspicuous defoliation. Coleophorids are most common on *Grayia*, the geometrid *Semiothisa* is an obligate on *Larrea*, gelechiids are major defoliators of both species of *Lycium*, yponomeutids dominate on *Lycium andersonii* and *Krameria parvifolia*. Most of the parasitic hymenopterans taken in 1972 were braconids. These wasps occurred on the same shrubs (*Lycium andersonii, Krameria*) as the lepidopterous larvae they probably parasitize (gelechiids and yponomeutids). Thrips (e.g., *Leptothrips mali, Frankliniella* sp.) were enormously abundant on flowers of shrubs. Phenologies of shrub-dwelling species were often 4-5 weeks advanced in 1972, relative to 1971. However, a few groups (e.g., melyrid beetles) were retarded. The shrub-dwelling fauna in Rock Valley--at least as revealed by D-Vac sampling--is dominantly phytophagous (around 80% of the species or species groups taken). This proportion is appreciably higher than the fraction previously reported (ca. 50%) for other communities.

The most abundant mammal on the validation site is *Perognathus longimembris*. Spring densities of this species in the three trapping grids were around 5-7/ha (ca. 13.5-17.5 g dry weight/ha). These densities were less than those observed in the spring of 1971, apparently reflecting the poor reproduction of 1971. Other rodents exhibited spring densities of less than 1/ha. When actual trapping data were extended from the three grids to the validation site as a whole the estimated total spring density of seven species of rodents was 7.3/ha, with an associated dry weight biomass of 32.3 g/ha. When trapping data were adjusted to compensate for likely deficiencies, the overall site density for these seven species was estimated at 9.5/ha with biomass of 49.5 g/ha. Reproduction during the spring and summer of 1972 was better than that of the previous year. When July trapping data were extended to the whole validation site the estimated density of *P. longimembris* was 9.9/ha (22.8 g/ha), that of *P. formosus* 3.5/ha (16.4 g/ha), and that of *Dipodomys merriami* 1.1/ha (10.4 g/ha). July totals for seven species were 15.7 individuals/ha (67.1 g/ha). With adjustments for likely deficiencies in the trapping data, the combined July density (of seven species) was 18.2/ha with an associated biomass of 85.6 g/ha. Aggregate density and biomass of rodents roughly doubled between the spring and summer. Seven jackrabbits were counted on the validation site in April of 1972; three in July. Estimated biomass values were 0.76 g dry weight/ha in April and 0.32 g/ha in July.

The most abundant reptile is the lizard, *Uta stansburiana*. In the spring of 1972 observed densities ranged from 25 to 40/ha (cf. 35 to 45/ha in 1971), with dry weight biomass estimates of 27 to 40 g/ha. The combined spring density of four other lizards was estimated at around 16/ha (72 g/ha). The 1972 spring populations generally reflected modest increases over the preceding year. Thirteen species of snakes and the desert

tortoise also occur on the validation site.

Two species of birds bred on the validation site in the spring of 1972: *Amphispiza bilineata* and *Toxostoma lecontei*. Estimated breeding densities were about 0.52 pairs/ha and 0.035/ha (4.3 and 1.3 g/ha). Thrasher density was essentially as observed in 1971, that of *Amphispiza* was increased about 22%. As in 1971, fringillids were the dominant species on the validation site during the spring. Twenty-eight other species of birds were observed on the validation site at one time or another. The most common were *Eremophila alpestris, Carpodacus mexicanus, Amphispiza belli, Spizella breweri* and *Zonotrichia leucophrys*. Of the larger birds, the raven was most commonly observed.

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Category	Assistance in field and laboratory research	Authorship in report
Abiotic	J. Childress, R. Johnson, A. Vollmer	E. M. Romney, H. W. Kaaz, F. B. Turner
Plants	T. Ackerman, H. W. Kaaz, A. Vollmer	S. A. Bamberg, T. Ackerman, A. Vollmer
Invertebrates	P. Arvin, M. Mispagel, D. Thomas	E. L. Sleeper, M. Mispagel, D. Thomas, R. Chew (ants)
Vertebrates	P. August, W. Cochrum, H. O. Hill, M. Johnson, B. Maza, P. A. Medica, S. Sanborn, M. Skivington, D. Smith	H. O. Hill, B. Maza, P. A. Medica, F. B. Turner
Chemical analysis	G. V. Alexander, T. Hartsock, J. Kinnear	E. M. Romney, A. Wallace
Soil	J. Childress, V. Q. Hale, R. Johnson, M. Skivington	E. M. Romney, S. A. Bamberg, A. Wallace
Secretarial assistance	A. Kehrer, P. Bacon, J. Grandilli, C. Jenkins, G. Johnson, Y. North	
Programing and computer analysis	B. Maza, H. Kaaz, D. Valeska	
Keypunching	J. Cunningham, C. Jenkins	
CETO Coordinator	A. Morrow, E. Schultz	

INTRODUCTION

In seeking to understand the functioning of arid land ecosystems, it was judged extremely important that predictive models of ecological processes be as general as possible. To this end, research areas have been established in each of four major arid land types in western North America--the Great Basin, the Mohave Desert, the Sonoran Desert, and the Chihuahuan Desert. The Desert Biome research design embraces two types of endeavors. One involves the investigation of specific abiotic and population processes and the development of models of these processes and of the function of larger systems. The other involves the testing of these models by comparing their predictions with actual measurements of changes in the states of desert ecosystems. The validation of a systems model requires, then, an exhaustive initial inventory of the system, followed by periodic evaluations of extensive arrays of state variables and of the external influences impinging upon the system (meteorological variables). Such measurements are being conducted at four validation sites located within the desert types designated above. One of these sites is in Rock Valley, Nye County, Nevada, in the northern Mohave Desert. The initial inventory in Rock Valley was begun in March of 1971. The measurements to be subsequently reported are generally applicable to the state of the system in the early spring of 1972. Because of the distinct changes in the state of the arthropod fauna, sampling was continued regularly from April until early fall. Measurements of changes in other system attributes were made at varying intervals depending upon expected rates of change.

OBJECTIVES

The objectives of the validation measurements are four-fold:

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

SITE DEVELOPMENT

Research facilities have existed in Rock Valley since about 1961. Because of the remoteness of Rock Valley and its location on the U. S. Atomic Energy Commission's Nevada Test Site, little in the way of formal site development and fencing was required. The validation site itself was established to the north of three fenced 8-ha areas which have been used since 1964 in a long-term irradiation experiment. Two air-conditioned laboratory trailers are located near the validation area. Electricity is available from gasoline-powered generators. Accommodations, services and laboratory facilities are available at Mercury, about 15 miles to the east.

During the spring of 1971 the validation site was delimited and mapped, and a 100-meter N-S, E-W rectilinear grid system established and marked with numbered stakes (Fig. 1). The site was about 0.46 km^2 in extent.

The vegetation on the Rock Valley validation site is heterogeneous, with a gradient of change downslope along a NNW-SSE line. Six areas of relatively homogeneous vegetation could be recognized, however, on the basis of aerial photography and counts made along belt transects. The Rock Valley Validation Site has been photographed on two occasions. Small scale aerial photographs were taken in July, 1970, and assisted in the recognition of homogeneous zones of vegetation on the area. In July, 1971, the site was photographed at two scales: 1:2400 and 1:600. These photographes are being kept as a permanent record of the validation site, and may also be used to evaluate changes brought about by continued use of the area. The areas of the six vegetational zones ranged from 14,080 m^2 to 212,080 m^2 (Fig. 2). Sampling of perennial vegetation was carried out in 190 quadrats of 2 x 25 m. The coordinates of these quadrats were generated by a computer program designed to insure a random dispersion.

Three mammal trapping grids (12 x 12, 15 m interval) were established in different zones of the validation site. Smaller areas for sampling reptiles were set up within these grids. A 60-ha area for counting birds was delimited within the validation site. Pitfall traps for the collection of terrestrial arthropods were set out in the same areas used for mammal trapping.

Meteorological measurements were made at five stations on or near the validation site at various times during 1972. Stations I - IV (Fig. 1) were established at the corners of the site in October of 1971. Station V (near the southeastern corner of the site) was a permanent station operated by the Air Resources Laboratory, NOAA.

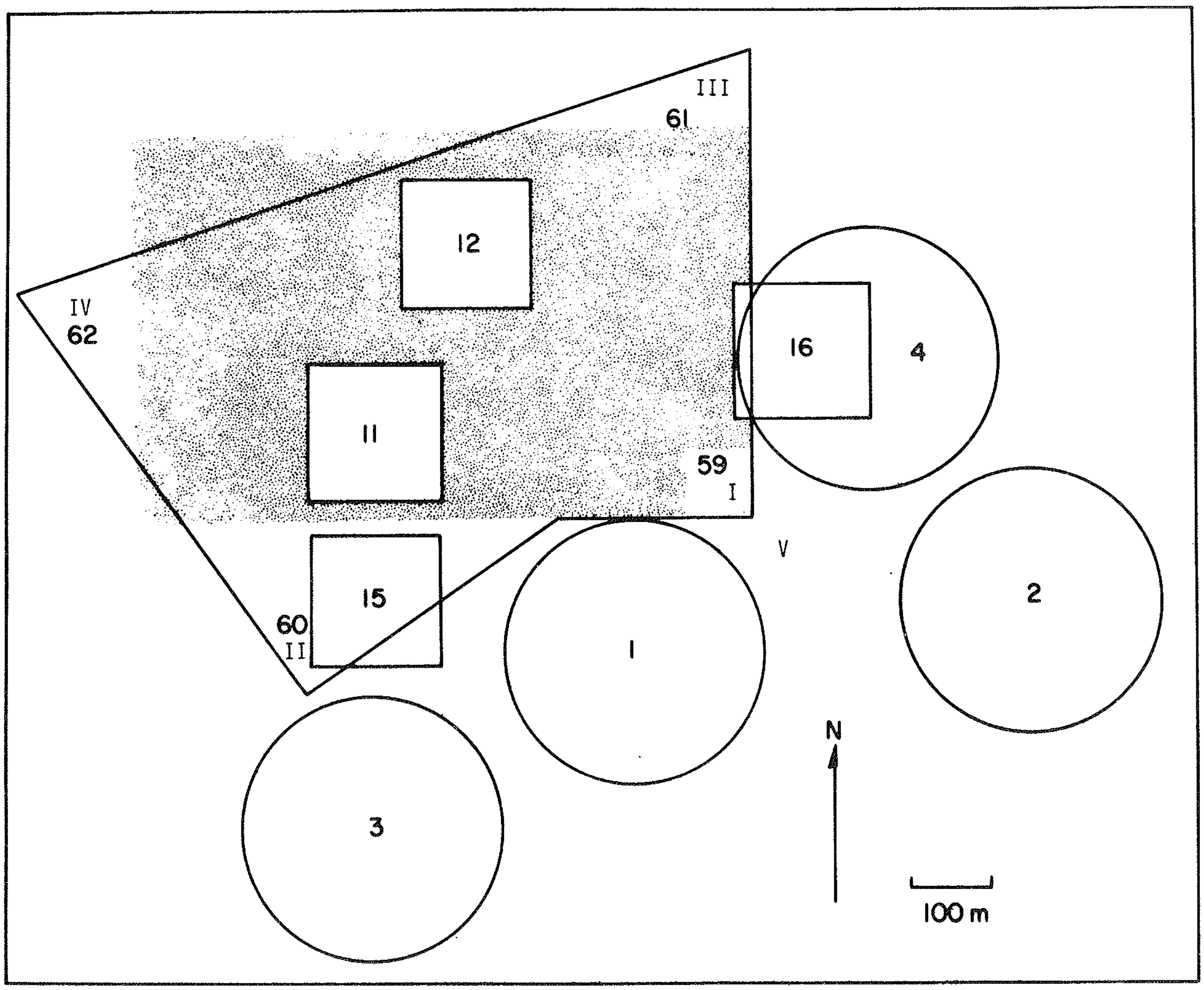

Figure 1. Study areas in Rock Valley, Nye County, Nevada. The five-sided polygon is the validation site (0.46 km^2). Circular areas 1, 2 and 3 are 9-ha fenced enclosures. Plot 4 is an unfenced 9-ha area. Plots 12, 15 and 16 were used in trapping mammals. Plots 11 and 12 were used in work on arthropods and reptiles. The stippled area (0.5 km^2) was used for jackrabbit drives. Roman numerals I - V (at the corners of the validation site) refer to stations where abiotic measurements were made. Figures 59-62 (at the corners) refer to soil pits.

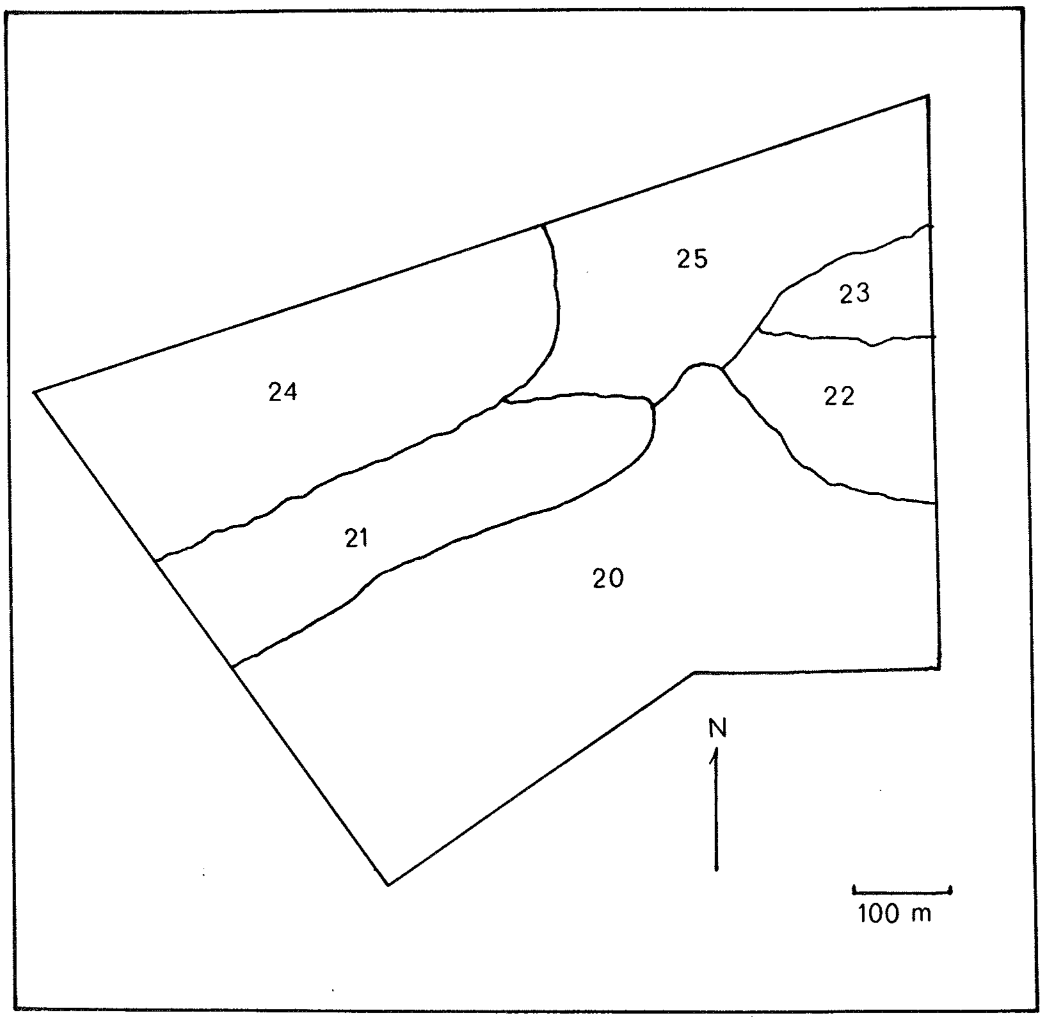

Figure 2. The Rock Valley Validation Site indicating the six zones of roughly homogeneous vegetation.

DATA COLLECTION DESIGN

General Type of Measurement	Parameters Measured and Investigator(s)	Data Set Code	Dates	Reported on page 2.2.2.2.-
Above ground vegetation	Perennials (Bamberg, Ackerman)	A3UTJ25	1971-	96
	Species		1971-	
	Density		1971	
	Foliage density		1971	
	Plant dimensions		1971	
	Number of dead plants		1971	
	Coverage		1971	
	Biomass and new growth		1971-	
	Phenology		1971-	
	Diversity and relative diversity		1971	
	Annuals (Bamberg, Ackerman)	A3UTJ20	1971-	81
	Species		1971-	
	Density		1971-	
	Biomass		1971-	
	Phenology		1971-	
Litter	Biomass (Bamberg)	A3UTJ70	1972-	211
	Plant type		1972-	
Microbes	Rhizosphere microorganisms (Au)	A3UTJ15	1971	
	numbers/g of soil		1971	
	relative abundance of 6 general types		1971	
	Non-rhizosphere microorganisms (Au)	A3UTJ16	1971	
	numbers/g of soil		1971	
	relative abundances of 6 general types		1971	
	Dehydrogenase activity (Skujins)		1972-	
	Cellulose decomposition rates (Skujins)		1972-	
Mineral content	Mineral element composition (Romney, Alexander)	A3UTJ21	1971-	
	Species		1971-	
	Plant parts		1971-	
	28 different minerals		1971-	

General type of measurement	Parameters measured and investigator(s)	Data Set Code	Dates	Reported on page 2.2.2.2.-
Invertebrates	Captures in pitfall traps (Sleeper, Mispagel)	A3UTJ30	1971-	112
	Species		1971-	
	Relative numbers		1971-	
	Seasonal distributions		1971-	
	Phenology		1971-	
	Soil type preferences		1971-	
	Dry weights		1972-	
	Stages		1971-	
	Captures by D-Vac (Sleeper, Mispagel)	A3UTJ34	1971-	132
	Species		1971-	
	Densities		1971-	
	Biomass		1972-	
	Stages		1971-	
	Host specificity		1971-	
	Phenology		1971-	
	Seasonal distributions		1971-	
	Shrub dimensions		1971-	
Vertebrates Reptiles	*Uta stansburiana* (Medica)	A3UTJ40	1971-	168
	Density			
	Biomass			
	Age distribution			
	Sex ratio			
	Whiptail and leopard lizards (Medica)	A3UTJ42	1971-	168
	Density			
	Biomass			
	Age distributions			
	Sex ratios			

General type of measurement	Parameters measured and investigator(s)	Data Set Code	Dates	Reported on page 2.2.2.2.-
	Other reptiles (Medica)	A3UTJ44	1971-	169
	Species			
	Relative numbers			
	Body weights			
Birds	Breeding birds (Hill)	A3UTJ60	1971-	174
	Species		1971-	
	Densities and pairs		1971-	
	Biomass		1971-	
	Clutch size		1972-	
	Nesting sites		1971-	
	Nesting materials		1971-	
	Nesting success		1971-	
	Phenology		1971-	
	Nonbreeding birds (Hill)	A3UTJ61	1971-	174
	Species		1971-	
	Counts and relative abundance		1971-	
	Utilization schedules		1971-	
Mammals				
Rodents	Heteromyids (Maza)	A3UTJ50	1971-	183
	Species			
	Densities			
	Biomass			
	Reproductive condition			
	Sex ratios			
	Cricetids and sciurids (Maza)	A3UTJ52	1971-	183
	Species			
	Densities			
	Biomass			
	Reproductive condition			
	Sex ratios			

General type of measurement	Parameters measured and investigator(s)	Data Set Code	Dates	Reported on page 2.2.2.2.-
Lagomorphs	Jackrabbits (Maza) Densities Biomass	A3UTJ54	1971-	185
Meteorological	Wind speed and direction, hourly, 3 m (Air Resources Laboratory)	A3UTJ01	1971-	52
	Air temperatures, hourly, one station, 2.4 m (Air Resources Laboratory)	A3UTJ02	1971-	18
	Air temperatures, every six hours, two cover types, two stations, 30 cm (Bamberg)	A3UTJ03	1972-	18
	Air temperatures, every six hours, two stations, 15 cm (Bamberg)	A3UTJ04	1972-	18
	Insolation, weekly totals at one station (Bamberg)	A3UTJ05	1971-	38
	Precipitation, daily, four stations (Bamberg)	A3UTJ06	1971-	41
	Precipitation, weekly totals at four stations (Air Resources Laboratory)	A3UTJ07	1971-	41
	Relative humidity, every six hours, two stations, 15 cm (Bamberg)	A3UTJ10	1972-	45

General type of measurement	Parameters measured and investigator(s)	Data Set Code	Dates	Reported on page 2.2.2.2.-
Soils	Soil survey (Romney, Hale) Color, consistency, texture, conductivity, organic matter, cation exchange capacity, cations, available elements, etc.	A3UTJ11	1971	203
	Soil temperatures, every six hours two cover types, two stations, four depths (Bamberg)	A3UTJ08	1971-	52
	Soil moisture by weight, weekly, four stations, two cover types, two depths (Romney)	A3UTJ09	1971-	71
	Soil moisture potential (bars), same as above (Romney)	A3UTJ12	1971-	71
Remote sensing	Aerial photography (Tueller)	A3UTJ99	1971	

FINDINGS

CONTENTS

Page Number 2.2.2.2.-

A. ABIOTIC

1. AIR TEMPERATURE

Air temperatures were measured at three heights in Rock Valley during 1972. At one station (V) temperatures were recorded hourly at 8 feet (244 cm) by the Air Resources Laboratory in Las Vegas, Nevada (A3UTJ02). At two stations (I and IV) air temperatures were recorded every six hours at 30 cm. These readings were made both in the open and beneath shrubs (A3UTJ03). Also at stations I and IV air temperatures were recorded continuously at 15 cm on Wescor hygrothermographs. When the hygrothermograph data were reduced temperatures were recorded at six-hour intervals (A3UTJ04).

Tables 1-4 give means and extreme temperatures recorded at stations I and IV (at 30 cm) in two situations on a monthly basis. Tables 5 and 6 give similar data recorded at these two stations at 15 cm. Table 7 gives comparable figures recorded at 244 cm at station V.

Figure 1 illustrates monthly mean air temperatures at stations I and IV. Air temperatures at 244 cm have been added to the upper portion of Figure 1 because station V is near station I. Figures 2 and 3 illustrate monthly minimum and maximum air temperatures in the same manner.

Table 8 gives weekly maximum and minimum air temperatures recorded at each of stations I-IV. Table 9 gives mean daily air temperatures recorded at station V (244 cm) and station I (15 and 30 cm) for three days of each month during 1972. Table 10 gives mean daily air temperatures recorded at station IV (15 and 30 cm). Figures 4 and 5 illustrate these same data.

Table 11 gives air temperatures recorded in four situations at six-hour intervals for three consecutive days at station I at four times of the year. Table 12 gives air temperatures recorded in three situations at six-hour intervals for three consective days at station IV. Figures 6-9 illustrate these same data.

Table 1. Air temperature data (C) at Rock Valley station no. I in open during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-1	21	7	-1 - 8	6 - 21	2 - 11
February	-1	28	11	-1 - 11	8 - 28	3 - 19
March	0	33	16	0 - 14	11 - 33	6 - 21
April	0	31	15	0 - 17	13 - 31	6 - 21
May	4	38	21	4 - 19	17 - 38	12 - 27
June	11	42	25	11 - 23	27 - 42	20 - 33
July	13	43	30	13 - 28	33 - 43	23 - 36
August	11	42	27	11 - 24	24 - 42	20 - 32
September	7	36	22	7 - 21	24 - 36	17 - 29
October	1	32	14	1 - 17	10 - 32	7 - 23
November	3	23	9	3 - 8	8 - 23	6 - 13

Table 2. Air temperature data (C) at Rock Valley station no. I in shrubs during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-1	16	7	-1 - 7	4 - 16	1 - 10
February	-1	25	10	-1 - 10	7 - 25	3 - 17
March	0	29	15	0 - 14	9 - 29	6 - 20
April	0	29	15	0 - 17	11 - 29	5 - 21
May	6	36	21	6 - 21	16 - 36	11 - 28
June	13	41	26	13 - 25	26 - 41	21 - 33
July	15	43	31	15 - 30	31 - 43	24 - 36
August	13	41	27	13 - 25	23 - 41	20 - 32
September	7	34	22	7 - 21	21 - 34	16 - 28
October	2	30	13	2 - 16	10 - 30	6 - 22
November	3	19	8	3 - 9	7 - 19	6 - 12

Table 3. Air temperature data (C) at Rock Valley station no. IV in open during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-2	19	5	-2 - 5	4 - 19	1 - 8
February	-3	25	9	-3 - 9	8 - 25	2 - 17
March	-1	31	14	-1 - 13	11 - 31	5 - 19
April	1	31	16	1 - 16	14 - 31	7 - 21
May	6	38	22	6 - 20	18 - 38	13 - 28
June	13	42	26	13 - 24	28 - 42	22 - 33
July	13	43	31	13 - 31	33 - 43	25 - 37
August	11	42	27	11 - 23	31 - 42	22 - 33
September	2	36	22	2 - 21	25 - 36	17 - 29
October	1	31	14	1 - 18	11 - 31	6 - 23
November	2	23	8	2 - 8	6 - 23	5 - 12

Table 4. Air temperature data (C) at Rock Valley station no. IV in shrubs during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-3	18	5	-3 - 5	4 - 18	1 - 9
February	-2	25	9	-2 - 9	6 - 25	1 - 17
March	-1	31	14	-1 - 15	8 - 31	6 - 21
April	1	30	16	1 - 16	11 - 30	6 - 22
May	8	37	22	8 - 23	17 - 37	13 - 29
June	12	43	26	12 - 25	27 - 43	21 - 33
July	14	43	31	14 - 31	31 - 43	23 - 37
August	13	42	27	13 - 23	23 - 42	20 - 33
September	7	36	22	7 - 21	23 - 36	17 - 28
October	1	32	14	1 - 17	11 - 32	6 - 23
November	2	23	8	2 - 9	6 - 23	5 - 13

Table 5. Air temperature data (C) at Rock Valley station no. I during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-8	15	3	-8 - 4	0 - 15	-4 - 8
February	-8	20	8	-8 - 8	6 - 20	-2 - 15
March	-2	26	14	-2 - 12	11 - 26	5 - 18
April	-3	26	13	-3 - 16	7 - 26	2 - 20
May	3	34	19	3 - 16	15 - 34	11 - 26
June	10	38	24	10 - 24	24 - 38	19 - 32
July	13	41	30	13 - 31	29 - 41	22 - 35
August	15	41	29	15 - 27	25 - 41	22 - 35
September	9	35	24	9 - 24	24 - 35	19 - 30
October	0	32	17	0 - 21	12 - 32	7 - 26
November	0	21	9	0 - 9	7 - 21	5 - 14
December	-9	19	5	-9 - 7	0 - 19	-6 - 12

Table 6. Air temperature data (C) at Rock Valley station no. IV during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-9	15	3	-9 - 3	0 - 15	-6 - 7
February	-5	23	8	-5 - 10	6 - 23	-2 - 16
March	-2	27	14	-2 - 12	10 - 27	5 - 19
April	-2	27	14	-2 - 16	8 - 27	3 - 20
May	2	34	20	2 - 18	16 - 34	11 - 27
June	10	40	24	10 - 22	16 - 40	16 - 31
July	13	41	29	13 - 28	29 - 41	22 - 34
August	16	40	28	16 - 26	22 - 40	20 - 32
September	6	34	22	6 - 22	23 - 34	17 - 28
October	-5	28	14	-5 - 18	8 - 28	4 - 23
November	-1	19	8	-1 - 9	5 - 19	4 - 13
December	-9	19	4	-9 - 7	0 - 19	-6 - 12

Table 7. Air temperature data (C) recorded at Rock Valley station V during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January*	0.3	14.0	6.5	-3.3 - 4.4	8.3 - 17.8	2.6 - 10.2
February*	3.7	19.7	11.7	-5.6 - 11.7	7.2 - 26.7	0.7 - 18.2
March*	10.7	28.2	19.3	4.4 - 14.4	19.4 - 32.7	11.7 - 21.7
April*	7.2	23.5	16.1	0.0 - 16.7	10.0 - 30.0	6.2 - 21.4
May	11.1	28.8	20.8	1.7 - 18.9	16.1 - 36.1	11.0 - 27.6
June	17.8	34.8	27.1	13.3 - 22.2	28.3 - 43.9	19.8 - 34.7
July*	24.3	41.7	34.1	17.2 - 32.2	34.4 - 48.9	27.1 - 41.3
August	19.9	36.3	28.3	15.0 - 26.1	23.9 - 43.3	21.1 - 35.6
September	16.1	31.9	23.9	8.3 - 21.1	25.0 - 36.7	18.7 - 29.3
October	7.9	20.5	14.2	-3.9 - 17.8	8.9 - 32.8	5.0 - 24.9
November	3.0	13.5	7.9	-2.2 - 10.0	3.3 - 21.1	4.1 - 12.8
December	-1.7	10.1	3.8	-9.4 - 4.4	-2.8 - 18.9	-5.8 - 10.4

* missing data

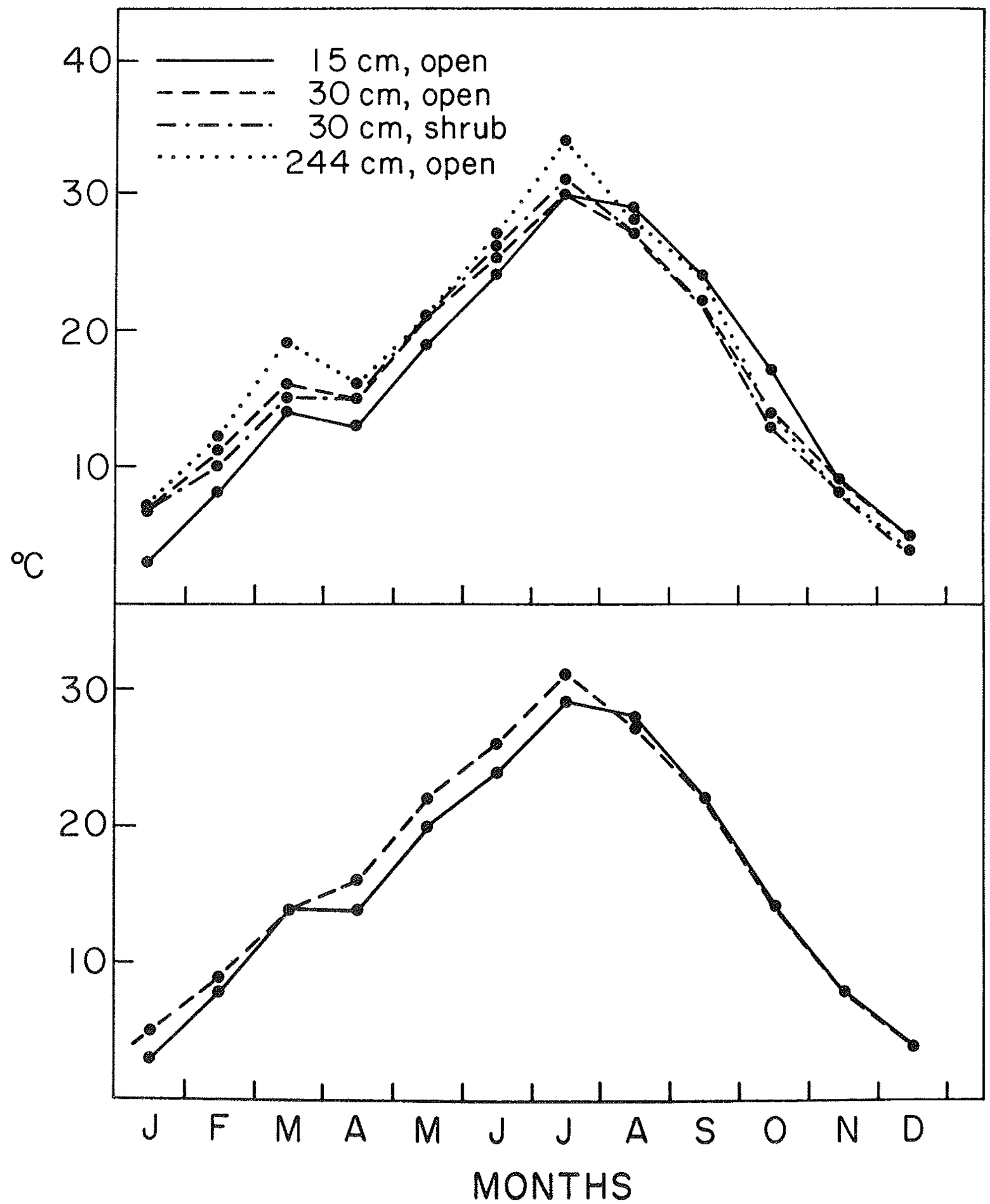

Figure 1. Monthly mean air temperatures measured at station I and V (above) and station IV during 1972. Mean temperatures at 30 cm beneath shrubs were identical with those in the open at station IV.

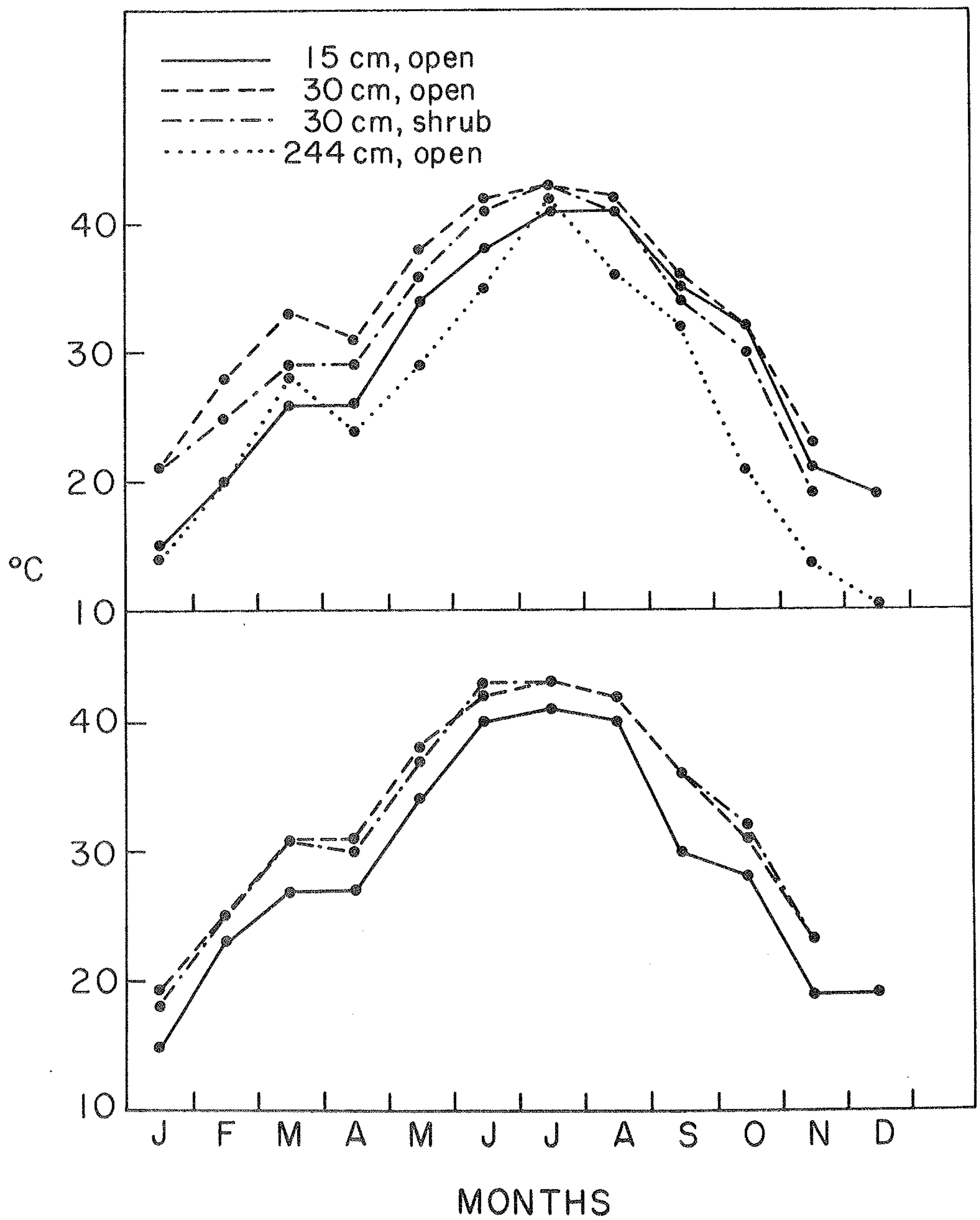

Figure 2. Monthly maximal air temperatures measured at station I and V (above) and station IV during 1972.

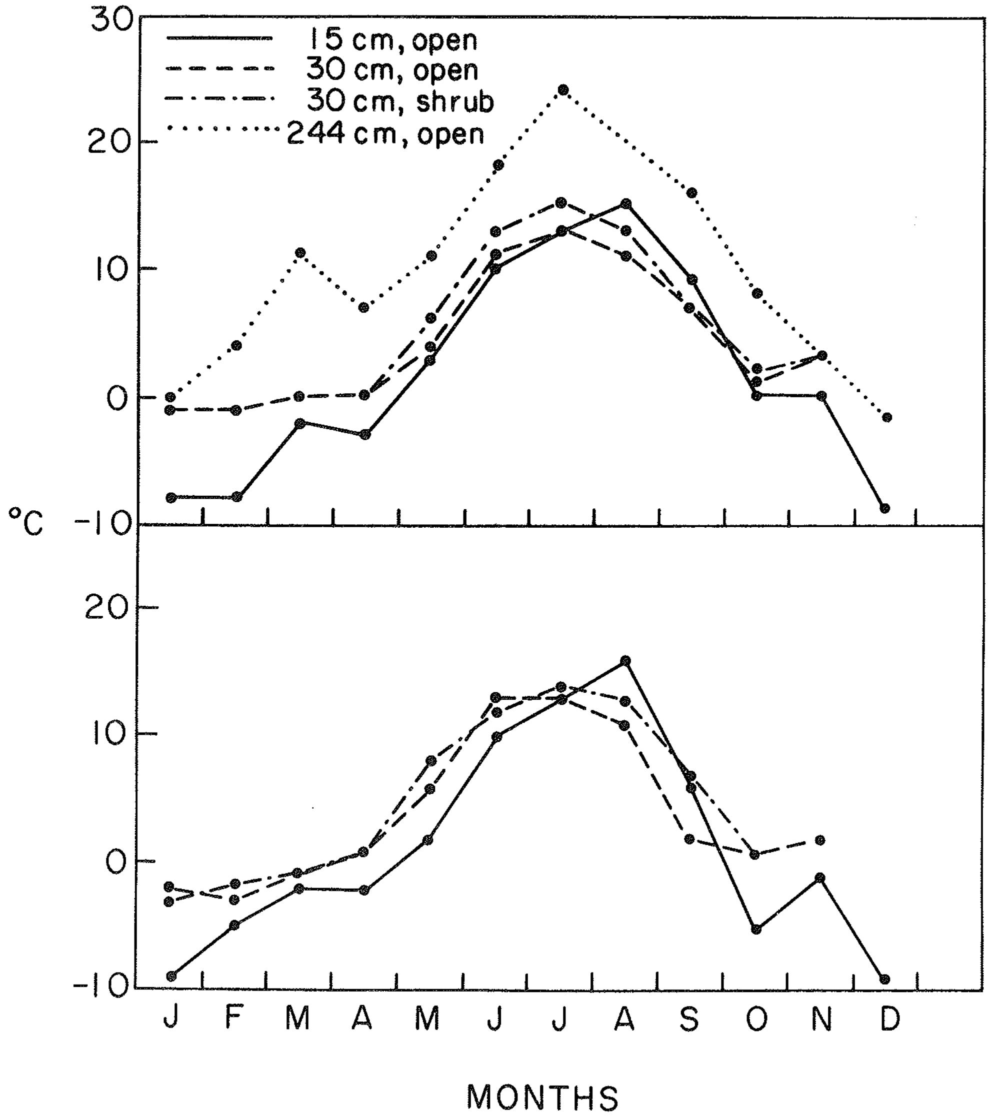

Figure 3. Monthly minimal air temperatures measured at station I and V (above) and station IV during 1972.

Table 8. Weekly temperatures (30 cm), Rock Valley during 1972 (C) at stations I, II, III, and IV

Week	Station 1		Station 2		Station 3		Station 4	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
011172	16	-3	16	-3	17	-2	16	-3
011872	18	-3	18	-3	18	-1	18	-3
012572	17	-7	17	-6	18	-4	17	-7
020172	14	-10	14	-10	16	-8	14	-10
020872	17	-8	17	-6	19	-6	17	-8
021572	21	-6	20	-5	22	-3	21	-5
022272	26	-1	25	0	26	1	26	-1
022972	27	-4	27	-3	28	-3	28	-2
030872	31	0	31	2	31	1	32	0
031472	31	7	31	7	32	8	31	7
032172	32	4	32	4	34	7	32	5
032872	29	-5	29	-4	31	-4	30	-6
040472	29	-6	29	-4	30	-4	29	-7
041272	29	1	29	2	30	2	29	1
041872	28	-4	28	-3	29	-2	28	-4
042672	31	2	30	0	31	0	31	-1
050372	34	-1	34	6	35	7	34	6
050972	34	7	36	6	37	6	36	6
051672	37	9	37	10	37	10	38	13
052372	35	1	35	2	36	2	36	1
053072	41	8	40	9	42	10	41	8
060672	39	16	39	17	40	18	40	17
061372	38	10	37	11	38	12	38	10
062072	39	11	39	13	40	14	40	12
062772	40	9	40	10	40	11	40	9
070572	46	15	46	17	47	18	47	17
071172	43	14	43	16	44	17	44	15
071872	47	18	48	19	47	19	48	19
072572	40	13	40	13	41	14	41	13
080172	43	17	44	18	44	18	44	17
080872	44	16	46	17	47	17	47	16
081572	44	16	44	17	41	17	44	17
082272	39	12	39	13	41	14	41	12
082972	40	17	40	17	42	17	41	17
090572	38	17	38	17	39	18	38	17
091272	34	8	34	12	36	10	36	12

Table 8. (cont.) Weekly temperatures (30 cm) Rock Valley during 1972 (C) at stations I, II, III and IV

Week	Station 1		Station 2		Station 3		Station 4	
	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum
091972	36	10	36	11	37	12	37	10
092672	32	6	32	6	34	7	34	6
100372	33	8	33	8	35	9	34	8
101072	32	7	32	8	34	9	32	7
101872	27	4	27	4	28	7	28	4
102472	24	4	25	5	26	6	26	3
103172	21	-6	22	-6	21	-5	22	-7
110972	23	-1	23	0	21	1	23	0
111672	18	-2	18	-1	17	-1	17	-2
112372	12	-3	18	-2	18	-2	12	-3
113072	22	-1	23	-1	23	-1	23	-2
120772	20	-8	21	-8	21	-7	22	-9
121472	8	-17	8	-17	9	-16	8	-18
122172	18	-6	19	-6	19	-4	18	-5
122872	64	30	65	30	66	31	66	29

Table 9. Mean daily air temperatures (C) at station I

Date		244 cm in open	30 cm in open	30 cm in shrub	15 cm in open
Jan	1	*	06	05	02
	10	07	08	08	04
	20	08	08	08	08
Feb	1	04	04	03	01
	10	*	08	07	05
	20	14	11	11	09
Mar	1	12	11	09	07
	10	22	20	20	18
	20	21	19	18	18
Apr	1	*	15	15	13
	10	18	15	16	14
	20	13	12	13	10
May	1	19	19	19	06
	10	18	20	20	18
	20	11	11	11	11
Jun	1	26	26	26	25
	10	24	21	21	20
	20	30	28	29	26
Jul	1	35	33	34	32
	10	34	29	30	30
	20	29	26	26	24
Aug	1	33	31	31	33
	10	21	32	31	34
	20	26	24	21	25
Sep	1	29	29	28	30
	10	25	24	24	24
	20	20	21	20	22
Oct	1	25	23	22	26
	10	14	13	13	18
	20	09	09	08	07
Nov	1		10	09	12
	10		09	09	08
	20		07	06	06
Dec	1		*	*	10
	10		*	*	-06
	20		*	*	12

*missing data

Table 10. Mean daily air temperatures (C) at station IV

Date		30 cm in open	30 cm in shrub	15 cm in open
Jan	1	04	05	02
	10	06	05	04
	20	07	06	06
Feb	1	02	01	00
	10	06	06	06
	20	10	09	10
Mar	1	08	09	08
	10	19	21	19
	20	16	16	14
Apr	1	15	14	13
	10	16	16	15
	20	13	14	11
May	1	21	20	15
	10	21	21	18
	20	13	13	11
Jun	1	27	27	26
	10	22	22	19
	20	26	26	27
Jul	1	33	33	32
	10	30	30	30
	20	26	26	24
Aug	1	31	31	31
	10	32	32	33
	20	24	23	25
Sep	1	29	29	28
	10	24	23	18
	20	17	20	19
Oct	1	23	23	22
	10	12	14	16
	20	08	08	07
Nov	1	08	08	09
	10	08	08	07
	20	05	04	05
Dec	1	*	*	10
	10	*	*	-06
	20	*	*	12

* missing data

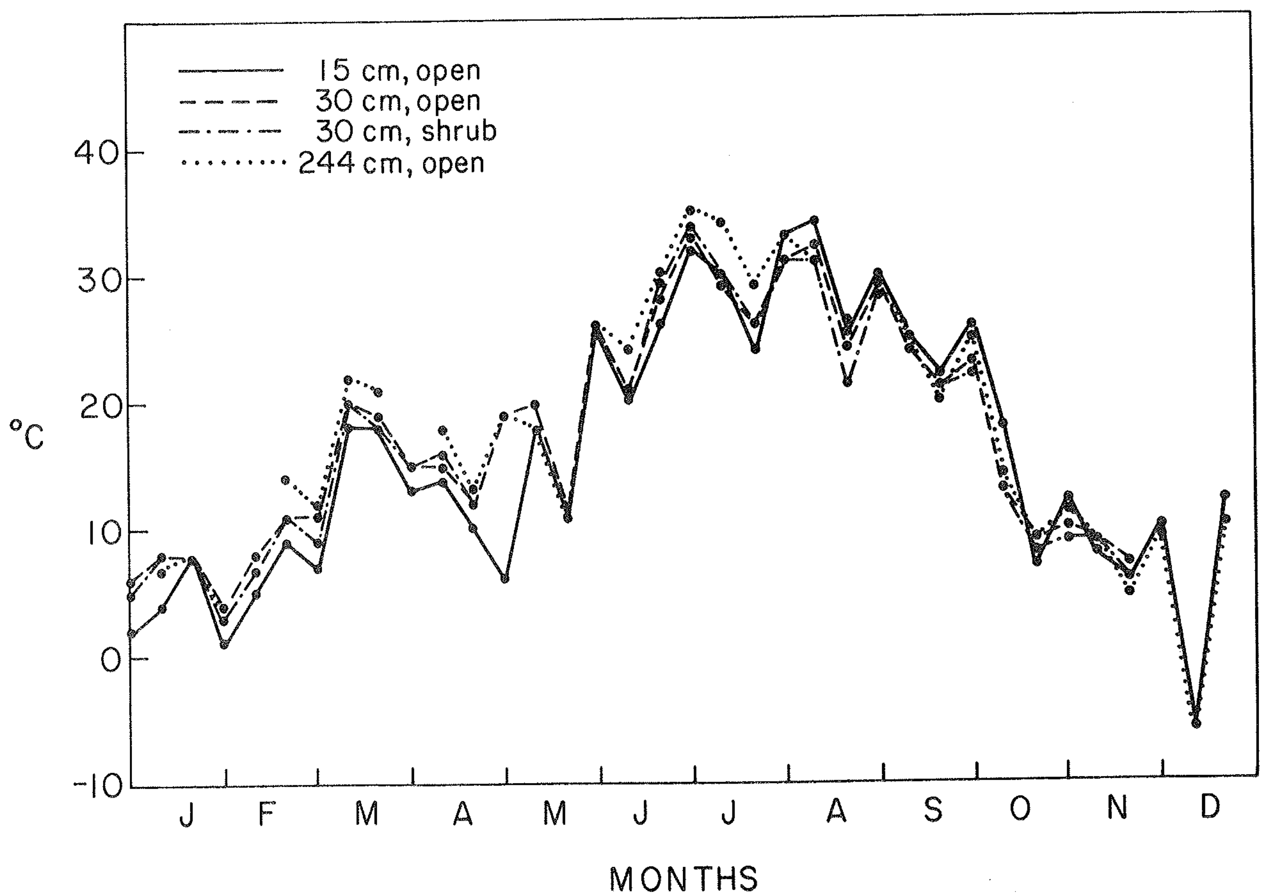

Figure 4. Mean daily air temperatures for three days of each month at station I and V during 1972.

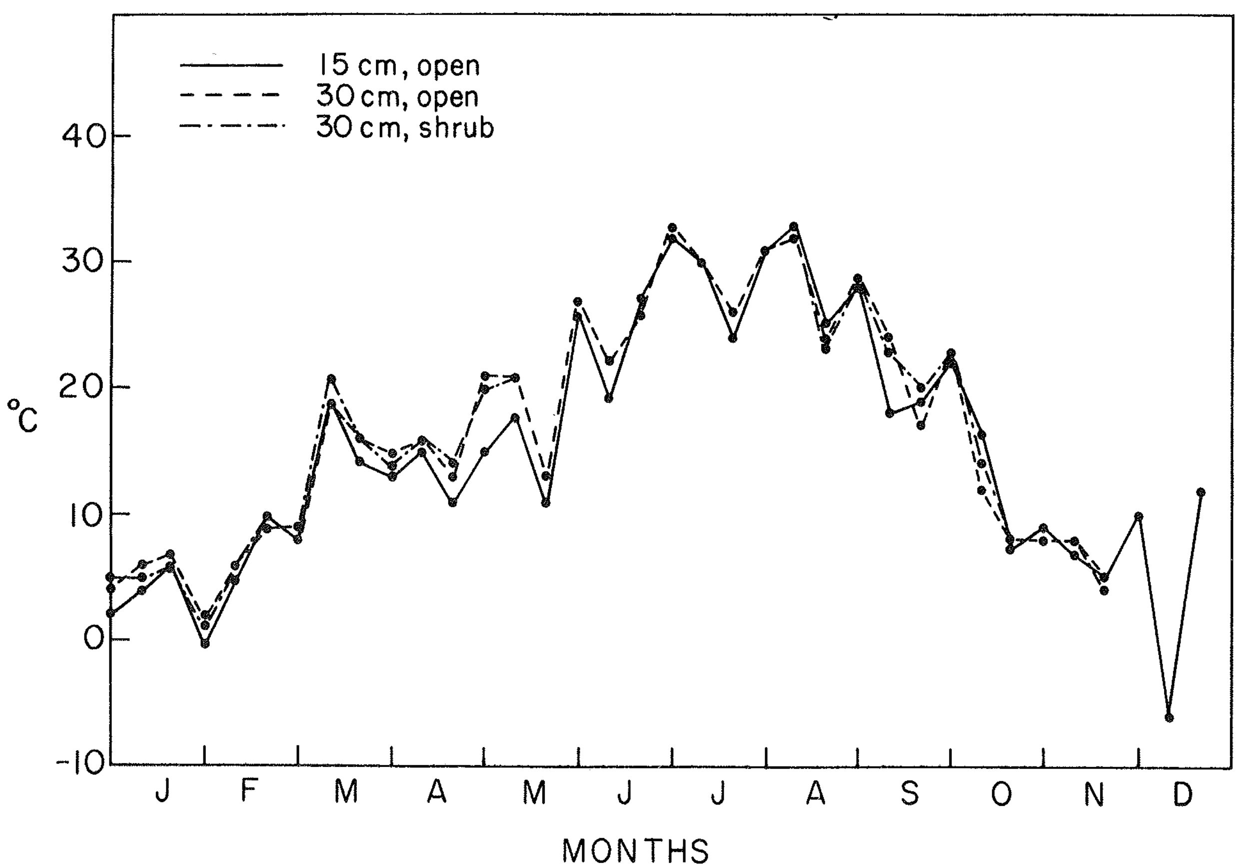

Figure 5. Mean daily air temperatures for three days of each month at station IV during 1972.

Table 11. Air temperatures (C) at four times of day for three days (quarterly) recorded at station I

Month	Situation	Dates and Hours											
		10th				11th				12th			
		0600	1200	1800	2400	0600	1200	1800	2400	0600	1200	1800	2400
Jan	244 cm, open	01	13	12	04	04	13	09	03	02	13	14	04
	30 cm, open	01	18	09	05	06	20	05	02	03	19	10	04
	30 cm, shrub	02	16	08	07	06	15	06	02	03	16	10	03
	15 cm, open	-02	10	05	01	-02	12	08	03	00	14	07	04
Apr	244 cm, open	19	18	19	17	14	12	16	12	10	16	12	06
	30 cm, open	16	16	16	13	13	12	13	09	08	19	14	08
	30 cm, shrub	16	16	16	14	14	12	13	10	10	18	13	08
	15 cm, open	15	15	15	13	12	10	13	09	07	16	13	07
Jul	244 cm, open	23	38	39	32	24	39	40	26	26	43	43	30
	30 cm, open	16	36	37	27	16	38	37	19	19	41	40	19
	30 cm, shrub	22	36	35	26	22	38	36	20	24	39	39	21
	15 cm, open	19	34	37	29	17	34	35	21	21	34	37	21
Oct	244 cm, open	10	18	14	09	10	22	21	16	16	19	16	13
	30 cm, open	08	21	17	06	07	24	15	13	13	18	14	11
	30 cm, shrub	10	19	18	07	07	24	13	14	13	18	13	11
	15 cm, open	18	22	19	12	13	25	22	19	19	22	19	17

Table 12. Air temperatures (C) at four times of day for three days (quarterly) recorded at station IV

Month	Situation	Dates and Hours											
		10th				11th				12th			
		0600	1200	1800	2400	0600	1200	1800	2400	0600	1200	1800	2400
Jan	30 cm, open	00	16	07	03	03	13	02	00	00	15	07	02
	30 cm, shrub	00	16	05	01	01	13	01	-01	00	16	09	05
	15 cm, open	-02	10	05	01	03	10	02	01	-01	07	01	03
Apr	30 cm, open	17	17	16	14	13	13	13	10	09	20	15	09
	30 cm, shrub	17	17	16	15	15	13	13	10	11	19	13	09
	15 cm, open	15	15	15	14	12	11	13	09	07	16	14	08
Jul	30 cm, open	18	38	37	27	16	38	38	19	24	41	38	21
	30 cm, shrub	21	37	36	26	19	38	37	19	26	43	38	20
	15 cm, open	19	34	37	29	17	34	38	21	21	34	37	21
Oct	30 cm, open	08	21	18	07	08	24	15	14	14	19	15	12
	30 cm, shrub	10	21	18	07	08	24	14	15	14	18	14	12
	15 cm, open	18	22	16	07	07	20	19	14	14	17	14	11

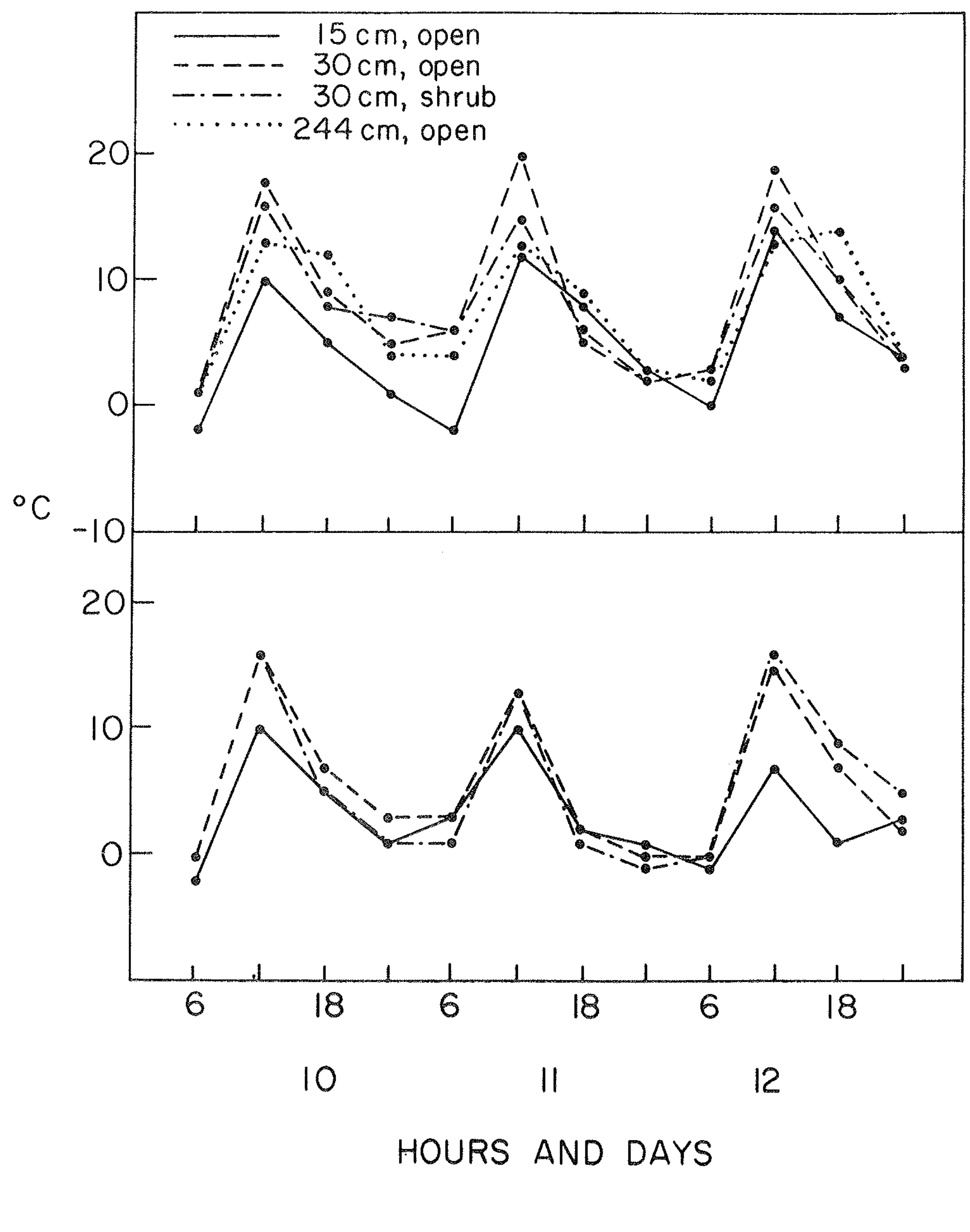

Figure 6. Air temperatures at 6-hour intervals for three days in January at station I and V (above) and station IV during 1972.

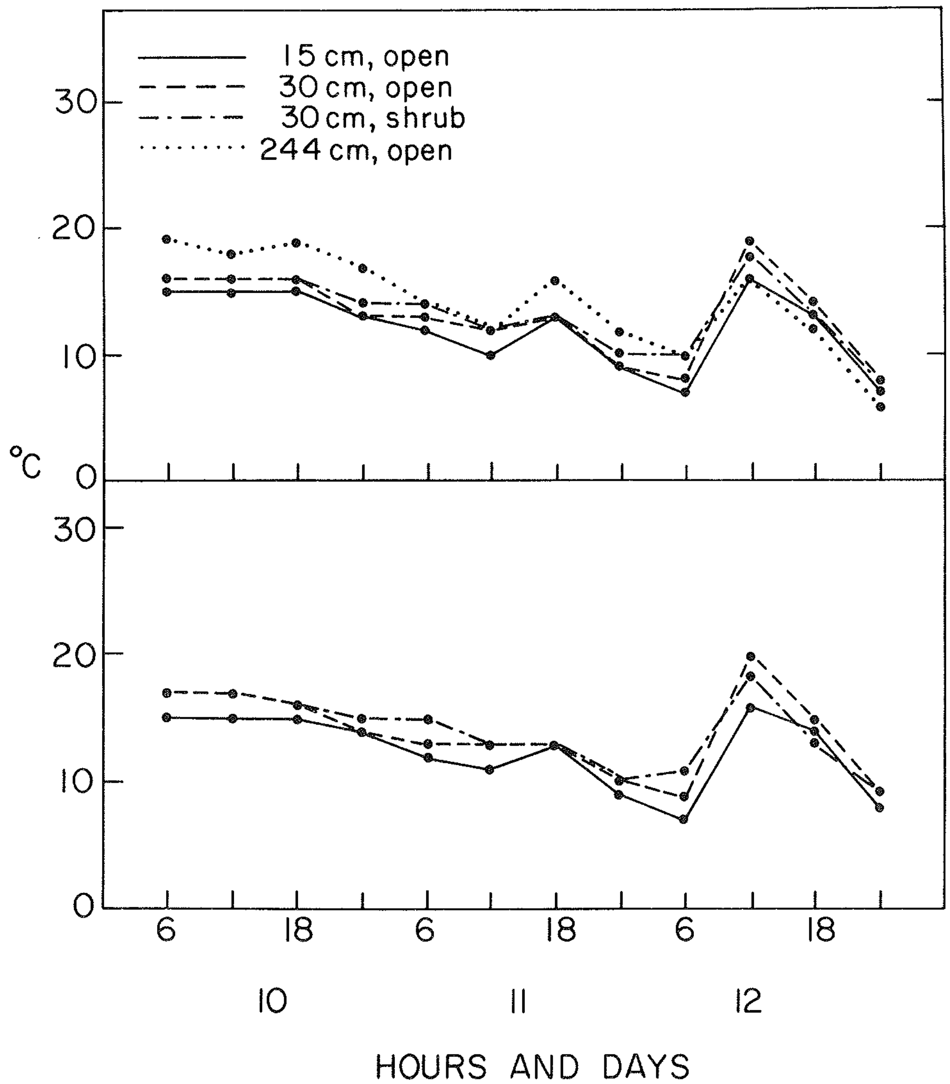

Figure 7. Air temperatures at 6-hour intervals for three days in April at station I and V (above) and station IV during 1972.

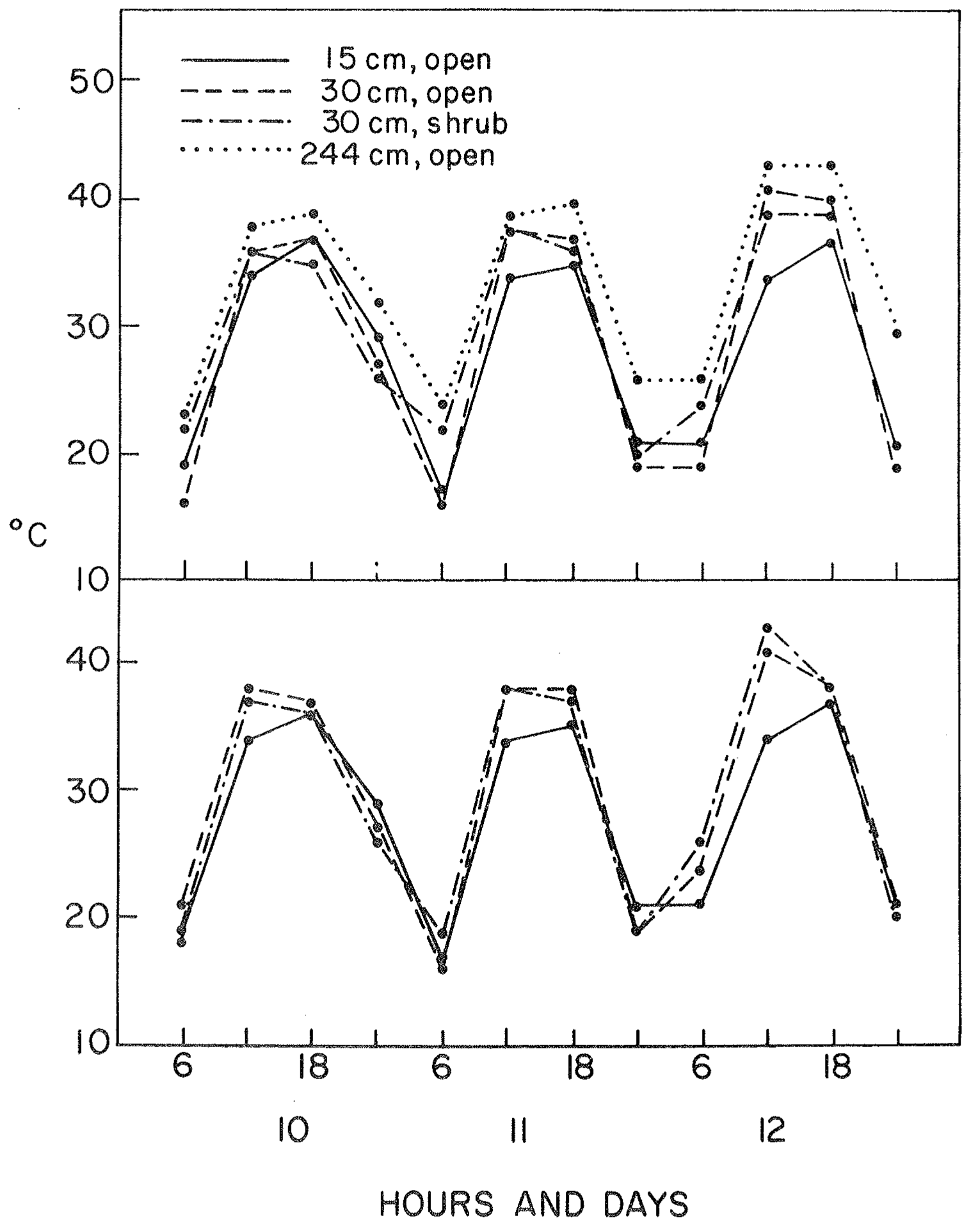

Figure 8. Air temperatures at 6-hour intervals for three days in July at station I and V (above) and station IV during 1972.

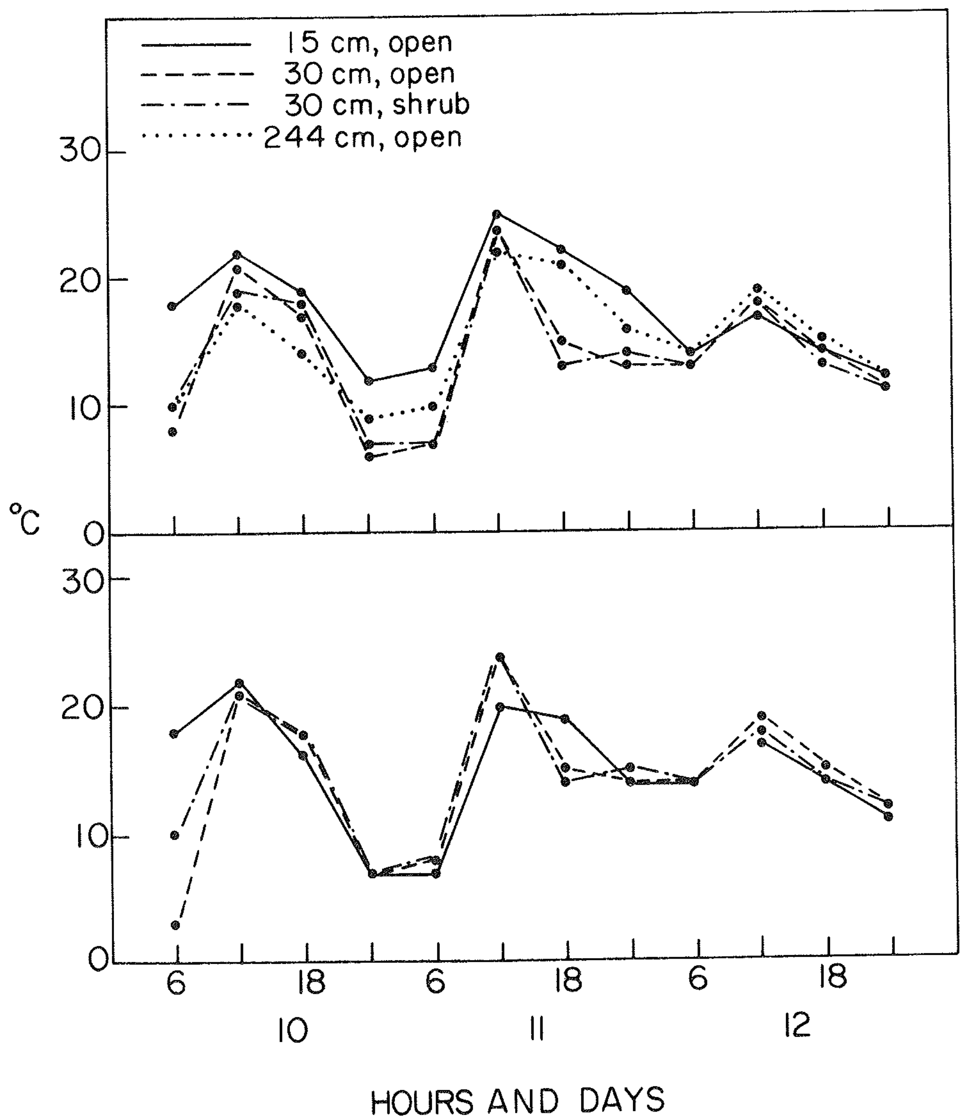

Figure 9. Air temperatures at 6-hour intervals for three days in October at station I and V (above) and station IV during 1972.

A.2. SOLAR RADIATION

Incident solar radiation (cal/cm^2) was measured at one station in Rock Valley with an integrating pyrheliometer (A3UTJ05). Data were recorded at approximately weekly intervals. Total radiation in 1972 was about 190,000 cal/cm^2 with a daily mean of around 520 cal/cm^2 (Table 13). About 37,000 cal/cm^2 was received during the first quarter of 1972 (ca. 400 cal/cm^2 per day), around 65,500 cal/cm^2 during the second quarter (daily mean of 712 cal/cm^2), about 60,000 cal/cm^2 during the third quarter (daily mean of 666 cal/cm^2), and only about 28,000 cal/cm^2 (ca. 300 cal/cm^2 daily) during the last quarter. Radiation between October 11 and December 31, 1971, was 24,246 cal/cm^2 (daily average of about 296 cal/cm^2). These figures are almost identical with those recorded over the same time span in 1971. Figure 10 illustrates weekly incident radiation totals.

Table 13. Incident solar energy (cal/cm^2) recorded during 1972

Time interval	Total incident solar energy (cal/cm^2)	Mean daily incident solar energy (cal/cm^2)
January 4-10	1435	205.0
January 11-17	2332	333.1
January 18-24	1913	273.3
January 25-31	2451	350.1
February 1-7	1973	281.9
February 8-14	2571	367.3
February 15-21	3229	461.3
February 22-28	2989	427.0
February 29-March 7	4185	523.2
March 8-13	2511	418.5
March 14-20	3408	486.9
March 21-27	4245	606.4
March 28-April 3	3528	504.0
April 4-11	3647	455.9
April 12-17	3767	627.8
April 18-25	5142	642.7
April 26-May 2	4245	606.4
May 3-8	4066	677.6
May 9-15	5022	717.4
May 16-22	5560	794.3
May 23-29	5142	734.6
May 30-June 5	6158	879.7
June 6-12	5859	837.0
June 13-19	5620	802.9
June 20-26	5560	794.3
June 27-July 4	5680	710.0
July 5-10	5262	877.0
July 11-17	5441	777.3
July 18-24	4963	709.0
July 25-31	5620	802.9
August 1-7	5142	734.6
August 8-14	4783	683.3
August 15-21	5022	717.4
August 22-28	4365	623.6
August 29-September 4	3767	538.1
September 5-11	4185	597.9
September 12-18	4066	580.9
September 19-25	4006	572.3
September 26-October 2	3348	478.3
October 3-9	3049	435.6
October 10-17	2571	321.4
October 18-23	2332	388.7
October 24-30	2571	367.3
October 31-November 8	2989	332.1
November 9-15	1256	179.4
November 16-22	1913	273.3
November 23-29	2212	316.0
November 30-December 6	1913	273.3
December 7-13	1674	239.1
December 14-20	1614	230.6
December 21-27	1794	256.3
December 28-January 3, 1973	1913	273.3
Total for year	190,009	519.2

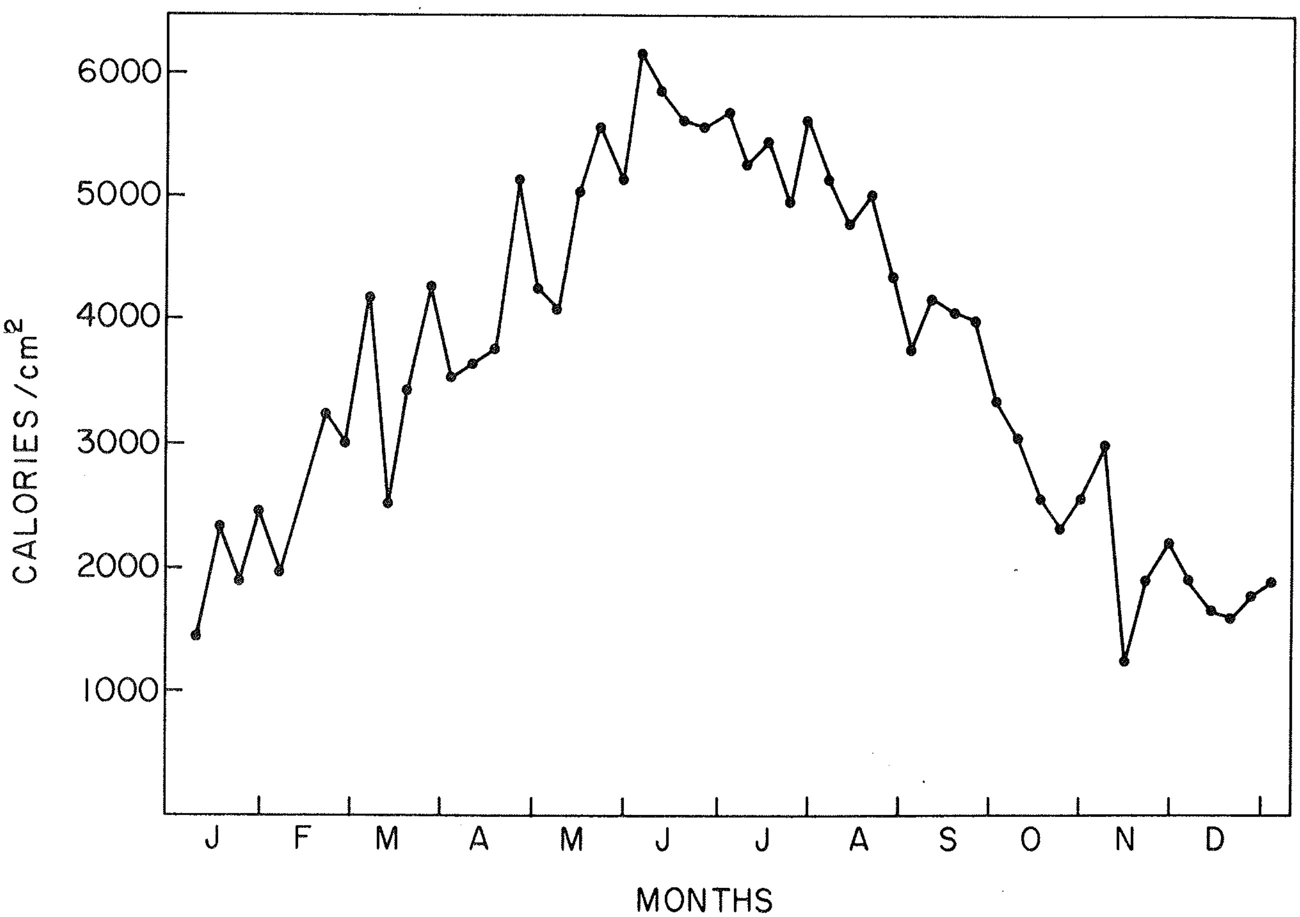

Figure 10. Weekly insolation recorded during 1972.

A.3. PRECIPITATION

Rainfall was recorded at four stations on the validation site (I-IV) at weekly intervals. Rain was collected in plastic, clearview rain gauges and totals were recorded weekly or following storms (A3UTJ06). Depth of percolation of moisture was recorded after each major rainfall. Rainfall was also recorded on a daily basis at a station (V) operated by the Air Resources Laboratory in Las Vegas, Nevada (A3UTJ07).

The number of rains occurring and the total rainfall (mm) in each month of 1972 at five stations are summarized in Table 14. Figure 11 illustrates the seasonal distributions of rainfall at each of the five stations. Total annual rainfall at these stations ranged from a low of 103.2 mm (station V) to a high of 117.8 mm (station II). Except for station V, annual rainfall on the validation site was quite similar (113.1 to 117.8 mm). The average annual rainfall, based on five stations, was 113.8 mm. Total rainfall in 1971 was 103.9 mm. Figure 12 illustrates climographs based on monthly air temperature and rainfall during 1971 and 1972. These graphs indicate several general points about the two years. First, air temperatures for the first six months of 1971 were lower than corresponding temperatures in 1972. The major rains of 1971 were in May, August and December. In 1972, rainfall was greatest in June, August, October and November. In 1972 rainfall between August and December accounted for 85.5% of the annual total; in 1971 precipitation during this interval was 71.9% of the annual total. Rain between October and December 1972 was 58.9% of the annual total; in 1971 this rainfall was only 39.8% of the yearly total.

Table 14. Monthly rainfall (mm) in Rock Valley during 1972

Month	Number of events	Stations I	II	III	IV	V	5-station means
January	0	0.0	0.0	0.0	0.0	0.0	0.0
February	0	0.0	0.0	0.0	0.0	0.0	0.0
March	0	0.0	0.0	0.0	0.0	0.0	0.0
April	2	2.3	2.1	1.9	1.9	1.8	2.0
May	0	0.0	0.0	0.0	0.0	0.0	0.0
June	5	14.4	15.2	13.0	18.6	11.2	14.5
July	0	0.0	0.0	0.0	0.0	0.0	0.0
August	3	21.5	19.4	22.0	23.7	20.1	21.3
September	2	11.0	12.2	8.6	4.6	8.4	9.0
October	6	35,6	35.6	34.0	33.8	32.0	34.2
November	5	32.3	33.3	33.6	35.1	29.7	32.8
December	0	0.0	0.0	0.0	0.0	0.0	0.0
Totals	23	117.1	117.8	113.1	117.7	103.2	113.8

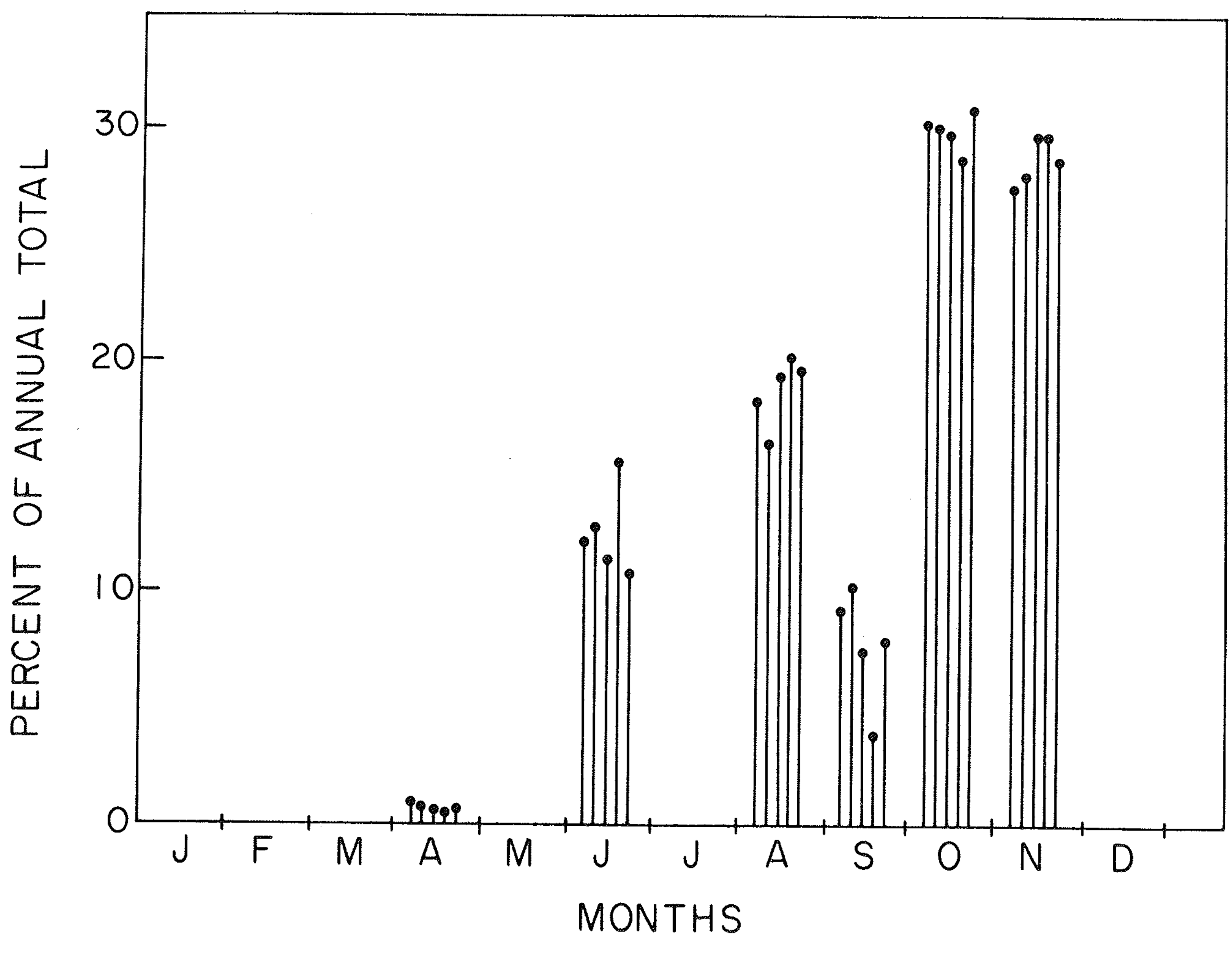

Figure 11. Monthly rainfall (as percent of annual total) recorded at five stations during 1972.

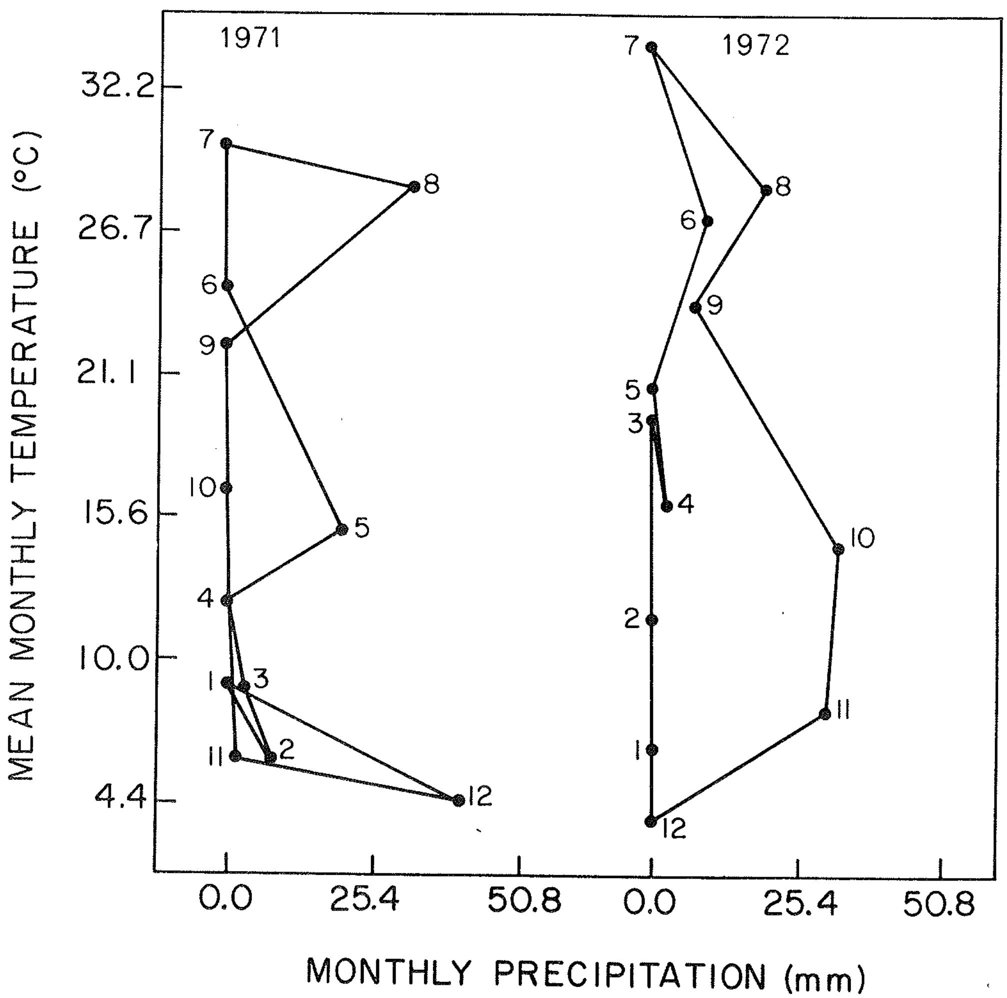

Figure 12. Climographs contrasting temperature-rainfall regimens during 1971 and 1972. Figures are based on measurements at station V.

A.4. RELATIVE HUMIDITY

Relative humidity was measured at two stations (I, IV) on the validation site at six-hour intervals during 1972 (A3UTJ10). Data were recorded on Wescor hygrothermographs at about 15 cm above ground level. Values are generally accurate to within ±5%. Chart readings of less than 5% were arbitrarily set at 5%. Errors in humidity sensing increase at lower levels. All readings are available in the aforementioned Data Set. Table 15 gives means and extremes based on monthly intervals at station I. For a given month, with _n_ days, the hourly mean is simply the mean of 4_n_ measurements. Table 16 gives similar data for station IV. Monthly means for both stations are illustrated in Figure 13. Average humidity during the last quarter of 1972 was fairly high (~60%) owing to the rains of October and November.

Table 17 gives mean daily humidities at stations I and IV for three days of each month of 1972 (Figure 14). Table 18 summarizes twelve consecutive readings over a 72-hour period at each of two stations during four months of 1972. Figure 15 illustrates these same data. Highest humidities were at 0600 during July, but were sometimes recorded at noon in other seasons.

Table 15. Relative humidity data (%) at Rock Valley station no. I during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	10	86	45	10 - 47	35 - 86	22 - 61
February	5	87	34	5 - 47	20 - 87	15 - 58
March	11	69	28	11 - 28	30 - 69	20 - 44
April	5	82	28	5 - 50	14 - 82	9 - 58
May	5	69	23	5 - 30	11 - 69	7 - 47
June	5	83	26	5 - 37	11 - 83	7 - 59
July	5	43	13	5 - 21	7 - 43	6 - 28
August	5	77	33	5 - 55	20 - 77	11 - 65
September	13	99	43	13 - 52	31 - 99	24 - 67
October	15	92	62	15 - 76	45 - 92	29 - 85
November	22	92	65	22 - 88	51 - 92	37 - 90
December	22	89	54	22 - 58	46 - 89	39 - 72

Table 16. Relative humidity data (%) at Rock Valley station no. IV during 1972

Month	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	12	86	45	12 - 47	23 - 86	19 - 66
February	5	91	36	5 - 38	27 - 91	18 - 71
March	8	64	27	8 - 26	23 - 64	16 - 40
April	5	91	24	5 - 47	5 - 91	5 - 55
May	5	70	25	5 - 29	13 - 70	9 - 42
June	5	84	23	5 - 35	11 - 84	7 - 59
July	5	52	15	5 - 21	8 - 52	6 - 35
August	5	84	35	5 - 40	23 - 84	15 - 65
September	5	99	37	5 - 50	11 - 99	9 - 71
October	5	91	52	5 - 60	31 - 91	20 - 76
November	20	92	63	20 - 88	43 - 92	34 - 90
December	20	83	47	20 - 50	32 - 83	26 - 69

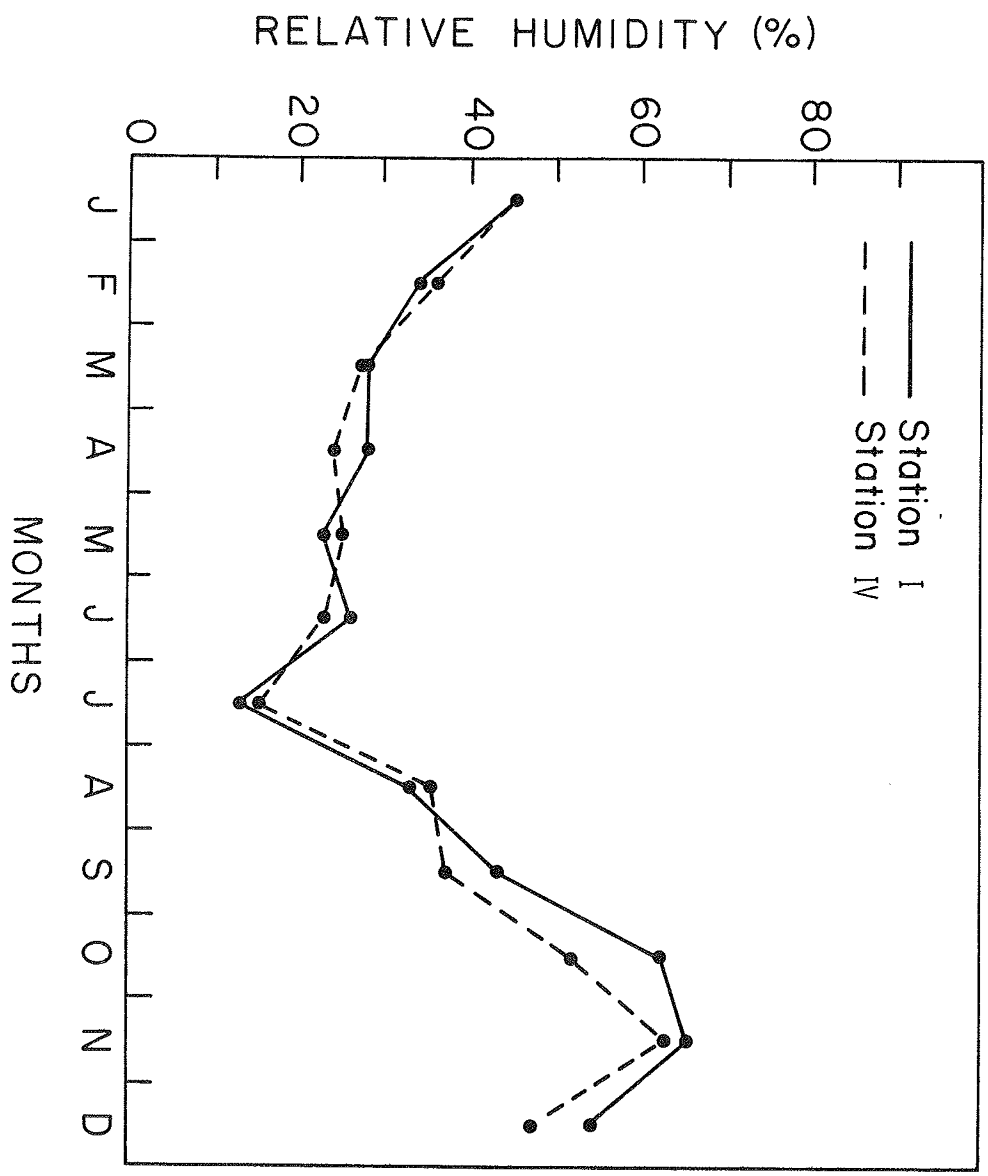

Figure 13. Monthly mean relative humidity recorded at two stations during 1972.

Table 17. Mean relative humidities (%) calculated from four readings three days of each month during 1972

Date		Station I	Station IV
Jan	1	47	53
	10	48	48
	20	52	54
Feb	1	33	37
	10	21	20
	20	37	36
Mar	1	28	27
	10	27	25
	20	24	22
Apr	1	28	32
	10	43	42
	20	19	20
May	1	07	05
	10	26	25
	20	41	39
Jun	1	40	38
	10	27	28
	20	13	16
Jul	1	07	07
	10	14	14
	20	20	25
Aug	1	19	17
	10	29	27
	20	39	39
Sep	1	40	40
	10	45	45
	20	40	32
Oct	1	39	28
	10	62	55
	20	79	77
Nov	1	36	24
	10	58	47
	20	67	67
Dec	1	58	58
	10	45	45
	20	62	62

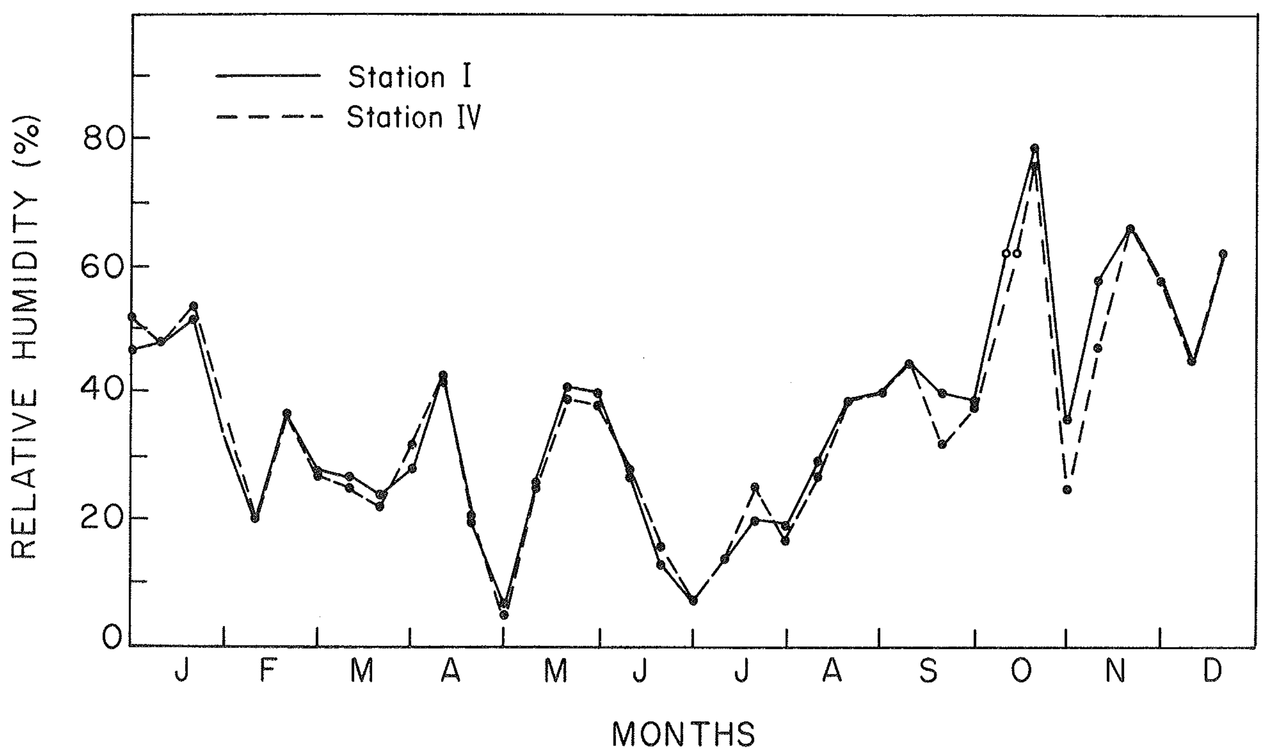

Figure 14. Mean daily relative humidities for three days of each month at two stations during 1972.

Table 18. Relative humidities (%) recorded at six-hour intervals for three days during each quarter of 1972

	10th				11th				12th			
Month	0600	1200	1800	2400	0600	1200	1800	2400	0600	1200	1800	2400
Station I												
January	69	28	29	65	72	35	31	64	64	27	36	62
April	30	43	48	50	52	69	50	62	64	32	31	60
July	22	14	07	13	25	13	04	10	14	08	04	07
October	64	53	51	81	76	43	38	72	72	63	90	91
Station IV												
January	69	28	29	65	70	30	34	62	68	32	37	64
April	30	43	47	52	51	70	51	63	64	36	28	59
July	22	14	07	13	25	13	05	09	16	09	04	06
October	64	53	34	69	65	29	20	56	55	47	76	82

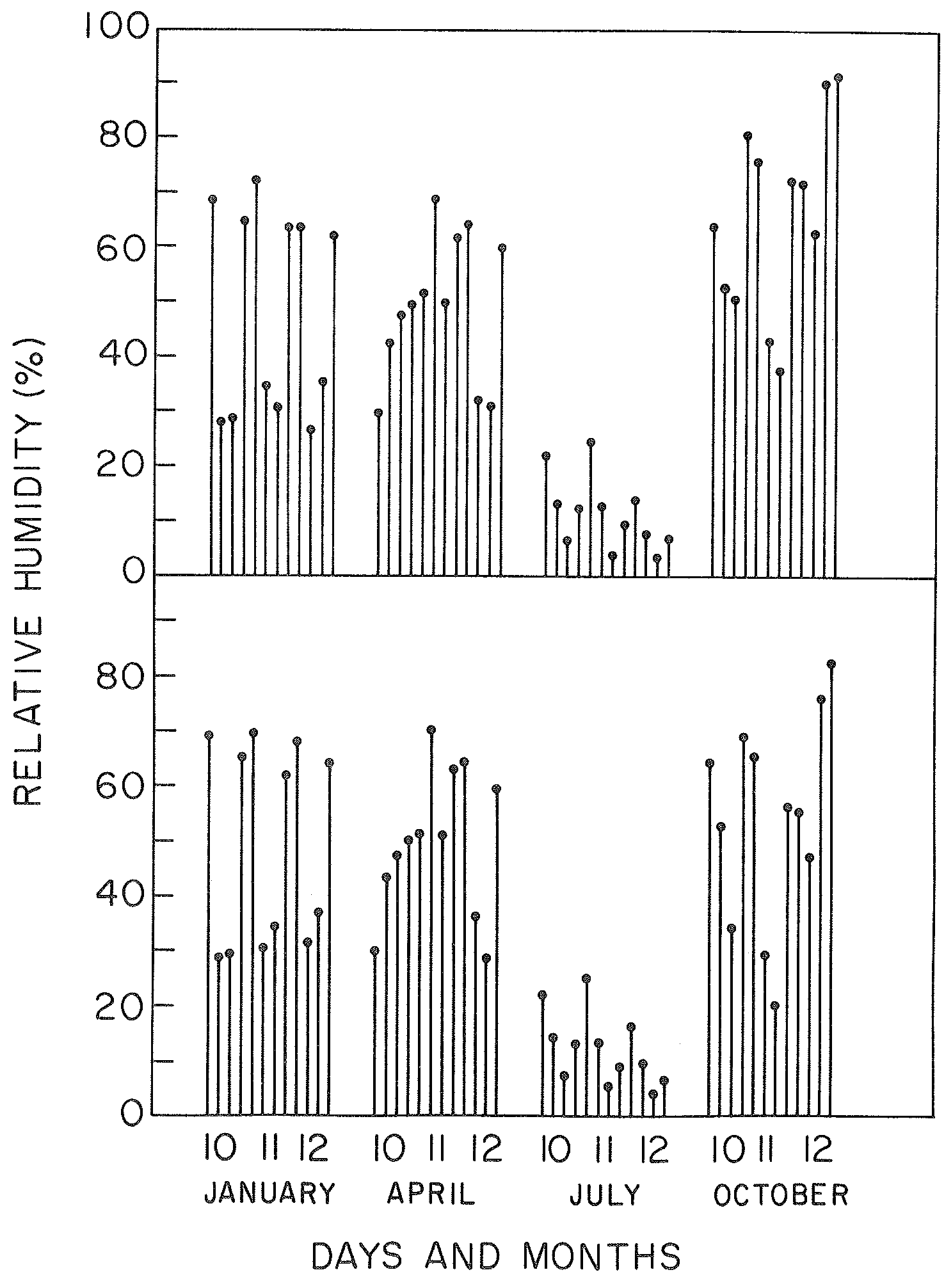

Figure 15. Relative humidities at 6-hour intervals for three days of each of four months at station I (above) and IV during 1972.

A.5. WIND

Wind direction and speed were recorded hourly at 3 m at station V by Air Resources Laboratory in Las Vegas, Nevada (A3UTJ01). Wind direction (° magnetic azimuth) was recorded to $\pm 5°$.

A.6. SOIL TEMPERATURE

Soil temperatures were measured every six hours with Fenwal KA31L4 thermistors buried at 3, 15, 30 and 45 cm. These measurements were made at two stations (I, IV) in the open and beneath shrubs (A3UTJ08). Chart readings (A) were in milliamperes and were converted to C according to the following function:

$$C = -11.42 + 87.77A - 33.12A^2$$

Tables 19 - 22 give monthly means and extremes measured at the four depths in two situations at the two stations. For a given month, of n days, the hourly mean was calculated from 4n measurements. No measurements were obtained during December owing to particularly cold weather. Figures 16 and 17 illustrate seasonal trends in soil temperatures based on the monthly means in Tables 19 - 22. Figures 18 - 21 illustrate seasonal trends in maximum and minimum soil temperatures recorded each month.

Tables 23 and 24 give daily average soil temperatures for three days of each month during 1972 at the two stations. Figures 22 - 25 illustrate these same data. Finally, Tables 25 and 26 give twelve consecutive readings taken on three consecutive days in each of four months during 1972.

Table 19. Soil temperature data (C) at Rock Valley station no. I in the open during 1972

Month	Cm. Depth	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-03	-1	18	6	-1 - 4	5 - 18	1 - 9
	-15	0	11	7	0 - 8	4 - 11	3 - 9
	-30	0	10	8	0 - 8	6 - 10	6 - 9
	-45	0	10	9	0 - 9	7 - 10	7 - 10
February	-03	-1	33	10	-1 - 8	7 - 33	3 - 17
	-15	4	17	11	4 - 14	7 - 17	6 - 15
	-30	6	15	11	6 - 13	8 - 15	7 - 14
	-45	8	15	11	8 - 13	8 - 15	8 - 14
March	-03	-1	40	17	-1 - 11	18 - 40	7 - 21
	-15	10	23	17	10 - 18	14 - 23	12 - 20
	-30	12	20	16	12 - 17	14 - 20	13 - 19
	-45	13	18	16	13 - 17	14 - 18	14 - 18
April	-03	1	42	17	1 - 13	13 - 42	8 - 22
	-15	10	24	17	10 - 18	15 - 24	13 - 21
	-30	13	20	17	13 - 18	16 - 20	14 - 19
	-45	15	19	16	15 - 18	15 - 19	15 - 18
May	-03	6	43	25	6 - 18	26 - 43	18 - 31
	-15	17	32	23	17 - 25	21 - 32	19 - 29
	-30	18	26	22	18 - 24	21 - 26	19 - 25
	-45	18	26	21	18 - 23	19 - 26	18 - 23
June	-03	13	43	29	13 - 23	33 - 43	23 - 34
	-15	21	36	28	21 - 29	28 - 36	24 - 32
	-30	23	30	26	23 - 28	25 - 30	24 - 29
	-45	23	27	25	23 - 26	24 - 27	23 - 27
July	-03	17	43	33	17 - 27	40 - 43	30 - 38
	-15	27	39	32	27 - 33	33 - 39	30 - 35
	-30	28	35	30	28 - 31	30 - 35	29 - 32
	-45	27	30	29	27 - 30	28 - 30	27 - 30
August	-03	15	43	29	15 - 24	22 - 43	19 - 35
	-15	20	38	30	20 - 32	25 - 38	24 - 34
	-30	24	33	29	24 - 31	27 - 33	26 - 32
	-45	26	31	28	26 - 30	27 - 31	26 - 30
September	-03	10	40	25	10 - 21	26 - 40	18 - 30
	-15	17	33	24	17 - 26	24 - 33	20 - 29
	-30	21	29	25	21 - 27	23 - 29	22 - 28
	-45	22	28	25	22 - 27	23 - 28	23 - 27
October	-03	3	33	15	3 - 18	13 - 33	8 - 24
	-15	8	26	16	8 - 22	13 - 26	10 - 24
	-30	10	24	18	10 - 23	13 - 24	12 - 23
	-45	14	24	19	14 - 23	16 - 24	15 - 23
November	-03	3	22	9	3 - 8	8 - 22	6 - 13
	-15	6	17	10	6 - 12	8 - 17	7 - 14
	-30	8	15	11	8 - 13	8 - 15	8 - 14
	-45	10	16	12	10 - 15	11 - 16	10 - 15

Table 20. Soil temperature data (C) at Rock Valley station no. I under shrub during 1972

Month	Cm. Depth	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-03	-1	14	6	-1 - 6	3 - 14	1 - 9
	-15	3	9	7	3 - 8	4 - 9	4 - 9
	-30	6	9	8	6 - 8	6 - 9	6 - 9
	-45	7	10	9	7 - 9	8 - 10	7 - 10
February	-03	0	24	10	0 - 10	8 - 24	3 - 16
	-15	4	15	10	4 - 14	6 - 15	6 - 14
	-30	6	15	10	6 - 13	7 - 15	7 - 14
	-45	4	13	10	4 - 13	8 - 13	8 - 13
March	-03	3	29	16	3 - 13	15 - 29	9 - 20
	-15	11	20	16	11 - 17	13 - 20	12 - 19
	-30	13	19	16	13 - 17	14 - 19	13 - 18
	-45	13	18	15	13 - 17	13 - 18	13 - 17
April	-03	3	34	17	3 - 17	12 - 34	6 - 23
	-15	11	21	17	11 - 18	15 - 21	13 - 20
	-30	13	19	16	13 - 18	15 - 19	14 - 18
	-45	14	25	16	14 - 17	15 - 25	14 - 19
May	-03	9	39	24	9 - 21	23 - 39	17 - 30
	-15	17	28	22	17 - 25	20 - 28	19 - 27
	-30	18	25	21	18 - 23	20 - 25	18 - 24
	-45	17	24	20	17 - 21	18 - 24	17 - 22
June	-03	16	43	29	16 - 26	30 - 43	22 - 35
	-15	22	33	27	22 - 29	25 - 33	23 - 31
	-30	19	28	25	19 - 27	24 - 28	22 - 28
	-45	22	26	24	22 - 25	23 - 26	22 - 26
July	-03	21	43	34	21 - 30	37 - 43	29 - 38
	-15	27	36	32	27 - 33	32 - 36	29 - 34
	-30	27	32	30	27 - 31	29 - 32	28 - 31
	-45	26	30	28	26 - 29	26 - 30	26 - 29
August	-03	17	43	29	17 - 28	21 - 43	20 - 36
	-15	18	35	29	18 - 33	26 - 35	24 - 34
	-30	25	32	28	25 - 31	26 - 32	26 - 32
	-45	21	30	27	21 - 30	26 - 30	25 - 30
September	-03	12	36	24	12 - 23	21 - 36	17 - 29
	-15	18	30	24	18 - 26	22 - 30	21 - 28
	-30	20	27	24	20 - 26	23 - 27	22 - 27
	-45	20	26	24	20 - 26	23 - 26	22 - 26
October	-03	5	28	14	5 - 19	10 - 28	8 - 23
	-15	8	27	16	8 - 22	11 - 27	10 - 23
	-30	13	24	18	13 - 23	14 - 24	13 - 23
	-45	15	24	19	15 - 23	17 - 24	16 - 23
November	-03	4	16	8	4 - 10	7 - 16	6 - 12
	-15	6	15	10	6 - 13	8 - 15	7 - 13
	-30	8	15	11	8 - 14	9 - 15	9 - 14
	-45	11	15	13	11 - 15	11 - 15	11 - 15

Table 21. Soil temperature data (C) at Rock Valley station no. IV in the open during 1972

Month	Cm. Depth	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-03	-2	18	5	-2 - 4	3 - 18	1 - 8
	-15	3	9	5	3 - 6	3 - 9	3 - 7
	-30	3	8	6	3 - 7	4 - 8	4 - 8
	-45	6	8	7	6 - 8	6 - 8	6 - 8
February	-03	-3	30	10	-3 - 8	8 - 30	2 - 17
	-15	3	18	10	3 - 15	6 - 18	4 - 16
	-30	5	16	10	5 - 13	6 - 16	5 - 15
	-45	6	15	10	6 - 13	7 - 15	7 - 14
March	-03	-1	40	17	-1 - 13	17 - 40	7 - 21
	-15	9	24	17	9 - 17	13 - 24	11 - 20
	-30	11	21	16	11 - 18	13 - 21	13 - 19
	-45	13	18	16	13 - 18	14 - 18	13 - 18
April	-03	2	43	18	2 - 14	13 - 43	9 - 24
	-15	11	27	18	11 - 20	15 - 27	14 - 23
	-30	13	23	17	13 - 20	15 - 23	14 - 21
	-45	14	21	17	14 - 20	15 - 21	14 - 20
May	-03	8	43	26	8 - 19	27 - 43	19 - 32
	-15	18	33	24	18 - 26	23 - 33	20 - 29
	-30	20	27	23	20 - 25	22 - 27	21 - 26
	-45	19	27	22	19 - 24	20 - 27	20 - 24
June	-03	15	43	30	15 - 26	33 - 43	23 - 35
	-15	21	39	30	21 - 31	29 - 39	25 - 35
	-30	24	34	29	24 - 31	27 - 34	26 - 33
	-45	25	31	27	25 - 30	25 - 31	25 - 30
July	-03	19	43	35	19 - 29	36 - 43	27 - 38
	-15	28	41	35	28 - 36	33 - 41	31 - 38
	-30	30	36	33	30 - 35	33 - 36	31 - 36
	-45	28	34	32	28 - 33	31 - 34	31 - 33
August	-03	17	43	31	17 - 26	27 - 43	22 - 36
	-15	23	42	32	23 - 35	28 - 42	27 - 38
	-30	27	35	31	27 - 34	29 - 35	28 - 34
	-45	28	37	31	28 - 33	29 - 37	28 - 34
September	-03	11	39	26	11 - 24	25 - 39	19 - 32
	-15	19	35	26	19 - 28	26 - 35	22 - 31
	-30	23	31	26	23 - 29	24 - 31	23 - 30
	-45	24	30	27	24 - 29	25 - 30	24 - 29
October	-03	3	33	16	3 - 20	13 - 33	9 - 25
	-15	8	28	17	8 - 24	13 - 28	10 - 25
	-30	12	26	19	12 - 24	14 - 26	13 - 25
	-45	15	26	20	15 - 25	17 - 26	16 - 25
November	-03	3	22	9	3 - 9	8 - 22	6 - 14
	-15	5	17	10	5 - 12	8 - 17	7 - 14
	-30	6	15	11	6 - 14	9 - 15	8 - 15
	-45	9	18	13	9 - 16	11 - 18	10 - 16

Table 22. Soil temperature data (C) at Rock Valley station no. IV under shrub during 1972

Month	Cm. Depth	Minimum	Maximum	Hourly Mean	Range of Daily Minima	Range of Daily Maxima	Range of Daily Means
January	-03	-2	13	4	-2 - 4	3 - 13	0 - 7
	-15	3	8	5	3 - 7	3 - 8	3 - 7
	-30	3	8	6	3 - 7	5 - 8	4 - 8
	-45	4	15	7	4 - 8	6 - 15	5 - 9
February	-03	-1	25	8	-1 - 8	6 - 25	1 - 15
	-15	3	15	9	3 - 13	5 - 15	4 - 14
	-30	5	14	9	5 - 13	6 - 14	5 - 13
	-45	6	13	9	6 - 13	6 - 13	6 - 13
March	-03	3	34	15	3 - 12	14 - 34	8 - 19
	-15	11	19	15	11 - 17	13 - 19	11 - 18
	-30	11	18	15	11 - 17	13 - 18	12 - 17
	-45	12	17	15	12 - 17	13 - 17	12 - 17
April	-03	3	39	17	3 - 16	13 - 39	7 - 23
	-15	12	23	17	12 - 19	15 - 23	14 - 20
	-30	13	20	17	13 - 19	15 - 20	14 - 20
	-45	13	20	16	13 - 18	14 - 20	13 - 19
May	-03	11	41	25	11 - 23	24 - 41	19 - 31
	-15	18	29	23	18 - 26	21 - 29	20 - 28
	-30	18	26	22	18 - 24	20 - 26	19 - 25
	-45	18	27	21	18 - 23	19 - 27	19 - 23
June	-03	14	43	29	14 - 27	28 - 43	21 - 35
	-15	23	35	28	23 - 30	26 - 35	24 - 32
	-30	23	31	27	23 - 28	25 - 31	24 - 29
	-45	24	28	26	24 - 28	24 - 28	24 - 28
July	-03	19	43	34	19 - 29	39 - 43	30 - 37
	-15	29	38	33	29 - 35	33 - 38	31 - 36
	-30	29	34	31	29 - 33	31 - 34	30 - 33
	-45	28	32	30	28 - 32	29 - 32	29 - 32
August	-03	11	43	29	11 - 26	23 - 43	21 - 35
	-15	21	37	30	21 - 33	27 - 37	24 - 35
	-30	26	33	30	26 - 33	27 - 33	26 - 33
	-45	27	32	30	27 - 32	27 - 32	27 - 32
September	-03	11	35	24	11 - 22	22 - 35	18 - 29
	-15	18	30	25	18 - 27	23 - 30	21 - 28
	-30	18	28	25	18 - 27	23 - 28	22 - 28
	-45	24	29	26	24 - 28	24 - 29	24 - 28
October	-03	3	30	14	3 - 18	10 - 30	7 - 23
	-15	8	25	16	8 - 23	11 - 25	10 - 24
	-30	11	24	18	11 - 23	13 - 24	12 - 23
	-45	15	25	20	15 - 24	16 - 25	15 - 24
November	-03	3	17	7	3 - 8	6 - 17	4 - 11
	-15	6	14	9	6 - 12	7 - 14	6 - 13
	-30	7	14	10	7 - 13	8 - 14	8 - 13
	-45	9	15	12	9 - 15	10 - 15	10 - 15

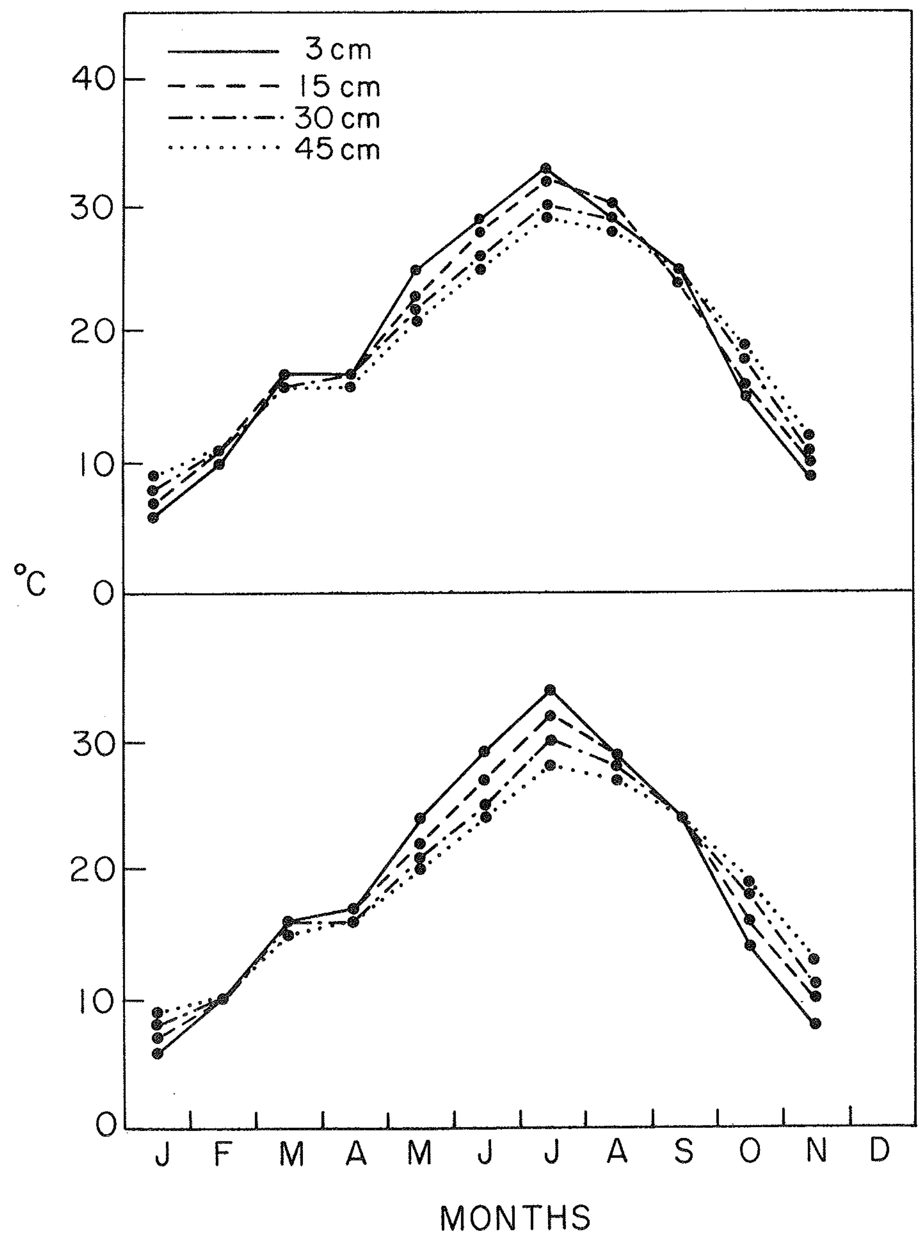

Figure 16. Monthly mean soil temperatures in the open (above) and beneath shrubs at station I during 1972.

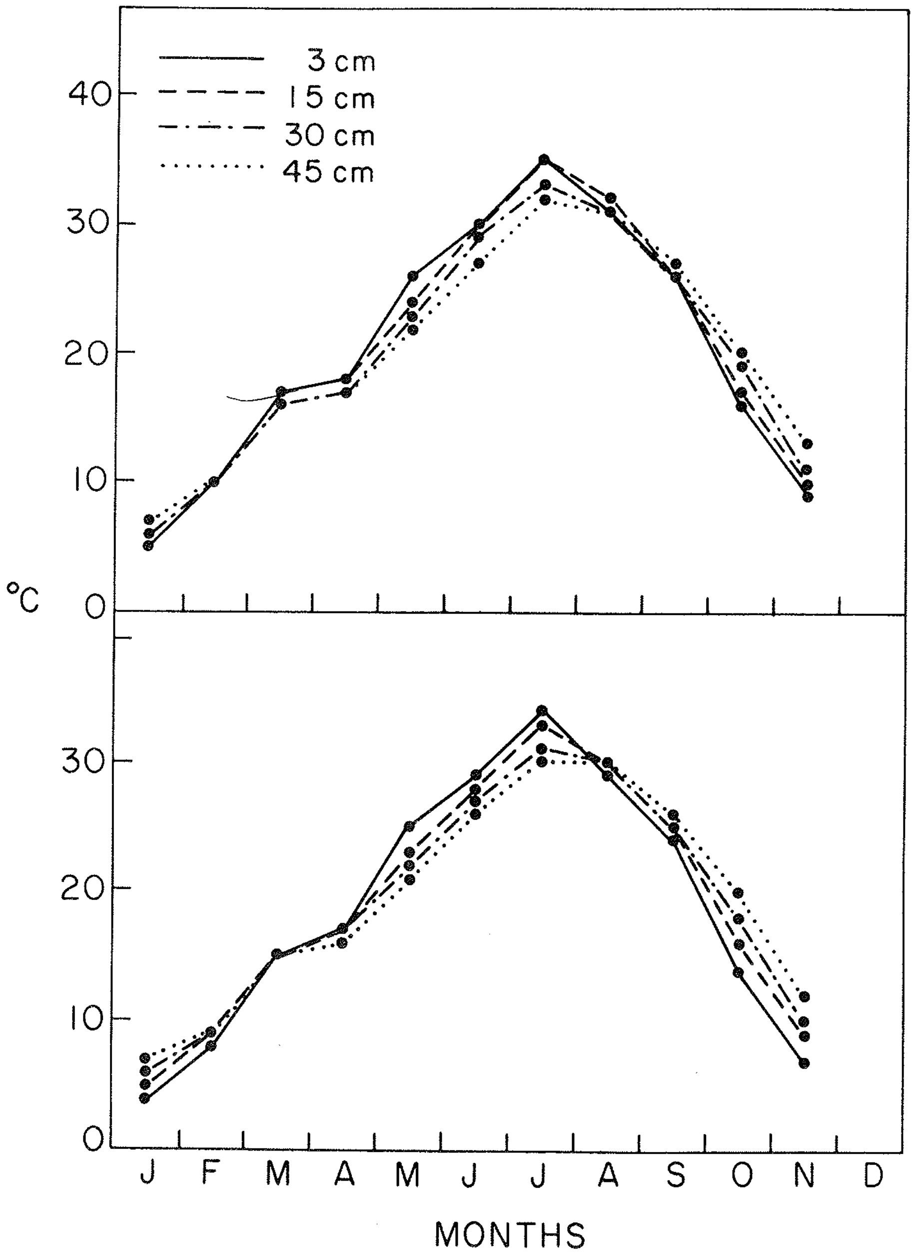

Figure 17. Monthly mean soil temperatures in the open (above) and beneath shrubs at station IV during 1972.

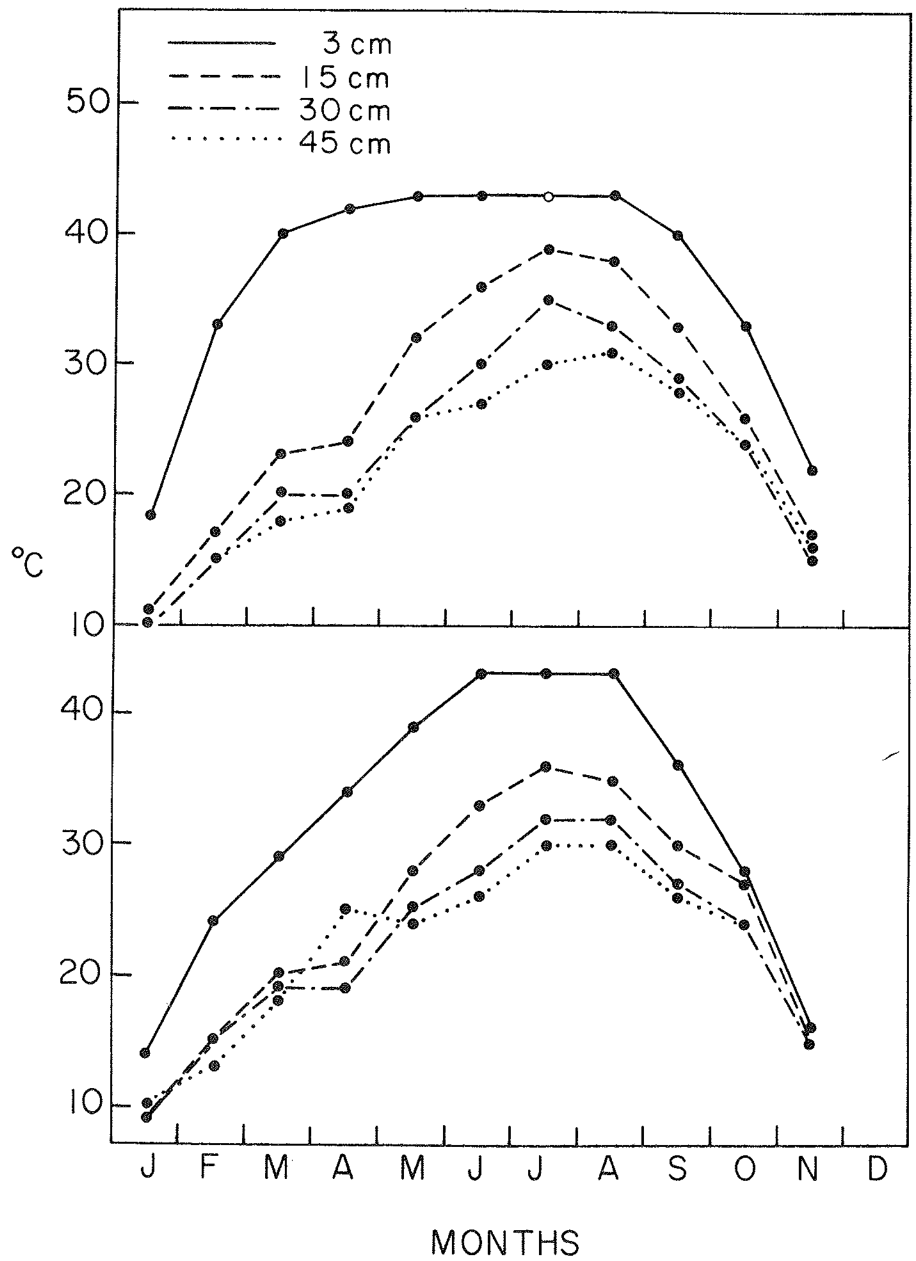

Figure 18. Monthly maximal soil temperatures in the open (above) and beneath shrubs at station I during 1972.

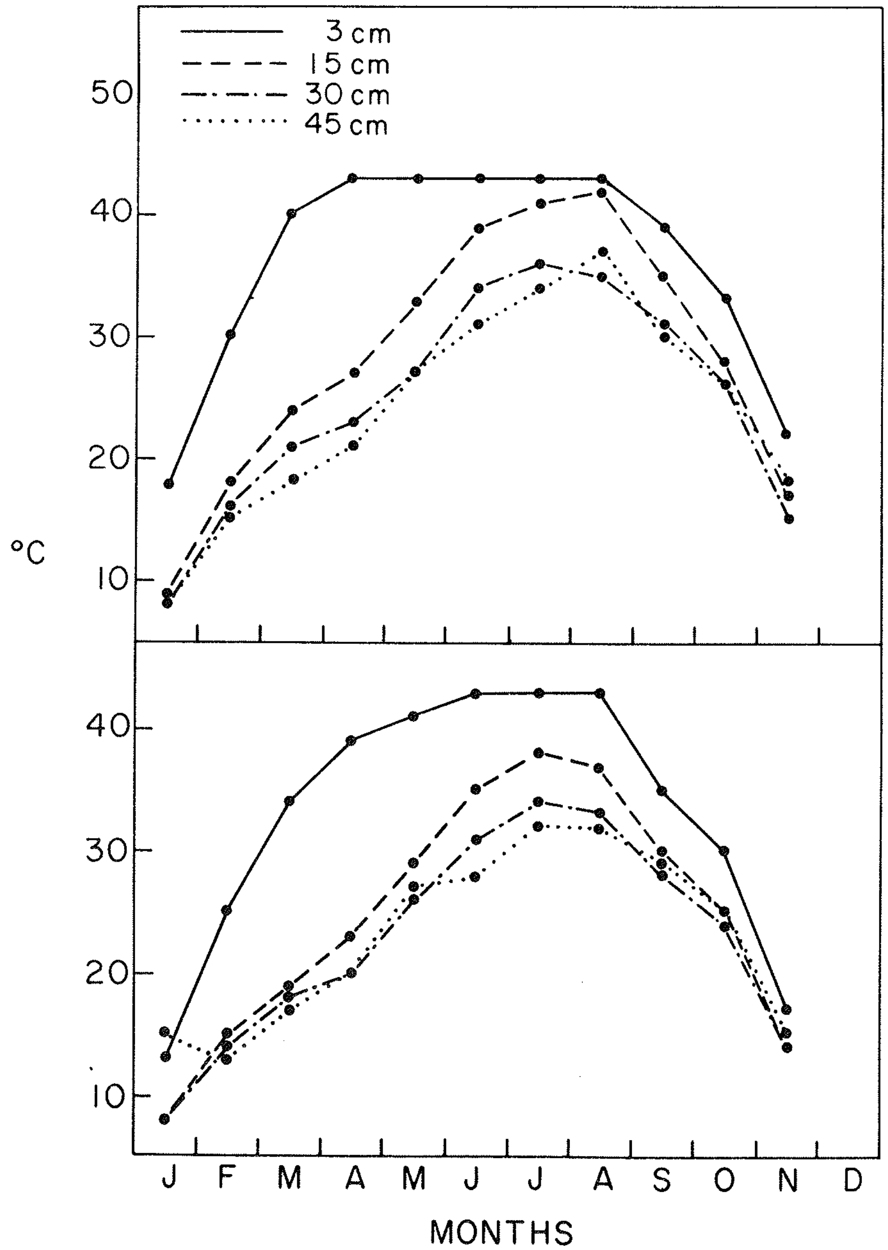

Figure 19. Monthly maximal soil temperatures in the open (above) and beneath shrubs at station IV during 1972.

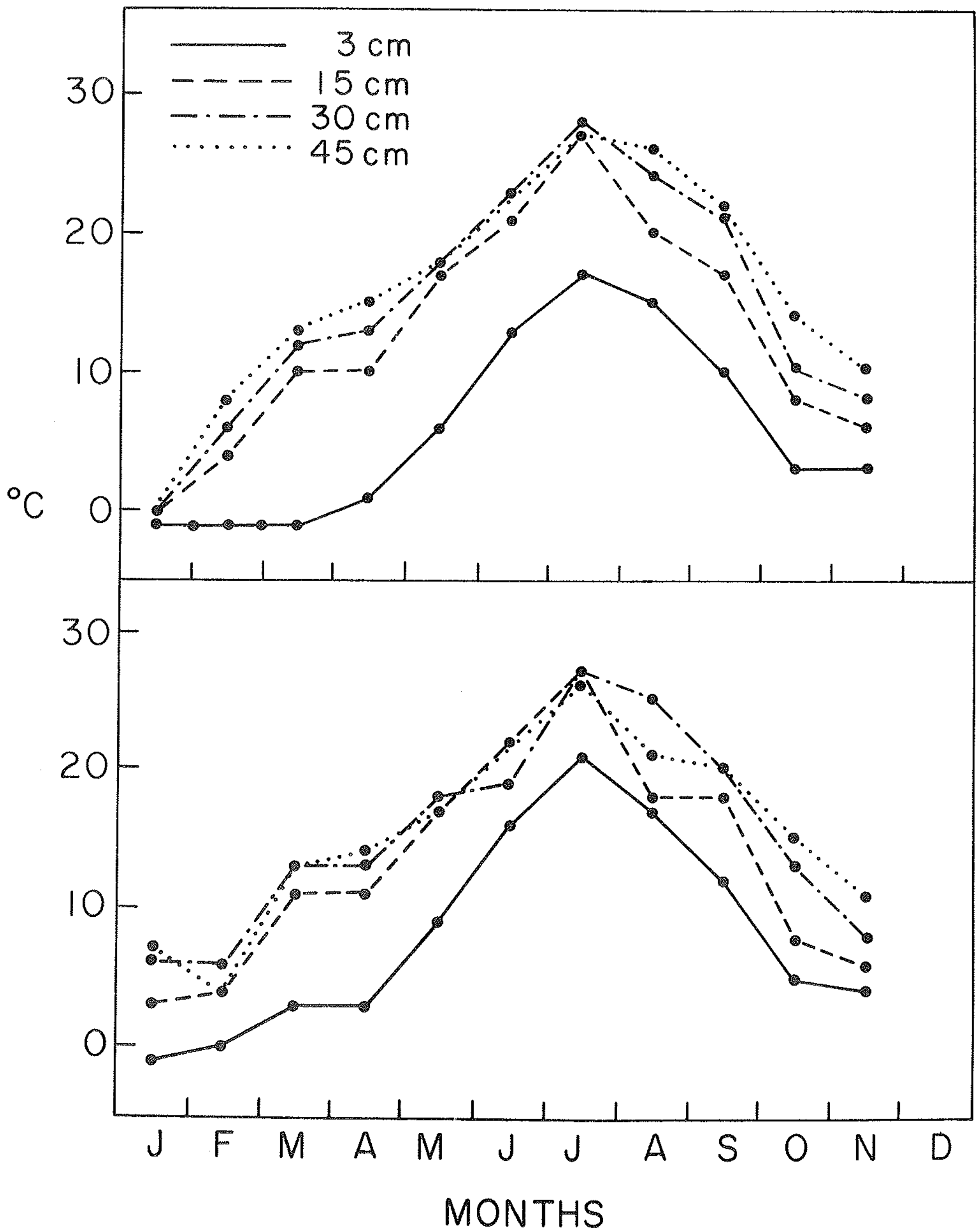

Figure 20. Monthly minimal soil temperatures in the open (above) and beneath shrubs at station I during 1972.

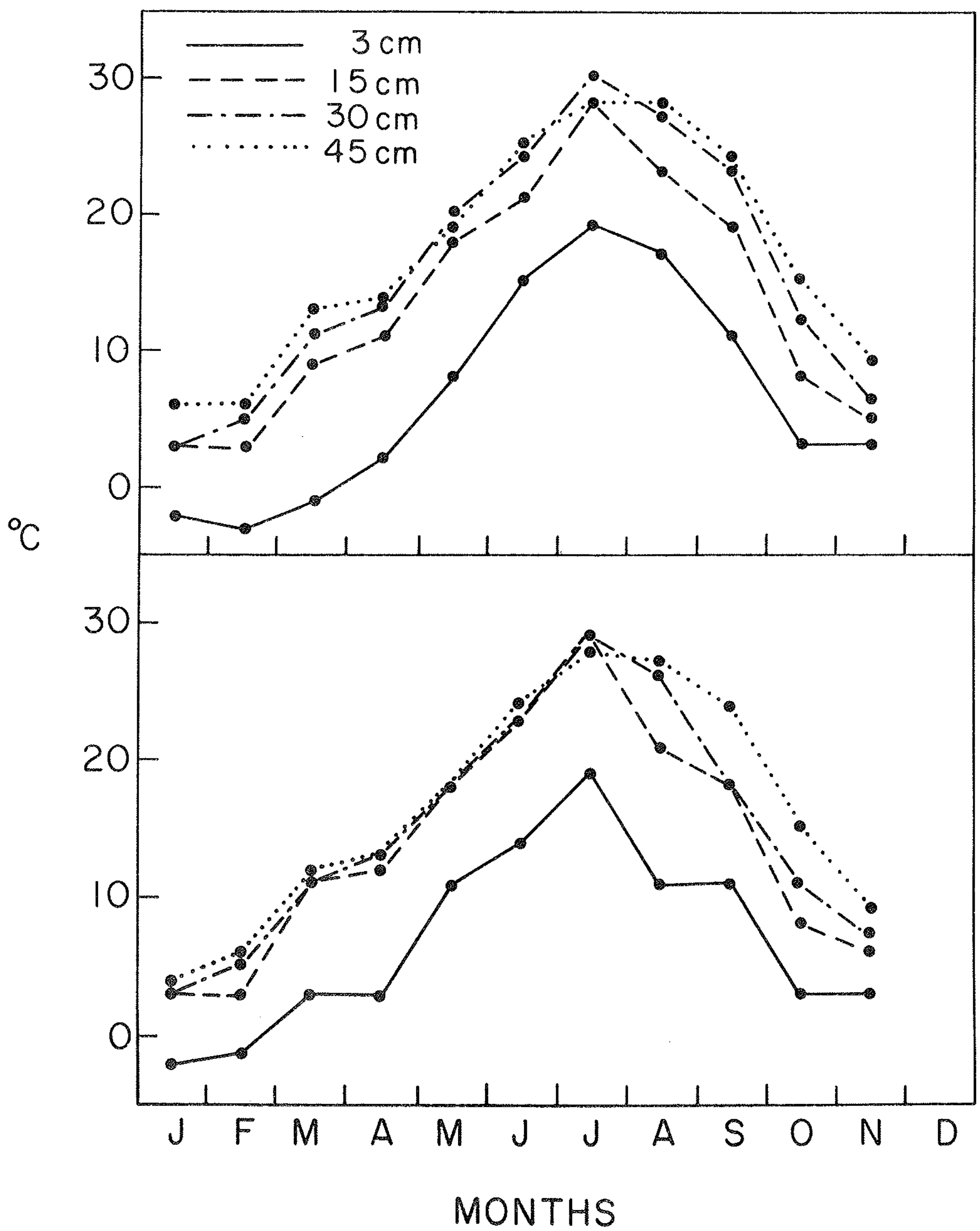

Figure 21. Monthly minimal soil temperatures in the open (above) and beneath shrubs at station IV during 1972.

Table 23. Daily average soil temperatures (C) at four depths in two situations at station I during 1972
(daily averages were based on four readings at 6-hr intervals)

Date		3 cm		15 cm		30 cm		45 cm	
		open	shrub	open	shrub	open	shrub	open	shrub
Jan	1	4	4	4	4	6	6	8	8
	10	7	7	7	7	7	7	8	8
	20	8	7	9	9	9	9	9	10
Feb	1	6	4	6	6	7	7	8	9
	10	7	8	9	9	10	10	10	10
	20	12	11	13	12	13	12	13	12
Mar	1	12	11	14	13	14	14	14	14
	10	19	19	18	18	17	16	16	15
	20	20	19	19	18	18	18	18	18
Apr	1	18	16	15	15	15	14	15	14
	10	14	15	17	14	17	17	17	16
	20	16	15	15	15	15	15	15	15
May	1	21	22	20	19	18	18	18	17
	10	23	20	21	20	20	19	21	20
	20	18	17	19	20	21	20	21	20
Jun	1	31	29	29	27	26	25	24	23
	10	25	25	25	24	24	23	23	22
	20	30	31	29	28	27	26	25	25
Jul	1	34	35	31	31	29	27	27	26
	10	33	33	32	31	30	29	28	28
	20	30	30	31	32	31	30	30	22
Aug	1	34	34	34	33	31	31	30	29
	10	35	36	34	34	32	31	30	29
	20	28	27	28	27	28	27	28	26
Sep	1	30	27	29	27	28	26	27	26
	10	26	27	26	26	26	26	26	25
	20	18	19	22	21	22	22	23	24
Oct	1	24	23	24	23	24	23	24	23
	10	16	15	18	17	20	19	17	21
	20	11	10	13	13	15	16	18	18
Nov	1	12	10	12	11	12	13	14	15
	10	9	9	11	11	12	13	11	15
	20	6	5	6	7	9	10	11	11

Table 24. Daily average soil temperatures (C) at four depths in two situations at station IV during 1972 (daily averages were based on four readings at 6-hr intervals)

Date		3 cm		15 cm		30 cm		45 cm	
		open	shrub	open	shrub	open	shrub	open	shrub
Jan	1	3	3	3	3	5	5	6	7
	10	6	4	6	5	6	5	7	6
	20	6	6	7	7	8	8	8	8
Feb	1	3	3	4	5	6	6	7	7
	10	7	6	9	8	10	8	10	9
	20	11	10	13	11	13	11	12	11
Mar	1	12	10	14	13	14	10	14	13
	10	20	19	19	17	18	16	17	15
	20	18	16	20	18	19	18	18	17
Apr	1	17	15	15	14	14	14	14	14
	10	15	16	18	18	18	18	18	17
	20	17	16	16	16	16	15	16	16
May	1	22	22	23	20	21	19	20	19
	10	25	22	22	21	21	20	22	20
	20	19	15	21	16	22	22	22	22
Jun	1	31	30	28	28	27	26	25	22
	10	27	24	27	25	26	24	25	24
	20	28	28	30	29	31	28	29	27
Jul	1	35	35	36	33	34	30	31	29
	10	34	34	34	33	32	31	31	30
	20	30	30	34	33	34	32	33	32
Aug	1	36	35	36	34	34	32	32	31
	10	36	35	38	35	34	33	33	32
	20	30	25	30	28	31	28	31	28
Sep	1	32	29	31	28	30	28	29	28
	10	28	25	28	26	28	27	28	27
	20	23	20	24	22	25	23	26	25
Oct	1	25	23	25	24	25	24	25	24
	10	17	15	19	18	22	20	23	22
	20	11	11	13	13	16	16	19	18
Nov	1	12	9	12	11	13	12	15	14
	10	9	9	11	11	13	12	14	14
	20	7	5	7	7	9	8	11	11

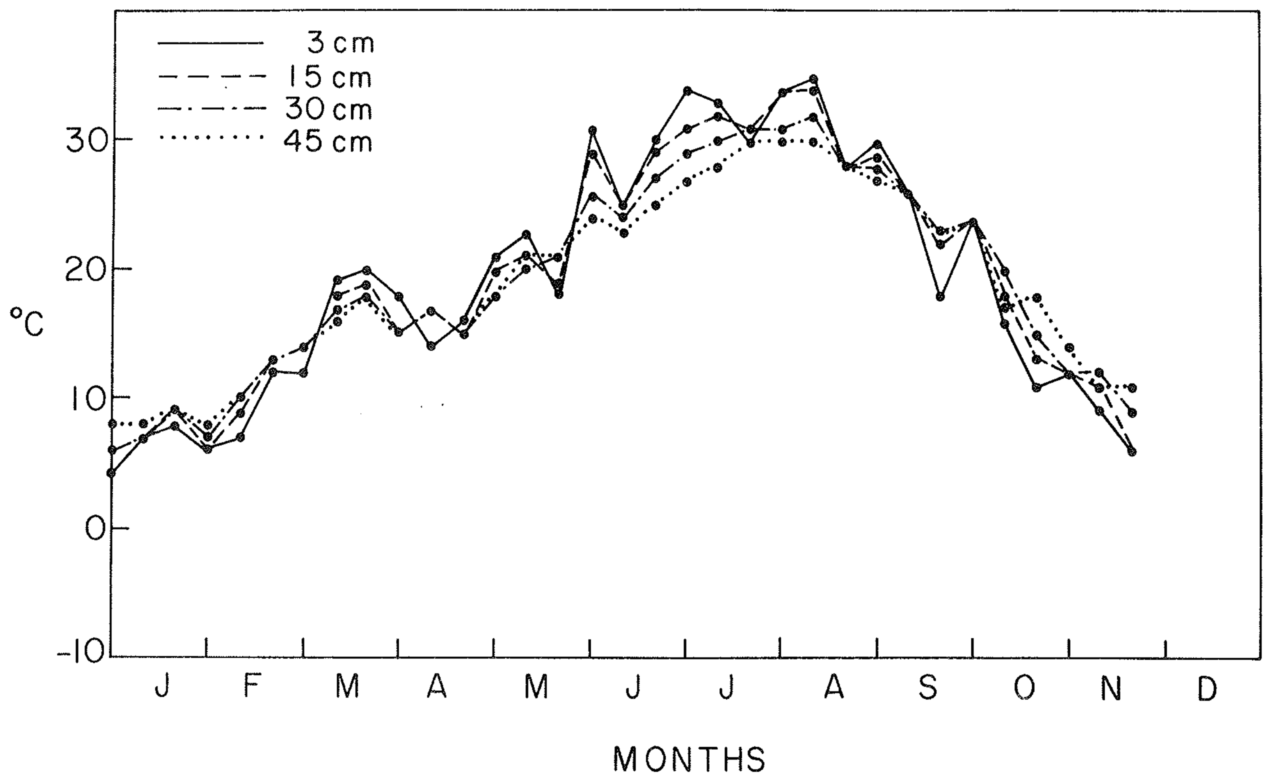

Figure 22. Mean soil temperatures for three days of each month in the open at station I during 1972.

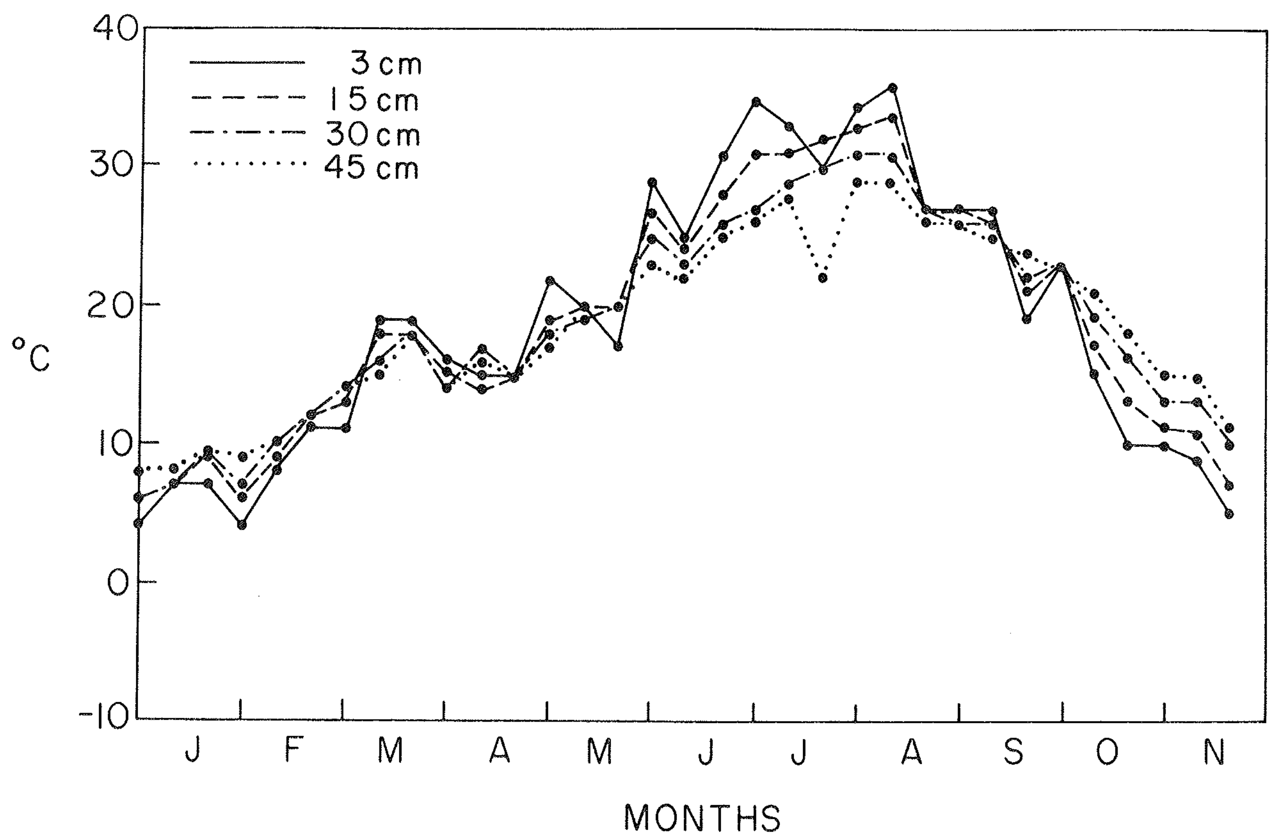

Figure 23. Mean soil temperatures for three days of each month beneath shrubs at station I during 1972.

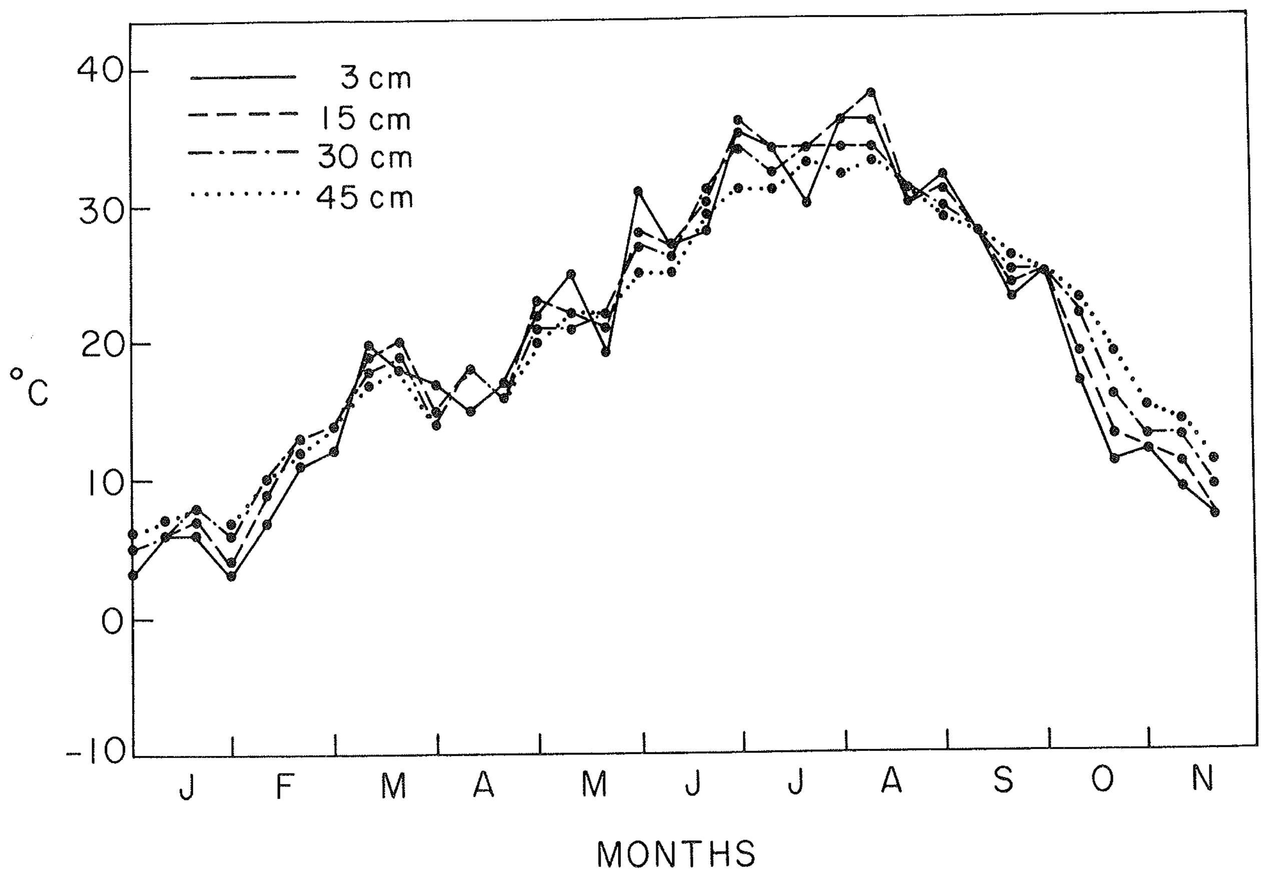

Figure 24. Mean soil temperatures for three days of each month in the open at station IV during 1972.

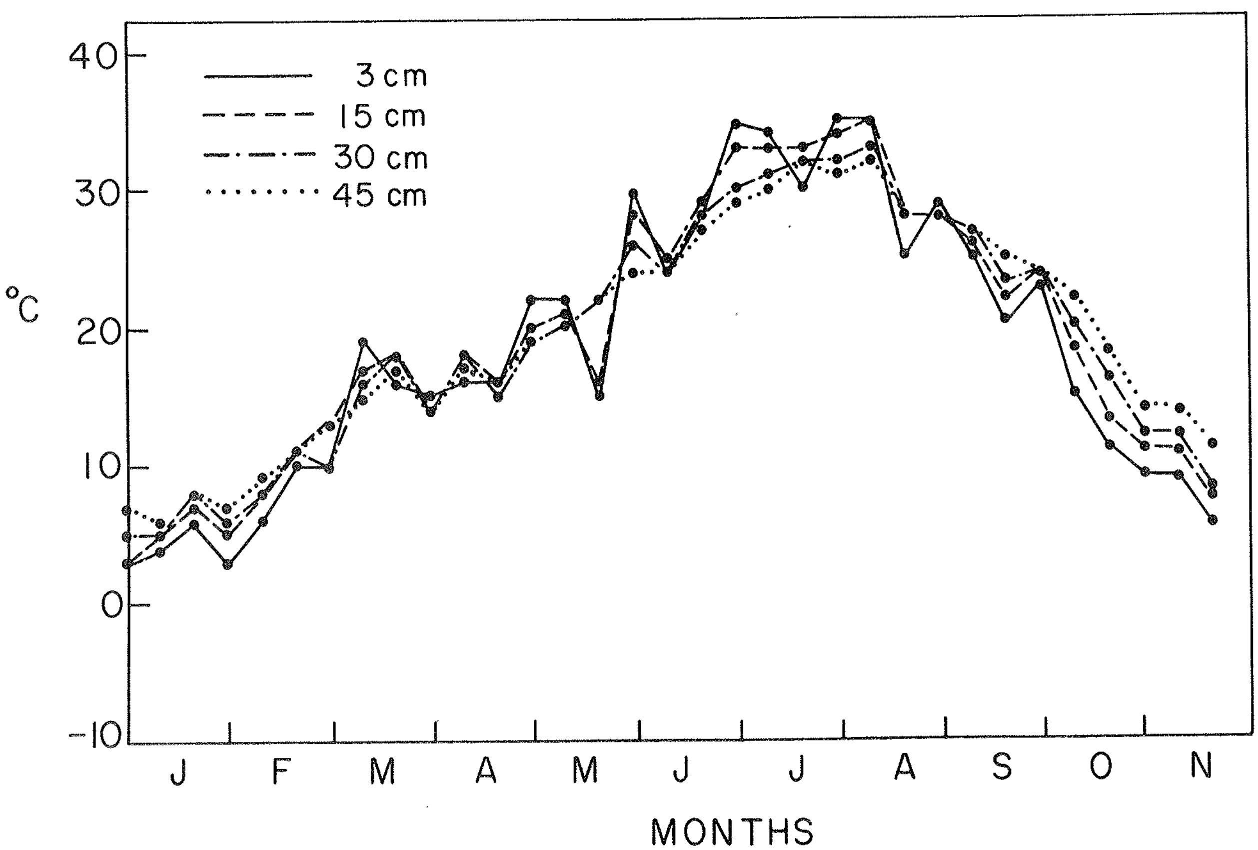

Figure 25. Mean soil temperatures for three days of each month beneath shrubs at station IV during 1972.

Table 25. Soil temperatures (C) recorded at station I in the open and beneath shrubs at four times of the day for three days (quarterly)

Month	Situation	10th				11th				12th			
		0600	1200	1800	2400	0600	1200	1800	2400	0600	1200	1800	2400
Jan	3 cm, open	02	17	07	03	03	17	06	03	03	15	07	04
	3 cm, shrub	03	12	08	06	05	11	06	03	03	13	09	04
	15 cm, open	06	06	08	07	06	06	09	07	06	06	09	08
	15 cm, shrub	06	06	08	07	06	07	08	02	07	07	08	08
	30 cm, open	07	06	07	08	08	07	08	08	08	07	08	08
	30 cm, shrub	08	06	08	08	08	08	08	08	08	08	08	08
	45 cm, open	08	08	08	08	08	08	08	09	08	08	08	08
	45 cm, shrub	08	08	08	08	08	08	08	08	09	08	08	09
Apr	3 cm, open	15	17	15	11	11	13	13	08	07	33	14	08
	3 cm, shrub	16	17	15	13	13	13	13	08	12	21	14	09
	15 cm, open	18	17	17	16	15	15	16	15	13	15	18	17
	15 cm, shrub	18	17	17	17	16	15	16	15	15	15	17	17
	30 cm, open	18	17	17	17	17	17	16	17	16	15	16	17
	30 cm, shrub	17	17	17	17	17	17	17	17	17	15	16	17
	45 cm, open	17	17	17	17	17	17	17	17	17	16	15	17
	45 cm, shrub	17	17	17	17	17	17	17	17	17	16	16	17
Jul	3 cm, open	20	43	43	28	19	43	43	25	20	43	43	26
	3 cm, shrub	24	40	41	30	23	41	41	27	24	42	42	28
	15 cm, open	30	30	35	33	30	30	35	33	29	30	35	35
	15 cm, shrub	31	30	33	33	31	30	33	33	30	30	33	33
	30 cm, open	30	29	29	31	31	29	29	31	30	28	29	31
	30 cm, shrub	30	29	29	30	30	29	29	30	30	28	28	30
	45 cm, open	29	28	28	28	29	28	28	29	29	28	27	28
	45 cm, shrub	28	27	27	28	28	28	28	28	28	27	27	28
Oct	3 cm, open	12	23	21	11	08	25	22	15	14	17	15	12
	3 cm, shrub	14	19	18	10	08	20	17	13	13	17	15	12
	15 cm, open	17	17	21	17	15	16	22	19	17	17	18	16
	15 cm, shrub	18	17	18	17	15	15	18	17	17	17	17	17
	30 cm, open	20	18	20	21	20	18	19	20	20	19	20	19
	30 cm, shrub	20	20	18	20	19	18	18	19	19	18	18	18
	45 cm, open	21	20	23	22	22	21	21	21	21	21	21	21
	45 cm, shrub	21	20	21	21	21	21	20	20	21	20	20	20

Table 26. Soil temperatures (C) recorded at station IV in the open and beneath shrubs at four times of the day for three days (quarterly)

Month	Situation	10th 0600	10th 1200	10th 1800	10th 2400	11th 0600	11th 1200	11th 1800	11th 2400	12th 0600	12th 1200	12th 1800	12th 2400
Jan	3 cm, open	02	16	06	03	03	13	04	02	01	03	14	07
	3 cm, shrub	02	06	03	03	02	10	03	02	01	03	11	07
	15 cm, open	05	05	07	06	06	04	05	06	04	04	05	07
	15 cm, shrub	05	04	06	05	05	03	06	05	03	04	04	06
	30 cm, open	06	06	06	06	06	04	06	06	06	06	05	06
	30 cm, shrub	06	05	05	06	06	03	06	06	06	05	05	05
	45 cm, open	07	06	07	07	07	06	06	07	07	07	06	06
	45 cm, shrub	06	06	06	06	06	04	06	06	06	06	06	06
Apr	3 cm, open	15	17	15	12	12	13	13	08	08	33	15	08
	3 cm, shrub	17	17	16	14	14	14	14	11	13	21	15	10
	15 cm, open	18	18	18	17	16	15	17	15	14	16	19	17
	15 cm, shrub	18	18	18	17	17	16	17	16	15	16	17	17
	30 cm, open	18	18	18	18	17	17	17	17	17	15	17	18
	30 cm, shrub	18	18	18	18	17	17	17	17	17	16	17	18
	45 cm, open	17	18	18	18	18	18	18	17	17	17	16	17
	45 cm, shrub	17	17	17	17	17	17	17	17	17	17	17	17
Jul	3 cm, open	23	43	43	28	22	43	43	26	23	43	43	28
	3 cm, shrub	23	42	43	30	22	43	43	25	23	43	43	27
	15 cm, open	32	33	38	33	32	33	38	35	31	33	39	36
	15 cm, shrub	32	31	35	33	32	31	35	34	31	31	36	35
	30 cm, open	34	32	33	31	34	32	33	34	33	32	33	35
	30 cm, shrub	32	30	31	30	32	30	31	32	32	30	31	32
	45 cm, open	32	31	31	28	32	31	31	32	32	31	31	32
	45 cm, shrub	31	30	30	28	31	30	30	31	31	30	30	31
Oct	3 cm, open	13	21	21	11	09	26	23	15	15	18	16	13
	3 cm, shrub	13	18	18	11	09	21	18	14	13	18	15	13
	15 cm, open	19	18	21	18	15	17	23	20	18	18	18	17
	15 cm, shrub	19	17	18	18	16	16	19	18	17	17	18	17
	30 cm, open	23	21	21	22	21	19	20	21	21	20	20	20
	30 cm, shrub	21	20	18	20	20	18	19	20	20	19	19	19
	45 cm, open	23	23	23	23	23	21	21	21	22	21	22	21
	45 cm, shrub	22	22	22	22	22	21	21	21	21	21	21	21

A.7. SOIL MOISTURE

Soil moisture tension was measured at four stations (I - IV) on the validation site at weekly intervals during 1972 (A3UTJ12). Data were taken from Wescor soil moisture psychrometers (PT51-10) buried at 15 and 30 cm in open areas and beneath shrubs. The readings from the psychrometers reflected both soil moisture (M, microvolts) and soil temperature conditions (T, millivolts), and were converted to negative bars moisture tension at 25 C by the following equation:

$$-Bars_{25°} = \frac{2.128M}{(0.325 + 0.68T)}$$

Moisture tension (-bars) values were converted to water content (percent by weight) on the basis of experiments with two validation site soil types conducted during 1971 (A3UTJ09). When soils were saturated the value of M was zero and under these conditions the soil moisture tension was arbitrarily taken as -0.1 bars. For the soil type generally representative of stations I and II, the transformation from bars (B) to water content, W (% by weight), was according to the following function:

$$W = 9.438 - 4.228 (\log B) + 0.262 (\log B)^2$$

with B the absolute bar values. The saturation level of this soil type was set at 11.5%, and moisture contents greater than this could not be measured. For the soil type representative of stations III and IV, the transformation from bars to water content was:

$$W = 11.249 - 2.933 (\log B) - 0.939 (\log B)^2$$

The saturation level of this soil type was set at 12.0%. In general, measurement of soil moisture becomes difficult under very wet or very dry conditions.

Weekly soil moisture tension values are given in Table 27, and corresponding estimates of water content are given in Table 28. Figures 26 - 29 illustrate seasonal changes in moisture tension at four stations. Soils were generally saturated or near saturation at the beginning of 1972, although moisture levels were somewhat lower beneath shrubs than in the open. Soils generally dried steadily through February and March and by late April exhibited water contents of around 4-5%. These low levels generally persisted until October. Rainfall during April (ca. 2 mm) and June (ca. 14 mm) had no detectable influence on moisture contents measured at 15 and 30 cm. Over 20 mm of rain fell in August and there was some increase in soil moisture at 15 cm in open areas at station I and III at this time. The rains of September, October and November finally saturated the soils at 15 and 30 cm in the open, but beneath shrubs moisture levels rarely reached saturation. There was no rainfall in December and soils began to dry again towards the end of the year. The apparent rise in soil moisture registered at station I on May 9th was probably due to instrument error, for no rain fell at this time. The heavier soil at station IV is somewhat less

wettable than those at the other stations. Over the last 17 weeks of the year the mean moisture contents at the four stations were as follows: 7.98% at one, 7.18% at two, 7.82% at three, and 6.95% at four.

Table 27. Soil moisture tension (-bars) measured in Rock Valley during 1972

Date		Station I				Station II				Station III				Station IV			
		15 cm		30 cm		15 cm		30 cm		15 cm		30 cm		15 cm		30 cm	
		Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub
January	11	0.1	0.1	2.6	0.1	0.1	5.7	0.1	2.6	1.2	3.6	1.1	3.7	0.1	2.6	0.1	1.1
January	18	0.1	0.1	0.1	0.1	0.1	4.9	0.1	1.7	0.8	1.7	2.2	3.0	0.1	0.1	3.1	0.9
January	25	0.1	0.1	0.1	0.1	0.1	5.1	2.4	16.8	3.6	2.2	2.4	3.3	4.7	1.7	4.8	0.1
February	1	0.1	0.1	0.1	0.1	1.0	5.6	1.0	17.7	3.3	0.1	5.1	4.3	3.3	2.0	6.0	0.1
February	8	0.9	0.1	0.1	0.1	1.8	5.1	3.0	17.4	8.4	3.2	4.4	3.5	7.8	1.8	8.6	0.1
February	15	0.8	0.1	0.1	0.1	3.3	4.0	3.4	18.4	8.0	4.0	5.7	3.8	6.2	1.5	8.1	1.9
February	22	5.8	3.9	4.0	2.3	3.6	4.2	2.2	15.5	8.4	1.8	4.6	4.2	7.0	3.3	8.9	3.2
February	29	2.7	6.2	2.7	2.4	3.6	5.1	2.6	16.9	10.8	3.7	6.3	4.8	8.9	5.1	10.8	3.8
March	8	3.0	3.6	3.6	3.9	3.9	5.4	3.5	14.7	10.6	8.5	8.3	8.1	8.9	9.4	10.8	10.1
March	14	3.6	5.7	4.4	7.0	3.6	5.6	4.5	16.9	10.8	11.4	10.8	4.6	13.3	16.4	15.2	17.7
March	21	8.8	5.0	5.4	9.2	8.3	8.6	5.4	17.3	14.2	11.9	9.0	9.9	18.1	15.2	17.6	12.4
March	28	10.0	6.9	7.1	11.6	6.6	11.4	6.6	20.3	19.7	15.2	10.1	12.1	23.0	25.1	19.6	19.7
April	4	14.8	8.3	13.3	14.5	10.3	12.9	8.3	21.6	19.2	19.9	10.8	17.5	26.6	29.5	23.3	20.6
April	12	16.1	12.0	18.6	14.6	12.0	15.7	9.9	20.8	23.0	21.0	13.5	17.8	33.3	39.8	28.4	24.8
April	18	19.1	14.3	22.8	19.9	11.5	21.5	5.7	24.9	25.5	24.4	15.0	22.0	35.7	48.6	32.1	30.3
April	26	28.9	22.0	29.5	28.5	13.4	30.3	13.4	27.4	29.7	31.3	16.9	25.1	37.8	50.7	36.2	33.1
May	3	41.0	23.4	34.2	24.3	17.4	38.6	16.6	32.5	35.8	47.3	18.9	30.2	43.2	54.8	37.6	36.4
May	9	22.4	46.4	23.8	37.5	28.1	33.7	38.0	36.3	51.4	69.1	22.1	35.8	41.5	46.1	43.5	41.9
May	16	43.5	53.7	43.0	44.3	36.0	45.1	27.8	42.6	41.5	51.2	43.6	38.2	36.2	41.0	44.6	43.1
May	23	42.6	47.1	45.6	46.4	36.1	36.2	34.3	45.3	38.7	51.9	29.0	43.8	35.2	43.4	45.6	48.6
May	30	39.8	46.6	49.6	48.7	44.3	33.6	37.3	45.1	36.6	47.4	29.8	44.9	34.8	41.0	47.4	48.5
June	6	41.7	48.3	54.1	49.9	40.0	35.2	44.4	47.4	37.6	49.6	36.2	52.2	36.9	40.0	52.8	51.6
June	13	42.6	48.9	54.1	51.6	36.2	48.8	44.0	56.3	36.2	48.8	44.0	56.3	36.0	40.0	52.8	51.9
June	20	42.7	48.3	53.4	43.1	27.7	32.0	47.2	49.4	40.7	47.5	50.5	53.7	36.1	39.7	50.8	52.8
June	27	42.1	48.5	55.9	39.2	27.9	31.3	46.2	51.9	40.8	47.5	52.8	54.3	38.6	41.1	50.5	49.3
July	5	42.0	47.0	52.8	35.8	50.0	34.2	49.5	51.0	38.3	46.2	50.0	48.8	35.2	38.6	47.9	49.5
July	11	40.7	47.5	39.8	35.2	40.2	32.0	49.2	52.8	38.4	44.7	49.5	46.7	34.2	39.1	47.5	46.3
July	18	38.6	43.7	32.5	33.6	36.5	30.1	47.5	48.3	36.0	43.1	47.5	45.3	35.7	39.7	45.2	42.4
July	25	40.3	49.3	38.1	36.3	42.7	38.3	50.0	40.7	38.0	45.0	50.0	44.5	32.5	38.3	48.7	37.5
August	1	33.3	48.3	33.5	32.5	37.2	45.2	46.3	46.3	37.0	42.7	44.7	45.4	46.1	37.2	44.7	30.7
August	8	36.2	42.1	34.9	33.4	40.6	43.8	42.7	36.3	34.0	45.1	45.4	45.0	39.3	39.5	43.6	34.5
August	15	3.5	37.3	33.7	29.7	7.8	30.8	39.7	40.3	5.0	38.3	35.4	38.2	35.4	35.1	36.1	35.6
August	22	3.8	45.1	32.8	30.7	10.8	30.7	35.7	34.8	13.9	46.1	42.3	42.6	29.9	51.6	37.3	33.6
August	29	8.4	45.4	32.2	24.6	14.2	33.3	40.5	34.7	19.9	48.6	45.6	44.0	35.4	50.9	42.4	34.7
September	5	13.8	50.0	51.6	31.7	23.8	28.0	42.9	32.1	23.8	44.0	42.1	36.2	33.4	50.5	41.4	29.9
September	12	16.1	45.9	57.0	30.7	28.6	37.2	51.9	37.0	29.0	52.2	51.9	48.8	34.7	40.8	44.6	35.7
September	19	28.3	44.5	54.5	36.7	38.6	40.1	53.7	38.1	39.2	45.6	51.9	46.3	37.0	41.3	47.1	36.7

Continued

Table 27.(cont.) Soil moisture tension (-bars) measured in Rock Valley during 1972

	Station I				Station II				Station III				Station IV			
	15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.	
Date	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub
September 26	23.0	45.4	55.4	32.0	34.3	36.5	50.8	37.0	34.9	44.8	51.1	44.8	35.3	41.3	46.6	34.9
October 3	24.0	45.3	51.1	30.7	42.0	38.9	54.1	34.1	39.9	41.9	51.1	42.2	32.0	40.9	46.1	38.1
October 10	26.7	37.3	53.9	31.8	4.7	41.1	55.4	41.3	10.8	15.2	55.4	49.0	36.1	45.5	46.4	37.7
October 18	7.3	33.8	42.0	34.5	7.1	46.6	50.3	43.6	14.5	23.5	55.0	49.5	36.9	55.3	47.8	42.5
October 24	5.5	13.8	14.5	34.2	5.6	45.7	6.0	47.3	2.8	5.5	52.2	53.2	48.6	51.8	50.4	40.6
October 31	10.2	13.6	5.3	46.7	5.1	56.3	7.1	52.8	6.7	7.4	58.6	56.7	33.4	20.5	56.7	49.0
November 9	0.1	2.9	4.2	33.7	6.2	51.1	10.9	49.0	13.5	13.9	46.6	56.7	28.9	19.8	55.0	42.5
November 16	0.1	9.8	0.1	25.5	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
November 23	0.1	9.8	0.1	7.6	0.1	15.9	0.1	55.9	3.9	14.3	0.1	64.5	0.1	4.6	0.1	13.1
November 30	0.1	6.6	0.1	4.7	0.1	13.4	0.1	48.5	1.7	11.2	3.1	7.7	0.1	0.1	0.1	3.9
December 7	0.1	0.1	0.1	0.1	0.1	23.8	0.1	0.1	0.1	0.1	2.3	8.8	4.4	4.5	6.7	4.5
December 14	0.1	11.6	0.1	5.1	0.1	13.1	0.1	0.1	0.1	13.1	8.9	11.4	0.1	0.1	0.1	0.1
December 21	0.1	7.8	0.1	6.0	3.5	14.1	2.0	3.3	9.1	2.0	8.4	10.6	5.3	3.8	8.3	7.7
December 28	0.1	1.6	0.1	1.4	3.5	13.8	2.4	5.6	6.9	7.6	8.6	10.2	7.3	7.2	8.5	6.8

Table 28. Soil moisture contents (% water by weight) measured in Rock Valley during 1972

Date		Station I				Station II				Station III				Station IV			
		15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.	
		Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub
January	11	>11.5	>11.5	7.7	>11.5	>11.5	6.4	>11.5	7.7	11.0	9.3	11.1	9.3	>12.0	9.9	>12.0	11.1
January	18	>11.5	>11.5	>11.5	>11.5	>11.5	6.6	>11.5	8.5	11.5	10.5	10.1	9.7	>12.0	>12.0	9.6	11.4
January	25	>11.5	>11.5	>11.5	>11.5	>11.5	6.6	7.9	4.7	9.3	10.1	10.0	9.5	8.9	10.6	8.8	>12.0
February	1	>11.5	>11.5	>11.5	>11.5	9.5	6.4	9.4	4.6	9.5	>12.0	8.7	9.0	9.5	10.3	8.4	>12.0
February	8	9.6	>11.5	>11.5	>11.5	8.3	6.6	7.5	4.6	7.7	9.5	9.0	9.4	7.9	10.4	7.7	>12.0
February	15	9.7	>11.5	>11.5	>11.5	7.3	7.0	7.3	4.5	7.8	9.1	8.5	9.2	8.3	10.7	7.8	10.3
February	22	6.4	7.0	7.0	7.9	7.1	6.9	8.0	4.8	7.7	10.4	8.9	9.0	8.1	9.5	7.6	9.5
February	29	7.7	6.2	7.7	7.8	7.2	6.6	7.7	4.6	7.2	9.3	8.3	8.8	7.6	8.7	7.2	9.2
March	8	7.5	7.2	7.2	7.0	7.0	6.5	7.2	4.9	7.2	7.7	7.8	7.8	7.6	7.5	7.2	7.4
March	14	7.2	6.4	6.8	6.1	7.2	6.4	6.8	4.6	7.2	7.1	7.2	8.9	6.8	6.3	6.5	6.1
March	21	5.7	6.6	6.5	5.6	5.8	5.7	6.5	4.6	6.6	7.0	7.6	7.4	6.1	6.5	6.1	6.9
March	28	5.5	6.1	6.0	5.2	6.1	5.3	6.2	4.4	5.9	6.5	7.4	7.0	5.5	5.3	5.9	5.9
April	4	4.8	5.8	5.0	4.9	5.4	5.1	5.8	4.3	5.9	5.9	7.2	6.2	5.2	4.9	5.5	5.8
April	12	4.7	5.2	4.5	4.9	5.2	4.8	5.5	4.3	5.5	5.7	6.7	6.1	4.6	4.2	5.0	5.3
April	18	4.5	4.9	4.2	4.4	5.3	4.3	6.4	4.0	5.3	5.4	6.5	5.6	4.4	3.6	4.7	4.8
April	26	3.8	4.2	3.8	3.8	5.0	3.7	5.0	3.9	4.9	4.8	6.2	5.3	4.3	3.5	4.4	4.6
May	3	3.3	4.1	3.6	4.1	4.6	3.4	4.7	3.6	4.4	3.7	6.0	4.9	3.9	3.3	4.3	4.4
May	9	4.2	3.1	4.1	3.4	3.9	3.6	3.4	3.5	3.5	2.7	5.6	4.4	4.0	3.8	3.9	4.0
May	16	3.2	2.9	3.2	3.2	3.5	3.2	3.9	3.2	4.0	3.5	3.9	4.3	4.4	4.1	3.9	3.9
May	23	3.2	3.1	3.1	3.1	3.5	3.5	3.6	3.2	4.2	3.5	5.0	3.9	4.5	3.9	3.8	3.6
May	30	3.3	3.1	3.0	3.0	3.2	3.6	3.4	3.2	4.4	3.7	4.9	3.8	4.5	4.1	3.7	3.6
June	6	3.3	3.1	2.9	3.0	3.3	3.5	3.2	3.1	4.3	3.6	4.4	3.4	4.3	4.1	3.4	3.5
June	13	3.2	3.0	2.9	3.0	3.5	3.0	3.2	2.8	4.4	3.6	3.9	3.2	4.4	4.1	3.4	3.5
June	20	3.2	3.1	2.9	3.2	3.9	3.7	3.1	3.0	4.1	3.7	3.5	3.4	4.4	4.2	3.5	3.4
June	27	3.3	3.1	2.8	3.4	3.9	3.7	3.1	3.0	4.1	3.7	3.4	3.3	4.2	4.1	3.5	3.6
July	5	3.3	3.1	2.9	3.5	3.0	3.6	3.0	3.0	4.3	3.8	3.6	3.6	4.5	4.2	3.7	3.6
July	11	3.3	3.1	3.3	3.5	3.3	3.7	3.0	2.9	4.2	3.8	3.6	3.7	4.5	4.2	3.7	3.8
July	18	3.4	3.2	3.6	3.6	3.5	3.8	3.1	3.1	4.4	3.9	3.7	3.8	4.4	4.2	3.8	4.0
July	25	3.3	3.0	3.4	3.5	3.2	3.4	3.0	3.3	4.3	3.8	3.6	3.9	4.7	4.3	3.6	4.3
August	1	3.6	3.1	3.6	3.6	3.4	3.2	3.1	3.1	4.3	4.0	3.8	3.8	3.8	4.3	3.8	4.8
August	8	3.5	3.3	3.5	3.6	3.3	3.2	3.2	3.5	4.6	3.8	3.8	3.8	4.2	4.2	3.9	4.5
August	15	7.2	3.4	3.6	3.8	5.9	3.7	3.3	3.3	8.7	4.3	4.5	4.3	4.5	4.5	4.4	4.4
August	22	7.1	3.2	3.6	3.7	5.3	3.7	3.5	3.5	6.7	3.8	4.0	4.0	4.9	3.5	4.3	4.6
August	29	5.7	3.2	3.7	4.1	4.9	3.6	3.3	3.5	5.9	3.6	3.8	3.9	4.5	3.5	4.0	4.5
September	5	5.0	3.0	3.0	3.7	4.1	3.9	3.2	3.7	5.4	3.9	4.0	4.4	4.6	3.5	4.1	4.9

Continued

Table 28. Soil moisture contents (% water by weight) measured in Rock Valley during 1972

	Station I				Station II				Station III				Station IV			
	15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.		15 cm.		30 cm.	
Date	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub	Open	Shrub
September 12	4.7	3.1	2.8	3.7	3.8	3.4	3.0	3.5	4.9	3.4	3.5	3.6	4.5	4.1	3.9	4.4
September 19	3.9	3.2	2.9	3.5	3.4	3.3	2.9	3.4	4.2	3.8	3.5	3.8	4.3	4.1	3.7	4.4
September 26	4.2	3.2	2.9	3.7	3.6	3.5	3.0	3.5	4.5	3.8	3.5	3.8	4.5	4.1	3.7	4.5
October 3	4.1	3.2	3.0	3.7	3.3	3.4	2.9	3.6	4.1	4.0	3.5	4.0	4.7	4.1	3.8	4.3
October 10	3.9	3.4	2.9	3.7	6.7	3.3	2.9	3.3	7.2	6.5	3.3	3.6	4.4	3.8	3.8	4.3
October 18	6.0	3.6	3.3	3.6	6.0	3.1	3.0	3.2	6.6	5.5	3.3	3.6	4.3	3.3	3.7	4.0
October 24	6.5	5.0	4.9	3.6	6.4	3.1	6.3	3.1	9.8	8.6	3.4	3.4	3.6	3.5	3.5	4.1
October 31	5.4	5.0	6.5	3.1	6.6	2.8	6.0	2.9	8.2	8.0	3.1	3.2	4.6	5.8	3.2	3.6
November 9	>11.5	7.5	6.9	3.6	6.3	3.0	5.3	3.0	6.7	6.7	3.7	3.2	5.0	5.9	3.3	4.0
November 16	>11.5	5.5	>11.5	4.0	>11.5	>11.5	>11.5	>11.5	>12.0	>12.0	>12.0	>12.0	>12.0	>12.0	>12.0	>12.0
November 23	>11.5	5.5	>11.5	5.9	>11.5	4.7	>11.5	2.9	9.2	6.6	>12.0	2.9	>12.0	8.9	>12.0	6.8
November 30	>11.5	6.2	>11.5	6.7	>11.5	5.0	>11.5	3.1	10.5	7.1	9.6	7.9	>12.0	>12.0	>12.0	9.2
December 7	>11.5	>11.5	>11.5	>11.5	>11.5	4.1	>11.5	>11.5	>12.0	>12.0	10.1	7.6	9.0	8.9	8.2	8.9
December 14	>11.5	5.2	>11.5	6.6	>11.5	5.0	>11.5	>11.5	>12.0	6.8	7.6	7.1	>12.0	>12.0	>12.0	>12.0
December 21	>11.5	5.9	>11.5	6.3	7.2	4.9	8.2	7.3	7.6	10.3	7.7	7.3	8.6	9.2	7.8	7.9
December 28	>11.5	8.6	>11.5	8.9	7.2	5.0	7.8	6.4	8.1	7.9	7.7	7.3	8.0	8.1	7.7	8.2

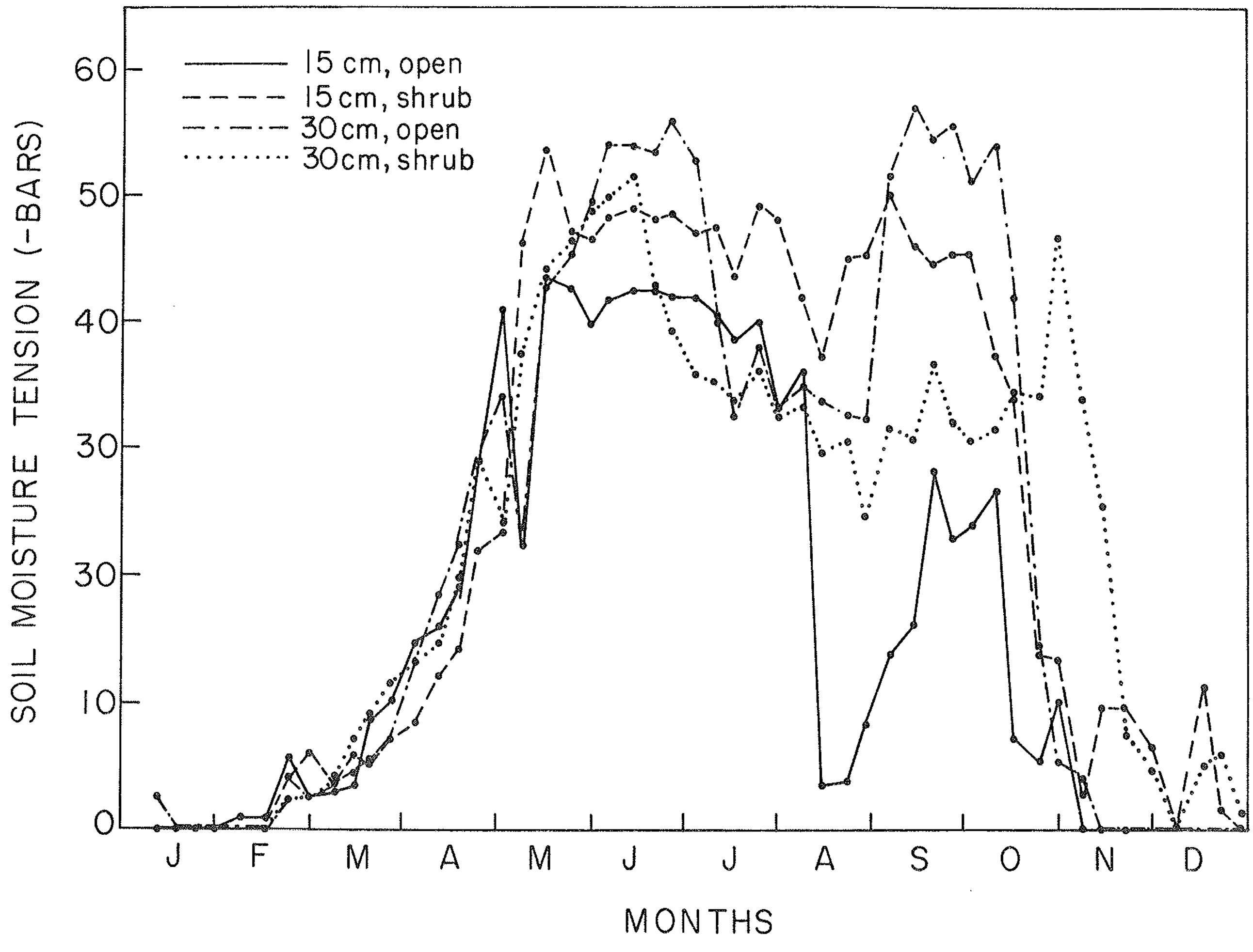

Figure 26. Weekly soil moisture tensions at station I during 1972.

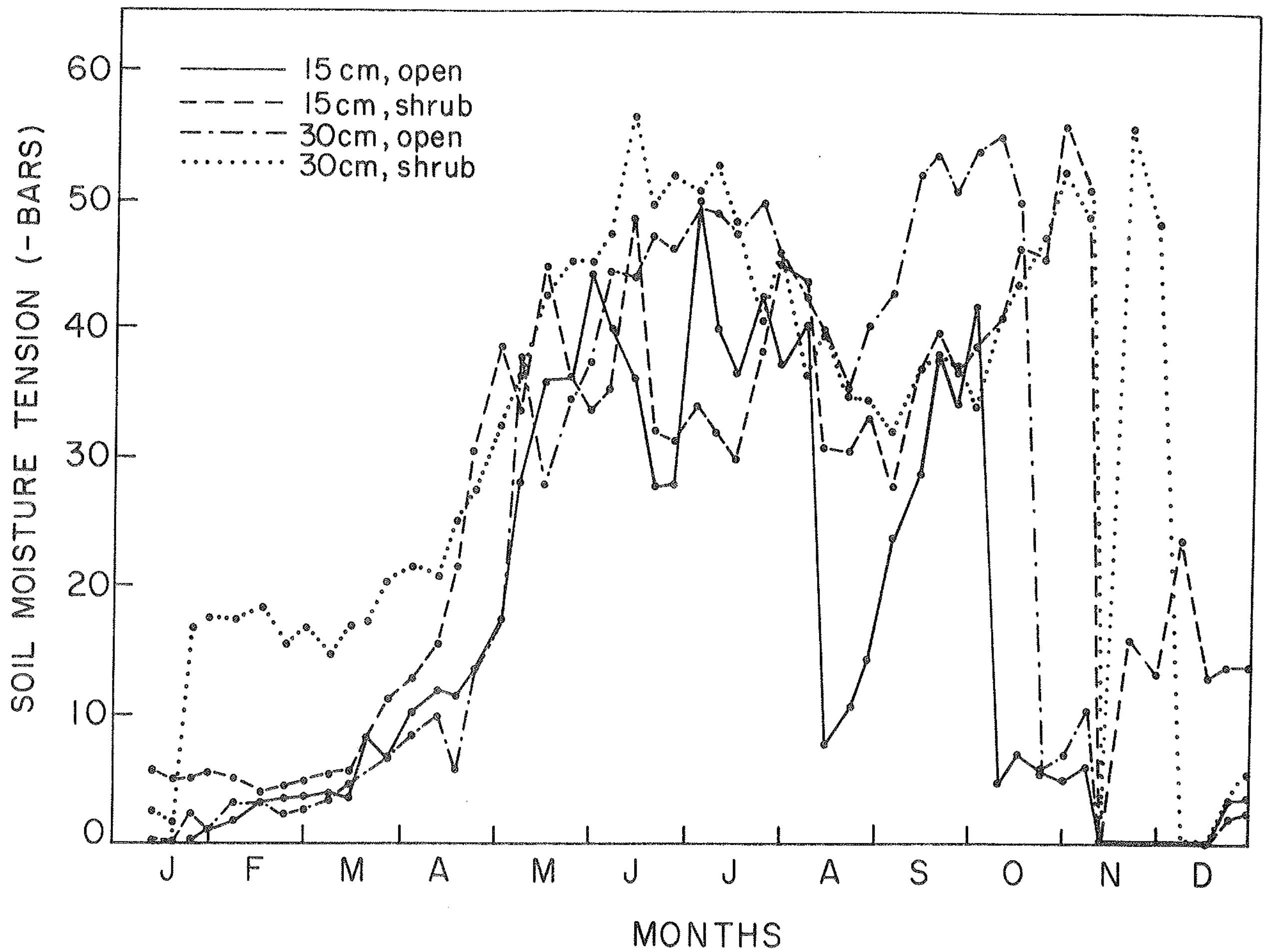

Figure 27. Weekly soil moisture tensions at station II during 1972.

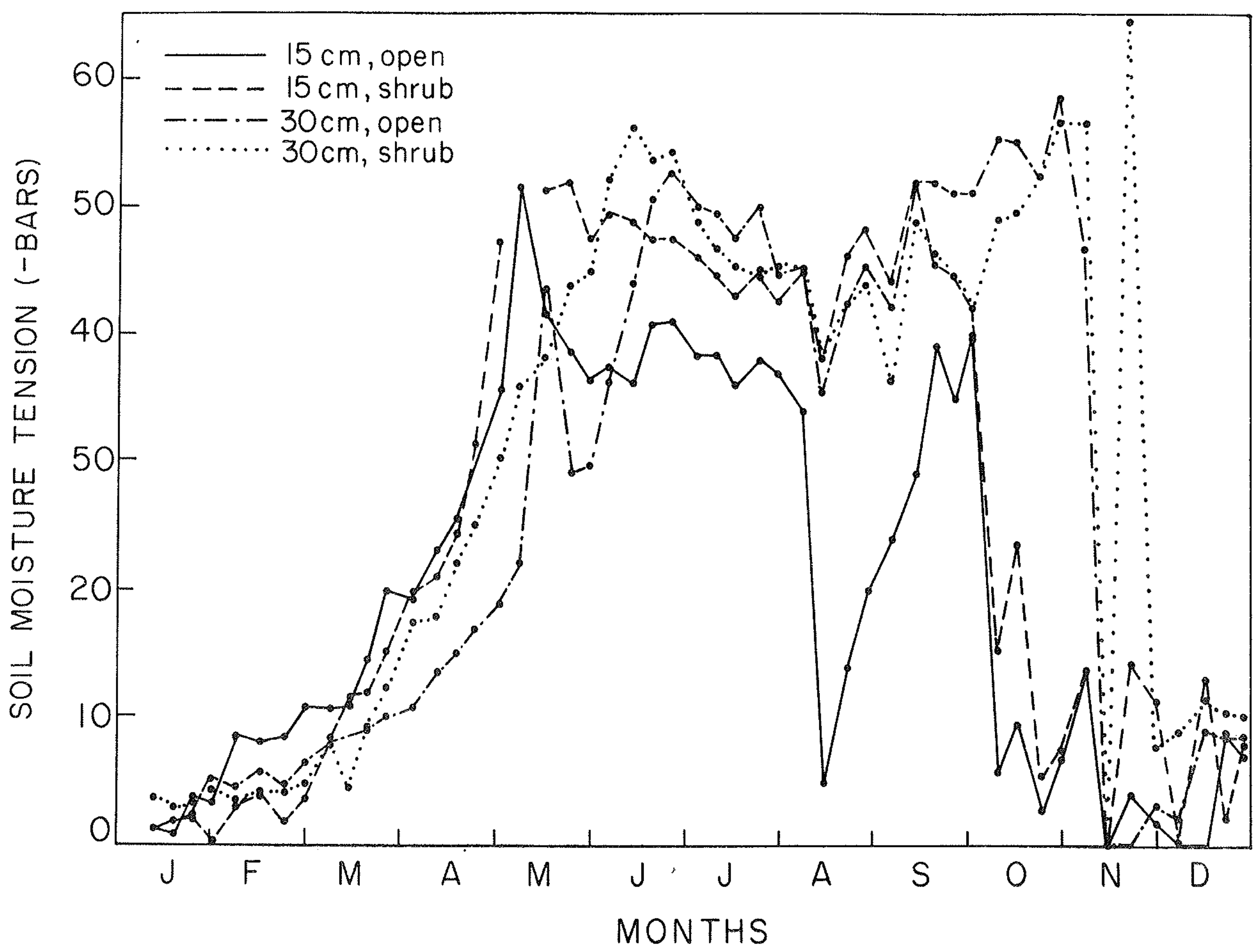

Figure 28. Weekly soil moisture tensions at station III during 1972.

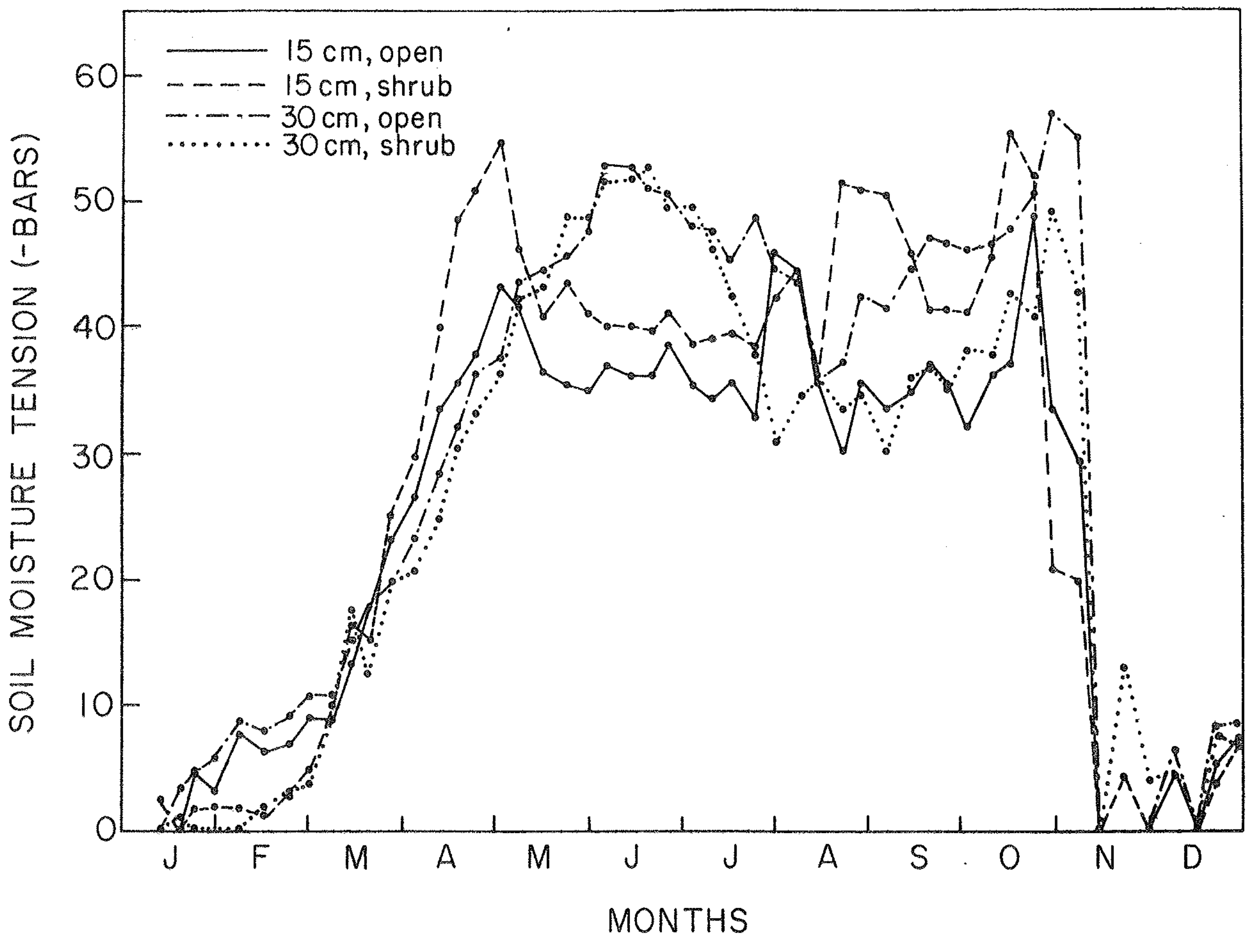

Figure 29. Weekly soil moisture tensions at station IV during 1972.

B. PLANTS

1. ANNUALS

Densities of winter annuals were estimated from counts made in 760 quadrats (A3UTJ20). The size of the quadrats used in 1972 was increased to 0.5 m^2--50 x 50 cm (cf. 0.1 m^2 in 1971). These quadrats were positioned in the four cardinal directions 10 m from each of the 190 randomly located points used in locating the perennial quadrats. A list of the species of annuals recorded in Rock Valley during 1971 and 1972 is given in Table 1. A total of 2080 annuals (40 species) was counted in 420 of the 0.5 m^2 quadrats. Table 2 gives estimated densities of annuals in each of six zones composing the Rock Valley Valid-tion Site. Densities varied between zones, but were always greater beneath shrubs than in bare areas or regions of desert pavement. Except for zone 22, overall densities in 1972 were higher than in 1971. However, on an individual species basis both increases and decreases were observed. The density of *Bromus rubens* was markedly lower in 1972. Densities of *Cryptantha pterocarya* remained the same in some zones, but decreased 10-fold in others. The 1972 density of *Festuca octoflora* was from 3 to 6.5 times that observed in 1971. When zone totals are combined one arrives at an estimate of a little over 5 million annuals on the entire validation site (46.11 ha), or an overall density of about 11/m^2.

Mean dry weights of entire plants and for plant parts are given in Table 3. Combining these values with the density estimates (Table 2) leads to biomass estimates for each species during two periods (April and May) during the spring of 1972 (Tables 4 and 5). Mean dry weights were based on whole plant collections at each time period followed by separation into component parts. As discussed in the 1971 report, sampling at two periods was necessary because of time differences in species maturation. A combination of the April and May assessments was used to estimate total annual production (Table 6). Revised estimates of annual production during 1971 are given in Table 7, and a comparison of differences between 1971 and 1972 is given in Table 8. Table 8 shows that in all zones, biomass of annuals was lower in 1972 than in 1971. This point should be contrasted with the fact that 1972 densities were, in general, higher. For example, the density of annuals in zone 20 during 1972 was about 57% higher than in 1971 but the 1972 biomass was 30% less than that estimated the previous year. Annuals were clearly smaller in 1972. In 1971 annuals received some moisture after germination, but in 1972 there was but a single winter rain. This rain (in late December) stimulated germination, but there was no ensuing rainfall as in 1971.

Total annual production was low in both 1971 and 1972, with an average for the site of 4.9 kg/ha in 1971 and 3.2 kg/ha in 1972. This compares to fruit production of 6.8 kg/ha by the shrub *Ephedra nevadensis* during 1971, and total shrub productivity of about 160 kg/ha. Species-specific differences in response between the two years are evident. Production by *Chorizanthe rigida* and *Rafinesquia neomexicana* increased in 1972, but *Chaenactis*

fremontii and *Phacelia vallis-mortae* exhibited decreases in all zones. Some species, e.g., *Chaenactis carphoclinia*, increased or decreased, depending upon the zone of reference. On an overall basis, however, annual production during 1972 decreased about 32%. Although aggregate densities in 1972 (ca. $11/m^2$) were higher than in 1971 (ca. $7.8/m^2$), the 1972 biomass was lower because the annuals were smaller.

The observations in 1972 showed that annuals can germinate and complete their life cycle on one winter (December 26-28, 1971) rain of 53.3 mm, although survival and productivity were low. Fruit and seed production in 1971 was 12% by weight and 15% in 1972, but biomass was lower (0.56 kg/ha in 1971, and 0.48 kg/ha in 1972).

Annuals germinated by January 10, 1972, after rains in late December of 1971 totaling 53.3 mm. Annual germination in 1971 occurred after late fall and early winter rains of 46.7 mm. There were no appreciable rains (less than 1.0 mm) during the spring of 1972, so growth of annuals (February 25) as well as flowering and fruiting were all supported by the late December rains. Distinct variations in the phenology of annual species in different microhabitats were observed because soil moisture was extremely critical.

The virtual absence of spring rain is undoubtedly the reason for the low survival in 1972 (Table 9). Annuals in zone 20 exhibited 19% survival in systematically selected areas (survivorship in the same systematically selected areas was 45% in 1971). Annual survival in systematically selected areas in zones 24 and 25 were 13% and 8% survival, respectively, in 1972 (cf. 33% in both zones in 1971).

In the fall of 1972, annuals germinated at three times: after the rains of October 4 (14.7 mm), October 21 (18.5 mm), and November 16-17 (22.3 mm). These rains resulted in the germination of moderate numbers of annuals during the spring of 1973.

Table 1. Annuals recorded in Rock Valley during 1971 and 1972

Amsinckia tessellata	*Eriophyllum pringlei*
Astragalus lentiginosus	*Festuca octoflora*
Bromus rubens	*Gilia cana*
Calycoseris wrightii	*G. transmontana*
Caulanthus cooperi	*Glyptopleura marginata*
C. lasiophyllus	*Ipomopsis polycladon*
Chaenactis carphoclinia	*Langloisia schottii*
C. fremontii	*L. setosissima*
C. macrantha	*Lepidium lasiocarpum*
C. stevioides	*Lygodesmia exigua*
Chorizanthe brevicornu	*Malacothrix glabrata*
C. rigida	*Mentzelia obscura*
Cryptantha circumscissa	*Oenothera munzii*
C. micrantha	*Oxytheca perfoliata*
C. nevadensis	*Pectocarya platycarpa*
C. pterocarya	*Phacelia fremontii*
C. recurvata	*P. vallis-mortae*
Descurainia pinnata	*Rafinesquia neomexicana*
Eriogonum maculatum	*Streptanthella longirostris*
E. nidularium	*Stylocline micropoides*
E. trichopes	

Table 2. Estimated densities (n/ha) of winter annuals in six zones composing the Rock Valley Validation Site during the spring of 1972, based on counts made between March 28 and April 24, 1972

Species	Vegetational Zone/Hectares					
	20 (21.21)	21 (5.66)	22 (3.01)	23 (1.41)	24 (7.83)	25 (6.99)
Amsinckia tessellata				1111	667	571
Astragalus lentiginosus		870		1111		286
Bromus rubens	10723	2174	1429	2222	333	857
Calycoseris wrightii	121					
Caulanthus cooperi	1566	3478	714	1111		1143
C. lasiophyllus	241			1111		
Chaenactis carphoclinia	7952	3913	714	4444	7000	2000
C. fremontii	8916	5217	9286	28889	5000	8000
C. stevioides	361	2609			2667	
Chorizanthe brevicornu	6024	2609	4286	1111	5000	2571
C. rigida	18072	6522	15714	25556	5000	5143
Cryptantha circumscissa	3855	2174	714	2222	667	286
C. micrantha	121				667	286
C. nevadensis	1566	2174		3333	1333	286
C. pterocarya	121	2174			333	286
C. recurvata	2530	2174	714	5556	1667	571
C. sp.	1325	1739		4444	333	2857
Descurainia pinnata	964	3044	1429	1111		
Eriogonum maculatum	602	435		1111		
E. nidularium				2222	333	
E. trichopes	2892	870		1111		
Eriophyllum pringlei	14096	7826	2857	3333	2000	2000
Festuca octoflora	40000	13478	22143	7778	1667	857
Gilia cana	121	2609			667	857
G. transmontana	361	3044			333	286
Glyptopleura marginata					333	
Ipomopsis polycladon	3494	1304				
Langloisia schottii		870				
L. setosissima	6265	435			1111	
Lepidium lasiocarpum		1739				
Lygodesmia exigua	602		714	1111	333	
Malacothrix glabrata					667	857
Mentzelia obscura	964	2174			1000	571
Oenothera munzii	3615		714			
Oxytheca perfoliata	121	2174		3333		286
Phacelia fremontii	964	4348				
P. vallis-mortae	4699	4348		15556	5667	4857

Continued

Table 2. (cont.)

Species	Vegatational Zone/Hectares					
	20 (21.21)	21 (5.66)	22 (3.01)	23 (1.41)	24 (7.83)	25 (6.99)
Pectocarya sp.	20964	870	2143		667	1429
Rafinesquia neomexicana	1928	435	714	3333	667	1714
Streptanthella longirostris	2530	435	2143	3333	1000	
Stylocline micropoides	121					
All species (n/ha)	168797	88265	66428	126664	46001	38857
All species (n/zone) (x 10^5)	35.799	4.992	2.000	1.783	3.603	2.716
Change in $\pm$ % over 1971	+57.1	+17.7	-2.1	+42.5	+18.6	+1.6

Table 3. Mean dry weights (mg) of parts of the species of winter annuals during April, 1972, and total dry weights of entire plants during April and May, 1972

	April						May
Species	Leaves	Stems	Flowers	Fruits	Roots	Total	Total
Amsinckia tessellata	7.0	16.0	36.0	11.0	20.0	90.0	
Astragalus lentiginosus	55.0	89.0	200.0		66.0	410.0	
Bromus rubens	1.0	4.0	10.3	6.8		22.2	39.2
Calycoseris wrightii	5.7	15.7	13.7	17.7		52.7	
Caulanthus cooperi	2.3	4.3	5.8		3.8	16.1	
C. lasiophyllus	1.0	3.0	3.0		6.5	13.5	
Chaenactis carphoclinia	3.6	5.0	10.7			19.3	39.0
C. fremontii	1.7	6.5	8.5	9.0	6.3	32.0	41.7
C. stevioides	3.0	4.4	5.4	9.6	2.5	24.9	
Chorizanthe brevicornu	0.8	1.5	3.0		2.9	8.1	19.6
C. rigida	2.4	2.0	9.6	5.9	4.0	24.0	47.5
Cryptantha circumscissa	0.6	1.1	2.5	3.4		7.6	
C. micrantha	4.0	1.0	2.5	1.0		8.5	
C. nevadensis	2.0	4.0	6.3	3.0		15.3	31.4
C. recurvata	1.6	2.0	4.4	3.9		11.9	28.5
Descurainia pinnata	1.8	2.5	3.3		2.8	10.5	
Eriogonum maculatum							21.7
E. nidularium							15.7
E. trichopes							59.5
Eriophyllum pringlei	0.4	0.7	1.4	2.0	1.0	5.6	
Festuca octoflora	0.6	0.4	1.6	2.7		5.4	9.0
Gilia cana	6.0	7.0	8.0	4.0	5.0	30.0	
G. transmontana	1.0	2.0	3.0	2.0	3.3	11.3	
Ipomopsis polycladon	2.8	2.3	7.5	1.7	1.0	15.2	12.7
Langliosia setosissima	0.8	1.4	6.1	2.3		10.6	26.8
Lygodesmia exigua	2.7	3.5	3.8	4.3		14.2	33.0
Malacothrix glabrata	9.0	10.0	16.0	26.0		61.0	
Mentzelia obscura	1.9	7.1	10.4	1.9	5.6	26.9	62.3
Oenothera munzii	3.2	9.7	10.7	5.8		29.3	68.8
Oxytheca perfoliata	1.6	2.0	6.7	5.3		15.6	
Phacelia fremontii	1.3	3.1	5.3	3.7	0.7	14.1	
P. vallis-mortae	2.4	16.6	20.1	11.7	1.4	52.2	34.0
Pectocarya sp.	0.7	2.6	3.5	2.5	2.3	11.6	
Rafinesquia neomexicana	5.0	30.5	21.0	26.0	14.0	96.5	50.3
Streptanthella longirostris	3.0	3.0	4.0	2.0		12.0	10.2

Table 4. Estimated biomass of winter annuals (g/ha) in six zones composing the Rock Valley Validation Site during April, 1972

	Zones					
Species	20	21	22	23	24	25
Amsinckia tessellata				100.0	60.0	51.4
Astragalus lentiginosus		356.5		455.6		117.1
Bromus rubens	237.7	48.2	31.7	49.3	7.4	19.0
Calycoseris wrightii	6.3					
Caulanthus cooperi	25.2	55.9	11.5	17.9		18.4
C. lasiophyllus	3.3			15.0		
Chaenactis carphoclinia	153.4	75.5	13.8	85.7	135.0	38.6
C. fremontii	285.6	167.1	297.4	925.3	160.2	256.2
C. stevioides	9.0	65.0			66.4	
Chorizanthe brevicornu	48.9	21.2	34.8	9.0	40.6	20.9
C. rigida	433.0	156.3	376.5	612.3	119.8	123.2
Cryptantha circumscissa	29.2	16.5	5.4	16.8	5.1	2.2
C. micrantha	1.0				5.7	2.5
C. nevadensis	24.0	33.3		51.1	20.4	4.4
C. recurvata	30.1	25.9	8.5	66.0	19.8	6.8
Descurainia pinnata	10.1	31.9	15.0	11.6		
Eriophyllum pringlei	78.9	43.8	16.0	18.7	11.2	11.2
Festuca octoflora	216.0	72.8	119.6	42.0	9.0	4.6
Gilia cana	3.6	78.3			20.0	25.7
G. transmontana	4.1	34.5			3.8	3.2
Ipomopsis polycladon	53.0	19.8				
Langloisia setosissima	66.1	4.6		11.7		
Lygodesmia exigua	8.5		10.1	15.8	4.7	
Malacothrix glabrata					40.7	52.3
Mentzelia obscura	25.9	58.4			26.9	15.3
Oenothera munzii	106.0		21.0			
Oxytheca perfoliata	1.9	33.9		52.0		4.6
Phacelia fremontii	13.6	61.5				
P. vallis-mortae	245.1	226.8		811.4	295.6	253.4
Pectocarya sp.	242.6	10.1	24.8		7.7	16.5
Rafinesquia neomexicana	186.0	42.0	68.9	321.7	64.3	165.4
Streptanthella longirostris	30.4	5.2	25.7	40.0	12.0	
All species (g/ha)	2578.5	1745.0	1080.7	3728.9	1136.3	1212.9
All species (g/zone)	54685	9868	3254	5250	8900	8477

Table 5. Estimated biomass of winter annuals (g/ha) in six zones composing the Rock Valley Validation Site during May, 1972

	Zones					
Species	20	21	22	23	24	26
Bromus rubens	419.9	85.1	56.0	87.0	13.1	33.6
Chaenactis carphoclinia	310.4	152.8	27.8	173.3	273.0	78.1
C. fremontii	371.5	217.4	386.9	1203.8	208.4	333.4
Chorizanthe brevicornu	118.3	51.2	84.1	21.8	98.2	50.5
C. rigida	858.4	309.8	746.4	1213.9	237.5	244.3
Cryptantha nevadensis	53.5	74.2		113.8	45.5	9.8
C. recurvata	72.1	62.0	20.4	158.3	47.5	16.3
Eriogonum maculatum	13.1	9.4		24.1		
E. nidularium				34.8	5.2	
E. trichopes	172.1	51.7		66.1		
Festuca octoflora	199.0	67.1	110.2	38.8	8.3	4.3
Ipomopsis polycladon	44.4	16.6				
Langloisia setosissima	168.0	11.7		29.8		
Lygodesmia exigua	19.9		23.6	36.7	11.0	
Mentzelia obscura	60.1	135.4			62.3	35.6
Oenothera munzii	248.7		49.2			
Phacelia vallis-mortae	159.8	147.8		528.9	192.7	165.1
Rafinesquia neomexicana	97.0	21.9	36.0	167.8	33.6	86.3
Streptanthella longirostris	259.1	44.5	219.4	341.3	102.3	
All species (g/ha)	3225.4	1458.6	1436.0	4240.2	1338.7	1057.3
All species (g/zone)	68404	8248	4324	5970	10485	7390

Table 6. Estimated total annual production (g/ha) by winter annuals on the Rock Valley Validation Site during spring of 1972

Species	Zones					
	20	21	22	23	24	25
Amsinckia tessellata				100.0	60.0	51.4
Astragalus lentiginosus		356.5		455.6		117.1
Bromus rubens	434.6	88.1	57.9	90.1	13.5	34.7
Calycoseris wrightii	6.3					
Caulanthus cooperi	25.2	55.9	11.5	17.9		18.4
C. lasiophyllus	3.3			15.0		
Chaenactis carphoclinia	330.7	162.7	29.7	184.8	291.1	83.2
C. fremontii	371.5	217.4	386.9	1203.8	208.4	333.4
C. stevioides	9.0	65.0			66.4	
Chorizanthe brevicornu	118.3	51.2	84.1	21.8	98.2	50.5
C. rigida	918.8	331.6	789.9	1299.2	254.2	261.5
Cryptantha circumscissa	29.2	16.5	5.4	16.8	5.1	2.2
C. micrantha	1.0				5.7	2.5
C. nevadensis	58.2	80.8		123.8	49.5	10.6
*C. pterocarya**	2.2	39.1			6.0	5.1
C. recurvata	82.0	70.4	23.1	179.9	54.0	18.5
C. sp.*	30.8	40.4		103.1	7.7	66.3
Descurainia pinnata	10.1	31.9	15.0	11.6		
Eriogonum maculatum	13.1	9.4		24.1		
E. nidularium				34.8	5.2	
E. trichopes	172.1	51.7		66.1		
Eriophyllum pringlei	78.9	43.8	16.0	18.7	11.2	11.2
Festuca octoflora	244.8	82.5	135.5	47.6	10.2	5.3
Gilia cana	3.6	78.3			20.0	25.7
G. transmontana	4.1	34.5			3.8	3.2
Glyptopleura marginata					NE	
Ipomopsis polycladon	67.9	25.0				
*Langloisia schottii**		23.3				
L. setosissima	168.7	11.7		29.9		
Lepidium lasiocarpum		NE				
Lygodesmia exigua	19.9		23.6	36.7	11.0	
Malacothrix glabrata					40.7	52.3
Mentzelia obscura	60.1	135.4			62.3	35.6
Oenothera munzii	248.7		49.2			
Oxytheca perfoliata	1.9	33.9		52.0		4.6
Phacelia fremontii	13.6	61.5				
P. vallis-mortae	250.8	232.0		830.2	302.4	259.2

Continued

Table 6. (cont.)

Species	Zones 20	21	22	23	24	25
Pectocarya sp.	242.6	10.1	24.8		7.7	16.5
Rafinesquia neomexicana	186.0	42.0	68.9	321.7	64.3	165.4
Streptanthella longirostris	275.8	47.4	233.6	363.3		
Stylocline micropoides	0.3					
All species (g/ha)	4484.1	2530.0	1964.1	5648.5	1658.6	1634.4
All species (g/zone)	95099	14307	5914	7953	12990	11423

*Biomass estimated from previous data.

Table 7. Revised estimate of total annual production (g/ha) by winter annuals on the Rock Valley Validation Site during spring of 1971

Species	Zones 20	21	22	23	24	25
Amsinckia tessellata	119.1	208.3			689.7	735.3
Bromus rubens	1029.1	257.2	705.6	411.7		36.4
Calycoseris wrightii	41.2					
Caulanthus cooperi	24.8	94.2			39.0	
*C. lasiophyllus**	119.1					
Chaenactis carphoclinia	1068.1				727.7	155.3
C. fremontii	728.8	283.3	1335.7	1511.2	351.7	950.0
C. macrantha	15.6					
C. stevioides	39.7	138.8				
Chorizanthe brevicornu	84.8	137.0	78.2	60.8	18.9	96.6
C. rigida	461.6	138.4	316.4	123.1	114.5	32.6
Cryptantha circumscissa	137.4	175.0	75.1		144.8	
*C. micrantha**		125.0				
C. nevadensis	82.4	48.0		513.3	40.0	68.0
C. pterocarya		150.0		100.0	62.1	39.7
C. recurvata	29.9	60.9	34.8	162.6	50.4	28.8
C. sp.*	16.7	18.8				
Descurainia pinnata	72.0	45.8	39.3	61.1		
*Eriogonum maculatum**	148.8					
E. nidularium						131.5
E. trichopes	300.5	350.6	200.4			
Eriophyllum pringlei	371.4	50.0			41.4	70.6
Festuca octoflora	135.6	19.0	65.2	25.4		
Gilia cana						21.3
G. transmontana	18.2	111.6				
Glyptopleura marginata				NE		
Ipomopsis polycladon	6.3	21.9				
Langloisia schottii		95.1				
L. setosissima	81.6					
Lupinus shockleyi		NE				
Lygodesmia exigua					16.4	
Malacothrix glabrata					31.9	
Mentzelia obscura						98.0
Oenothera munzii	157.9		157.9			
*Oxytheca perfoliata**		187.5			77.6	

Continued

Table 7. (cont.)

Species	Zones					
	20	21	22	23	24	25
Phacelia fremontii	42.3				61.2	
P. vallis-mortae	628.7	338.4	580.3	1805.6	700.5	717.0
Pectocarya sp.	85.0	35.0				
Rafinesquia neomexicana	117.5					
Streptanthella longirostris	186.0		1116.1	2604.2	269.4	
*Stylocline micropoides**	59.5					
All species (g/ha)	6409.6	3089.8	4705.0	7390.0	3437.2	3181.1
All species (g/zones)	135,935	17,473	14,167	10,390	26,920	22,233

*Biomass estimated from previous data.

Table 8. Comparison of the change of winter annual production (g/ha) of 1972 over 1971: + indicates an increase and - indicates a decrease of 1972 over 1971 (NE signifies that no estimate was made)

Species	20	21	22	23	24	25
Amsinckia tessellata	-119[a]	-208[a]		+100[b]	-630	-684
Astragalus lentiginosus		+357[b]		+456[b]		+117[b]
Bromus rubens	-594	-169	-648	-322	+ 14[b]	- 1
Calycoseris wrightii	- 35					
Caulanthus cooperi	0	- 38	+ 12[b]	+ 18[b]	- 39[a]	+ 18[b]
C. lasiophyllus	-116			+ 15[b]		
Chaenactis carphoclinia	-737	+163[b]	+ 30[b]	+185[b]	-437	- 72
C. fremontii	-357	- 66	-949	-307	-144	-617
C. macrantha	- 16[a]					
C. stevioides	- 31	- 74			+ 66[b]	
Chorizanthe brevicornu	+ 33	- 86	+ 6	- 39	+ 79	- 46
C. rigida	+457	+194	+483	+1176	+139	+229
Cryptantha circumscissa	-108	-158	- 70	+ 17[b]	-140	+ 2[b]
C. micrantha	+ 1[b]	-125[a]			+ 6[b]	+ 3[b]
C. nevadensis	- 24	+ 33		-389	+ 10	- 57
C. pterocarya	+ 2	-111		-100[a]	- 56	- 35
C. recurvata	+ 52	+ 9	- 12	+ 17	+ 4	- 10
C. sp.	+ 14	+ 21		+103[b]	+ 8[b]	+ 66[b]
Descurainia pinnata	- 62	- 14	- 24	- 49		
Eriogonum maculatum	-136	+ 9[b]		+ 24[b]		
E. nidularium				+ 35[b]	+ 5	-132[a]
E. trichopes	-129	-299		+ 66[b]		
Eriophyllum pringlei	-292	- 6	+ 16[b]	+ 19[b]	- 30	- 60
Festuca octoflora	+109	+ 64	+ 70	+ 22	+ 10[b]	+ 5[b]
Gilia cana	+ 4[b]	+ 78[b]			+ 20[b]	+ 5
G. transmontana	- 14	- 77			+ 4[b]	+ 3[b]
Glyptopleura marginata				NE	NE	
Ipomopsis polycladon	+ 62	+ 3				
Langloisia schottii		- 72				
L. setosissima	+ 87	+ 12[b]		+ 30[b]		
Lepidium lasiocarpum		NE				
Lygodesmia exigua	+ 20[b]		+ 24[b]	+ 37[b]	- 5	
Malacothrix glabrata					+ 9	+ 52[b]
Mentzelia obscura	+ 60[b]	+135[b]			+ 62[b]	- 62
Oenothera munzii	+ 91		-109			

Continued

Table 8. (cont.)

Species	20	21	22	23	24	25
Oxytheca perfoliata	+ 2[b]	-154		+ 52[b]	- 78[a]	+ 5[b]
Phacelia fremontii	- 28	+ 62[b]			- 61[a]	
P. vallis-mortae	-378	-107	-580[a]	-976	-399	-458
Pectocarya sp.	+158	- 25	+ 25[b]		+ 8[b]	+ 17
Rafinesquia neomexicana	+ 68	+ 42[b]	+ 69[b]	+322[b]	+ 64[b]	+165
Streptanthella longirostris	+ 90	+ 47[b]	-882	-2241	-269[a]	
Stylocline micropoides	- 59					
Total species	-1925	-560	-2739	-1729	-1780	-1547
Change with respect to 1971 (± %)	-30.0	-18.1	-58.2	-23.4	-51.8	-48.6

[a]Species did not occur in zone during 1972

[b]Species did not occur in zone during 1971

Table 9. Survival of winter annuals in three zones of the Rock Valley Validation Site during 1971 and 1972

Situation	Zone	Year	Number of plots observed	Percent survival
Shrub	20	1971	8	53.0
		1972	8	20.3
	24	1971	10	36.1
		1972	8	9.3
	25	1971	14	39.9
		1972	15	8.6
Loose soil	20	1971	6	38.7
		1972	6	13.3
	24	1971	8	33.0
		1972	2	4.6
	25	1971	2	8.7
		1972	2	0.0
Desert pavement	20	1971	6	31.4
		1972	5	23.2
	24	1971	2	11.8
		1972	2	0.0
	25	1971	3	12.5
		1972	3	7.1
All situations	20	1971	20	45.0
		1972	19	19.2
	24	1971	20	32.6
		1972	20	12.6
	25	1971	19	32.8
		1972	20	8.0

B.2. PERENNIALS

Assessments of perennial plants on the validation site were directed toward two objectives in 1971: to determine the initial states of the various vegetation components and to determine the incremental changes in these components with time. Using this base of information, incremental changes in the vegetation again were assessed in 1972 (A3UTJ25).

Densities of perennials on the validation site were estimated from counts made in 190 50-m^2 quadrats (25 x 2 m) distributed at random over the entire site. Because plants counted along the edges of the quadrats extended beyond the quadrat boundaries, the actual quadrat area (in terms of plants enumerated) was estimated at about 66 m^2. For a given zone the density (n/ha) of a species was estimated as the total number of plants counted in all of the quadrats in the zone divided by the total area (in ha) of these quadrats. Estimates of woody (stem) biomass of important perennial plants on the validation site as of February 1 were based on dimension analysis. These estimates included both live and dead stems, and the weights of live stems were estimated as varying proportions of total stem weight (based on destructive analysis of shrubs collected in areas adjoining the validation site). The initial regression equations relating stem biomass to plant size were based on cylindrical volumes calculated as:

$$V = \pi[(D_1 + D_2)/4]^2H \qquad (1)$$

with D_1 and D_2 shrub diamaters 90° apart and H the height of the shrub. Relationships between stem biomass (W) and shrub volume were examined by simple linear regression with forced zero intercepts, and these equations are given in Table 10. Figure 1 illustrates data pertaining to *Larrea divaricata*.

Relationships between root biomass and total above-ground stem biomass of 10 Rock Valley shrubs have been worked out by Bamberg et al. (1973). Over 100 shrubs were carefully excavated, dried and weighed in the course of this work. From these results average root-stem ratios were calculated . Then, given estimates of above-ground standing crops, associated root biomass values could be estimated. These ratios incorporated a correction based on the assumption that 15% of the roots were not recovered in the field. Root/stem ratios for ten species of shrubs are given in Table 10.

Entire shrubs were collected at the apparent height of their spring growth in order to assess change in state during 1971. These shrubs were dismembered and the ratios of the dry weights of new leaves, new shoots, flowers and fruits to total old stem weight determined. These proportions were then used to estimate above-ground production (P) during the spring:

$$P = aW + bW + cW + dW \qquad (2)$$

with a, b, c, and d the appropriate coefficients for new parts. The new state of the system,

as of July 15, could then be estimated in terms of the original stem biomasses plus the new above-ground production of each important species.

From an examination of the 1971 biomass data, we determined that standing old live stem of each species would provide the best basis for subsequent biomass increment estimates. Consequently, in 1972, plant samples were partial shrub collections from which the weights of new stems, leaves, flowers, and fruits were determined as proportions of the weight of the living branch. These ratios tended to be somewhat high for some species because the weight of the shrub base was not included. Two incremental shrub samples were taken: one at the time of flowering (which generally coincided with maximum vegetative development), and the other at the time of maximum fruit development. A combination of these two samples was used for estimating ratios.

Our methods of estimating biomass are not sensitive enough to detect changes in shrub cover or volume during a year in which new stem growth is slight. We do not believe that the above-ground live shrub biomass composing the mature Rock Valley community changes markedly from year to year. However, appreciable declines could occur in very bad years owing to death and pruning of live parts, and increases due to new stem growth could result during particularly good years. New stem production in most species is from the base of the plant and this does not change the ouside dimensions from which biomass is estimated.

Table 11 gives estimated densities of major perennial species in the six zones on the validation site, together with the aggregate densities in each zone. In all six zones eight shrubs (*Ambrosia, Ephedra, Eurotia, Grayia, Krameria, Larrea, Lycium andersonii,* and *L. pallidum*) compose from 94-97% of the perennial populations. However, the zones differ in aggregate densities and the relative abundances of various species. In all zones *Ambrosia dumosa* is the most common species, often exceeding the density of the next most abundant shrub by a factor of two (zones 21, 22, 23). Zones 24 and 25, at the northern edge of the site and nearest the wash, are set apart from the others by relatively higher densities of *Atriplex confertifolia, Grayia spinosa* and *Lycium pallidum*, and lower densities of *Krameria parvifolia* and *L. andersonii*. Zone 22 is the only zone in which the relative abundance of *Coleogyne ramosissima* exceeds 1%. Zone 20 has relatively high densities of *Krameria* and *Lycium andersonii* and a low density of *Eurotia* relative to zones 21 and 23. The aggregate zone densities, coupled with zone areas, yield an estimate of about 400,000 perennials growing on the validation site (46.11 ha). The overall perennial density is, then, on the order of 8672/ha.

Cover ranged from about 16.3 (zone 21) to 24.3% (zone 22) in the six zones (Table 12). Taking into account the areas of the various zones, average cover for the validation site was about 20%. Seven species (*Ambrosia, Ephedra, Grayia, Krameria, Larrea, Lycium andersonii* and *L. pallidum*) contribute from 92.5 to over 99% of the cover. Greatest coverage by a single species is that of *Larrea divaricata* (ca. 4%).

Table 10. Regression equations used to estimate total stem biomass, W/(kg), of 13 perennial species in Rock Valley from shrub volumes, V (m^3), and ratios of root weight to live stem weight

Species	n	Regression Equation	F value	r value	Root/Stem
Acamptopappus shockleyi	43	W=2.793V	171.3	0.90	0.527
Ambrosia dumosa	62	W=2.238V	318.0	0.92	1.155
Atriplex confertifolia	28	W=4.864V	609.7	0.98	0.427
Coleogyne ramosissima	16	W=5.232V	279.4	0.98	-
Ephedra nevadensis	7	W=1.492V	26.9	0.92	0.835
Eurotia lanata	56	W=3.046V	274.0	0.91	0.900
Grayia spinosa	53	W=2.002V	105.3	0.82	0.715
Krameria parvifolia	34	W=1.937V	51.3	0.78	0.789
Larrea divaricata	41	W=1.539V	170.6	0.90	1.240
Lycium andersonii	56	W=1.975V	118.1	0.83	0.835
L. pallidum	29	W=0.786V	33.8	0.75	1.646
Machaeranthera tortifolia	11	W=1.615V	15.0	0.79	-
Oryzopsis hymenoides	7	W=1.044V	8.8	0.80	-

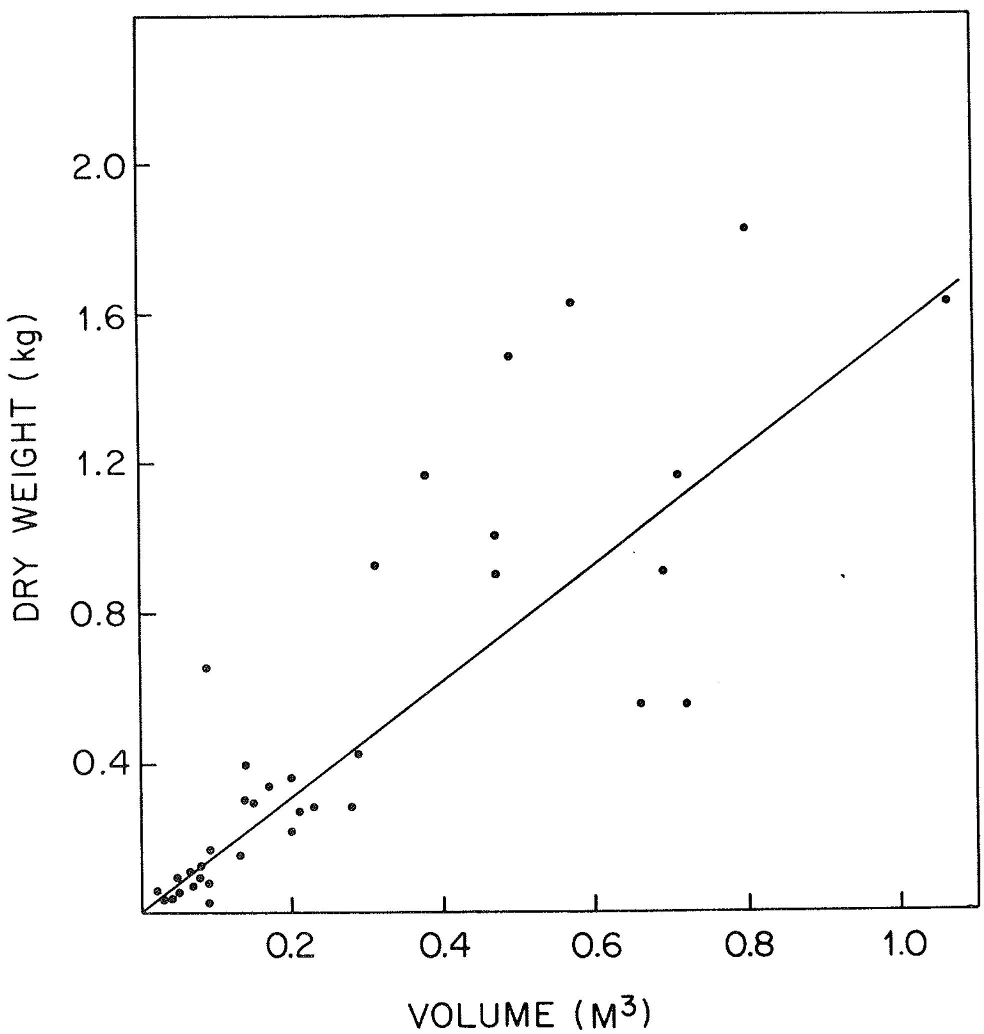

Figure 1. Regression of total stem dry weights (kg) of *Larrea divaricata* in Rock Valley on volumes (m^3) estimated from linear dimensions of shrubs.

Table 11. Estimated densities (n/ha) of the more abundant perennials in six zones on the Rock Valley validation site with relative abundance, as percents (when ≥ 1%), given in parentheses

Species	Zones 20 n	20 %	21 n	21 %	22 n	22 %	23 n	23 %	24 n	24 %	25 n	25 %
Acamptopappus shockleyi	32		0		0		33		21		98	
Ambrosia dumosa	1876	(26.0)	2342	(29.6)	3038	(34.9)	3134	(26.0)	2946	(32.3)	3647	(29.2)
Atriplex confertifolia	9		8		0		0		371	(4.1)	226	(1.8)
Coleogyne ramosissima	7		0		181	(2.1)	50		0		4	
Dalea fremontii	4		24		0		3		0		4	
Encelia virginensis	2		0		0		0		0		0	
Ephedra nevadensis	789	(10.9)	660	(8.3)	949	(10.9)	1360	(11.3)	422	(4.6)	0	(6.2)
Eurotia lanata	139	(1.9)	1022	(12.9)	149	(1.7)	1559	(12.9)	438	(4.8)	720	(5.8)
Grayia spinosa	194	(2.7)	692	(8.7)	235	(2.7)	1757	(14.6)	1942	(21.3)	3229	(25.8)
Krameria parvifolia	1784	(24.7)	935	(11.8)	1652	(19.0)	1559	(12.9)	803	(8.8)	1167	(9.3)
Larrea divaricata	1000	(13.9)	731	(9.2)	1141	(13.1)	746	(6.2)	912	(10.0)	997	(8.0)
Lycium andersonii	1086	(15.1)	589	(7.4)	863	(9.9)	763	(6.3)	160	(1.8)	332	(2.7)
L. pallidum	144	(2.0)	652	(8.2)	277	(3.2)	829	(6.9)	942	(10.3)	1065	(8.5)
Machaeranthera tortifolia	28		16		64		50		72		106	
Menodora spinescens	4		0		0		0		0		0	
Mirabilis bigelovii	7		0		0		0		0		0	
Opuntia echinocarpa	0		0		0		0		5		0	
Oryzopsis hymenoides	112	(1.6)	165	(2.1)	53		182	(1.5)	82		141	(1.1)
Salazaria mexicana	0		79	(1.0)	0		0		0		0	
Sphaeralcea ambigua	0		0		0		0		0		9	
Tridens pulchellus	0		0		0		0		5		0	
TOTALS	7217		7915		8699		12054		9121		12503	

Table 12. Estimated coverage (%) of nine shrubs in six vegetative zones composing the validation site and the whole site in Rock Valley (totals reflect a small percentage of other shrub species)

Species	Zones						
	20	21	22	23	24	25	Site
Ambrosia dumosa	2.47	2.45	4.27	4.40	3.83	4.59	3.20
Atriplex confertifolia	0.01	0.01	-	-	1.12	0.28	0.24
Coleogyne ramosissima	0.01	-	1.29	0.01	-	0.03	0.09
Ephedra nevadensis	1.45	0.63	2.68	3.73	0.70	2.39	1.51
Grayia spinosa	0.31	0.78	0.62	1.86	2.03	3.16	1.16
Krameria parvifolia	4.79	2.43	5.01	4.45	2.23	3.17	3.82
Larrea divaricata	4.44	3.42	4.12	3.69	3.86	3.69	4.06
Lycium andersonii	6.12	2.80	4.92	2.53	0.39	1.50	3.85
L. pallidum	0.46	3.82	1.43	2.45	4.12	3.83	2.13
Total cover	20.06	16.34	24.34	23.12	18.28	22.64	20.06

Table 13 gives estimates of old live stem and root standing crops on a dry weight basis (kg/ha) for ten perennial species on the validation site. Root weights were obtained by multiplying live stem weights by the root/stem ratios given in Table 10 (A3UBD04, A3UBD05). Taking into account the areas of the six zones the total live stem biomass on the validation site would be estimated at around 41,363 kg, or about 897 kg/ha. The largest contributors to stem standing crop on the site are *Larrea divaricata* and *Lycium andersonii*. Root biomass for the whole site is estimated at around 873 kg/ha, about the same as that of live stems. According to Bamberg et al. (1973), "Root biomass for the total of all plants considered [113] was about 45% of the sum of stem and root weights." This would imply that root weight in Rock Valley would be only about 82% of live stem weight. However, the plants analyzed by Bamberg and his colleagues did not match the overall pattern of relative species abundance on the site. Species with high root/stem ratios (e.g., *Ambrosia, Larrea* and *Lycium pallidum*) may have been under-represented. The high weight of roots relative to that of stems is remarkable in view of earlier comments by Woodwell and Whittaker (1968), who pointed out that "It has been assumed that the dry weight of roots is about 20-35% of the above-ground biomass, but root weight may be as low as 10% of above-ground weight in some mature forests...The Brookhaven forest, in contrast, is a small forest adapted to fire, in which young above-ground shoots grow from older roots which have survived the fire. Here root weight is 56% of above-ground biomass." Evidently, in more arid regions root/stem ratios may be much higher, for West (1972) has recorded root biomasses far exceeding those of above-ground tissue in *Atriplex confertifolia* and *Eurotia lanata* areas in northern Utah.

Table 14 gives amounts of standing dead material on the validation site. In Rock Valley the ratio of standing dead to living plant material is about 5:4, and this does not include totally dead shrubs (about 10% of the number of live shrubs).

Table 15 gives revised estimates of new growth during 1971--expressed in terms of new leaves, stems, flowers and fruits. (cf. Turner, 1972: RM 72-2, p. 34). Table 15 gives similar data for 1972, as well as comparisons with production in 1971. The data in these tables express validation site totals calculated from zone-specific data. Data for each of the six zones are available upon request. In both years, most of the total net production was manifested in leaves -- 76% in 1971 and 63% in 1972. Flower and fruit production was markedly enhanced in 1972. However, the increased production in 1972 was largely attributable to the relatively greater production of new leaves and stem tissues by *Ambrosia* and to a lesser degree to greater fruit production by *Grayia*. For the six other species for which comparisons are possible, differences in net production in the two years were so slight that they could hardly be considered statistically significant (Table 16). Patterns of production were not identical in all species of shrubs. For example, the early spring moisture in 1972 resulted in far more stem growth by *Ambrosia dumosa* than was observed in 1971. On the other hand, additional moisture during the late spring of 1971 led to much higher stem production by *Krameria parvifolia* during that year

(Fig. 2). Weight distributions of shrubs may be generated using linear dimensions (Equation 1) and the regression equations given in Table 10. Table 17 gives statistical attributes of such distributions for 10 species of shrubs in Rock Valley. All stem weight distributions are positively skewed, and generally exhibit large standard deviations relative to the means. Three distributions are illustrated in Fig. 3. The shape of the distribution of *Ambrosia dumosa* typifies most species. Age cannot be equated with size since many older shrubs have died back to a small size, and habitat differences and aggregation and association affect shrub size.

Shrub species diversity was estimated as $\hat{H}'$, as defined by Pielou (1969) for each zone and for the validation site as a whole. $\hat{H}'$ assumes that the sample is from an infinite population and was estimated from the various estimates of $\hat{P}$, obtained from the quadrat counts:

$$\hat{H}' = -\sum^{s} \hat{P}_i \log \hat{P}_i \quad (3)$$

where $\hat{P}_i$ is the estimated relative frequency of the *i*th shrub species. $\hat{H}'_{max}$ was also estimated, and relative diversities calculated as $\hat{H}'/\hat{H}'_{max}$. The nature of our data is probably not appropriate for the calculation of $\hat{H}$, which assumes the sample is from an infinite population,

$$\hat{H} = \frac{1}{N} \log \frac{N!}{N_1!\, N_2! \ldots N_s!} \quad (4)$$

but we performed this operation as above, with N the total number of shrubs and N_i the abundance of the *i*th species (see Pielou, 1969:232). Estimates of diversity and relative diversity are summarized in Table 18.

Shrubs entering the spring growing season of 1972 received 53.3 mm of moisture during December of 1971, but no more significant rain until June -- when 17.8 mm fell in Rock Valley. All the shrubs had already flowered and fruited by the time of the June rains, and air temperatures were already high (38 C maximum and 11 C minimum). Hence, there was little noticeable effect on phenology (Table 19).

The earliest species (*Lycium andersonii* and *L. pallidum*) started to put out leaf buds on January 21 -- only a few days later than in 1971, but cold weather delayed further development. The *Lycium* spp. again began to bud on February 8, and produced leaves by February 18 -- 24 days later than in 1971. Because of the cold period in late January 1972 most shrubs leafed out two or more weeks later than in 1971. *Larrea* came out about the same time both years. In contrast to times of leaf appearance, most shrubs flowered earlier in 1972 than in 1971. *Larrea*, both species of *Lycium*, *Eurotia*, and *Krameria* flowered almost a month earlier in 1972. The others were about two weeks earlier, except

for *Atriplex* which remained the same. *Ambrosia* and both *Lycium* species went dormant a month earlier in 1972.

Two summer rains in August totaled over 21.6 mm, with maximum temperatures of 40-44 C. These rains were intense and produced appreciable runoff. Some species (e.g., *Larrea, Krameria* and *Atriplex*) put out a few new leaves. In general, *Ambrosia* and both species of *Lycium* remained dormant. Only a few individuals of these species (located in or near drainages) put out leaves. After October rains -- totaling over 33 mm -- all shrubs except *Ephedra, Grayia* and *Krameria* put out new leaves. At this time *Krameria* was starting to drop its leaves and go dormant because of minimum temperatures of near 5 C at night. Leaf enlargement in several *Grayia spinosa* was observed during the fall season of 1972.

Rock Valley received November rains totaling around 33 mm. Most of this moisture should be available in the spring of 1973, because temperatures in November were too cool to permit much growth (maximum 15-20 C and minimum around -2 C).

Perennial seedlings were counted in several plots, but over the past two years few perennials have germinated. *Ambrosia* seedlings were the most abundant in 1971 but only 8% survived. A few *Larrea* and *Eurotia* seedlings were counted in 1972 and their survival will be followed during 1973.

Table 13. Estimated old live stem and root biomass (kg/ha) of ten perennials on the Rock Valley validation site during the winters of 1971 and 1972 (upper line for each species refers to stem weights)

Species	Zones					
	20	21	22	23	24	25
Acamptopappus shockleyi	0.67 0.35	- -	- -	6.06 3.19	0.24 0.13	1.80 0.95
Ambrosia dumosa	63.21 73.01	56.07 64.76	122.42 141.40	114.91 132.72	99.11 114.47	116.10 134.10
Atriplex confertifolia	0.01 -	0.01 -	- -	- -	136.51 58.29	29.79 12.72
Ephedra nevadensis	74.32 62.06	28.80 24.05	151.06 126.14	196.97 164.47	42.91 35.83	128.19 107.04
Eurotia lanata	3.42 3.08	17.85 16.07	2.28 2.05	37.80 34.02	11.39 10.25	22.95 20.66
Grayia spinosa	18.91 13.52	47.28 33.81	42.26 30.22	111.52 79.74	109.45 78.26	170.50 121.91
Krameria parvifolia	149.48 117.94	72.71 57.37	145.51 114.81	126.77 100.02	69.26 54.65	91.35 72.08
Larrea divaricata	139.15 172.55	111.91 138.77	123.64 153.31	111.65 138.45	131.94 163.61	118.34 146.74
Lycium andersonii	486.96 406.61	223.31 186.46	378.85 316.34	190.81 159.33	32.70 27.30	113.79 95.01
L. pallidum	15.78 25.97	144.90 238.51	57.29 94.30	86.24 141.95	162.49 267.46	136.60 224.84
Total live stem	951.91	702.84	1023.31	982.73	796.00	929.41
Total roots	875.09	795.80	978.57	953.89	810.25	936.05
Total biomass	1827	1499	2002	1937	1606	1865

Table 14. Standing dead plant material (% completely dead shrubs based on counts in 190 random quadrats) and proportion of living shrubs composed of standing dead material in Rock Valley

Species	Zones						Total site	Proportion of living shrub made up of dead material (%)*
	20	21	22	23	24	25		
Ambrosia dumosa	6.8	14.4	7.8	17.1	13.2	13.4	11.2	66.5
Atriplex confertifolia	-	-	-	-	29.3	21.0	25.4	54.9
Ephedra nevadensis	26.1	20.8	29.9	6.8	12.8	19.4	22.5	29.4
Eurotia lanata	1.4	3.7	6.9	7.9	8.6	9.1	6.5	66.3
Grayia spinosa	7.6	16.2	21.4	7.0	13.7	12.6	12.5	47.9
Krameria parvifolia	0.9	1.7	1.9	3.1	0.6	1.4	1.2	32.8
Larrea divaricata	7.2	6.0	4.4	11.7	4.8	9.3	7.1	68.6
Lycium andersonii	1.3	5.0	10.0	2.2	0.0	4.9	2.7	29.2
L. pallidum	1.4	5.6	21.3	2.0	5.7	6.0	5.7	26.1

*Based on destructive partitioning of entire shrubs.

Table 15. Revised estimates of biomass increments (kg/ha) for new leaf, new stem, flower, fruit and total new biomass in eight species of perennial shrubs in Rock Valley during the spring of 1971

Species	New Leaf	New Stem	Flower	Fruit	Total New Biomass
Ambrosia dumosa	15.40	1.47	0.02	0.02	16.91
Ephedra nevadensis	-	1.28	4.57	8.02	13.87
Eurotia lanata	2.20	0.52	0.30	1.68	4.70
Grayia spinosa	12.57	0.85	0.08	0.34	13.84
Krameria parvifolia	42.47	9.45	0.59	0.01	52.52
Larrea divaricata	14.40	4.54	2.32	0.69	21.95
Lycium andersonii	24.53	0.18	0.16	0.24	25.11
L. pallidum	7.82	0.07	0.02	0.00	7.91
Zone totals	119.39	18.36	8.06	11.00	156.81

Table 16. Estimated increments of biomass (kg/ha) for new leaf, new stem, flower, and fruit in nine species of perennial shrubs in Rock Valley during the spring of 1972, with total new biomass and percentage change for 1972 given for the nine species

Species	New Leaf	New Stem	Flower	Fruit	Total New Biomass	Comparison of 1972 to 1971 (± kg/ha)	(± %)
Ambrosia dumosa	20.08	6.05	1.38	0.11	27.62	10.71	63.3
Atriplex confertifolia	6.77	1.23	0.17	0.37	8.54		
Ephedra nevadensis	-	7.47	4.06	4.26	15.79	1.92	13.8
Eurotia lanata	2.46	0.97	0.39	0.53	4.35	-0.35	-7.4
Grayia spinosa	10.83	1.78	1.11	5.65	19.37	5.53	40.0
Krameria parvifolia	42.78	4.24	4.75	0.25	52.02	-0.50	-1.0
Larrea divaricata	12.54	4.71	2.46	0.87	20.58	-1.37	-6.24
Lycium andersonii	13.67	0.27	4.75	8.02	26.71	1.60	6.4
L. pallidum	5.78	0.01	1.56	0.46	7.81	-0.10	-1.3
Zone total	114.91	26.73	20.63	20.52	182.79	17.44*	11.1*

**A. confertifolia* biomass not included

Table 17. Some statistical attributes of distributions of total stem weights (g) of ten Rock Valley shrubs

Species	n	Mean	Std. Dev.	Max.	Min.	Range
Acamptopappus shockleyi	23	68.3	82.8	371.8	0.9	370.9
Atriplex confertifolia	37	33.7	32.8	107.2	2.1	105.2
Ephedra nevadensis	387	119.1	202.9	2878.0	0.7	2877.0
Eurotia lanata	234	62.7	96.9	640.9	>0.1	640.9
Ambrosia dumosa	1183	108.7	111.0	952.6	0.1	952.5
Grayia spinosa	591	74.3	85.8	716.0	0.3	715.7
Krameria parvifolia	732	136.4	96.9	682.6	1.0	681.6
Larrea divaricata	517	437.9	454.1	3164.0	>0.1	3164.0
Lycium andersonii	351	371.4	244.3	1470.0	8.2	1462.0
L. pallidum	227	264.4	216.4	1041.0	1.2	1040.0

Table 18. Estimates of diversity, maximum diversity, and relative diversity of shrubs occupying the Rock Valley validation site

Region Sampled	Area (ha)	Number of species	$\hat{H}$	$\hat{H}_{max}$	$\hat{H}'$	$\hat{H}'_{max}$	Relative Diversity
Zone 20	21.21	17	0.816	1.224	1.890	2.833	0.67
Zone 21	5.66	13	0.890	1.098	2.079	2.565	0.81
Zone 22	3.01	11	0.804	1.026	1.884	2.309	0.79
Zone 23	1.41	13	0.886	1.094	2.078	2.565	0.81
Zone 24	7.83	14	0.845	1.136	1.965	2.639	0.74
Zone 25	6.99	15	0.856	1.169	1.985	2.708	0.73
Validation Site	46.11	21	0.903	1.319	2.084	3.045	0.69

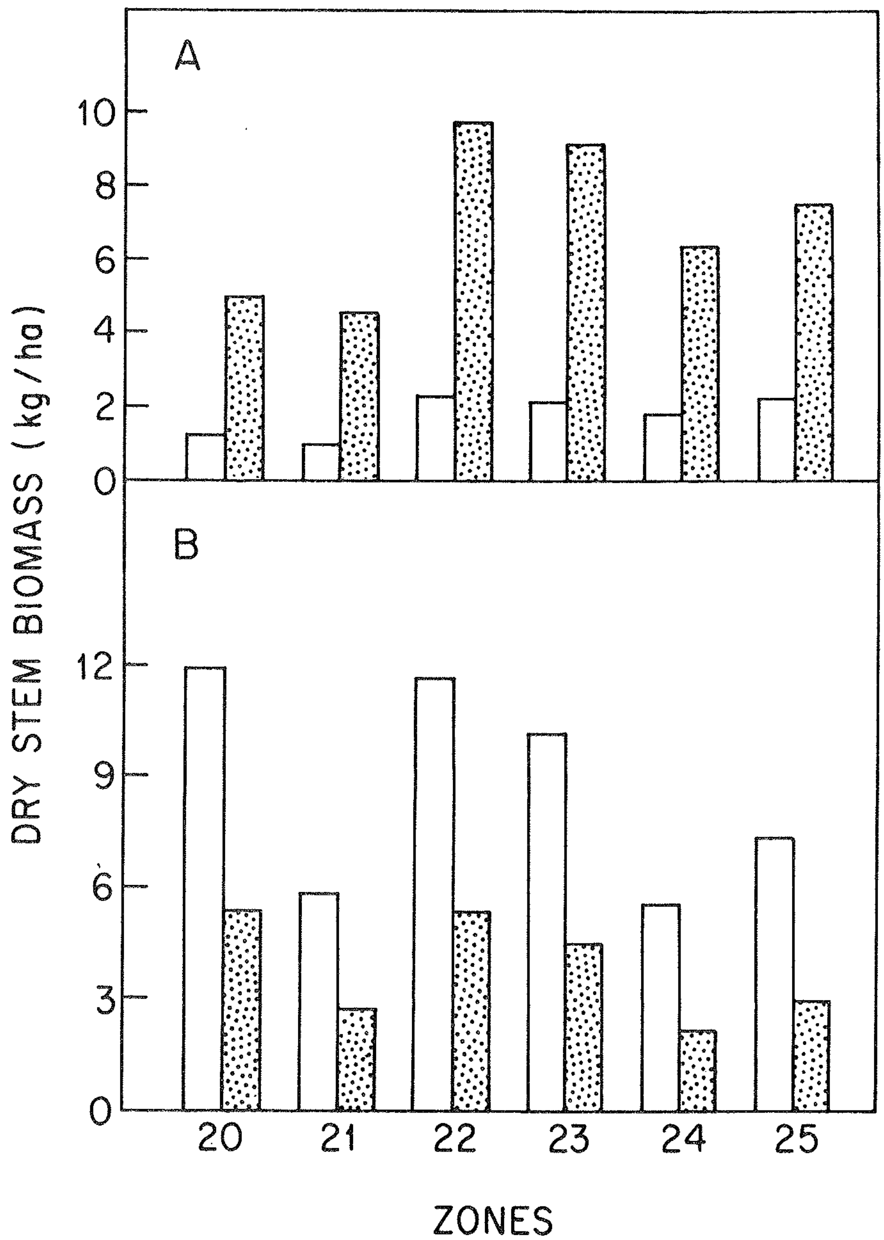

Figure 2. Dry stem production (kg/ha) by (A) *Ambrosia dumosa* and (B) *Krameria parvifolia* in six zones composing the Rock Valley validation site during 1971 and 1972 (stipled).

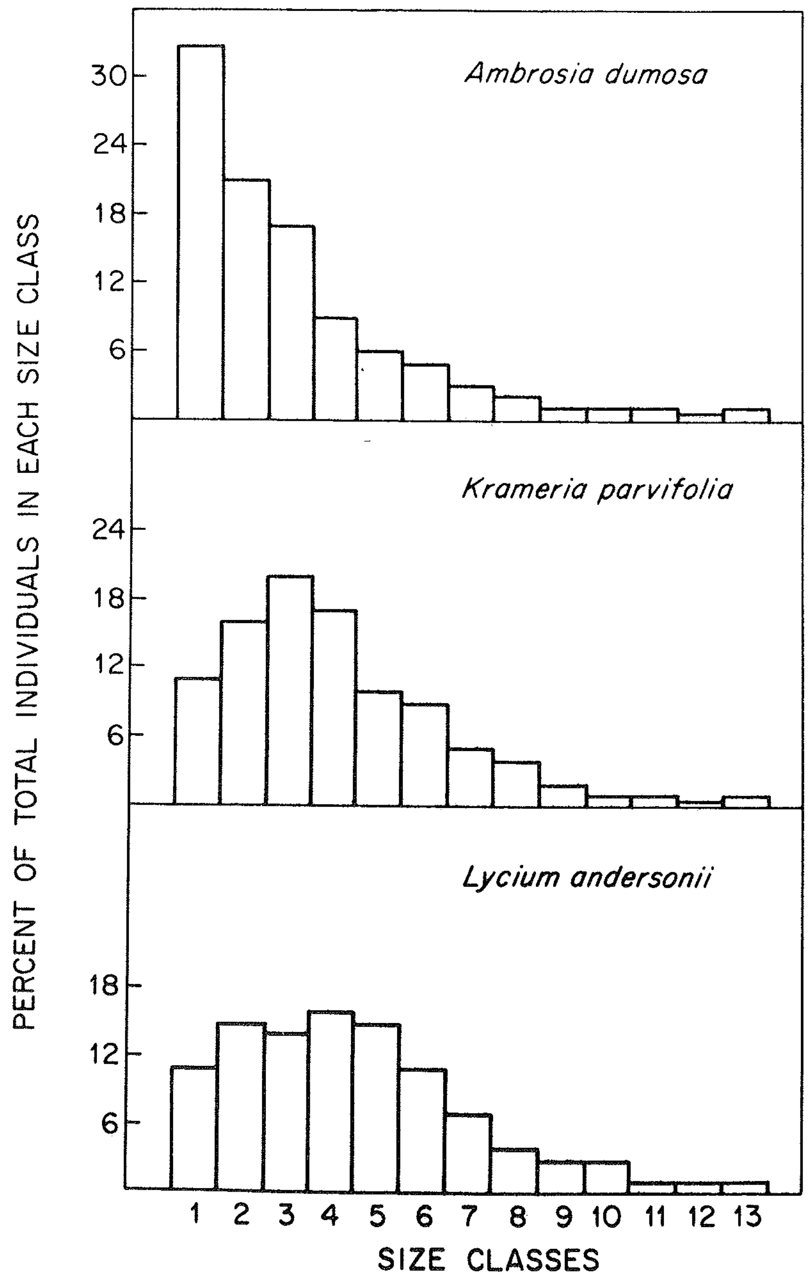

Figure 3. Size distributions of three shrub species based on live stem dry weights. Size class intervals are 43 g for *Ambrosia*, 38 g for *Krameria*, and 91 g for *Lycium*.

Table 19. Phenology of important perennials in Rock Valley during 1972

Species	Leaf bud	Leaf	Flower bud	Flower	Fruit	Seed fall	Leaf fall	Dormant
Atriplex confertifolia	Feb 8 Aug 24	Feb 15 Aug 28 Oct 11, 26	Mar 8	Mar 17	Apr 5	Sept 20	May 18	
Eurotia lanata	Feb 9	Feb 11 Oct 11. 26	Feb 18	Mar 8	Mar 24	Apr 20	May 1	
Ephedra nevadensis		Feb 18	Feb 18	Mar 18	Mar 27	May 18		
Ambrosia dumosa	Feb 14 Aug 19	Feb 17 Aug 26 Oct 12, 26*	Mar 15	Apr 16	Apr 21	May 7	May 8 Dec 10*	June 23
Grayia spinosa	Feb 11 Nov 10	Feb 18 Nov 20	Feb 20	Mar 4	Mar 10	Apr 15	Apr 26	May 28
Krameria parvifolia	Mar 8	Mar 14 Aug 26	Mar 27	Apr 13	Apr 29	May 28	July 18 Oct 9	Oct 30
Larrea divaricata		Mar 1 June 16 Aug 26 Sept 1 Oct 13	Mar 11 Nov 1	Apr 19	May 2	June 23	May 15 July 10	
Lycium andersonii	Jan 21 Feb 7 Aug 16 Oct 10	Feb 16 Oct 13, 26 Nov 21	Feb 25	Mar 9	Mar 14	May 18	Apr 28 May 11 Dec 10	May 28
L. pallidum	Jan 21 Feb 8 Aug 18	Feb 18 Oct 26	Feb 22	Mar 7	Mar 15	Apr 15	Apr 30 May 11	June 5

*paired together

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C. ARTHROPODS

1. PITFALL CAPTURES

Pitfall captures of arthropods are presumed to be reasonable measures of relative abundance when comparisons are based on equal trapping efforts. Eventually it may be possible to interpret pitfall captures in terms of absolute densities if appropriate 'calibration' studies are conducted. Until such time as these studies can be accomplished we suggest that the methods described in this report continue to be used to utilize data accumulated in Rock Valley. Pitfalls capture a diverse array of ground-dwelling arthropods, species which are often difficult to sample by other means. Table 1 lists the various groups trapped in Rock Valley during 1972. This list also indicates all groups taken in 1971. It will be seen that several more have been found in 1972 and that the species have been enumerated where determined. The entire body of these data, including additional information too lengthy to be treated here, have been transmitted to the Biome central office (A3UTJ30, A3UTJ31).

Arthropods were taken in pitfall traps in four areas during 1972: Plots 1 and 2, which are quadrants containing 100 traps each within the fenced 9-ha enclosures adjoining the validation site (see Fig. 1, p. 2.2.2.2.-9) and plots 11 and 12, which are 2.7-ha plots on the validation site -- each of 50 traps. When trapping was carried out in a grid the traps were opened on Wednesday morning, left open for 48 hours, and then inspected and closed. Arthropods were recorded and released (or, in some cases, preserved). Between March 6, 1972 (week 10), and September 23, 1972 (week 38), 11,200 trap nights (TN) were registered (3200 TN in Plot 1, 2400 TN in Plot 2, 2800 TN in Plot 11, and 2800 TN in Plot 12).

A relative density index (I) was calculated for all species with enough captures to be workable (a minimum of 25 individuals for the total season). These indices were calculated from the total number of captures (C) of a given species taken per 100 trap nights (TN) during the season. For each species, trap nights were counted only in the plots where the particular species being considered was abundant (n = 10+) and only for the period that the animal was active. The formula used for determining the index was:

$$I = \frac{C \times 100}{TN} \qquad (1)$$

For example, the tenebrionid beetle, *Edrotes orbus* was active only between May 6 (week 22) and cessation of sampling in September (week 38). Hence, it was susceptible to capture for only 2000 trap nights in plot 1, 1400 in plot 2, 1700 in plot 11, and 1500 in plot 12. During 1972, 178 of these beetles were taken in plots 1 and 2. The seasonal index was then calculated as follows:

$$I = \frac{178 \times 100}{3400} = 5.238$$

Table 2 summarizes basic can trapping data for 28 arthropod species (or species groups) in Rock Valley during 1971 and 1972. The Table indicates not only the total numbers trapped in both years and the associated relative density indexes (I), but also the periods of activity (or trapability) and the weeks of apparent maximum abundance. The selection of species in Table 2 was based on food habits and the apparent importance in Rock Valley. While those listed were classifed as predators, omnivores, herbivores, and scavengers, the preponderance of them are in the first two groups (42% predaceous, 32% omnivorous). It should be kept in mind that the omnivorous forms are also herbivorous part of the time, scavengers at other times, and not infrequently facultative predators. The omnivores seem to consume nearly anything that could serve as food. Again, however, it should be emphasized that the tables do not represent the total pitfall captures, but only those species with enough seasonal captures to be used (n = 25+ total in the plots analyzed).

The camel cricket, *Ceuthophilus fossor*, was most abundant in plot 1 (I = 1.11 for 1800 TN) and least abundant in plot 2 (I = 0.33 for 1200 TN). In 1972 the index for plots 11 and 12 was 0.851 for 4700 TN. The 1971 index for plots 11 and 12 was 0.841 for 4400 TN. In 1971 the trapping was not initiated until week 16 (April 16). Examination of 1972 trapping results verified our suggestion in the 1971 report that if trapping had begun earlier larger numbers of individuals would have been taken. More than 33 % of the total season catch was trapped before week 16 (in 6 weeks) while the remaining 67% were taken over the remaining season (until week 36, 21 weeks). The peak activity data from 1971 and 1972 may be biased. In 1971 the peak week (17) was only the second week of sampling effort and a peak could have been reached previously. The peak month of April (2nd week of effort) was nearly exceeded by June (4 weeks of effort) with 13 individuals trapped. In 1972, May was the peak month (even with week 21 lost) but it scarcely exceeded the catch for March (18). The peak week in 1972 was in March also (the first week of sampling). It should be emphasized that we obviously did not sample the entire population of this species because only about 10% of the individuals taken were immatures.

The desert cockroach, *Arenivaga* sp., has been included this year with the addition of the 1971 data as well. This cockroach is a secretive, nocturnal form, which should be classed as a scavenger with somewhat omnivorous habits. They have been observed to feed in the field on injured insects of their own or other species. The greater part of the diet is made up of dried plant material, particularly leaves and other less woody parts. This animal is encountered more frequently in the pitfalls in the middle to late summer period. It will be noted from Table 2 that the week of peak activity was nearly 4 weeks later in 1972 than in 1971. The numbers of individuals taken at the peak times was similar. No explanation for this can be offered here, but short-term climatic factors can be ruled out after examination of temperatures and precipitation data.

Table 1. List of arthropods collected in Rock Valley during 1971 and 1972. (The numbers 1 and 2 refer, respectively, to 1971 and 1972; other symbols are as follows: P - taken by pitfall, V - taken by D Vac, N - taken by net, S - taken by sweeping net, BL - taken with black light, WL taken by white light, R - reported in Rock Valley but not observed on study site).

Species	Pitfalls	Vacuum	Other
CHELICERATA			
Class ARACHNIDA			
Order Acarina			
Argasidae	P1		
Calyptostomidae			02
Erythraeidae		V1 V2	
Neophyllobiidae			02
Oribatidae			02
Tetranychidae	P1	V1 V2	
Trombiculidae			02
Order Pseudoscorpionida			02
Order Phalangida			
Phalangiidae			
Eurybunus riversi	P1 P2		
Order Solpugida			
Ammotrechidae	P1 P2		
Eremobatidae	P1 P2	V2	
Order Scorpionida			
Vejovidae			
Anuroctonus phaeodactylus	P1 P2		
Hadrurus spadix	P1 P2		
Hadrurus arizonensis	P1 P2		
Vejovis boreus	P1 P2		
Vejovis confusus	P1 P2	V1	
Vejovis becki	P1 P2		
Order Araneida			
Agelenidae			
Agelenopsis aperta	P1 P2		
Araneidae			
Metepeira gosoga		V2	
Caponiidae			
Orthronops gertschi	P1 P2		
Clubionidae			
Micaria gosiuta	P1 P2		
Syspira eclectica	P1 P2	V1 V2	
Ctenizidae			
Aptostichus stanfordianus	P2		
Dictynidae			
Dictyna personata	P2		
Diguetidae			
Digueta canities	P2		
Filistatidae			
Filistata utahana	P1 P2		
Gnaphosidae			
Herphyllus hesperolus	P1 P2		
Callilepis sp.	P1 P2		
Cesonia classica	P1 P2		
Homalonychidae			
Homalonychus theologus	P2		
Linyphiidae	P2	V2	
Loxoscelidae			
Loxosceles unicolor	P1 P2		

Continued

Table 1. (cont.)

Species	Pitfalls		Vacuum		Other
Lycosidae					
Pardosa ramulosa	P1	P2			
Geolycosa rafaelana		P2			02
Tarentula kochi		P2			
Schizocosa sp.	P1	P2			
Oxyopidae					
Oxyopes tridens	P1	P2	V1		
Pholcidae					
Psilochorus utahensis	P1	P2	V1	V2	
Plectreuridae					
Kibramoa paiuta	P1	P2			
Plectreurys tristis	P1	P2			
Salticidae					
Marpissa californica	P1	P2		V2	
Metacyrba sp.		P2			
Peckhamia sp.				V2	
Pellenes sp.	P1	P2	V1		
Phidippus sp.		P2		V2	
Habronattus agilis		P2		V2	
Theraphosidae					
Aphonopelma sp.	P1				01,02
Aphonopelma steindachneri	P1	P2			02
Theridiidae					
Achaearanea sp.	P1	P2	V1		
Latrodectus hesperus		P2			
Unknown gen. and sp.	P1	P2			
Thomisidae					
Ebo sp.	P1	P2	V1	V2	
Misumenops sp.	P1		V1	V2	
Apollophanes texanus	P1	P2	V1	V2	
Xysticus sp.		P2			
MANDIBULATA					
Class CRUSTACEA					
Order Isopoda					
Armadillidiidae					
Venezillo arizonicus	P1	P2		V2	
Class CHILOPODA					
Order Scolopendromorpha					
Scolopendridae					
Scolopendra michelbacheri	P1	P2			
Class DIPLOPODA					
Order Spirobolida					
Atopetholidae		P2			
Class INSECTA					
Apterygota					
Order Collembola					
Poduridae			V1		
Sminthuridae	P1	P2	V1	V2	
Entomobryidae			V1	V2	
Order Thysanura					
Lepismatidae		P2			
Pterygota					
Order Orthoptera					

Continued

Table 1. (cont.)

Species	Pitfalls	Vacuum	Other
Acrididae	P1 P2	V1 V2	
Aeolopides tenuipennis		V2	
Ageneotettix sp.		V2	
Bootettix punctata		V1 V2	
Cibolacris parviceps			O2,R
Eremiacris pallida		V1	
Ligurotettix coquilletti	P1	V1 V2	
Melanoplus complanatipes		V2	
Poecilotettix sanguineous			O1,O2,R
Trimerotropis pallidipennis		V1 V2	
Gryllacrididae			
Ceuthophilus fossor	P1 P2		
Gryllidae			
Acheta assimilis	P1 P2		
Cycloptilum comprehenduns	P1 P2		
Mantidae			
Litaneutria minor	P1 P2	V1 V2	N1,N2,BL
Stagmomantis californicus		V2	N2
Phasmidae			
Parabacillus hesperus		V1 V2	
Polyphagidae			
Arenivaga erratica	P1 P2		
Eremoblatta subdiaphana			O1
Tanaoceridae			
Tanaocerus koebeli	P1 P2	V1 V2	O1,O2
Tettigoniidae			
Anoplodusa arizonensis		V1	
Ateloplus luteus		V1	
Capnobotes fulginosus	P1 P2		
Insara covilleae		V1 V2	
Insara elegans		V1 V2	
Order Isoptera			
Termitidae	P1 P2		
Order Psocoptera			
Liposcelidae		V1	
Psocidae		V1 V2	
Psyllipsocidae		V1	
Order Embioptera			
Oligotomidae	P2		
Oligotoma corona-rubra	P2		
Order Odonata			
Libellulidae			O1,O2
Order Thysanoptera			
Heterothripidae		V2	
Thripidae		V1 V2	
Frankliniella minuta		V1 V2	
Phloeothripidae		V1 V2	
Leptothrips mali	P1	V1 V2	
Order Hemiptera			
Anthocoridae	P1	V1 V2	
Coreidae	P1 P2		
Corimelaenidae	P1 P2		
Cydnidae			
Pangaeus congruus	P1		
Lygaeidae			
Nysius ericae	P1 P2	V1 V2	
Geocoris pallens		V1	

Continued

Table 1. (cont.)

Species	Pitfalls	Vacuum	Other
Miridae	P1 P2	V1 V2	
Clivinema sp.	P2	V1 V2	
Phytocoris candidus		V1 V2	
Phytocoris nigripubescens		V1 V2	
Slaterocoris sp.	P2	V2	
Stittocapsis franseriae		V2	
Nabidae			
Nabis sp.	P1	V2	
Pentatomidae			
Chlorochroa sayi	~~P2~~		
Dendrocoris contaminatus			01,02
Chlorochroa sayi	P2	V1 V2	
Thyanta pallido-virens	P1 P2	V2	
Phymatidae			
Macrocephalus sp.	P2	V1 V2	
Ploiariidae		V2	
Reduviidae	P1 P2		
Zelus sp.	P1 P2		
Rhopalidae			
Harmostes fraterculus		V1 V2	
Tingidae			
Corythuca sp.		V1 V2	
Order Homoptera			
Acanaloniidae			
Acanalonia mollicula		V1 V2	
Achilidae	P1		
Aleyrodidae	P2	V1 V2	
Aphidae		V1	
Cercopidae		V1	
Cicadellidae	P1 P2	V1 V2	
Dixianus utahensis	P2	V1 V2	
Lycioides loculatus	P2	V1 V2	
Spathanus excavatus	P2	V1 V2	
Scaphytopius torridus		V1	
Scaphytopius nigricollis		V1 V2	
Stragania sp.		V1 V2	
Acerataglia sp.		V1 V2	
Acerataglia cinerea		V1 V2	
Ballana sp.		V1	
Cicadidae			01,02
Cixiidae	P2	V2	
Coccidae		V1 V2	01
Delphacidae		V2	
Diaspidae			01,02
Dictyopharidae	P1	V1 V2	
Scolops sp.	P1		
Flattidae	P1		
Mistharnophantia sonorana		V1	
Ormensis infuscata		V1 V2	
Fulgoridae		V2	
Issidae			
Hysteropterum sp.	P2	V1 V2	
Lacciferidae			01,02

Continued

Table 1. (cont.)

Species	Pitfalls		Vacuum		Other
Margarodidae				V2	
Membracidae	P1	P2	V1	V2	
Centrodontus atlas	P1	P2	V1	V2	
Multareis cornutus			V1	V2	
Multareoides bifurcatus			V1	V2	
Phylloxeridae			V1		
Pseudococcidae	P1		V1	V2	
Psyllidae			V1	V2	
Order Neuroptera		P2	V1	V2	
Chrysopidae		P2	V1	V2	
Hemerobiidae			V1	V2	
Myrmeleontidae	P1	P2	V1	V2	
Order Lepidoptera					
Aegeriidae				V2	
Alucitidae			V1		
Arctiidae		P2			
Blastobasidae		P2	V1	V2	
Coleophoridae		P2	V1	V2	
Coleophora sp.			V1		
Cosmopterygidae			V1	V2	
Gelechiidae		P2	V1	V2	
Anacampsis sp.			V1	V2	
Unknown gen. & sp.			V1	V2	
Geometridae					
Semiothisa sp.	P1	P2	V1	V2	
Unknown gen. & sp.		P2		V2	
Glyphipterygidae	P1	P2	V1		
Gracillariidae		P2	V1	V2	
Heliozeiidae					
Coptodisca sp.	P1				
Lasiocampidae					
Malacosoma fragilis			V1		
Liparidae		P2			
Lyonetiidae		P2	V1	V2	
Olethreutidae			V1	V2	
Phalaenidae		P2	V1	V2	
Plutellidae				V2	
Psychidae					
Thyridopteryx meadei		P2	V1	V2	
Pterophoridae	P1	P2	V1	V2	
Pyralidae		P2	V1	V2	
Saturniidae					
Hemileuca nevadensis					O1,O2
Sphingidae					
Hyles lineata					BL1,BL2,O1,O2
Stenomidae				V2	
Tineidae	P1		V1		
Tortricidae		P2		V2	
Yponomeutidae	P1	P2	V1	V2	
Order Hymenoptera					
Andrenidae		P2	V1		
Apidae	P1		V1	V2	
Argidae			V1		

Continued

Table 1. (cont.)

Species	Pitfalls	Vacuum	Other
Bethylidae		V1 V2	
Braconidae	P2	V1 V2	
Chalcididae	P2	V1 V2	
Cynipidae		V1 V2	
Dryinidae	P2	V1 V2	
Encyrtidae		V1 V2	
Eulophidae		V1 V2	
Eupelmidae		V1 V2	
Eurytomidae		V1 V2	
Figitidae		V1 V2	
Formicidae			
Aphaenogaster megommatus	P1	V1 V2	
Camponotus hyatti			R
Crematogaster depilis	P2		
Crematogaster mutans	P1	V1 V2	
Crematogaster nocturna	P1	V1	
Leptothorax sp.	P2	V1 V2	
Leptothorax nitens		V1	
Myrmecocystus flaviceps	P1	V1	
Myrmecocystus lugubris	P1 P2	V1 V2	
Myrmecocystus koso	P1 P2		
Myrmecocystus n. sp. 1	P1 P2	V1 V2	
Myrmecocystus mexicanus			R
Myrmecocystus n. sp. 2	P1 P2		
Iridomyrmex pruniosus	P1 P2	V1 V2	
Pheidole desertorum	P1 P2	V1 V2	
Pheidole bicarinata	P1	V2	
Veromessor pergandei	P1 P2	V1	
Pogonomyrmex californicus	P1 P2	V1	
Pogonomyrmex rugosus	P1 P2		
Solenopsis molesta			R
Halictidae		V1 V2	
Ichneumonidae	P2	V1 V2	
Ophion sp.	P2	V1 V2	
Unknown gen.		V1 V2	
Megachilidae	P2		
Mutillidae	P1		
Dasymutilla sp.	P1 P2		
Photopsis sp.	P1 P2	V1 V2	
Sphaeropthalma sp.	P1 P2	V1 V2	
Mymaridae		V1 V2	
Pamphilidae		V1	
Platygasteridae			
Platygaster sp.		V1 V2	
Inostema sp.		V1	
Pompilidae	P1		
Proctotrupidae		V1	
Pteromalidae		V1 V2	
Perilampidae		V2	
Scelionidae		V1	
Sphecidae	P1 P2	V2	
Tanaostigmatidae		V2	
Tiphiidae	P1 P2	V1 V2	
Torymidae	P1	V1 V2	

Continued

Table 1. (cont.)

Species	Pitfalls	Vacuum	Other
Trichogrammatidae		V1 V2	
Vespidae	P2	V2	
Vespula pennsylvanica		V2	
Order Diptera	P1 P2	V2	
Anisopodidae		V1	
Anthomyidae		V1	
Asilidae			
Efferia benedicti		V2	N2
Efferia staminea		V2	
Efferia sp.	P2	V1 V2	N2
Unknown gen.	P1	V2	
Bibionidae		V1	
Bombyliidae	P1 P2	V1 V2	
Aphoebantus sp.	P1 P2		
Lordotus sp.		V2	N2
Mythicomyia sp.	P1 P2	V1 V2	
Calliphoridae	P1		
Cecidomyidae	P2	V1 V2	
Asphondylia sp.	P1	V2	
Unknown gen.			02
Ceratopogonidae		V2	
Chironomidae		V1 V2	
Chloropidae		V1 V2	
Dolichopodidae		V1 V2	
Drosophilidae		V1	
Empididae		V1	
Helomyzidae		V1 V2	
Lonchaeidae		V1	
Muscidae		V1 V2	
Mydidae			N2,02
Pseudomoneura californica			
Unknown gen. and sp.			N2
Otitidae		V2	
Piophilidae		V1 V2	
Pipunculidae		V2	
Sarcophagidae	P2	V1 V2	
Scatopsidae		V2	
Sepsidae		V1	
Simuliidae		V1	
Syrphidae		V1 V2	
Pyritis sp.			N2
Tachinidae	P1 P2	V2	
Tephritidae		V1 V2	
Therevidae	P2	V1 V2	
Tipulidae		V1	
Order Coleoptera			
Anobiidae		V1	BL1,BL2
Buprestidae			
Acmaeodera sp.		V2	
Unknown gen.		V2	
Carabidae	P1 P2		
Calosoma sp.	P2		

Continued

Table 1. (cont.)

Species	Pitfalls		Vacuum		Other
Carabidae (cont.)					
Harpalus sp.	P1				
Lebia sp.		P2			
Pterostichus sp.		P2			
Cerambycidae				V2	
Moneilema semipunctatum	P1	P2			
Chrysomelidae	P1	P2	V1	V2	
Chaetocnema sp.				V2	
Monoxia sp.		P2	V1	V2	
Octatoma sp.			V1	V2	
Pachybrachis sp.			V1	V2	
Diplocapsis sp.			V1		
Trirhabda sp.			V1		
Cicindelidae					
Cicindela sp.					BL1
Cleridae	P1	P2	V1	V2	
Cymatodera sp.		P2		V2	
Trichodes inornata					01,02
Phyllobaenus sp.			V1	V2	
Coccinellidae		P2	V1	V2	
Hippodamia convergens		P2	V1	V2	
Hippodamia parentheses			V1		
Hyperapsis sp.			V1	V2	
Curculionidae					
Apion albidulum				V2	
Anthonomus tenuis					01,02
Cylindrocopturus sp.			V1		
Dinocleus farctus	P1				
Minyomerus sp.	P1	P2	V1	V2	
Eucyllus vagans	P1	P2	V1	V2	
Eucyllus unicolor	P1	P2			
Neocercopedius sp.		P2		V2	
Miloderes mercuryensis	P1	P2			
Smicronyx imbricata		P2	V1	V2	
Ophryastes gemminatus		P2			
Ophryastes varius	P1	P2	V1	V2	
Brachyogonus ornatus			V1	V2	
Cybocephalidae					
Cybocephalus californicus			V1	V2	
Dermestidae				V2	
Elateridae	P1	P2			
Horistonotus sp.	P1	P2		V2	BL1,BL2
Heteroceridae					BL1,R
Histeridae					
Saprinus sp.		P2			
Leptodiridae	P1				
Ptomaphagus sp.			V1		
Meloidae					
Cysteodemus armatus					02
Lytta sp.		P2			
Melyridae					
Asydates sp.			V1	V2	
Listrus sp.			V1	V2	
Malachius sp.		P2	V1	V2	
Trichochrous sp.			V1		
Melyrodes sp.		P2	V1	V2	

Continued

Table 1. (cont.)

Species	Pitfalls		Vacuum		Other
Nitidulidae					
Carpophilus hemipterus	P1	P2			
Oedemeridae				V2	02
Ostomidae			V1		
Phalacridae			V1		
Scarabaeidae					
Aphodius sp.		P2			BL1,BL2
Chnaunanthus flavipennis		P2		V2	
Bothynus sp.					BL1,BL2
Cyclocephala longula		P2			BL1,BL2
Diplotaxis moerens	P1	P2			
Diplotaxis subangularis	P1	P2			BL1,BL2
Paracotalpa granicollis		P2			01
Phyllophaga sociatus	P1	P2	V1	V2	BL1,BL2
Cremastocheilus sp.	P1				N1,N2
Silphidae	P1				
Staphylinidae			V1	V2	
Tenebrionidae	P1	P2	V1	V2	
Alaephus nevadensis	P1	P2	V1		
Anepsius brunneus	P1	P2	V1		
Araeoschizus sulcicollis	P1	P2			
Blapstinus pubescens	P1				
Bothrotes sp.					WL
Asidina semilaevis	P1	P2			
Auchmobius subboreus	P1	P2			
Centrioptera muricata	P1	P2			
Chilometopon abnorme	P1				
Conibiosoma elongatum	P1	P2		V2	
Coniontis nevadensis		P2			
Cryptoglossa verrucosa	P1	P2			
Edrotes orbus	P1	P2			
Eleodes armata	P1	P2			
Eleodes dissimilis	P1	P2			
Eleodes extricata		P2			
Eleodes grandicollis	P1	P2			
Eusattus agnatus	P1				R
Eusattus dubius	P1	P2		V2	
Eupsophulus castaneus	P1	P2	V1		BL1,BL2
Euschides luctata	P1				
Helops attenuatus					BL1
Helops sp.					S2
Metoponium convexicolle	P1	P2	V1	V2	
Notibius substriatus	P1				
Philolithus pantex	P1	P2			
Trogloderus costatus	P1	P2			
Triorophus laevis	P1	P2	V1		
Trichiasida acerba		P2			01,02
Sphaeriontis dilatata	P1				

Table 2. Pitfall trapping data relating to selected arthropods in Rock Valley during 1971 (upper lines for each species) and 1972 (numbers in parentheses refer to numbers trapped during week of peak activity)

Taxa	Plots	Total trapped	Weeks active	Week of peak activity	Trap nights (hundreds)	Relative index, I
Orthoptera						
Ceuthophilus fossor	11, 12	37	16 - 38	17 (10)	44	0.841
		40	10 - 36	10 (14)	47	0.851
Arenivaga sp.	All 4	39	21 - 38	29 (9)	66	0.591
		48	11 - 38	32 (10)	78	0.615
Hemiptera						
Zelus sp.	All 4	67	19 - 37	25 (13)	62	1.081
		51	10 - 32	20 (8)	74	0.689
Coleoptera						
Anepsius brunneus	1, 2	37	21 - 36	28 (5)	30	1.233
		63	11 - 32	24 (10)	44	1.432
Araeoschizus sulcicollis	All 4	187	16 - 38	24 (21)	86	2.174
		279	10 - 38	26 (24)	112	2.491
Auchmobius subboreus	All 4	13	28 - 36	31 (5)	28	0.464
		28	23 - 35	25 (8)	33	0.848
Asidina semilaevis	2, 11, 12	67	32 - 38	34 (27)	18	3.722
		56	32 - 36	33 (40)	12	4.667
Centrioptera muricata	11, 12	81	20 - 37	29 (16)	36	2.250
		84	14 - 35	22 (22)	38	2.211
Coniobiosoma elongatum	All 4	53	16 - 38	28 (10)	74	0.716
		59	10 - 34	31 (6)	83	0.711
Cryptoglossa verrucosa	11, 12	109	19 - 38	29 (33)	40	2.725
		95	12 - 32	30 (13)	40	2.375
Edrotes orbus	1, 2	80	24 - 38	31 (36)	30	2.667
		178	22 - 38	27 (41)	34	5.235
Eleodes armata	All 4	56	17 - 38	36 (15)	78	0.718
		61	10 - 38	38 (10)	81	0.753
Eusattus dubius	1, 2	11	17 - 27	19 (3)	16	0.688
		47	11 - 22	11 (9)	22	2.136
Metoponium convexicolle	All 4	17	16 - 34	28 (3)	44	0.386
		43	14 - 36	22 (13)	56	0.768
Triorophus laevis	11, 12	201	16 - 34	29 (37)	36	5.583
		66	13 - 32	-	35	1.886
Trogloderus costatus	11, 12	174	16 - 38	37 (52)	44	3.955
		123	17 - 36	35 (26)	38	3.237
Spiders						
Apollophanes texanus	All 4	18	-	17 (3)	-	-
		91	10 - 32	19 (27)	45	2.022

Continued

Table 2. (cont.)

Taxa	Plots	Total trapped	Weeks active	Week of peak activity	Trap nights (hundreds)	Relative index, I
Herphyllus hesperolus	All 4	25	-	-	-	-
		47	10 - 37	23 (6)	70	0.671
Marpissa californica	All 4	12	-	31 (3)	-	-
		72	10 - 32	18 (15)	44	1.635
Loxosceles unicolor	1, 2	28	21 - 38	no peak	44	0.636
		38	11 - 38	"	44	0.864
Psilochorus utahensis	All 4	420	16 - 38	33 (61)	88	4.770
		797	11 - 38	23 (94)	106	7.515
Syspira eclectica	All 4	85	19 - 37	24 (9)	70	1.215
		100	16 - 38	20 (15)	78	1.282
Solpugids	All 4	44	16 - 38	-	78	0.565
		77	12 - 38	-	94	0.835
Scorpions						
Hadrurus arizonicus	11, 12	35	19 - 37	32 (9)	38	0.921
		36	20 - 36	29 (6)	31	1.162
H. spadix	1, 2	10	19 - 33	-	10	1.000
		13	20 - 36	37 (4)	12	1.083
Vejovis sp.	All 4	100	17 - 38	28 (12)	78	1.282
		76	10 - 38	33 (7)	72.5	1.050
Centipede						
Scolopendra michelbacheri	All 4	50	16 - 37	31 (12)	78	0.641
		51	10 - 38	32 (6)	80	0.638
Isopod						
Venezillo arizonicus	All 4	275	16 - 38	31 (13)	82	3.353
		360	12 - 38	33 (50)	100	3.600

The assassin bug, *Zelus* sp., is also a new addition this year. This insect usually forages over the vegetation to prey upon soft-bodied forms found there. Why it is taken almost exclusively in pitfall traps is unknown. It is one of the more aggressive and larger predatory insects. Not only does it directly destroy large numbers of soft-bodied forms, but it also causes increased mortality with a sticky coating of a mucilaginous material to which minute sap-sucking insects adhere and die. *Zelus* demonstrated no plant preference and cannot be related to the destruction of any particular group of arthropods on any species of plant. Its week of peak activity in 1971 (25) and 1972 (20) illustrates a phenomenon noted in many species taken in the pitfalls, as well as by vacuuming, viz., that the 1972 peaks were frequently four weeks earlier than corresponding highs in 1971. We judge this to be associated with the generally higher spring temperatures in 1972 (see Fig. 12 in section A.3) and possibly with the earlier flowering of shrubs described in the preceding section.

The remaining insects in Table 2 are tenebrionid beetles. Several additions have been made to the 1971 list. Most of the 1971 omissions were due to uncertainties as to methods by which the data could be analyzed or to lack of recaptures of marked specimens. In 1972 the trapping results changed the picture and several of those forms not listed in 1971 contributed significantly to the numbers and biomass per hectare in 1972.

Araeoschizus sulcicollis, an ant associate, was encountered every week of the 1972 trapping season. As in 1971 this beetle was less common in plot 1 than in any other plot (only about 9% of all taken in 1971 and about 15% of the 1972 total were captured in plot 1). May was the peak month for 1972 activity (with week 21 missing); the 1971 peak was in mid-June (week 24).

Asidina semilaevis appears to be one of the important tenebrionids in Rock Valley. Unfortunately we do not obtain the full picture of this species since trapping is discontinued only 8 weeks after its initial appearance each year. It does not appear in the traps before week 31 (first week in August). In 1971 and 1972, though, the peaks apparently came before trapping was discontinued. The population builds up swiftly then begins to drop almost as rapidly, with the largest numbers encountered approximately three weeks after first appearance.

Auchmobius subboreus has been included this year primarily to demonstrate how a population can fluctuate from year to year. The 1972 take was more than twice that of 1971. Again there was a significant advance (5 weeks) in the time of first appearance. A striking increase in numbers captured in 1972 is also apparent in *Edrotes orbus* and *Eusattus dubius*. As yet we have been unable to determine the reason for these changes. The peak activity week was 5-6 weeks earlier in these three species. *Eusattus* is an early season form but *Edrotes* is active later in the year. Captures of other tenebrionids remained about the same, e.g., *Centrioptera muricata, Conibiosoma elongatum, Eleodes armata,* and *Metoponium convexi-*

colle. Still others were apparently reduced in numbers: *Triorophus laevis* and *Trogloderus costatus*.

The peak activity periods for 1972 are somewhat deceiving for at least five species: *Conibiosoma elongatum, Metoponium convexicolle, Eleodes armata, Eusattus dubius* and *Trogloderus costatus*. The first two do not have a real peak week of activity. While six *Conibiosoma* were captured in week 31, two weeks in May (18, 20) each had catches of five. Had week 21 not been lost there is an excellent probability that the month of May would have been the peak month, and brought this animal in line with the following species. Data for *Metoponium convexicolle* were similar. If week 22 is excluded, the take for each of 9 other weeks were ± 1 individual of each other in the total catch. Both of these species have their periods of activity associated with the flowering of desert shrubs.

Eusattus dubius, Eleodes armata and *Trogloderus costatus* data are influenced by the seasonality of each form. *Eusattus* is an early species and the individuals trapped were from a declining population. *Eleodes armata* and *Trogloderus costatus* are late season species and their numbers were increasing when trapping was suspended. Peak numbers of *Eleodes armata* (Table 2) were taken during September in both 1971 and 1972, but in 1972 the number taken was 52% lower, indicating that the peak had not yet been reached. This late season activity has been previously noted by Allred et al. (1963). Rock Valley is near the northern extent of the range of this species, in *Larrea-Ambrosia* habitats (Tanner & Packham, 1965), and this probably explains the low densities there. *E. armata* is a nocturnal (occasionally cloudy day) forager. It was encountered in Rock Valley pitfalls from the first week of March through the last week in November. In study areas at Joshua Tree National Monument it has been taken by this method every month of the year at similar elevations. It has been found to live as long as three years there (from mark-release-recapture studies, Sleeper 1958-63, unpubl.). *Trogloderus costatus* is also present through most of the trapping season, but reaches its peak population in the last weeks of effort or later. This assumption is based on the fact that numbers taken were increasing during September in 1971 and 1972. Here again the total take during September, 1972, was down (only 34% of 1971). Both of these species are part of the mark-release-recapture program and were not removed from their respective sites of capture.

Several of the tenebrionid beetles have definite preferences for specific soil types, and this may be an indication of soil moisture requirements. In 1972 four species, *Cryptoglossa verrucosa* (96%), *Trogloderus costatus* (89%), *Triorophus laevis* (84%), and *Centrioptera muricata* (82%) were almost exclusively limited to the much finer, sandier soils of plots 11 and 12 on the validation site. Three species, *Anepsius brunneus* (97%), *Edrotes orbus* (83%), and *Eusattus dubius* (84%), were taken almost invariably on the coarser, gravelly soils of plots 1 and 2. Similar trends were seen for these species in 1971.

Table 2 also lists 12 other arthropods encountered frequently in the pitfalls in Rock

Valley. Eleven of these are predaceous and one is an omnivorous feeder (the sowbug, *Venezillo arizonicus*). Six of the eleven predators are spiders, three are scorpions. The general increase in the predatory forms can probably be credited to the higher densities of prey species (mostly phytophagous).

It was generally found that the total scorpions in Rock Valley increased in 1972, but the species occuping plots 11 and 12 were different. The relative indexes of both *Hadrurus arizonensis* and *H. spadix* increased over the 1971 level, but that of *Vejovis becki* declined. There was a distinct increase in the numbers of *Anuroctonus phaeodactylus* taken in 1972. This scorpion seems to prefer finer soils, and 90% were taken from plots 11 and 12. There were no specimens taken in plot 1 in either 1971 or 1972. September was the month of highest abundance of *Anuroctonus* in both years. However the peak week was 3 weeks earlier in 1972 (week 35). *Hadrurus arizonensis* peaked about 3 weeks earlier (July) in 1972 while *H. spadix* was about three weeks later in 1972 than 1971. These two species are probably not in competition with each other since the former seems to prefer the finer sandier soils and the latter the coarser gravelly soils. *Vejovis* sp. was the most frequently encountered of our scorpions. For *Vejovis* the peak months remained the same but the peak week in 1972 was five weeks later.

Among the spiders there are some perplexing problems. Why was *Loxosceles unicolor* limited almost entirely to plots 1 and 2 (1971 = 84%, and in 1972 = 92% of those trapped), while all other species of spiders are generally distributed over the entire area? Why did *Loxosceles* not have a peak period, occurring instead at roughly the same level all season? Why the sudden increase in the numbers of *Psilochorus utahensis* trapped in 1972 relative to 1971? Its peak in 1972 did correspond to those of several soft-bodied shrub-dwelling forms (see D-Vac section). However, nothing is known of the feeding habits of *Psilochorus*. Some comments on other spiders follow.

Apollophanes texanus - In 1972 about five times as many individuals were captured as in 1971.

Herphyllus hesperolus - In 1971 there was no peak period. Many of the weeks throughout the sampling season had the same trapability value. In 1972 this picture did not appear to change but many more individuals were taken in week 23 (June 4-10). This was probably due to the high prey activity in weeks 19-24. Even though the peak week fell in June the peak month was September with 20% more than June and with one sampling week absent. There were about twice as many captured in 1972 than in 1971.

Marpissa californica - In 1972 the peak week (18) was in May. May was also the peak month with 17% more than the next largest, even though data for one sampling week were absent.

Loxosceles unicolor - There was no definite peak in either 1971 or 1972 for this spider. The 1972 population level was about the same as that observed in 1971. In 1972 there was a tendency toward a peak in August (monthly index or m.i. = 1.833) while in 1972 this peak occurred in September (m.i. = 2.166) -- one month later.

Psilochorus utahensis - In 1971 and 1972 this species had definite peaks. The 1971 peak week exceeded the next largest by 44%; 1972 by 33%. In both years the peak week and month coincided. The apparent density of this species increased, as did most other spiders.

Syspira eclectica - In 1971 this spider did not demonstrate an obvious peak abundance. Week 24 was designated as the peak week, but at least 3 other weeks (23, 34 & 21) were within 2% of that week. May was designated as the month of greatest abundance (m.i. = 2.00) but it was closely followed by June (m.i. = 1.75) and August (m.i. = 1.50). In 1972 the densities fit a more conventional pattern with May the peak and a week in May the peak week. No other month or week was within 5% of the month of May and week 20. No sampling was undertaken in week 21. The apparent abundance of this spider in 1972 was essentially the same as that of 1971.

We have so far been unable to determine the sun spiders (or Solpugida) to below the family level. This is due to the large number of juvenile forms encountered. For this reason we have treated them at the family level, even though this is fraught with danger in a group with such different specific habits and behavior. In 1971 and 1972, activity in plots 11 and 12 was much greater than in plots 1 and 2. In general the activity in plots 11 and 12 was the same (1971 = 0.75 & 0.76 respectively; 1972 = 1.18 in both) while that in plots 1 and 2 were from one-half to one-third that level. In plots 11 and 12 the 1972 level was nearly two times that of 1971, while plot 1 was up 1.5 times and plot 2 up 1.3 times. In 1971 there was no clear-cut peak period although abundance was up during the last weeks of July and early weeks of August, and more were taken per trap night in the latter than in any other month. During 1972 the peak activity period shifted to the month of May with all other months at least 30% lower. The peak week fell near the end of May. Like many other predators the sun spiders are general feeders on nearly any group of arthropods they encounter.

Scolopendra michelbacheri is apparently the only centipede in Rock Valley. It never reaches the abundance of any of the other large predators. The 1972 abundance was about the same as that observed in 1971. In 1971 these centipedes were most frequently encountered during the last two weeks of July and the first week of August, with the latter the peak week. In 1972 the largest numbers were encountered in March (m.i. = 0.69) and August (m.i.= 0.75). No definite week could be specified as the peak week of activity. The size range of this species--even in the adult stage--leads to difficulty in biomass evaluation.

The sowbug, *Venezillo arizonicus*, is the major omnivore (scavenger) among the non-insect

groups in Rock Valley. In both years sowbugs were most abundant in August. However the peak week in 1972 was two weeks later (week 33). We found that this species apparently prefers plots 11 and 12. The abundance in plot 12 in 1972 was 2.1 times that of plot 1 and 1.7 times that of plot 2 (plot 11 was 1.5 times plot 1 even though these plots have somewhat similar plant compositions).

Data pertaining to five species of tenebrionid beetles (*Asidina semilaevis, Centrioptera muricata, Cryptoglossa verrucosa, Eleodes armata,* and *Trogloderus costatus*) were examined in terms of capture-recapture analysis. Proportions of individuals recaptured were invariably low. The procedure followed was that described by Overton and Davis (1969), with which population size (N) is estimated from frequencies of captures of marked beetles:

$$N = \frac{n}{1 - (n/t)} \qquad (2)$$

Here, n is the total number of individuals captured and t is the total number of captures (i.e., all initial captures and recaptures combined). Densities of five species of beetles in both 1971 and 1972 were estimated in this manner. We also calculated the relationship between the estimated densities (D) and the trapping indexes (I). Table 3 gives values of n and t for five species of beetles, the areas of reference, the corresponding density estimates, and values of D/I. The D/I ratios represent a tentative step in the direction of relating can trap capture success to absolute numbers. We recognize that the estimates of both D and I have been influenced by numerous variables, so that it is hard to judge the utility of a jointly derived scaling factor. In spite of this problem we have used two of these scaling factors to estimate densities of seven other tenebrionids for which no capture-recapture data were available (Table 4). This was done by matching each of these seven species with the most appropriate "model" in terms of feeding behavior and general patterns of activity (and presumed trapability). Densities of *Anepsius brunneus, Auchmobius subboreus, Coniobiosoma elongatum, Eusattus dubius, Metoponium convexicolle* and *Triorophus laevis* during 1971 and 1972 were estimated by multiplying respective values of I by the scaling factors (D/I) derived for *Centrioptera muricata*. The density of *Edrotes orbus* was based on scaling factors derived for *Cryptoglossa verrucosa*. No suitable model was available for *Araeoschizus sulcicollis*. We stress that the estimates for *Trogloderus* and *Eleodes armata* are undoubtedly low because these beetles are increasing in numbers at the time that sampling is suspended in the fall.

Table 3. Capture-recapture data, estimated densities, and ratios of density (D) to relative trapping indexes (I) for five species of tenebrionid beetles in Rock Valley during 1971 and 1972

Species	Plots	Combined area of plots (ha)	Year	n	t	Density, D (n/ha)	D/I
Asidina semilaevis	2, 11, 12	3.82	1971	67	70	410	110.16
			1972	56	58	426	91.28
Centrioptera muricata	11, 12	1.60	1971	81	96	324	144.00
			1972	84	100	328	148.35
Cryptoglossa verrucosa	11, 12	1.60	1971	109	125	532	195.23
			1972	95	102	865	364.21
Eleodes armata	1, 2, 11, 12	6.10	1971	56	62	95	132.31
			1972	61	66	132	175.30
Trogloderus costatus	11, 12	1.60	1971	87	92	1000	252.84
			1972	73	76	1155	356.81

Table 4. Estimated densities of seven species of tenebrionid beetles in Rock Valley during 1971 and 1972

Species	Plots	Year	I	D (n/ha)
Anepsius brunneus	1,2	1971	1.233	178
		1972	1.432	212
Auchmobius subboreus	All 4	1971	0.464	67
		1972	0.848	126
Coniobiosoma elongatum	All 4	1971	0.716	103
		1972	0.711	105
Edrotes orbus	1,2	1971	2.667	521
		1972	5.235	1907
Eusattus dubius	1,2	1971	0.688	99
		1972	2.136	317
Metoponium convexicolle	All 4	1971	0.386	56
		1972	0.768	114
Triorophus laevis	11,12	1971	5.583	804
		1972	1.886	280

C.2. VACUUMING SAMPLES

Vacuum collections were made at preplanned daily intervals. Usually at least ten samples were made each day. Periodically (every 14th day) samples were taken at 4-hr intervals during a 24-hr period. Sampling extended over a period of 29 weeks during 1972 (A3UTJ34)and A3UTJ35). During this time 1096 shrubs were vacuumed: 160 in plot 1, 110 in plot 2, 574 in plot 11 (of these 314 were in the course of the 24-hour sampling), and 252 in plot 12. Sampling was distributed among the shrub species in accordance to their relative importance as follows: *Ambrosia dumosa* (15%), *Larrea divaricata* (25%), *Lycium andersonii* (25%), *Ephedra nevadensis* (10%), *Lycium pallidum* (2%), *Grayia spinosa* (6%), *Krameria parvifolia* (15%), *Acamptopappus schockleyi* (1%), and *Eurotia lanata* (1%). In plot 12 effort was slightly modified to allow for different plant densities. There the *Lycium andersonii* was switched with *Lycium pallidum* because of the higher density of the latter, and *Atriplex confertifolia* replaced *Acamptopappus*. The effort expended on the other plants in each plot remained the same throughout all plots.

Over 197 kinds of arthropods were taken by vacuuming in 1972 in contrast to the 194 taken in 1971 (Table 1). Of these, 93 (47%) were determined to genus only and 57 (29%) to species. Most of the specimens allocated to families or orders were immature stages or mites. All punched IBM cards with the actual numbers of specimens of each species in each sample, along with time of collection and meteorological information, have been transmitted to the Biome central office.

In this report we discuss species of apparent importance in the plant community. These species may be consumers of leaves, flowers, stems or sap. Importance was evaluated by considering i) apparent densities, ii) reproductive potential (occasionally inferred from that of very closely related species), iii) relative importance of the host shrub (or in the case of predators and parasites, the prey's importance to the host shrub) upon which the species subsisted, and iv) the types and amount of plant material consumed. For instance a relatively uncommon species might be a major defoliator of an important shrub and hence more important than a species whose massive numbers are rather unimportant as consumers. Table 5 gives the estimated densities of the shrub species from which arthropods were vacuumed in Rock Valley. These values supersede those presented in 1971 and will be used to extrapolate numbers of insects collected per shrub to per hectare density estimates.

The springtails of the family Sminthuridae (Collembola) are not usually associated with a host plant. Little is known of the feeding habits of many species, but those that have been studied have been found to feed on decaying plant material, such as litter beneath shrubs (and associated molds and yeasts). However, in Rock Valley a large proportion (>45%) were vacuumed from *Krameria parvifolia*. The sminthurids are not important in the consumption of green plant material but must be of some importance in the breakdown of litter beneath shrubs. They have been reported to cause damage to new seedling growth, but

Table 5. Estimated densities (n/ha) of important shrubs serving as hosts for various phytophagous insects in Rock Valley

	PLOTS			
Species	1	2	11	12
Ambrosia dumosa	1467	1747	1876	3647
Atriplex confertifolia	-	-	-	226
Eurotia lanata	-	-	-	720
Krameria parvifolia	1737	340	1784	1167
Larrea divaricata	1091	1018	1000	997
Lycium andersonii	1389	1001	1086	332
L. pallidum	-	534	-	1065

probably are not important in this role in Rock Valley. Their greatest importance is probably as food for immature (and occasionally mature) stages of predatory arthropods. The eggs are consumed in large numbers by nymphs and adults of such groups as mites and assassin bugs. In both years the population dropped to a low point in week 17-18. In 1972 there was rainfall of approximately 1 cm during the week of week 16. About 2.5 cm of rainfall was known to have fallen in week 18 of 1971. Temperatures for both years were well within suitable ranges for sminthurids. The usual number of *Krameria parvifolia* was sampled during this span of time each year. In both years the populations were high at the beginning and end of the sampling season. The apparently lower numbers taken between weeks 17 and 31 may reflect no more than seasonality of behavior. In 1972 observations indicated a significant increase in numbers of individuals, usually temporary, approximately 3-4 weeks after each rainfall.

The 1971 and 1972 densities of the grasshopper *Bootettix punctata* exhibited a high degree of variability between individual plots. The maximum density in 1972 was reached in weeks 25-26. In both 1971 and 1972 this grasshopper was first encountered in week 17. Consideration of meteorological data and plant phenology shed little light on this. However, within a two-week period prior to the first appearance of *Bootettix* there was a cooling trend in air temperatures. General experience has indicated that the numbers of *Bootettix* taken by D-Vac may be influenced by air temperatures. To examine the possibility of such a relationship, biweekly densities for both 1971 and 1972 were regressed on the mean maximum air temperatures for corresponding two-week periods. The correlation coefficients (0.684 for 1971, and 0.596 for 1972) and F values (5.52 and 8.83, respectively) indicated positive correlations between the numbers of *Bootettix* taken and maximum air temperatures prevailing at the times of collection. These correlations were significant at the 5% level, but not at the 1% level. Figure 1 illustrates the 1972 data.

In 1972 (as in 1971) the first individuals encountered in the sampling (first week in May) were newly-hatched nymphs. These nymphs constituted the first apparent peak in density each year. Adults first appeared during the last week of June in 1972 (as in 1971) and made up less than 4% of the total estimated density (9% in 1971). By August the situation was reversed and less than 4% of the individuals were in the nymphal stage (15% in 1971). In both years no nymphs were taken in the month of September. *Bootettix* is the most abundant of the chewing defoliators, making up about 30% of such insects and ca. 6% of all phytophagous arthropods on *Larrea*.

In 1971 the major peak density of the grasshopper, *Tanaocerus koebeli*, came in week 31 (first week in August), with other minor peaks in weeks 21 and 25 and an upswing in the population beginning in week 35. In 1972 there were three conspicuous peaks with the highest density in weeks 25-26 (late June), the second highest peak in weeks 29-30 and the lowest in weeks 21-22 (late May). Consideration of meteorological data indicated no obvious correlation between density, temperature and precipitation.

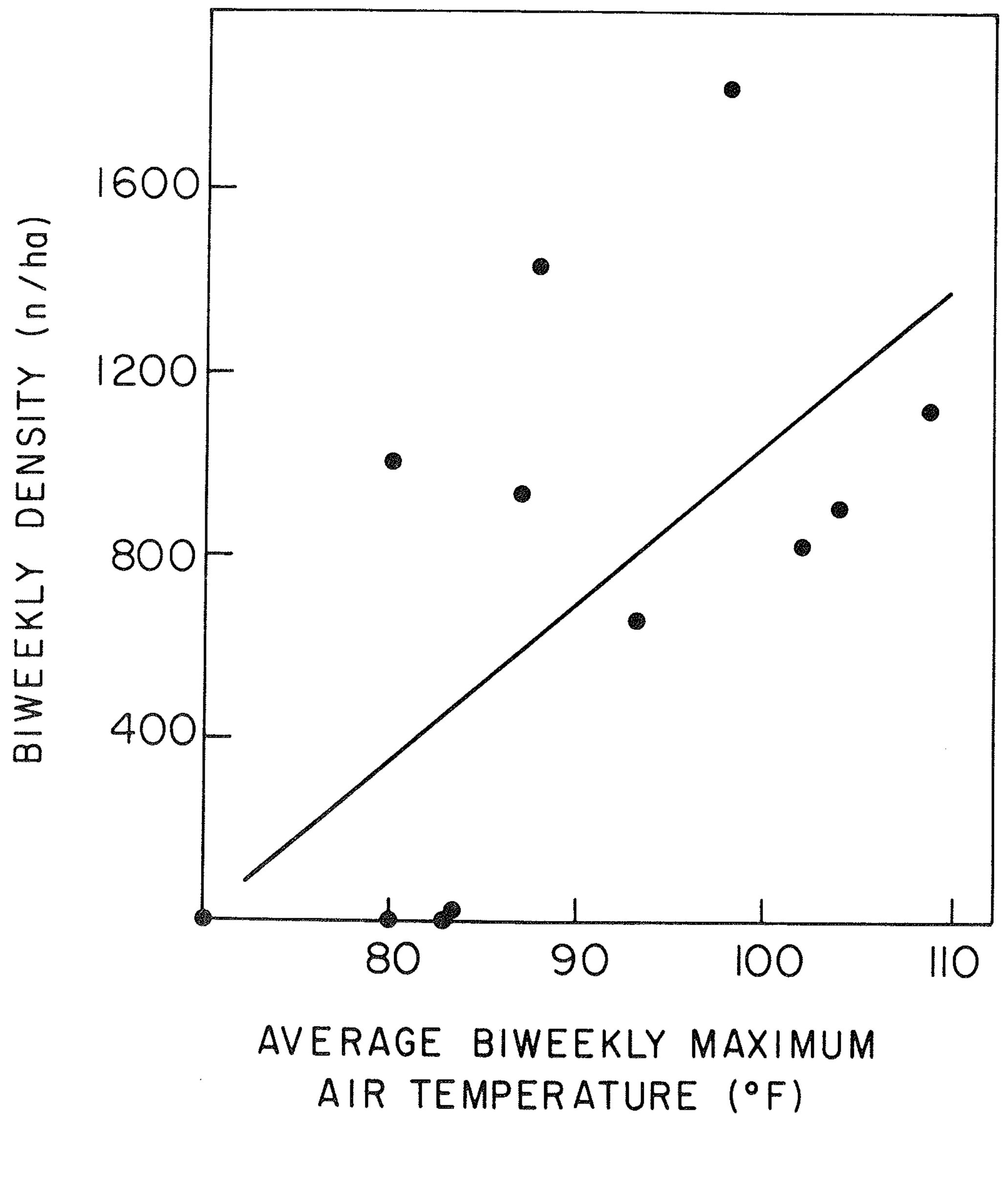

Figure 1. Regression of biweekly estimates of the density of the grasshopper, *Bootettix punctata*, on mean daily maximum air temperatures in 1972.

In 1972 there was a six-week advancement in the peak for *Tanaocerus* taken from *Krameria parvifolia*. There is no obvious correlation between numbers of these grasshoppers and the phenology of the host plant. Peak numbers occurred about 7 1/2-8 weeks after the first flowering of *Krameria* in both 1971 and 1972. Peak densities on *Ambrosia dumosa* occurred at about the same time each year. We cannot explain why the major peaks on both host plants coincided in 1972, but believe that this reinforces our contention that plant phenology is not a major factor in the density of this species--beyond the availablity of food in general. Studies in Joshua Tree National Monument in California have shown that during warmer, wetter seasons females (the only sex really observed in these studies) were decimated by at least two diseases (one fungal, the other bacterial). However, for the second consecutive year in Rock Valley no females were taken by D-Vac or in pitfalls during the sampling season. In November, 1971, females were observed on numerous shrubs, with large numbers on *Ambrosia dumosa* and *Krameria parvifolia*. In Joshua Tree National Monument and in the Sierra Kino of Baja California, Mexico, the sex ratio in this species (and related species) is usually about 58 males:42 females.. If this same ratio were applied to the data from Rock Valley, the apparent densities would be roughly doubled!

Creosote bush is the sole host for the sap-sucking plant bug *Phytocoris* sp. (Miridae) in Rock Valley. Only wandering adults are encountered on other plants. Comparison of the 1971 and 1972 data indicates that 1972 numbers were higher than those of 1971. The 1972 population reached its maximum density and matured four weeks earlier than in 1971.

Temperature seemed to have an effect on the number of *Phytocoris* taken by D-Vac. In general, fewer of these bugs were collected at high air temperatures. This relationship was examined by regressing biweekly densities for both 1971 and 1972 on mean maximum and mean minimum air temperatures for corresponding two-week periods. All four of these tests gave similar results. When 1972 densities were regressed on mean maximum air temperatures the correlation coefficient (-0.696) indicated a significant inverse correlation between the numbers of *Phytocoris* taken and maximum air temperatures prevailing at the times of collection. The analysis of 1972 densities and mean minimum air temperatures yielded a correlation coefficient of -0.733, also significant. Figure 2 illustrates the relationship between numbers collected in 1972 and mean minimum air temperatures.

One of the most enigmatic arthropods in Rock Valley is a leafhopper, *Spathanus excavatus*. This may be an important insect in that its host is creosote bush and because, like most leafhoppers, it consumes far more sap than it utilizes for food. The excess is secreted as "honey-dew", or only slightly-altered sap. This bug is an active jumper and some individuals eluded capture; hence, the apparent numbers are probably somewhat lower than true densities. In 1971 and 1972 this species was taken by D-Vac almost exclusively from plots 11 and 12 (1971 = 90%; 1972 = 92% of individuals vacuumed). None was taken by D-Vac in plot 2 during either year. This insect is frequently encountered in pitfall traps in plots 1 and 2. The occurrence in the pitfall traps is not a behavioral reaction to heat.

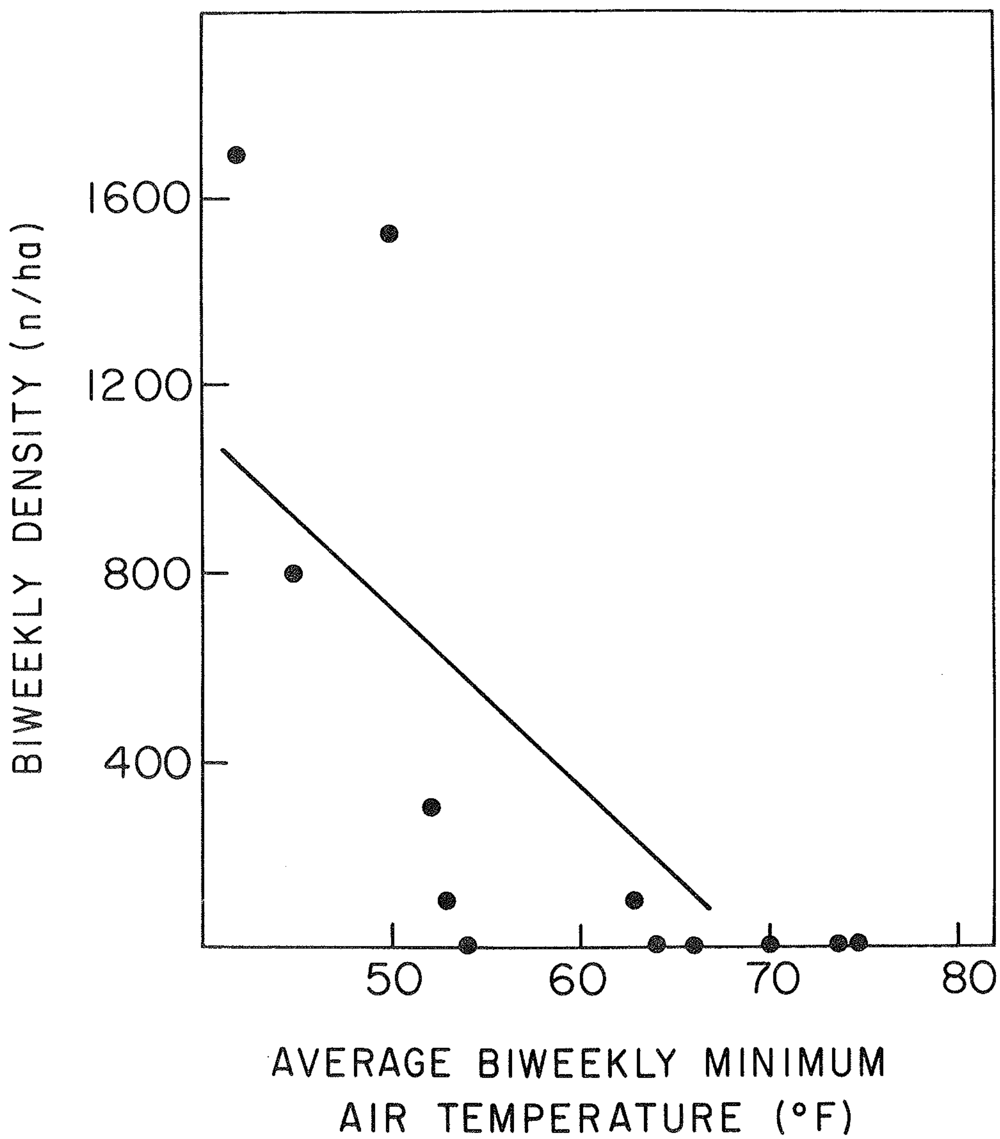

Figure 2. Regression of biweekly estimates of the density of the plant bug, *Phytocoris* sp., on mean daily minimum air temperatures in 1972.

The largest numbers (23% of sampling season total) were taken in the pitfalls in week 22 when the above-ground temperature mean maximum was 32.2 C and the above-ground population was at its peak (21% of the sampling season total).

The apparent declines in density in both 1971 and 1972 during weeks 25-26 and 29-30 coincided with hot dry periods (36-38 C). It is probable that these insects either seek shelter from the heat during the hours of sampling or become so active that they cannot be captured. If they seek shelter it is not within the pitfall traps (total pitfall take between weeks 23 and 35 was 2 in 4500 trap nights)!

Membracids constitute an important part of the sap-removing fauna of Rock Valley. Three species are known to be on *Larrea* and a fourth (unidentified) species occurs occasionally on malvaceous herbs. Here we discuss only those forms encountered on *Larrea*. Of these species, *Centrodontus atlas* is by far the most abundant. The adults are taken more than twice as often as *Multaroides bifurcatus* and about eight times more frequently than *Multareis cornutus*. The nymphs are very difficult to identify, and we have not attempted to discriminate between species of nymphs.

In 1972 adults of *Multareis cornutus* reached a maximum density in week 20 (mid-May). The comparable data in 1971 was week 18. Adult *Centrodontus atlas* peaked in week 24 (2nd week of June) in 1972; during week 23 in 1971. Adult *Multareoides bifurcatus* were most abundant during week 34 (last week of August) in 1972. By inference we conclude that nymphs of these species attained their maximum densities during 1972 in weeks 14, 19 and 31, respectively. The decline in numbers of adult membracids between weeks 32-35 in 1971 was due to the rapid fall of the *Centrodontus atlas* population and the near absence of *Multareis cornutus*. When peaks for the nymphs and adults were compared we observed that the highest densities for the two occurred at the same time during 1971 and 1972: for nymphs between weeks 19-20 and for adults between weeks 23-24. The maximum mean temperatures were nearly identical for the respective weeks in both 1971 and 1972. Note particularly that the maximum mean temperature for the weeks of maximum density in 1971 were 27 and 33.2 C (respectively); for 1972, 27 and 33 C (respectively). The minimum means were not comparable. Peak numbers of *Centrodontus* occurred at about the same time (week 23) in 1971 and 1972. However, the buildup to maximum numbers required four weeks in 1972; in 1971 it took only two weeks. This species seems to reach its maximum density near the middle of seed production by *Larrea* after flowering has ceased. *Multareis cornutus* reaches its peak at the beginning of flowering. *Multareoides bifurcatus* reaches maximum density just as the second period of new leaf growth is beginning. We do not know to what factor(s) the higher 1972 densities can be attributed. The impact of treehoppers upon *Larrea* has yet to be determined. If we consider numbers and biomass as criteria of importance (rather than actual physical damage), then this group as a whole must be significant. The membracids make up about half of the sap-sucking species and 28.3% of all the phytophagous forms on *Larrea*.

The mealy bugs (Pseudococcidae) are one of the most abundant sap-consuming arthropods in Rock Valley. Among the forms involved with sap removal, this family sustains some of the highest densities of any we have estimated. Like the leafhoppers, mealy bugs extract far more sap than they utilize for food. The resulting "honeydew" attracts other insects which have no other relationship with the shrub than to feed upon the secretions of the mealy bugs. Table 6 clearly indicates the numerical importance of this group on Rock Valley shrubs.

They are exceeded on *Larrea* by membracids, upon *Grayia* by margarodid scales, and upon *Krameria* by leafhoppers. The apparent numbers of mealy bugs exhibited unexplained fluctuations during both 1971 and 1972. They may be due in part to the fact that we are considering this group at the family level when there are in fact several genera involved in this grouping. Conspicuous peaks occurred in weeks 22, 25 and 29-30. The greatest apparent densities occurred during weeks 19 (on *Ambrosia* in plot 12) and 18 (on *Ambrosia* in plot 12). In May (weeks 18-22), 42.5% of the season total of mealy bugs was taken.

Larval lepidopterans are one of the major insect groups consuming vegetation in Rock Valley. They are responsible for most of the conspicuous defoliation. The case-bearing moth larvae of the family Coleophoridae were not treated in the 1971 report. In Rock Valley during 1972 these larvae principally consumed *Ambrosia dumosa* (22% of their season total), *Lycium andersonii* (18%), *Grayia spinosa* (50%) and occasionally *Larrea* (2.66%), *Krameria parvifolia* (5.3%) and *Ephedra nevadensis* (1.77%). If we look at these larvae in another light--as defoliators--we find a slightly different picture. Considering all of the defoliating insects and all host shrubs, the coleophorids make up the following percentages of defoliators: *Ambrosia dumosa* 8.36%, *Lycium andersonii* 8.62%, *Grayia spinosa* 55.45%, *Larrea divaricata* 0.62%, *Krameria parvifolia* 1.72% and *Ephedra nevadensis* 10.0%. It is clear that, while the numbers of individuals taken on some shrubs were reasonably high, these larvae are probably important consumers of solid plant material only on *Grayia*. They also contribute to loss of foliage from *Lycium andersonii* and *Ambrosia dumosa*. In 1971 *Grayia*, *Ambrosia* and *Krameria* were the favored host plants, but most larvae occurred on the first shrub. In 1972 larvae on *Grayia* and *Lycium andersonii* contributed the major peak in weeks 15-16, while the second peak in weeks 23-24 reflected those on *A. dumosa* in plot 12 and *K. parvifolia* in plot 2. The activity span is brief (9-14 weeks) on all of the shrubs except *Ambrosia*, upon which individuals were present and feeding for 20 weeks. We have no explanation for the erratic pattern of apparent numbers observed in both 1971 and 1972, nor for the variety of host shrubs. However, measureable precipitation occurred in weeks 16 and 23.

The gelechiid moths were omitted from the 1971 report because of inadequate information. Gelechiid larvae are evidently the major defoliators of both species of *Lycium*, and can inflict appreciable losses on *Larrea* and *Krameria*. This group was primarily responsible for loss of foliage on *Lycium pallidum* in 1971 (1971 report p. 33, "Practically no

Table 6. Occurrence of pseudococcids on shrubs in Rock Valley during 1972

Shrub species	Number of weeks pseudococcids were taken from shrubs	First and last weeks of occurrence	Proportion of total seasonal take of pseudococcids (%)	(5)*	(6)*
Larrea divaricata	20	10-36	58.9	0.36	0.20
Ambrosia dumosa	14	11-35	13.1	0.26	0.03
Lycium andersonii	10	12-24	6.1	0.51	0.11
L. pallidum	7	10-19	1.3	0.43	0.08
Ephedra nevadensis	3	19-25	2.5	0.56	0.02
Grayia spinosa	6	10-37	1.1	0.19	0.03
Krameria parvifolia	6	20-36	1.3	0.26	0.02
Eurotia lanata	5	14-23	3.7	0.74	0.64
Atriplex confertifolia	6	10-38	12.0	0.70	0.53

*Column 5 gives the fractional contribution of pseudococcids to the total number of sap-sucking insects collected on various shrubs. Column 6 gives the fractional contribution of pseudococcids to the total number of phytophagous insects collected.

fruit was formed and 40-80% of the leaves were eaten"). Densities on *Lycium pallidum* reached phenomenal levels. As defoliators, gelechiid larvae constituted more than 78% of the total on *Lycium pallidum,* 20% on *Ambrosia dumosa,* 35% on *Lycium andersonii,* 17% on *Krameria parvifolia,* and *Larrea,* 14% on *Grayia,* 20% on *Ephedra nevadensis*. Only 21 individual arthropods were taken on *Ephedra* that could be classified as defoliators. Large numbers of adult gelechiid moths are attracted to the cones of *Ephedra* just before the peak of pollen production.

In Joshua Tree National Monument one genus (*Anacampsis*) is of major significance in seed destruction. On numerous occasions nearly an entire season's seed production was destroyed. Adults of this genus have been taken occasionally in Rock Valley.

The measuring worms (*Semiothisa* sp.: Geometridae) are apparently obligatory feeders on *Larrea* and are rarely encountered on other shrubs. There is an early season peak with densities greatly reduced by early July. However, the larvae remain to some extent on *Larrea* until mid-February, at which time they seem to disappear. At least 2 instars have been taken in January during survey observations. In 1971 there was an apparent increase in densities in all plots beginning in week 36--shortly after the rain of the preceding week and the development of new leaves on the host shrub. In 1972 the corresponding increase in density was slight,compared with that in 1971, although the rain fell again in week 35 and *Larrea* was in new leaf. Measuring worms are the second largest and most abundant of the moth larvae on *Larrea*. However, we presently have no information on food consumption and biomass of these larvae. In 1971 and 1972 these larvae made up slightly more than 18% of the chewing defoliators (exceeded only by *Bootettix punctata*), and nearly 4% of all the phytophagous forms on *Larrea*.

Another important group of lepidopterans are larvae of the family Yponomeutidae. In 1971 the population built up rapidly on *Lycium andersonii* to an early peak in weeks 17-18, then dropped nearly as rapidly in weeks 19-20 and to zero 10 weeks later in weeks 29-30. Beginning in week 17 the population on *Krameria parvifolia* increased rapidly until weeks 25-26, then dropped in week 35 and thereafter. In 1972 the sampling season began in week 10 (March 6). In that week larvae occurred on *Lycium andersonii*, and their numbers increased to a seasonal peak in weeks 11-12. After this, the population declined, disappearing completely from *Lycium* in week 25. As in the preceding year this insect was present on *Krameria parvifolia* at the initiation of sampling in weeks 11-12. Numbers increased gradually to a seasonal peak in weeks 19-20, then declined at the end of the sampling season in weeks 37-38.

We have noted what appears to be an inverse relationship between numbers of gelechiid moth larvae and ermine moth larvae. This was true when weekly densities of the two kinds of larvae were compared on a plot-by-plot basis for each of the two shrubs. It is possible that these two species are in direct competition for food and space in Rock Valley.

Parasitic hymenopterans of the superfamily Ichneumonoidea are represented in Rock Valley primarily by the families Ichneumonidae and Braconidae. Without knowing the parasite-host relationships of the various species it is difficult to evaluate their role. So far only one ichneumonid in the genus *Ophion* has had its parasitic role determined. These wasps parasitize the scarab beetles *Diplotaxis* and *Phyllophaga*. In 1972 more than 87% of the Ichneumonoidea taken were braconids. More than 22% of all individuals of this superfamily were taken from *Lycium andersonii*. Braconid wasps, gelechiid moth larvae, and ermine moth larvae are the only major groups in Rock Valley that frequent these two shrubs in large numbers. Of course, this does not establish a parasite-host relationship, but it should be noted that many braconids parasitize moth caterpillars or larvae.

More than 93% of the beeflies (Bombyliidae) taken in Rock Valley in 1972 (82% in 1971) were of the genus *Mythicomyia*. This is a large genus with more than 200 species in the southwestern United States. The immature stages of beeflies are parasitic (occasionally predatory) upon ground dwelling insects or egg pods of grasshoppers. However, the immature stages of this genus are completely unknown. They seem to have a "perching" preference for *Larrea* and *Krameria*. They were most abundant upon *Krameria* in week 20, during flowering, and may have been attracted to that shrub by the nectar of the flowers. There were no flowers upon *Larrea* during the period of the estimated peak density of these flies.

A number of families of the wasp superfamily Chalcidoidea occur in Rock Valley. All chalcidoid wasps taken in the sampling were determined to at least the family level. Many members of this complex are probably important natural enemies of the shrub consumers. Of all of the chalcidoid wasps taken in Rock Valley during 1972, 31.9% were pteromalids, 23.2% were eulophids, 7.7% were eupelmids, 6.1% were encyrtids, and 4.5% were chalcids. Proportions in 1971 were similar, except that chalcids made up 28% of the total in that year. The first four are large families of a rather broad spectrum of obligate primary parasites of beetles, moth larvae, flies, bugs, wasps and mites. The chalcids are primary parasites of beetles, moth larvae and flies. These parasitic wasps may be important factors in the natural mortality of some of the phytophagous insects on *Larrea*; as much as 79% of the eupelmids were taken on creosote bush. Alternatively, the wasps may have been only partaking of the "honeydew" produced by mealy bugs or the leaf and treehoppers. It is interesting to compare the apparent numbers of parasitic wasps with those of the measuring worm, *Semiothisa* sp. Three of the larger families (Pteromalidae, Eupelmidae, and Eulophidae) have many species parasitic on moths (including the Geometridae), and increased significantly on *Larrea* as the *Semiothisa* larvae were increasing.

A number of apparently important defoliating beetles occur in Rock Valley. Leaf beetles (Chrysomelidae) are defoliators in both the immature and adult stages. They feed upon most of the dominant shrubs, especially *Larrea, Ambrosia, Lycium andersonii* and *Krameria*. Most species are host-specific, but we have been unable to determine the adults taken to the species level. Several genera were extremely common on *Grayia* and *Ambrosia*.

The broad-nosed weevils (Curculionidae) are defoliators only as adults. The immature stages are feeders in or upon the roots of shrubs. As with the leaf beetles, we have combined several genera and species in this report because of similarity in feeding habits. However, most species are host-specific. It is difficult to estimate the true densities of many weevils for they are not dislodged and captured by vacuuming. Repeated tests with the D-Vac and by "beating" (placing beating cloths beneath the vacuumed shrub as well as under adjacent unvacuumed shrubs of the same species and then beating the shrub with a stick) indicated that the vacuuming removed at best only about 20% of the tightly clinging adults. Then, too, these weevils are almost exclusively nocturnal and well camouflaged, complicating visual inspection of the shrub after vacuuming. All weevils were determined to species. One species of the genus *Minyomerus* was extremely abundant in early May on *Ambrosia*, as was a new genus of broad-nosed weevil on *Eurotia lanata* in mid-March. *Krameria*, *Ephedra* and *Atriplex* are the only major shrubs in Rock Valley that appear devoid of weevils. However, less than 2.0 km east of the study area, *Atriplex* is densely populated by this group, and several species of weevils have been observed gnawing upon new growth of *Ephedra*. The most abundant long-snouted weevil in the study area is *Smicronyx imbricata*. We have separated it from the broad-nosed forms because it is, like other long-snouted species, not a defoliator in the normal sense of the word. Long-snouted weevils push their mouthparts deep into the plant tissue and gnaw upon internal tissues--mostly of stems, flowers, and fruits. Most of the long-snouted weevils in Rock Valley are seed-destroying forms. *Ambrosia dumosa* is the definitive host for the immature stages of *Smicronyx imbricata* in Rock Valley, though the adult is often found upon nearly any plant or other erect object there. Larvae of this species develop in the ovaries and adjacent stem tissue of the flowers of *Ambrosia*. Comparison of apparent peak densities in 1971 and 1972 with the phenology of *Ambrosia* show that the peaks occur during the flowering periods each year. What the loss in seed production might be on an annual basis has not been investigated. The increase in estimated density in 1972 is related to enhanced flowering of *Ambrosia* and better conditions for the weevil.

A family of very aggressive predatory beetles, the Melyridae, also occurs in Rock Valley. We have considered jointly five genera and seven species with similar behavior and feeding habits both as immatures and adults. Melyrids are general predators upon many soft-bodied arthropods. The higher densities of these soft-bodied types in 1972 presumably led to higher densities of melyrids. These beetles are generally strong fliers and many of those in Rock Valley may have been migrants from adjoining, less suitable areas. The 1971 estimated peak density occurred four weeks earlier than in 1972, the reverse of what was observed in many other species.

Two important groups of phytophagous arthropods have not been formally treated in this report: thrips (Thysanoptera) and mites. We have not been able to interpret the data pertaining to these groups. Three families of thrips occur in Rock Valley. Two species have been identified. Thrips reach exceedingly high densities on many species of

shrubs. When the shrubs flower the thrips/plant ratio increases rapidly. Thus, thrips often made up a large part of all the phytophagous species taken on shrubs during 1972: *Larrea* 22%; *Ambrosia* 82%; *Lycium andersonii* 22%; *Ephedra* 95%; *Grayia* 47%; and *Acamptopappus* 95%. We emphasize that the estimated peak densities always coincided with flowering of the shrubs. When *Larrea* was in flower during 1972 *Leptothrips mali* attained high densities in plots 1, 11 and 12; *Frankliniella minuta* was particularly abundant in plots 1 and 12, less so in plot 11. During the non-flowering period densities were generally lower. Plot 12 exhibited an increase during weeks 34-35 after some of the *Larrea* flowered for a second time. The largest numbers of thrips occurred on *Ambrosia* during flowering in weeks 18 and 19. Even upon *Ephedra*, estimated thrips densities (mostly *Frankliniella*) were high in week 18. Levels on *Grayia* peaked in week 15. Thus far we have not attempted biomass studies of these minute insects.

We have done little with mites because of difficulties in identifying specimens to even the family level. An associate to the project will complete a program in mite identification, and we will be able to then give more explicit information on this important group of arthropods.

C.3. ANTS

One aspect of the studies of ants on the validation site has been a search for an adequate method of quantifying ant presence and activity. A method has been tested in the Chihuahuan Desert near Portal, Arizona, and used several times in Rock Valley. Briefly, the method consists of using bait boards distributed in a grid to attract ants. The boards are baited with a small cup of honey water and a small dab of peanut butter; the bait is protected from vertebrates by wire mesh. The boards are visited in early morning and early evening; ants are collected from the honey-cups and are aspirated from the board and immediate vicinity of the board. In Rock Valley marked nests were also repeatedly observed and incidental searching and collecting carried out.

Samples of ants from Rock Valley have been identified by Mr. Roy Snelling of the Los Angeles Museum of Natural History (Table 7). Mr. Snelling has also checked all of the *Pogonomyrmex* and *Myrmecocystus* in the reference collection of the CETO laboratory. The genus *Myrmecocystus* is presently being monographed by Snelling. Some of the identifications of *Pogonomyrmex* and *Myrmecocystus* are different from earlier listings (such as the 1971 Annual Report, RM 72-2).

Ants were collected at bait boards in the south half of Plot 3 on four dates in 1972. Table 8 summarizes the resulting information. Four collections afford a meager picture of ant activity for a year, but they do suggest some interesting points. Diversity of species was greatest in June, when almost all the shrubs were in fruit or had shed fruit. Abundance of ants was greatest in July; all species exhibiting an abundance of >1 per board had their greatest abundance in July. It was at this time that the highest temperatures of subsurface soil occurred. The occurrences of maximum importance are spread over the four collections. Each of the four most abundant species exhibited their maximum importance in a different month. Trends of importance values were also different: *Pheidole desertorum* increased progressively; *Conomyrma insana* decreased progressively; *Iridomyrmex pruniosus* peaked in June and *Myrmecocystus koso* in July. These differences may have something to do with the coexistence of species.

As judged from general comments in Creighton (1950), the Rock Valley ants have three general feeding habits. The species of the genera *Pheidole, Pogonomyrmex* and *Veromessor* are seed eaters. *Iridomyrmex pruinosus* and species of *Myrmecocystus* feed upon honey-dew. *Conomyrma insana* is predatory. Therefore, the four most abundant and important species (Table 8) exhibit three different feeding habits. The seed feeders in Plot 3 are quite different in size, from largest to smallest: *Pogonomyrmex rugosus* > *P. californicus* > *Pheidole desertorum* > *Ph. bicarinata*. This suggests a diversity of food habits. *P. californicus* and *P. desertorum* overlapped in the size of the seeds they collected, but generally gathered larger and smaller items respectively. The honey-dew feeders also showed a gradation in size: *M. mexicanus* > *M. koso* > *M. lugubris* > *Crematogaster depilis* > *I. pruinosus*.

There must be uncertainties in any quantitative evaluation of the collections from bait boards, but the tests thus far suggest that this method may yield considerable information. Species-area curves suggest that 20 bait boards are sufficient to detect all the species present (that are attracted to the bait). This number of boards can easily be sampled repeatedly through time and in a variety of areas.

Table 7. Ants of Rock Valley, particularly Plot 3, based on 1971 and 1972 collections of R. Chew and the reference collection of CETO laboratory (Determinations by Roy Snelling, Los Angeles County Museum of Natural History)

Subfamily Myrmicinae

- *Pogonomyrmex californicus* (Buckley)[a]
- *P. rugosus* Emery
- *Crematogaster depilis* Wheeler
- *C. mutans*
- *C. nocturna*
- *Aphenogaster megommatus* M. Sm.
- *Veromessor pergandei* (Mayr)
- *V. smithi* Cole
- *Pheidole desertorum* Wheeler
- *P. bicarinata paiute* Gregg
- *Leptothorax nitens*
- *Solenopsis molesta*

Subfamily Dolichoderinae

- *Iridomyrmex pruinosus* (Roger)
- *Conomyrma insana* (Buckley)
  - = *Dorymyrmex pyramicus* (Roger)[b]

Subfamily Formicinae

- *Camponotus hyattii*
- *Myrmecocystus koso* n. sp. Snelling[c]
- *M. lugubris* Wheeler
- *M. mexicanus* Wesmael
- *M. placodops*

[a]in Snelling's opinion, specimens previously identified in the reference collection as *P. magnacanthus* are *P. californicus*, but a larger series is needed for a definitive identification.

[b]synonymy is opinion of Snelling.

[c]in Snelling's opinion specimens in the reference collection identified as *M. flaviceps* and *M. mendax* are this new taxon, described in a monograph in preparation.

Table 8. Seasonal variability of any activity in Plot 3, Rock Valley, 1972 (N = av. no. individuals'bait board; I.V. = importance value = rel. frequency)

Species	March 31		June 9		July 24		October	
	N	IV	N	IV	N	IV	N	IV
Ph. desertorum			34.4	0.417	61.9	0.507	12.7	0.688
I. pruinosus	0.524	0.137	25.1	0.385	38.5	0.165	0.062	0.0005
C. insana	0.286	0.0496	2.58	0.0229	4.26	0.0197	0.229	0.0004
M. koso	0.048	0.0021	1.47	0.0131	4.23	0.0240	0.167	0.0058
Ph. bicarinata			0.632	0.0026	0.087	0.00003		
Leptothorax sp.	0.048	0.0021	0.526	0.0021				
Po. californicus			0.211	0.0007				
M. lugubris	0.190	0.0165	0.158	0.0004			0.083	0.0005
V. smithi			0.053	0.00004				
C. depilis					12.8	0.0457		
Total no./board	1.10		65.1		109.0		13.2	
No. boards	23		19		23		48	
No. species	5		9		6		5	

C. 4. BIOMASS STUDIES

Table 9 summarizes initial biomass data relating to selected arthropods in Rock Valley. The specimens analyzed were taken in Rock Valley outside of the sampling areas during August, September, and October. All individuals of a particular species were taken during a single week during this time. The animals were immobilized, weighed and then frozen. The frozen material was returned to California State University, Long Beach, and dried. All specimens were dried at 38 C until weights stabilized. The time needed for drying varied with the species. The drying of several tenebrionid beetles required nearly 2 weeks. After dry weights were recorded the material was stored or shipped to Utah State University for calorimetric studies. Mean live weights, dry weights, and water contents were determined for each species. When weight data were available for the same species for both 1971 and 1972 (depending upon sample size), a t-test for the significance of the difference between two sample means was made.

In general, mean body weights did not differ between 1971 and 1972. The exception was the grasshopper, *Bootettix punctata.* Average dry weights in 1972 were significantly greater than those determined in 1971 (Table 9). For example, the mean dry weight of males in 1971 (0.018 g) was about 70% of the 1972 mean (0.026 g). The 1972 water content (ca. 68%) was significantly lower than that measured in 1971 (ca. 77%).

Dry weight biomass values were calculated for six species of tenebrionid beetles using density estimates set forth in Tables 3 and 4 and dry weights obtained as described above (Table 9). Dry weights of six species totalled about 342 g/ha in 1971 and 542 g/ha in 1972.

Several important points relative to estimates of dry weight biomass have emerged. First, some species (e.g., *Bootettix*) may exhibit year-to-year differences in body weights and water contents. Second, sex ratios may not always be 1:1, and males and females may have different body weights. Finally water contents may differ appreciably from the 70% often assumed for vertebrates (Table 9). Preliminary measurements indicate that the water content of female *Araeoschizus sulcicollis* is only about 17.5%.

We have analyzed the relationship between live weight at time of capture and subsequently determined dry weights for eight species (Table 10). Figures 3 and 4 illustrate this relationship for *Bootettix punctata* and *Eleodes armata*. In all cases the two weights are highly (and positively) correlated, with most of the r values above 0.9. All of the F values indicate highly significant non-zero slopes and the intercepts are generally near zero.

Table 9. Estimates of live and dry weights, water contents and dry weight biomass of selected arthropods in Rock Valley

Species	Year	n	Average live weight, g	s	Average dry weight, g	s	Average water content (%)	Estimated dry weight, g/ha
Orthoptera								
Bootettix								
punctata males	1971	7	0.07571	0.0072	0.01829	0.0059	76.25	
	1972	6	0.08183	0.0110	0.02598	0.0021	68.05	
females	1971	10	0.15222	0.0254	0.03490	0.0110	77.40	
	1972	8	0.17531	0.0134	0.05634	0.0050	67.84	
Coleoptera								
Asidina								
semilaevis	1971	33	0.64383	0.1555	0.17315	0.0302	71.70	71.0
	1972	37	0.61805	0.1522	0.17814	0.4159	70.76	75.9
Centrioptera								
muricata	1971	6	0.34530	0.1491	0.13430	0.0648	61.59	43.5
	1972							44.1
Cryptoglossa								
verrucosa	1971	6	0.55570	0.0702	0.24733	0.0157	54.91	131.6
	1972	8	0.64050	0.0875	0.30074	0.0433	53.06	260.1
Edrotes								
orbus	1971	11	0.07700	0.0138	0.02227	0.0048	70.84	11.6
	1972	25	0.07868	0.0187	0.02716	0.0063	65.40	51.8
Eleodes								
armata	1971	21	0.82578	0.2452	0.34167	0.0902	57.75	32.5
	1972	36	0.91784	0.2868	0.37519	0.1159	58.02	49.5
Eleodes								
grandicollis	1971	8	1.78838	0.2517	0.60088	0.1337	66.36	
	1972	6	2.14400	0.5392	0.92675	0.3939	58.16	
Philolithus								
pantex	1971	7	0.37421	0.0898	0.12343	0.0251	66.71	
Trogloderus								
costatus	1971							52.1
	1972	19	0.10181	0.3224	0.05211	0.0145	49.96	60.2

Continued

Table 9. (cont.)

Species	Year	n	Average live weight, g	s	Average dry weight, g	s	Average water content (%)	Estimated dry weight, g/ha
Coleoptera (cont.)								
Diplotaxis morens	1972	18	0.08717	0.02475	0.03274	0.0095	62.54	
Ophryastes varius	1971	13	0.07415	0.02797	0.03446	0.0139	54.08	
Homoptera								
Centrodontus atlas	1971	23	0.000913	-	0.000675	-	26.07	
	1972	22	0.000955	-	0.000666	-	30.89	
Misc. Nymphs								
	1971	46	0.000435	-	0.000227	-	52.15	
	1972	45	0.000444	-	0.000210	-	47.30	
Hymenoptera								
Veromessor pergandei	1972	22	0.00443	0.0020	0.00142	0.0004	68.91	
Majors only		15	0.00580	0.0005	0.00189	0.000001	69.03	
Minors only		7	0.00150	0.0000	0.00047	0.000000	68.59	
Araneida								
Psilochorus utahensis	1972	13	0.00442	0.0021	0.00120	0.0006	76.23	
Loxosceles unicolor	1972	6	-	-	-	-	70.95	
Scorpionida								
Anuroctonus phaeodactylus	1972	7	1.21890	0.1170	0.39290	0.0435	67.70	

Continued

Table 9. (cont.)

Species	Year	n	Average live weight, g	s	Average dry weight, g	s	Average water content(%)	Estimated dry weight, g/ha
Scorpionida (cont.)								
Hadrurus arizonensis	1972	9	4.56810	0.7425	1.45330	0.3298	68.44	
Vejovis becki	1972	14	0.19500	0.0894	0.059855	0.0316	70.38	
Solpugida								
Eremobatidae	1972	6	-	-	-	-	69.54	
Isopoda								
Venezillo arizonicus	1972	12	0.06200	0.0114	0.02877	0.0045	53.28	
Scolopendromorpha								
Scolopendra michelbacheri	1972	9	-	-	-	-	76.15	

Table 10. The results of linear regressions of live (wet) weight (W) on dry weight (d) of selected arthropods collected in 1972, which show that in all cases the two weights are highly (and positively) correlated

Species	n	Equation for live weight (W) in terms of dry weight (d)	r
Eleodes armata	36	W = 2.21d + 0.060	0.97
Asidina semilaevis	37	W = 2.90d + 0.101	0.80
Edrotes orbus	25	W = 2.61d + 0.008	0.94
Trogloderus costatus	19	W = 2.11d - 0.008	0.97
Diplotaxis moerens	18	W = 2.49d + 0.005	0.98
Bootettix punctata	40	W = 3.19d - 0.001	0.99
Psilochorus utahensis	14	W = 3.16d	0.91
Vejovis spp.	14	W = 2.58d + 0.040	0.96

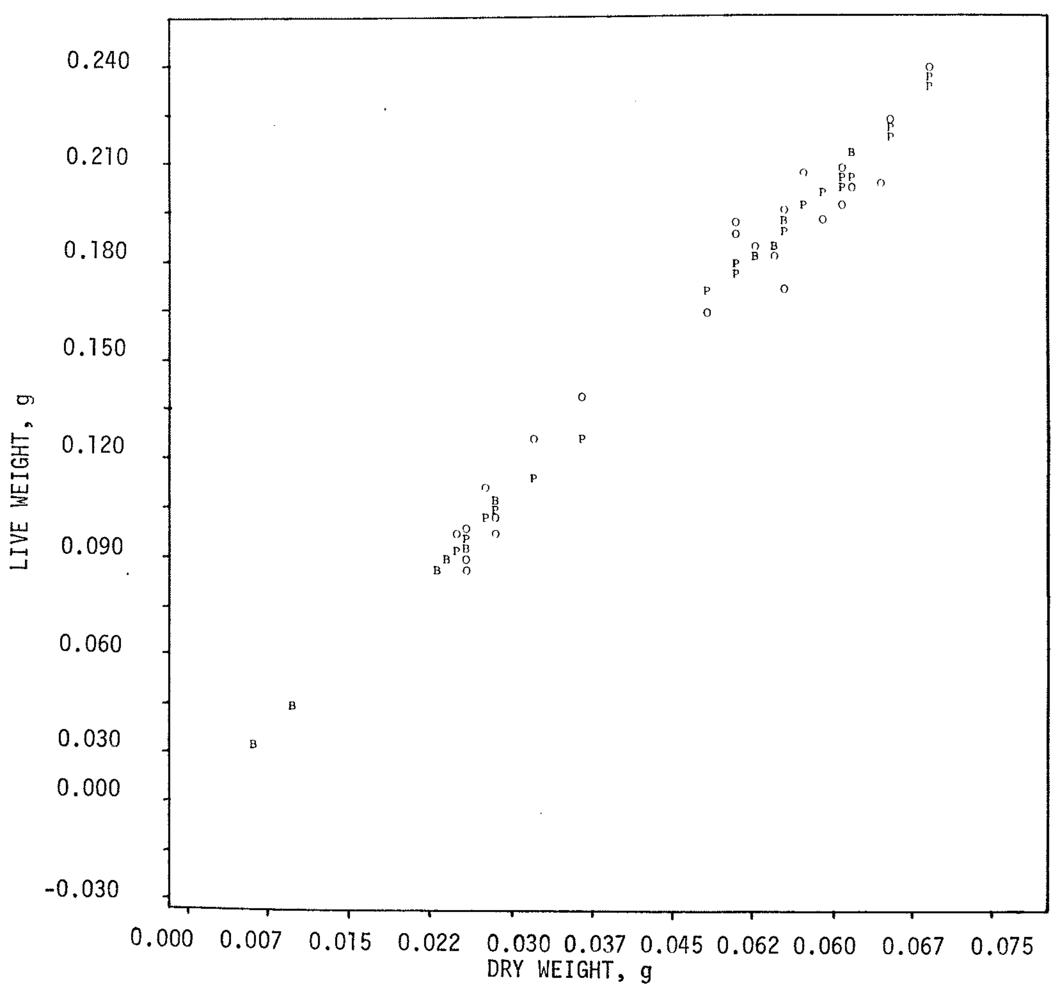

Figure 3. Regression of live weights on dry weights of *Bootettix punctata* taken in the vicinity of Rock Valley. O: observed data points; P: points predicted by regression equation; B: points where O and P are essentially the same.

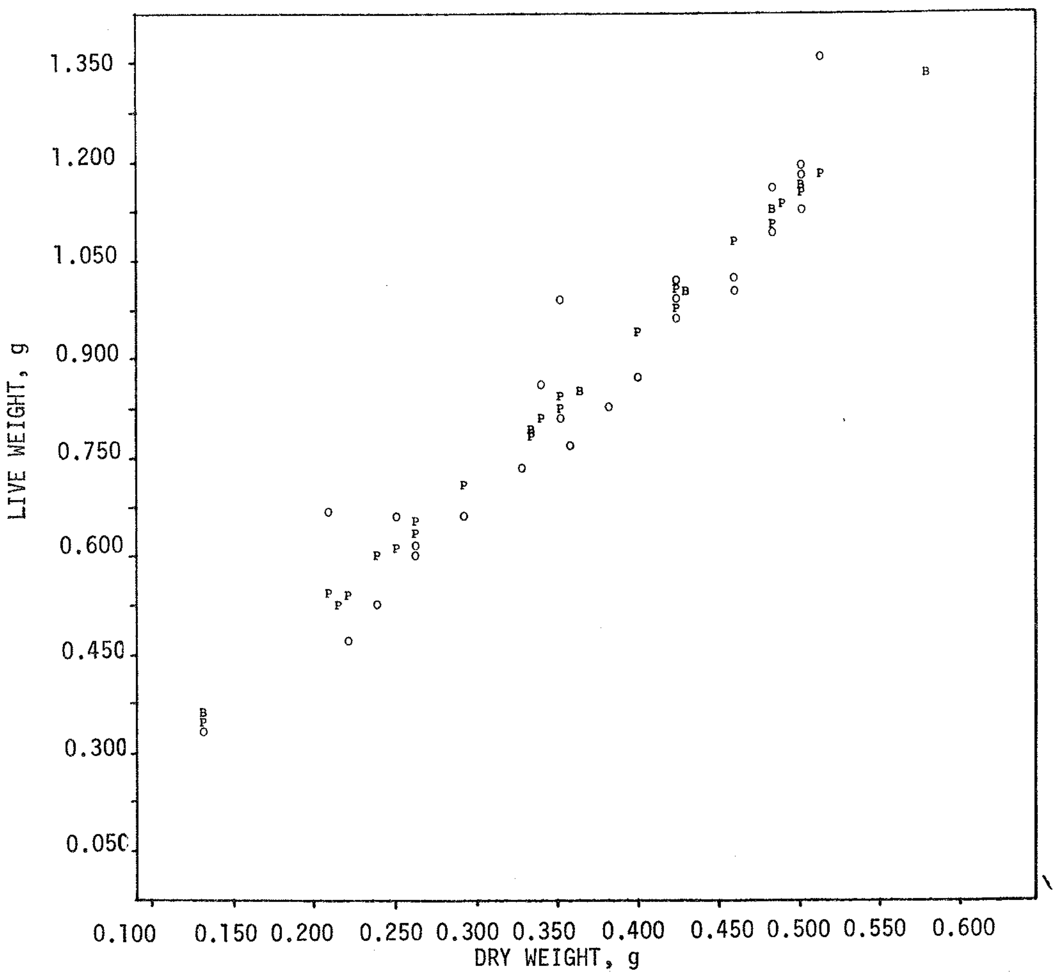

Figure 4. Regression of live weights on dry weights of *Eleodes armata* taken in the vicinity of Rock Valley. Symbols as in Figure 3.

C.5. ANALYSIS OF THE COMPOSITION OF THE PLANT-INHABITING ARTHROPODS

It is useful, in an ecological study of this nature, to consider the composition of the insects encountered upon various species of shrubs. We have determined the numbers of each species of arthropod taken each week on each species of shrub. We now comment on some features of this analysis which are of general interest.

Table 11 gives numbers and percentages of arthropods taken from principal shrub species in Rock Valley in 1972. The arthropods have been grouped according to feeding mode (predator-parasite, phytophagous, etc.). Table 11 indicates considerable variability in the "suitability" of various shrubs as food for insects. The fraction of phytophagous forms varied from 66% on *Lycium andersonii* to 94% on *Ambrosia dumosa*. That the percentage of phytophagous forms is relatively low on *Lycium* and obviously high on *Ambrosia dumosa* may seem surprising in view of the conspicuous defoliation of *Lycium* and the negligible consumption of *Ambrosia*. However, numbers of insects measure neither the amount of vegetation consumed nor physical damage to the shrub. Clearly, 100 gelechiid larvae will cause more physical damage to the plant through defoliation than 10,000 thrips can accomplish in a relatively brief visit to the flowers of that same plant. The thrips may cause a reduction in the seed crop of that plant, but the long-term damage to the shrub itself is less significant.

If thrips are excluded from consideration,the totals of phytophagous arthropods may, for some shrubs, be significantly reduced. For example, on *Ambrosia* the remainder would be only 701; for *Ephedra* only 56. About 95% of the phytophagous forms encountered on *Ephedra* were thrips and 91% of these were taken in week 18 while the shrub was in flower.

The predator-parasite data for each shrub may indicate indirectly the relative degree of entomophagous control of specific phytophagous forms. The parasites are often tied to a limited number of hosts among the entomofauna of each plant community. If the hosts of these parasites are host-specific, then the parasites will appear to be associated with a shrub when numbers alone are considered. The same is true to some extent of predators, though most of these are more generalized in their predatory activities.

Tables 12-15 are further extensions of vacuuming data. The main purpose of each is to indicate the major arthropods active on each shrub. These tables give comparisons of relative abundance of groups with the same mode of feeding, as well as abundances relative to all phytophagous forms on various shrub species.

Table 12 treats major shrub defoliators in Rock Valley. With few exceptions the percentages are expressed at the family level. Two grasshoppers and a measuring worm (*Semiothisa*) are treated as genera. Table 13 abstracts data in Table 12 and lists simply the five most abundant defoliators on each shrub. The five most abundant types are the

Gelechiidae, Yponomeutidae, miscellaneous Lepidoptera larvae, Curculionidae, and Coleophoridae. Four of these five are families of moths. Only two of these groups were of any importance on *Larrea*. As has often been noted the entomofauna of the creosote bush is different from that occupying associated plants in the same community (see also Tables 14 and 15).

Tables 14 and 15 refer to those groups that remove sap from the host shrub. Table 14 treats all of the sap-removing forms, including those that remove sap by piercing the plant tissues and sucking in the sap (sap-sucking forms), and those that rasp or tear the tissue with the mouthparts and suck up the fluid and macerated cells (those designated as non-sucking). The latter group is represented by only one order, the thrips (Thysanoptera). The sap-sucking forms are mostly Hemiptera and Homoptera. Here again we find that certain groups dominate the picture. The most abundant five are mealy bugs (Pseudococcidae), miscellaneous froghoppers (Fulgoroidea), miscellaneous leafhoppers (Cicadellidae), miscellaneous plant bugs (Miridae), and miscellaneous scales (mostly Margarodidae).

We do not claim that the ranking of these groups necessarily indicates their actual importance as consumers. However, the rankings in Table 14 of the principal defoliators of *Larrea, Lycium pallidum, Grayia spinosa* (and probably *Lycium andersonii*) are in general accord with the consumption of vegetation. Evaluating Tables 14 and 15 is more difficult. While thrips are frequently the most abundant sap feeders, it is doubtful whether they consume enough to seriously affect shrubs in Rock Valley. Thrips do damage flowering parts, however, and indirectly take their toll of the plant by consequent reductions of seed production. Thrips are abundant on shrubs only during the flowering periods. Pseudococcids are present in appreciable numbers on all shrubs. Table 15 also indicates the possible importance of various fulgoroids as sap consumers. Considering the rapidity of movement of these homopterans it seems likely that we missed many during sampling in the warmer weeks of summer.

Table 11. Analysis of arthropods vacuumed from the major shrubs in Rock Valley, Nevada during 1972, with the arthropods grouped according to feeding method

SHRUB SPECIES	Total Arthropods	Total Non-Phytophagous	Total Phytophagous	% Phytophagous	Total Insects Predatory or Parasitic	% Predatory or Parasitic	Non-Insect Arthropods	% Non-Insect Arthropods	Total Insects	% Total Insects	Unclassified Insects	% Predators Non-Insect	% of Total Arthropods Predat./Parasitic
Larrea divaricata	3282	968	2314	71.00	392	11.90	513	15.60	2769	84.40	63	1.60	13.60
Ambrosia dumosa	4348	262	4086	94.00	109	2.50	144	3.30	4204	96.70	9	0.09	2.59
Lycium andersonii	719	248	471	66.00	117	16.30	72	10.00	647	90.00	59	1.00	17.25
Ephedra nevadensis	1288	89	1199*	93.10*	32	2.50	50	3.90	1238*	96.10*	7	1.60	4.04
Lycium pallidum	154	29	125	81.16	14	9.10	12	7.80	142	92.20	3	3.25	12.34
Grayia spinosa	344	78	266	77.30	14	4.10	61	17.70	283	82.30	3	0.00	17.44
Krameria parvifolia	732	229	503	68.70	95	8.10	107	14.60	625	85.40	27	1.50	14.48
Eurotia lanata	52	5	47	90.40	1	1.90	4	7.70	48	92.30	0	0.00	1.92
Atriplex confertifolia	212	41	171	80.16	14	6.60	26	12.26	183	86.32	1	0.94	7.54

*See the values for *Frankliniella* and *Leptothrips* in Table 14, and text of report.

Table 12 Analysis of defoliators consuming solid material vacuumed from the major shrubs at Rock Valley, Nevada in 1972 (All values are expressed in percentages)

SHRUB SPECIES	Chrysomelidae	Curculionidae	Coleophoridae	Cosmopterygidae	Gelechiidae	*Semiothisa* sp. (Geometridae)	Miscellaneous Geometridae	Phalaenidae	Yponomeutidae	Moth larvae (Miscellaneous)	*Bootettix punctata* (Acrididae)	*Tanaocerus koebelei*	Miscellaneous Grasshoppers
Larrea	4.81*	6.69	0.63	0.00	17.36	18.41	4.18	0.21	0.84	2.30	29.29	0.21	2.09
divaricata	0.99**	1.38	0.13	0.00	3.59	3.80	0.86	0.04	0.17	0.48	6.05	0.04	0.43
Ambrosia	5.02	35.78	8.63	5.35	20.07	0.00	2.68	1.67	4.68	15.71	0.00	7.36	4.35
dumosa	0.37	2.62	0.61	0.39	1.47	0.00	0.20	0.12	0.34	1.15	0.00	0.54	0.32
Lycium	7.76	6.90	8.62	0.00	34.91	0.00	7.33	6.47	16.81	11.20	0.00	0.00	0.00
andersonii	3.82	3.40	4.25	0.00	17.20	0.00	3.61	3.18	8.28	5.52	0.00	0.00	0.00
Ephedra	0.00	25.00†	10.00	0.00	21.00	0.00	0.00	5.00	30.00	10.00	0.00	0.00	0.00
nevadensis	0.00	0.42	0.17	0.00	0.33	0.00	0.00	0.08	0.50	0.17	0.00	0.00	0.00
Lycium	0.00	3.33	0.00	0.00	78.02	0.00	0.00	3.30	5.50	9.89	0.00	0.00	0.00
pallidum	0.00	2.4	0.00	0.00	56.80	0.00	0.00	2.40	4.00	7.20	0.00	0.00	0.00
Grayia	4.95	1.98	55.45	17.82	13.86	0.00	0.00	0.00	1.98	1.98	0.00	1.98	0.00
spinosa	1.88	0.75	21.05	6.77	5.26	0.00	0.00	0.00	0.75	0.75	0.00	0.75	0.00
Krameria	1.72	0.00	1.72	2.01	16.91	0.00	2.58	4.87	57.88	8.02	0.00	2.58	1.72
parvifolia	1.19	0.00	1.19	1.39	11.73	0.00	1.79	3.38	40.16	5.57	0.00	1.79	1.19
Atriplex	46.66	0.00†	6.67	0.00	20.00	0.00	0.00	0.00	6.67	6.67	0.00	0.00	13.33
confertifolia	4.09	0.00	0.58	0.00	1.75	0.00	0.00	0.00	0.58	0.58	0.00	0.00	1.17

†See text of report under this group and this shrub.

*The first line for each shrub species is the percentage this group represents of the total defoliators for each shrub species.

**The second line is the percentage of the total this defoliator represents among all the phytophagous forms on that shrub.

Table 13. Summary of Table 12: for each host shrub the 4 or 5 most abundant groups are listed by percentage of defoliators and percentage of total phytophagous forms known to occur in Rock Valley on that species of shrub

SHRUB		% of Defoliators		% of Phytophagous forms
Larrea divaricata				
Bootettix punctata		29.29		6.05
Semiothisa		18.41		3.80
Gelechiidae		17.36		3.59
Curculionidae		6.69		1.38
Chrysomelidae		4.81		0.99
	Totals	76.56		14.76
Ambrosia dumosa				
Curculionidae		35.78		2.62
Gelechiidae		20.07		1.47
Moth larvae (misc.)		15.71		1.15
Coleophoridae		8.36		0.61
Tanaocerus koebelei		4.35		0.54
	Totals	84.27		6.39
Lycium andersonii				
Gelechiidae		34.92		17.20
Yponomeutidae		16.81		8.28
Moth larvae (misc.)		11.20		5.52
Coleophoridae		8.42		4.25
Chrysomelidae		7.76		3.82
	Totals	79.10		39.07
Ephedra nevadensis				
Yponomeutidae		30.00		0.50
Curculionidae		25.00	(perching)	0.42
Gelechiidae		21.00		0.33
Coleophoridae		10.00		0.17
Moth larvae (misc.)		10.00		0.17
	Totals	96.00		1.59
Lycium pallidum				
Gelechiidae		78.02		56.80
Moth larvae (misc.)		9.89		7.20
Yponomeutidae		5.50		4.00
Phalaenidae		3.30		2.40
Chrysomelidae		3.30		2.40
	Totals	99.99		72.80
Grayia spinosa				
Coleophoridae		55.45		21.05
Cosmopterygidae		17.82		6.77
Gelechiidae		13.86		5.26
Chrysomelidae		4.95		1.88
	Totals	92.08		34.96
Krameria parvifolia				
Yponomeutidae		57.88		40.16
Gelechiidae		16.91		11.73
Moth larvae (misc.)		8.02		5.57

Continued

Table 13. (cont.)

SHRUB		% of Defoliators	% of Phytophagous Forms
Phalaenidae		4.87	3.38
Geometridae larvae (misc.)		2.58	1.79
Tanaocerus		2.58	1.79
	Totals	92.84	64.42
Atriplex confertifolia			
Chrysomelidae		46.66	4.09
Gelechiidae		20.00	1.75
Grasshoppers (misc.)		13.33	1.17
Coleophoridae		6.67	0.58
Yponomeutidae		6.67	0.58
Moth larvae (misc.)		6.67	0.58
	Totals	100.00	8.75

Table 14. Analysis of shrub-dwelling consumers vacuumed from the major shrubs in Rock Valley, Nevada, in 1972, divided into the sap-sucking forms and those that are not sap-sucking (only the thrips are in this group)

	Miscellaneous Miridae	*Phytocoris* sp. (Miridae)	Tingidae	% Hemiptera Total	Psylliidae	Miscellaneous Cicadellidae	*Scaphytopius nigricollis*	*Spathanus excavatus*	Fulgoroidea	Pseudococcidae	Miscellaneous Scale Insects	% Homoptera exclud. Membracids	*Frankliniella* Phloeothripidae	*Leptothrips* Thripidae	% of Total Arthropods = Thrips	% of Phytophagous Arthropoda Sap-Sucking	% of Total Arthropoda Sap-Sucking
Larrea	0.69*	5.57	0.00	6.06	1.38	3.15	1.23	1.92	0.46	35.69	0.38	44.20	0.00	0.00	0.00	56.30	39.70
divaricata	0.39**	3.03	0.00	3.41	0.78	1.77	0.69	1.09	0.26	20.12	0.22	24.89	5.36	16.38	21.73		
Ambrosia	1.99	0.00	62.69	64.68	0.00	5.72	0.00	0.00	2.99	15.62	1.00	35.32				9.84	9.25
dumosa	0.20	0.00	6.17	6.36	0.00	0.56	0.00	0.00	0.29	2.52	0.10	3.47	0.93	77.44	78.36		
Lycium	6.38	0.00	0.00	6.38	12.77	22.33	0.00	0.00	7.44	51.06	0.00	93.62				19.96	13.07
andersonii	1.27	0.00	0.00	1.27	2.55	4.46	0.00	0.00	1.49	10.19	0.00	18.68	4.03	15.50	19.53		
Ephedra	5.55	0.00	0.00	5.55	0.00	0.00	0.00	0.00	38.89	55.56	0.00	94.44				3.00	2.80
nevadensis	0.17	0.00	0.00	0.17	0.00	0.00	0.00	0.00	1.17	1.67	0.00	2.84	0.25	90.99	91.24		
Lycium	8.70	0.00	0.00	8.70	26.03	4.34	0.00	0.00	17.39	43.48	0.00	91.30				18.40	14.94
pallidum	1.60	0.00	0.00	1.60	4.80	0.80	0.00	0.00	3.20	8.00	0.00	16.80	0.80	4.80	5.60		
Grayia	21.21	0.00	0.00	21.21	0.00	0.00	0.00	0.00	0.00	27.27	51.52	78.78				12.41	9.59
spinosa	2.73	0.00	0.00	2.73	0.00	0.00	0.00	0.00	0.00	3.38	6.39	9.77	0.75	45.11	45.86		
Krameria	4.26	0.00	0.00	4.26	4.26	44.67	0.00	0.00	25.53	21.28	0.00	95.74				9.34	6.42
parvifolia	0.40	0.00	0.00	0.40	0.40	4.17	0.00	0.00	2.39	1.99	0.00	8.95	4.37	10.74	15.11		
Atriplex	7.35	0.00	0.00	7.35	0.00	1.47	0.00	0.00	2.21	69.85	19.12	92.64				67.58	58.02
confertifolia	5.49	0.00	0.00	5.49	0.00	1.10	0.00	0.00	1.65	52.19	14.29	69.23	2.20	13.74	15.93		

Membracids on *Larrea divaricata* only

(1)	(2)	(3)	(4)	(5)	(6)
23.41	17.11	7.14	2.07	49.73	93.94
13.18	9.64	4.02	1.17	28.00	52.90

1 = Membracid nymphs
2 = *Centrodontus atlas*
3 = *Multarioides bifurcatus*
4 = *Multareis cornutus*
5 = % Membracidae total
6 = % Total Homoptera on *Larrea*

*The first line for each species of shrub is the percentage of the sap-sucking forms this group represents on that shrub.

**The second line is the percentage this group is of the total phytophagous forms on the shrub. The thrips are included only in the second line analysis.

Table 15. Summary of Table 14: for each host shrub the 4 or 5 most abundant groups are listed by percentage of the total sap-sucking forms and by the percentage of the total phytophagous forms known to occur in Rock Valley on that species of shrub

SHRUB		% of Sap-Sucking forms	% of Phytophagous forms
Larrea divaricata			
Thrips		0.00	21.73
Membracidae (all)		49.73	28.00
Pseudococcidae		35.69	20.12
Phytocoris spp.		5.37	3.03
Leafhoppers (Misc.)		3.15	1.77
Spathanus (Cicadellidae)		1.92	1.09
	Totals	95.85	75.74
Ambrosia dumosa			
Thrips		0.00	78.36
Tingidae		62.69	6.17
Pseudococcidae		15.62	2.52
Leafhoppers (Misc.)		5.72	0.56
Fulgoroidea		2.99	0.29
Miridae (Misc.)		1.99	0.20
	Totals	89.01	88.10
Lycium andersonii			
Thrips		0.00	19.53
Pseudococcidae		51.06	10.19
Leafhoppers (Misc.)		23.34	4.46
Psyliidae		12.77	2.55
Fulgoroidea		7.44	1.49
Miridae (Misc.)		6.38	1.27
	Totals	99.99	30.53
Ephedra nevadensis			
Thrips		0.00	91.24
Pseudococcidae		55.56	1.67
Fulgoroidea		38.89	1.17
Miridae (Misc.)		5.55	0.17
	Totals	100.00	94.25
Lycium pallidum			
Thrips		0.00	5.60
Pseudoccidae		43.48	8.00
Psylliidae		26.07	4.80
Fulgoroidea		17.39	3.20
Miridae (Misc.)		8.70	1.60
Leafhoppers (Misc.)		4.34	0.80
	Totals	99.99	24.00
Grayia spinosa			
Thrips		0.00	45.86
Scales (Misc.)		51.52	6.39
Pseudococcidae		27.27	3.38
Miridae (Misc.)		21.21	2.63
	Totals	100.00	58.26

Continued

Table 15. (cont.)

SHRUB		% of Sap-Sucking Forms	% of Phytophagous Forms
Krameria parvifolia			
Thrips		0.00	15.11
Leafhoppers (Misc.)		44.67	4.17
Fulgoroidea		25.52	2.39
Pseudococcidae		21.28	1.99
Miridae (Misc.)		4.26	0.40
Psylliidae		4.26	0.40
	Totals	100.00	24.46
Atriplex confertifolia			
Thrips		0.00	15.93
Pseudococcidae		69.85	52.20
Scales (Misc.)		19.12	14.29
Miridae (Misc.)		7.35	5.49
Fulgoroidea		2.21	1.65
Leafhoppers (Misc.)		1.47	1.10
	Totals	100.00	90.66

C.6. DISCUSSION

In 1972 a total of 5525 arthropods (3305 in 1971) were examined in the course of pitfall studies and 11,131 (4872 in 1971) were taken during the vacuuming studies. About twice as many arthropods were taken during 1972. Because there were no changes in sampling techniques, and only a slight change in the composition of field personnel, it seems reasonable to conclude that the abundance of arthropods increased in 1972. This increase was noted both among arthropods taken by pitfalls (up 1.67-fold) and D-Vac (up 2.28-fold).

Field studies in 1972 indicated that there are apparently no important species that we are not capturing in the pitfalls. In 1972 we attempted to relate pitfall captures of various species to absolute abundances. A methodology study to evaluate pitfall sampling methods would be useful. A system of analysis should be developed to utilize the large quantities of pitfall data that have been accumulated from Rock Valley and other areas. Methods of marking arthropods other than beetles must be perfected. Only the beetles have been successfully marked with an identifying mark lasting more than a year. It is also desirable to identify other species which live more than a few weeks. This would be particularly useful for some of the larger forms such as scorpions, tarantulas, and camel crickets. A peripheral benefit of the capture-recapture studies has been the accumulation of other data about the species involved, such as life span, movements, and home range size.

Numerous "early season" species, i.e., those normally active before week 26 (July 1), appeared earlier than usual in 1972. Several of these reached their maximum abundance in 1972 as much as four weeks before the 1971 peaks, and we have already referred the reader to previous sections in this regard. This was particularly true among phytophagous beetles (e.g., *Metoponium convexicolle* and *Triorophus laevis*) and predaceous types (e.g., most of the spiders). The earlier periods of peak abundance were not surprising among the spiders and assassin bugs, which prey almost entirely upon phytophagous arthropods. The latter, as reported in connection with the vacuuming data, were often as much as four weeks earlier in 1972. Several of the typically "late season" (week 31 on) ground-dwelling omnivores were somewhat later in 1972 (e.g., *Eleodes armata, Arenivaga* sp., and the sowbug *Venezillo arizonicus*). It might seem that the late season *Asidina semilaevis* and *Trogloderes costatus* were inconsistent in this regard, but these beetles usually reach their maximum abundance after sampling has been discontinued. Later surveys demonstrated that these reached their maximum abundance 2-4 weeks later than usual.

In 1972 the treatment of the shrub sampling data was modified somewhat from that used in 1971. The primary difficulty with these data arises when numbers of arthropods taken on individual shrubs are extrapolated to large areas. Insofar as possible we attempted to treat the vacuuming data with biological judgement. This "tempering" of the data took

several routes. We did not use data from samples in which a large number of individuals of one species were taken from a single plant (if this were the only shrub of a respective species sampled). For example, during week 19, in plot 12, one flesh fly (Sarcophagidae) was taken from *Ambrosia*. The density of this shrub in plot 12 is about 3647/ha. Hence, one might estimate the abundance of this species as 3647/ha. However, anyone familiar with these flies knows that they are not associated with *Ambrosia* but are nekrozoophagous. Hence, this is an unreasonable density estimate. Similarly, we ignored incidental records (e.g., *Smicronyx imbricata* on *Ephedra nevadensis*) where an insect was encountered simply resting on a shrub, but not feeding or ovipositing thereon.

There were some difficulties we could not remedy. One of these was the failure of the vacuum device to remove all of the insects from the sampled shrub. Often, shrubs were examined after vacuuming and found to have some of the tightly clinging insects still in place. Less than 20% of the broad-nosed weevil, *Ophryastes varius*, and only about 30% of some of the tenebrionids were removed by the suction device. These beetles cling to twigs and stems with their specially adapted forelegs and tarsi. We were unable to obtain valid estimates of the densities of other species because of behavioral traits that could not be compensated for in the vacuum sampling regimen. Numerous beetles (e.g., certain tenebrionids, curculionids and chrysomelids) have cyclic feeding habits. Thus, if a plot was sampled once a week, only that portion of the population feeding that day was sampled. The remainder of the population was resting at or near the base of plants and was not susceptible to capture by the vacuum device. At Joshua Tree National Monument we found that individual weevils of the genus *Ophryastes*, several galerucine leaf beetles, and certain longhorn beetles fed only every second to third day (or night). Hence it is probable that some of our density estimates, particularly those of beetles, may represent only 1/3 to 1/2 of the total population.

About 70% of the forms we considered increased in apparent abundance during 1972. This was particularly true of those species that chew up plant tissue. This goes along with the advance in certain phenological events of the host plants already referred to. Those that remove sap depend only on the source of sap, and may not be influenced by dramatic seasonal shifts in the timing of leafing, flowering, budding, etc.

In analyzing the composition of the plant inhabiting arthropods (Tables 11-15) we stressed the important species vacuumed from the major shrubs in 1972. The major shrubs species were subjected to heavier attack from phytophagous forms in 1972 than in 1971. Phytophagous forms taken from *Larrea* increased as did defoliators and sap-removing forms. The major increases occurred in plant bug, treehoppers, mealy bugs, and measuring worms. *Ambrosia* exhibited increases of defoliators and sap-removing forms. The major increases were displayed by mealy bugs and case-bearing moth larvae. Table 12 suggests that the weevils were highly important defoliators. In fact, this is a good example of the relative unimportance of an abundant species. Weevils were indeed the most abundant defoliators, but this group was composed almost solely of one species which fed upon and destroyed only a

portion of the flowers and/or seeds. Numerically, weevils appreciably exceeded the most important defoliator (gelechiid larvae), but when feeding habits and amount of material consumed is compared the relative unimportance of weevils is made clear. Phytophagous species on *Lycium* exhibited an overall increase, both in terms of defoliators and sap-removing forms. The major forms on *L. andersonii* were gelechiid and ermine moth larvae (defoliators), and mealy bugs and leafhoppers (sap-removers). The major forms on *L. pallidum* were mealy bugs, jumping plant lice, gelechiid and ermine moth larvae. This shrub suffered defoliation from other moth larvae as well. Phytophagous species on *K.parvifolia* displayed an overall increase, only modestly among defoliating forms, but distinctly among sap-removing species. The relatively low increases on *Ambrosia* and *Krameria* can be related directly to the defoliating forms. On *Ambrosia*, tanaocerid grasshoppers were down from the abundance estimated in 1971. *Krameria* showed a large decrease in ermine moth larvae, which were apparently displaced by gelechiid larvae. The latter increased markedly. Other forms on these shrubs also increased in 1972 over the estimated abundance for 1971.

Our information on parasitic and predatory forms is sketchy (numerous families were lumped together), but we judge that 1972 abundance was higher than in 1971. Bee flies were up, probably reflecting decreased natural mortality rather than an increase in hosts. The ichneumonoid wasp parasites did not change in apparent abundance. Parasitic chalcidoid wasps, however, increased appreciably. The predaceous melyrid beetles also increased over 1971.

The trophic composition of the Rock Valley arthropod fauna--at least insofar as revealed by D-Vac sampling--differs significantly from that reported by Weiss (1925, 1926) and reviewed by Chapman (1931:161). Weiss (1926) concluded that about half of the species of insects occupying a community were phytophagous, around 25% saprophagous, about 15% predatory, and 10% were parasitic. These figures were based not only on studies in which insects were collected only from various herbaceous strata but also investigations in which insects were collected from all components of the environment. In Rock Valley 185 species or species groups (e.g., pseudococcids, fulforoids) taken by D-Vac were classified as to food habits. About 80% were phytophagous (cf. 50% above), and predators and parasitic forms combined composed only about 8% of the total (cf. 25% above).

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D. VERTEBRATES

1. REPTILES

Selected species of reptiles were enumerated on the validation site and in two adjoining 9-ha fenced plots (plots 1 and 3) during the spring of 1972. Densities of *Uta stansburiana* were determined by absolute counts in one 0.8-ha area (plot 12) and in a 1.4-ha area lying within plot 3 (A3UTJ40). This work was done between mid-March and mid-April. We work with *Uta* in a manner similar to that described by Tinkle (1967). From two to four people walk back and forth systematically within the plots. When a lizard in observed, a numbered marker is dropped at the location. Then the lizard is noosed (over 95% of adult *Uta* are noosed). After capture, *Uta* are placed in numbered plastic vials. The location, vial number, and marker number are recorded on a 3 x 5 index card so that the lizard can be later returned to the spot where it was captured. Then the lizard in the vial is placed upside down in a sack containing 20 such vials. Sampling continues until the entire plot has been searched. Lizards are taken to a trailer for processing. All *Uta* are weighed to the nearest 0.1 g on a "Dial-a-Gram" balance, measured to the nearest mm, palped, toe-clipped if not already marked, and painted. After all of the lizards have been processed they are released at points of capture and the numbered markers retrieved. Our experience has been that all of the resident *Uta* can be enumerated in this manner, and the spring density (as of March 1) is taken as the total roster of all different individuals registered. We believe that *Uta* densities can also be effectively estimated indirectly by capture-recapture analysis, assuming that a chain of four or five consecutive samples are utilized (see Turner et al., 1969). Numbers of leopard lizards (*Crotaphytus wislizenii*) and horned lizards (*Phrynosoma platyrhinos*) captured in fenced plot 1 during 1972 have been used as estimates of minimal densities of these species in that 9-ha area (A3UTJ42). These estimates include only animals at least 8 months of age and no attempt was made to record the abundance of hatchlings in the summer. Densities of *Cnemidophorus tigris* and *Callisaurus draconoides* were estimated in a 9-ha area (plot 19) on the validation site (A3UTJ42). Counts of these species were made on eight occasions between June 6 and July 8. These counts included all age classes of *Callisaurus*, but only whiptail lizards at least 18 months of age. In our judgement, yearling whiptails (~ 8 months) are not recorded with the same efficiency as older individuals. The average count ($\bar{N}$) was then multiplied by an appropriate scaling factor. The scaling factor used for *Cnemidophorus* was 3.33; for *Callisaurus* it was 2.0 (see Medica et al., 1971). The resulting density estimate for *Cnemidophorus* was then adjusted to compensate for the absence of yearlings. Among 150 whiptail lizards of known age captured in fenced plots (1 and 3) during 1972, 47 (31.3%) were yearlings. The total spring density of whiptails (n/ha) was thus estimated as:

$$(3.33\bar{N}/9)/0.687$$

The number of desert tortoises (*Gopherus agassizi*) registered in fenced plot 1 was taken as a minimal density estimate for this species.

The proportion of yearling *Uta* (~ 8 months of age) was based upon 67 individuals from the validation site. The estimated proportion of yearling *Cnemidophorus* was based on 150 lizards of known age captured within fenced plots. For other species, distinctions between yearlings and older animals were made on the basis of body size. Reproduction by *Phrynosoma* and *Crotaphytus* was negligible in 1971, so the number of yearlings observed in 1972 was essentially zero. Estimated dry weights of reptiles have been taken simply as 30% of live weights. The dry weight of the desert tortoise has been estimated assuming that the shell is 22% of the total live weight.

Table 1 lists reptiles occurring on the Rock Valley Validation Site. The herpetofauna of the area also includes three lizards which occur on the rocky hillsides surrounding the valley (*Sauromalus obesus, Xantusia vigilis* and *Crotaphytus collaris*). Two additional snakes may occur in Rock Valley--*Trimorphodon lamda*, which has been collected in Mercury Valley, and *Tantilla planiceps*, which has been found at Cane Springs (Tanner, 1969).

Table 2 gives mean dry weights of six lizards and the desert tortoise, and Table 3 gives similar data for ten snakes found on the validation site (A3UTJ44). Table 4 gives census data for *Cnemidophorus tigris* and *Callisaurus draconoides* from plot 19 during June and July, 1922. Table 5 gives estimates of density and biomass for five species of lizards and the desert tortoise during 1972. Comparisons between 1972 and 1971 are given when possible. It should be pointed out that the biomass reported for *Cnemidophorus tigris* in 1971--99.9 g/ha (live weight)--pertained only to animals 18 months of age of older. When this figure is adjusted to compensate for the absence of yearlings the 1971 estimate becomes 107.8 g/ha (live weight), or 32.3 g/ha dry weight. The only other lizard of importance on the validation site is the nocturnal gecko (*Coleonyx variegatus*). The species seems to be quite uniformly distributed and densities may be as high as 30/ha (see Parker, 1972). The most common snake is the shovelnosed snake, *Chionactis occipitalis*. Relative abundance varies topographically, and this species is more numerous in the lower (northern) plots. Densities may be around 5-10/ha. Another fairly abundant snake is the red racer, *Masticophis flagellum*, probably uniformly dispersed at around 0.5 - 1/ha. The sidewinder, *Crotalus cerastes*, occurs all over Rock Valley at lower densities; ca. 0.2 - 0.5/ha. Other species with likely densities in the range of 0.05 - 0.2/ha are *Salvadora hexalepis* and *Rhinocheilus lecontei*. The other six snakes listed initially have been observed but rarely.

Table 6 lists the dates of first appearance for five species of lizards common to the validation site for the past five years. The predator-prey interactions between reptiles and other organisms observed in Rock Valley are shown in Table 7. *Lycium andersonii* berries are readily eaten by many organisms when they are available. Normally predatory leopard lizards (*Crotaphytus wislizenii*) have been observed in bushes eating the berries (Turner et al., 1969). Stomachs of horned lizards (*Phrynosoma platyrhinos*) contained berries in May, 1972 (Tanner and Krogh, 1973), and stomachs of chuckwallas (*Sauromalus obesus*) con-

tained berries, leaves and flowers of this plant (Sanborn, 1972). Cloacal and oral hemorrhaging as reported by McCoy and Gehlbach (1967) has been observed in *Rhinocheilus lecontei*. Cloacal hemorrhaging has also been observed in *Pituophis*. We have never observed the emission of blood from the eyes of *Phrynosoma platyrhinos*, which is in agreement with Tanner and Krogh (1973). While collecting snakes on the roads in Rock Valley and vicinity we have observed the following species of lizards sleeping on the pavement at night: *Uta stansburiana, Crotaphytus wislizenii, Callisaurus draconoides, Phrynosoma platyrhinos, Sceloporus magister,* and *Dipsosaurus dorsalis.* Mays and Nickerson (1968) have also observed some of the above species sleeping on the pavement at night.

Table 1. Reptiles occurring on the Rock Valley Validation Site

Lizards
Callisaurus draconoides
Cnemidophorus tigris
Coleonyx variegatus
Crotaphytus wislizenii
Phrynosoma platyrhinos
Sceloporus magister
Uta stansburiana
Snakes
Arizona elegans
Chionactis occipitalis
Crotalus cerastes
C. mitchelli
Hypsiglena torquata
Lampropeltis getulus
Leptotyphlops humilis
Masticophis flagellum
Phyllorhynchus decurtatus
Pituophis melanoleucus
Rhinocheilus lecontei
Salvadora hexalepis
Sonora semiannulata
Turtle
Gopherus agassizi

Table 2. Mean dry weights of six lizards and a tortoise found on the Rock Valley Validation Site in 1972

Species		sex	n	Minimum s-v† length (mm)	Mean body weight (g)	Range
Uta stansburiana	adult	M	10	48	1.3	1.1-1.6
	adult	F	21	46	1.3	0.9-1.5
	yearling	M	63	40	1.1	0.9-1.4
	yearling	F	76	41	1.0	0.7-1.3
Cnemidophorus tigris	adult	M	44	71	4.7	3.1-7.0
	adult	F	78	71	4.1	2.7-5.6
	yearling	M	32	53	2.0	1.0-3.1
	yearling	F	23	51	3.0	1.3-3.0
Crotaphytus wislizenii	adult	M	32	94	9.2	5.5-11.3
	adult	F	10	101	13.1	8.7-16.5
Phrynosoma platyrhinos	adult	M	21	73	7.2	6.0-8.8
	adult	F	19	74	7.9	6.0-10.8
Callisaurus draconoides	adult	M	9	70	5.5	3.7-6.4
	adult	F	15	70	3.8	3.1-4.1
Coleonyx variegatus	adult	M	40	50	0.8	0.6-1.4
	adult	F	18	50	0.9	0.4-1.3
Gopherus agassizi		M	5	180*	544.3	283.1-819.9
		F	13	126*	202.5	102.5-819.5

† Snout-vent length
* Plastron length

Table 3. Mean dry weights of ten snakes found on the Rock Valley Validation Site

Species	n	Minimum s-v length (mm)	Mean body weight (g)	Range
Chionactis occipitalis	77	200	2.6	1.4-3.7
Sonora semiannulata	6	250	2.7	2.1-3.7
Rhinocheilus lecontei	7	569	20.3	10.0-30.2
Masticophis flagellum	19	590	29.9	14.8-55.6
Salvadora hexalepis	2	630	21.5	16.1-27.0
Lampropeltis getulus	3	700	43.5	30.8-62.1
Pituophis melanoleucus	6	975	85.6	66.3-130.1
Phyllorhynchus decurtatus	2	289	4.7	4.1-5.3
Crotalus cerastes	17	400	32.8	13.2-55.8
Crotalus mitchelli	3	640	76.7	62.8-94.0

Table 4. Census data for adult (≥ 18 months) *Cnemidophorus tigris* and all *Callisaurus draconoides* obtained on the validation site during 1972

Date (1972)	*Cnemidophorus*	*Callisaurus*
June 6	18	9
June 7	17	10
June 8	36	10
June 9	25	14
June 12	11	15
July 5	10	15
July 7	21	6
July 8	17	11
Totals observed	155	90
Mean	19.4	11.3
Estimated numbers on 9 ha	64.6*	22.6**
Estimated density/ha	7.2	2.5

*scaling factor of 3.33 for 1972.

**estimated scaling factor of 2.

Table 5. Estimated densities and biomass (dry weight) of six reptiles in Rock Valley during 1972

Species	Plot	Size of plot(ha)	n/ha	g/ha	Percent change in biomass 1971-1972	Percent of Population composed of yearlings
Uta stansburiana	12	0.8	40	40.2	+ 0.75	71.9
"	3	1.4	25	26.6	-	77.2
Cnemidophorus tigris	19	9.0	10.4	38.0	+17.6	31.3
Callisaurus draconoides	19	9.0	2.5	11.6	-22.3	-
Crotaphytus wislizenii	1	9.1	0.97	10.1	+18.7	0.0
Phrynosoma platyrhinos	1	9.1	1.7	12.4	+15.6	0.0
Gopherus agassizi	1	9.1	0.6	224	+12	-

Table 6. Dates of first appearance of adult lizards in Rock Valley or Mercury Valley over the past five years

Species	1968	1969	1970	1971	1972
Uta stansburiana			ACTIVE YEAR ROUND		
Cnemidophorus tigris	27 Mar.	17 Apr.	7 Apr.	8 Apr.	20 Mar.
Crotaphytus wislizenii	1 Mar.	26 Mar.	13 Apr.	5 Apr.	10 Mar.
Phrynosoma platyrhinos	28 Feb.	17 Mar.	16 Mar.	9 Mar.	15 Feb.
Callisaurus draconoides	14 Mar.	26 Mar.	16 Mar.	11 Mar.	6 Mar.

Table 7. Observed predator-prey relations involving reptiles

	Prey							
Predator	*Uta stansburiana*	*Cnemidophorus tigris*	*Phrynosoma platyrhinos*	*Sceloporus magister*	*Chionactis occipitalis*	*Phyllorhynchus decurtatus*	*Perognathus* sp.	*Dipodomys* sp.
Uta stansburiana	X							
Crotaphytus wislizenii	X	X	X				X	
Coleonyx variegatus	X*							
Rhinocheilus lecontei				X		X*	X	
Masticophis flagellum		X						
Lampropeltis getulus					X			
Crotalus cerastes	X	X						X
Lanius ludovicianus	X		X					
Corvus corax		X						
Hadrurus hirsutus	X*							
tarantula	X*							
solpugid	X*							

* in can trap

D.2. BIRDS

Observations of birds in Rock Valley continued in 1972, with observations extending between February and June and resuming again in November. Two plots were fenced circular 9-ha areas (1 and 2), and one (18) was an unfenced rectangular area of 25 ha. Plot 18 contains portions of each of the six vegetational zones illustrated on p.2.2.2.2.-10. The relative contribution of each of these zones to the extent of plot 18 is about the same as the zone areas relative to the total validation site area (0.46 km^2), though zone 20 is somewhat underrepresented. Spring breeding bird densities were estimated by the Williams spot map census technique (Williams, 1936; Kendeigh, 1944). Observations were made along parallel lines 50 m apart. Four to five censuses were taken each month from February to June and five censuses were conducted in November. Non-breeding species (transients, winter visitants), whether singing or not, were also tallied in the course of each census. Nest searching augmented regular census techniques for species lacking strong territorial behavior or distinctive song. Mean body weights were based on the literature, and dry weights were taken as 30% of live weights.

Birds observed at one time or another in the three plots are listed in Table 8. Estimated densities of the two breeding species are given in Table 9. Pairs were estimated to the nearest 0.25 in each plot (A3UTJ60). As in 1971, *Amphispiza bilineata* was the dominant breeding species. Populations of these sparrows were higher in 1972 than in 1971, and the 1972 densities were quite similar in all three plots. The increase between 1971 and 1972 was greater in the plot with the lowest density in 1971 (18). Counts of non-breeding species during the spring and early summer are given in Tables 10 and 11. Comparable data for the winter (November) are given in Table 12 (A3UTJ61). Actually, those birds observed during February are part of a winter community. For transient species the total numbers of individuals counted during all of the censuses are given. Tables 11 and 12 also give the estimated period of time each species was present on the validation site, and the number of censuses conducted while each species was present. As in 1971, there were more birds in plot 2, while the lowest densities were observed in plot 18. *Amphispiza belli* is the dominant species for *Eremophila alpestris, Anthus spinoletta* and *Carpodacus mexicanus* are of sporadic occurrence. The latter three species do most of their feeding outside the plots. One of the principal reasons for low winter populations on the validation site is that several species (particularly sage sparrows) congregate in areas of Russian thistle (*Salsola paulsenii* and *S. pestifera*). These shrubs occur principally along roadsides.

Transients utilize the plots from March to June. The maximum concentration of individuals is in April and the greatest number of species is in May. Migration was longer, heavier, and more diversified than in 1971. Specific changes included an extension of tyrannid migration into June, a longer visiting period by *Spizella breweri* (nine weeks in 1972 as compared to two weeks in 1971) and a many-fold increase in house finches and transient sage sparrows (*Amphispiza belli*). A gap in time separated the wintering and migrating

Table 8. Birds observed in three plots in Rock Valley

Species	Status*	Plots 1	2	18
Cathartes aura	T	X		
Circus cyaneus	W,T		X	X
Falco mexicanus	P			X
Falco sparverius	P	X		
Zenaidura macroura	T	X	X	X
Speotyto cunicularia	P			X
Phalaenoptilus nuttallii	T		X	X
Aeronautes saxatalis	T	X		X
Tyrannus verticalis	T	X	X	X
Tyrannus vociferans	T	X	X	
Myiarchus cinerascens	T	X	X	X
Sayornis saya	T		X	X
Pyrocephalus rubinus	T			X
Eremophila alpestris	W,T	X		X
Tachycineta thalassina	T		X	X
Iridoprocne bicolor	T		X	
Stelgidopteryx rufficollis	T	X		X
Hirundo rustica	T	X		
Petrochelidon pyrrhonota	T	X		
Corvus corax	P	X	X	X
Salpinctes obsoletus	W	X	X	X
Mimus polyglottos	T	X	X	X
Toxostoma lecontei	P	X	X	X
Polioptila caerulea	T		X	X
Regulus calendula	T			X
Anthus spinoletta	W	X		X
Phainopepla nitens	T	X		
Lanius ludovicianus	W,T		X	X
Sturnus vulgaris	W	X		X
Dendroica petechia	T	X	X	X
Dendroica auduboni	T	X	X	X
Dendroica negrescens	T		X	
Wilsonia pusilla	T		X	X
Icterus parisorum	T		X	
Euphagus cyanocephalus	T	X	X	
Molothrus ater	T	X	X	
Carpodacus mexicanus	W,T	X	X	X
Amphispiza bilineata	S	X	X	X
Amphispiza belli	W,T	X	X	X
Junco oreganus	W	X		
Spizella breweri	T	X	X	X
Zonotrichia leucophrys	T	X	X	X

* Status designations as follows: P, permanent resident; W, winter resident; S, summer resident; T, transient.

Table 9. Estimated densities and biomass of two species of breeding birds in Rock Valley during the spring of 1972

Species	Plot	Area (ha)	Pairs	Pairs/ha	g/ha*	% change in biomass between 1971 and 1972
Toxostoma lecontei	1	9	0.25	0.028	1.05	-
	2	9	0.25	0.028	1.05	-
	18	25	1.00	0.040	1.50	-
	all 3	43	1.50	0.035	1.32	-
Amphispiza bilineata	1	9	4.75	0.53	4.35	+18.0
	2	9	4.75	0.53	4.35	+11.3
	18	25	13.00	0.52	4.26	+26.8
	all 3	43	22.50	0.52	4.26	+21.7

* Mean dry body weight of *Toxostoma* was assumed to be 18.8 g; that of *Amphispiza* 4.1 g.

Table 10. Birds observed in three plots in Rock Valley, Feb-Jun 1972

Numbers in parentheses indicate censuses conducted during the time when each species was present in the valley. For winter residents the highest number recorded on any one day is given

Species	Status	Visiting period (weeks)	Plot 1 Feb	Plot 1 Mar	Plot 1 Apr	Plot 1 May	Plot 1 June	Plot 2 Feb	Plot 2 Mar	Plot 2 Apr	Plot 2 May	Plot 2 June	Estimated stay in area
Zenaidura macroura	T[†]	1				1(5)					0(5)		May 10-16
Phalaenoptilus nuttallii	T	1			0(4)					0(4)			Apr 13-19
Aeronautes saxatalis	T	5				2(5)					0(4)		May 9-June 8
Tyrannus verticalis	T	5				1(3)					0(2)		May 11-Jun 12
Tyrannus vociferans	T	5			0(4)	2(5)				0(4)	2(5)		Apr 10-May 14
Myiarchus cinerascens	T	5				0(1)	2(5)					2(5)	May 13-Jun 16
Sayornis saya	T	1					0(4)					1(3)	Jun 8-14
Pyrocephalus rubinus	T	-	-	-	-	-	-	-	-	-	-	-	-
Eremophila alpestris	W,T	18*	0(5)	0(5)				0(5)	0(5)				Nov 15-Mar 20 Jun 7-10
Iridoprocne bicolor	T	1				0(5)					1(5)		May 8-14
Stelgidopteryx rufficollis	T	7				1(1)					0(2)		Mar 23-May 9
Hirundo rustica	T	4			1(1)	0(5)					0(5)		Apr 17-May 17
Petrochelidon pyrrhonota	T	1				1(5)					0(4)		May 9-13
Salpinctes obsoletus	W	13*	0(5)					1(5)					Nov 16-Feb 12
Mimus polyglottos	T	8				0(5)	0(5)				0(5)	4(5)	Apr 20-Jun 16
Polioptila caerulea	T	1			0(1)					1(1)			Apr 15-19
Regulus calendula	T	1			0(1)								Apr 16-22
Anthus spinoletta	W	13	0(5)					0(5)					Nov 16-Feb 17
Lanius ludovicianus	W,T	14	0(4)	0(5)	0(4)	0(5)		1(4)	0(5)	0(4)	0(5)		Feb 9-May 16
Dendroica petechia	T	1				1(5)					0(5)		May 8-14
Dendroica auduboni	T	4			1(4)					1(4)			Mar 22-Apr 21
Dendroica nigrescens	T	1				0(5)					1(5)		May 8-14
Wilsonia pusilla	T	1				0(5)					3(5)		May 8-16
Carpodacus mexicanus	T	13		9(5)	21(4)	8(5)	7(1)		7(5)	17(4)	5(5)		Mar 14-Jun 11
Amphispiza belli	W,T	21*	5(5)		0(1)	0(5)		3(5)			0(5)		Nov 15-Feb 18 Apr 16-Jun 6
Spizella breweri	T	9		1(5)	5(4)	0(5)			1(5)	3(4)	1(5)		Mar 14-May 17
Zonotrichia leucophrys	T	5		18(4)	20(4)				6(4)	62(4)			Mar 15-Apr 21

† W = winter resident; T = transient

* visiting period calculated from fall, 1971.

Table 11. Birds observed in three plots in Rock Valley, Feb-Jun 1972

Numbers in parentheses indicate censuses conducted during the time when each species was present in the valley. For winter residents the highest number recorded on any one day is given.

Species	Status	Minimum visiting period (weeks)	Plot 18 Feb	Mar	Apr	May	June	Estimated stay in area
Zenaidura macroura	[†]T	1				4(4)		May 10-16
Phalaenoptilus nuttallii	T	1			1(2)			Apr 13-19
Aeronautes saxatalis	T	5				0(5)	1(3)	May 9-Jun 8
Tyrannus verticalis	T	5				1(5)		May 11-Jun 12
Tyrannus vociferans	T	5			0(4)	0(2)		Apr 10-May 14
Myiarchus cinerascens	T	5				1(5)	3(5)	May 13-Jun 16
Sayornis saya	T	1					1(5)	Jun 8-14
Pyrocephalus rubinus	T	-	1(2)					Feb 14-16
Eremophila alpestris	W,T	18*	15(5)	2(1)			3(4)	Nov 15-Mar 20; Jun 7-10
Iridoprocne bicolor	T	1				0(2)		May 8-14
Stelgidopteryx rufficollis	T	7		2(1)				Mar 23-May 9
Hirundo rustica	T	4			0(3)	2(5)		Apr 17-May 17
Petrochelidon pyrrhonota	T	1				0(1)		May 9-13
Salpinctes obsoletus	W	13*	-	-	-	-	-	-
Mimus polyglottos	T	8			0(2)	2(5)	0(5)	Apr 20-Jun 16
Polioptila caerulea	T	1			0(2)			Apr 15-19
Regulus calendula	T	1			2(4)			Apr 16-22
Anthus spinoletta	W	13	6(5)					Nov 16-Feb 17
Lanius lucovicianus	W,T	14	0(5)	0(5)	1(4)	1(4)		Feb 9-May 16
Dendroica petechia	T	1				0(2)		May 8-14
Dendroica auduboni	T	4		1(2)	7(4)			Mar 22-Apr 21
Dendroica nigrescens	T	1				0(2)		May 8-14
Wilsonia pusilla	T	1				2(4)		May 8-16
Carpodacus mexicanus	T	13		27(5)	35(4)	5(5)	3(5)	Mar 14-Jun 11
Amphispiza belli	W,T	21*	9(5)		5(4)	12(5)	1(1)	Nov 15-Feb 18; Apr 16-Jun6
Spizella breweri	T	9		13(5)	27(4)	10(5)		Mar 14-May 17
Zonotrichia leucophrys	T	5		27(5)	12(4)			Mar 15-Apr 21

† W = winter resident; T = transient

* visiting period calculated from fall, 1971.

populations. House finches used the area primarily for resting, although feeding was more frequent than in winter. No counts were made of migrating black-throated sparrows (*Amphispiza bilineata*) because they could not be distinguished from the breeding population. The birds were apparently present on several occasions in plot 1 during mid-April. Others may have occurred in lesser numbers between March and May. Ravens were present in the same abundance as in 1971.

The black-throated sparrow arrived three weeks earlier than in 1971. This initiated a four-month breeding season beginning in March and continuing through June. Nestings were confined to May and June in 1971. Reproductive data are given in Table 13. Clutch size in 1972 averaged 3.3, compared to 3.0 in 1971. We judge that breeding success was less in 1972 than in 1971 because of fewer known fledged young and more known failures due to cold weather and predation. Eight located nests contained eggs; of these three failed and one fledged 1 of 3 hatchlings. Six nests were found in 1971; two failed and one was successful. One of the latter failures was due to egg predation.

Toxostoma lecontei bred from late February to early June. Clutch size averaged 3.3 in 1972, unchanged from 1971 (Table 13). Two pairs were observed during the spring. One pair (plot) 18) nested in May at its 1971 site after a March nesting outside the plot. The other pair built a nest in late February and renested at an old location (man-made structure) in April and May. One nest (plot 18) is known to have failed. Presence of juveniles in plot 2 during early May and mid-June indicates some young were fledged. Successful nestings of thrashers were probably more frequent than of sparrows, as a survey outside the plots showed three of four thrasher nests successful and at least two of five sparrow nests as failures.

Nest placement data are given in Table 14. The sparrows show a difference in selection of nest sites between the 8-ha (1 and 2) and the 25-ha (18) plots. In the former, five of the six nests were in *Lycium andersonii* at a mean height of 26 cm (18-33). The latter had three nests in three different plants at a mean height of 17 cm (11-24). Two of these three nest sites were in plant zone 23, an area with a meager population of *L. andersonii*. When *L. andersonii* was selected for nesting, the plant chosen was usually small with erect branches and a full crown. This excellent concealment permitted close sitting and a minimum of disturbance during incubation and other critical periods.

Two thrasher nests were placed at an average height of 46 cm, somewhat less than the 58 cm of 1971. The 1972 figure seems to be more typical of the species throughout Rock Valley. *Lycium* bushes were generally chosen for nest sites because they provide stout stems for attaching bulky nests. Nests placed in *L. andersonii* are well concealed but nests in *L. pallidum* are exposed and easily detected.

Nest construction data are given in Table 15. Sparrows used *Bromus rubens* as the primary material. In 1971 *Eurotia lanata* was equally important. Measurements of seven nests

Table 12. Winter resident birds observed in three plots in Rock Valley during November, 1972

Numbers in parentheses indicate censuses conducted during the time when each species was present in the valley.

Species	Minimum visiting period (weeks)	Plots 1	Plots 2	Plots 18	Estimated period of stay in area
Eremophila alpestris	1	1(5)		7(5)	November 13-21
Salpinctes obsoletus	1	1(5)	2(5)	2(5)	November 13-21
Anthus spinoletta	1	2(5)		6(5)	November 13-21
Sturnus vulgaris	1	1(5)		1(4)	November 15-21
Carpodacus mexicanus	1	1(5)	1(5)	8(5)	November 13-21
Amphispiza belli	1	3(5)	5(5)	6(5)	November 13-21
Junco oreganus	1	2(4)			November 15-19

Table 13. Summary of reproductive data on three Rock Valley sites

Number of nests in each sample is in parentheses.

Species	Plot(s)	Total number of nests	Mean clutch size	Percent of eggs hatched	Percent fledged
Amphispiza bilineata	1	2	4.0 (2)	100.0 (2)	0.0 (1)
	2	3	3.0 (2)	0.0 (1)	0.0 (1)
	18	3	3.0 (2)	100.0 (1)	16.7 (2)
	1,2,18	8	3.3 (6)	84.6 (4)	8.3 (4)
Toxostoma lecontei	2	3	3.5 (2)	100.0 (1)	
	18	1	3.0 (1)	66.7 (1)	0.0 (1)
	2,18	4	3.3 (3)	85.7 (2)	0.0 (1)

Table 14. Location of nests of two breeding species of birds in Rock Valley

Two nestings by thrashers in a man-made structure are omitted.

Nest location	*Toxostoma lecontei* Plot 1	*Toxostoma lecontei* Plot 2	*Toxostoma lecontei* Plot 18	*Amphispiza bilineata* Plot 1	*Amphispiza bilineata* Plot 2	*Amphispiza bilineata* Plot 18
Ambrosia dumosa						1
Atriplex confertifolia						1
Eurotia lanata					1	
Grayia spinosa						1
Lycium andersonii		1		2	2	
L. pallidum			1			

Table 15. Materials used in nest construction by two birds nesting in Rock Valley

Species	Nest date	Nest structure	Nest lining
Amphispiza bilineata	Mar 17	*Bromus rubens*, stems	*Eurotia lanata*, fruit
	Apr 15	" " "	*Bromus* stems
	May 9	" " "	*Eurotia* fruit
	May 9	" " "	*Bromus* fibers
	May 9	*Eurotia* stems	*Bromus* stems
	May 11	*Bromus* stems	cloth
	May 17	" "	*Bromus* stems
	June 8	" "	" "
	June 12	" "	*Larrea divaricata* fruit
Toxostoma lecontei	Mar 14	*Lycium andersonii* twigs	cloth, matted plants
	Apr 10	" " "	" " "
	May 13	*L. pallidum* twigs	*Larrea* fruit, fibers

showed an average diameter of 98 mm and a depth of 74 mm; the dimensions of the nest cavity were 47 by 42 mm. Six of nine nests were placed in a north or east exposure. As in 1971, thrasher nests were constructed primarily of *Lycium* twigs lined with cloth or fibers. Measurements of two nests averaged 206 by 161 mm with cavity dimensions of 99 and 66 mm. All nests examined in and outside of the plots had a north or east exposure.

Some evidence of predation was noted. One sparrow nest with young 3-5 days old was later found empty with a hole near the bottom of the nest. Another nest with young 4-6 days old was found partially crumpled. In 1971, one nest was raided and all three eggs were removed. In 1972, the young disappeared from one thrasher nest at an age of 5-7 days, whereas last year there was no evidence of predation on nests of this species.

The black-throated sparrow is known to be strongly territorial. This was clearly demonstrated from March to mid-June when the males vigorously defended their territories. Defense was usually by song but occasionally an invading male was physically repelled. Males frequently climaxed their defense by choosing a perch and bursting into song. Defense occurred more often during the initial stages of nesting.

Sparrows were often seen feeding on the ground, both beneath bushes and in the open. Less frequently they foraged in bushes. The diet probably consists of both plant and animal matter. On several occasions adults were seen carrying insects to nestlings. One male was observed carrying insects to a nest where a female had recently flown to feed her young. Feeding habits of the more secretive thrashers were observed less frequently. In early winter, thrashers were sometimes observed vigorously probing the soil with their pick-like beaks. Arthropods are probably one of the main constituents of thrashers' diets.

Juvenile sparrows were observed on most censuses during June. The birds were readily identified by their streaked breast and the absence of a black throat. They were seen both individually and in company with a parent. Adults were seen several times feeding their offspring. Juvenile thrashers were seen on the plots in April, May and June. Those observed in plots 1 and 18 were raised in nests adjacent but outside the census area, whereas the individuals in plot 2 were hatched within its boundaries.

D.3. MAMMALS

Inspection of the 1971 data indicated that traps located in plots 11 and 12 were too close (less than 100 meters). Interchanges of animals between the plots were common. We also judged that trapping effort could be distributed more effectively in terms of the observed heterogeneity of the validation site as a whole. Hence, plot 11 was discontinued and two new trap grids established --15 and 16 (see p. 2.2.2.2.-9). Plot 15 was located directly south and upslope from old plot 11 in an area believed to support more *Perognathus formosus*. Plot 16 was located in an area with soil type and vegetation differing from that of plots 12 and 15. Plot 16 lies at the western edge of plot 4, an unfenced circular plot used in earlier Rock Valley studies. The length of trapping periods was increased from five to ten days in an effort to give even the most 'trap-shy' individuals ample opportunity to be captured (see Anderson, 1971).

The 1972 trapping periods were in April (16, 17, 19, 20, 21, 22, 24, 25, 26) and July (6, 7, 8, 9, 10, 11, 12, 13, 14, 15). The April pre-reproductive census was interrupted twice and shortened to 9 days due to adverse weather conditions which would have jeopardized trapped animals. Trapping was conducted simultaneously on three 2.7-ha plots (11, 15, 16). Each plot involved 144 trap stations fifteen meters apart (with two traps per station). The general procedures of trapping and data recording were the same as in 1971. No special trapping effort was undertaken to enumerate squirrels in 1972. However, traps were activated early (3-4 p.m.) and were operative during the late afternoon activity period of the sciurids. No effort was made to enumerate pocket gophers on the validation site itself. Jackrabbits were counted on a 1/2-km^2 area (plot 17) during April and again in July (see Balph, 1971). Carnivores were not censused and no road count data, of the sort supplied by the Nevada Fish and Wildlife Service in 1971, were available for 1972.

Because the rodents occupying the trap grids move about in varying degrees it was necessary to adjust the effective area sampled in accordance with the relative vagility of the different species. Circular home range sizes have been estimated in the past for Rock Valley rodents, using the technique described by Calhoun and Casby (1958). For each species, the effective area trapped was estimated by extending the boundaries of the trap grids (165 m x 165 m) the distance of three sigma.

Live body weight of animals were recorded in the field with a Pesola spring scale read to the nearest gram. The mean live body weights of females were computed omitting weights of pregnant females obviously near term. Live body weights were converted to dry weight equivalents by multiplying by 0.3, following the suggestion of Golley (1960).

Species densities were estimated from the actual numbers of individuals registered during the two trapping periods, taking into account the effective area presumed to be trapped. However, we have attempted to go somewhat beyond this. In our 1971 report

(RM 72-2) we called attention to the fact that trapping records sometimes indicated situations which could not possibly be representative of the system, i.e., the absence of adults coupled with significant recruitment of young (the recruitment of young far in excess of what could have been borne by the apparent stock of females) or the total absence of one sex combined with obvious reproduction. Hence, in two Appendixes we have attempted to revise the actual census data in the light of probable biological realities. These adjustments were based on the following assumptions.

1. From nine years of experience in Rock Valley we judge that populations of heteromyids exhibit 1:1 sex ratios.
2. The mean number of young actually recruited per reproducing female (i.e., the effective litter size) is two (*Perognathus longimembris, Dipodomys microps*) or three (*P. formosus, D. merriami, Ammospermophilus leucurus, Onychomys torridus,* and *Peromyscus crinitus*). We emphasize that these figures are significantly lower than reported litter sizes, which have generally been based on embryo counts (Alcorn, 1941; Bradley and Mauer, 1971; Chew and Butterworth, 1964; Davis and Davis, 1947; Eisenberg and Isaac, 1963; Egoscue, 1964; Hayden, Gambino and Lindberg, 1966; Neal, 1965; Pinter 1970, 1972; Sheppe, 1963; Taylor, 1968). Our experience has indicated that the number of implanted embryos appreciably exceeds the number of young recruited. For example, the mean embryo count from 77 female *Perognathus formosus* was 5.6 $\pm$ 1.4 (French et al., in press). However, only about three young mice are trapped in the vicinity of known pregnant females. In general, survival between implantation and the time of actually entering the trapable population is on the order of 50%.
3. 95% of the adult female populations took part in the primary reproductive effort of 1972. There was a small secondary effort noted in the fenced enclosures (where trapping was more frequent), but we did not detect this on the validation site.
4. If an adult rodent was trapped in July it was assumed to have been alive and present in April, even if it was not registered at that time.

In practice, the changes reflected in Appendixes A and B involved adjustment of the sex ratios of heteromyids, adjustments in the numbers of adults to correspond with observed numbers of young, and adjustments in the numbers of young to correspond with numbers of pregnant females. This last change pertained, with one exception, only to *Ammospermophilus leucurus*.

Biomass values were calculated from the numbers of individuals trapped, the mean dry weights of each sex and age group, and the effective areas trapped for each species. For example, the biomass (g dry weight/ha) of *Dipodomys microps* on plot 12 in April, 1972, was estimated as:

$$[(2 \times 19.7)+(3 \times 15.5)+(17.3)+(3 \times 12.9)]/10.49$$

Table 16 lists species of mammals known to occur on or near the validation site. Tables 17, 18 and 19 indicate the actual numbers of different individuals of various species trapped on three 2.7-ha plots during April and July of 1972 (A3UTJ50, A3UTJ52). Data are

broken down by sex and age groups. Table 20 gives mean body weights (g dry weight) for species collected during 1972. Tables 21 and 22 give estimated numbers (n/ha) and biomass (g dry weight/ha) for seven rodents occupying the three 2.7-ha plots during April and July 1972 (A3UTJ50, A3UTJ52).

The data in Tables 21 and 22 can be extended to the validation site as a whole by assuming that plot 12 is representative of vegetation zones 21, 24 and 25 (total of 20.48 ha), that plot 15 is representative of zone 20 (21.21 ha), and that plot 16 is representative of zones 22 and 23 (total of 4.42 ha). Table 23 gives density and biomass extended from actual trapping data to the validation site as a whole (46.11ha). Table 24 gives changes in the estimated states of populations of five rodents occupying plot 12 between the summer of 1971 and the spring of 1972, and from the spring of 1972 to the summer of 1972.

Seven jackrabbits were counted on the validation site in April 1972, and three in July. Estimated biomass values are 0.76 g dry weight/ha in April and 0.32 g dry weight/ha in July (A3UTJ54). Dingman's work with pocket gophers in an area near the southern edge of the validation site indicated densities of about 4/ha. Densities on the validation site might be lower because of differences in soil composition and texture.

Hypothesized states of populations of seven species of small mammals during April and July 1972 are given in Appendixes A and B. These figures may be extended to the validation site as a whole in the same manner that the actual trapping data were extrapolated (Table 24). Table 25 gives hypothetical data for the validation site.

From the results of microscopic examination of stomach and cheek pouch contents, French et al. (in press) concluded that there is very little difference in the species of plants utilized by the heteromyid rodents in Rock Valley. Table 26 (from French et al., in press) illustrates the diet of the pocket mouse, *Perognathus formosus*.

Discussion

The addition of one trapping grid and the relocation of another did not change the known species composition of the validation site. In 1971 the four major heteromyid species averaged 94.8% of the total small rodent biomass, and the remainder was made up by three other species. In 1972 the heteromyids averaged 94.0% of the estimated biomass (94.1% in April, 93.9% in July). In all but the August 1971 sampling *Perognathus longimembris* has accounted for more biomass than any other species: 41.0% in May 1971, 44.8% on April, 1972, and 34.6% in July, 1972. Only 13.8% of the estimated biomass in August, 1971, was attributed to this species, and we will comment on this later.

It is not clear that increasing the trapping intervals from five to ten days added significant information. In fact, it may have introduced two problems. First, the augmented

Table 16. Mammal species captured or known to be present on Rock Valley Validation Site

Species code	Species
PERFOR	*Perognathus formosus*
PERLON	*Perognathus longimembris*
DIPMER	*Dipodomys merriami*
DIPMIC	*Dipodomys microps*
DIPDES	*Dipodomys deserti*
AMMLEU	*Ammospermophilus leucurus*
ONYTOR	*Onychomys torridus*
PERCRI	*Peromyscus crinitus*
LEPCAL	*Lepus californicus*
THOBOT	*Thomomys bottae*
SYLAUD	*Sylvilagus auduboni*
NEOLEP	*Neotoma lepida*
CANLAT	*Canis latrans*
SPIGRA	*Spilogale gracilis*
VULMAC	*Vulpes macrotis*
TAXTAX	*Taxidea taxus*
PIPHES	*Pipistrellus hesperus*
ANTPAL	*Antrozous pallidus*
MYOCAL	*Myotis californicus*
SPETER	*Spermophilus tereticaudus*

Table 17. Small rodents trapped on plot 12 during April (upper line) and July (lower line) of 1972

Species	Adults		Juveniles		Total captured	Percent Juveniles
	Males	Females	Males	Females		
PERFOR	0	0	0	0	0	-
	0	0	5	5	10	100
PERLON	23	18	0	0	41	0
	12	16	8	11	47	40
DIPMER	4	3	0	0	7	0
	1	3	5	5	14	71
DIPMIC	2	1	3	3	9	67
	6	4	1	2	13	23
AMMLEU	0	0	0	0	0	-
	2	1	0	0	3	0
ONYTOR	1	2	0	0	3	0
	3	1	1	2	7	43
PERCRI	1	0	0	0	1	0
	0	0	2	0	2	100

Table 18. Small rodents trapped on plot 15 during April (upper line) and July (lower line) of 1972

Species	Adults Males	Adults Females	Juveniles Males	Juveniles Females	Total captured	Percent Juveniles
PERFOR	4	0	0	0	4	0
	1	2	17	13	33	91
PERLON	22	24	0	0	46	0
	19	19	26	34	98	61
DIPMER	7	3	0	0	10	0
	6	1	6	6	19	63
DIPMIC	0	0	0	0	0	-
	1	0	0	0	1	0
AMMLEU	0	0	0	0	0	-
	1	5	0	0	6	0
ONYTOR	3	2	2	0	7	29
	0	0	3	5	8	100
PERCRI	0	0	0	0	0	-
	0	1	0	2	3	67

Table 19. Small rodents trapped on plot 16 during April (upper line) and July (lower line) of 1972

Species	Adults Males	Adults Females	Juveniles Males	Juveniles Females	Total captured	Percent Juveniles
PERFOR	2	1	0	0	3	0
	0	1	21	17	39	97
PERLON	21	33	0	0	54	0
	19	36	31	27	113	51
DIPMER	6	1	0	0	7	0
	1	1	5	5	12	83
DIPMIC	2	2	0	2	6	33
	3	3	4	5	15	60
AMMLEU	0	0	0	0	0	-
	2	1	0	0	3	0
ONYTOR	0	4	1	0	5	20
	1	3	1	0	5	20
PERCRI	0	0	0	0	0	-
	0	0	1	1	2	100

Table 20. Mean dry body weights (g) of small rodents trapped on three 2.7-ha plots on the validation site during April and July, 1972 with data for all sites and trapping periods combined; jackrabbit data drawn from previous years

	Adult males			Adult females			Juvenile males			Juvenile females		
Species	n	Mean	Range	n	Mean	Range	n	Mean	Range	n	Mean	Range
PERFOR	10	6.4	6.0-7.8	3	6.2	6.0-6.6	36	4.5	3.0-5.4	34	4.6	3.0-5.7
PERLON	110	2.6	1.8-3.6	142	2.5	2.1-3.6	55	2.1	1.8-2.7	65	2.1	1.2-2.7
DIPMER	22	13.2	11.4-15.3	13	13.4	11.1-16.2	14	8.3	4.8-10.8	12	8.0	5.1-10.2
DIPMIC	13	19.7	17.1-22.2	11	17.3	13.2-20.7	9	15.5	12.9-18.6	11	12.9	9.0-16.2
AMMLEU	5	23.0	20.1-25.5	5	22.4	21.0-24.0	-	-	-	-	-	-
ONYTOR	9	6.4	5.4-7.5	10	8.0	6.6-11.4	8	4.9	4.2-5.7	7	4.2	3.0-7.2
PERCRI	1	5.4	-	1	4.8	-	3	3.6	2.7-4.5	2	3.8	3.3-4.2
THOBOT	10	22.3										
LEPCAL	257	*540										

* Sex and age not differentiated

Table 21. Density and biomass of rodents trapped on the validation site during April, 1972

Species	Plot	Effective area trapped (ha)	Adults		Juveniles		Totals	
			n/ha	g/ha	n/ha	g/ha	n/ha	g/ha
PERFOR	15	6.62	0.60	3.87	-	-	0.60	3.87
	16	6.62	0.45	2.60	-	-	0.45	2.60
PERLON	12	7.77	5.28	13.49	-	-	5.28	13.49
	15	7.77	5.92	15.08	-	-	5.92	15.08
	16	7.77	6.95	17.64	-	-	6.95	17.64
DIPMER	12	15.11	0.46	6.15	-	-	0.46	6.15
	15	15.11	0.66	8.80	-	-	0.66	8.80
	16	15.11	0.46	6.13	-	-	0.46	6.13
DIPMIC	12	10.49	0.29	5.41	0.57	8.12	0.86	13.53
	16	10.49	0.38	7.05	0.19	2.46	0.57	9.51
ONYTOR	12	23.22	0.13	0.75	-	-	0.13	0.75
	15	23.22	0.22	1.28	0.09	0.42	0.31	1.70
	16	23.22	0.17	1.38	0.04	0.28	0.21	1.66
PERCRI	12	26.95	0.04	0.20	-	-	0.04	0.20

Table 22. Density and biomass of rodents trapped on the validation site during July, 1972

Species	Plot	Effective area trapped (ha)	Adults		Juveniles		Totals	
			n/ha	g/ha	n/ha	g/ha	n/ha	g/ha
PERFOR	12	6.62	0	0	1.51	6.87	1.51	6.87
	15	6.62	0.45	2.84	4.53	20.59	4.98	23.43
	16	6.62	0.15	0.94	5.74	26.09	5.89	27.03
PERLON	12	7.77	3.60	9.16	2.45	5.14	6.05	14.30
	15	7.77	4.89	12.47	7.72	16.22	12.61	28.69
	16	7.77	7.08	17.94	7.46	15.64	14.54	33.62
DIPMER	12	15.11	0.26	3.53	0.66	5.39	0.92	8.92
	15	15.11	0.46	6.13	0.79	6.47	1.25	12.60
	16	15.11	0.13	1.76	0.66	5.39	0.79	7.15
DIPMIC	12	10.49	0.95	17.86	0.29	3.94	1.24	21.80
	15	10.49	0.10	1.88	0	0	0.10	1.88
	16	10.49	0.57	10.58	0.86	12.06	1.43	22.64
AMMLEU	12	35.58	0.08	1.92	0	0	0.08	1.92
	15	35.58	0.17	3.79	0	0	0.17	3.79
	16	35.58	0.08	2.02	0	0	0.08	2.02
ONYTOR	12	23.22	0.17	1.17	0.13	0.57	0.30	1.74
	15	23.22	0	0	0.34	1.54	0.34	1.54
	16	23.22	0.17	1.31	0.04	0.21	0.21	1.52
PERCRI	12	26.95	0	0	0.07	0.28	0.07	0.28
	15	26.95	0.04	0.19	0.07	0.28	0.11	0.47
	16	26.95	0	0	0.07	0.27	0.07	0.27

Table 23. Spring and summer densities and biomass of seven rodents on the validation site as a whole

Species	April		July	
	n/ha	g/ha	n/ha	g/ha
PERFOR	0.32	2.03	3.53	16.42
PERLON	5.73	14.62	9.88	22.77
DIPMER	0.55	7.37	1.06	10.44
DIPMIC	0.44	6.92	0.73	12.72
AMMLEU	0	0	0.12	2.79
ONYTOR	0.22	1.27	0.31	1.63
PERCRI	0.02	0.09	0.09	0.37
Totals	7.28	32.30	15.72	67.14

Table 24. Observed state changes in five rodent populations occupying Plot 12

Species	Changes in numbers (%)		Changes in biomass (%)	
	August 1971 - April 1972	April 1972 - July 1972	August 1971 - April 1972	April 1972 - July 1972
PERFOR	none trapped in April	-	-	-
PERLON	+412.6	+ 14.6	+412.9	+ 6.0
DIPMER	- 30.3	+100.0	- 24.4	+ 45.0
DIPMIC	+ 13.2	+ 44.4	+ 2.3	+ 61.0
AMMLEU	none trapped in April	-	-	-
ONYTOR	+225.0	+130.8	+257.1	+132.0
PERCRI	- 42.9	+ 75.0	- 39.4	+ 40.0

Table 25. Hypothesized spring and summer densities and biomass of seven rodents on the validation site as a whole

Species	April		July	
	n/ha	g/ha	n/ha	g/ha
PERFOR	2.17	13.66	5.49	28.78
PERLON	5.73	14.62	9.88	22.77
DIPMER	0.60	7.93	1.20	12.26
DIPMIC	0.61	10.01	0.91	15.06
AMMLEU	0.07	1.56	0.20	3.82
ONYTOR	0.23	1.33	0.41	2.22
PERCRI	0.07	0.38	0.14	0.66
Totals	9.48	49.49	18.23	85.57

Table 26. Summary of diet evaluation of 80 *Perognathus formosus* given in total grams per 80 stomachs (Unpublished data of N.R. French et al.)

Plant Species	Seed	Fruit	Flower and/or Leaf	Stem and/or Unknown	Total	% of Total
Brodiaea pulchella	.28		.29		.57	1.50
Bromus rubens	9.78		.39		10.17	26.74
Bromus trinii	.70				.70	1.84
Festuca octoflora	.17				.17	.45
Amsinckia tessellata	.07		.01		.08	.21
Cryptantha decipiens			.02		.02	.05
Cryptantha nevadensis	.22				.22	.59
Pectocarya platycarpa	.10				.10	.26
Eurotia lanata			.05		.05	.13
Grayia spinosa	.02				.02	.05
Chaenactis carphoclinia	.08				.08	.21
Chaenactis stevioides	.40		.02		.42	1.10
Ambrosia dumosa	1.23				1.23	3.23
Glyptopleura marginata	.01				.01	.03
Descurainia pinnata			.22		.22	.58
Lepidium fremontii	.14				.14	.37
Thelypodium lasiophyllum	.20	.10	9.69	.11	10.10	26.56
Cuscuta nevadensis	.02				.02	.05
Phacelia fremontii	.01		.44	.07	.52	1.37
Phacelia vallis-mortae	.48				.48	1.26
Mentzelia obscura	.06				.06	.16
Plantago insularis	.53				.53	1.39
Gilia sp.	.70	1.52	.38		2.60	6.84
Chorizanthe rigida	.14				.14	.37
Eriogonum trichopes	.10				.10	.26
Coleogyne ramosissima			.35		.35	.92
Lycium andersonii	.04	.58	2.40		3.02	7.94
Larrea divaricata	.99				.99	2.60
Eriogonum sp.	.28				.28	.74
Nemacladus sigmoideus	.02				.02	.05
Pectocarya sp.	.14				.14	.37
Miscellaneous	.15		1.04	1.89	3.08	8.10
Arthropod parts					1.40	3.68
TYPE TOTALS	17.06	2.20	15.30	2.07	38.03	
TYPE PERCENT	44.86	5.79	40.23	5.44	100.00	

trapping interval placed additional stress on the resident animals by increasing the frequency with which individuals were captured. Second, it appears possible that the five additional nights of trapping increased the likelihood of registering non-resident transients. Cumulative capture curves often continued to rise during the entire 10 days of trapping, particularly during July (Figs. 1 and 2). Did these increases (after an initial interval of 5 days) represent the registration of transients occupying an area beyond the estimated effective trapping area? To test this possibility we examined the spatial distribution of initial captures of *Perognathus longimembris* during the first and second halves of the trapping effort. The trapping data were arranged in a 2x2 contingency table of the following form:

	First 5 days	Second 4 or 5 days	Totals
Peripheral traps	a	b	a + b
Internal traps	c	d	c + d
Totals	a + c	b + d	n

If registration of new animals were unaffected by dilution, one would expect the internal and peripheral traps to perform with the same relative efficiency during the latter portion of the trapping period as they did during the first five days. Then, the expected value of a would be: (a + b) (a + c)/n as given by Snedecor (1956:223). Total Chi-squared is the sum of the squared deviations divided by the expected values in each cell. The same type of analysis was applied to trapping data pertaining to all four species of heteromyids. Results of Chi-squared tests are given in Table 27. With one degree of freedom in all cases, the value of Chi-square would have to exceed 3.84 in order to excite belief in this hypothesis. In general, the proposition is not confirmed by the trapping data. New animals taken during the latter half of trapping intervals are as likely to be captured by the 100 internal traps as by the 44 peripheral traps. Even those instances in which all of the new animals during the second half were taken in peripheral traps (e.g., plot 12 in April) apparently do not differ significantly from random expectations. During July, the trapping of *Perognathus longimembris* does give reason to suspect dilution.

It appears that our specially designed traps (full treadle and sensitivity to 6 grams), and the fact that the trap stations are permanent, enhances our ability to census populations of heteromyids. Trap stations on plot 12 have been on location since mid-January, 1970. The plot 16 stations, except for those few lying outside the old circular plot (4) have been present since October of 1964. Plot 15 was newly established in 1972, but traps were set out in February, about two months before the first official census. Using these traps and

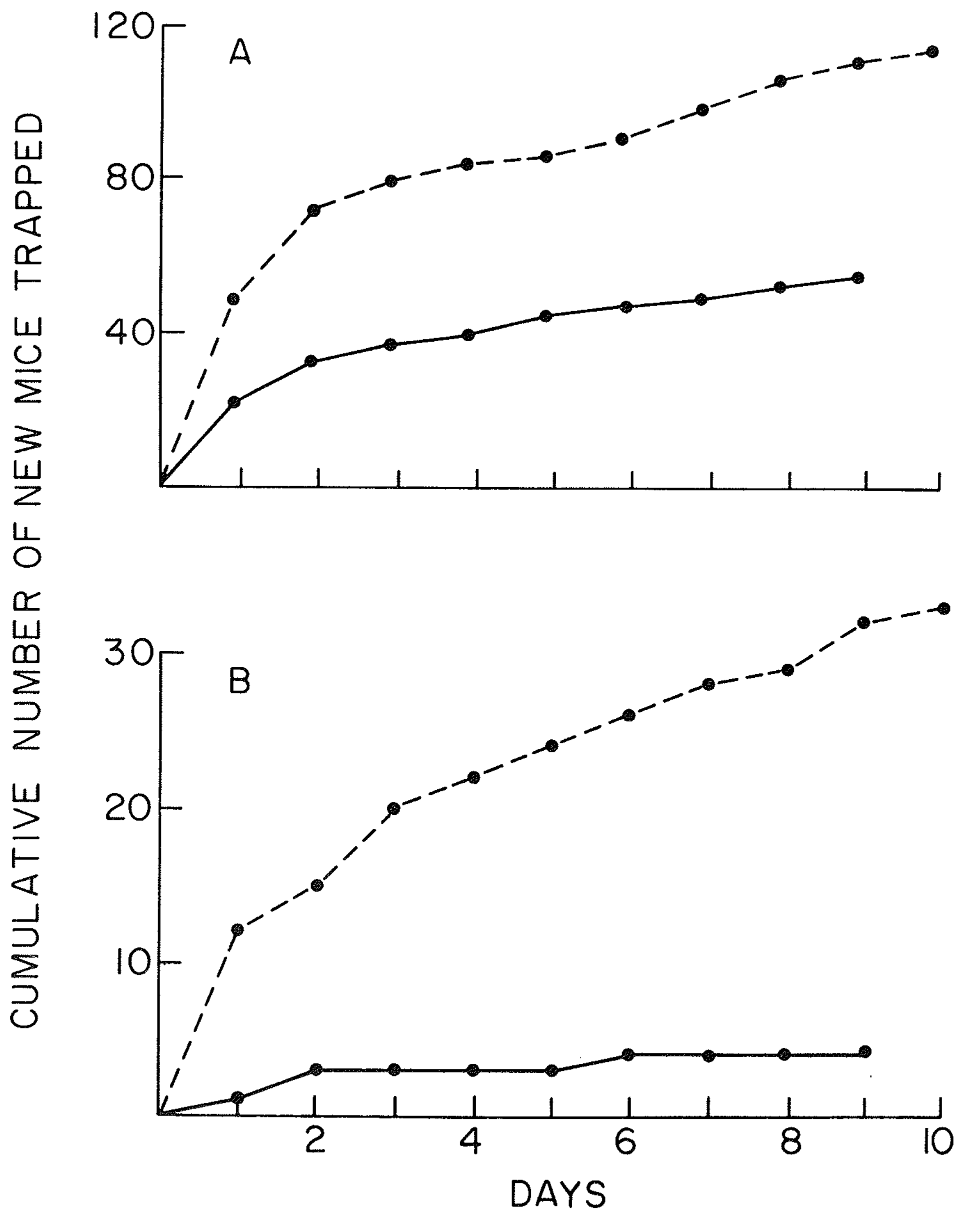

Figure 1. Cumulative totals of newly captured *Perognathus longimembris* in Plot 16 (above) and of *P. formosus* in Plot 15 during 1972. Solid lines pertain to trapping during April; dashed lines to trapping during August.

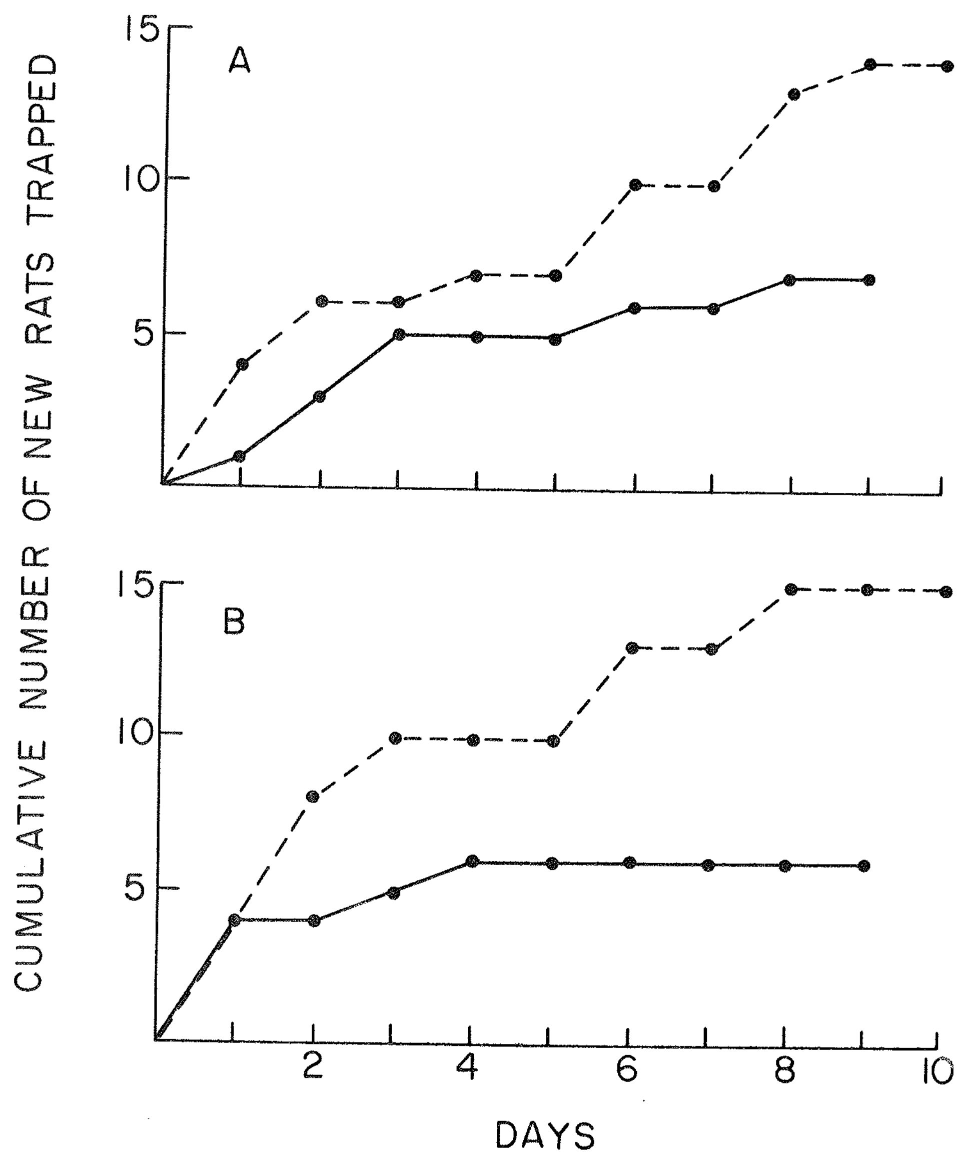

Figure 2. Cumulative totals of newly captured *Dipodomys merriami* in Plot 12 (above) and of *D. microps* in Plot 16 during 1972. Solid lines pertain to trapping during April; dashed lines to trapping during August.

Table 27. Chi-squared totals associated with tests of the hypothesis that peripheral traps register proportionally more new animals during the latter portions of trapping periods

	April	July
Perognathus longimembris		
12	3.15	n.s.
15	1.05	2.61
16	1.96	4.11*
all plots	0.76	6.87**
All heteromyids		
12	6.26*	n.s.
15	1.36	0.90
16	1.16	2.93
all plots	0.95	2.59

* $P < 0.05$
**$P < 0.01$

the same conditions of permanence (400 permanent single trap stations, 15 m grid), French et al.(in press) demonstrated that rodent populations in two 9-ha enclosures in Rock Valley were adequately censused in three consecutive days. They showed that 81% to 88% of the time three nights of trapping accounted for 95% or more of the resident population. The 'known resident population' levels were determined retroactively after eight years of continuous monthly trapping.

In spite of past success in trapping heteromyids there are several problems in the interpretation of Table 24. Populations of rodents in Rock Valley undergo a period of recruitment during the late spring and summer (there may be some reproduction by *Dipodomys* sp. as early as February). Unless reproduction is extremely poor, one expects to see an increase in numbers between an April census (generally prior to the appearance of young) and a summer census. However, one must bear in mind that long-range excursions by males and emigrations by rapidly maturing young may act to reduce growth of populations between the spring and summer censuses. For example, reproduction in 1971 was curtailed. Because of the very low recruitment and other deleterious factors, trapping during August often registered fewer animals than were captured during the spring (Turner 1972). In contrast to 1971, reproduction during 1972 was improved and all five of the species treated in Table 24 exhibited increases in numbers between April and July. Two species (*Perognathus formosus* and *Ammospermophilus leucurus*) were not registered in April, but were present in the July trapping.

Peak numbers of rodents normally occur during the summer and then decline through fall and winter to a low just prior to next year's reproduction. Table 24, however, indicates impossible increases in the apparent numbers of *Perognathus longimembris* and *Onychomys torridus* occupying plot 12 between the summer of 1971 and the spring of 1972, as well as a small increase in numbers of *Dipodomys microps*. During the summer of 1971 the density of *P. longimembris* in plot 21 was estimated at only 1.0/ha (cf. 9.4/ha during the spring of 1971). We believe that there were a considerable number of adult *P. longimembris* alive in plot 12 during August of 1971, but that many of these were not trapped (see Turner 1972: 65). A consideration of meteorological conditions (temperature, precipitation, wind, cloud cover) during the four days of the 1971 August census fails to reveal any obvious cause for inactivity of pocket mice. Air temperatures during the evening to morning hours (1800 to 0600) ranged from 33 to 20.6 C, with a mean of 23.7. Light to heavily overcast skies prevailed, with 0.5 mm of rain falling on the second day of trapping and 23.4 mm on the fourth day. Possibly summer rains, with attendant cooler temperatures, may serve to trigger the onset of inactivity in pocket mice (particularly *P. longimembris*). The apparent increase in numbers of grasshopper mice between the summer of 1971 and the spring of 1972 is consistent with past experience in Rock Valley, viz., that *Onychomys* appears to become more active (or more trapable) during times when the densities of heteromyids are relatively low. This observation also implies that trapping procedures will often fail to register all individuals of this species. The slight increase in density of *Dipodomys microps* is apparently

owing to reproduction by this species early in 1972. In fact, this species exhibited a second, though reduced, reproductive effort during the spring.

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Appendix A. Hypothesized states of small rodent populations occupying the validation site during April, 1972. Asterisks indicate modification of actual trapping data (Table 21). Other assumptions are discussed in the text.

Species	Plot	Effective area trapped (ha)	Adults		Juveniles		Totals	
			n/ha	g/ha	n/ha	g/ha	n/ha	g/ha
PERFOR	12	6.62	0.91*	5.71*	-	-	0.91*	5.71*
	15	6.62	3.02*	19.03*	-	-	3.02*	19.03*
	16	6.62	3.93*	24.74*	-	-	3.93*	24.74*
PERLON	12	7.77	5.28	13.49	-	-	5.28	13.49
	15	7.77	5.92	15.08	-	-	5.92	15.08
	16	7.77	6.95	17.64	-	-	6.95	17.64
DIPMER	12	15.11	0.46	6.15	-	-	0.46	6.15
	15	15.11	0.73*	9.66*	-	-	0.73*	9.66*
	16	15.11	0.60*	7.90*	-	-	0.60*	7.90*
DIPMIC	12	10.49	0.48*	8.70*	0.57	8.12	1.05*	16.82*
	15	10.49	0.09*	3.53*	-	-	0.19*	3.53*
	16	10.49	0.38	7.05	0.19	2.46	0.57*	9.51*
AMMLEU	12	35.58	0.08*	1.92*	-	-	0.08*	1.92*
	15	35.58	0.06*	1.28*	-	-	0.06*	1.28*
	16	35.58	0.06*	1.28*	-	-	0.06*	1.28*
ONYTOR	12	23.22	0.13	0.75	-	-	0.13	0.75
	15	23.22	0.22	1.28	0.09	0.42	0.31	1.70
	16	23.22	0.26*	1.92*	0.04	0.28	0.30*	2.20*
PERCRI	12	26.95	0.07*	0.38*	-	-	0.07*	0.38*
	15	26.95	0.07*	0.38*	-	-	0.07*	0.38*
	16	26.95	0.07*	0.38*	-	-	0.07*	0.38*

Appendix B. Hypothesized states of small rodent populations occupying the validation site during July, 1972. The dry weight of a juvenile ground squirrel was assumed to be 13 g. Asterisks indicate modifications of actual trapping data (Table 22). Other assumptions are discussed in the text.

	Plot	Effective area trapped (ha)	Adults		Juveniles		Totals	
			n/ha	g/ha	n/ha	g/ha	n/ha	g/ha
PERFOR	12	6.62	0.91*	5.71*	1.51	6.87	2.42*	12.58*
	15	6.62	3.02*	19.03*	4.53	20.59	7.55*	39.62*
	16	6.62	4.08*	25.68*	5.74	26.09	9.82*	51.77*
PERLON	12	7.77	3.60	9.16	2.45	5.14	6.05	14.30
	15	7.77	4.89	12.47	7.72	16.22	12.61	28.69
	16	7.77	7.08	17.94	7.46	15.64	14.54	33.62
DIPMER	12	15.11	0.26	3.53	0.66	5.39	0.92	8.92
	15	15.11	0.66*	8.79*	0.79	6.47	1.45*	15.26*
	16	15.11	0.60*	7.90*	0.66	5.39	1.26*	13.29*
DIPMIC	12	10.49	0.95	17.86	0.29	3.94	1.24	21.80
	15	10.49	0.29*	5.41*	0.19*	1.55*	0.48*	6.96*
	16	10.49	0.57	10.58	0.86	12.06	1.43	22.64
AMMLEU	12	35.58	0.08	1.92	0.08*	1.04	0.16*	2.96*
	15	35.58	0.17	3.79	0.08*	1.04	0.25*	4.83*
	16	35.58	0.08*	1.92*	0.08*	1.04	0.16*	2.96*
ONYTOR	12	23.22	0.17	1.17	0.13	0.57	0.30	1.74
	15	23.22	0.22*	1.28*	0.34	1.54	0.56*	2.82*
	16	23.22	0.17	1.31	0.04	0.21	0.21	1.52
PERCRI	12	26.95	0.07*	0.38*	0.07	0.28	0.14*	0.66*
	15	26.95	0.07*	0.38*	0.07	0.28	0.14*	0.66*
	16	26.95	0.07*	0.38*	0.07	0.27	0.14*	0.66*

E. CALORIMETRY AND CHEMICAL ANALYSIS

The nutrient element contents of perennial plants from the Rock Valley Validation Site are given in Table 1 (A3UTJ21). In general, tissues of flowers contained higher levels of nitrogen than did other plant parts. Nitrogen contents were comparable in leaves and fruits, and fell within the range (2-3%) commonly observed in cultivated crops. Phosphorus contents decreased in 1972, particularly in *Grayia spinosa, Lycium andersonii* and *L. pallidum*. The highest concentrations of potassium were found in *G. spinosa*. The flowers and leaves of *L. pallidum* also contained high levels of potassium. Both species of *Lycium* contained high calcium contents in leaves. Noticeably lower levels of magnesium occurred in *Larrea divaricata*. Micronutrient levels were within the range commonly observed for these species. Highest levels of iron were found in *Ambrosia dumosa, Krameria parvifolia* and *L. divaricata*. Copper and manganese contents tended to be lower in 1972 than in 1971. These declines, along with those of phosphorus (see above) are attributed to the prolonged drought during which the plant tissues developed; 1972 was the third of three successive dry years.

Table 1. Mineral element contents of perennial vegetation of the Rock Valley IBP Validation Site, 1972 (dry weight basis)

Plant Species	Sample date	Plant part	N %	P %	K %	Ca %	Mg %	Zn ppm	Cu ppm	Fe ppm	Mn ppm
Ambrosia	4 May	flower	2.51	.48	2.65	.57	.43	57	8.5	669	19
dumosa	"	fruit	2.04	.28	2.21	.20	.29	57	2.9	482	9
	"	leaf	2.18	.33	2.33	3.49	1.11	51	1.7	379	55
	"	stem	1.26	.16	2.77	2.23	.66	39	37.1	167	41
Atriplex	7 April	flower	1.78	.22	2.24	1.92	.82	42	1.8	143	17
confertifolia	"	leaf	1.98	.09	2.85	2.20	1.04	49	1.6	49	38
	"	stem	1.81	.08	3.00	1.97	.66	57	2.8	23	12
Ephedra	3 April	flower	2.63	.28	4.88	.55	.18	33	4.1	331	25
nevadensis	"	fruit	2.40	.40	3.21	.42	.36	45	4.7	211	14
	"	shoot	2.64	.33	2.71	.68	.20	30	3.9	142	16
	"	stem	1.17	.08	.48	1.00	.23	43	2.5	39	7
Grayia	3 April	fruit	1.89	.10	4.57	.72	1.02	68	2.6	75	34
spinosa	"	leaf	2.46	.02	6.64	1.78	1.68	47	3.6	108	65
	"	stem	1.80	.10	3.17	1.15	.75	53	4.7	84	22
Krameria	4 May	flower	2.08	.34	2.47	.32	.22	32	4.7	474	20
parvifolia	"	leaf	1.81	.21	1.43	1.80	.35	19	3.7	361	52
	"	stem	1.64	.22	1.72	1.22	.27	23	6.9	291	23
	"										
Larrea	10 May	flower	2.31	.32	1.81	.91	.12	26	4.6	436	32
divaricata	"	fruit	2.35	.22	1.72	.65	.11	20	5.7	123	16
	"	leaf	2.10	.19	1.90	1.47	.15	15	2.9	266	40
	"	stem	2.08	.12	1.38	1.15	.21	21	7.8	506	28
Lycium											
andersonii	13 March	flower	4.23	.38	3.42	.99	.30	34	8.4	51	11
	26 April	fruit	2.40	.19	3.32	.40	.19	18	2.0	150	7
	"	leaf	2.26	.09	2.57	8.52	.78	21	4.9	240	38
	"	stem	1.17	.06	1.22	2.51	.31	17	7.7	98	14
Lycium											
pallidum	13 March	flower	3.31	.31	4.63	.81	.47	33	6.6	130	19
	26 April	fruit	2.28	.22	2.99	.31	.24	17	3.7	78	7
	"	leaf	2.20	.08	4.35	4.18	1.44	23	2.1	195	81
	"	stem	1.13	.07	.78	1.26	.22	16	10.2	60	7

F. SOIL

1. PHYSICAL AND CHEMICAL PROPERTIES

The soils of the Rock Valley Validation Site are derived from a heterogeneous, highly calcareous alluvium, composed primarily of Cambrian limestones with some tuff and basalt. The soils surface is a well-developed desert pavement underlain with a massive and strongly cemented caliche layer at depths ranging from 30 to 70 cm. Variations in microrelief and soil structure are responsible for several vegetation patterns on the validation site.

As is generally true of desert soils formed on unconsolidated sand, silt and clay with low rainfall, the vertical profile horizons of Rock Valley soils are young and often poorly developed. Aeolian deposits form at the base of shrubs, particularly those occurring in clumps, and form an A_1 horizon generally not present in the vertical profile of bare soil between shrub clumps. These A_1 horizons contain higher levels of organic matter, available cations, and nitrogen, phosphorus, chloride, and sulfate, than are found in deeper horizons or in the surface horizon of bare desert pavement. Another distinctive feature of these soils is the strongly-cemented caliche layer--virtually impervious to plant roots--which serves as a restrictive layer preventing moisture loss to greater depths in the soil. The salt concentration in these soils is low and mainly consists of calcium and magnesium salts. Cation exchange capacities are low, partly owing to low silt and clay contents. Sodium usually accounts for only about 10 percent of the exchangeable cations. The levels of available micronutrients are also low in these soils.

The soils of the site have low cation exchange capacities, CEG/clay ratios of 2 to 3, and low levels of soluble and exchangeable potassium. These indicate the presence of considerable amounts of amorphous clays. The source of these clays is apparently volcanic glass, ash and pumice present in the general area. Ash falls and wind action are probably responsible for the wide distribution of these materials (Ehren, 1968).

More detailed characterizations of soils of the validation site have been developed from four soil pits excavated at each of the four corners of the site (Sites 59, 60, 61 and 62; Site Development, Fig. 1). These pits, 0.74 x 2.0 m in size, were dug by hand in October, 1970. Pits were dug to the restrictive hard pan underlying the area. The soil profiles were described and characterized according to the USDA 1960 Soil Classification and 7th Approximation System. Field descriptions of four validation site soil profiles follow. Tables 1-4 give physical and chemical attributes of soils from these sites (A3UTJ11).

<u>Rock Valley - Site no. 59</u>

Site No. 59 is located in the southeast corner of the IBP validation plot in the Rock Valley study area on an alluvial fan on the north side of Specter Range. Slope is northeast at 3%;

parent material is limestone; well-drained; smooth relief; slight erosion; moderate permeability; surface about 50% rock and gravel; elevation 3360 feet. Perennial vegetation is *Larrea divaricata Lycium andersonii, Ambrosia dumosa, Ephedra nevadensis, Lycium pallidum* and *Krameria parvifolia.*

Profile Under Shrub (*Larrea divaricata*)

A11	0-6 cm	Brown (10YR5/3) loamy sand, dark grayish brown (10YR4/2) moist; very weak friable platy structure; breaking to single grain; loose, friable, non-sticky; violently effervescent; pH 8.3; abrupt smooth boundary.
A12	6-12 cm	Pale brown (10YR6/3) loamy sand, brown to dark brown (10YR4/3) moist; weak medium subangular blocky structure; soft, friable, non-sticky; violently effervescent; pH 8.8; clear smooth boundary.
C1	12-23 cm	Very pale brown (10YR7/3) loamy sand, brown to dark brown (10YR4/4) moist; weak medium subangular blocky structure; soft, friable, non-sticky; violently effervescent; pH 8.8; clear smooth boundary.
C2	23-34 cm	Very pale brown (10YR7/3) loamy sand, dark yellowish brown (10YR4/4) moist; weak medium subangular blocky structure; soft, friable, non-sticky; violently effervescent; pH 8.8; clear smooth boundary.
C3ca	34-57 cm	Pale brown (10YR6/3) cobbly gravelly loamy sand, dark yellowish brown (10YR4/4) moist; weak fine subangular blocky structure; soft, friable, non-sticky; violently effervescent; 20% gravel; pH 8.7.

Profile not sampled in bare area

Rock Valley - Site no. 60

This site is located in the southwest corner of the IBP validation plot in the Rock Valley study area on an alluvial fan on the north side of Specter Range. Slope is northeast at 1%; parent material is limestone; well-drained; smooth relief; slight erosion; rapid permeability; surface about 70% gravel with some outcrops of cobbles; elevation 3360 feet. Perennial vegetation is *Lycium andersonii, Larrea divaricata, Ambrosia dumosa, Lycium pallidum, Krameria parvifolia* and *Ephedra nevadensis.*

Profile Under Shrub (*Larrea divaricata, Krameria parvifolia*)

A1	0-5 cm	Brown (10YR5/3) loamy sand, brown to dark brown (10YR4/3) moist; weak fine platy structure; soft, friable, non-sticky; violently effervescent; pH 7.9; abrupt smooth boundary.

A2	5-18 cm	Very pale brown (10YR7/3) sandy loam, brown (10YR5/3) moist; strong medium platy structure; slightly hard, friable, slightly sticky; violently effervescent; pH 8.6; abrupt wavy boundary.
A3	18-38 cm	Pale brown (10YR6/3) gravelly loamy sand, yellowish brown (10YR5/4) moist; very weak subangular blocky structure; soft, friable, non-sticky; violently effervescent; 25% gravel; pH 8.7; clear smooth boundary.
C1	38-63 cm	Very pale brown (10YR7/3) gravelly loamy sand, yellowish brown (10YR5/4) moist; single grain structure; loose, non-sticky; violently effervescent; 45% gravel; pH 8.6.

Profile not sampled in bare area.

Rock Valley - Site no. 61

This site is located in the northeast corner of the IBP validation plot in the Rock Valley study area on an alluvial fan on the north side of Specter Range. Slope is northeast at 1%; parent material is limestone; well-drained; smooth relief; slight erosion; rapid permeability; surface about 30% gravel; elevation 3360 feet. Perennial vegetation is *Larrea divaricata, Eurotia lanata, Ambrosia dumosa, Ephedra nevadensis, Lycium pallidum* and *Grayia spinosa.*

Profile Under Shrub (*Larrea divaricata*)

A1	0-9 cm	Brown to dark brown (10YR4/3) loamy sand, dark brown (10YR3/3) moist; very weak subangular blocky structure; breaking to single grain; soft, friable, non-sticky; strongly effervescent, pH 8.1; clear smooth boundary.
A2	9-19 cm	Very pale brown (10YR7/3) loamy sand, dark yellowish brown (10YR4/4) moist; weak medium subangular blocky structure; slightly hard, friable, very slightly sticky; violently effervescent; pH 8.6; abrupt smooth boundary.
B	19-37 cm	Light yellowish brown (10YR6/4) gravelly loamy sand, brown to dark brown (7.5YR4/4) moist; weak fine subangular blocky structure breaking to single grain; soft, friable, non-sticky; violently effervescent; 20% gravel; pH 8.7; clear smooth boundary.
C1	37-47 cm	Very pale brown (10YR7/3) gravelly loamy sand, light yellowish brown (10YR6/4) moist; moderate fine subangular blocky structure; slightly hard, friable, non-sticky; violently effervescent; 30% gravel; pH 8.7.

Profile not sampled in bare area.

Rock Valley - Site no. 62

Site No. 62 is located in the northwest corner of the IBP validation plot in the Rock Valley study area on an alluvial fan on the north side of Specter Range. Slope is northeast at 2%; parent material is limestone; well-drained; smooth relief; moderate erosion; moderate permeability; surface about 30% rock and gravel; elevation 3340 feet. Perennial vegetation is *Lycium pallidum, Atriplex canescens, Grayia spinosa, Ambrosia dumosa, Eurotia lanata Larrea divaricata*.

Profile Under Shrub (*Larrea divaricata*)

A1	0-9 cm	Yellowish brown (10YR5/4) loamy sand, brown to dark brown (10YR4/3) moist; very weak fine subangular blocky structure; soft, friable, non-sticky; effervescent; pH 8.3; clear smooth boundary.
A2	9-21 cm	Very pale brown (10YR7/3) loamy sand, yellowish brown (10YR5/4) moist; moderate medium subangular blocky structure; slightly hard, friable, slightly sticky; violently effervescent; pH 8.7; clear smooth boundary.
C1	21-32 cm	Very pale brown (10YR7/3) gravelly loamy sand, yellowish brown (10YR5/4) moist; weak fine subangular blocky structure; soft, very friable, non-sticky; violently effervescent; 15% gravel; pH 8.7; clear smooth boundary.
C2	32-50 cm	Very pale brown (10YR7/3) gravelly sandy loam, light yellowish brown (10YR6/4) moist; moderate medium subangular blocky structure; slightly hard, friable, non-sticky; violently effervescent; 20% gravel; pH 8.7.

Profile not sampled in bare area.

Table 1. Physical and chemical attributes of soil at Site 59 (southeast corner of validation site)

Site No.	Area	Elevation Ft	Slope %	Aspect	Physiography	Erosion	% Surface Stoniness	Soil Origin	Relief	Drainage	Permeability
59	Rock Valley	3360	3	NE	Bajada	Slight	40-60%	Limestone	Smooth	Well	Moderate

Profile Type	Hor-izon	Depth cm	Color Dry	Color Wet	Phase	Consistence Dry	Consistence Moist	Consistence Wet	Particle Size Distribution (mm) % Coarse sand 2-0.25	Fine sand 0.25-0.05	Silt 0.05-0.002	Clay <0.002
Shrub	A11	000-006	10YR5/3	10YR4/2	Gravelly	Loose	Friable	Non-sticky	9.6	82.8	3.9	3.7
Shrub	A12	006-012	10YR6/3	10YR4/3	Smooth	Soft	Friable	Non-sticky	8.6	84.5	4.3	2.7
Shrub	C1	012-023	10YR7/3	10YR4/3	Smooth	Soft	Friable	Non-sticky	8.0	80.2	7.2	4.6
Shrub	C2	023-034	10YR7/3	10YR4/4	Smooth	Soft	Friable	Non-sticky	10.0	78.8	7.2	4.1
Shrub	C3C	034-057	10YR6/3	10YR4/4	Cobb & Gravl	Soft	Friable	Non-sticky	26.8	63.8	5.6	3.8

Profile Type	Hor-izon	Per cent Moisture Retention 0 Sat.	1/3 Bar	1 Bar	15 Bar	pH Paste	pH Sat. Ext.	Ec 25 (mmhos/cm)	Per cent Lime (<2.0mm)	Sat. Extract Soluble Na (MEQ/liter)	K	Ca	Mg	Cations and Anions Cl (MEQ/liter)	NO3	SO4	Sat. Ext Boron ppm
Shrub	A11	31.5	8.9	7.7	5.8	8.3	8.9	1.37	11.4	0.60	1.25	13.42	3.53	1.20	0.00	0.35	0.00
Shrub	A12	28.8	8.1	6.9	5.2	8.7	8.9	0.61	5.5	0.25	0.70	8.05	1.08	0.70	0.00	0.16	0.00
Shrub	C1	27.6	10.5	9.3	5.6	8.8	9.0	0.44	15.0	0.30	0.60	3.87	1.34	0.50	0.00	0.14	0.00
Shrub	C2	27.5	12.2	9.3	5.4	8.8	9.0	0.42	16.0	0.40	0.73	4.02	1.19	1.50	0.00	0.14	0.00
Shrub	C3C	27.4	12.6	9.2	5.7	8.7	8.8	0.42	36.5	0.45	1.00	2.68	1.23	1.10	0.00	0.14	0.00

Profile Type	Hor-izon	Organic Carbon %	Exchangeable cations (MEQ/100 gm) Na	K	Ca+Mg	Exch. Na %	Cation Exch. Cap. (MEQ/100gm)	P (NaHCO3) ppm	Dtpa-extractable micronutrients Fe ppm	Zn ppm	Cu ppm	Mn ppm	Organic N %	Structure
Shrub	A11	0.87	0.83	1.34	7.33	8.7	9.5	2.36	1.7	2.75	0.20	12.00	.091	Wk.Fine Platy
Shrub	A12	0.49	0.74	1.36	7.99	7.4	10.0	1.64	1.2	1.45	0.15	4.00	.047	Wk.Fine Sub.Ang.Bl
Shrub	C1	0.38	0.97	1.56	8.72	8.6	11.3	0.40	0 6	1.10	0.20	3.85	.041	Wk.Fine Sub.Ang.BL
Shrub	C2	0.32	1.07	1.48	6.95	11.3	9.5	0.00	0.6	0.85	0.18	4.30	.034	Wk.Fine Sub.Ang.Bl
Shrub	C3C	0.30	1.29	1.67	7.04	12.9	10.0	0.00	0.7	1.70	0.18	4.10	.032	Wk.Fine Sub.Ang.Bl

Table 2. Physical and chemical attributes of soil at Site 60 (southwest corner of validation site)

Site No.	Area	Elevation Ft	Slope %	Aspect	Physiography	Erosion	% Surface Stoniness	Soil Origin	Relief	Drainage	Permeability
60	Rock Valley	3360	1	NE	Bajada	Slight	60-80%	Limestone	Smooth	Well	Rapid

Profile Type	Hor-izon	Depth cm	Color Dry	Color Wet	Phase	Consistence Dry	Consistence Moist	Consistence Wet	Particle Size Distribution (mm) % Coarse sand 2-0.25	Fine sand 0.25-0.05	Silt 0.05-0.002	Clay <0.002
Shrub	A1	000-005	10YR5/3	10YR4/3	Gravelly	Soft	Friable	Non-sticky	11.6	77.9	5.8	4.7
Shrub	A2	005-018	10YR7/3	10YR5/3	Smooth	Sltly hard	Friable	Sltly sticky	10.0	65.6	16.5	7.9
Shrub	A3	018-038	10YR6/3	10YR5/4	Gravelly	Soft	Friable	Non-sticky	21.0	64.1	8.6	6.2
Shrub	C1	038-063	10YR7/3	10YR5/4	Gravelly	Loose	Loose	Non-sticky	24.4	62.7	6.6	6.3

Profile Type	Hor-izon	Per cent Moisture Retention 0 Sat.	1/3 Bar	1 Bar	15 Bar	pH Paste	pH Sat. Ext.	Ec 25 (mmhos /cm)	Per cent Lime (<2.0mm)	Sat. Extract Soluble Na (MEQ/liter)	K	Ca	Mg	Cations and Anions Cl (MEQ/liter)	NO3	SO4	Sat. Ext Boron ppm
Shrub	A1	33.0	9.6	8.3	6.1	7.9	8.5	1.21	5.0	1.00	4.10	20.13	13.77	1.60	0.00	0.40	0.00
Shrub	A2	17.5	12.9	11.0	7.0	8.6	8.8	0.45	13.5	0.70	0.29	4.69	1.83	0.60	0.00	0.10	0.00
Shrub	A3	28.8	14.2	10.4	7.0	8.7	8.8	0.45	21.7	0.90	0.65	3.35	1.87	1.50	0.00	0.15	0.00
Shrub	C1	34.5	13.2	10.9	6.4	8.6	8.9	0.62	19.0	3.00	0.13	4.02	1.26	1.40	0.00	0.16	0.00

Profile Type	Hor-izon	Organic Carbon %	Exchangeable Cations (MEQ/100 gm) Na	K	Ca+Mg	Exch. Na %	Cation Exch. Cap. (MEQ/100gm)	P (NaHCO3) ppm	DTPA-Extractable Micronutrients Fe ppm	Zn ppm	Cu ppm	Mn ppm	Organic N %	Structure	
Shrub	A1	1.07	1.05	1.81	6.14	11.7	9.0	3.04	2.0	1.20	0.24	14.50	.120	Wk.Fine	Platy
Shrub	A2	0.24	1.24	0.99	9.02	11.0	11.3	0.52	0.7	0.70	0.32	2.75	.030	Str.Med.	Platy
Shrub	A3	0.34	1.35	1.36	8.54	12.0	11.3	0.52	0.7	0.80	0.20	5.60	.032	Wk.Fine	Sub.Ang.Bl
Shrub	C1	0.27	1.28	0.65	7.57	13.5	9.5	0.06	1.2	0.70	0.15	5.90	.030	No Str.	Single.Gr

Table 3. Physical and chemical attributes of soil at Site 61 (northeast corner of validation site)

Site No.	Area	Elevation Ft	Slope %	Aspect	Physiography	Erosion	% Surface Stoniness	Soil Origin	Relief	Drainage	Permeability
61	Rock Valley	3360	1	NE	Bajada	Slight	20-40%	Alluvium	Smooth	Well	Rapid

Profile Type	Hor-izon	Depth cm	Color Dry	Color Wet	Phase	Consistence Dry	Consistence Moist	Consistence Wet	Particle Size Distribution (mm) % Coarse sand 2-0.25	Fine sand 0.25-0.05	Silt 0.05-0.002	Clay <0.002
Shrub	A1	000-009	10YR4/3	10YR3/3	Smooth	Soft	Friable	Non-sticky	46.0	45.8	3.6	4.6
Shrub	A2	009-019	10YR7/3	10YR4/4	Smooth	Sltly hard	Friable	Sltly sticky	33.3	39.5	17.7	9.5
Shrub	B	019-037	10YR6/4	7.5YR4/4	Gravelly	Soft	Friable	Non-sticky	43.6	42.5	8.3	5.6
Shrub	C1	037-047	10YR7/3	10YR6/4	Gravelly	Sltly hard	Friable	Non-sticky	51.0	36.9	8.3	3.8

Profile Type	Hor-izon	Per cent Moisture Retention 0 Sat.	1/3 Bar	1 Bar	15 Bar	pH Paste	pH Sat. Ext.	Ec 25 (mmhos /cm)	Per cent Lime (<2.0mm)	Sat. Extract Soluble Na (MEQ/liter)	K	Ca	Mg	Cations & Anions Cl (MEQ/liter)	NO3	SO4	Sat. Ext Boron ppm
Shrub	A1	33.0	9.4	8.0	4.4	8.1	8.2	2.27	3.1	2.85	4.19	25.49	9.71	5.10	0.00	0.89	0.00
Shrub	A2	27.6	14.2	12.8	7.9	8.6	8.9	0.69	5.5	0.95	1.13	8.05	2.38	1.40	0.00	0.30	0.00
Shrub	B	28.8	13.0	11.3	8.1	8.7	9.0	0.53	3.2	0.90	0.73	4.22	4.91	1.00	0.00	0.18	0.00
Shrub	C1	29.3	15.2	12.7	7.3	8.7	8.8	0.53	3.6	1.20	0.25	4.02	1.20	2.30	0.00	0.09	0.00

Profile Type	Hor-izon	Organic Carbon %	Exchangeable Cations (MEQ/100 gm) Na	K	Ca+Mg	Exch. Na %	Cation Exch. Cap. (MEQ/100gm)	P (NaHCO3) ppm	DTPA-Extractable Micronutrients Fe ppm	Zn ppm	Cu ppm	Mn ppm	Organic N %	Structure
Shrub	A1	1.95	1.36	1.54	10.35	10.3	13.3	4.36	2.0	0.90	0.20	14.00	.193	Wk.Fine Sub.Ang.Bl
Shrub	A2	0.25	1.43	2.93	12.64	8.4	17.0	1.20	0.8	0.55	0.20	3.05	.030	Wk.Med. Sub.Ang.Bl
Shrub	B	0.21	1.22	2.93	12.85	7.2	17.0	0.52	1.0	0.25	0.17	4.35	.023	Wk.Fine Sub.Ang.Bl
Shrub	C1	0.18	1.71	1.57	9.22	13.7	12.5	0.24	0.6	0.28	0.19	2.10	.036	Mod.Fine Sub.Ang.Bl

Table 4. Physical and chemical attributes of soil at Site 62 (northwest corner of validation site)

Site No.	Area	Elevation Ft	Slope %	Aspect	Physiography	Erosion	% Surface Stoniness	Soil origin	Relief	Drainage	Permeability
62	Rock Valley	3340	2	NE	Bajada	Moderate	20-40%	Alluvium	Smooth	Well	Moderate

Profile Type	Hor-izon	Depth cm	Color Dry	Color Wet	Phase	Consistence Dry	Consistence Moist	Consistence Wet	Particle Size Distribution (mm) % Coarse sand 2-0.25	Fine sand 0.25-0.05	Silt 0.05-0.002	Clay <0.002
Shrub	A1	000-009	10YR5/4	10YR4/3	Smooth	Soft	Friable	Non-sticky	40.3	51.2	4.7	3.8
Shrub	A2	009-021	10YR7/3	10YR5/4	Smooth	Sltly Hard	Friable	Sltly sticky	45.4	33.9	13.4	7.3
Shrub	C1	021-032	10YR7/3	10YR5/4	Gravelly	Soft	Very friable	Non-sticky	43.4	40.3	10.2	6.1
Shrub	C2	032-050	10YR7/3	10YR6/4	Cobb & Gravl	Sltly Hard	Friable	Non-sticky	55.4	34.7	7.5	2.4

Profile Type	Hor-izon	Per cent moisture retention 0 Sat.	1/3 Bar	1 Bar	15 Bar	pH Paste	pH Sat. Ext.	Ec 25 (mmhos /cm)	Per cent Lime (<2.0mm)	Sat. Extract Soluble Na	K	Ca	Mg (MEQ/liter)	Cations and Anions Cl	NO3	SO4 (MEQ/liter)	Sat. Ext Boron ppm
Shrub	A1	27.1	8.2	7.1	6.4	8.3	8.8	1.93	4.0	7.05	3.75	28.18	18.76	9.80	0.00	1.03	0.00
Shrub	A2	22.0	13.5	11.9	8.1	8.7	8.9	0.70	6.5	1.75	1.50	8.05	2.63	1.30	0.00	0.21	0.00
Shrub	C1	27.3	14.1	11.3	8.3	8.7	9.0	0.49	6.4	1.20	0.92	4.02	4.03	0.60	0.00	0.15	0.00
shrub	C2	29.1	15.4	13.0	7.8	8.7	8.9	0.65	20.0	2.70	1.00	2.68	1.23	1.10	0.60	0.14	0.00

Profile Type	Hor-izon	Organic Carbon %	Exchangeable Cations (MEQ/100 gm) Na	K	Ca+Mg	Exch. Na %	Cation Exch. Cap. (MEQ/100gm)	P (NaHCO3) ppm	DTPA-Extractable micronutrients Fe ppm	Zn ppm	Cu ppm	Mn ppm	Organic N %	Structure
Shrub	A1	1.18	1.56	3.40	7.90	1.2	12.9	3.80	1.2	0.49	0.19	4.35	.081	Wk.Fine Sub.Ang.Bl
Shrub	A2	0.42	1.41	4.27	10.57	8.7	16.3	1.08	1.0	0.49	0.10	2.35	.048	Mod.Med. Sub.Ang.Bl
Shrub	C1	0.36	1.22	4.27	9.51	8.1	15.0	0.80	1.5	0.57	0.13	8.10	.027	Wk.Fine Sub.Ang.Bl
Shrub	C2	0.28	2.05	4.77	7.68	14.1	14.5	0.52	0.8	0.55	0.18	3.20	.048	Mod.Med. Sub.Ang.Bl

F.2. LITTER

In 1972 we attempted to determine amounts of litter present beneath various shrubs (A3UTJ70). Litter was collected from under the canopy of shrubs of various sizes using a modified D-vac. Soil was later separated, and the dry weight of remaining organic matter determined (Table 5). Separation of litter into stems, leaves, etc., was not attempted because the small amount of litter left after three years (1970-1972) of relatively low productivity was mainly composed of small indistinguishable particles.

Litter fall during 1972 increased amounts beneath shrubs slightly, but by late July fresh litter had been sorted and collected by rodents and insects and by early autumn only small amounts remained. Plant material falling to the ground--particularly fruits and leaves--is quickly sorted and carried off by animals. That which remains breaks down, so little material has accumulated in the last few years. Biomass of litter present underneath shrubs in 1972 was only a small fraction (<2%) of the standing dead material.

Table 5. Estimates of litter (g/m^2) beneath shrubs in Rock Valley during 1972

Species	n	Date	Mean	Range
Ambrosia dumosa	7	9-72	1.78	0.60- 3.47
Atriplex confertifolia	6	9-72	5.95	4.15- 8.53
Ephedra nevadensis	6	7-72	3.31	0.55- 5.41
Eurotia lanata	6	9-72	5.03	2.55- 8.37
Grayia spinosa	6	5-72	5.54	2.84-10.45
	7	8-72	5.58	1.77-10.25
Krameria parvifolia	12	3-72	3.32	0.90-10.75
	7	9-72	4.18	3.23- 5.68
Larrea divaricata	8	8-72	3.66	1.57- 6.92
Lycium andersonii	12	3-72	2.63	0.80- 5.92
	8	7-72	6.44	1.94-16.22
L. pallidum	7	8-72	2.49	1.33- 3.18

Literature Cited

Ehren, E. G. 1968. Geologic setting of the Nevada Test Site and Nellis Air Force Range. Geol. Soc. Amer. Mem. 110:11-19.

1972 PROGRESS REPORT

TUCSON VALIDATION SITES REPORT

Coordinator: John L. Thames

University of Arizona
Tucson, Arizona

Research Memorandum 73-3

MAY 1973

ABSTRACT

In 1972 emphasis was on the Silverbell bajada site, a rather typical Sonoran Desert locality. Work was completed on a perturbation treatment that consisted of repeated passes with four-wheel drive vehicles on a grid covering 18 hectares.

The soils of the site are heterogeneous, five major types being represented. Additionally, the site is traversed by a complex of ramifying streams and rivulets covering at least 15% of the area. This situation strongly influences the water dispersion and concomitantly that of the plants. Weather data are recorded automatically and transmitted by radio to Mt. Lemmon where they are then placed on telephone lines connecting to a computer. The dominating weather feature of 1972 was the extremely wet October-November period.

A hydrological model of surface runoff was developed and validated with data from a watershed similar to the Silverbell site for which long-term records are available. The model appears to predict hydrographs on an individual storm basis reasonably well.

The densities (#/ha) of dominant plants on the site are: *Franseria deltoidea*, 1244; *Larrea divaricata*, 92; *Cercidium microphyllum*, 27; *Acacia constricta*, 24; *Olneya tesota*, 14; *Cereus gigantea*, 7. The biomass (kg/ha) was: *F. deltoidea*, 124.8; *Larrea*, 385.24; *Cercidium*, 1032.4; *Olneya*, 3106; *Acacia*, 183; annual grasses, 0.86; annual forbs, 0.62. Analysis indicates a high variance with all these data.

Production (kg/ha) of new terminal branch growth of leaves, flowers and fruits for the five major species was: *Cercidium*, 6.69; *Olneya*, 24.77; *Acacia*, 12.04; *Larrea*, 23.57; and *Ambrosia*, 485.72, respectively. Some annuals produced 131 kg/ha on the treated site and 105 kg/ha on the untreated site. Litter amounted to 2,639 kg/ha.

Bird density and biomass on the Santa Rita Experimental Range Site were slightly lower in the first four months of 1972 than in the previous two years. During May-September, 1972, biomass exceeded 1970 or 1971 values and was about twice as great as in 1971. Biomass in the last three months of 1972 was roughly the same as in 1970. The higher figures in summer, 1972, are attributable to higher densities of nesting resident species (Cactus Wren, Curve-billed Thrasher, Rufous-winged Sparrow), and to more quail and doves on the plot. "Nomadic" species did not nest on the plot in 1972.

On the Silverbell site, density and biomass were about the same in 1971 and 1972. August, 1972, had more doves nesting than in 1971 and consequently had a higher biomass. The slightly greater figures for 1972 in other months represent a slightly higher number of nesting pairs of birds.

Total bird biomass on the Silverbell site is substantially higher than on the Santa Rita site. Although an analysis has not been made, it appears that the numerous saguaros on the Silverbell site are used by hole-nesting individuals that are not present at Santa Rita.

The biomass of small mammals at the Santa Rita sites is approximately twice that at the Silverbell sites. There appears to be significantly more biomass on the manipulated areas of both sites. The greater disturbance at the Santa Rita site resulted in a greater increase than did the manipulation (vehicular traffic) at the Silverbell site. Feral house mice, *Mus musculus*, appeared for the first time in all trapping sites in the fall of 1972. They were most common in the Silverbell manipulated sample areas. Late summer rains in 1972 resulted in large amounts of seeds and other foods being available. Thus, the rodents (especially *Dipodomys merriami*) were not susceptible to trapping and consequently estimates are believed too low. This phenomenon has been documented on two live-trap grids being operated bi-monthly or monthly in the same region.

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METEROLOGY	L. Hekman J. Thames
INVERTEBRATES	F. Werner T. Sloss D. Chandler W. Spitzer
REPTILES*	C. Lowe
HYDROLOGY MODEL	J. Ryan J. Thames

*The reptile studies will be reported after calibration, which was initiated in 1973.

INTRODUCTION

Work this past year has been concentrated on the new Silverbell site located in Sec. 21 R9E, T11S. The section is being leased from the Bureau of Land Management. Mineral entry and grazing have been excluded. The section is now fenced, power lines are installed and experimental areas laid out. A remote-controlled meteorological station is in operation, and a small watershed is instrumented near the center of the section. A van equipped as a field laboratory is also stationed on the site. Part of the area has undergone a perturbation treatment consisting of repeated passes with four-wheel drive vehicles on a grid pattern laid out over a 18 ha area. Production of plant biomass has been followed during 1972.

The initial inventories of composition, density and biomass have been completed. This past year efforts have been concentrated on estimating biomass production of *Ambrosia, Larrea, Cercidium, Olneya,* and *Acacia. Ambrosia* did not flower but had the greatest production of leaves and new stem growth. Total production of flowers, fruits, leaves, and new terminal growth was 553 kg/ha. Annual production was somewhat higher on the treated area at 131 kg/ha than the untreated area with 105 kg/ha. Litter amounted to 2,639 kg/ha.

The soils of the area have been mapped and profiles drawn up in detail. Chemical and physical analyses have been made on material from profiles of the major series.

Total avian biomass on the Santa Rita Experimental Range and Silverbell Validation Sites was determined monthly by line transect and direct mapping methods as in previous years. Density and biomass estimates for 1971 are similar to those of 1972 with the exception of two important differences. First, there was an exceptionally high value derived for August of 1971. This value resulted presumably from a great influx of breeding Mourning Doves into the area; also, there was a greater total biomass in 1972.

Insect sampling was primarily conducted on a 3 ha study plot on the Silverbell site. Frass trap samples of fecal pellets indicated dry weights of chewing insects of ca. $6 g/m^2$ of cover of *Cercidium* and *Acacia* for 1972, $5 g/m^2$ of *Olneya* and $1 g/m^2$ of *Larrea*. Peak activity occurred from mid-July through September on legumes, with a barely indicated response to unseasonal rains in early June. Emergence-trap samples peaked in August but declined only gradually to November in 1971, and continued all winter. Scarab beetles peaked in July, 1971, and may have started emerging slightly earlier in 1972. They were particularly abundant under *Cercidium* . Other shrubs had less, and *Larrea* was particularly low.

Both *Celerio* and *Gelechia,* which had been the most common insects in the larval stage in 1971, were very scarce in 1972.

Small rodent sampling traps were operated for four periods on both the undisturbed and untreated sections of the Santa Rita sites, and for two periods on the two sections of the Silverbell sites. There was a greater biomass on the manipulated areas of both sites. At the Santa Rita sites, densities were greater in May, 1972, than in June, 1971. This may have been the result of the greater proportion of young in the earlier months of the season.

OBJECTIVES

The objectives of the validation measurements are four-fold:

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

DATA COLLECTION DESIGN

General Type of Measurement	Parameters Measured	DATA SET CODE	Reported on page 2.2.2.3.-
Meterological	Air temperature	A3UTC50	8
	Solar radiation		8
	Relative humidity		14
	Wind		14
	Precipitation	A3UTC52	14
Above Ground Vegetation	Perennials		
	Cover and density	A3UTC21	30
	Standing biomass		
	Ambrosia, Destruct sample	A3UTC21	31
	Ambrosia, Within jeep trails	A3UTC22	31
	Larrea, Destruct sample	A3UTC23	31
	Larrea, Within jeep trails	A3UTC22	31
	Cercidium, Destruct sample	A3UTC24	31
	Olneya, Destruct sample	A3UTC25	31
	Acacia, Destruct sample	A3UTC26	31
	Biomass Component Production		
	Inflorescences	A3UTC27	32
	Blooming/non-blooming plant ratio	A3UTC28	32
	Fruits	A3UTC29, 30	33
	Leaves	A3UTC31	33
	Terminal growth	A3UTC32	35
	Annuals		
	Production sampling	A3UTC33	37
	Seed and root production	A3UTC34	38
	Litter		
	Production sampling	A3UTC35	39
Fauna	Invertebrates		
	Fecal pellet samples	A3UWH07	40
	Emergence trap samples		
	Silverbell site	A3UWH05	42
	Santa Rita site	A3UWH06	42
	Litter Arthropod samples	A3UWH08	44
	Ants	A3UWH12,13	46
	Vertebrates		
	Reptiles		
	Birds		
	Species, population density, biomass		
	Silverbell site	A3URJ12	49
	Estimated biomass	A3URJ13	58
	Santa Rita site	A3URJ01	60
	Rodents		
	Species, biomass, home range, population size		
	Santa Rita (control)	A3UCE09	66
	Santa Rita (manipulated)	A3UCE10	66
	Silverbell Destruct Sample (control)	A3UCE12	66
	Silverbell Destruct Sample (manipulated)	A3UCE13	66
	Silverbell Validation (control)	A3UCE14	67
	Silverbell Validation (manipulated)	A3UCE15	67

Soil	Soil Survey Color, consistency, texture, organic matter, available elements, soil moisture, Soil pH, conductivity	A3UHD01	76

FINDINGS

CONTENTS

A. ABIOTIC

1,2. AIR TEMPERATURE AND SOLAR RADIATION

Meteorological data for the Silverbell site are summarized in Tables 1, 2 and 3. Raw data are compiled on DSCODE A3UTC50. These data were taken basically on an hourly basis. However, time intervals were not consistently uniform, and programs were required to take this into account. November is omitted from the data; the meteorological system was being changed over during this month. The meteorological station at the Silverbell site now has a complete array of sensors and is operating satisfactorily.

Table 1. Temperature and radiation summary, 1972—DSCODE A3UTC50

Date	Temperature (C) Min	Max	Mean	Radiation-(Langleys) Max	Total
1/ 1/72	7.3	18.0	11.7	.90	282.0
1/ 2/72	2.8	19.1	10.0	.90	342.0
1/ 3/72	Insufficient data				
1/ 4/72	3.3	16.9	9.1	.90	363.5
1/ 5/72	-3.4	14.9	5.1	1.00	367.1
1/ 6/72	-1.6	16.1	5.7	1.00	366.2
1/ 7/72	2.2	17.9	11.9	1.00	456.3
1/ 8/72	No data				
1/ 9/72	No data				
1/10/72	7.0	18.3	10.3	.90	368.3
1/11/72	.5	19.5	9.8	.95	431.2
1/12/72	.4	19.5	9.3	.93	329.1
1/13/72	2.6	20.7	11.3	.94	356.7
1/14/72	2.2	19.0	11.2	.95	361.6
1/15/72	5.2	22.9	13.5	.96	386.5
1/16/72	6.4	23.5	13.7	.96	320.0
1/17/72	1.1	21.4	11.7	.88	343.8
1/18/72	1.5	21.1	11.5	.97	378.2
1/19/72	2.3	20.3	11.9	.95	365.5
1/20/72	3.5	19.7	11.6	.92	365.6
1/21/72	2.5	19.8	11.4	1.10	387.2
1/22/72	1.6	20.3	11.7	1.10	353.0
1/23/72	1.9	21.5	12.5	1.00	395.3
1/24/72	4.6	19.6	12.3	1.00	394.7
1/25/72	11.9	24.4	19.1	1.10	588.0
1/26/72	9.2	20.6	14.0	.69	184.3
1/27/72	4.2	16.5	10.0	1.00	402.2
1/28/72	1.1		11.2	.93	375.6
1/29/72	4.0	17.6	11.2	1.10	445.7
1/30/72	4.9	15.2	9.6	1.10	323.8
1/31/72	.9	14.4	7.7	1.10	428.1

Table 1. Continued

Date	Temperature (C) Min	Max	Mean	Radiation-(Langleys) Max	Total
2/ 1/72	.1	15.0	7.7	.64	200.0
2/ 2/72	3.1	13.7	8.7	1.30	436.9
2/ 3/72	.1	17.9	8.4	1.10	437.4
2/ 4/72	5.7	21.1	12.4	1.30	306.6
2/ 5/72	9.5	18.7	13.7	.83	443.8
2/ 6/72	4.0	17.5	11.0	1.10	412.2
2/ 7/72	1.5	19.4	11.7	1.20	433.8
2/ 8/72	2.9	20.8	12.5	1.20	441.4
2/ 9/72	6.0	18.1	12.3	.42	168.7
2/10/72	7.5	18.3	12.7	1.10	332.5
2/11/72	4.4	19.3	11.6	1.10	435.5
2/12/72	6.2	20.7	13.0	1.10	485.1
2/13/72	3.7	23.5	12.6	1.10	461.2
2/14/72	4.1	22.2	13.2	1.10	475.7
2/15/72	6.2	19.5	13.3	1.10	465.8
2/16/72	2.4	19.4	12.0	.94	410.1
2/17/72	2.7	23.7	14.0	1.20	486.2
2/18/72	4.6	26.9	16.1	.90	286.1
2/19/72	8.7	29.4	17.8	1.30	400.2
2/20/72	8.2	27.7	17.9	1.10	466.8
2/21/72	4.7	26.9	17.4	1.20	465.7
2/22/72	10.3	26.0	18.1	1.20	457.6
2/23/72	8.3	25.2	17.3	1.20	511.5
2/24/72	4.1	25.7	15.9	1.20	502.2
2/25/72	5.9	26.9	17.5	1.20	498.6
2/26/72	5.8	28.2	17.9	1.10	499.1
2/27/72	7.5	28.2	19.0	1.30	520.2
2/28/72	7.9	29.1	18.9	1.20	525.5
3/ 1/72	5.8	28.0	18.9	1.20	520.5
3/ 2/72	12.6	21.3	17.1	1.30	534.8
3/ 3/72	3.6	23.9	15.2	1.20	513.6
3/ 4/72	9.1	29.4	20.1	1.20	512.4
3/ 5/72	10.6	31.9	22.1	1.20	520.8
3/ 6/72	11.2	31.8	23.0	1.20	525.2
3/ 7/72	11.2	31.8	22.5	1.20	514.0
3/ 8/72	10.5	32.9	22.6	1.30	527.3
3/ 9/72	11.1	34.8	23.6	1.30	540.0
3/10/72	12.9	33.7	23.9	1.20	529.9
3/11/72	10.5	32.9	23.0	1.30	522.0
3/12/72	Insufficient data				
3/13/72	18.8	32.7	24.2	1.30	589.7
3/14/72	12.7	29.2	21.7	1.20	402.8
3/15/72	11.8	39.4	22.4	1.30	470.9
3/16/72	13.6	33.8	22.9	1.30	516.0
3/17/72	12.1	30.9	22.1	1.30	584.6
3/18/72	9.9	30.9	21.3	1.30	585.8
3/19/72	12.4	29.5	21.7	1.30	578.7
3/20/72	15.2	25.2	22.2	1.00	591.6
3/21/72	No data				
3/22/72	21.0	28.3	26.7	.60	377.0
3/23/72	14.6	28.1	22.3	1.40	686.8
3/24/72	10.5	24.3	34.5	1.40	645.3
3/25/72	11.6	28.7	21.0	1.50	510.6
3/26/72	12.5	27.7	20.9	1.40	578.2
3/27/72	12.0	21.1	17.0	1.50	510.3
3/28/72	7.3	17.9	12.2	1.50	683.9
3/29/72	- .1	19.5	11.6	1.50	679.2
3/30/72	6.7	19.6	13.3	1.50	675.0
3/31/72	6.7	21.6	15.0	1.50	671.7

Continued

Table 1. Continued

Date	Temperature (C) Min	Max	Mean	Radiation-(Langleys) Max	Total
4/ 1/72	5.1	26.9	17.9	1.50	591.9
4/ 2/72	7.7	29.9	20.2	1.40	636.6
4/ 3/72	9.1	30.7	21.8	1.40	631.7
4/ 4/72	11.4	29.8	22.0	1.30	559.9
4/ 5/72	15.4	35.1	25.3	1.40	608.2
4/ 6/72	14.5	30.4	23.4	1.50	598.1
4/ 7/72	14.0	29.9	21.7	1.40	641.4
4/ 8/72	10.2	30.4	22.2	1.50	687.6
4/ 9/72	9.8	32.2	22.9	1.60	644.2
4/10/72	18.0	33.2	25.9	1.40	573.8
4/11/72	18.2	32.4	25.5	1.40	498.9
4/12/72	16.0	28.0	21.3	1.60	506.9
4/13/72	12.5	23.5	18.0	1.50	670.3
4/14/72	8.6	16.2	12.3	1.50	696.3
4/15/72	4.9	23.9	15.2	1.50	754.7
4/16/72	5.7	30.7	20.8	1.50	706.7
4/17/72	12.1	28.6	21.2	1.50	696.0
4/18/72	14.1	24.7	18.9	1.30	498.0
4/19/72	6.2	23.5	15.4	1.50	676.5
4/20/72	10.0	19.9	14.7	1.30	642.8
4/21/72	9.7	27.6	19.0	1.50	720.4
4/22/72	11.2	29.5	21.7	1.50	719.9
4/23/72	9.6	33.1	22.8	1.50	723.3
4/24/72	11.6	33.9	24.5	1.50	718.8
4/25/72	13.2	28.7	22.1	1.50	724.8
4/26/72	14.0	26.9	21.5	1.50	735.2
4/27/72	9.9	28.9	21.0	1.50	723.4
4/28/72	10.9	32.0	21.7	1.50	789.7
4/29/72	10.3	33.4	23.6	1.50	730.8
4/30/72	14.6	31.7	24.3	1.50	688.2
5/ 1/72	15.9	31.6	24.7	1.30	556.8
5/ 2/72	12.0	40.0	26.9	1.50	730.1
5/ 3/72	14.8	35.8	26.3	1.40	625.7
5/ 4/72	17.7	32.3	25.7	1.70	632.1
5/ 5/72	17.2	30.5	24.1	1.50	690.9
5/ 6/72	14.5	30.0	23.0	1.50	737.4
5/ 7/72	13.3	29.6	22.9	1.50	729.3
5/ 8/72	13.3	31.5	23.2	1.50	733.4
5/ 9/72	13.4	32.4	24.6	1.50	715.2
5/10/72	12.0	30.1	23.7	1.50	726.4
5/11/72	14.4	30.7	24.2	1.50	729.3
5/12/72	12.2	36.9	23.5	1.50	484.8
5/13/72	15.5	33.4	26.4	1.50	735.6
5/14/72	17.6	36.4	26.6	1.50	744.0
5/15/72	16.7	34.8	26.3	1.50	697.5
5/16/72	15.4	35.0	27.7	1.50	658.8
5/17/72	18.7	34.3	27.7	1.50	736.4
5/18/72	16.9	32.0	25.2	1.50	676.8
5/19/72	15.8	27.8	22.0	1.60	783.0
5/20/72	11.2	28.6	20.9	1.50	756.6
5/21/72	11.7	27.1	20.6	1.50	674.8
5/22/72	14.4	29.2	22.2	1.50	747.6
5/23/72	13.9	32.9	24.5	1.50	744.8
5/24/72	12.4	34.3	26.1	1.50	615.6
5/25/72	15.5	33.7	25.4	1.60	757.8
5/26/72	13.7	34.8	25.3	1.10	514.4
5/27/72	18.6	35.4	27.7	1.30	446.7
5/28/72	21.0	34.9	27.8	1.50	468.0
5/29/72	17.9	32.5	24.0	1.40	477.2
5/30/72	18.0	32.1	23.3	1.20	439.0
5/31/72	16.5	33.6	24.9	1.50	667.8

Table 1. Continued

Date	Min	Temperature (C) Max	Mean	Radiation-(Langleys) Max	Total
6/ 1/72	20.9	35.4	28.2	1.50	637.5
6/ 2/72	20.5	35.9	27.8	1.60	631.5
6/ 3/72	20.1	35.9	27.9	1.50	693.6
6/ 4/72	22.1	35.3	27.1	1.50	541.3
6/ 5/72	19.2	32.2	24.8	1.70	462.8
6/ 6/72	19.3	34.9	25.3	1.60	523.8
6/ 7/72	19.8	31.3	24.6	1.60	526.2
6/ 8/72	17.8	33.3	25.1	1.60	603.2
6/ 9/72	19.1	33.8	25.9	1.70	578.9
6/10/72	20.0	34.3	28.0	1.60	784.0
6/11/72	21.8	37.5	30.2	1.50	695.4
6/12/72	21.3	36.3	28.6	1.30	441.2
6/13/72	19.9	36.4	27.6	1.50	500.4
6/14/72	20.3	40.0	31.0	1.10	659.5
6/15/72	28.7	38.9	32.1	1.50	798.8
6/16/72	25.3	41.0	33.4	1.50	792.9
6/17/72	22.8	40.6	33.3	1.50	670.2
6/18/72	22.0	39.1	33.8	1.50	652.5
6/19/72	29.5	42.6	36.4	1.50	852.1
6/20/72	24.9	42.3	33.0	1.50	677.9
6/21/72	20.0	38.4	28.4	1.50	639.2
6/22/72	21.8	36.4	27.3	1.70	731.5
6/23/72	22.5	35.5	29.4	1.60	857.2
6/24/72	No data				
6/25/72	No data				
6/26/72	27.3	37.3	32.5	1.50	946.0
6/27/72	18.7	38.1	30.2	1.60	810.0
6/28/72	20.1	41.0	32.1	1.60	753.6
6/29/72	21.4	42.2	33.6	1.50	765.8
6/30/72	20.4	42.8	35.3	1.50	754.7
7/ 1/72	24.2	43.4	36.3	.99	231.3
7/ 2/72	23.7	42.0	35.3	.73	221.4
7/ 3/72	24.3	41.9	34.7	.98	277.2
7/ 4/72	24.8	42.8	35.4	1.50	755.2
7/ 5/72	24.9	41.1	34.8	1.50	727.5
7/ 6/72	25.8	39.8	33.4	1.50	703.7
7/ 7/72	22.1	40.1	32.8	1.60	721.0
7/ 8/72	25.0	38.7	31.9	1.40	587.7
7/ 9/72	22.3	40.3	32.4	1.60	669.3
7/10/72	30.9	39.8	36.9	1.40	864.6
7/11/72	25.0	42.0	34.0	1.50	685.5
7/12/72	26.5	41.1	34.4	1.50	655.5
7/13/72	26.4	41.0	34.4	1.40	729.5
7/14/72	28.1	40.8	34.5	1.50	735.7
7/15/72	24.2	38.9	31.4	1.50	714.0
7/16/72	18.5	35.0	29.6	1.50	490.6
7/17/72	25.8	31.8	29.8	1.10	695.1
7/18/72	23.7	36.2	30.4	1.40	716.3
7/19/72	24.2	38.8	32.3	1.60	766.1
7/20/72	22.7	39.2	32.0	1.30	642.7
7/21/72	23.0	40.0	32.5	1.50	742.5
7/22/72	26.1	39.7	33.0	1.50	738.3
7/23/72	21.6	39.4	30.1	1.60	576.9
7/24/72	23.4	35.7	28.8	1.70	425.4
7/25/72	28.7	37.6	35.1	1.40	929.3
7/26/72	24.1	40.1	32.8	1.50	610.3
7/27/72	25.0	42.0	34.8	1.40	706.0

Continued

Table 1. Continued

Date	Temperature (C)			Radiation-(Langleys)	
	Min	Max	Mean	Max	Total
8/ 1/72	36.4	44.1	41.2	1.50	847.7
8/ 2/72	28.4	40.1	34.8	1.50	700.3
8/ 3/72	24.2	39.7	33.0	1.50	720.4
8/ 4/72	26.4	37.8	31.5	1.20	584.5
8/ 5/72	24.2	36.2	31.6	1.50	646.3
8/ 6/72	No data				
8/ 7/72	26.8	36.9	33.5	1.40	845.2
8/ 8/72	22.4	36.8	30.3	1.40	695.4
8/ 9/72	Insufficient	data			
8/10/72	20.9	37.2	28.6	1.40	622.8
8/11/72	23.5	38.5	31.0	1.50	613.1
8/12/72	Insufficient	data			
8/13/72	No data				
8/14/72	26.5	34.8	32.0	1.60	916.2
8/15/72	19.4	36.0	28.9	1.40	683.5
8/16/72	21.4	36.3	29.2	1.20	647.2
8/17/72	20.9	35.9	29.8	1.20	598.2
8/18/72	23.3	33.7	29.6	1.60	398.0
8/19/72	27.2	35.2	30.2	1.30	615.0
8/20/72	Insufficient	data			
8/21/72	29.6	39.1	34.4	1.30	776.5
8/22/72	21.9	40.1	32.7	1.40	680.9
8/23/72	21.9	40.9	33.0	1.40	684.6
8/24/72	23.3	39.0	31.0	1.40	697.2
8/25/72	22.2	36.4	29.5	1.50	610.0
8/26/72	22.9	35.1	27.8	1.60	432.9
8/27/72	21.5	34.4	28.0	1.70	737.1
8/28/72	21.9	35.7	26.8	1.30	422.5
8/29/72	22.3	33.7	27.2	1.30	393.6
8/30/72	20.3	36.2	29.2	1.40	624.6
9/ 1/72	22.2	38.2	28.6	1.40	571.8
9/ 2/72	20.7	37.7	27.6	1.30	629.9
9/ 3/72	22.0	33.2	27.2	1.60	437.4
9/ 4/72	20.6	35.4	28.1	1.30	648.9
9/ 5/72	20.2	37.5	30.5	1.40	645.6
9/ 6/72	23.2	38.9	31.9	1.40	603.3
9/ 7/72	24.8	35.8	29.9	1.40	654.1
9/ 8/72	19.8	31.0	26.1	.52	223.2
9/ 9/72	20.8	39.3	28.2	1.40	561.9
9/10/72	19.5	35.0	26.2	1.40	545.3
9/11/72	20.8	39.2	29.9	1.30	562.8
9/12/72	18.9	35.9	29.9	1.40	680.7
9/13/72	No data				
9/14/72	No data				
9/15/72	No data				
9/16/72	No data				
9/17/72	No data				
9/18/72	No data				
9/19/72	No data				
9/20/72	No data				
9/21/72	No data				
9/22/72	28.7	34.8	31.6	1.40	634.9
9/23/72	21.1	33.3	28.3	1.30	584.4
9/24/72	17.8	29.4	24.2	1.20	452.8
9/25/72	14.5	31.8	24.4	1.30	529.0
9/26/72	14.4	31.2	23.8	1.30	483.1
9/27/72	16.6	33.2	25.6	1.30	530.9
9/28/72	16.2	33.6	25.9	1.30	541.3
9/29/72	16.4	34.1	25.5	1.30	553.3
9/30/72	18.0	37.9	27.4	1.30	550.8

Continued

Table 1. Continued

Date	Temperature (C) Min	Max	Mean	Radiation-(Langleys) Max	Total
10/ 1/72	17.3	38.9	28.7	1.30	544.1
10/ 2/72	19.8	35.4	28.4	1.20	484.9
10/ 3/72	19.0	26.0	21.7	.37	128.8
10/ 4/72	20.1	22.6	20.8	.20	131.1
10/ 5/72	Insufficient	data			
10/ 6/72	21.1	28.7	23.2	1.20	330.5
10/ 7/72	17.9	26.6	21.8	1.70	540.6
10/ 8/72	16.3	30.1	22.7	1.30	556.7
10/ 9/72	16.3	30.8	22.7	1.20	488.2
10/10/72	14.7	31.7	22.8	1.80	739.5
10/11/72	14.3	33.3	23.0	1.30	494.7
10/12/72	15.1	34.9	24.6	1.30	395.5
10/13/72	15.9	35.1	24.6	1.20	487.0
10/14/72	12.4	34.9	24.1	1.20	422.5
10/15/72	16.3	34.4	25.7	1.30	397.2
10/16/72	15.1	34.4	25.1	1.20	415.8
10/17/72	16.4	22.8	19.3	1.00	140.9
10/18/72	16.9	25.8	20.1	.98	320.7
10/19/72	17.4	20.0	18.0	.35	151.5
10/20/72	15.0	18.5	15.5	1.70	317.4
10/21/72	10.4	19.8	15.0	1.50	602.4
10/22/72	7.6	21.6	13.6	1.10	424.1
10/23/72	8.3	23.5	16.2	.85	473.5
10/24/72	11.2	21.9	15.9	.34	125.1
10/25/72	10.6	18.1	13.6	1.00	361.6
10/26/72	Insufficient	data			
10/27/72	Insufficient	data			
10/28/72	Insufficient	data			
10/29/72	Insufficient	data			
10/30/72	10.1	14.7	12.6	1.30	313.6
10/31/72	Insufficient	data			
12/ 1/72	No data				
12/ 2/72	No data				
12/ 3/72	No data				
12/ 4/72	No data				
12/ 5/72	1.7	11.4	8.9	.24	156.3
12/ 6/72	.7	14.5	5.0	.71	226.6
12/ 7/72	.7	11.9	7.5	.37	111.6
12/ 8/72	3.4	12.3	9.3	1.10	199.1
12/ 9/72	No data				
12/10/72	No data				
12/11/72	No data				
12/12/72	No data				
12/13/72	Insufficient data				
12/14/72	Insufficient data				
12/15/72	3.0	10.3	9.1	1.00	668.2
12/16/72	3.1	17.4	8.6	1.10	370.2
12/17/72	- .4	16.8	7.6	1.80	366.0
12/18/72	5.2	20.5	10.9	1.80	675.7
12/19/72	.4	20.9	9.8	.96	344.7
12/20/72	2.7	17.0	9.7	2.00	935.6
12/21/72	1.0	20.2	12.3	1.70	599.4
12/22/72	.9	24.0	11.6	2.00	725.2
12/23/72	1.4	20.6	9.8	.93	386.7
12/24/72	.2	23.6	12.1	1.50	516.1
12/25/72	6.2	20.5	11.9	.97	315.0
12/26/72	1.1	20.6	11.2	.93	328.1
12/27/72	6.6	17.3	12.2	1.60	339.9
12/28/72	6.4	21.7	11.9	.69	157.2
12/29/72	.6	10.6	5.9	.96	333.2
12/30/72	-6.5	17.5	3.4	1.90	447.6
12/31/72	-5.1	10.6	2.7	.93	357.9

A,3. PRECIPITATION

Rainfall records from the meteorological station on the Silverbell site are presented in Table 2.

Table 2. Rainfall at Silverbell, 1972——DSCODE A3UTC52

Date	Amount(in.)	Date	Amount(in)
23 March	trace	29 August - 3 September	0.20
29 May	0.13	8 September	0.30
2 - 3 June	0.86	10 September	0.35
7 - 8 June	0.23	11 September	0.32
9 June	trace	12 September	0.08
10 - 12 June	0.07	3 October	0.45
21 June	0.50	4 October	0.54
22 June	0.13	5 October	0.26
7 July	0.30	7 - 12 October	0.16
16 July	0.53	18 October	1.18
17 July	1.08	19 October	1.42
24 July	0.18	22 October	0.32
27 July	0.05	26 - 27 October	0.15
29 July	0.13	3 - 8 November	0.10
31 July	0.03	10 - 15 November	0.97
6 August	1.15	17 - 22 November	0.59
9 August	0.05	23 November	0.31
13 August	1.04	8 December	0.15
17 August	0.02	10 December	0.25
22 August	0.07	28 - 29 December	0.27

A.4,5 RELATIVE HUMIDITY
WIND

Mean, minimum and maximum values for relative humidity are reported on a daily basis in Table 3. This Table also records wind speed.

Table 3. Relative humidity and wind distance summary, 1972——DSCODE A3UTC50

	Relative Humidity			Wind Distance mi/hr		mi/day
Date	Min	Max	Mean	Min	Max	Total
1/ 1/72	29.0	64.0	43.8	.2	7.1	92.2
1/ 2/72	29.0	46.0	38.3	.1	6.5	90.3
1/ 3/72	Insufficient data					
1/ 4/72	19.0	54.0	33.9	.2	15.0	179.1
1/ 5/72	12.0	40.0	24.2	.1	16.4	103.4
1/ 6/72	12.0	40.0	30.1	.5	13.8	160.8
1/ 7/72	13.0	40.0	17.0	.2	4.6	72.6
1/ 8/72	No data					
1/ 9/72	No data					
1/10/72	Insufficient data			1.8	5.7	61.3

Continued

Table 3. Continued

Date	Relative Humidity Min	Relative Humidity Max	Relative Humidity Mean	Wind Distance mi/hr Min	Wind Distance mi/hr Max	Wind Distance mi/day Total
1/11/72	13.0	15.0	14.6	.0	5.6	71.2
1/12/72	11.0	40.0	24.6	.5	10.6	118.3
1/13/72	11.0	40.0	20.9	.0	7.8	81.2
1/14/72	15.0	40.0	23.3	.3	14.5	105.2
1/15/72	11.0	40.0	19.7	.2	7.1	89.9
1/16/72	12.0	40.0	21.2	.4	7.0	105.5
1/17/72	13.0	40.0	23.8	.4	9.2	98.1
1/18/72	13.0	40.0	24.1	.2	13.2	104.8
1/19/72	13.0	42.0	24.7	.3	6.5	89.2
1/20/72	16.0	40.0	26.2	.2	7.2	89.8
1/21/72	15.0	45.0	26.5	.2	5.9	78.2
1/22/72	12.0	42.0	24.1	.3	6.2	80.8
1/23/72	13.0	40.0	22.6	.1	9.1	84.6
1/24/72	13.0	40.0	20.5	.1	6.8	86.8
1/25/72	10.0	13.0	12.0	.1	7.7	70.1
1/26/72	18.0	40.0	27.5	.0	13.7	150.2
1/27/72	19.0	52.0	34.2	.2	7.9	89.3
1/28/72	12.0	41.0	25.0	.0	8.0	86.3
1/29/72	11.0	18.0	15.5	.0	7.6	95.2
1/30/72	14.0	40.0	24.5	.2	9.6	125.3
1/31/72	12.0	40.0	18.3	.2	6.8	90.4
2/ 1/72	12.0	40.0	23.9	.1	12.9	105.3
2/ 2/72	11.0	47.0	23.0	.3	13.9	168.0
2/ 3/72	8.0	40.0	16.2	.5	7.5	105.9
2/ 4/72	8.0	11.0	9.2	.2	13.9	111.6
2/ 5/72	8.0	17.0	10.6	.2	52.5	407.2
2/ 6/72	20.0	46.0	28.6	.2	7.6	82.8
2/ 7/72	15.0	61.0	28.3	.1	9.0	100.3
2/ 8/72	11.0	40.0	20.2	.1	6.4	105.4
2/ 9/72	13.0	40.0	21.0	.0	6.7	74.3
2/10/72	21.0	53.0	34.7	.2	7.5	83.5
2/11/72	11.0	40.0	23.0	.2	7.9	112.8
2/12/72	10.0	16.0	12.5	.1	9.4	97.5
2/13/72	9.0	15.0	10.7	.2	9.5	104.6
2/14/72	9.0	40.0	16.2	.2	8.6	98.4
2/15/72	12.0	40.0	20.0	.1	11.7	108.0
2/16/72	12.0	40.0	20.4	.1	9.1	84.4
2/17/72	11.0	40.0	19.4	.0	6.5	82.7
2/18/72	9.0	40.0	18.5	.1	10.0	100.0
2/19/72	10.0	27.0	14.6	.3	8.6	99.3
2/20/72	10.0	32.0	16.0	.2	8.8	106.9
2/21/72	8.0	40.0	15.6	.2	10.3	62.1
2/22/72	10.0	26.0	15.8	.1	7.2	97.9
2/23/72	9.0	41.0	18.4	.3	6.5	79.0
2/24/72	7.0	40.0	14.3	.2	8.3	99.6
2/25/72	9.0	40.0	14.0	.2	13.0	125.2
2/26/72	9.0	40.0	16.8	.2	9.4	100.3
2/27/72	10.0	40.0	16.3	.2	6.6	95.7
2/28/72	10.0	40.0	16.5	.2	5.8	75.2

Continued

Table 3. Continued

Date	Relative Humidity Min	Relative Humidity Max	Relative Humidity Mean	Wind Distance mi/hr Min	Wind Distance mi/hr Max	Wind Distance mi/day Total
3/ 1/72	8.0	40.0	15.2	.2	14.0	159.6
3/ 2/72	8.0	20.0	11.8	.4	14.7	204.0
3/ 3/72	8.0	40.0	15.0	.1	7.9	95.4
3/ 4/72	10.0	40.0	17.1	.2	8.5	105.2
3/ 5/72	10.0	43.0	18.6	.2	7.3	101.5
3/ 6/72	10.0	42.0	17.9	.3	10.3	116.2
3/ 7/72	10.0	44.0	18.2	.2	8.4	114.0
3/ 8/72	10.0	45.0	17.9	.2	7.3	76.0
3/ 9/72	8.0	41.0	16.5	.2	8.5	108.0
3/10/72	8.0	28.0	12.8	.2	11.1	109.9
3/11/72	8.0	33.0	14.6	.1	8.9	103.9
3/12/72	No data					
3/13/72	8.0	15.0	10.8	.1	8.7	78.2
3/14/72	8.0	21.0	12.3	.1	9.7	96.3
3/15/72	10.0	90.0	31.8	.2	9.4	97.3
3/16/72	8.0	90.0	19.8	.1	8.0	83.9
3/17/72	6.0	13.0	8.9	.2	10.7	106.4
3/18/72	7.0	30.0	12.1	.1	9.5	105.9
3/19/72	10.0	24.0	13.0	.2	14.7	169.2
3/20/72	19.0	43.0	11.5	.5	13.6	58.0
3/21/72	No data					
3/22/72	Insufficient data			4.8	12.4	243.3
3/23/72	11.0	55.0	22.0	.2	11.5	143.8
3/24/72	9.0	28.0	14.5	.6	7.3	89.8
3/25/72	7.0	18.0	11.5	.2	13.7	147.4
3/26/72	9.0	48.0	19.0	1.2	19.0	314.6
3/27/72	11.0	39.0	22.8	.7	18.6	310.8
3/28/72	8.0	24.0	12.6	.4	11.7	130.6
3/29/72	8.0	40.0	12.9	.1	15.3	159.6
3/30/72	11.0	40.0	16.1	.3	10.6	142.3
3/31/72	9.0	40.0	13.7	.3	10.9	118.2
4/ 1/72	8.0	18.0	10.2	.2	8.4	87.2
4/ 2/72	8.0	15.0	9.6	.2	9.3	104.6
4/ 3/72	10.0	39.0	15.8	.1	6.5	89.8
4/ 4/72	11.0	31.0	15.0	.1	9.1	101.0
4/ 5/72	8.0	21.0	11.9	.2	9.1	109.5
4/ 6/72	9.0	26.0	13.2	.1	13.2	158.3
4/ 7/72	8.0	17.0	11.6	.4	8.3	106.8
4/ 8/72	7.0	19.0	10.1	.2	8.2	108.1
4/ 9/72	7.0	20.0	9.7	.1	7.6	84.8
4/10/72	7.0	11.0	8.3	.2	11.3	140.1
4/11/72	9.0	13.0	11.0	.4	16.8	210.6
4/12/72	12.0	40.0	22.5	.2	14.1	140.4
4/13/72	11.0	27.0	17.4	1.1	18.0	273.1
4/14/72	8.0	15.0	10.8	.5	13.9	193.6
4/15/72	12.0	12.0	12.0	.2	8.4	87.7
4/16/72	8.0	40.0	11.5	.2	7.3	115.6
4/17/72	9.0	16.0	10.6	.4	15.8	191.4
4/18/72	9.0	17.0	12.0	.3	17.1	244.0
4/19/72	10.0	40.0	17.1	.2	12.9	149.6
4/20/72	11.0	15.0	13.5	.3	12.0	146.8
4/21/72	8.0	21.0	11.5	.2	8.7	133.8
4/22/72	7.0	19.0	9.8	.2	10.0	123.5
4/23/72	6.0	16.0	9.2	.1	8.8	108.2
4/24/72	7.0	14.0	9.1	.2	12.9	128.8
4/25/72	7.0	12.0	9.6	.3	13.6	131.5
4/26/72	7.0	12.0	8.6	.4	11.9	172.6
4/27/72	7.0	13.0	8.4	.0	8.8	110.1
4/28/72	7.0	90.0	19.3	.1	7.8	96.7
4/29/72	7.0	15.0	9.3	.3	14.0	139.0
4/30/72	7.0	14.0	9.2	.4	7.7	118.5

Table 3. Continued.

Date	Relative Humidity Min	Relative Humidity Max	Relative Humidity Mean	Wind Distance mi/hr Min	Wind Distance mi/hr Max	Wind Distance mi/day Total
5/ 1/72	7.0	12.0	8.9	.2	10.1	113.5
5/ 2/72	7.0	18.0	9.7	.0	30.7	105.0
5/ 3/72	7.0	11.0	8.7	.1	11.4	120.9
5/ 4/72	6.0	12.0	8.0	.4	13.5	169.8
5/ 5/72	10.0	24.0	12.4	.4	13.1	189.3
5/ 6/72	8.0	23.0	10.9	.3	13.9	158.4
5/ 7/72	7.0	31.0	12.1	.3	11.1	157.8
5/ 8/72	9.0	38.0	13.8	.2	8.5	107.5
5/ 9/72	6.0	20.0	10.4	.1	13.2	130.7
5/10/72	9.0	15.0	10.2	.4	11.2	138.6
5/11/72	7.0	33.0	11.2	.3	12.3	146.7
5/12/72	8.0	90.0	29.3	.2	9.5	104.1
5/13/72	7.0	10.0	8.6	.2	12.5	137.3
5/14/72	7.0	12.0	9.6	.2	18.5	140.9
5/15/72	7.0	27.0	13.3	.1	10.7	118.4
5/16/72	8.0	16.0	9.7	.2	14.4	137.5
5/17/72	6.0	10.0	7.6	.3	13.3	177.8
5/18/72	8.0	12.0	9.4	.3	17.8	228.8
5/19/72	9.0	15.0	11.2	.6	18.6	233.3
5/20/72	10.0	34.0	15.8	.2	15.9	175.8
5/21/72	9.0	27.0	14.0	.2	11.3	141.3
5/22/72	9.0	19.0	10.7	.3	8.1	115.0
5/23/72	7.0	16.0	10.0	.2	9.0	110.9
5/24/72	6.0	20.0	9.6	.2	10.6	128.3
5/25/72	6.0	13.0	8.1	.5	12.5	182.4
5/26/72	6.0	11.0	7.0	.2	12.1	106.1
5/27/72	6.0	11.0	7.7	.2	13.4	141.6
5/28/72	9.0	16.0	11.6	.2	25.2	164.4
5/29/72	16.0	68.0	31.1	.7	17.1	164.6
5/30/72	19.0	78.0	40.4	.2	13.1	100.5
5 31/72	18.0	83.0	38.1	.1	9.2	79.9
6/ 1/72	13.0	55.0	25.7	.2	14.2	129.4
6/ 2/72	17.0	54.0	25.8	.5	17.5	130.4
6/ 3/72	14.0	57.0	26.1	.3	18.5	139.5
6/ 4/72	16.0	60.0	33.3	.2	12.0	117.6
6/ 5/72	28.0	74.0	43.5	.4	10.2	107.5
6/ 6/72	21.0	62.0	38.2	.2	12.6	110.8
6/ 7/72	21.0	63.0	35.8	.4	13.8	189.3
6/ 8/72	19.0	78.0	33.8	.2	13.9	119.0
6/ 9/72	22.0	72.0	37.8	.1	12.2	146.1
6/10/72	27.0	60.0	36.3	.5	9.4	122.4
6/11/72	15.0	40.0	20.8	.3	19.7	146.2
6/12/72	18.0	53.0	27.3	.8	13.9	167.6
6/13/72	19.0	68.0	32.3	.3	13.9	132.7
6/14/72	21.0	57.0	33.7	.0	9.1	81.4
6/15/72	14.0	41.0	25.3	.3	9.1	101.3
6/16/72	10.0	31.0	18.3	.1	13.6	133.4
6/17/72	9.0	90.0	21.7	.2	16.2	170.9
6/18/72	8.0	11.0	8.4	.3	11.1	153.6
6/19/72	8.0	12.0	10.2	2.0	10.4	142.6
6/20/72	11.0	90.0	24.2	.2	17.3	146.7
6/21/72	18.0	85.0	38.6	.1	22.5	96.7
6/22/72	31.0	78.0	51.1	.1	13.7	132.3
6/23/72	9.0	49.0	22.6	.4	12.5	184.6
6/24/72	No data					
6/25/72	No data					
6/26/72	8.0	10.0	9.2	3.3	10.1	154.2
6/27/72	8.0	17.0	9.4	.2	8.5	110.2
6/28/72	7.0	17.0	9.2	.2	8.9	109.7
6/29/72	7.0	14.0	9.1	.3	9.6	127.0
6/30/72	7.0	17.0	9.3	.3	9.6	134.9

Table 3. Continued

Date	Relative Humidity Min	Relative Humidity Max	Relative Humidity Mean	Wind Distance mi/hr Min	Wind Distance mi/hr Max	Wind Distance mi/day Total
7/ 1/72	8.0	16.0	9.1	.4	12.9	173.4
7/ 2/72	7.0	11.0	8.6	.5	13.0	169.4
7/ 3/72	8.0	20.0	11.0	.3	12.1	105.4
7/ 4/72	7.0	22.0	10.4	.3	11.6	134.6
7/ 5/72	11.0	34.0	18.6	.1	15.7	172.5
7/ 6/72	14.0	40.0	20.0	.3	18.7	153.7
7/ 7/72	13.0	32.0	18.2	.3	15.7	170.3
7/ 8/72	16.0	56.0	30.8	.7	9.7	123.9
7/ 9/72	14.0	43.0	21.6	.6	10.4	140.6
7/10/72	13.0	15.0	14.2	.5	7.1	61.4
7/11/72	11.0	39.0	16.8	.0	10.4	142.9
7/12/72	10.0	47.0	21.1	.4	12.7	154.9
7/13/72	14.0	52.0	23.4	.6	10.3	126.7
7/14/72	16.0	40.0	23.1	.3	18.6	183.3
7/15/72	21.0	55.0	33.8	.5	11.4	173.5
7/16/72	32.0	74.0	40.9	.8	12.2	175.4
7/17/72	42.0	46.0	44.0	.0	9.1	46.3
7/18/72	18.0	37.0	24.1	.4	10.8	125.5
7/19/72	13.0	35.0	19.0	.4	12.3	136.6
7/20/72	12.0	46.0	21.1	.4	12.3	155.7
7/21/72	12.0	48.0	21.8	.1	9.0	118.5
7/22/72	11.0	40.0	17.2	.3	16.2	144.7
7/23/72	17.0	68.0	31.2	.3	18.1	161.0
7/24/72	35.0	82.0	50.5	.5	12.6	95.8
7/25/72	24.0	32.0	30.2	.4	6.3	115.8
7/26/72	18.0	63.0	29.7	.1	8.3	85.3
7/27/72	13.0	64.0	25.7	.1	9.7	111.3
8/ 1/72	10.0	12.0	11.2	6.6	37.0	559.8
8/ 2/72	10.0	56.0	24.3	.7	12.4	206.1
8/ 3/72	13.0	47.0	26.1	.2	14.0	122.8
8/ 4/72	20.0	53.0	31.6	.5	11.5	157.9
8/ 5/72	26.0	66.0	38.1	.2	9.4	137.4
8/ 6/72	No data					
8/ 7/72	30.0	38.0	35.1	.4	19.7	261.6
8/ 8/72	18.0	90.0	37.7	.1	9.0	90.7
8/ 9/72	No data					
8/10/72	19.0	75.0	37.2	.6	10.9	120.3
8/11/72	35.0	64.0	40.3	.4	8.3	130.7
8/12/72	31.0	32.0	28.0			
8/13/72	No data					
8/14/72	32.0	38.0	35.8	.0	37.1	259.5
8/15/72	11.0	67.0	30.0	.2	10.0	137.5
8/16/72	11.0	45.0	18.5	.2	8.6	98.8
8/17/72	11.0	38.0	16.9	.3	7.5	111.2
8/18/72	23.0	34.0	24.5	.5	8.1	107.8
8/19/72	11.0	25.0	15.8	.6	8.3	108.1
8/20/72	No data					
8/21/72	12.0	17.0	14.7	.3	8.5	86.5
8/22/72	10.0	45.0	17.7	.2	9.5	116.5
8/23/72	10.0	36.0	16.3	.4	16.1	157.4
8/24/72	14.0	51.0	24.6	.9	15.9	204.4
8/25/72	15.0	43.0	24.4	.3	15.6	185.0
8/26/72	24.0	56.0	37.3	.5	11.2	117.0
8/27/72	19.0	68.0	34.2	.4	8.9	109.4
8/28/72	18.0	82.0	38.4	.4	14.6	99.2
8/29/72	35.0	65.0	45.1	.3	8.1	88.6
8/30/72	26.0	76.0	38.9	.1	7.3	81.1

Continued

Table 3. Continued

	Relative Humidity			Wind Distance mi/hr		mi/day
Date	Min	Max	Mean	Min	Max	Total
9/ 1/72	20.0	60.0	33.8	.1	20.3	116.7
9/ 2/72	22.0	82.0	38.0	.1	13.4	137.8
9/ 3/72	28.0	73.2	42.3	.3	8.9	118.3
9/ 4/72	20.0	78.0	37.7	.5	7.5	109.9
9/ 5/72	14.0	68.0	26.7	.2	7.8	84.9
9/ 6/72	12.0	48.0	21.8	.2	8.5	113.2
9/ 7/72	16.0	41.0	23.6	.4	15.9	222.1
9/ 8/72	36.0	63.0	46.7	.3	15.4	135.6
9/ 9/72	26.0	62.0	35.0	.4	20.1	157.3
9/10/72	25.0	85.0	44.6	.3	15.4	155.2
9/11/72	11.0	51.0	24.9	.5	21.9	243.6
9/12/72	16.0	48.0	23.1	.3	10.8	127.5
9/13/72	No data					
9/14/72	No data					
9/15/72	No data					
9/16/72	No data					
9/17/72	No data					
9/18/72	No data					
9/19/72	No data					
9/20/72	No data					
9/21/72	No data					
9/22/72	19.0	22.0	21.4	6.1	19.9	345.7
9/23/72	11.0	47.0	22.0	1.2	28.3	386.6
9/24/72	12.0	55.0	28.9	3.0	28.7	375.2
9/25/72	10.0	90.0	27.9	.2	17.5	156.6
9/26/72	24.0	50.0	32.6	.4	10.3	124.5
9/27/72	19.0	67.0	32.2	.6	12.7	169.5
9/28/72	11.0	70.0	26.6	.3	12.3	137.9
9/29/72	10.0	49.0	17.5	.2	11.4	124.9
9/30/72	8.0	37.0	15.9	.5	11.8	151.1
10/ 1/72	9.0	28.0	14.1	.5	16.6	200.3
10/ 2/72	11.0	29.0	17.7	.4	21.5	237.9
10/ 3/72	28.0	90.0	77.8	.4	20.5	224.5
10/ 4/72	8.0	90.0	18.3	.0	8.2	143.8
10/ 5/72	90.0	90.0	90.0			
10/ 6/72	48.0	90.0	65.3	1.8	35.1	489.4
10/ 7/72	65.0	90.0	75.7	.7	22.0	275.2
10/ 8/72	50.0	90.0	65.9	.3	12.9	178.0
10/ 9/72	31.0	75.0	50.1	.5	20.2	282.8
10/10/72	44.0	90.0	59.8	.9	15.2	197.1
10/11/72	35.0	90.0	53.2	.3	10.8	144.6
10/12/72	30.0	90.0	47.6	.1	20.8	133.7
10/13/72	29.0	90.0	47.9	.1	12.3	155.4
10/14/72	13.0	90.0	34.7	1.5	11.4	146.0
10/15/72	21.0	83.0	40.1	.6	13.5	185.1
10/16/72	25.0	90.0	44.4	.2	12.9	167.4
10/17/72	57.0	90.0	79.4	.3	16.8	140.6
10/18/72	9.0	90.0	72.8	.2	14.2	135.5
10/19/72	75.0	90.0	81.0	.3	18.9	301.3
10/20/72	60.0	90.0	69.7	.8	24.6	176.4
10/21/72	49.0	90.0	66.6	.5	15.6	153.5
10/22/72	48.0	90.0	64.5	2.5	43.0	302.3
10/23/72	Insufficient data			.3	99.9	829.1
10/24/72	Insufficient data			.4	99.9	1031.
10/25/72	50.0	76.0	62.6	3.4	99.9	1726.
10/26/72	Insufficient data					
10/27/72	Insufficient data					
10/28/72	51.0	82.0	68.6			
10/29/72	44.0	47.0	45.6			
10/31/72	24.0	62.0	37.4	2.1	99.9	1271.

Continued

Table 3. Continued

Date	Relative Humidity Min	Relative Humidity Max	Relative Humidity Mean	Wind Distance mi/hr Min	Wind Distance mi/hr Max	Wind Distance mi/day Total
12/ 1/72	No data					
12/ 2/72	No data					
12/ 3/72	No data					
12/ 4/72	No data					
12/ 5/72	Insufficient data			.2	1.7	31.4
12/ 6/72	56.0	90.0	75.9	.0	2.5	9.8
12/ 7/72	71.0	90.0	78.1	.0	2.1	17.6
12/ 8/72	72.0	90.0	40.4	.1	4.8	42.3
12/ 9/72	No data					
12/10/72	No data					
12/11/72	No data					
12/12/72	No data					
12/13/72	Insufficient data					
12/14/72	Insufficient data					
12/15/72	Insufficient data			.0	2.3	20.3
12/16/72	12.0	62.0	26.0	.1	3.9	33.1
12/17/72	18.0	90.0	48.0	.0	3.6	25.0
12/18/72	17.0	59.0	34.4	.1	3.7	25.0
12/19/72	6.0	56.0	28.7	.0	3.4	25.1
12/20/72	40.0	57.0	46.7	.0	5.3	37.1
12/21/72	16.0	90.0	40.0	.0	2.6	25.1
12/22/72	16.0	90.0	31.6	.0	3.0	20.7
12/23/72	6.0	54.0	33.2	.0	3.4	24.8
12/24/72	12.0	66.0	32.8	.1	2.7	22.3
12/25/72	14.0	65.0	34.8	.1	4.7	35.5
12/26/72	14.0	82.0	32.4	.2	4.7	37.5
12/27/72	36.0	59.0	48.9	.1	3.3	22.2
12/28/72	11.0	90.0	58.4	.0	10.2	95.2
12/29/72	35.0	73.0	48.1	.1	4.3	60.3
12/30/72	16.0	40.0	32.5	.0	3.6	31.1
12/31/72	28.0	78.0	42.8	.0	3.8	27.3

B. PLANTS

B.1. PLANT SAMPLING PROBLEMS

Validation sites are operated to collect data for testing and calibrating models. Collecting the data is a decision-making problem where trade-offs between precision and costs must be made against a background of natural variability.

Sometimes, no matter how much care and effort is put into sampling, the greatest precision that can be obtained may be so poor as to render the data useless. When this occurs, parameters of the model which require the data are rendered useless as well.

If a model is being developed for prediction purposes, then a feedback system must be provided to maintain the alignment of its development with what can be measured and how precisely it can be measured. This also requires a secondary feedback system which operates during the sampling process itself to optimize costs and precision as the sampling is being carried forward.

The problem of estimating the biomass of the inflorescences of palo verde illustrates some of these points.

The problem may be set up in this fashion:

$$\frac{\text{FLOWER WEIGHT}}{\text{HECTARE}} = \frac{\text{FLOWER WEIGHT}}{\text{BRANCH WEIGHT}} \times \frac{\text{TREES IN FLOWER}}{\text{ALL TREES}} \times \frac{\text{BRANCH WEIGHT}}{\text{TREE}} \times \frac{\text{TREES}}{\text{HECTARE}} \quad (1)$$

Estimates of plant density and the weight of branches 2.5 cm or less per tree were obtained. Flower weight was estimated by picking and weighing the flowers on branches (2.5 cm or less) sampled from trees which were in bloom. All trees were not in bloom at the time of sampling, so another estimate is needed to determine the ratio of those in bloom to the total number. The flower samples were taken during a three-day period when maximum blooming occurred.

Regression analysis cannot be used; e.g., develop one regression equation of flower weight versus stem weight and another for stem weight versus crown area, measure the crown area of every tree in the density sample and then compute flower biomass. This is a violation a basic assumption explicit in the analysis that arises when a dependent variable of one regression is used as the independent variable of another, particularly when the independent variable in the first regression is a sample estimate itself.

One way to determine both the number and an estimate of its precision is to obtain means and variances for each quantity and invoke the product rule. This essentially is what we did with the exception that stratification was used wherever possible to improve the estimate.

For example, in estimating weight of branches 2.5 cm or less per tree, the relative precision was seven times greater when the sample was stratified on the basis of crown cover (Table 1).

Table 1. Stratified vs. random sample for estimating branch weight of palo verde.

	Variance	Relative Precision	Error Reduction
Stratified	14.2	7	85%
Simple Random	99.3	1	

In order to stratify on the basis of crown area, the crown area of each tree in the density sample was measured and separated into size classes. Crown areas were measured with a dot grid overlay on IR film.

The validation site is dissected by numerous channels which make up about 15% of the area. Therefore, it was also necessary to stratify by upland and channel sites as well.

Four crown classes were used (Table 2). The channel site has a greater total number of trees and a greater than proportional number in the larger size classes. Values for both sites were pooled (Table 3). There were between 23 and 30 palo verde trees per hectare over all size classes.

In equation (1) we now have an estimate of trees per hectare by crown class, an estimate of branches 2.5 cm or less in diameter by crown class, an estimate of proportion of trees in flower, and an estimate of the weight of branch. All estimates are assumed independent. Since the trees were either in conspicuous bloom or not, the distribution of the second term on the right is binomial. The errors of all other terms were assumed to be normally distributed.

Figures 1 through 4 show the success of estimating each component on the right hand side of equation (1).

The density sample included about 30% of the area and gave an estimate of the number of trees within 12% of the mean. It would not have been efficient to have taken a larger sample (Figure 1).

The sample of branch weight per tree, based on a destruct sample of 24 trees gave an estimate within 15% of the mean (Figure 2). A precision equal to that of the density sample could only have been obtained by destructively sampling all the palo verde trees on an equivalent of 4 acres. This would have been almost prohibitively expensive.

Table 2. Density of palo verde for upland and channel sites -- untreated area

Crown Class m^2	Upland No/ha		Upland 95% C.L.	Channel No/ha		Channel 95% C.L.
< 10.20	12.06	±	2.30	36.26	±	10.05
10.20 - 17.93	6.96	±	1.17	16.74	±	3.58
17.93 - 25.66	2.26	±	.53	7.65	±	4.11
25.66 <	1.39	±	.33	8.56	±	4.45

Table 3. Pooled density of palo verde -- untreated area

Crown Class m^2	No/ha		95% C.L.
<10.20	14.19	±	2.42
10.20 - 17.93	7.82	±	1.20
17.93 - 25.66	2.73	±	.61
25.66<	2.02	±	.49

The sample of trees in flower involved more than 600 individuals, nearly as many as grow on the untreated validation area (Figure 3). Any larger sample, short of examining every tree on the area, would have been unrealistic.

The final estimate, flower weight per weight of branch, was handled as a ratio (Figure 4). The precision was not as high as that obtained for the other estimates, and could have been improved by taking additional samples. An extra two man-days in the field could have brought the estimate to within 18% of the mean, but probably no closer.

In order to determine the variance of the final estimate of flower weight per hectare, the product rule was invoked.

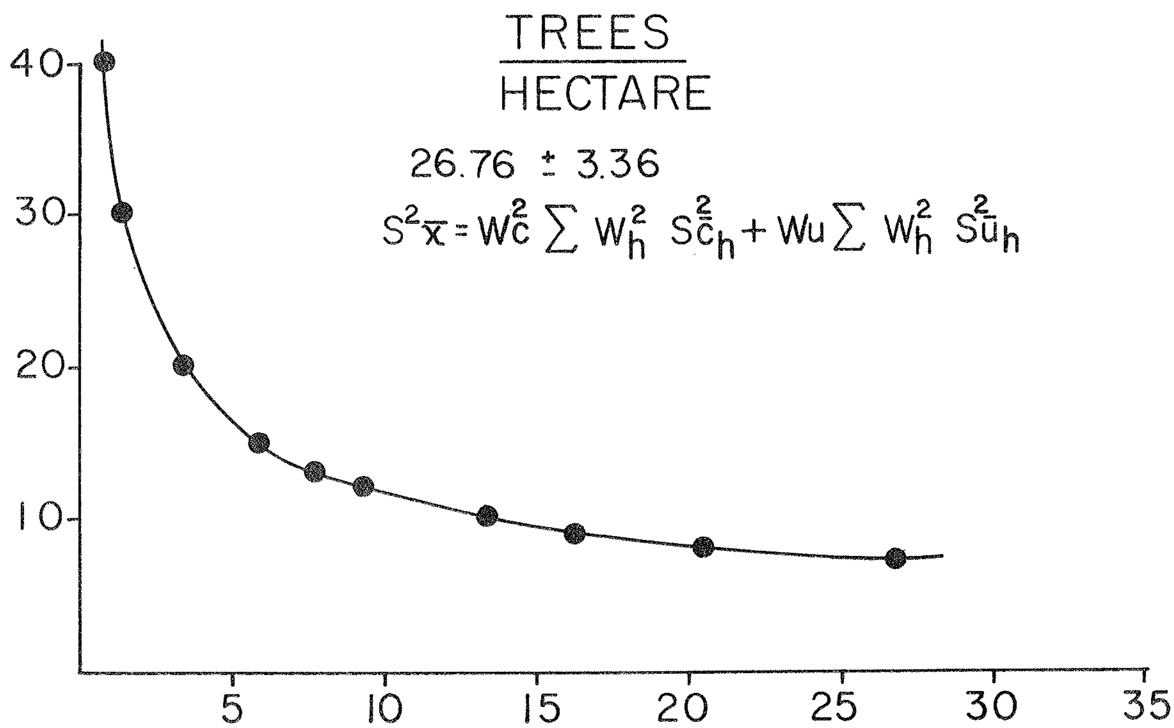


Figure 1. Variability associated with number of samples for estimating tree density of palo verde.

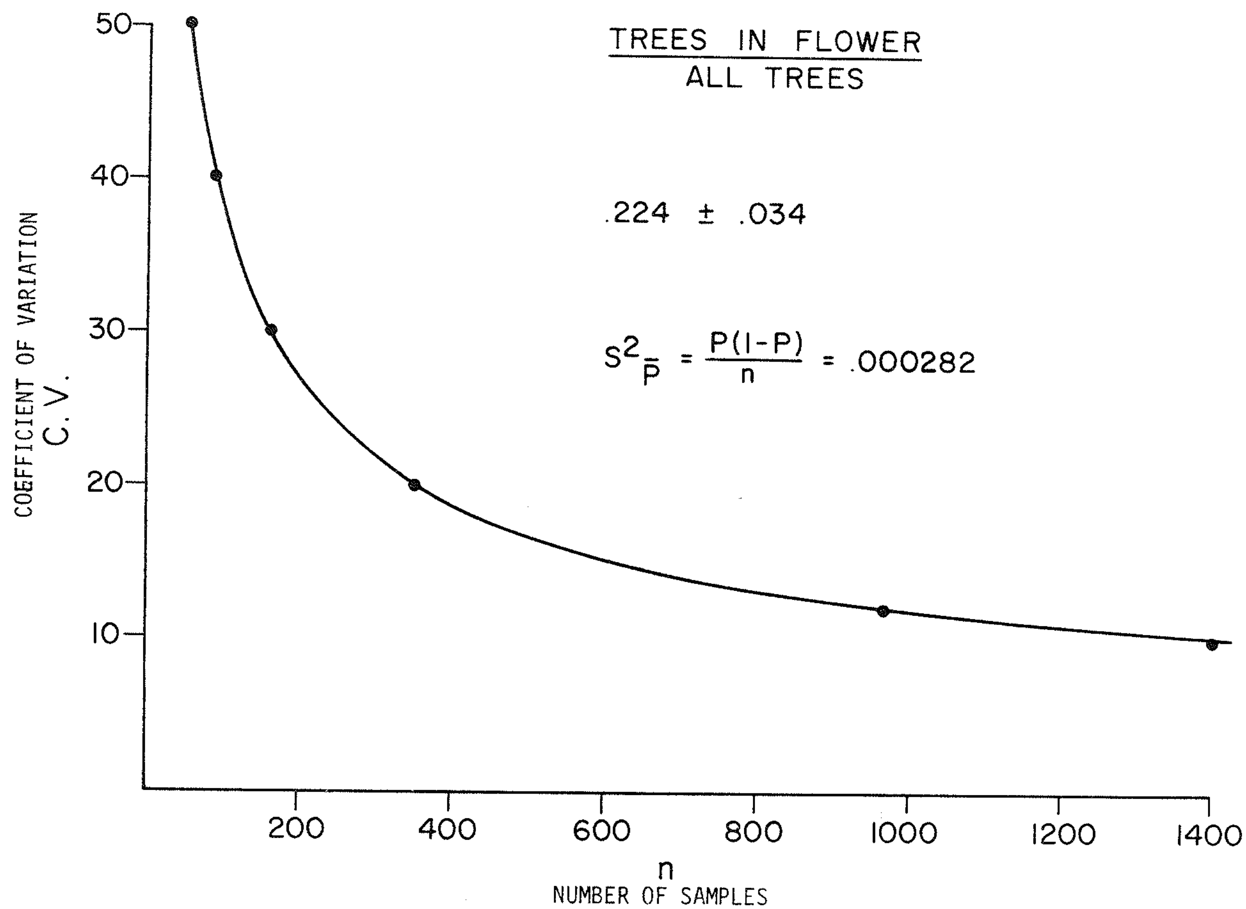


Figure 2. Variability associated with sampling number for estimating proportion of palo verde trees in flower.

A summary of the variance estimates is shown in Table 4. Pooling branch weight per tree and trees per hectare gave an estimate of 276 kg. of branches per hectare within about 35% of the mean.

The flower weight per branch weight for all trees (whether in bloom or not) is estimated within 30% of the mean.

When these two values are pooled, the final estimate of flower weight per hectare (about 11 kg) is only estimated within 42% of the mean.

The estimate could have been improved slightly by taking a larger flower sample. However, a significant improvement would require a better estimate of the branch weight per tree -- which is an extremely expensive measurement. And under no circumstance could a final estimate be obtained within 10% of the true value no matter what the effort.

If it were necessary to use this final value to estimate another quantity, e.g., carbon, then the variance of the carbon sample would be an additional error contribution.

If the estimate of biomass for flowers is to be added to some other quantity (stem wood, for instance) then it would be swamped by the sample error, since the variance of the two would be additive.

Despite the wide confidence band for flower biomass the estimate may still be satisfactory for validation, but we can't know until there is some feedback on model structure and sensitivity.

In the meantime, we know the precision of the validation estimates that have been made. We can estimate what precision is possible, and how much it will cost. Hopefully this information can be built into the model.

Table 4. Palo verde flower biomass obtained by using equation (1)

$\frac{\text{Flower Weight}}{\text{Branch Weight}}$	.158 ± .041	.012 ± .003	
$\frac{\text{Trees in Flower}}{\text{All Trees}}$	.224 ± .034		3.33 ± 1.91
$\frac{\text{Branch Weight}}{\text{Tree}}$	10.34 ±1.56	276.70 ± 104.98	
$\frac{\text{Trees}}{\text{Hectare}}$	26.76 ±3.36		

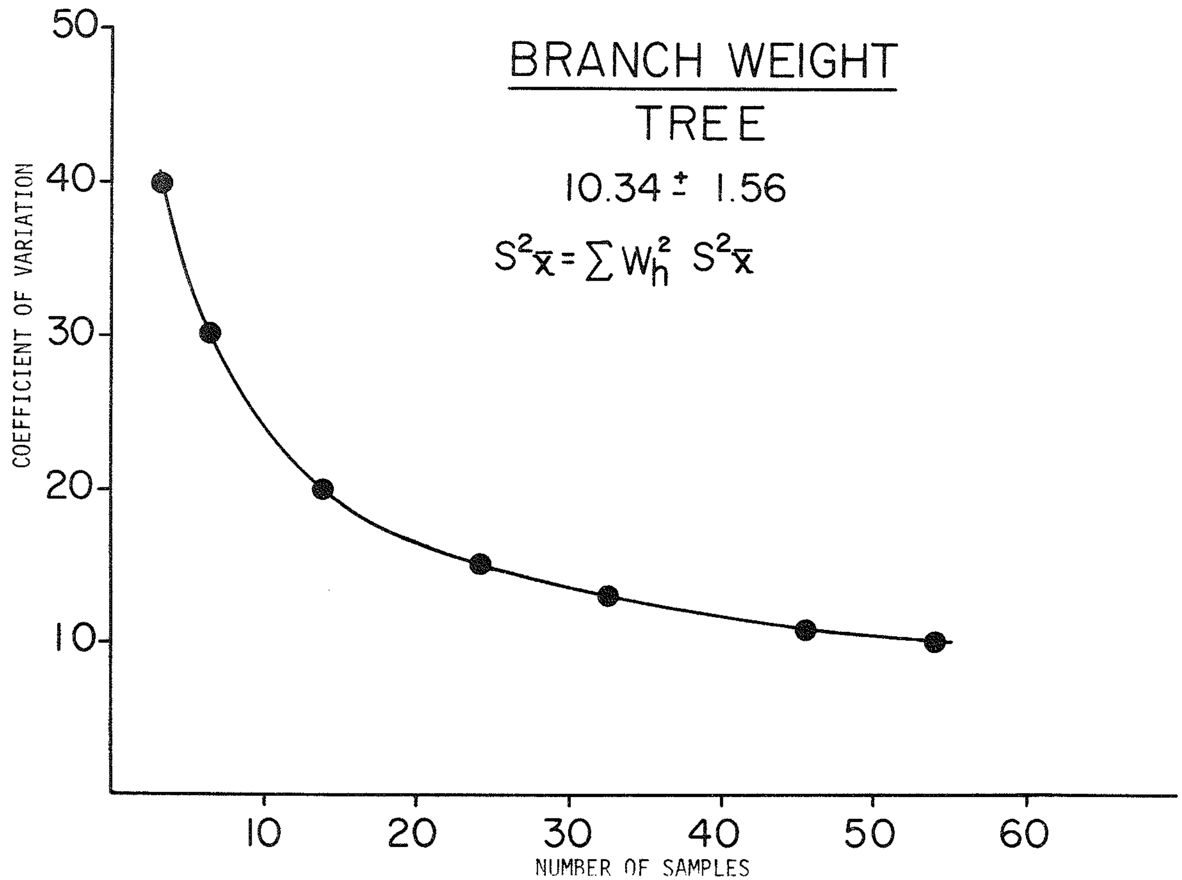


Figure 3. Variability associated with sample number for estimating weight of branches ≤2.5 cm on a palo verde tree.

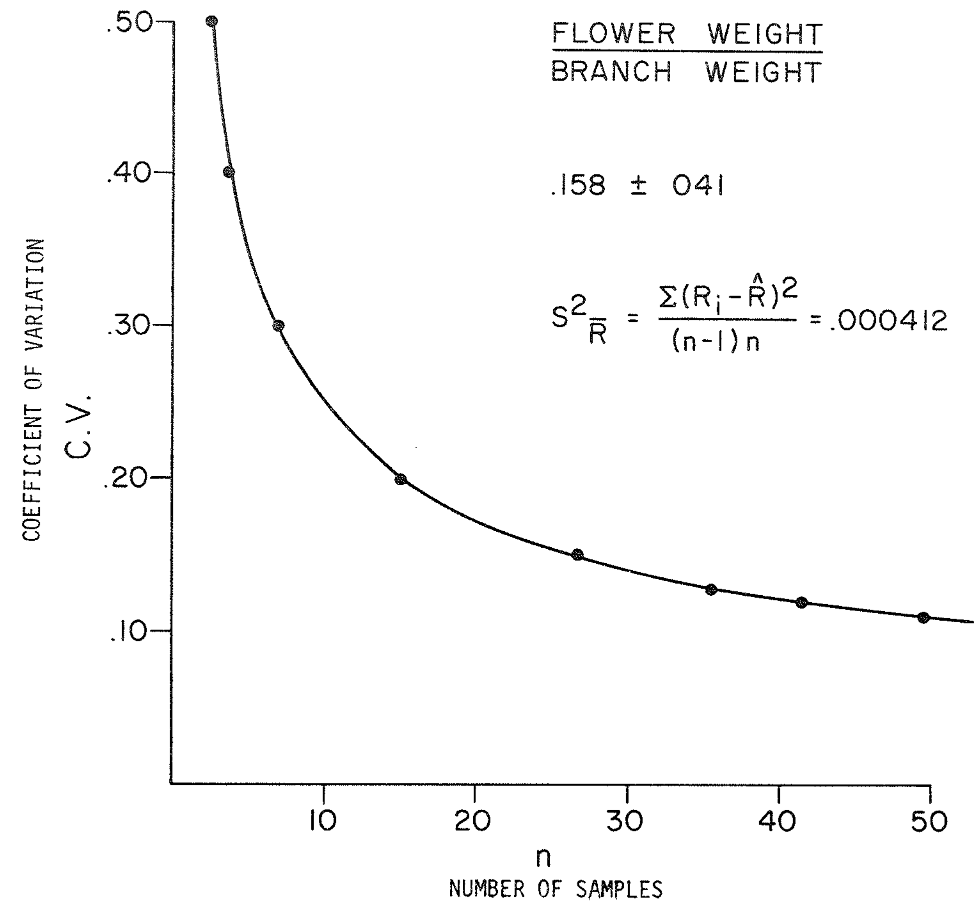


Figure 4. Variability associated with number of samples for estimating flower weight per branch of palo verde.

B.2 PERENNIALS

The composition of the vegetation on the Silverbell site is complex, varied, and in contrast to other portions of western desert, relatively lush. Because of the large number of species on the site, efforts were directed to those most abundant in terms of number and total biomass. The six species chosen for measurement were bur-sage, creosote bush, palo verde, whitethorn (restricted primarily to channel banks), ironwood, and saguaro.

The plan was to estimate, by direct sampling, density and coverage of these species. Biomass would be determined indirectly by destructive subsampling and extrapolating the results. Where feasible, the above ground parts of the subsample were separated into leaves and several diameter-classes of stems. Because annuals represent a large portion of the total production on the site, they were also sampled for biomass. Efforts this past year have been concentrated on measuring production.

Cover and density

Plant cover and density estimates on the Silverbell site were made for *Larrea*, *Acacia* and *Olneya* using aerial photographs. Infra-red (IR) color transparencies (58 by 58 mm) were viewed on a steroscopic roll film viewer. A dot grid of 3925 dots per square inch under eight diameter magnification of the transparencies was used to estimate the crown cover. The dot grid was made from coordinated dot screen material, code number 650-10, manufactured by Para-tone Incorporated. The area represented per dot was calculated using 3-foot wide butcher-paper markers, placed on the ground for flight line locaters.

The sampling plots were delineated by the limits of the randomly selected transparencies whose scale was 1:1600. Sampling plot areas varied form 128 x 128 m to 136 x 136 m, depending upon the elevation flown. Each plant within a plot was gridded.

Eight plots, each represented by a transparency frame, were sampled on the upland sites for each of the treated and untreated areas. The channel vegetation was sampled on irregular-shaped plots which conformed to the boundaries of the areas delineated as channel sites. Five channel reaches of arbitrary length were chosen at random on each of the treated and untreated areas, and the plants therein dot gridded.

Estimates for the entire area were made by weighting the measurements by the proportion of the area covered by each site. The channel sites on the untreated area covered 8.8% of the total area and 10.4% of the treated area. Weighting procedures and stratification schemes are reported in RM 72-3. Coverage values for the principal species are summarized in Table 5. Densities are summarized in Table 6. Grid counts are filed on DSCODE A3UTC20.

Table 5. Coverage summary - Silverbell Validation Site, 1972

	m^2ha^{-1}	95%C.L.	m^2ha^{-1}	95% C.L.
Species	Untreated		Treated	
Ambrosia	261	55	171	47
Larrea	462	72	393	52
Cercidium	323	36	522	67
Olneya	165	24	150	30
Acacia	117	44	153	52

Table 6. Density summary - Silverbell Validation Site, 1972

Species	Plants/ha	95%C.L.	Var. of mean	Plants/ha	95%C.L.	Var. of mean
	Untreated			Treated		
Ambrosia	5,938	1,694	684326.	4,349	719	125370.
Larrea	188	23	85.6212	103	12	22.6781
Cercidium	27	3	1.8700	27	3	1.8103
Olneya	16	2	.9415	11	2	.6529
Acacia	22	3	1.7064	25	4	2.2894

Standing biomass

Standing biomass was extrapolated to the site from measurements made on destruct samples taken off-site and analyzed by the methods described in RM 72-3. The analysis is summarized in Table 7.

Ambrosia: The destruct sample consisted of the 10 nearest neighbors taken at 10 m intervals along a 100 m transect. Four plants were lost during processing. The plants were separated into stems and leaves, oven-dried and weighed (DSCODE A3UTC21). Extrapolation was made using the coverage data. Biomass within the jeep trails on the treated site was determined by clipping and weighing all live material within 25 randomly located 2 x 10 m plots (DSCODE A3UTC22).

Larrea: The destruct sample consisted of 50 bushes taken along a 100 m transect -- five nearest neighbors at 10 m intervals (DSOCDE A3UTC23.) Dry weights were determined from aliquots. Two plants were lost during processing. Biomass within jeep trails was determined in the same manner as for *Ambrosia* (DSCODE A3UTC22).

Cercidium: A destruct sample of 24 palo verde trees was taken along a 80 m transect -- three nearest neighbors at 10 m intervals (DSCODE A3UTC24). The plants were separated into stem diameter classes of 2.5 cm or less, 2.5 to 7.6 cm or less, 7.6 cm or greater, and weighed. Dry weight was determined from aliquots. Weight of dead wood was also recorded. Maximum plant diameter, minimum diameter, and height of crown were measured. Number of stems and their diameter, and dead wood were recorded. Only the results of analyses of total dry weight of live material are reported here.

Olneya: Ironwood has the lowest density of the species studied. However, because of its large size, it makes up a significant component of the total biomass on the Silverbell site. Six trees were destructively sampled (DSCODE A3UTC25). Height, maximum and minimum diameters, number and diameter of main stems were recorded. Plant

parts were separated into stem diameter classes of 2.5 cm or less, 2.5 to 5 cm, and 5 cm or greater. Dead wood was also weighed, but as with *Cercidium* only analyses of live material are reported here. Interestingly, mistletoe on 6 trees accounted for 2% of the total green weight of the trees.

Table 7. Standing biomass of principal species - Silverbell, 1972

Species	Untreated		Treated	
	kg ha^{-1}	90% C.L.	kg ha^{-1}	90% C.L.
Ambrosia	125	52	125	52
Larrea	385	47	358	40
Cercidium	1,032	596	1,906	443
Olneya	3,106	1,278	2,709	907
Acacia	183	87	209	99

Acacia: Destruct samples were taken on transects running along two of the major channels of the site (DSCODE A3UTC26). Three nearest neighbors at five intersections along a total 100 m length were destructively sampled. Plants were separated into branch classes of 2.5 cm or less, 2.5 to 5 cm, and 5 cm or over. Heights, maximum crown diameter and minimum crown diameter were measured. Number of stems and basal diameter were also recorded.

Biomass component production

Production of flowers, leaves, fruits, and new terminal growth were estimated for the five major perennial species by subsampling.

Inflorescences: Samples of inflorescences were taken from *Larrea, Cercidium, Olneya,* and *Acacia* (DSCODE A3UTC27). *Ambrosia* was not sampled. Few, if any, of the ambrosia bloomed the past year, probably due to the long dry spell of the previous season. Some plants are now (December, January) responding to unseasonal rains that occurred last fall. Blooming is restricted to plants on south aspects.

Field sampling consisted of clipping branches of certain sizes from the plants in conspicuous bloom, stripping the inflorescences, and determining both the oven dry weight of the branches and inflorescences. The sampling was made at times when blooming was judged at maximum. In order to translate these data to biomass, transects were also taken at the same time to determine the ratio of blooming to non-blooming plants (DSCODE A3UTC28). Results of the transect analyses are given in Table 8. The inflorescence-branch analyses are given in Table 9.

Fruits: Fruits of the major species, excepting *Ambrosia*, were sampled in the same manner as the inflorescences (DSCODE A3UTC29). Transects and samples of fruits were taken at times when fruiting was judged at maximum (DSCODE A3UTC30). Sampling intensity and analysis are summarized in Table 10. The fruit weight-branch weight analyses are summarized for all species in Table 11.

Leaves: Of the five major species sampled (DSCODE A3UTC31), *Acacia* is the only truly deciduous species. *Ambrosia*, during the very dry periods, such as occurred last season, is essentially deciduous. Thus, good estimates of new leaf production can be obtained by stripping and weighing all leaves, determining the leaf weight-branch weight ratio and extrapolating to g per ha from the density sampling. This was done for these two species in October.

Cercidium was not sampled for leaf biomass, partly because it may have several leafing periods, but primarily because its leaves are such a minute portion of the total biomass, their inclusion is so confounded by sampling errors in extrapolation as to be meaningless.

Larrea and *Olneya* are evergreen perennials. New leaves are impossible to separate from old. Therefore, rather than work with absolute values, it became necessary to sample differences; that is, the difference in leaf biomass from year to year. The problem of the sampling intensity needed to adequately determine differences then arises. Analysis of last season's measurements are now underway to determine how large a sample is necessary. Sampling these species was carried forward as with *Acacia* and *Ambrosia*. Analyses for all species are given in Table 12.

Table 8. Transect analysis - plants in flower

Species	Plants Inventoried (No.)	Plants in Bloom (%)	Confidence Limits (95%)	Variance of mean
Larrea	2,047	11.3	1.9	.00005
Cercidium	616	23.7	4.7	.00029
Olneya	140	31.2	10.9	.00153
Acacia	390	11.9	4.6	.00027

Table 9. Inflorescence/branch weight analysis

Species	Sample Size (No.)	Infl. Wt. / Branch Wt. (ratio)	Confidence Limits (95%)	Var. of Mean
Larrea	65	.08089	.01645	.0000676
Cercidium		.05157	.03191	.0002052
Olneya	45	.01256	.00640	.0000101
Acacia	35	.02367	.00760	.0000140

Table 10. Transect analysis - plants fruiting

Species	Plants Inventoried (No.)	Plants Fruiting (%)	Confidence Limits (95%)	Var. of Mean
Larrea	1,607	82.9	2.6	.00009
Cercidium	445	36.0	6.3	.00052
Olneya	127	21.6	10.1	.00133
Acacia	310	17.6	6.0	.00047

Table 11. Fruit/branch weight analysis

Species	Sample Size (No.)	Fruit/Wt. / Branch Wt. (ratio)	Confidence Limits (95%)	Var. of Mean
Larrea	177	.07390	.01051	.0000287
Cercidium	33	.01916	.01043	.00002614
Olneya	246	.00269	.00122	.00000039
Acacia	106	.00998	.00339	.00000293

Table 12. Leaf/branch weight analysis

Species	Sample (No.)	Leaf Wt. / Branch Wt. (ratio)	Confidence Limits (95%)	Var. of Mean
Larrea	13	.172	.047	.00048
Cercidium	9	.0015	.0004	.00000003
Olneya	15	.036	.018	.000072
Acacia	24	.067	.016	.000060
Ambrosia	23	.640	.236	.01154

Terminal growth: Twenty terminal branches on each species were selected for growth measurements (DSCODE A3UTC32). The branches were marked and tagged several cm from their apex before the growing season. After the growing season, the new growth length was measured as the difference between the initial distance from apex to marker and the final distance. The new growth was removed, oven dried and weighed. The weight of the entire stem from the beginning of new growth to specified diameters as given in Table 14 was also determined. Analyses of sample data are given in Table 13.

Production summary

In order to determine biomass of production components, inflorescence and fruit production, equation (1) was used. The following equation was used to determine leaf and terminal growth production:

$$\frac{\text{LEAF WT.}}{\text{HECTARE}} = \frac{\text{LEAF WT. or GROWTH WT.}}{\text{BRANCH WT.}} \times \frac{\text{BRANCH WT.}}{\text{PLANT}} \times \frac{\text{PLANTS}}{\text{HECTARE}} \qquad (2)$$

Data given in Tables 6, 8, 9, and 14 were pooled and analyzed to give the biomass of inflorescences for the untreated site and the undisturbed portion of the treated site. Summaries of the analyses are given in Tables 15 and 16. Fruit production is also summarized in Tables 15 and 16 and was obtained from analyses of data presented in Tables 6, 10, 11, and 14. Leaf and new growth production are summarized for the two sites in Tables 17 and 18 from analyses of data given in Tables 6, 12, and 14 (leaves), and Tables 6, 13, and 14. There were essentially no significant differences in the four components of biomass between the untreated site and the undisturbed portion of the treated site. Fruit production on *Larrea* was the one exception due to the greater density of the species on the untreated site.

The perennial growth in the jeep trails of the treated site was estimated by removing all new growth of *Larrea* and *Ambrosia*, the only species significantly damaged by the treatment, from 20 m^2 plots taken at random within the trails; 171 *Ambrosia* and 41 *Larrea* plants were taken. Material was oven dried and weighed. Results are summarized in Table 19. Production within the trails was greater for *Ambrosia* because of its higher density. Production of *Larrea*, new growth and leaves, was greater in the trails than on the undisturbed portion of the site.

$$\frac{\text{TREES}}{\text{HECTARE}} \times \frac{\text{BRANCH WT.}}{\text{TREE}} \times \frac{\text{LEAF (GROWTH)}}{\text{BRANCH WT.}} = \frac{\text{LEAF (GROWTH)}}{\text{HECTARE}} \qquad (3)$$

Table 13. Terminal growth/branch weight analysis

Species	Sample Size (No.)	Fruit Wt. / Branch Wt. (ratio)	Confidence Limits (95%)	Var. of Mean
Ambrosia	15	.33880	.03643	.00029
Larrea	18	.00998	.00551	.0000687
Cercidium	21	.00486	.00251	.00000146
Olneya	9	.00957	.00475	.00000441
Acacia	14	.01781	.00987	.0000212

Table 14. Branch weight per plant analysis

Species	Sample No.	Branch Size (in)	Weight / Plant (9 ms)	Confidence Limits (95%)	Var. of Mean
Larrea	97	Total Plant	906.67	164.34	6,911.78
Cercidium	24	≤ 1 inch	10,109.44	854.90	172,830.12
Olneya	6	≤ 1 inch	44,824.01	4,064.55	27,512,901.20
Acacia	14	≤ 1/2 inch	5,384.14	631.30	87,316.43
Ambrosia	38	Total Plant	114.11	16.40	65.8314

Table 15. Inflorescence and fruit production - untreated site

Species	Inflorescences kg/ha	Fruits kg/ha
Cercidium	3.34±1.91	1.88±1.04
Olneya	2.24±1.39	0.42±0.24
Acacia	.33± .15	0.21±0.09
Larrea	1.56± .75	10.45±2.61

Table 16. Inflorescence and fruit production -undisturbed portion of treated site

Species	Inflorescences kg/ha	Fruits kg/ha
Cercidium	3.34±1.92	1.88±1.04
Olneya	1.54±0.96	.76±0.38
Acacia	0.38±0.17	0.24±0.10
Larrea	.85±0.41	5.72±1.45

Table 17. New growth and leaf production - undisturbed portion of the treated site

Species	Leaves kg/ha	New growth kg/ha
Ambrosia	317.30±124.20	167.97±39.30
Cercidium	0.41± 0.11	1.33± 0.68
Olneya	17.75± 8.68	4.72± 2.17
Acacia	9.02± 2.50	2.40± 1.27
Larrea	16.07± 5.15	0.93± 0.52

Table 18. New growth and leaf production - untreated site

Species	Leaves kg/ha	New growth kg/ha
Ambrosia	433.24±194.86	229.33±73.90
Cercidium	0.41± 0.11	1.33± 0.68
Olneya	25.82± 12.46	6.86± 3.10
Acacia	7.94± 2.19	2.11± 1.12
Larrea	29.33± 9.45	1.70± 0.92

Table 19. Perennial growth in jeep trails

Species	Density	Mean Wt. New Growth (kg/Plant)	Biomass kg/ha
Ambrosia	3,240	.096	311
Larrea	103	.945	96

B. 3. ANNUALS

A nested design was used in sampling annual production. Seventeen sample points consisting of three 3.48m^2 plots were randomly selected on the untreated portion of the validation sites (DSCODE A3UTC33). Eight similar sampling points were taken within the jeep trails. All annuals including forbs were removed from plots, separated into species, oven dried and weighed. Results of analyses of variance for annual production in the sample plots are given in Tables 20 and 21.

Seed and root production

Twenty five *Bouteloua aristidoides*, the most abundant species (74% of all annuals) were removed and separated into seeds, roots, and above ground parts (DSCODE A3UTC34).

Average above ground plant weight was 0.59 g. Seeds were about 12% of the total weight, and roots about 40%. Ratios of seed and root weight to above ground weight are given in Table 22.

A summary of annual production is given in Table 23.

Table 20. Analysis of variance for annual production - undisturbed site

Source	Degrees of Freedom	Sum of Squares	Mean Square
Plots	16	83,329.48	5,208.04
Within Plots	34	39,165.55	1,151.93

Table 21. Analysis of variance for annual production - within trails

Source	Degrees of Freedom	Sum of Squares	Mean Square
Plots	7	57,747.28	8,249.61
Within Plots	16	42,217.52	2,638.59

Table 22. Ratio of seed and root weight to total above-ground plant weight -- *Bouteloua aristidoides*

Sample Size	Seed Wt. / Plant Wt. (g/g)	95% CL	Variance of Mean	Root Wt. / Plant Wt. (g/g)	95% CL	Variance of Mean
25	.132	± .039	0.000352	0.399	0.064	0.000962

Table 23. Annual plant production

	Untreated kg/ha	Within Trails kg/ha
Above ground	105.13±60.0	131.29±62.4
Roots	22.48	39.98
Seeds	7.44	13.23

B.4 LITTER PRODUCTION

Eight, 1-m^2 plots were established for litter measurements on the undisturbed site (DSCODE A3UTC35). Large pieces of litter and branches, cactus joints, etc., were hand picked from the plots. An industrial type vacuum cleaner was used to collect the remaining material. Samples were then hand picked, separating layer pieces of wood. Soil was separated by flotation. The litter material was then oven dried and separated into fecal and non-fecal material. The data are summarized in Table 24.

Table 24. Litter sampling analysis

	Sample		Total Site		
Separate	Weight (g)	Variance of Mean	Weight Hectare (kg/ha)		95% Confidence Limits (g/ha)
Wood	209.3	5730.1	2093	±	1786
Non wood	52.2	362.6	522	±	448
Feces	1.1	8.78	11	±	69
Total	263.9	1713.2	2639	±	977

C. INVERTEBRATES

Sampling was carried out mainly on the 3-ha invertebrate study plot located 500 to 800 m N. and 600 to 700 m W. of the bench mark at the S.E. corner of Section 21. This plot is 100 m E. of the undisturbed validation site and parallel to it. It overlaps slightly the plot laid out for the bird validation measurements. The most complete record is of fecal pellets from under the dominant shrub species and of insects emerging from the soil. Two additional samples were taken over a wider area. Litter from beneath *Olneya tesota* was sampled for soil arthropods in May and September, as representative of the greatest accumulation of litter under shrubs. Dr. Charles Gaspar, of Gembloux, Belgium, censused ants on the validation sites. His report has been submitted as a separate study. [Gaspar's report was written in French and is awaiting translation. It will appear as RM 73-50.]

C.1 METHODS AND FINDINGS

Fecal pellet samples (DSCODE A3UWH07)

Frass traps of thin cloth folded to form a cone with an equilateral triangle for its open base, fastened to stakes ringed with Tree Tanglefoot, were maintained under a sample of the dominant larger shrubs from March to November, 1972. These traps had been installed in midsummer of 1971, but required repair or replacement at the beginning of the season.

Figure 1 shows the results obtained in 1972. *Cercidium microphyllum*, *Olneya tesota*, and *Acacia constricta* appear to have been consumed by chewing insects at approximately the same rate, as one might expect because of their close relationship. The other legume, *Prosopis juliflora*, was not sampled early in the spring, when its leaves were new. Actually, the sample represents only a single weak tree on the site, which is almost mesquite-free.

The total dry weight of fecal pellets under each of the dominant legumes was nearly comparable to that produced by *Gelechia albipectus* caterpillars on *Cercidium microphyllum* in 1971 (14 g/m^2), but the period involved in measurement was much longer. There was no obvious defoliation of any of the shrubs, and the web tubes of *Gelechia* were barely noticeable. By late summer, 1971, *Cercidium microphyllum* had lost all its leaves to caterpillars and the trees were heavily webbed.

Of particular interest is the lack of any substantial response to the unseasonal period of rainfall in early June. The shrubs responded, but the chewing insects did so only briefly and only slightly. There seems to have been a larger and more sustained population in late March and early April.

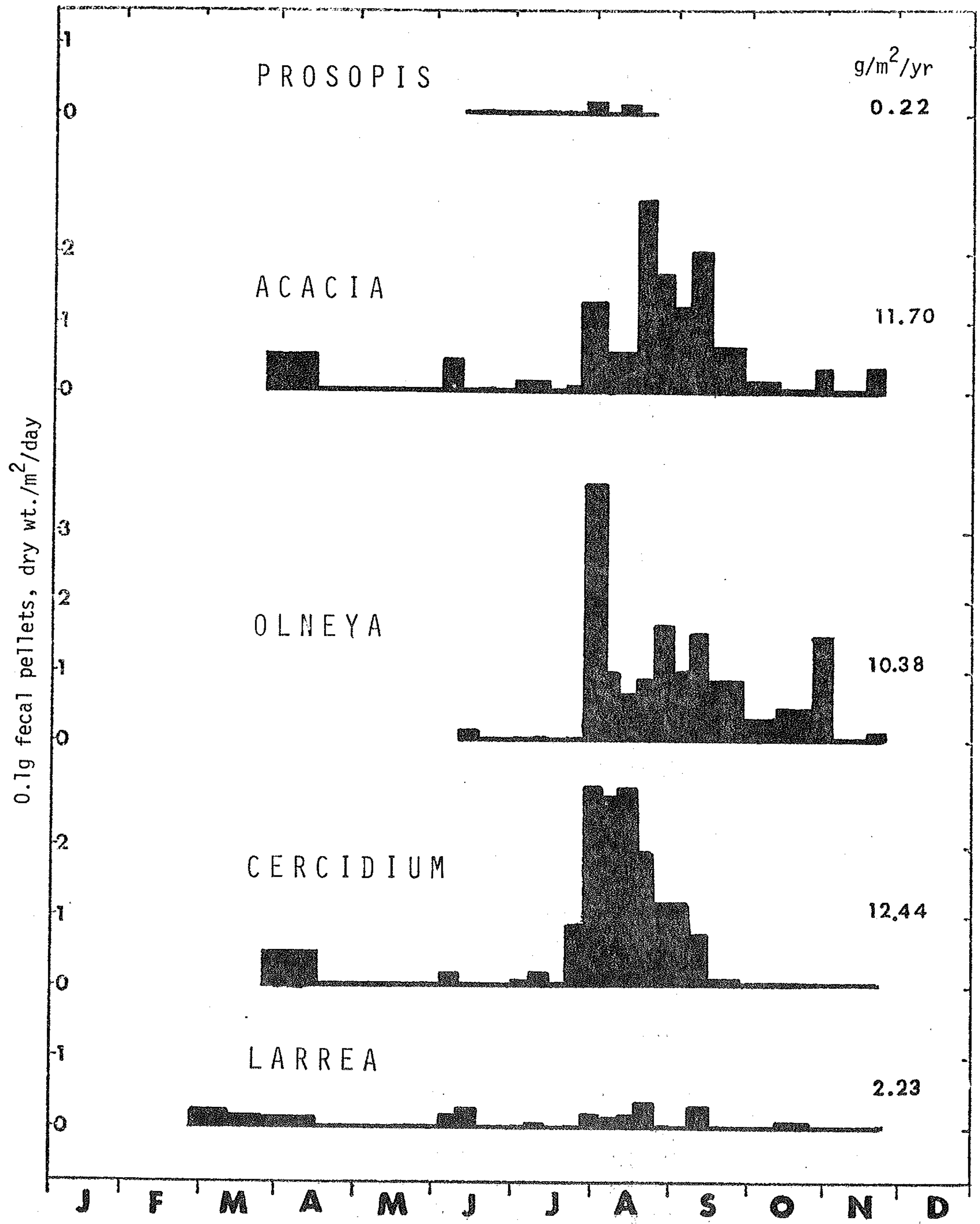


Figure 1. Fecal pellets obtained in frass traps under trees and shrubs on the invertebrate study plot at Silverbell in 1972 (DSCODE A3UWH07).

The samples from *Larrea divaricata* show that this shrub did not contribute heavily to the insects available as bird and lizard food. There may have been slightly larger populations than the graph indicates for the spring season, becuase some sucking insects can be found then and these would not contribute to the fecal pellet weights.

Conversion of fecal pellet weight to insect dry weight is approximated by dividing the weight by two.

Emergence trap samples (Silverbell DSCODE A3UWH05; Santa Rita A3UWH06)

A series of 2 m x 2 m pyramidal screen traps was set up on the soil in late June, 1971, and maintained at Silverbell through a 13-month period. The traps were surplus when we acquired them, and have deteriorated to the extent that only a few survived through the whole period. The original 51 traps at Silverbell had been set up in association with the dominant plants and over bare soil as indicated by the bottom part of Figure 3. The distribution of traps was 5 per dominant plant species, one for an *Olneya* stump, and 10 for bare soil.

The total catch of arthropods other than worker ants is shown in the bottom part of Figure 2, expressed in terms of 0.01 arthropods/m^2/day. The catch included species one would expect to emerge from the soil during the period, but also some probably caught above-ground when the traps were installed or grown inside the trap on included plants.

That the catch is related to the productivity of the site is evident by a comparison with the catch from another series set up at Santa Rita (Figure 2) by Dr. Nutting and his co-workers, to obtain information on termite flights. The traps used here had to be returned at the end of the season, so a whole-year comparison is not possible. But the total catch for 1971 was considerably above what it was for Silverbell (4.94 arthropods/m^2 at Santa Rita and 2.46 at Silverbell).

The only large group of insects with soil-dwelling larvae recovered in the Silverbell traps was several species of scarabaeid beetles, mostly of the genera *Phyllophaga* and *Diplotaxis*. The emergence record of these is shown in the middle graph of Figure 3, in terms of 0.001 beetles/m^2/day. Adults leave the soil in the evening to fly up to leaves to feed and mate, returning to the soil in the morning. Most of them would probably find their way into the jar on top of the emergence traps in the first day or two. The bottom graph of Figure 3 shows the scarab-plant associations indicated for 1971, when all traps were maintained. The *Acacia constricta* figures may be low, because this shrub is almost completely confined to the washes and the first runoff flattened several of the traps during the weeks when peak scarab emergence occurred elsewhere.

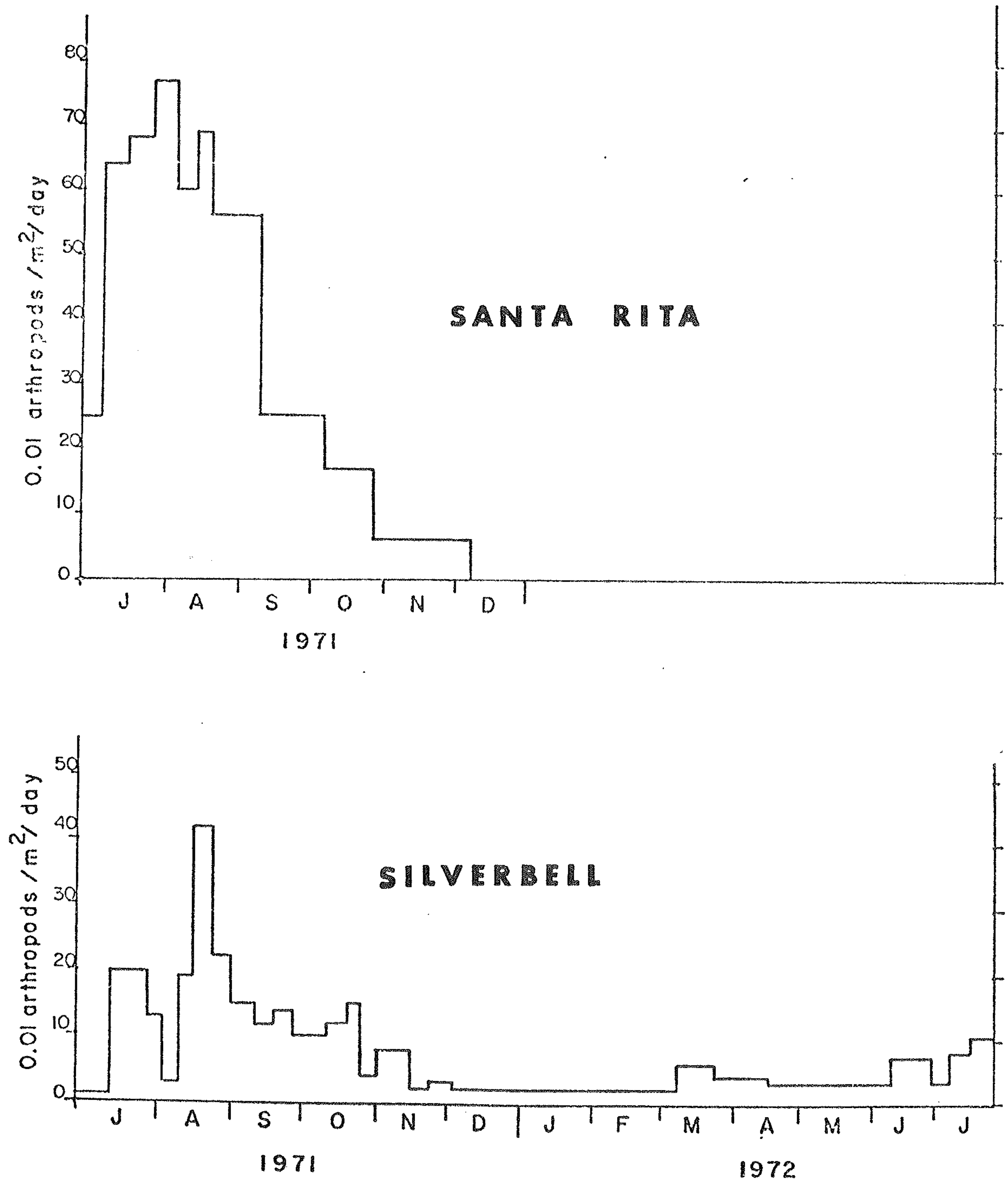


Figure 2. Emergence trap records of all insects emerging from soil other than worker ants. Traps set up on undisturbed treatment at Santa Rita (A3UWH06) and the invertebrate study plot at Silverbell (A3UWH05).

The traps set up over saguaro stumps produced three adults of *Phileurus illatus*, the only species not a soil-root feeder in the larval stage. Its larvae are associated with decaying wood and the adults do not feed on leaves. All associations are subject to some error resulting from the difficulty of placing a trap so as to cover roots of only one species. As in the frass trap samples, *Larrea divaricata* made very little contribution to invertebrate number.

These beetles would serve as food for nocturnal insectivores while in flight or on leaves, and for insectivores searching in the soil and litter during the day. Until we had emergence trap data, the only way we could hope to count them was to sample trees at night, a difficult and time-consuming process subject to great errors because of the fact that one cannot readily distinguish beetles that have been going back and forth from soil to tree from newly-emerged individuals. Of note here is the fact that the drought of early 1971 seems not to have had a serious effect on the scarabs, and that emergence occurred again in 1972. The larvae must have moved laterally in the soil, because a one-year cycle is normal.

Some predacious and parasitoid insects were recovered also. It may be possible to obtain some clues as to host associations by establishing correlations within traps. The Santa Rita traps, in particular, produced a number of mutillid wasps in excess of what one would expect if they were associated with the subsocial Hymenoptera taken in the sample.

The top graph of Figure 3 shows the emergence pattern of cutworm moths, *Peridromia saucia*. These had obviously been in the soil as pupae when the traps were installed, the moths emerging in mid-winter.

<u>Litter arthropod samples</u> (DSCODE A3UWH08)

Samples were taken under *Olneya tesota* during May and September, and the arthropods separated by the Salt-Hollick flotation method. Eighteen samples were taken each month, 76.2 cm^2 and 5 cm deep each. The results indicate the following numbers of arthropods/m^2 in this substrate, which appeared to be the richest on the site:

	May	Sept.
Acarina	1800/m^2	660/m^2
Collembola	80	180
Ants	130	130
Other Insects	80	240
Spiders	0	50

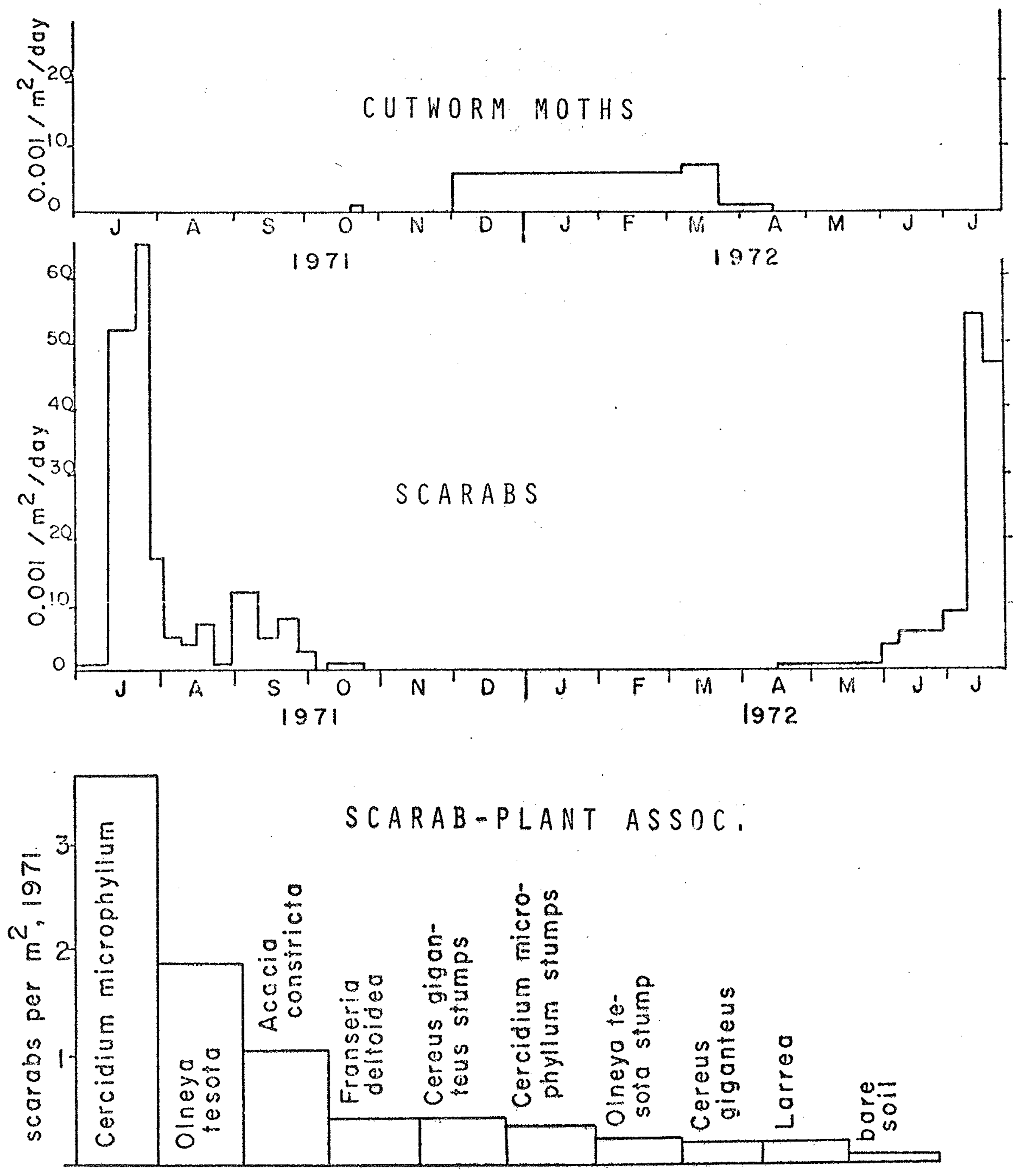


Figure 3. Cutworm moths (*Peridromia saucia*) and scarab beetles (Family Scarabaeidae) obtained in emergence traps on the invertebrate study plot at Silverbell. Bottom graph correlates scarab records with trap locations in relation to plants (A3UWH05).

Visual sampling

Only occasional visual sampling was reported, but it was obvious that the food plants of the sphingid, *Celerio lineata*, caterpillar were not being consumed during the summer. Even *Boerhaavia* and *Allionia* (Nyctaginaceae) were unaffected. Moths were conspicuously missing at lights and in gardens at Tucson. So the huge numbers of larvae that went into pupation in 1971 did not foreshadow a deluge in 1972; instead, there was a population crash, for unknown reasons. It was area-wide, affecting both the Silverbell and the Santa Rita sites, so neither of the insects that had been abundant at Silverbell in 1971, *Celerio lineata* and *Gelechia albipectus*, was conspicuous in 1972.

Ants (DSCODES A3UWH12,A3UWH13).

A detailed ant census was carried out by Dr. Charles Gaspar, of the Faculty of Agronomic Sciences at Gembloux, Belgium. This is reported separately because of its length and complexity. We had marked colonies of some of the large and conspicuous species in 1971, but have not previously attempted to deal with the seemingly omnipresent smaller species. We marked colonies of several large species in the hectare to the south of the telemetering tower so that they would be included in the aerial photographs taken at the time. These will be available for comparative purposes if anyone wishes to attempt to count ant nests from photographs. It did not seem to us at the time of marking that the contrast would be great enough to permit reliable counts.

C.2 SUMMARY

Frass trap samples of fecal pellets indicated dry weights of chewing insects of ca. 6g/m^2 of cover of *Cercidium microphyllum* and *Acacia constricta* for 1972, 5g/m^2 of *Olneya tesota* and 1g/m^2 of *Larrea divaricata*. Peak activity occurred from mid-July through September on legumes, with barely indicated response to unseasonal rains in early June.

Emergence trap samples peaked in August but declined only gradually to November in 1971, and continued all winter. Scarab beetles peaked in July in 1971 and may have started emerging slightly earlier in 1972. They were particularly abundant under *Cercidium microphyllum* (est. 4/m^2/yr.). Other shrubs had less, and *Larrea divaricata* was particularly low.

Litter samples indicate that small numbers of soil arthropods were present in the uppermost layer under *Olneya tesota* in May and September.

D. VERTEBRATES

1. REPTILES

Report not available.

2. BIRDS

Total avian biomass on the Santa Rita Experimental Range and Silverbell Validation Site was determined monthly by line transect and direct mapping methods as in previous years. Results are summarized in Table 1. The change in biomass from 1971 to 1972 is indicated in Table 2, expressed as a proportional change of the 1971 biomass.

On the Santa Rita Experimental Range, data for February, March, April and May, 1972, are considered less accurate than in other months. The error cannot be objectively evaluated but is probably less than 50%. On the Silverbell plot, data in 1971 were not processed properly and the data in Table 1 (density) and Table 2 (biomass) of RM 72-31 are inaccurate (discussed further in next section). However, in Table 2 of this report, data used to calculate change from 1971 to 1972 were calculated on the same basis and the relative change indicated should be accurate. The 1971 data will be reprocessed and a correction made in a subsequent report.

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

Table 1. Total bird biomass in g/ha on the Santa Rita Experimental Range Validation Site by month in 1970, 1971, and 1972, and on the Silverbell site in 1972.

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
SPER												
1970	NE*	NE	NE	360	208	175	198	270	260	273	105	NE
1971	308	188	225	200	225	100	108	178	143	NE	NE	NE
1972	NE	100	146	140	253	303	409	321	306	267	162	161
Silverbell												
1972	345	485	485	485	470	495	565	500	395	380	370	330

* NE: not estimated

Table 2. Change in bird biomass on the Santa Rita Experimental Range and Silverbell Validation Sites from 1971 to 1972 (expressed as proportional change of 1971 biomass)

	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
SPER	NE*	-.47	-.35	-.30	+.12	+2.03	+2.80	+.81	+1.14	NE	NE	NE
Silverbell	NE	NE	NE	NE	NE	+ .13	+ .14	-.57	+ .056	+.21	+.20	NE

* NE: not estimated

Silverbell Site (DSCODE A3URJ12)

Validation studies on the birds of the Silverbell site were begun in June of 1971. Density and biomass at this time were derived directly from linear transect counts. In 1972 data gathering began in January and it was possible to supplement linear transect counts with territorial mapping. The latter permitted greater accuracy in determining total monthly density and biomass.

In order to compare 1971 and 1972, it was necessary to treat both sets of data in the same way. Densities (Table 3) and biomass (Table 4) derived solely from transect counts were therefore used to compare variations between the two years (Figure 1). Adjusted values are also presented in Figure 1 to show the most accurate estimate of the magnitude of density and biomass in the area.

Density and biomass estimates for 1971 are quite similar to those of 1972. Two important differences, however, do occur. The first is an exceptionally high value derived for August of 1971. This value resulted presumably from a great influx of breeding Mourning Doves into the area. The second major difference is the generally greater biomass in 1972. The higher estimates represent a real increase in the number of breeding pairs in the area. Rufous-winged Sparrows bred in the area for the first time, and Scotts Orioles and Harris Hawks attempted to breed for the first time. Several species, most notably Verdins, had increased numbers of territories within the area.

In general, overall biomass is lowest during the post-breeding fall and winter season. It rises sharply in February with the influx of breeding visitors (Table 5) and reaches a peak in July when all breeding species are at their highest densities and newly-fledged young from first nestings are still being attended on the territories of the adults.

Table 3. Number of birds per 40 ha derived solely from daily census counts on the Silverbell Validation Site: upper column, 1971; lower column, 1972.

Species		Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Harris Hawk	1971	-	-	-	-	-	0	0	0	0	0	0	0
Harris Hawk	1972	0	+ *	+	0	0	0	1	0	0	0	0	-
Sparrow Hawk		-	-	-	-	-	0	+	0	0	0	0	0
Sparrow Hawk		0	0	0	0	0	0	0	1	1	1	0	-
Gambel Quail		-	-	-	-	-	10	9	4	6	2	1	2
Gambel Quail		0	4	2	3	2	3	1	1	4	0	0	-
White-winged Dove		-	-	-	-	-	14	11	1	0	0	0	0
White-winged Dove		0	0	0	+	5	11	8	1	3	0	0	-
Mourning Dove		-	-	-	-	-	0	3	20	2	-	-	+
Mourning Dove		1	7	6	2	2	3	6	1	0	0	1	-
Roadrunner		-	-	-	-	-	0	0	0	0	0	0	0
Roadrunner		0	0	0	0	0	0	0	+	0	0	0	-
Lesser Nighthawk		-	-	-	-	-	+	0	0	0	0	0	0
Lesser Nighthawk		0	0	0	0	0	0	0	0	0	0	0	-
Hummingbird sp.		-	-	-	-	-	0	0	0	0	+	0	0
Hummingbird sp.		0	0	0	0	0	0	0	0	0	0	0	-
Gilded Flicker		-	-	-	-	-	2	8	4	4	4	2	2
Gilded Flicker		2	8	6	3	3	7	6	4	3	4	10	-
Gila Woodpecker		-	-	-	-	-	6	10	8	8	7	10	8
Gila Woodpecker		5	6	4	7	11	10	9	5	6	10	11	-
Ladder-backed Woodpecker		-	-	-	-	-	0	0	+	+	+	0	+
Ladder-backed Woodpecker		+	1	1	2	2	0	2	+	0	0	2	-
Wied Crested Flycatcher		-	-	-	-	-	4	6	3	0	0	0	0
Wied Crested Flycatcher		0	0	0	+	3	4	5	1	0	0	0	-

Continued

Table 3. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Ash-throated Flycatcher	-	-	-	-	-	3	3	2	0	+	0	0
Ash-throated Flycatcher	0	0	3	+	+	4	4	+	0	0	0	-
Empidonax sp.	-	-	-	-	-	0	0	0	0	0	0	+
Empidonax sp.	+	0	0	0	+	+	0	0	0	0	0	-
Purple Martin	-	-	-	-	-	0	1	1	0	0	0	0
Purple Martin	0	0	0	0	+	1	0	0	0	0	0	-
Raven	-	-	-	-	-	0	0	0	0	0	0	0
Raven	0	0	1	0	0	0	0	0	0	0	0	-
Verdin	-	-	-	-	-	6	2	+	9	7	4	8
Verdin	8	7	9	10	14	17	19	15	14	18	12	-
House Wren	-	-	-	-	-	0	0	0	0	0	2	+
House Wren	+	0	0	0	0	0	0	0	0	2	2	-
Bewick Wren	-	-	-	-	-	0	0	0	0	0	0	0
Bewick Wren	0	0	0	0	0	0	0	0	0	1	0	-
Cactus Wren	-	-	-	-	-	6	12	19	9	8	11	6
Cactus Wren	4	8	11	8	14	12	17	12	18	10	11	-
Canon Wren	-	-	-	-	-	0	0	0	0	0	+	0
Canon Wren	0	0	0	0	0	0	0	0	0	0	0	-
Mockingbird	-	-	-	-	-	0	0	0	0	4	6	4
Mockingbird	5	5	2	1	0	0	+	0	1	4	8	-
Curve-billed Thrasher	-	-	-	-	-	3	9	10	9	7	11	6
Curve-billed Thrasher	2	5	9	4	10	8	7	6	9	11	5	-
Western Bluebird	-	-	-	-	-	0	0	0	0	0	0	3
Western Bluebird	0	1	0	0	0	0	0	0	0	0	0	-
Blue-grey Gnatcatcher	-	-	-	-	-	0	0	0	0	0	0	0
Blue-grey Gnatcatcher	0	0	+	0	0	0	0	0	0	0	0	-

Continued

Table 3. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Black-tailed Gnatcatcher	-	-	-	-	-	3	5	3	2	3	3	3
Black-tailed Gnatcatcher	2	3	2	2	8	4	6	3	3	4	1	-
Ruby-crowned Kinglet	-	-	-	-	-	0	0	0	0	+	2	6
Ruby-crowned Kinglet	3	2	2	0	+	0	0	0	0	3	4	-
Phainopepla	-	-	-	-	-	0	+	0	4	6	17	16
Phainopepla	13	14	+	0	0	0	+	0	1	11	16	-
Loggerhead Shrike	-	-	-	-	-	0	0	0	+	1	0	+
Loggerhead Shrike	1	1	0	0	0	0	0	0	0	0	3	-
Starling	-	-	-	-	-	0	0	0	0	4	8	+
Starling	3	4	3	2	1	0	+	0	0	4	6	-
Gray Vireo	-	-	-	-	-	0	0	0	0	0	0	0
Gray Vireo	0	0	+	0	0	0	0	0	0	0	0	-
Solitary Vireo	-	-	-	-	-	0	0	0	0	0	0	0
Solitary Vireo	0	0	+	0	0	0	0	0	0	0	0	-
Warbling Vireo	-	-	-	-	-	0	0	0	0	0	0	0
Warbling Vireo	0	0	0	0	+	0	0	0	0	0	0	-
Orange-crowned Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Orange-crowned Warbler	0	0	0	0	1	0	0	0	0	0	0	-
Yellow Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Yellow Warbler	0	0	0	0	+	0	0	0	0	0	0	-
Audubon Warbler	-	-	-	-	-	0	0	0	0	0	0	+
Audubon Warbler	1	0	0	0	0	0	0	0	0	0	0	-
Wilson Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Wilson Warbler	0	0	0	0	2	0	0	0	0	0	0	-
MacGillivray Warbler	-	-	-	-	-	0	0	0	2	0	0	0
MacGillivray Warbler	0	0	0	0	0	0	0	0	0	0	0	-

Continued

Table 3. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Hooded Oriole	-	-	-	-	-	0	0	0	0	0	0	0
Hooded Oriole	0	0	0	+	0	0	0	0	0	0	0	-
Scott Oriole	-	-	-	-	-	0	+	+	0	+	0	0
Scott Oriole	0	0	0	1	1	0	0	0	0	0	0	-
Bullock Oriole	-	-	-	-	-	0	0	+	0	0	0	0
Bullock Oriole	0	0	0	0	4	0	0	0	0	0	0	-
Brown-headed Cowbird	-	-	-	-	-	0	2	+	0	0	0	0
Brown-headed Cowbird	0	0	0	2	5	2	3	0	0	0	0	-
Cardinal	-	-	-	-	-	0	0	0	+	0	0	0
Cardinal	0	0	0	0	0	0	0	0	0	0	0	-
Pyrrhuloxia	-	-	-	-	-	0	1	8	2	2	+	0
Pyrrhuloxia	1	1	4	4	2	3	3	3	0	1	0	-
House Finch	-	-	-	-	-	0	+	+	0	0	2	0
House Finch	0	1	1	1	1	0	0	0	0	0	2	-
Green-tailed Towhee	-	-	-	-	-	0	0	0	0	0	0	0
Green-tailed Towhee	0	0	0	1	1	0	0	0	0	0	0	-
Rufous-sided Towhee	-	-	-	-	-	0	0	0	0	0	0	2
Rufous-sided Towhee	0	1	+	0	0	0	0	0	0	0	0	-
Brown Towhee	-	-	-	-	-	+	2	4	1	1	2	2
Brown Towhee	1	3	1	0	+	1	1	3	4	3	3	-
Rufous-winged Sparrow	-	-	-	-	-	0	+	+	0	+	+	0
Rufous-winged Sparrow	0	0	0	0	0	1	2	2	4	3	1	-
Black-throated Sparrow	-	-	-	-	-	2	6	8	12	15	8	11
Black-throated Sparrow	7	5	5	2	1	1	5	14	17	16	16	-
Brewer Sparrow	-	-	-	-	-	0	0	0	0	2	2	39
Brewer Sparrow	34	47	35	12	8	0	0	0	0	0	9	-

Continued

Table 3. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
White-crowned Sparrow	-	-	-	-	-	0	0	0	0	0	0	1
White-crowned Sparrow	0	4	4	0	0	0	0	0	0	0	1	-
Lincoln Sparrow	-	-	-	-	-	0	0	0	0	+	0	0
Lincoln Sparrow	0	0	0	0	0	0	0	0	0	0	0	-
Song Sparrow	-	-	-	-	-	0	0	0	0	0	0	0
Song Sparrow	+	0	0	0	0	0	0	0	0	0	0	-

* + = density of less than 1 individual/40 ha.

Table 4. Biomass (g per 40 ha) derived solely from daily census counts on the Silverbell Validation Site: upper column, 1971; lower column, 1972 (excluding those species which had densities of less than 1 bird per 40 ha)

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Harris Hawk 1971	-	-	-	-	-	0	0	0	0	0	0	0
Harris Hawk 1972	0	0	0	0	0	0	1563	0	0	0	0	-
Sparrow Hawk	-	-	-	-	-	0	0	0	0	0	0	0
Sparrow Hawk	0	0	0	0	0	0	0	97	97	97	0	-
Gambel Quail	-	-	-	-	-	1696	1526	678	1018	339	170	339
Gambel Quail	0	678	339	509	339	509	170	170	678	0	0	-
White-winged Dove	-	-	-	-	-	2041	1604	146	0	0	0	0
White-winged Dove	0	0	0	0	729	1604	1166	146	437	0	0	-
Mourning Dove	-	-	-	-	-	0	393	2620	262	0	0	0
Mourning Dove	131	917	786	262	262	393	786	131	0	0	131	-
Gilded Flicker	-	-	-	-	-	208	832	416	416	416	208	208
Gilded Flicker	208	832	624	312	312	728	624	416	312	416	1040	-
Gila Woodpecker	-	-	-	-	-	420	700	560	560	490	700	560
Gila Woodpecker	350	420	280	490	770	700	630	350	420	700	770	-
Ladder-backed Woodpecker	-	-	-	-	-	0	0	0	0	0	0	0
Ladder-backed Woodpecker	0	31	31	61	61	0	61	0	0	0	61	-
Wied Crested Flycatcher	-	-	-	-	-	184	276	138	0	0	0	0
Wied Crested Flycatcher	0	0	0	0	138	184	230	46	0	0	0	-
Ash-throated Flycatcher	-	-	-	-	-	84	84	56	0	0	0	0
Ash-throated Flycatcher	0	0	84	0	0	112	112	0	0	0	0	-
Purple Martin	-	-	-	-	-	0	0	49	0	0	0	0
Purple Martin	0	0	0	0	0	49	49	0	0	0	0	-
Raven	-	-	-	-	-	0	0	0	0	0	0	0
Raven	0	0	525	0	0	0	0	0	0	0	0	-

Continued

Table 4. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Verdin	-	-	-	-	-	44	15	0	67	52	30	59
Verdin	59	52	67	74	104	126	141	111	104	133	89	-
House Wren	-	-	-	-	-	0	0	0	0	0	20	0
House Wren	0	0	0	0	0	0	0	0	0	20	20	-
Bewick Wren	-	-	-	-	-	0	0	0	0	0	0	0
Bewick Wren	0	0	0	0	0	0	0	0	0	10	0	
Cactus Wren	-	-	-	-	-	229	458	726	344	306	420	229
Cactus Wren	153	306	420	306	535	458	649	458	688	382	420	-
Mockingbird	-	-	-	-	-	0	0	0	0	198	297	198
Mockingbird	248	248	99	46	0	0	0	0	46	198	396	-
Curve-billed Thrasher	-	-	-	-	-	246	738	820	738	574	902	492
Curve-billed Thrasher	164	410	738	328	820	656	574	492	738	902	410	-
Western Bluebird	-	-	-	-	-	0	0	0	0	0	0	69
Western Bluebird	0	23	0	0	0	0	0	0	0	0	0	-
Black-tailed Gnatcatcher	-	-	-	-	-	17	28	17	11	17	17	17
Black-tailed Gnatcatcher	11	17	11	11	44	22	33	17	17	22	6	-
Ruby-crowned Kinglet	-	-	-	-	-	0	0	0	0	0	12	36
Ruby-crowned Kinglet	18	12	12	0	0	0	0	0	0	18	24	-
Phainopepla	-	-	-	-	-	0	0	0	104	156	442	416
Phainopepla	338	364	0	0	0	0	0	0	26	286	416	-
Loggerhead Shrike	-	-	-	-	-	0	0	0	0	47	0	0
Loggerhead Shrike	47	47	0	0	0	0	0	0	0	0	141	-
Starling	-	-	-	-	-	0	0	0	0	284	568	0
Starling	213	284	213	142	71	0	0	0	0	284	426	-
Orange-crowned Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Orange-crowned Warbler	0	0	0	0	9	0	0	0	0	0	0	-

Continued

Table 4. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Audubon Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Audubon Warbler	12	0	0	0	0	0	0	0	0	0	0	-
Wilson Warbler	-	-	-	-	-	0	0	0	0	0	0	0
Wilson Warbler	0	0	0	0	14	0	0	0	0	0	0	-
MacGillivray Warbler	-	-	-	-	-	0	0	0	20	0	0	0
MacGillivray Warbler	0	0	0	0	0	0	0	0	0	0	0	-
Scott Oriole	-	-	-	-	-	0	0	0	0	0	0	0
Scott Oriole	0	0	0	39	39	0	0	0	0	0	0	-
Bullock Oriole	-	-	-	-	-	0	0	0	0	0	0	0
Bullock Oriole	0	0	0	0	132	0	0	0	0	0	0	-
Brown-headed Cowbird	-	-	-	-	-	0	78	0	0	0	0	0
Brown-headed Cowbird	0	0	0	78	195	78	117	0	0	0	0	-
Pyrrhuloxia	-	-	-	-	-	0	36	284	71	71	0	0
Pyrrhuloxia	36	36	142	142	71	107	107	107	0	36	0	-
House Finch	-	-	-	-	-	0	0	0	0	0	38	0
House Finch	0	19	19	19	19	0	0	0	0	0	38	-
Green-tailed Towhee	-	-	-	-	-	0	0	0	0	0	0	0
Green-tailed Towhee	0	0	0	28	28	0	0	0	0	0	0	-
Rufous-sided Towhee	-	-	-	-	-	0	0	0	0	0	0	84
Rufous-sided Towhee	0	42	0	0	0	0	0	0	0	0	0	-
Brown Towhee	-	-	-	-	-	0	90	180	45	45	90	90
Brown Towhee	45	135	45	0	0	45	45	135	180	135	135	-
Rufous-winged Sparrow	-	-	-	-	-	0	0	0	0	0	0	0
Rufous-winged Sparrow	0	0	0	0	0	16	31	31	62	47	16	-
Black-throated Sparrow	-	-	-	-	-	26	79	105	157	197	105	144
Black-throated Sparrow	92	66	66	26	13	13	66	183	223	210	210	-

Continued

Table 4. Continued

Species	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Brewer Sparrow	-	-	-	-	-	0	0	0	0	20	20	390
Brewer Sparrow	340	470	350	120	80	0	0	0	0	0	90	-
White-crowned Sparrow	-	-	-	-	-	0	0	0	0	0	0	26
White-crowned Sparrow	0	104	104	0	0	0	0	0	0	0	26	-
Total - 1971	-	-	-	-	-	5195	6986	6795	3813	3212	4039	3357
Total - 1972	2465	5513	4955	3293	4835	5800	7105	2890	4028	3896	4865	-

Table 5. Estimated biomass (kg/20 ha) on the Silverbell plot (A3URJ13, in part)

Species Category	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Residents	4.8	4.7	4.7	4.4	4.7	5.6	6.1	5.7	5.7	4.9	4.8	4.8
Breeding visitors	0.2	3.1	3.3	4.3	4.3	4.3	5.0	4.1	2.0	1.8	1.7	0.2
Non-breeding visitors	1.9	1.8	1.6	0.8	0.3	0.0	0.2	0.2	0.2	0.9	0.9	1.6
Irregular visitors	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	0.1
Total	6.9	9.7	9.7	9.5	9.4	9.9	11.3	10.0	7.9	7.6	7.4	6.6

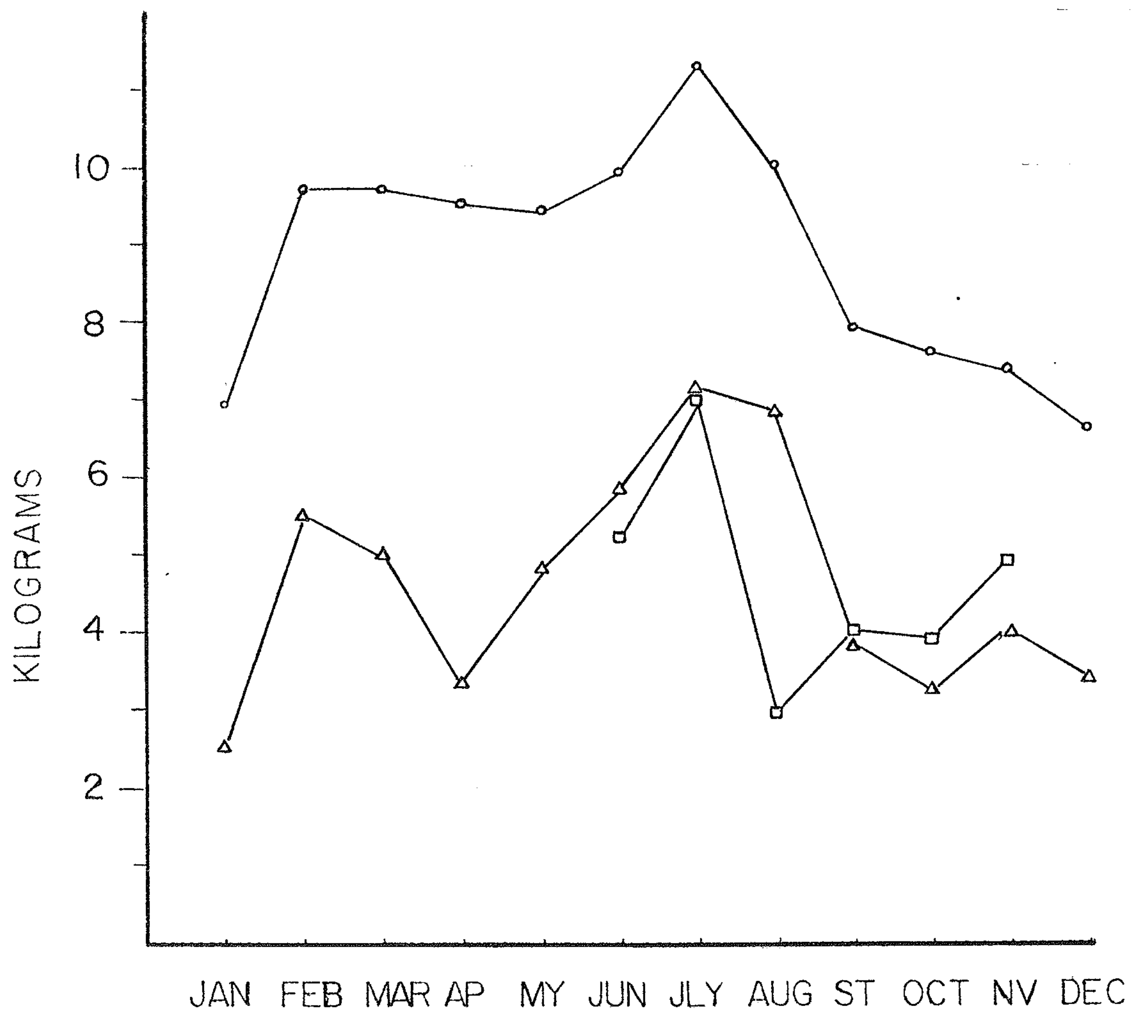


Figure 1. Biomass estimates of birds on Silverbell Validation Site. Circles represent most accurate 1972 estimate on a 20-ha plot, based on line transect counts adjusted by mapping of territories. Triangles represent 1972 estimate per 40 ha based on line transect counts only, and squares represent 1971 estimates per 40 ha also by line transect counts only.

Santa Rita Experimental Range Site (DSCODE A3URJ01)

As indicated above, data for February-May, 1972, are approximate (Tables 6 and 7) but the total biomass indicated in these months is probably slightly lower than was present in 1971. Months from May through the remainder of 1972 had a much higher biomass than 1971 and were roughly comparable to 1970 (Table 1). High biomass figures in 1972 are to a great extent due to nesting quail and doves that may not nest in the plot every year, and to higher numbers of Cactus Wrens, Curve-billed Thrashers, and Rufous-winged Sparrows. Rains in 1972 were well distributed and the "nomadic" species that appeared in numbers to breed in 1970 did not repeat in 1972.

Table 6. Bird density on the Santa Rita Experimental Range in 1972 expressed as birds/40 ha; data for February-May are least reliable

Species	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Vulture, Turkey	-	-	+*	+	+	-	-	-	-	-	-
Hawk, Coopers	-	-	-	-	-	-	-	-	-	+	-
" Sparrow	-	-	-	-	+	1	1	1	1	-	-
Quail, Scaled	2	2	2	2	10	9	6	4	3	3	2
" Gambels	+	+	+	2	2	6	6	2	+	+	+
†Dove, White-wg.	-	-	-	2	2	4	1	-	-	-	-
" Mourning	-	6	6	12	12	20	6	4	1	-	-
Roadrunner	+	+	2	6	3	2	2	2	1	+	+
Owl, Screech	+	+	+	+	+	+	+	+	+	+	+
" Great-horned	+	+	+	+	+	+	+	+	+	+	+
Nighthawk, Lesser	-	-	-	2	2	4	+	-	-	-	-
Flicker, Gilded	4	4	2	2	2	4	4	2	3	2	-
Woodpecker, Gila	3	3	+	3	3	5	6	4	2	1	-
" Ladder-back	+	+	+	2	2	3	3	2	2	4	4
Kingbird	-	-	-	-	+	+	+	-	-	-	-
Flycatcher, Wieds-cr.	-	-	-	-	-	1	-	-	-	-	-
" Ash-thr.	-	-	-	2	5	5	5	2	-	-	-
" Western	-	-	-	-	-	-	+	-	-	-	-
Swallow, Cliff	-	-	-	-	-	+	-	-	-	-	-
Martin, Purple	-	-	-	-	-	+	+	-	-	-	-
Verdin	6	4	4	10	10	14	8	14	25	11	8
Wren, Cactus	17	13	18	36	43	65	36	36	36	23	23
Mockingbird	-	-	-	-	-	+	+	+	-	-	-
Thrasher, Curve-b.	15	23	23	29	30	31	45	48	40	27	40
Gnatcatcher, Blk.-tl.	2	2	4	4	5	5	5	3	4	2	2
Kinglet, Ruby-crn.	-	-	-	-	-	-	-	+	-	+	-
Phainopepla	+	-	-	-	-	+	+	-	-	-	-
Shrike, Loghd.	-	-	-	-	-	+	1	2	2	-	-
Warbler, Nashville	-	-	-	-	-	-	+	-	-	-	-
" Lucy's	-	-	+	2	2	-	-	-	-	-	-
" Audubon	-	+	-	+	-	-	-	-	-	-	-
" McGillivray's	-	+	+	-	-	-	-	+	-	-	-
Yellowthroat	-	-	-	-	-	-	+	-	-	-	-
Warbler, Wilson's	-	6	8	10	-	-	-	+	-	-	-
Meadowlark, sp?	-	-	-	-	-	+	-	-	-	-	-

Continued

Table 6. Continued

Species	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Oriole, Hooded	-	-	-	-	-	-	+	-	-	-	-
" Scotts	-	-	-	-	-	2	2	4	-	-	-
Cowbird, Brown-headed	-	-	-	2	4	6	2	-	-	-	-
" Bronze	-	-	-	-	-	+	-	-	-	-	-
Tanager, Western	-	-	-	-	-	-	+	-	-	-	-
Pyrrhuloxia	-	-	-	+	4	2	+	-	-	-	-
Grosbeak, Blue	-	-	-	-	-	2	2	-	-	-	-
Finch, House	+	-	-	+	2	3	4	20	6	12	0
Towhee, Green-tailed	-	-	-	-	-	-	+	5	3	-	-
" Brown	2	2	4	8	16	19	12	12	12	4	2
Bunting, Lark	-	-	-	-	-	-	6	-	-	-	-
Sparrow, Lark	-	-	-	-	-	-	-	+	-	-	-
" Vesper	-	-	-	-	-	-	-	-	+	+	+
" Rufous-winged	50	56	56	70	80	118	95	132	105	69	42
" Cassin's	-	-	-	-	-	2	2	+	-	-	-
" Black-throated	14	46	-	-	-	15	22	38	62	51	60
" Brewer's	-	-	-	-	-	-	-	12	100	94	98
Total-individuals	115	167	129	206	239	348	282	349	408	303	281

* + = density of less than 1 individual/40 ha.

† Nesting doves generally forage off the site.

Table 7. Bird biomass on the Santa Rita Experimental Range in 1972 expressed as biomass/40 ha; data for February-May are least reliable

Species	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Turkey, Vulture	-	-	+*	+	+	-	-	-	-	-	-
Hawk, Coopers	-	-	-	-	-	-	-	-	-	+	-
" Sparrow	-	-	-	-	+	97	97	97	97	-	-
Quail, Scaled	400	400	400	400	2000	1800	1200	800	600	600	400
" Gambels	+	+	+	339	339	1018	1018	339	+	+	+
⊦Dove, White-winged	-	-	-	292	292	584	146	-	-	-	-
" Mourning	-	788	788	1576	1576	2626	788	525	131	-	-
Roadrunner	+	+	479	1438	719	479	479	479	240	+	+
Owl, Screech	+	+	+	+	+	+	+	+	+	+	+
" Great-Horned	+	+	+	+	+	+	+	+	+	+	+
Nighthawk, Lesser	-	-	-	80	80	160	+	-	-	-	-
Flicker, Gilded	416	416	208	208	208	416	416	208	312	208	-
Woodpecker, Gila	210	210	+	210	210	350	420	280	140	70	-
" Ladder-back	+	+	+	61	61	92	92	61	61	122	122
Kingbird	-	-	-	-	+	+	+	-	-	-	-
Flycatcher, Wieds-cr.	-	-	-	-	-	46	-	-	-	-	-
" Ash-thr.	-	-	-	56	140	140	140	56	-	-	-
" Western	-	-	-	-	-	-	+	-	-	-	-
Swallow, Cliff	-	-	-	-	-	+	-	-	-	-	-
Martin, Purple	-	-	-	-	-	+	+	-	-	-	-
Verdin	44	30	30	74	74	104	59	104	185	81	59
Wren, Cactus	651	498	689	1379	1647	2490	1379	1379	1379	88	88
Mockingbird	-	-	-	-	-	+	+	+	-	-	-
Thrasher, Curve-b.	1230	1886	1886	2378	2460	2542	3690	3936	3280	2214	3280
Gnatcatcher, Black-t.	11	11	22	22	28	28	28	17	22	11	11
Kinglet, Ruby-crn.	-	-	-	-	-	-	-	+	-	+	-
Phainopepla	+	-	-	-	-	+	+	-	-	-	-
Shrike, Logna.	-	-	-	-	-	+	47	94	94	-	-
Warbler, Nashville	-	-	-	-	-	-	+	-	-	-	-
" Lucy's	-	-	+	20	20	-	-	-	-	-	-
" Audubon	-	+	-	+	-	-	-	-	-	-	-
" McGillivray's	-	+	+	-	-	-	-	+	-	-	-
Yellowthroat	-	-	-	-	-	-	+	-	-	-	-

Continued

Table 7. Continued

Species	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Warbler, Wilson's	-	43	57	72	-	-	-	+	-	-	-
Meadowlark, sp.?	-	-	-	-	-	+	-	-	-	-	-
Oriole, Hooded	-	-	-	-	-	-	+	-	-	-	-
" Scotts	-	-	-	-	-	77	77	154	-	-	-
Cowbird, Brown-headed	-	-	-	78	156	234	78	-	-	-	-
Tanager, Western	-	-	-	-	-	-	+	-	-	-	-
Pyrrhuloxia	-	-	-	+	142	71	+	-	-	-	-
Grosbeak, Blue	-	-	-	-	-	66	66	-	-	-	-
Finch, House	+	-	-	+	38	57	76	380	114	228	-
Towhee, Green-tailed	-	-	-	-	-	-	+	142	85	-	-
" Brown	90	90	180	360	720	855	540	540	540	180	90
Bunting, Lark	-	-	-	-	-	-	235	-	-	-	-
Sparrow, Lark	-	-	-	-	-	-	-	+	-	-	-
" Vesper	-	-	-	-	-	-	-	-	+	+	+
" Rufous-winged	765	857	857	1071	1224	1805	1454	2020	1607	1056	643
" Cassin's	-	-	-	-	-	36	36	+	-	-	-
" Black-thr.	183	603	-	-	-	197	288	498	812	668	786
" Brewer's	-	-	-	-	-	-	-	120	1000	940	980
Cowbird, Bronze	-	-	-	-	-	+	-	-	-	-	-
Total Biomass	4000	5832	5596	10114	12134	16370	12849	12229	10699	6466	6459
Total Biomass/ha	100	146	140	253	303	409	321	306	267	162	161

* + = density of less than 1 individual/40 ha.

† Nesting doves generally forage off the site.

D.3. RODENTS

Introduction

Several methods of approximating the population of small mammals in an area have been proposed. For a variety of reasons most have only limited application in an area such as the IBP Desert Biome validation site where, ideally, the ecosystem should not be disturbed.

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

Live traps are set at 32 stations arranged equidistantly in two rows.

a. Run traps two times per night for three nights.
b. Examine, weigh, toe clip and release each animal caught and record the time and station of capture as well as sex and weight.

To convert the resulting data into an estimate of biomass per unit area, information derived from mark-release studies of adjacent populations is needed as to the average home range size of the various components of the population. The radius of the average home range size is used to compute the area sampled for a given species. The number captured and average weights give a value of g per area.

This approach makes certain assumptions that are not necessarily true.

i. During the trapping period all individuals present will be trapped at least once. Obviously the use of live traps automatically restricts potential captures to those individuals active above ground (hibernating and aestivating individuals and very young not subject to capture). Since captures depend upon bait as attractants, certain species and individuals are not equally attracted to the traps.
ii. During the three-night sampling period an individual will visit all parts of its home range.
iii. The size of the home range in adjacent populations does not differ significantly from the home range of the individuals in the population being sampled.
iv. From the statistical viewpoint the shape of the home range of an individual can be considered to be circular. It is well known that home ranges are rarely, if ever, circular but generally are long, more or less elliptical in form. Further, in many species (e.g. *Neotoma*) home ranges may be more or less linear, superimposed upon some linear microhabitat (along a rock ledge, along a riparian association of a narrow wash). Areas of each of the home ranges can be computed, using a minimum area approach involving multiple recaptures at several stations.

Further such values can be converted into average values for a given species in a given habitat and season. Finally, by assuming the area to be circular, a value for "r", the radius of this circle, can be calculated.

Finally, in a linear transect, in a more or less uniform microhabitat, the long axes of non-circular home ranges should lie at all angles (from right angle to parallel) to the transit line, thus permitting each home range to be considered statistically as a circle.

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

Sampling

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

1. DSCODE A3UCE09. Section 14, T18S, R14E, Santa Rita Experimental Range, Pima County, Arizona. This is the original "undisturbed" Tucson Basin Validation Site. The traps were operated for 4 periods as follows: June, 1971 (= midnight 1 June, sunup and midnight 2 June, sunup and midnight 3 June, and sunup 4 June); November, 1971 (= midnight 11 Nov., sunup and midnight 12 Nov., and sunup and midnight 13 Nov.); May, 1972 (= midnight 25 May, sunup and midnight 26 May, sunup and midnight 27 May, and sunup 28 May); and September, 1972 (= midnight 29 Sept., sunup and midnight 30 Sept., sunup and midnight 1 Oct., and sunup 2 Oct.). Stations were situated at intervals of 20 m and 3 traps were at each station.
2. DSCODE A3UCE10. Section 11, T18S, R14E, Santa Rita Experimental Range, Pima County, Arizona. This is the original "manipulated" Tucson Basin validation site where all the cacti and woody vegetation were destroyed by chaining. The traps were operated as indicated in DSCODE A3UCE09.
3. DSCODE A3UCE12. Section 21, T11S, R9E, Silverbell Bajada site, Pima County, Arizona. This is the "destructive sampling permitted" area of the unmanipulated (control or undisturbed) portion of the validation site. Live traps were operated for 2 periods as follows: June, 1972 (= midnight 5 June, sunup and midnight 6 June, sunup and midnight 7 June, and sunup 8 June) and October, 1972 (= midnight 6 Oct., sunup and midnight 7 Oct., sunup and midnight 8 Oct., and sunup 9 Oct.). Stations were situated at 15 m intervals with 2 traps per station.
4. DSCODE A3UCE13. Section 21, T11S, R9E, Silverbell Bajada site, Pima County, Arizona. This is the "destructive sampling permitted" area of the "manipulated" portion of the validation site where the vehicles had traversed the area. Live traps were operated as indicated in DSCODE A3UCE12.

5. DSCODE A3UCE14. Section 21, T11S, R9E, Silverbell Bajada site, Pima County, Arizona. This is the "validation" area of the undisturbed portion of the site. Live traps were operated as indicated in DSCODE A3UCE12.
6. DSCODE A3UCE15. Section 21, T11S, R9E, Silverbell Bajada site, Pima County, Arizona. This is the "validation" area of the "manipulated" portion of the site.

Results

Results are tabulated in Tables 9-12 and constants used in computing these values are given in Table 8. Figures 2-4 are pictorial representations of the results.

Table 8. Values used as constants in computing the g/ha data in Tables 2-5

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

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

Table 9. Nocturnal rodent biomass for Santa Rita control area, A3UCE09

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

*N = number of individuals per hectare.
**Abbreviations are translated in Table 8.

Table 10. Nocturnal rodent numbers (N = number/ha) and biomass for Santa Rita manipulated area A3UCE10

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

*Abbreviations are translated in Table 8.

Table 11. Nocturnal rodent numbers (N = number/ha) and biomass for Silverbell unmanipulated areas, A3UCE12 (destructive sampling permitted) and A3UCE14 (validation)

	A3UCE12				A3UCE14			
	June 72		Oct 72		June 72		Oct 72	
	N	g/ha	N	g/ha	N	g/ha	N	g/ha
DIPMER*	7.6	302	4.9	192	1.4	55	2.1	82
PERAMP	11.5	126	2.5	27	5.7	63	2.5	27
PERPEN	4.5	88	2.7	53	0	0	1.8	35
PERBAI	0	0	0	0	.8	27	1.6	55
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	0	0	0	0	0	0
MUSMUS	0	0	3.5	42	0	0	2.6	31
Subtotals	23.6	516	13.6	314	7.9	145	10.6	230
NEOALB	0	0	0	0	0	0	0	0
Totals	23.6	516	13.6	314	7.9	145	10.6	230

*Abbreveations are translated in Table 8.

Table 12. Nocturnal rodent numbers (N= number/ha) and biomass for Silverbell manipulated areas, A3UCE13 (destructive sampling permitted) and A3UCE15 (validation)

	A3UCE13				A3UCE15			
	June 72		Oct 72		June 72		Oct 72	
	N	g/ha	N	g/ha	N	g/ha	N	g/ha
DIPMER*	4.9	192	6.3	247	5.6	219	5.6	219
PERAMP	9.0	99	4.9	54	4.9	54	1.6	18
PERPEN	3.6	70	2.7	53	3.6	70	3.6	70
PERBAI	3.3	111	1.6	55	0	0	0	0
PERFLA	0	0	0	0	0	0	0	0
REIFUL	0	0	0	0	0	0	0	0
ONYTOR	0	0	0	0	0	0	0	0
SIGARI	0	0	0	0	0	0	.9	44
MUSMUS	0	0	7.8	94	0	0	2.6	31
Subtotal	20.8	472	23.3	503	14.1	343	14.3	382
NEOALB	.9	163	0	0	0	0	0	0
Totals	21.7	635	23.3	503	14.1	343	14.3	382

*Abbreviations are translated in Table 8.

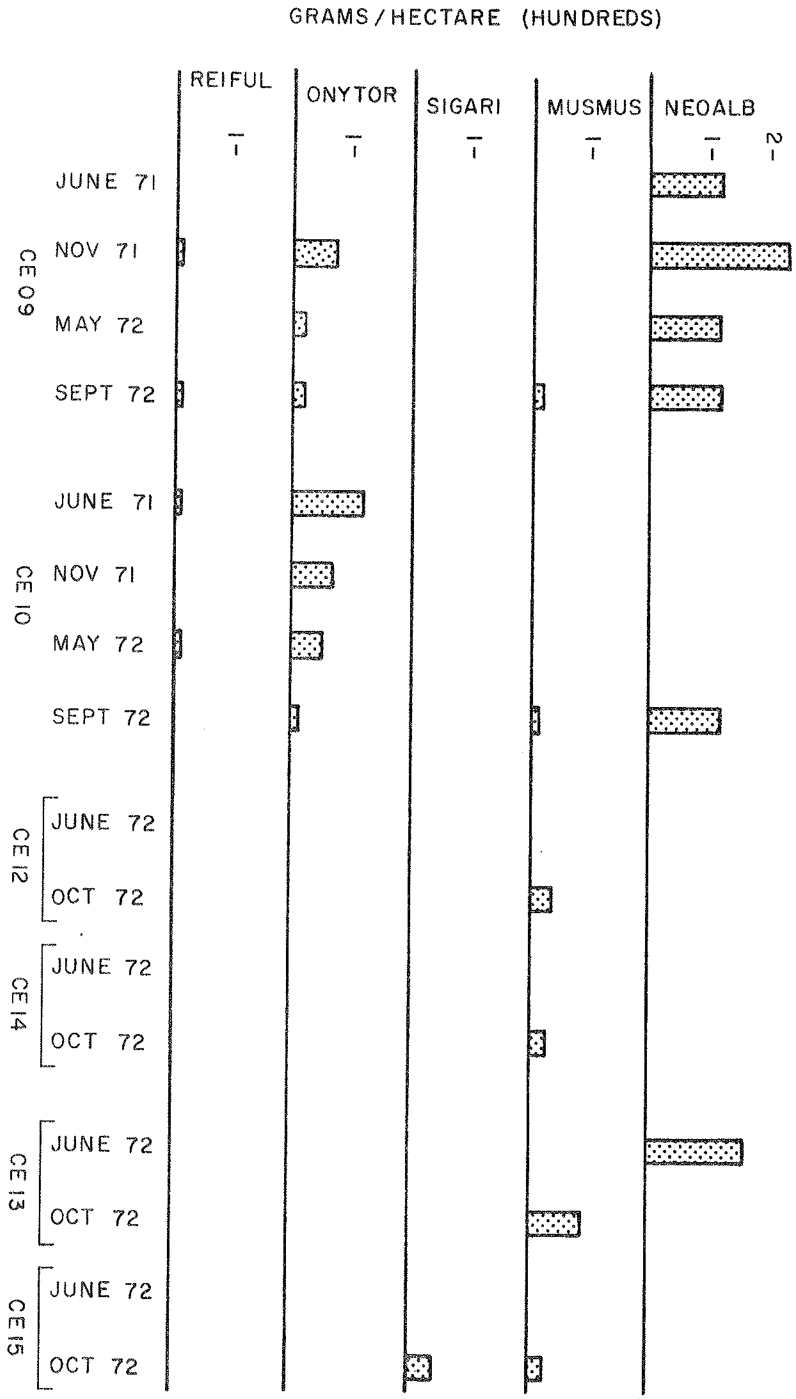


Figure 2. Biomass estimates (g/ha) of five rodents on Santa Rita (CE09,10) and Silverbell (CE12, 13, 14, 15). Data from undisturbed sites are represented by DSCODES CE09, CE12 (destructive sampling area) and CE14 (validation area). Data from disturbed sites are represented by DSCODES CE10 (chained), CE13 (vehicle traffic, destructive sampling area) and CE15 (vehicle traffic, validation area). Species codes are translated in Table 8.

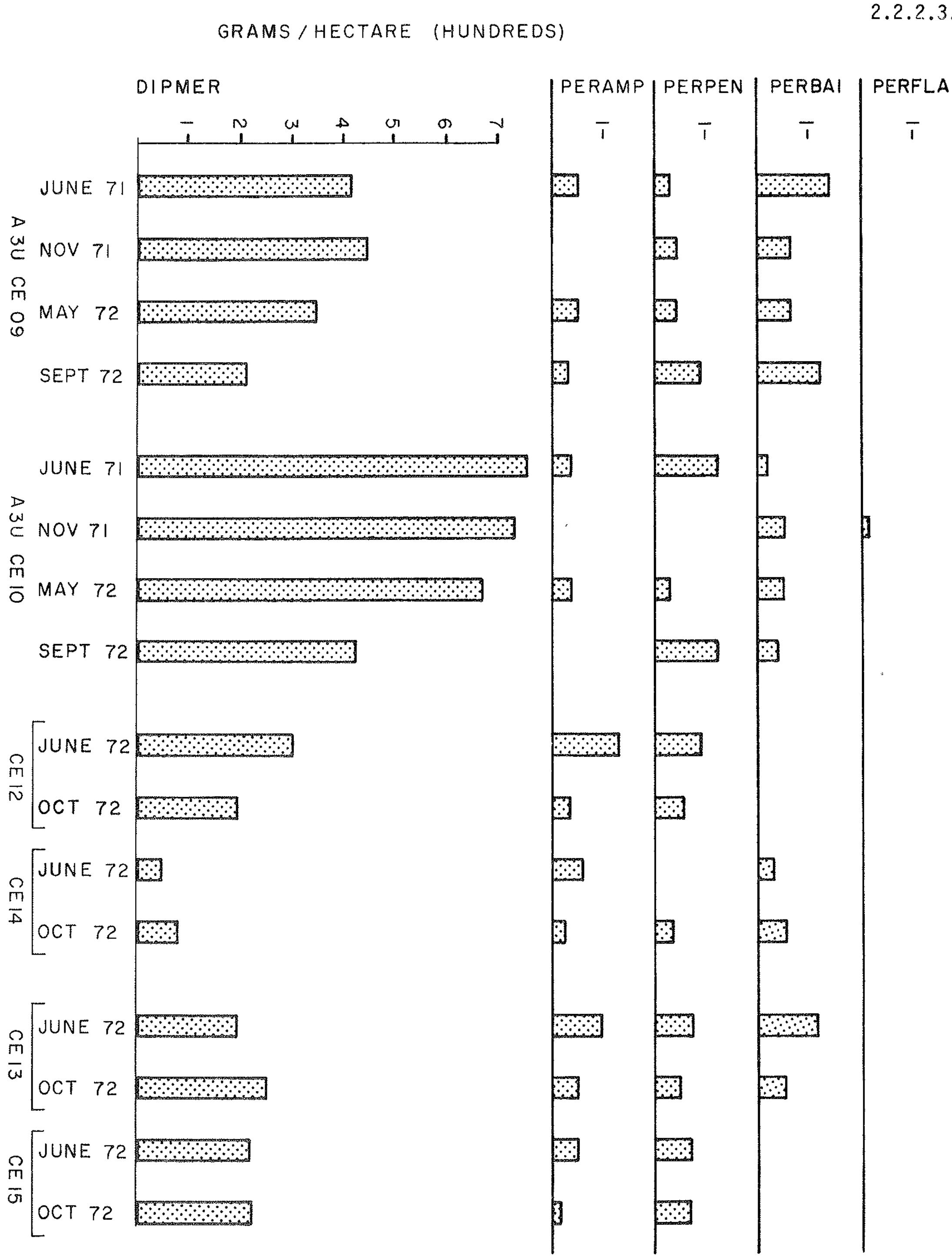


Figure 3. Biomass estimates (g/ha) of *Dipodomys*, *Perognathus* and *Peromyscus* on Santa Rita and Silverbell sites. DSCODES are explained in the legend for Figure 2. Species codes are translated in Table 8.

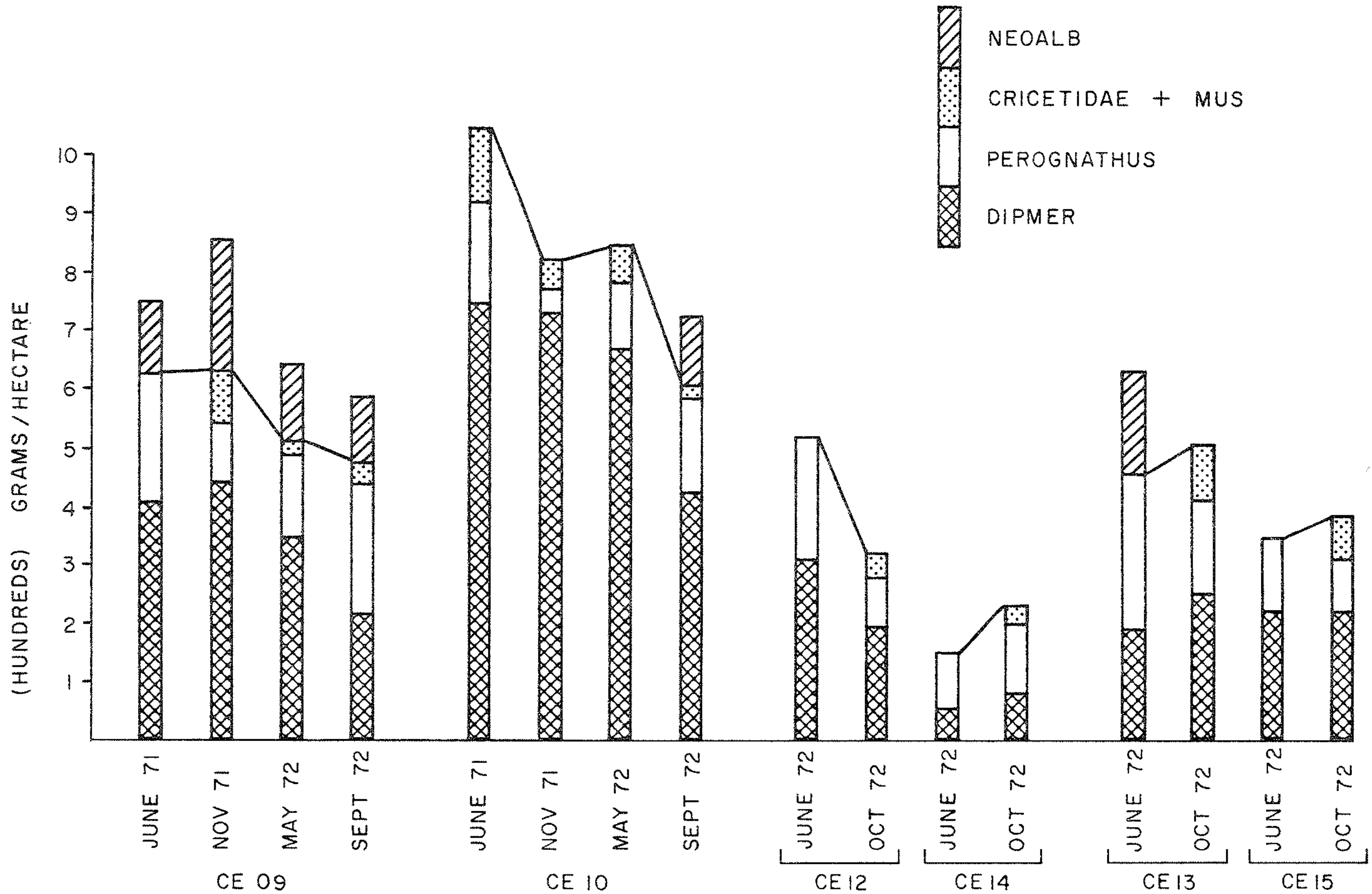


Figure 4. Summary of biomass estimates (g/ha) of rodents on the Santa Rita and Silverbell sites. DSCODES are explained in the legend for Figure 2. Species codes are translated in Table 8.

Discussion

Several facts are evident from the data.

1. The biomass at Santa Rita sites (A3UCE09 and A3UCE10) is approximately twice that at the Silverbell Sites (A3UCE12, 13, 14, 15).
2. The biomass estimates of *Neotoma albigula* are not valid and probably should be eliminated from comparisons of these data. Basically the two parallel lines technique does not sample enough area to give a realistic estimate of *Neotoma*. A separate census procedure for *Neotoma* will be instituted this spring. In fact, there are some *Neotoma* on each of the sites, with the densest population (as shown by the data) on the Santa Rita "control" (A3UCE09).
3. There appears to be significantly more biomass on the manipulated areas (A3UCE10, 13, and 15). The greater disturbance at the Santa Rita site (A3UCE10, chained) resulted in a greater increase than did the manipulation (vehicles) at the Silverbell site.
4. The November trapping in 1971 at the Santa Rita sites was so late that *Perognathus* had essentially become inactive. As far as *Perognathus amplus* is concerned, in all samples, individuals captured in May or June were not recaptured in September, October or November (although at the Santa Rita sites, 2 *P. amplus* marked in May, 1971, were recaptured in June, 1972).
5. The low values for September, 1972, for the Santa Rita sites (A3UCE09 and 10) are misleading. The actual values should be much higher. Late summer rains in 1972 resulted in large amounts of seeds and other foods being available. Thus the rodents (especially *Dipodomys merriami*) were not susceptible to trapping. This phenomenon has been documented on the two live trap grids being operated bi-monthly or monthly in the same region (A3UCE02 and 04).
6. Feral house mice, *Mus musculus*, appeared for the first time in all trapping sites in the fall of 1972. They were most common in the Silverbell manipulated sample areas.
7. At both Santa Rita sites (A3UCE09 and 10) the June 1971 densities are greater than the May 1972 values. This reflects the fact that by June a number of young of the year make up a part of the population. For this reason the "spring" sampling time in 1972 was changed to May.

Other Activities

Carl Hoagstrom was the Graduate Research Assistant on IBP funding from September through December. Mr. Hoagstrom gathered data on which the above analysis is based. In addition, Mr. Hoagstrom spent considerable time in the Silverbell region attempting to quantify factors (vegetation, soil, slope, etc.) influencing the distribution of rodents.

Tom Vaughan was the Graduate Research Assistant on IBP funding for January through June. He continued to operate, monthly, the two grids at the Santa Rita sites (A3UCE02 and 04). He also analyzed recapture data to determine home range values and mortality rates in the populations being monitored.

Non-IBP-financed activities included:

Pamela Vaughan completed a M.S. thesis "Dispersal in a Small Mammal Population". Data on which this is based are filed under DSCODE A3UCE08. The abstract of this follows:

"Dispersal in three species of desert rodents was studied from July through November, 1971, on the Santa Rita Experimental Range in southern Arizona. Four lines of live traps radiating from a central grid area were located partially on an area which had been cleared of all large woody vegetation approximately one year previously. The rest were on undisturbed areas.

It was found that *Dipodomys merriami* and *Perognathus penicillatus* have relatively small dispersal distances, while *Onychomys torridus* move large distances. Most shifts in home range were made by adults and probably occurred in a short time period since the maximum distance between successive recaptures (D_{max}) was approximately equal to the maximum distance between all points of capture ($\bar{M}$).

A significant correlation was noted between the mean distance between successive recaptures ($\bar{D}$) and the average maximum distance between all points of capture ($\bar{M}$). This makes possible the prediction of average dispersal distances in a population when only the more readily determined $\bar{D}$ is known.

Little difference was found in numbers or movements of individuals on disturbed and undisturbed areas. However, a difference in trap response on the two areas was noted which may have been due to greater food availability on the disturbed area".

Ronald Olding conducted 2 replications of the Polish IBP kill-trap system, one in the Silverbell area and one in the Santa Rita area. This work, for a M.S. thesis to be finished in the spring of 1973, will furnish an independent check of the validity of the biomass determinations reported above.

John Wondelleck operated the two livetrap grids at the Santa Rita sites, at monthly intervals form July through December. He is developing computer programs to analyze these data.

E. CALORIMETRY AND CHEMICAL ANALYSIS

Data were not available for inclusion in this report. The next annual progress report covering research conducted in 1973 will include chemical analysis data.

F. SOILS

1. DESCRIPTION OF THE SOILS (DSCODE A3UHD01)

Anthony Series

The Anthony series formed in moderately coarse textured mixed alluvium derived mostly from granite, andesite, and sedimentary quartzite. The soils lack development other than A and C horizons. They are well drained and have moderately rapid permeability. A representative pedon is located 360 feet north and 800 feet east of the southwest corner of the site and is described as follows:

Anthony gravelly sandy loam

A1 0-8 cm - Brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; weak medium platy structure; soft, friable, slightly sticky, slightly plastic; few fine roots; very slightly effervescent; moderately alkaline (pH 7.9); gradual smooth boundary.

C1 8-22 cm - Brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; few medium and fine roots; slightly effervescent; moderately alkaline (pH 8.0); gradual smooth boundary.

C2 22-35 cm - Brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; few fine roots, strongly effervescent; moderately alkaline (pH 8.2); gradual smooth boundary.

C3 35-45 cm - Brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; few medium and fine roots; strongly effervescent; moderately alkaline (pH 8.2); clear smooth boundary.

IIC4ca 45-85 cm - Brown (7.5YR 5/4) very gravelly sandy loam, dark brown (7.5YR 3/4) moist; pink (7.5YR 7/4) lime coating on gravels, reddish yellow (7.5YR 6/6) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; violently effervescent; moderately alkaline (pH 8.2).

House Mountain Series

The House Mountain series consists of shallow soils formed in place on basalt and andesite. They lack profile development other than A and C horizons. They are well drained and have moderate infiltration and permeability. A pedon representative of the House Mountain series is located 1200 feet south and 1200 feet west of the northeast corner of the site and is described as follows:

House Mountain gravelly loam

A1 0-7 cm - Brown (7.5YR 5/3) gravelly loam, dark brown (5YR 3/3) moist; weak medium subangular blocky structure; soft, friable, slightly sticky, slightly plastic; few fine roots; mildly alkaline (pH 7.4); gradual smooth boundary.

C1 7-20 cm - Brown (7.5YR 5/3) gravelly loam, dark brown (5YR 3/3) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; few fine roots; mildly alkaline (pH 7.6); clear wavy boundary.

R1 20-30 cm - Fractured andesite rock.

Lehmans Series

The Lehmans series has developed in place on andesite and to a limited extent on basalt. The soils are strongly developed consisting of a cobbly or very gravelly clay loam A1 horizon overlying a gravelly clay B2t horizon. They are well drained, have moderately slow to slow permeability and medium to rapid runoff. A representative pedon is located 1600 feet south and 120 feet west of the northeast corner of the site and is described as follows:

Lehmans very gravelly clay loam

A1 0-5 cm - Brown (7.5YR 5/4) very gravelly clay loam, dark brown (7.5YR 3/4) moist; weak medium platy structure; slightly hard, friable, slightly sticky, slightly plastic; few fine roots, slightly acid (pH 6.2); clear smooth boundary.

B1 5-12 cm - Brown (7.5YR 5/4) gravelly heavy clay loam, dark brown (7.5YR 3/4) moist; weak medium subangular blocky structure; hard, firm, sticky, plastic; common medium and few fine roots; neutral (pH 6.7); clear smooth boundary.

B21t 12-22 cm - Reddish brown (5YR 5/4) gravelly clay, reddish brown (5YR 4/4) moist; moderate medium subangular blocky structure; very hard, very firm, very sticky, very plastic; clay films on ped faces; few fine roots; slightly effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

B22t 22-32 cm - Reddish brown (5YR 5/4) gravelly clay, reddish brown (5YR 4/4) moist; moderate medium blocky structure; very hard, very firm, very sticky, very plastic; clay films on ped surfaces; few fine roots; strongly effervescent; moderately alkaline (pH 8.1); abrupt wavy boundary.

R1 32-40 cm - Fractured andesite with thin lime coatings on surfaces.

Rillito Series

The Rillito series have formed in calcareous alluvium derived primarily from andesite, basalt, granite and quartzite. The soils are calcareous throughout with maximum carbonate accumulation generally occurring at a depth of 30 to 50 cm. In some areas the carbonates form a weakly cemented layer at this depth. The textures

are gravelly sandy loam and gravelly loam. The soils are well drained and have moderate permeability. A representative pedon is located 60 feet north and 200 feet west of the southeast corner of the site and is described as follows:

Rillito gravelly sandy loam

3-0 cm - About seventy percent of the surface covered by gravel.

A11 0-4 cm - Light brown (7.5YR 6/4) gravelly sandy loam, brown (7.5YR 4/4) moist; moderate coarse platy structure; soft, friable, nonsticky, nonplastic; very few fine and very fine roots; strongly effervescent; moderately alkaline (pH 8.0); abrupt smooth boundary.

A12 4-11 cm - Light brown (7.5YR 6/4) gravelly sandy loam, brown (7.5YR 4/4) moist; structureless massive; soft, friable, nonsticky, nonplastic; very few fine and very fine roots; strongly effervescent; moderately alkaline(pH 8.3); clear smooth boundary.

B2 11-25 cm - Light brown (7.5YR 6/4) gravelly loam, brown (7.5YR 4/4) moist; structureless massive; soft, very friable, slightly sticky, slightly plastic; plentiful medium and few fine roots; moderately alkaline (pH 8.3); abrupt smooth boundary.

C1ca 25-40 cm - Pink (7.5YR 7/3) gravelly loam, brown (7.5YR 5/3) moist; structureless massive; soft, friable, slightly sticky, slightly plastic; very few medium and few fine roots; violently effervescent; strongly alkaline (pH 8.5); clear smooth boundary.

C2Ca 40-60 cm - Pink (7.5YR 8/3) gravelly loam, light brown (7.5YR 6/4) moist; structureless massive; hard, firm, sticky, plastic; very few fine roots; violently effervescent; strongly alkaline (pH 8.7).

Tres Hermanos Series

The Tres Hermanos series have formed in alluvium derived primarily from granitic rocks or in mixed alluvium derived primarily from andesite, basalt, granite and quartzite. These soils have moderately well to well developed profiles having gravelly sandy loam A1 horizons over gravelly sandy clay loam or gravelly clay loam B2t horizons. They are well drained and have moderate permeability. Pedon descriptions representative of the Tres Hermanos soils in each of the two mapping units in which they occur are given. The following pedon is representative of the Tres Hermanos fine gravelly sandy loam, 1-3 percent slope mapping unit, and is located 100 feet south and 2250 feet west of the northeast corner of the site:

Tres Hermanos fine gravelly sandy loam

A1 0-3 cm - Brown (7.5YR 5/4) fine gravelly sandy loam, dark brown (7.5YR 3/4) moist; weak medium platy structure; soft, friable, slightly sticky, slightly plastic; few fine roots; very slightly effervescent; neutral (pH 7.2); clear smooth boundary.

B21t 3-11 cm - Yellowish red (5YR 4/6) fine gravelly clay loam, dark yellowish red (5YR 3/6) moist; weak medium and fine subangular blocky structure; hard, friable, sticky, plastic; few fine roots; very slightly effervescent; mildly alkaline (pH 7.4); clear smooth boundary.

B22t 11-21 cm - Yellowish red (5YR 4/8) fine gravelly clay loam, dark yellowish red (5YR 3/6) moist; weak medium and fine subangular blocky structure; hard, friable, sticky, plastic; few fine roots; very slightly effervescent; mildly alkaline (pH 7.8); clear wavy boundary.

B23tca 21-37 cm - Yellowish red (5YR 4/8) fine gravelly clay loam, yellowish red (5YR 4/6) moist; common pink (5YR 7/4) lime filaments and mottles, light reddish brown (5YR 6/3) moist; structureless massive; hard, friable, sticky, plastic; few fine roots; violently effervescent; moderately alkaline (pH 8.0); clear wavy boundary.

B24tca 37-52 cm - Brown (7.5YR 5/4) fine gravelly clay loam, strong brown (7.5YR 4/6) moist; common pinkish white (7.5YR 8/2) lime mottles, pink (7.5YR 7/4) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; few fine roots; violently effervescent; moderately alkaline (pH 8.0); abrupt wavy boundary.

C1ca 52-65 cm - Pink (7.5YR 8/4) light gravelly loam, reddish yellow (7.5YR 6/6) moist; structureless massive; hard, firm, nonsticky, nonplastic; violently effervescent, moderately alkaline (pH 8.1).

The following pedon description is representative of the Tres Hermanos series as it occurs in the Tres Hermanos gravelly sandy loam, 1-3 percent slope mapping unit. It is located 400 feet east and 600 feet north of the southwest corner of the site.

Tres Hermanos gravelly sandy loam

A1 0-16 cm - Brown 7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; moderate medium platy structure; soft, friable, slightly sticky, slightly plastic; few fine roots; clear smooth boundary.

B2t 16-34 cm - Yellowish red (5YR 4/6) gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; soft, friable, slightly sticky, slightly plastic; few fine roots; very slightly effervescent; mildly alkaline (pH 7.7); clear wavy boundary.

IIC1a 34-55 cm - Dark brown (7.5YR 4/4) very gravelly loam, dark brown (7.5YR 3/4) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; plentiful medium and few fine roots; violently effervescent; moderately alkaline (pH 8.3); clear wavy boundary.

IIC2ca 55-75 cm - Brown (7.5 YR 5/4) very gravelly sandy loam, dark brown (7.5YR 3/4) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; few medium roots; violently effervescent; moderately alkaline (pH 8.4).

Tubac Series

The Tubac series had formed in alluvium derived primarily from andesite, basalt, granite and quartzite. The soils have strongly developed profiles consisting of thin gravelly sandy loam A2 horizons which changes abruptly to underlying gravelly clay B2t horizons. The soils are well drained and have slow permeability. A desert pavement, in some cases containing desert varnish, is quite common on these soils. A pedon representative of the Tubac series is located 10 feet north and 1200 feet west of the southeast corner of the site and is described as follows:

Tubac gravelly sandy loam

A2 0-2 cm - Reddish yellow (7.5YR 6/6) gravelly sandy loam, dark brown (7.5YR 3/4) moist; moderate medium platy structure; soft, friable, nonsticky, nonplastic; few fine roots; neutral (pH 6.9); very abrupt smooth boundary.

B21t 2-12 cm - Yellowish red (5YR 3/6) gravelly clay, dark reddish brown (5YR 3/4) moist; weak medium prismatic structure; hard, friable, sticky, plastic; few fine roots; neutral (pH 6.9); clear smooth boundary.

B22t 12-22 cm - Yellowish red (5YR 3/6) gravelly clay, dark reddish brown (5YR 3/6) moist; weak medium prismatic structure; hard, friable, sticky, plastic; few fine and medium roots; clear smooth boundary.

B23t 22-31 cm - Yellowish red (5YR 4/6) gravelly clay, dark reddish brown (5YR 3/6) moist; structureless massive; hard, friable, sticky, plastic; few fine and medium roots; slightly effervescent in a few scattered spots; neutral (pH 7.1); clear smooth boundary.

B31ca 31-40 cm - Yellowish red (5YR 5/6) gravelly clay loam, dark reddish brown (5YR 3/6) moist; common pink (5YR 8/3) lime filaments and mottles, light reddish brown (5YR 6/3) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; few fine and medium roots; strongly effervescent; moderately alkaline (pH 7.9); clear wavy boundary.

IIB32ca 40-50 cm - Yellowish red (5YR 5/6) very gravelly sandy clay loam, dark reddish brown (5YR 3/6) moist; abundant pink (5YR 8/3) lime filaments and nodules, light reddish brown (5YR 6/3) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; violently effervescent; strongly alkaline (pH 8.8); clear wavy boundary.

IIC1ca 50-70 cm - Reddish yellow (5YR 6/6) very gravelly sandy loam, yellowish red (5YR 4/6) moist; common pink (5YR 8/4) lime coatings on lower side of gravels, pink (5YR 7/4) moist; structureless massive; slightly hard, friable, slightly sticky, slightly plastic; slightly effervescent on tops of gravels; violently effervescent on bottoms of gravels; moderately alkaline (pH 8.2).

Unnamed Soil Series 1

These soils have properties outside the range of currently recognized soil series. They have formed in place on andesite and have well developed profiles. They consist of cobbly or gravelly sandy loam A1 horizons overlying gravelly sandy clay loam B2t horizons. The soils are well drained, have moderately slow permeability and medium runoff. A representative pedon is located 280 feet south and 1800 feet east of the southwest corner of the site and is described as follows:

Unnamed Lithic Haplargid - 1

A1 0-2 cm - Brown (7.5YR 5/4) gravelly sandy loam, dark brown (7.5YR 3/4) moist; weak medium platy structure; soft, friable, slightly sticky, slightly plastic; few very fine and fine roots; common fine and very fine vesicular pores; mildly alkaline (pH 7.5); abrupt smooth boundary.

B21t 2-14 cm - Yellowish red (5YR 4/6) gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; weak fine and medium subangular blocky structure; slightly hard, firm, sticky, plastic; few fine roots; clay films on gravels; mildly alkaline (pH 7.5); clear wavy boundary.

B22t 14-22 cm - Dark yellowish red (5YR 3/6) very gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; structureless massive; slightly hard, firm, sticky, plastic; few fine and medium roots; clay films on gravels; mildly alkaline (pH 7.6); abrupt irregular boundary.

R 22-30 cm - Fractured andesite with lime coating on rock surfaces.

Unnamed Soil Series 2

These soils have properties outside the range of currently recognized soil series. They have formed in place on basalt. They have moderately well developed profiles consisting of cobbly or gravelly sandy loam A1 horizons overlying gravelly loam B2t horizons. The soils are well drained, have moderate permeability and medium runoff. A representative pedon is found 520 feet south and 800 feet west of the northeast corner of the site and is described as follows:

Unnamed Lithic Heplargid - 2

A1 0-5 cm - Reddish yellow (7.5YR 8/4) gravelly sandy loam, dark brown (7.5YR 3/3) moist; weak medium platy structure; soft, friable, slightly sticky, slightly plastic; few medium and fine roots; neutral (pH 7.0); clear wavy boundary.

B2t 5-18 cm - Yellowish red (5YR 4/6) gravelly loam, dark reddish brown (5YR 3/4) moist; weak medium subangular blocky structure; soft, friable, slightly sticky, slightly plastic; few medium and fine roots; neutral (pH 7.2); abrupt wavy boundary.

R1 18-30 cm - Fractured basalt rock.

Unnamed Soil Series 3

These soils have properties outside the range of currently recognized soil series. They have formed in place on granitic rock and have strongly developed profiles consisting of gravelly sandy loam A1 horizons overlying gravelly clay loam B2t horizons. The soils are well drained, have moderately slow permeability and medium runoff. A representative pedon is found 480 feet north and 1240 feet east of the southwest corner of the site and is described as follows:

A1 0-5 cm - Reddish yellow (7.5YR 6/6) gravelly sandy loam, light brown (7.5YR 6/4) moist; weak medium subangular blocky structure; slightly hard, soft, slightly plastic; few fine roots; neutral (pH 6.6); abrupt smooth boundary.

B21t 5-15 cm - Yellowish red (5YR 4/8) gravelly sandy clay loam, dark reddish brown (5YR 3/4) moist; moderate medium subangular blocky structure; slightly hard, friable, sticky, plastic; few medium and fine roots; mildly alkaline (pH 7.5); clear wavy boundary.

B22t 15-25 cm - Yellowish red (5YR 4/8) gravelly clay loam, dark yellowish red (5YR 3/6) moist; moderate medium subangular blocky structure; hard, friable, sticky, plastic; few medium and fine roots; mildly alkaline (pH 7.8); clear wavy boundary.

B3t 25-30 cm - Yellowish red (5YR 4/8) very gravelly sandy clay loam, dark yellowish red (5YR 3/6) moist; structureless massive; hard, friable, sticky, plastic; common medium roots; very slightly effervescent; moderately alkaline (pH 7.9); abrupt wavy boundary.

R1 30-40 cm - Weathered granitic rock with clay coating the fracture surfaces.

The placement of the soils in their subgroups and families in the Soil Taxonomy is shown in Table 1.

Table 1. Classification of the soils according to the Soil Taxonomy.

Soil Series	Subgroup	Family
Anthony	Typic Torrifluvent	Coarse-loamy, mixed, thermic
House Mountain	Lithic Torriorthent	Loamy, mixed, thermic
Lehmans	Lithic Haplargid	Fine, montmorillonitic, thermic
Rillito*	Typic Calciorthid	Coarse-loamy, mixed, thermic
Tres Hermanos	Typic Haplargid	Fine-loamy, mixed, thermic
Tubac	Typic Paleargid	Fine, mixed, thermic
Unnamed 1	Lithic Haplargid	Fine-loamy, mixed, thermic
Unnamed 2	Lithic Haplargid	Coarse-loamy, mixed, thermic
Unnamed 3	Lithic Haplargid	Fine-loamy, mixed, thermic

*The Rillito series has recently been reclassified into a hyperthermic temperature family. In the recently published Tucson-Arva Valley Soil Survey the Rillito is in a thermic family since the correlation of the survey took place prior to the establishment of hyperthermic families in central Arizona. For the purpose of this report the name Rillito will be retained for this series.

F.2 MAPPING UNIT DESCRIPTIONS

The soil mapping units consist of phases of the above soil series together with miscellaneous land types. In cases where two soil phases occur together in such an intricate manner that they cannot be delineated or mapped separately, the mapping units are designated as complexes. All mapping units contain inclusions of soil units different from those which make up the bulk of the mapping unit but are too small to be delineated. The soil maps of the Silverbell site are presented in Figures 1-4.

A - Anthony gravelly sandy loam, 1-3 percent slopes

This unit occurs along some of the stream channels. It contains inclusions of gravelly alluvial land and Tres Hermanos gravelly sandy loam, 1 to 3 percent slopes.

A-R - Anthony-Rillito Complex

This unit consists of Anthony gravelly samdy loam and Rillito gravelly sandy loam. The dominant slope is 1 to 3 percent. Tres Hermanos gravelly sandy loam and gravelly alluvial land occur as inclusions. This unit occurs in the southwestern part of the site.

A-H - Anthony-Tres Hermanos complex

This unit consists of the Anthony gravelly sandy loam and Tres Hermanos gravelly sandy loam. The dominant slope is 1 to 3 percent. Inclusions of Rillito gravelly sandy loam and the gravelly alluvial land are found in this unit. The unit occurs along the stream channel in the southern part of the site.

G - Gravelly Alluvial Land

This unit consists of unconsolidated stratified gravelly and sandy recently deposited alluvium in and along stream channels. It is subject to overflow and change by shifting stream channels. It contains inclusions of Anthony gravelly sandy loam.

H - House Mountain gravelly loam, 3-8 percent slopes

This unit consists of shallow soils on andesite and occurs in the northeastern part of the site. It contains inclusions of rock outcrop and unnamed soil 1 and 2.

L - Lehmans very gravelly clay loam, 3-8 percent slopes

This unit is found on the side slopes running south from the large hill in the northeastern corner of the site. It contains inclusions of unnamed soil 1.

R - Rillito gravelly sandy loam, 1-3 percent slopes

This unit is fairly extensive in the central and southern portions of the site. Small areas of Tubac gravelly sandy loam and Tres Hermanos gravelly sandy loam and areas with slopes greater than 3 percent are included.

R-TH - Rillito-Tres Hermanos Complex

This unit consists of Rillito gravelly sandy loam and Tres Hermanos gravelly sandy loam and is found in the western and southwestern part of the site. Inclusions of Anthony are found in the unit.

TH1 - Tres Hermanos fine gravelly sandy loam, 1-3 percent slopes

This unit occupies a fairly extensive area in the northern part of the site. It differs form TH2 primarily in containing gravel mostly of fine (5-2 mm) size and has formed in granitic alluvium. TH1 and TH2 were kept separate because of differences in the composition and density of the vegetation associated with each.

TH2 - Tres Hermanos gravelly sandy loam, 1-3 percent slopes

This unit if found in the southwestern part of the site. The soils have formed in mixed alluvium. Inclusions of Rillito are common.

Tu1 - Tubac gravelly sandy loam, 1-3 percent slopes

This unit is fairly extensive in the central and southern part of the site. Inclusions include Rillito gravelly sandy loam and Tubac gravelly sandy loam having slopes outside the indicated range.

Tu2 - Tubac gravelly sandy loam, 3-8 percent slopes

This unit is found on outwash material derived from the large hill in the northeastern part of the site. Unnamed-2 and Lehmans gravelly sandy loam together with Tubac cobbly sandy loam occur as inclusions.

Tu-R - Tubac-Rillito Complex

This unit consists of Tubac gravelly sandy loam and Rillito gravelly sandy loam. Most of this unit is within the 1-3 percent slope range. The unit is found mostly in the southern and in the west-central part of the site. Inclusions of Tres Hermanos gravelly sandy loam are present.

U1 - Unnamed 1 gravelly sandy loam, 1-8 percent slopes

This unit consists of shallow soils found on a small hill of andesite near the northern boundary of the site and associated with small andesite rock outcrops scattered throughout the site. Inclusions include rock outcrop, House Mountain gravelly loam, and soils with cobbly sandy loam surface texture.

U2 - Unnamed 2 gravelly sandy loam, 5-20 percent slopes

This unit is found associated with the large hill in the northeast part of the site. It contains inclusions of rock outcrop, House Mountain soils and Unnamed 1 soils.

U3 - Unnamed 3 gravelly sandy loam, 1-5 percent slopes

This unit is associated with small hills and outcrops of granite occurring mainly on the southwestern and western part of the site. Granitic rock outcrops are common inclusions.

Summary of mapping units

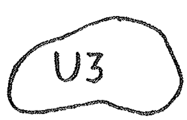
SOIL LEGEND

A1	Anthony gravelly sandy loam, 1 to 3 percent slopes
A-R	Anthony-Rillito complex
A-TH	Anthony-Tres Hermanos complex
G	Gravelly alluvial land
H	House Mountain gravelly loam, 3 to 8 percent slopes
L	Lehmans very gravelly clay loam, 3 to 8 percent slopes
R	Rillito gravelly sandy loam, 1 to 3 percent slopes
R-TH	Rillito-Tres Hermanos complex
TH1	Tres Hermanos fine gravelly sandy loam, 1 to 3 percent slopes
TH2	Tres Hermanos gravelly sandy loam, 1 to 3 percent slopes
Tu1	Tubac gravelly sandy loam, 1 to 3 percent slopes
Tu2	Tubac gravelly sandy loam, 3 to 8 percent slopes
Tu-R	Tubac-Rillito complex
U1	Unnamed Lithic Haplargid No. 1
U2	Unnamed Lithic Haplargid No. 2
U3	Unnamed Lithic Haplargid No. 3

LEGEND

Site boundary

1/4 Section boundary



Soil boundary and soil symbol

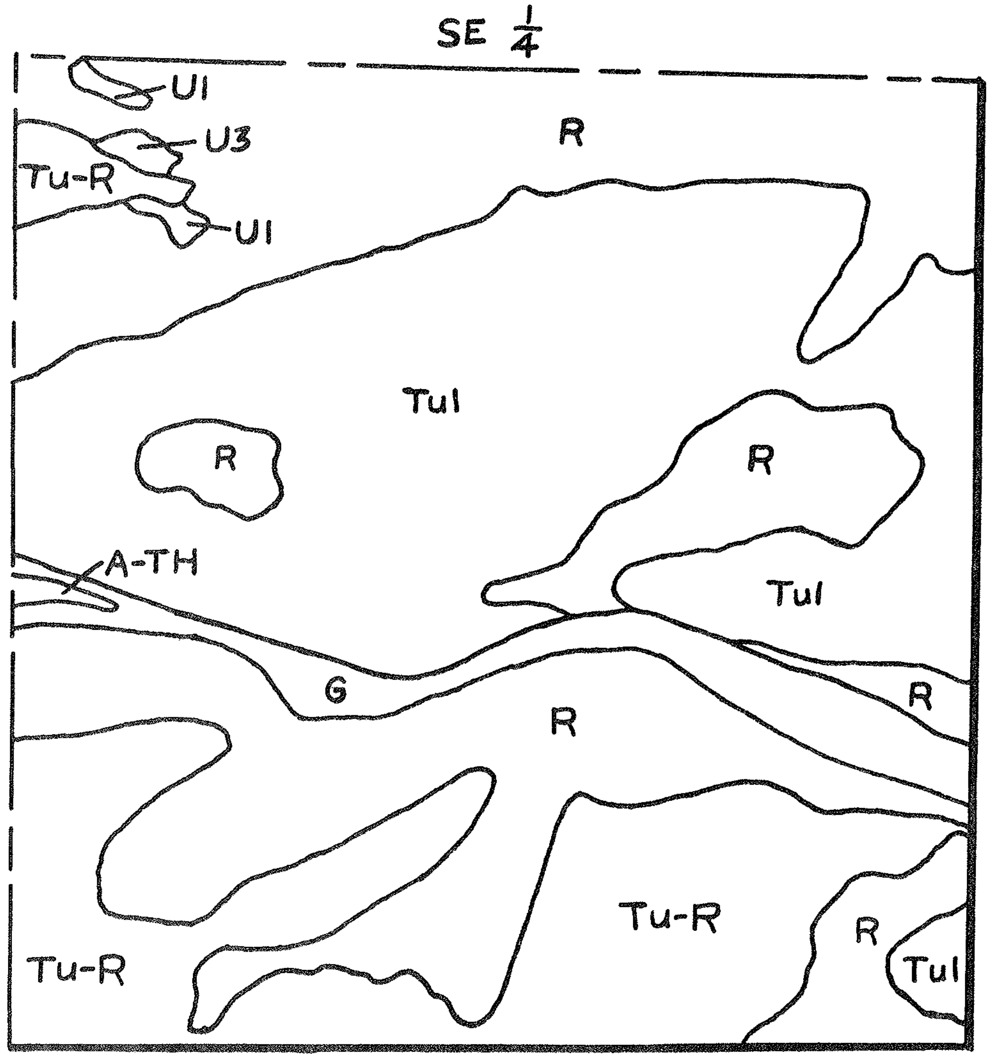


Figure 1. Soil survey map of the Silverbell Validation Site, southeast quarter. See text for legend of symbols.

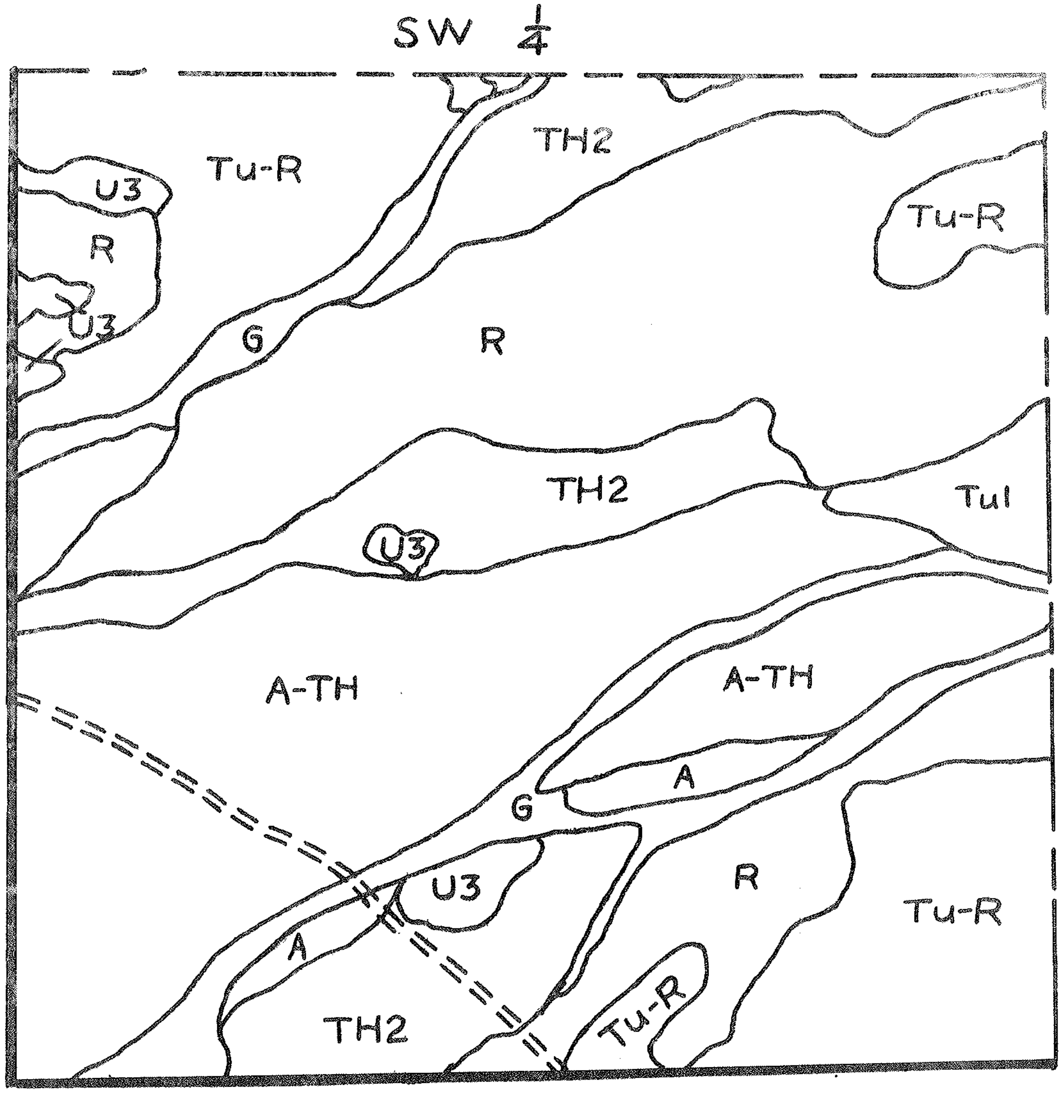


Figure 2. Soil survey map of the Silverbell Validation Site, southwest quarter. See text for legend of symbols.

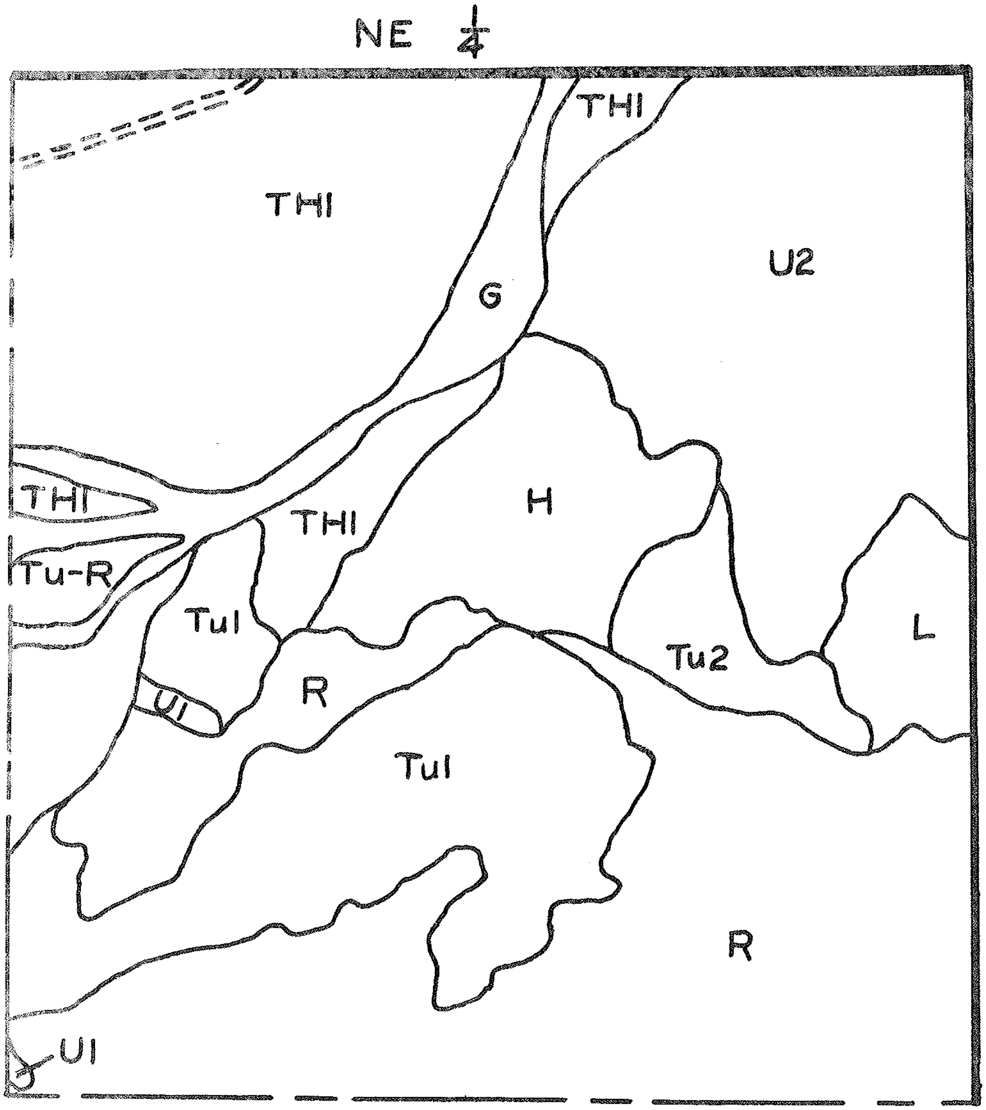


Figure 3. Soil survey map of the Silverbell Validation Site, northeast quarter. See text for legend of symbols.

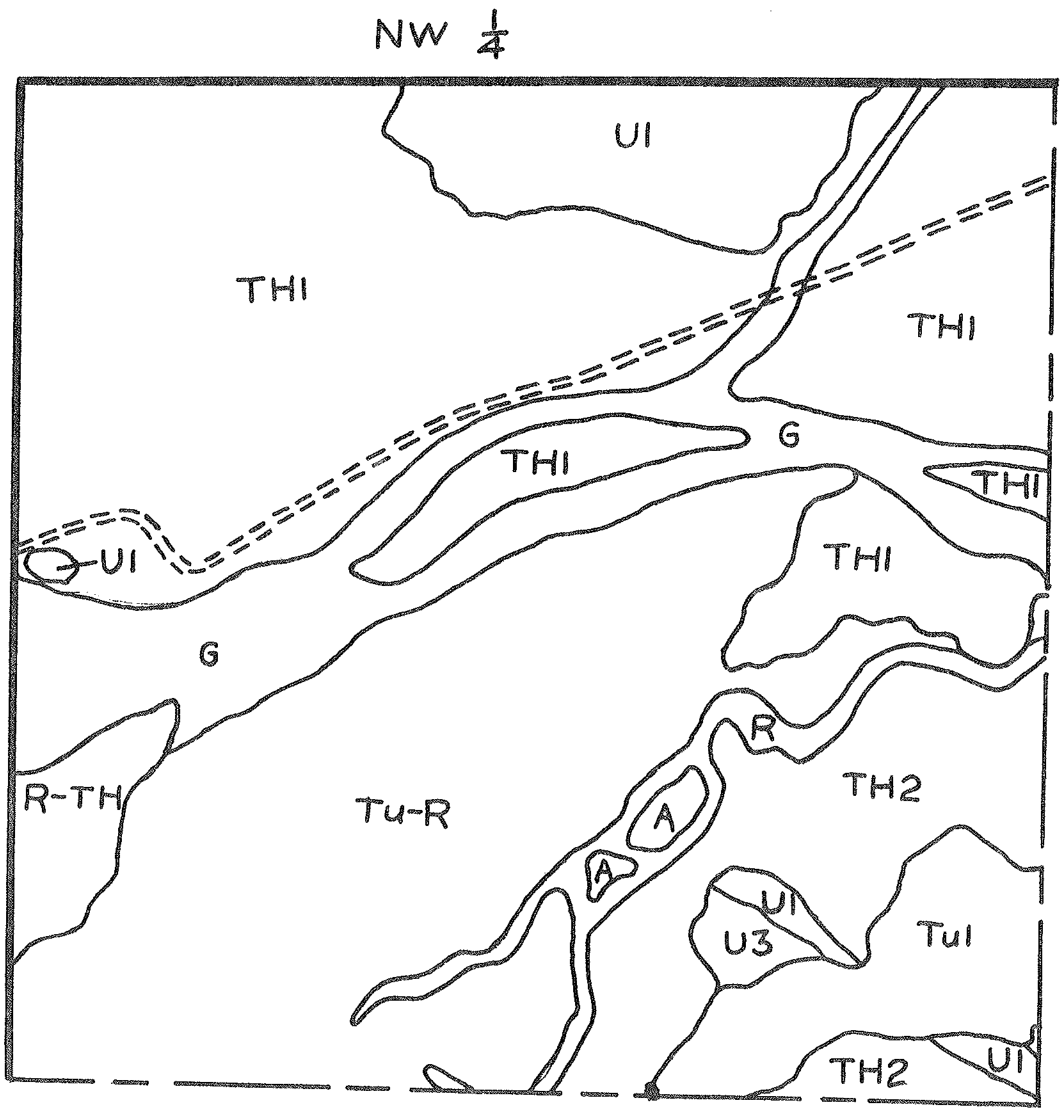


Figure 4. Soil survey map of the Silverbell Validation Site, northwest quarter. See text for legend of symbols.

G. HYDROLOGIC MODELS

A watershed model has been developed which will be tested with the data collected using the Silverbell plume installation. Sufficient validation data have not been collected with the installation at this time. However, model predictions were compared with actual data from a similar watershed in the Tucson Basin for which long-term records were available.

Watersheds in the Sonoran Desert such as those in the Tucson Basin in Arizona are characterized by a subdued topography, sparse vegetation, the absence of soil surface cover, high evaporation rates and infrequent rainfall. Runoff is almost entirely the product of overland flow, most of which is quickly lost by transmission in the highly permeable sandy channels which dissect the region. Interception is negligible and is more a redistribution of rainfall by the characteristic funnel-shaped vegetation than an actual loss.

Rainfall generally occurs during two distinct periods that are separated by prolonged dry spells. Cyclonic storms prevail from December through March and normally have low intensities and long durations. High intensity, short duration convection storms occur primarily during July and August and September. These storms have the greatest potential for producing ephemeral runoff.

The processes selected for modelling desert watersheds are shown in Figure 1. The arrows represent flow processes and the rectangles storages. The input, rainfall, is first operated on by interception. The rainfall then reaching the soil surface starts to fill small depressions which allows water to build up on the surface without contributing to overland flow. The rate at which depression storage is satisfied is the difference between rainfall intensity and the infiltration rate. Once depression storage is satisfied, water is available for surface detention storage.

Interception and depression storage are grouped together since they are both considered in the model as subtractions from water available for runoff. Interception is an abstraction from rainfall input. Depression storage is subtracted from excess rainfall. Depression storage may be satisfied and depleted several times during a storm.

The model calculates infiltration rates using a form of Philip's equation. The effects of low rainfall intensities during a storm may be accounted for as well as antecedent moisture. The equation used for calculating infiltration is:

$$\text{Infiltration} = (\text{Saturated conductivity}) \times \left(1 + \frac{\text{Soil suction}}{\text{Depth}}\right)$$

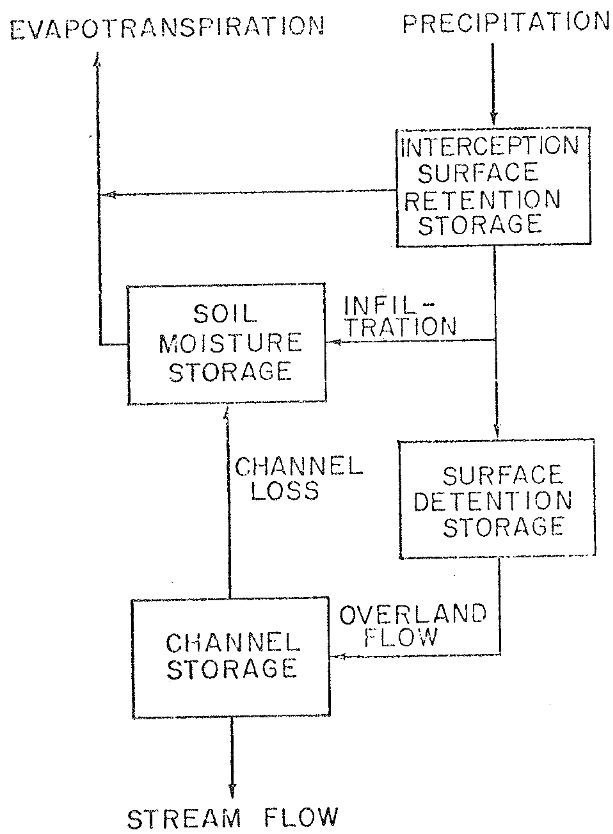


Figure 1. Qualitative hydrologic model of a small desert watershed.

When the rainfall rate equals or exceeds the infiltration rate, the rate of wetting behind the wetting front is assumed to be equal to the saturated conductivity. The rate of advancement of the front is calculated by the ratio of infiltration rate to the saturated moisture content minus the initial water content.

When the rainfall rate is less than the infiltration rate, wetting behind the front is assumed to be at a rate equal to rainfall rate. The rate of advancement of the front is calculated using the ratio of rainfall intensity to the unsaturated water content. Water content is calculated with Irmay's equation:

$$\text{Water content} = \left(\frac{\text{Rainfall intensity}}{\text{Saturated conductivity}}\right)^{1/3} \times \left(\text{Saturated water content} - \text{Threshold water content}\right)$$

The method used avoids the problems of dealing with time-based equations when rainfall is supplied at a rate equal to or greater than the infiltration rate.

Moisture, even from the larger storms, seldom penetrates much more than a foot into the soil in the uplands of the region. Because the test watershed was small and the channel was short, moisture infiltrating into soil moisture storage was considered an eventual loss from the system by evapotranspiration. A channel loss component, however, can be readily added.

The model computes antecedent moisture before each storm using a simple exponential depletion relationship which reduces soil moisture by a constant, less than one, for every day when no rainfall occurs. The reduction includes both the depletion by evapotranspiration and downward movement from the control zone. The value of the constant is changed throughout the year to account for seasonal differences.

Once rainfall intensity exceeds infiltration and depression storage is satisfied, water goes into surface detention storage and is simultaneously depleted by overland flow. Overland flow proceeds to the channel where it is concentrated into channel storage. Channel storage is then depleted as flow from the watershed outlet or as transmission losses into the channel bed.

Loss to the soil from surface flows, or delayed infiltration, is one of the more important processes of desert watersheds. It constitutes a redistribution of the rainfall input to soil moisture due to the increased time for infiltration when water is flowing over the surface. Thus, the rate at which flows are concentrated and the time they remain on the watershed is important in determining outflow from the watersheds. This means that watershed geometry plays and important role.

Obviously, not every rill and flow obstacle can be accounted for. However information on surface slope, degree of convergence, and length of overland flow can be obtained from watershed contours.

The watershed is segmented in the manner shown in the simplified representation in Figure 2. The channel is divided into rectangular elements of equal length. Straight lines are projected from the corners of the channel segments to the watershed divide normal to the contours. The areas bounded by adjacent lines are considered flow paths. All surface runoff originating within a flow path is assumed to flow in the direction of the intersected channel segment without crossing flow path boundary lines. If the boundary lines are not parallel, they can be extended to a point of intersection, thus forming converging or in some cases diverging sections.

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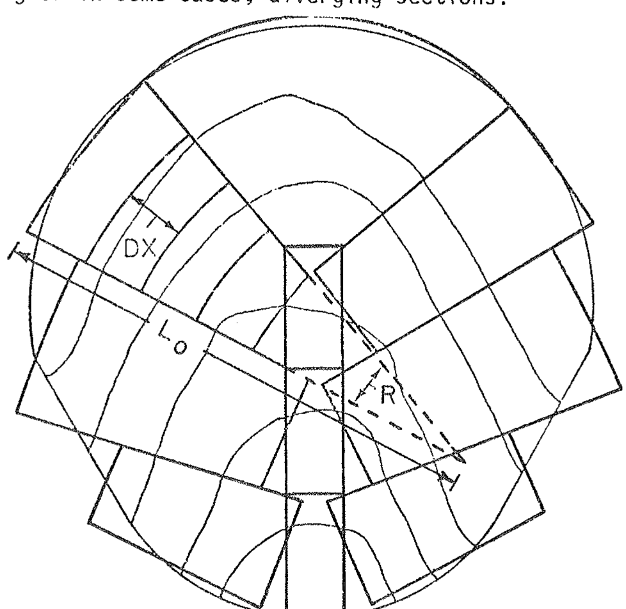

Figure 2. Segmentation of a watershed for simulating converging flows.

Each flow path is divided lengthwise into increments of equal length, DX. These increments are the basic elements for hydrologic input and flow routing procedures. Element geometry is approximated by rectangular planes. The area of any element in a flow path can be calculated from:

1. The mean distance, Lo, between the intersection of adjacent flow path boundary lines and the watershed divide.
2. The angle of intersecion, R, in radians.
3. The number of elements, n, in a flow path.

Dividing the calculated area by DX the width of the element is calculated.

Using the kinematic approximation, surface flows are routed sequentially from the watershed divide through flow path elements to the channel segment, and then down the channel segments to the watershed outlet.

Continuity of mass is maintained for each element by a finite differencing solution of the continuity equation at 30-second time increments. Flow rate is assumed a function of mean surface detention depth, and is calculated using Manning's equation. The cascade of planes of varying width serves as an approximation for the concentration of flow. The unit width inflow into a particular element from the unit width outflow of the upslope element is increased by the ratio of the upslope to downslope width.

Segmenting a watershed serves more than providing a flow routing structure and simulating flow convergence. It allows each element to be individually characterized by soil, slope and vegetation or what have you. Thus, the distributive properties of the watershed can be simulated. But just as important, the delayed infiltration on the slopes and the transmission losses in the channels can be simulated.

The model requires the 14 parameters shown in Table 1. The first six are determined from the geometry of the watershed. The next four were determined from measurements made by other investigators. The last three were determined form calibration. Roughness could have been obtained from a table of Manning's coefficients and an estimate of zero depression storage would have been sufficient. Soil suction is the only parameter that cannot be easily determined.

Manning's roughness coefficient, surface depression storage, and a constant representing soil suction at the wetting front of the infiltration profile had to be estimated by calibrating model output with measurement runoff.

The model was applied to a 16-acre experimental watershed near Tucson. Three runoff events were used for calibration, two of which are shown in Figures 3 and 4. Four criteria were used in calibration: peak flow rate, time to peak, duration of flow, and runoff volume.

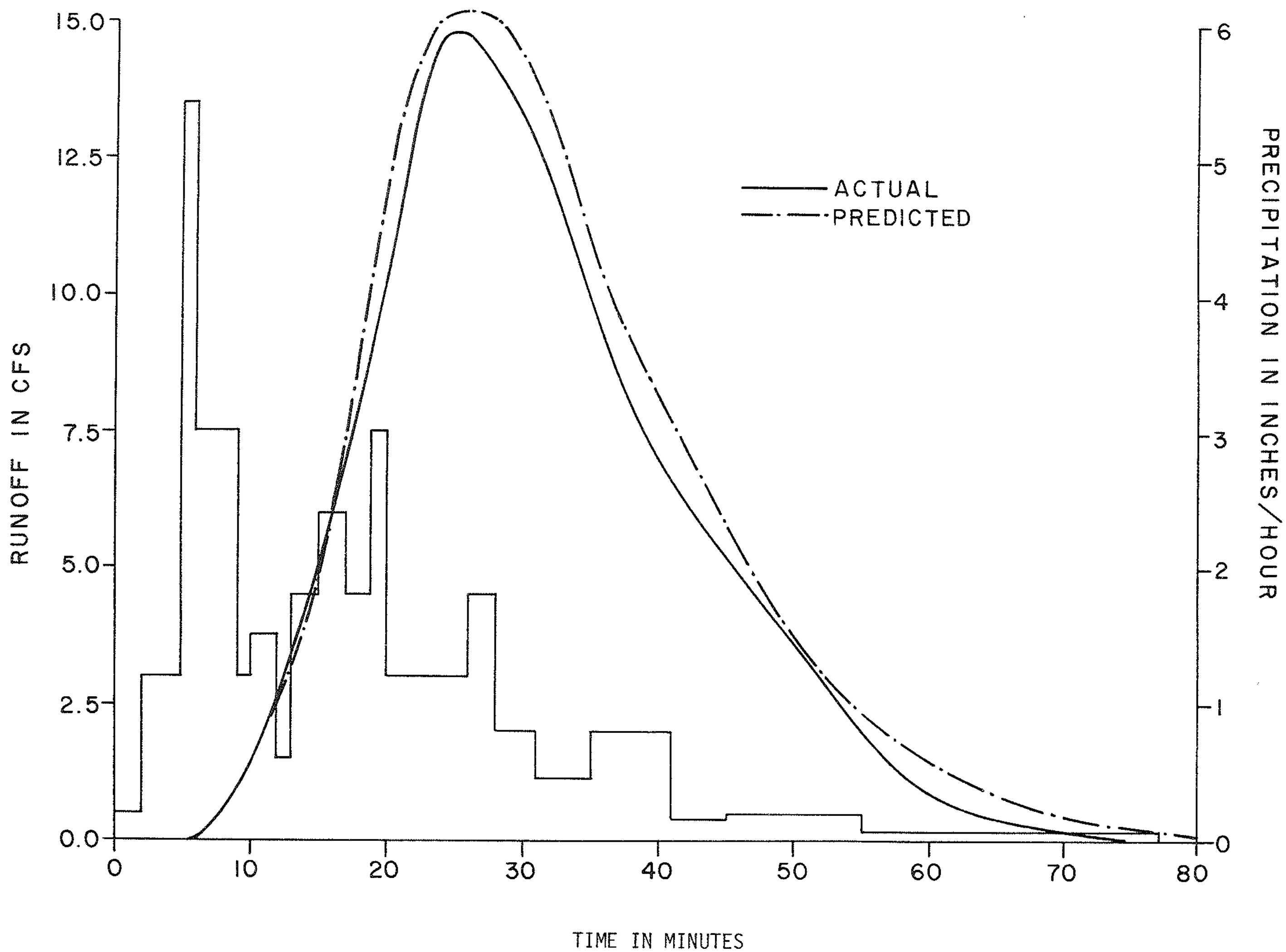

Figure 3. Runoff hydrograph for Atterbury watershed HL-2, July 21, 1970.

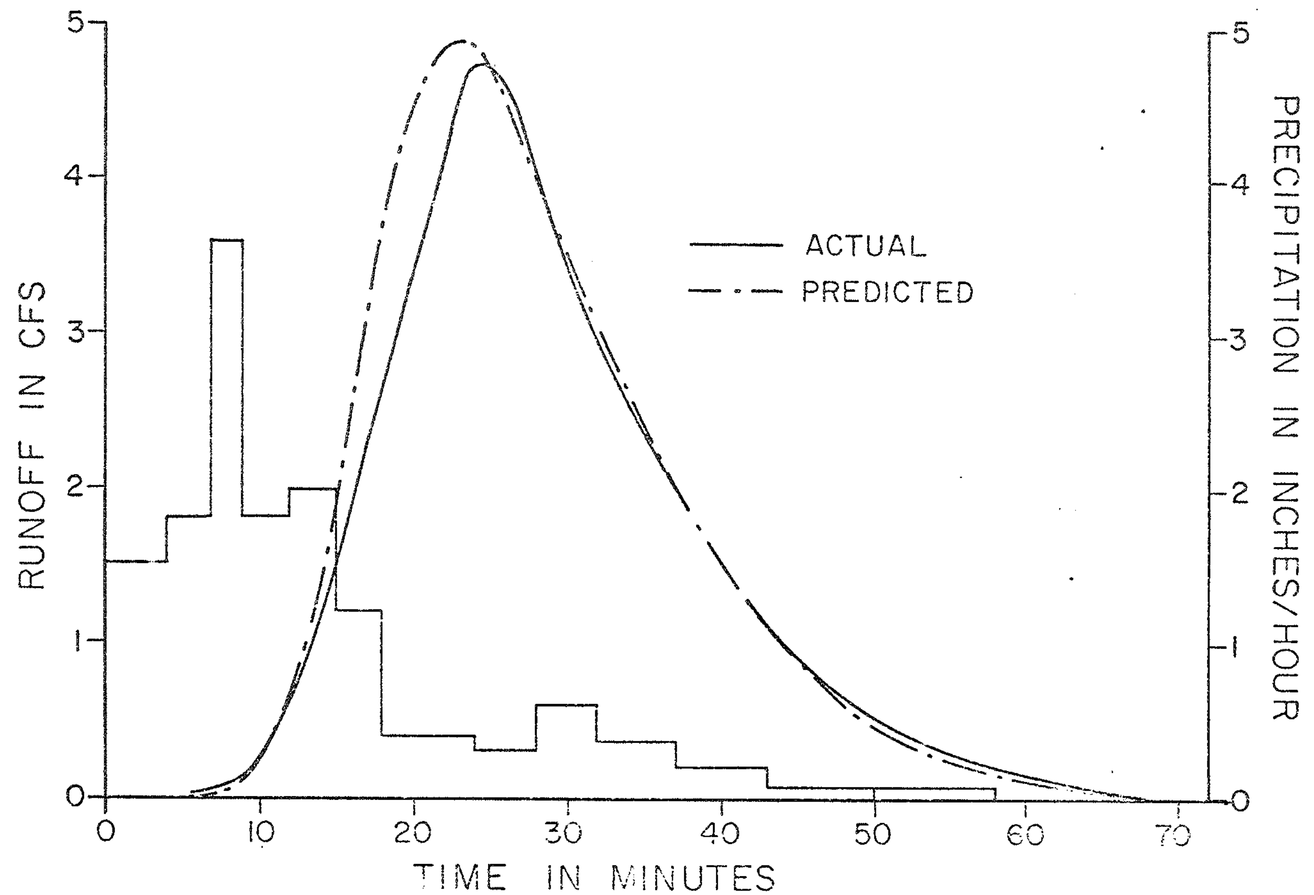

Figure 4. Runoff hydrograph for Atterbury watershed HL-2, August 7, 1969.

Table 1. Listing of 14 parameters for segmenting watershed elements which allows for individual characterization and simulation of distributive properties.

<u>Determined from watershed activity</u>	
Distance of Divide to Channel	
Number of Elements in Flow Path	
Angle of Convergence	
Slope of Elements	
Length of Channel Elements	
Width of Channel Elements	
<u>Measured independently</u>	
Interception	0
Soil Porosity	.35
Hydraulic Conductivity	.15 in./hr
Infiltration Capacity	.15 in./hr
<u>Determined from calibration</u>	
Depression Storage	.0007 ft.
Soil Suction at Wetting Front	4 in.
Roughness	
Upland	.035
Channel	.040

After values were assigned to the parameters, the results were validated by applying the calibrated model to an entire year of rainfall data and comparing model output with observed runoff. All parameters were given the values derived from the calibration and held constant throughout the year; antecedent moisture, of course, being the exception.

Results, in general, were very satisfactory as shown in Figures 5 through 8 for several major runoff events that occurred during the year. For storms with peak flows greater than one c.f.s., runoff volume was predicted within 14% of that observed and peak flow rates within 18%.

Storms with peak flow rates less than one c.f.s. were predicted less precisely on a percentage basis, as expected. Predictions ranged from 115% over to 50% under the observed runoff. Peak flow rates for these storms were overpredicted; on one occasion by 60%. None of the small storms yielded volumes greater than thirteen hundredths of a watershed inch or peak rates more than one half c.f.s., which explains in part the high percentage errors. However, the model simulated zero runoff for all storms which indeed did not produce runoff, and predicted total annual runoff within less than 4% of the total observed.

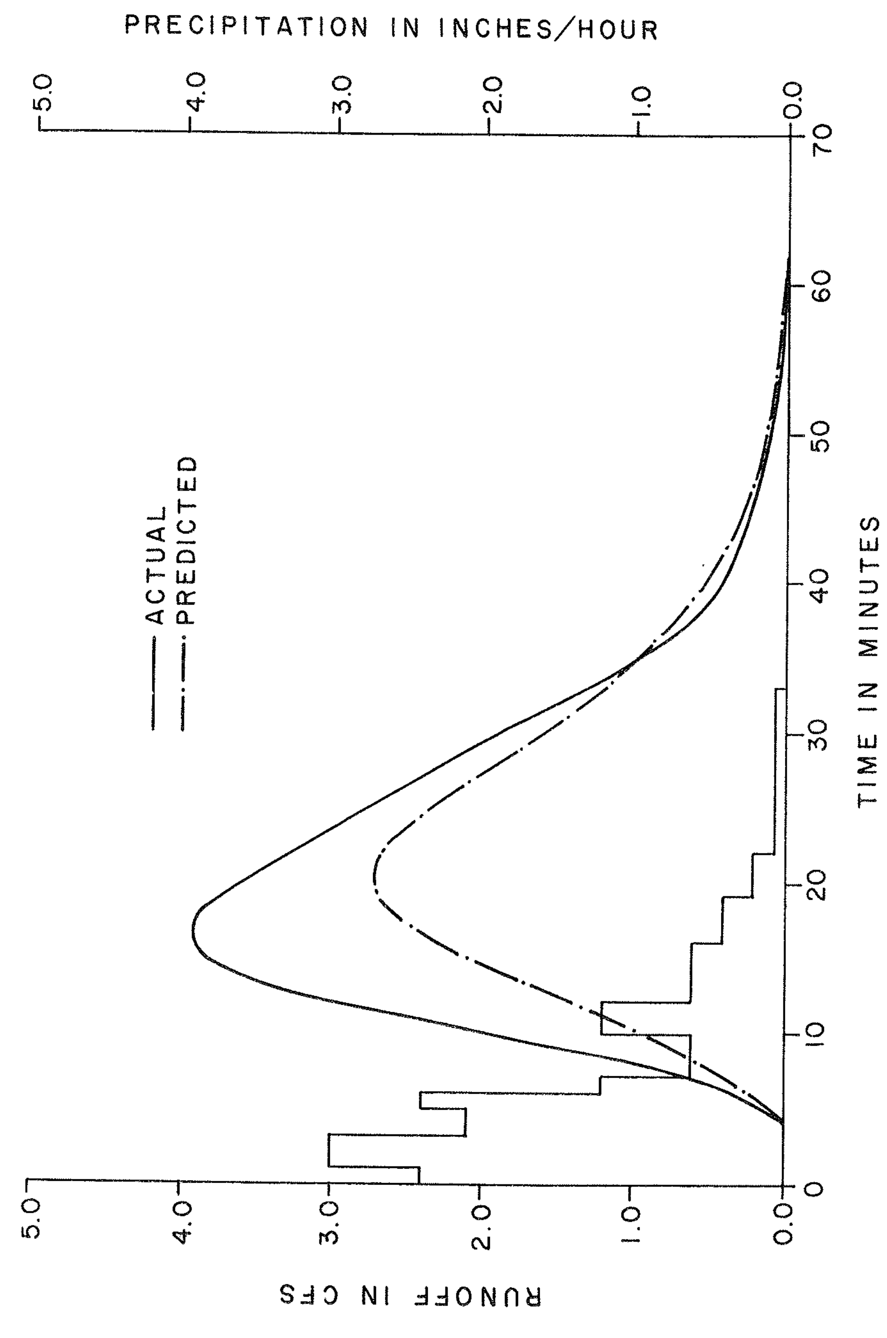

Figure 5. Runoff hydrograph for Atterbury watershed HL-2, July 8, 1970.

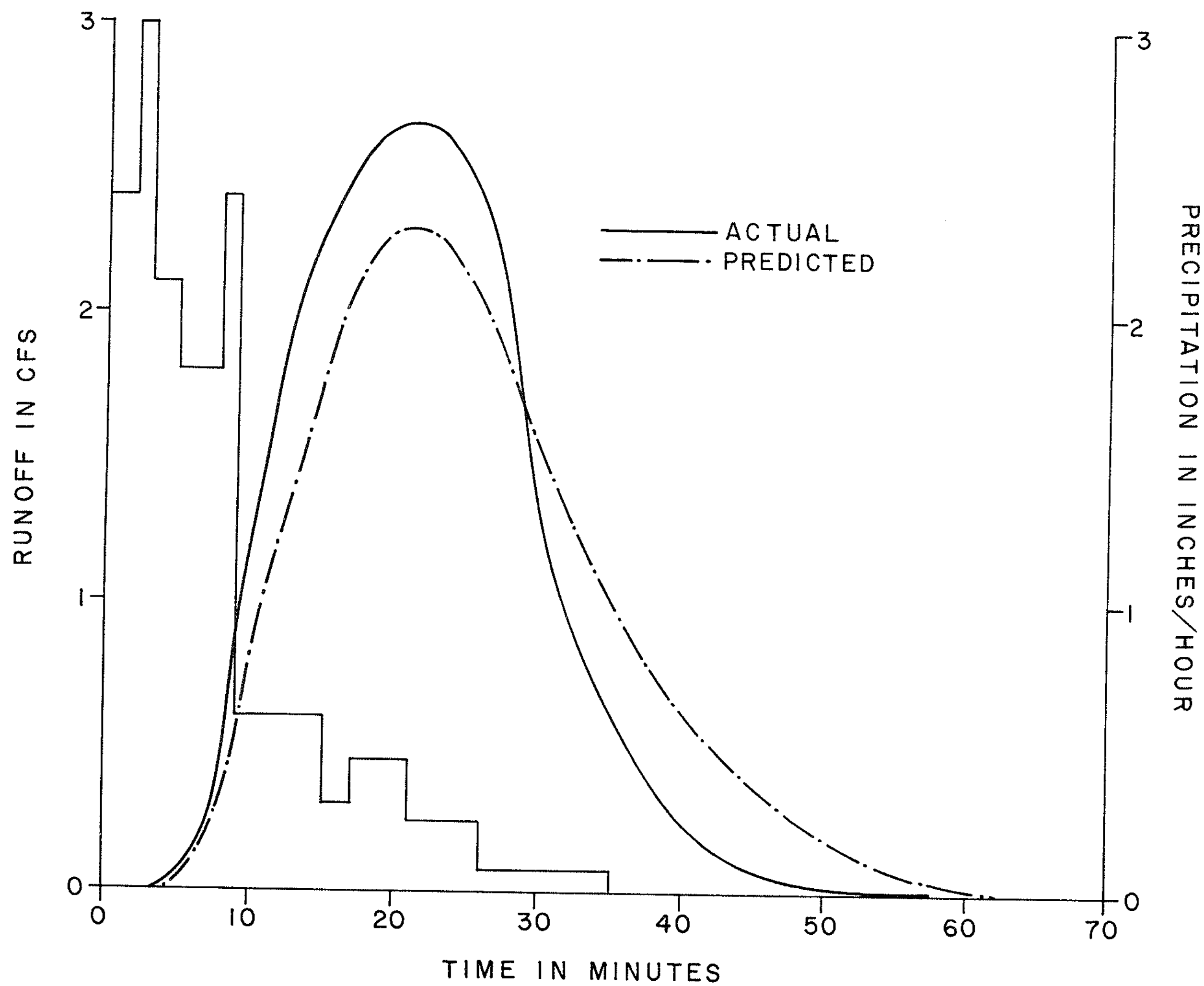

Figure 6. Runoff hydrograph for Atterbury watershed HL-2, July 31, 1972.

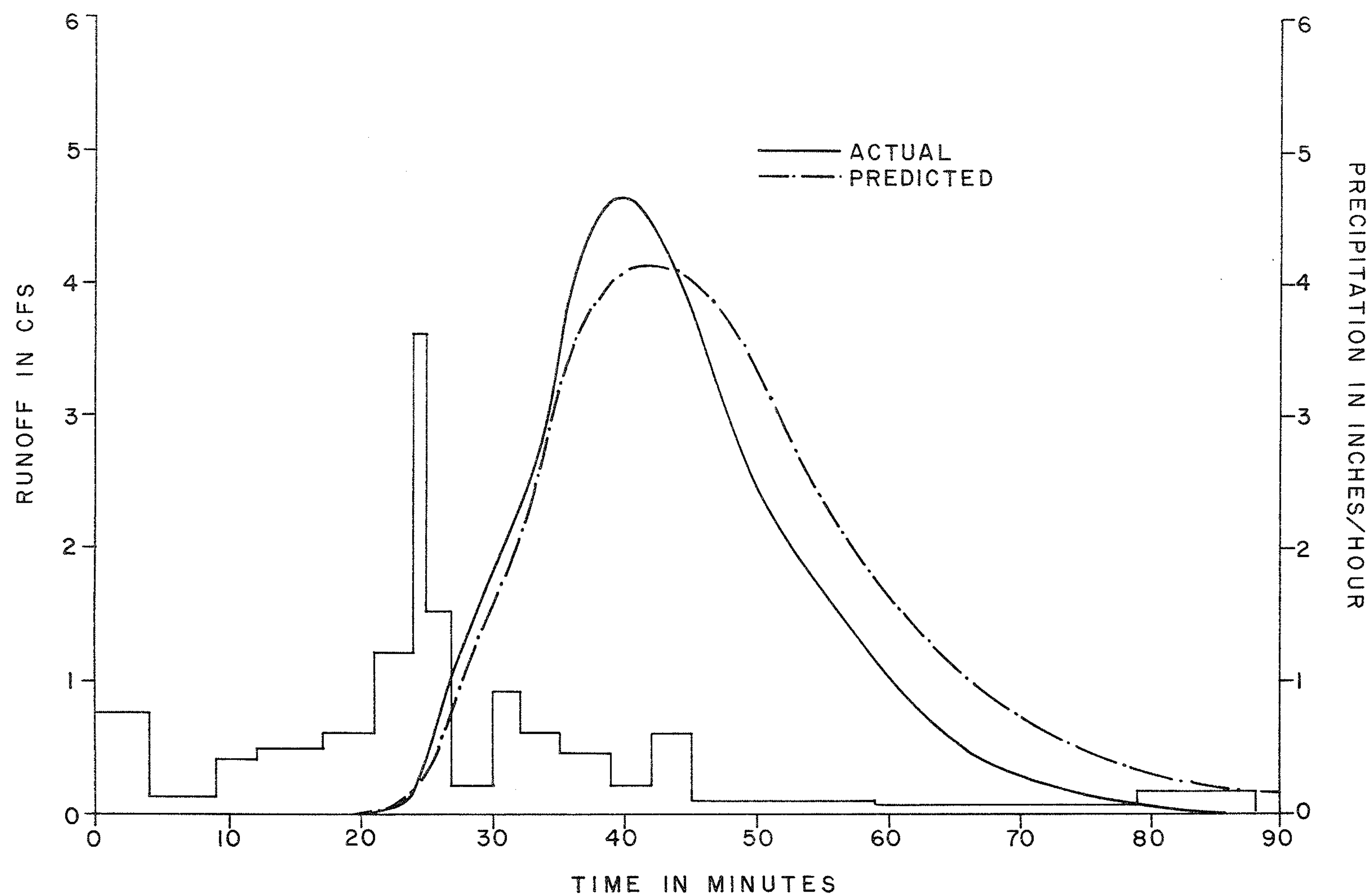

Figure 7. Runoff hydrograph for Atterbury watershed HL-2, August 1, 1970.

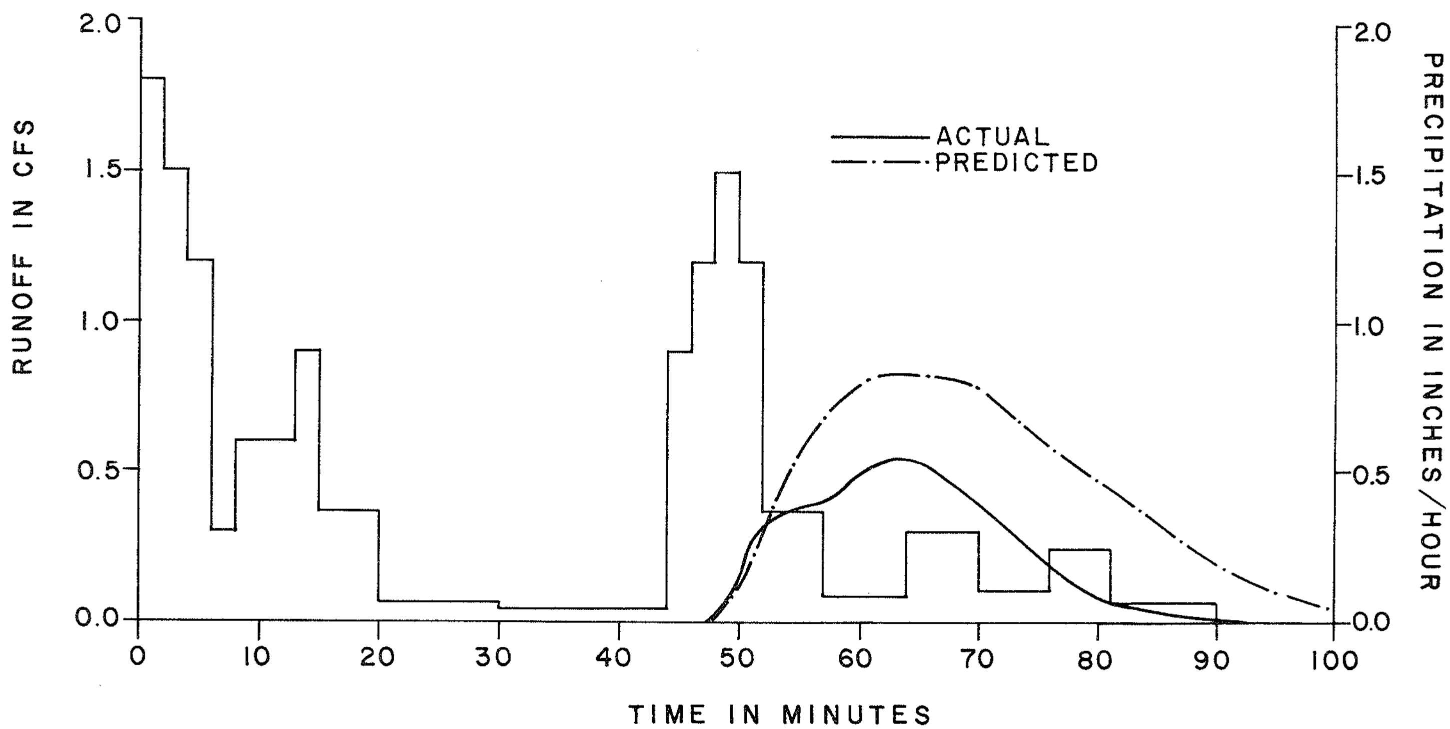

Figure 8. Runoff hydrograph for Atterbury watershed HL-2, August 14, 1970.

1972 PROGRESS REPORT

JORNADA VALIDATION SITE REPORT

Coordinator: Walter G. Whitford

New Mexico State University
Las Cruces, N. M.

Research Memorandum 73-4

MAY 1973

Report Volume 2

Page 2.2.2.4.

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.

ACKNOWLEDGEMENTS

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.

Category	Assistance in field or laboratory	Authorship in Report
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	Thomas O'Laughlin*	Gaylin Nickell[+]
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	Teri LaBlanc	
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Soils	Gaylin Nickell[+]	Gaylin Nickell[+]
Vertebrates-Birds	Stuart Pimm*	Ralph Raitt[+]
	Elisabeth Schaublin	Stuart Pimm*
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	Kenneth Hoover*	
	Phil Barbee	
	Ross Zimmerman	
	Scott Dick-Peddie	
	John Schaub	
	Barry McLaughlin	

Category	Assistance in field or laboratory	Authorship in Report
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Reptiles	Martha Whitson[+] Fenton Kay* Scott Dick-Peddie	Walter G. Whitford[+]
Arthropods	Norman Dronen* Patrick Larragoite Tom Bellows Ross Zimmerman Elisabeth Schaublin John Schaub Anthony Smith	Walter G. Whitford[+]
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Graphic Assistance	David Walters John Schaub	
Secretarial Assistance	Marie Spellenberg	
Key Punch	Barbara O'Brien	

[+] Faculty

* 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		

FINDINGS

CONTENTS

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.		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.

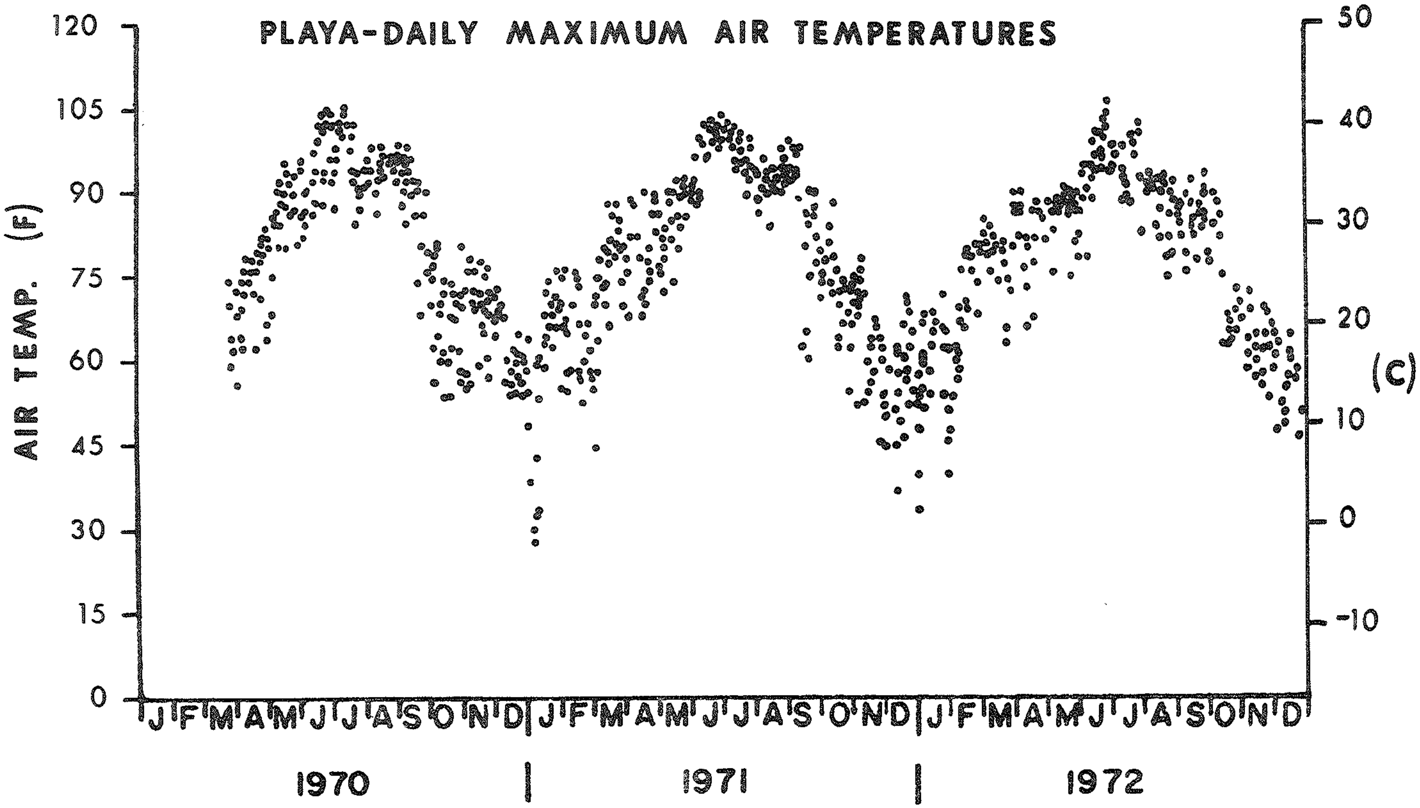

Figure 1. Daily mean air temperature for 1970, 1971 and 1972 at the playa.

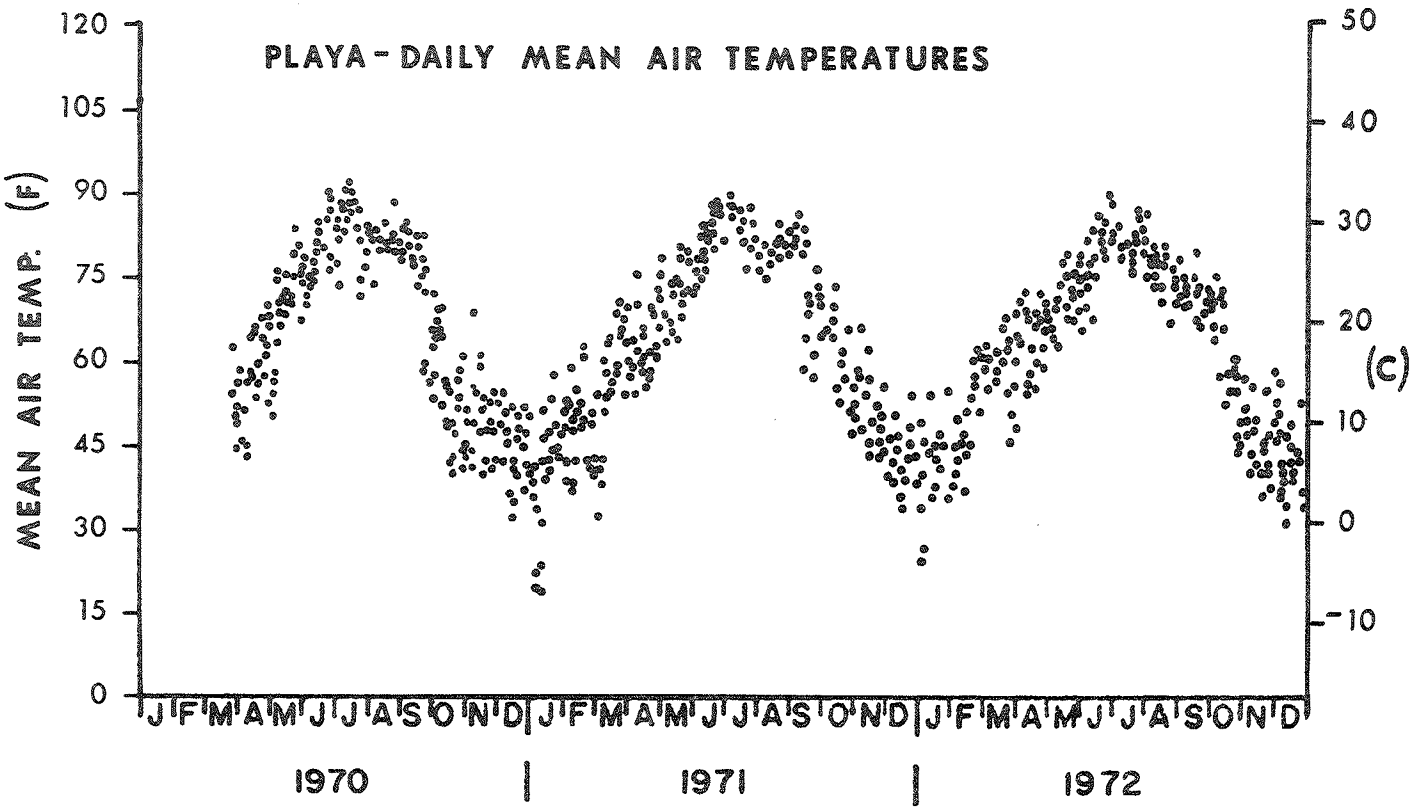

Figure 2. Daily maximum air temperatures for 1970, 1971 and 1972 at the playa.

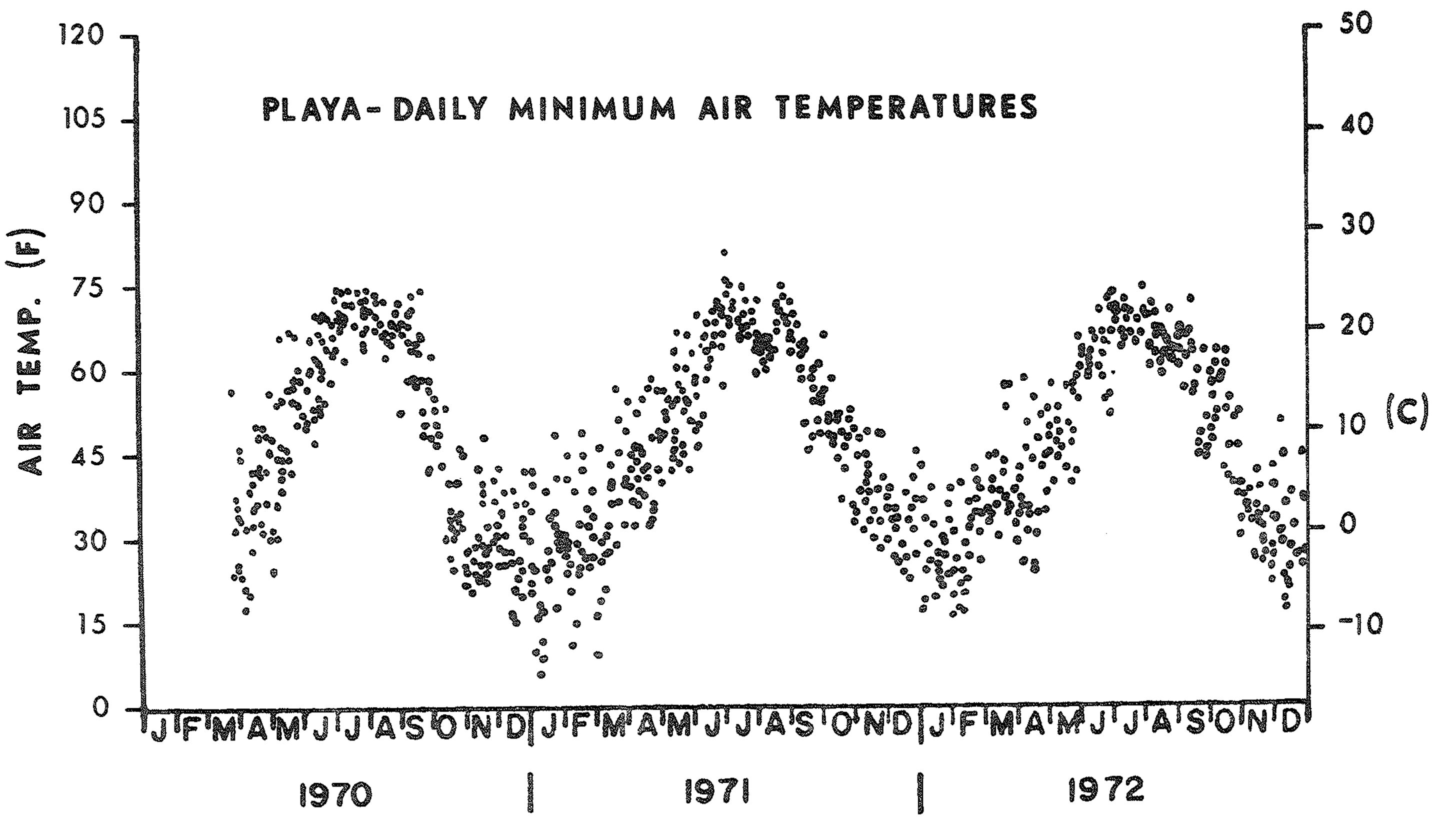

Figure 3. Daily minimum air temperatures for 1970, 1971 and 1972 at the playa.

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.

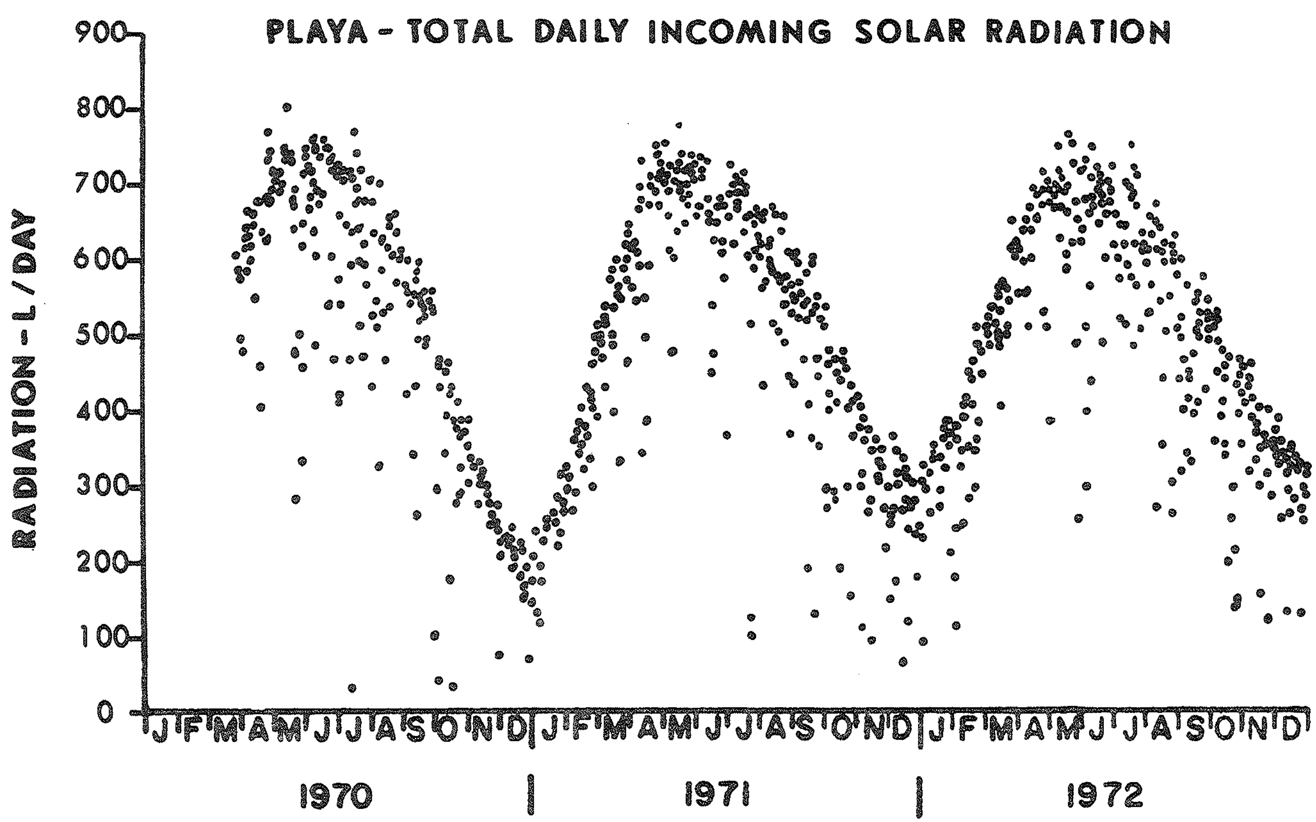

Figure 4. Daily total incoming solar radiation (langleys/day) for 1970, 1971 and 1972 at the playa.

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.

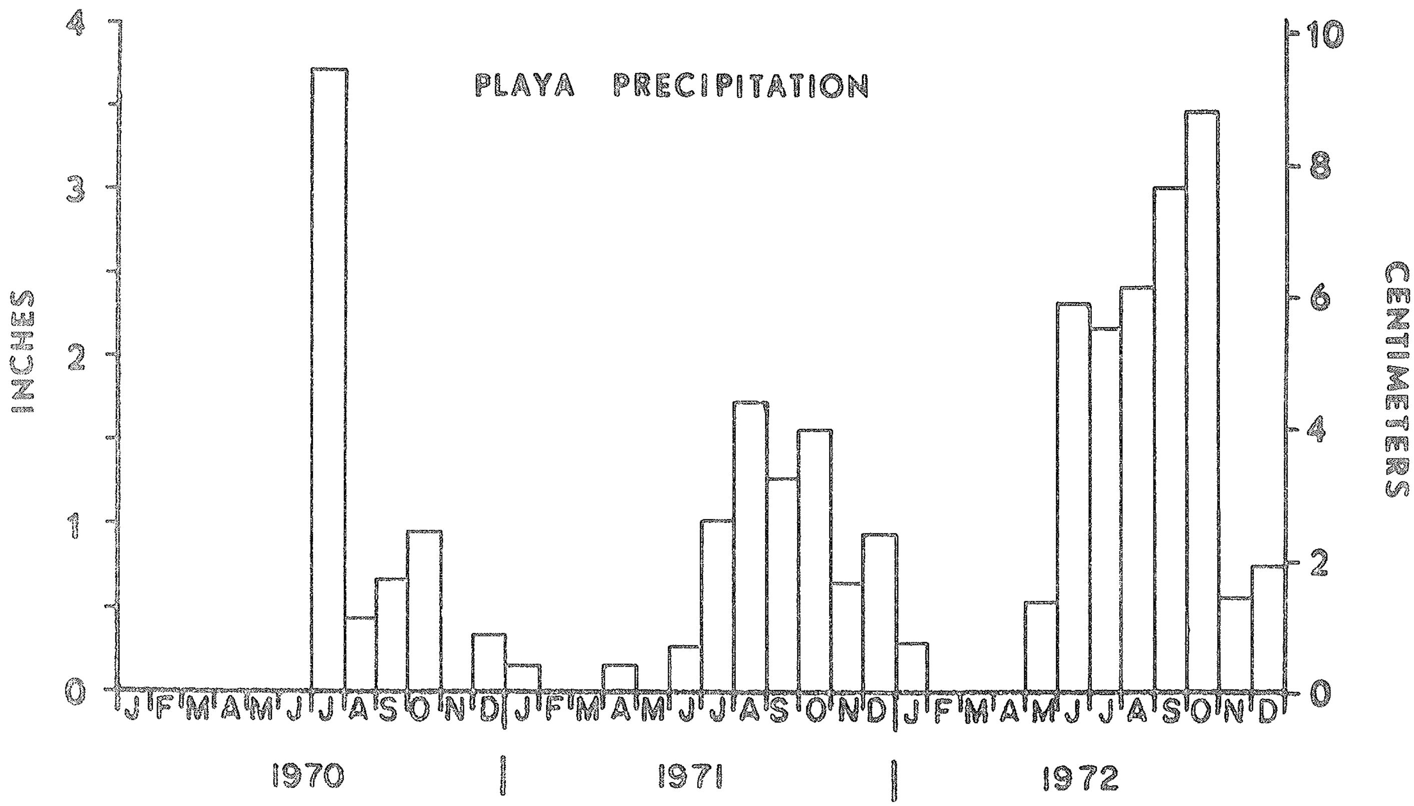

Figure 5. Monthly total precipitation patterns for 1970, 1971 and 1972 at the playa.

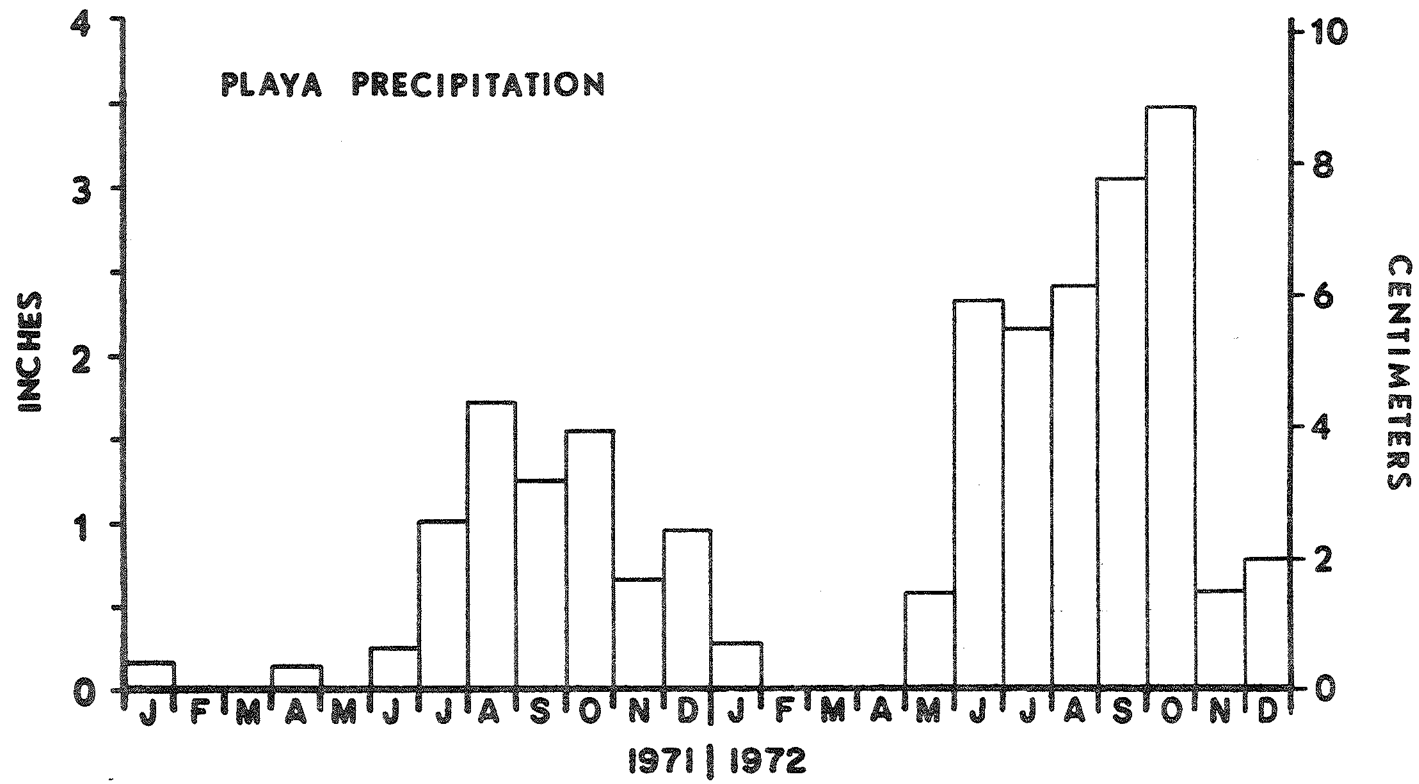

Figure 6. Monthly total precipitation patterns for 1971 and 1972 at the playa.

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.

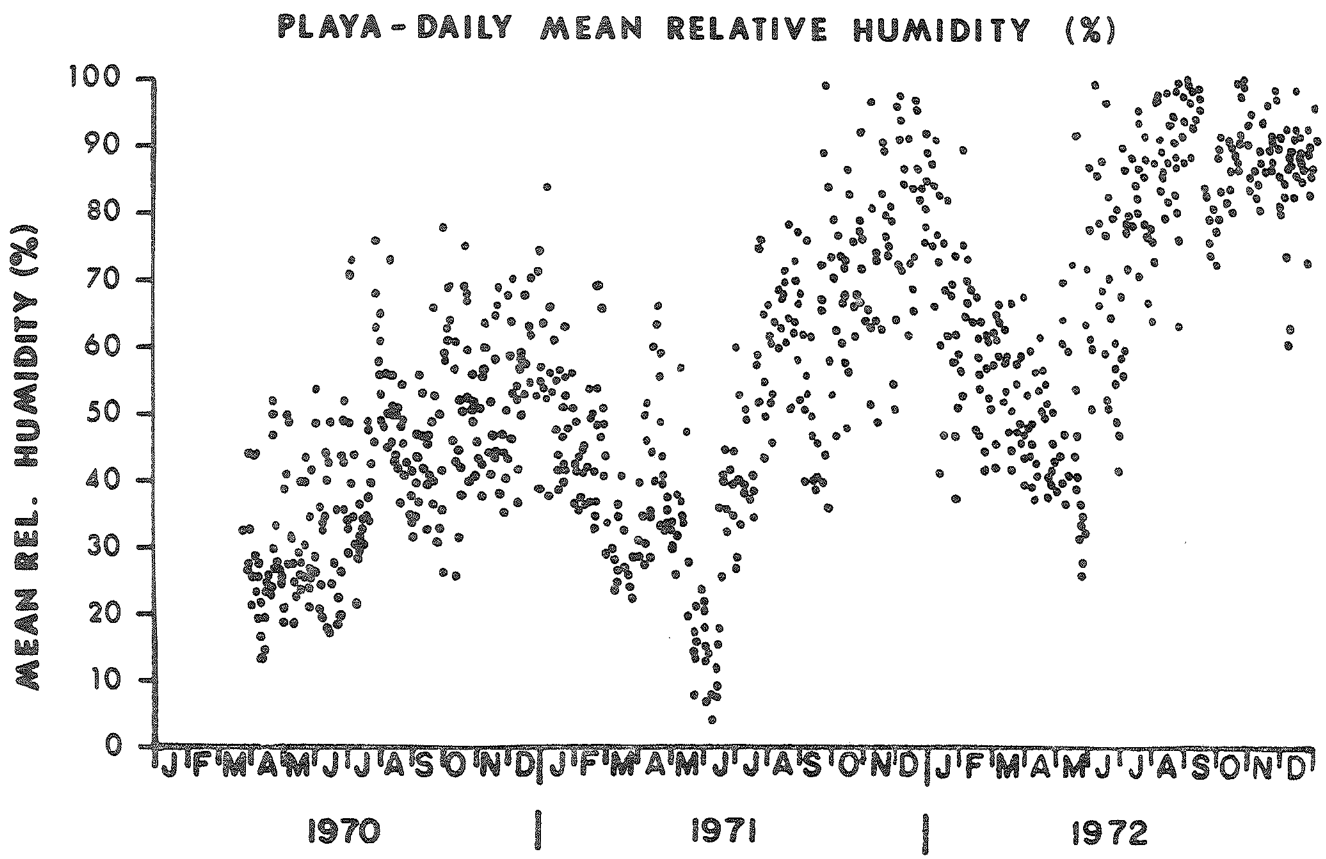

Figure 7. Daily mean relative humidities for 1970, 1971 and 1972 at the playa site.

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).

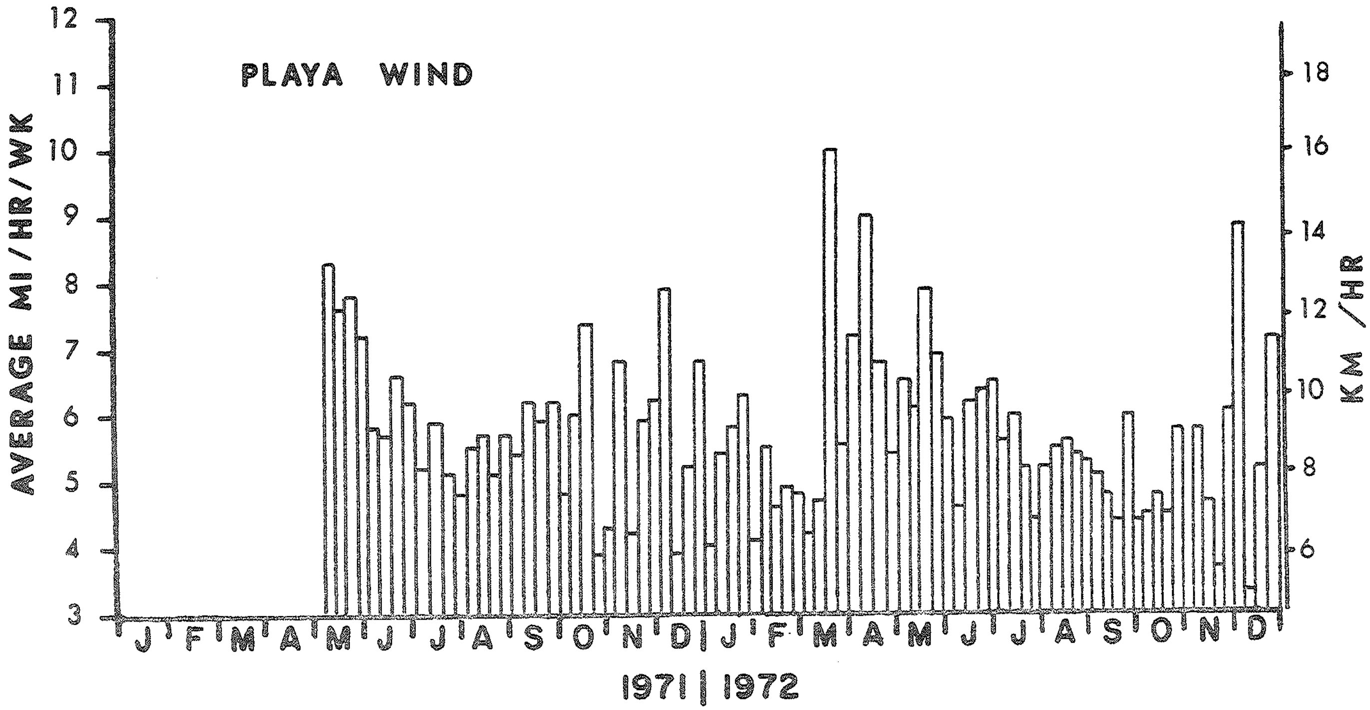

Figure 8. Average wind speed (miles/hr/week) on the playa site in 1971 and 1972.

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.

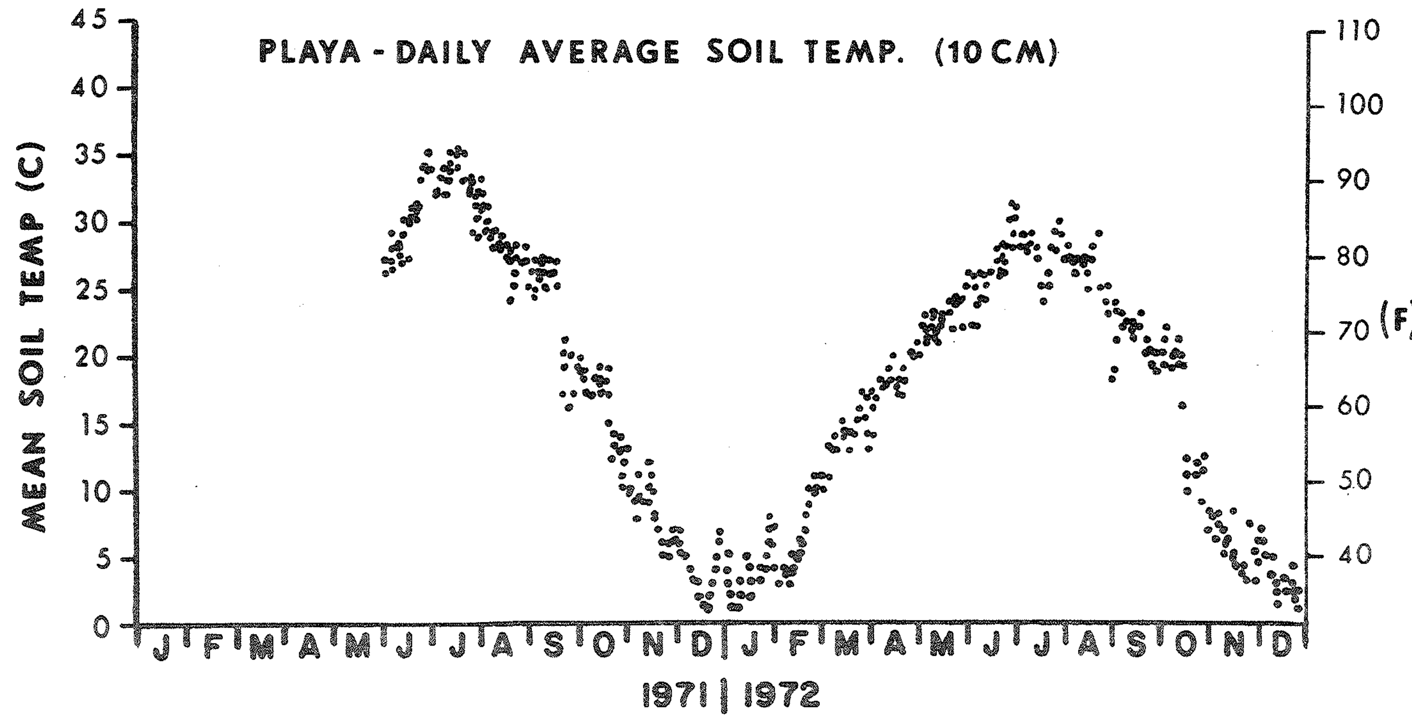

Figure 9. Daily mean soil temperatures at 10 cm for 1971 and 1972 at the playa site.

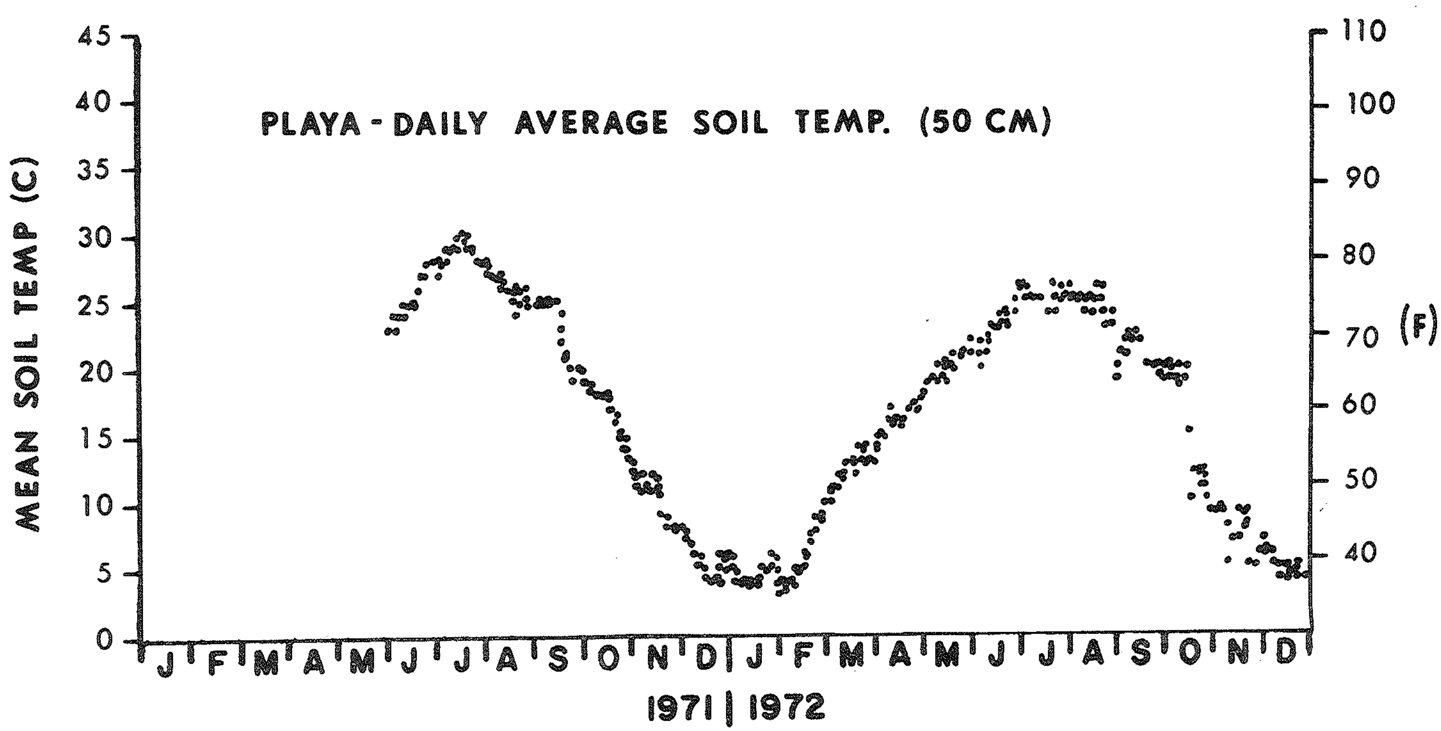

Figure 10. Daily mean soil temperatures at 50 cm for 1971 and 1972 at the playa site.

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

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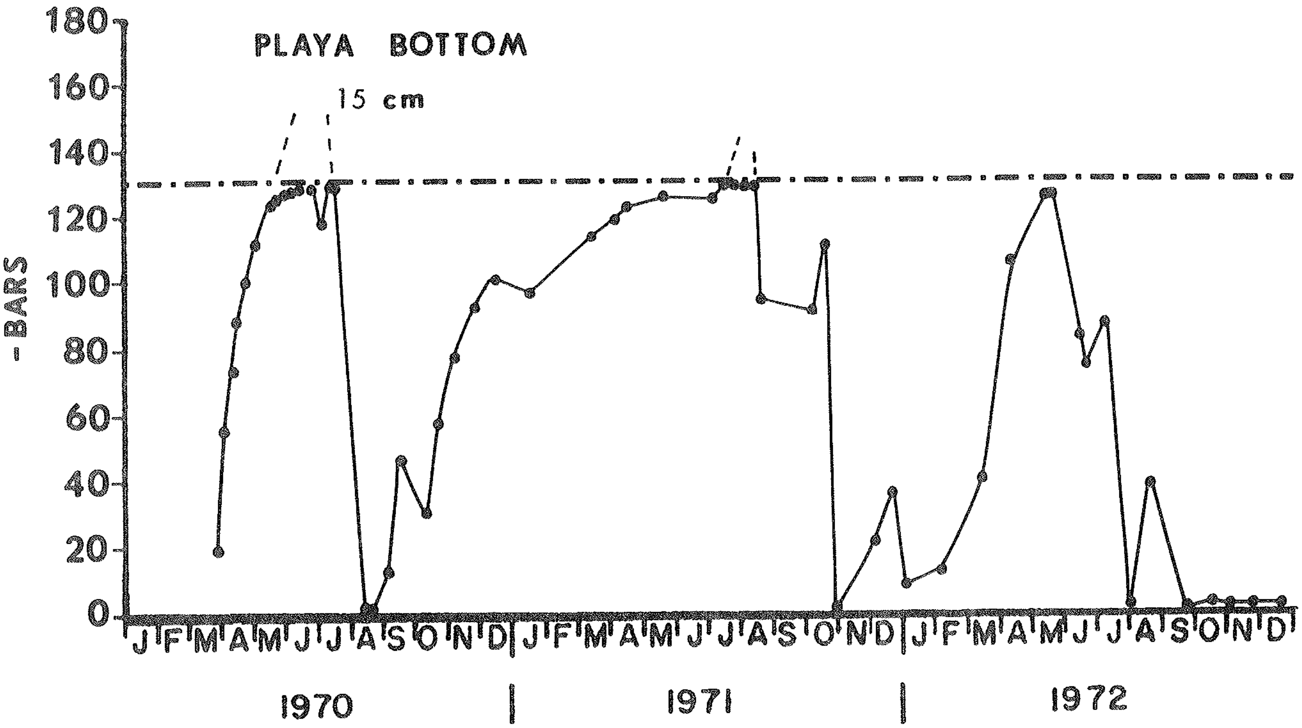

Figure 11. Soil water potentials at 15 cm for 1970, 1971 and 1972 on the playa botto bottom (vine-mesquite grass area).

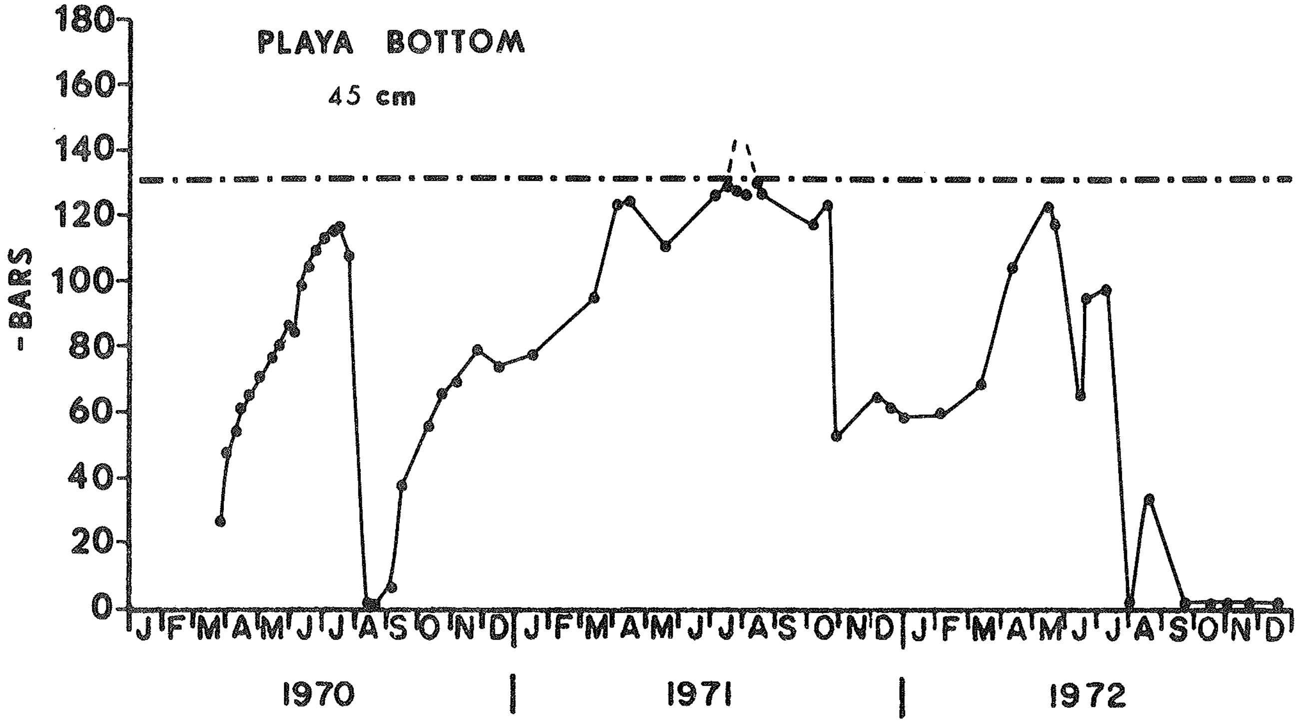

Figure 12. Soil water potentials at 45 cm for 1970, 1971 and 1972 on the playa bottom (vine-mesquite grass area).

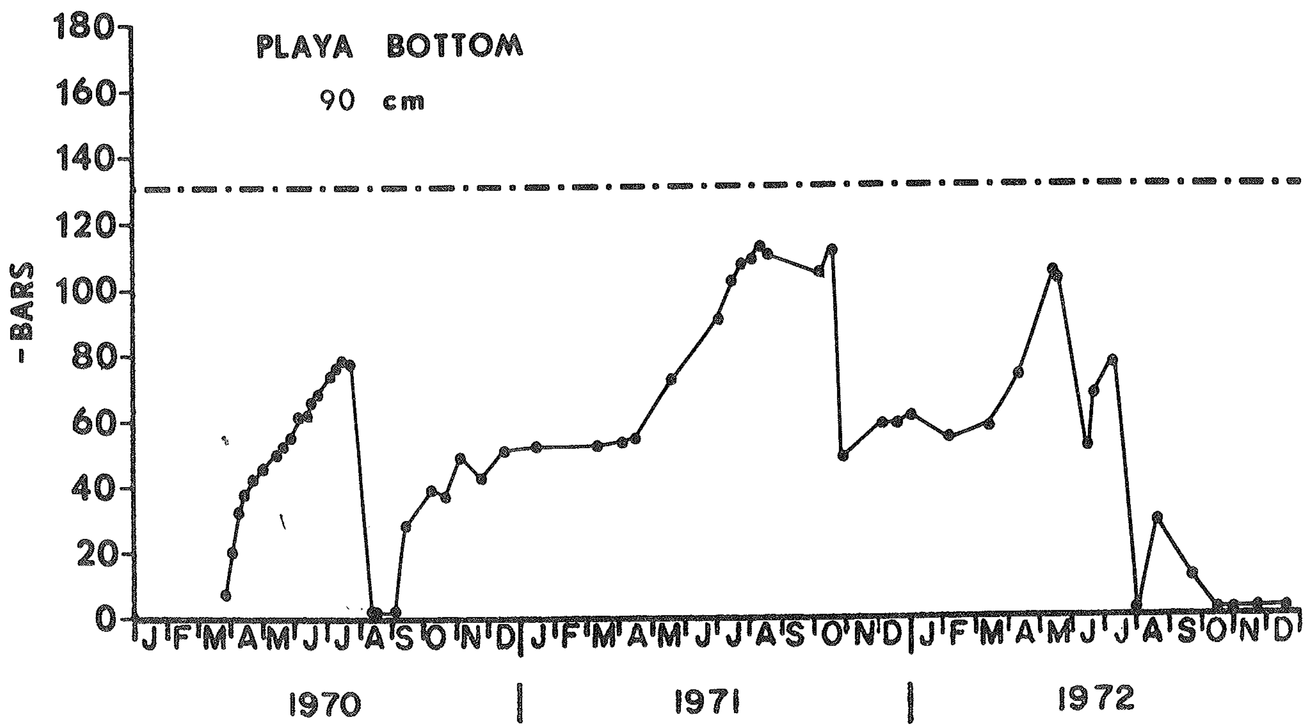

Figure 13. Soil water potentials at 90 cm for 1970, 1971 and 1972 on the playa bottom (vine-mesquite grass area).

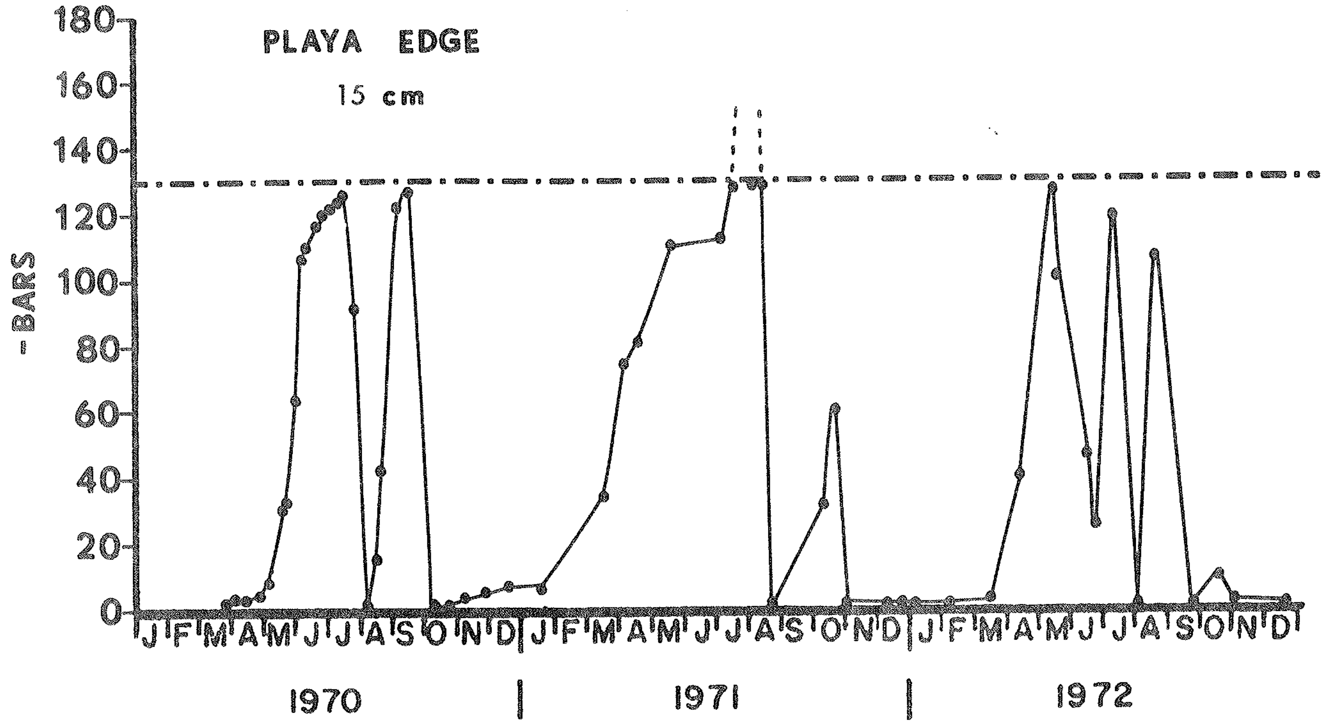

Figure 14. Soil water potentials at 15 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

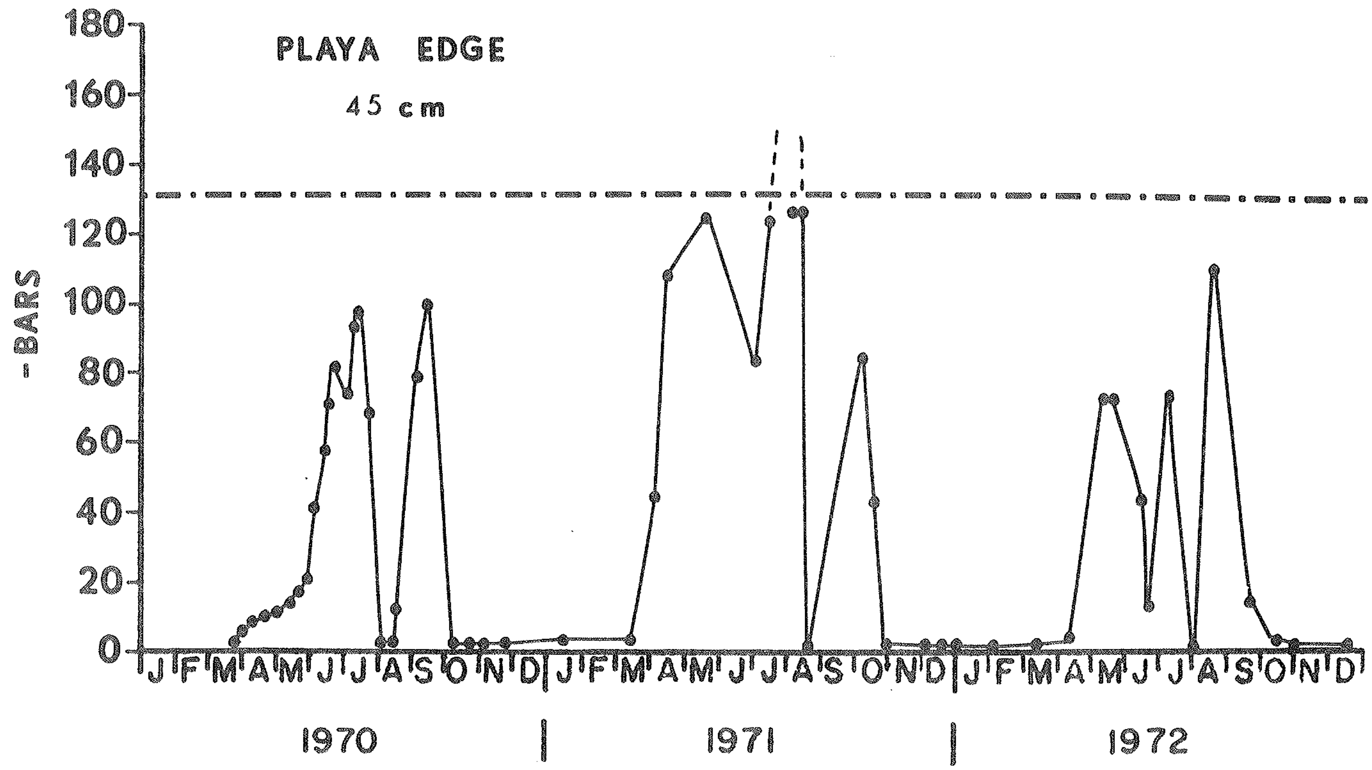

Figure 15. Soil water potentials at 45 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

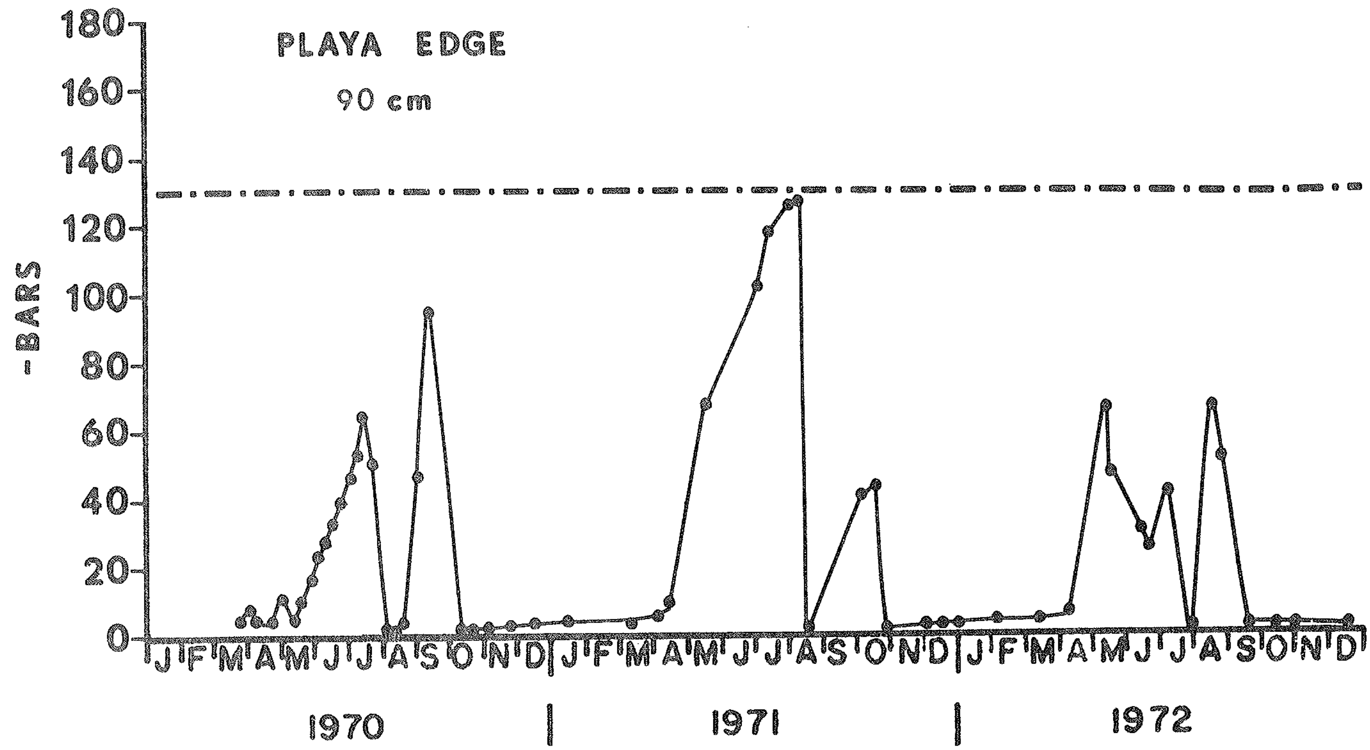

Figure 16. Soil water potentials at 90 cm for 1970, 1971 and 1972 on the playa edge (tobosa grass area).

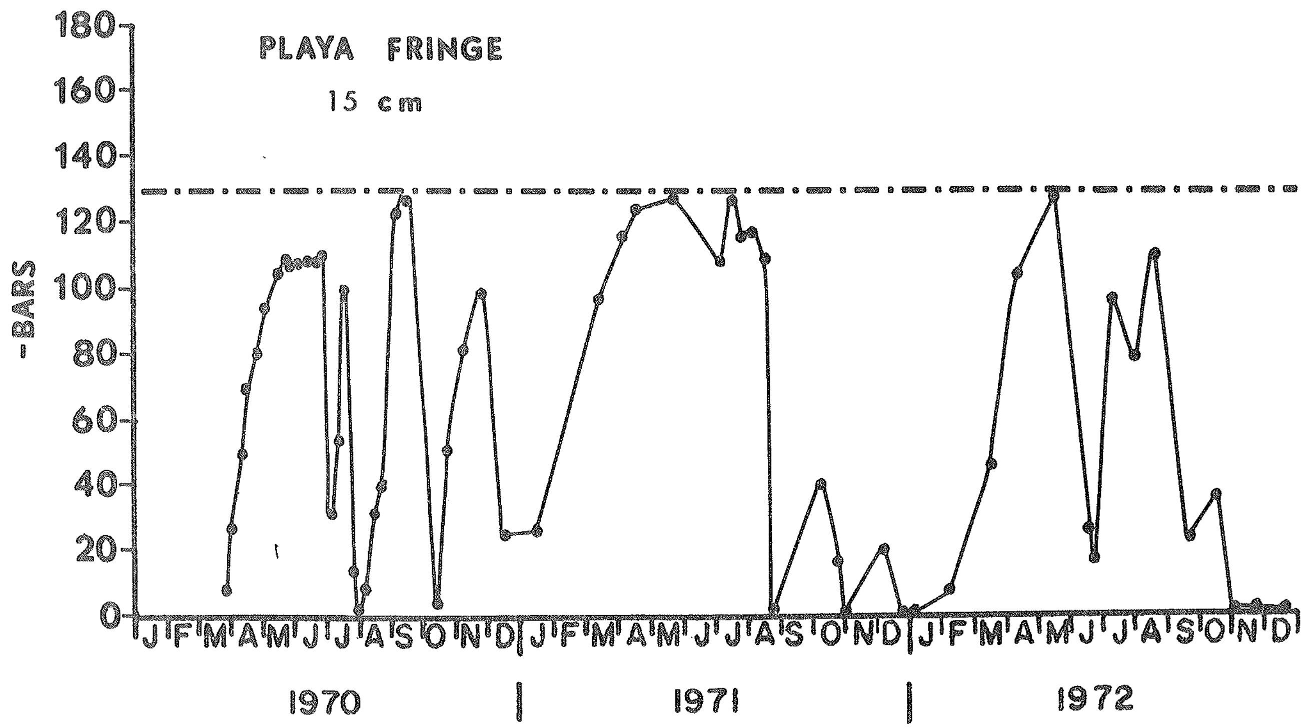

Figure 17. Soil water potentials at 15 cm for 1970, 1971 and 1972 around the playa fringe.

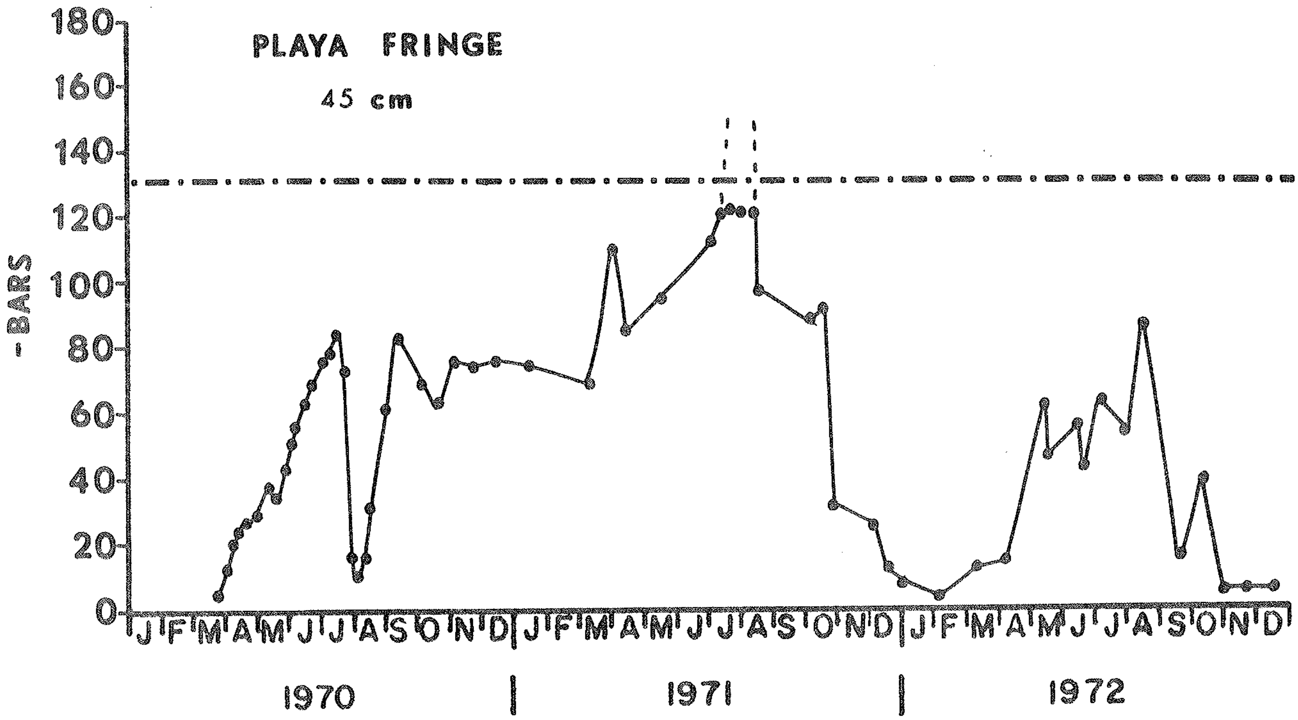

Figure 18. Soil water potentials at 45 cm for 1970, 1971 and 1972 around the playa fringe.

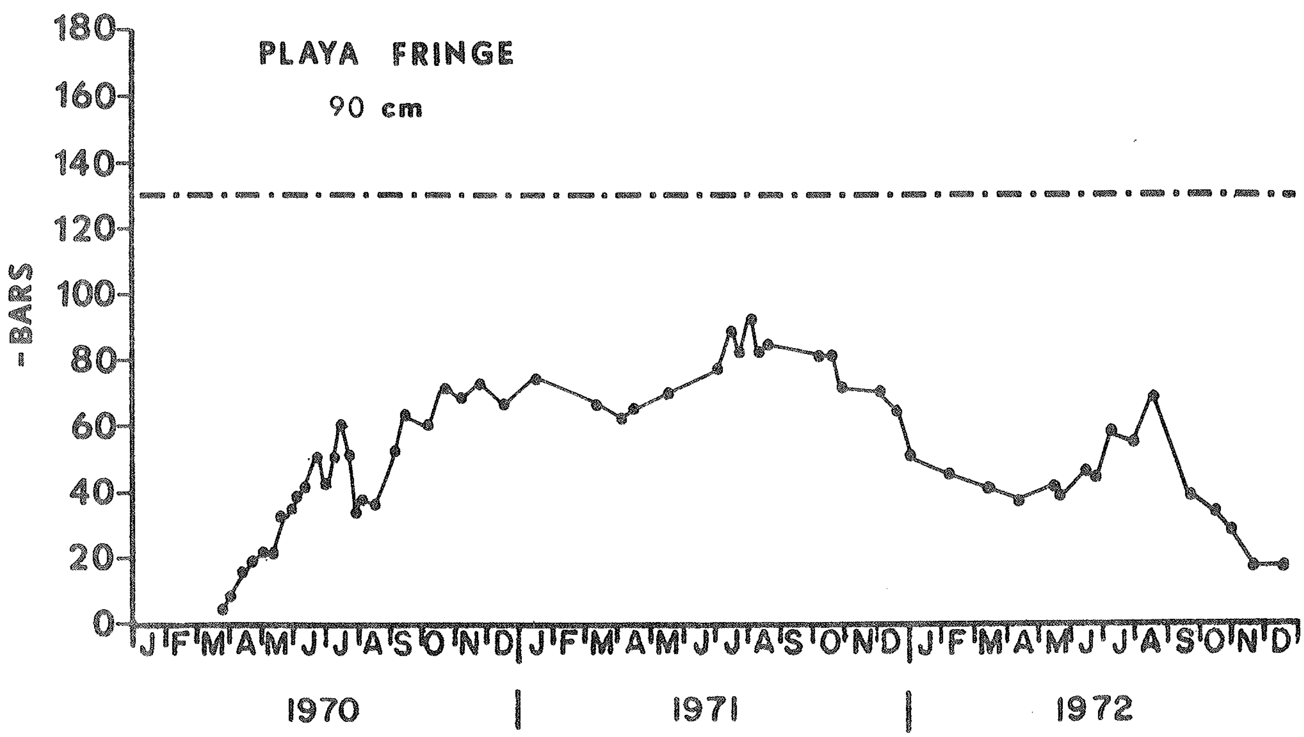

Figure 19. Soil water potentials at 90 cm for 1970, 1971 and 1972 around the playa fringe.

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 specie , 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)			
	1971	1972		
Species	6 October	27 June	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.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 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)

Species	1970 10 July	1970 2 October	1971 6 October	1972 27 June	1972 22 August	1972 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.

Species	Density (no. per hectare) 1971 6 October	1972 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.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 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 10 Jul.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 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)

Species	1970		1971		1972	
	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

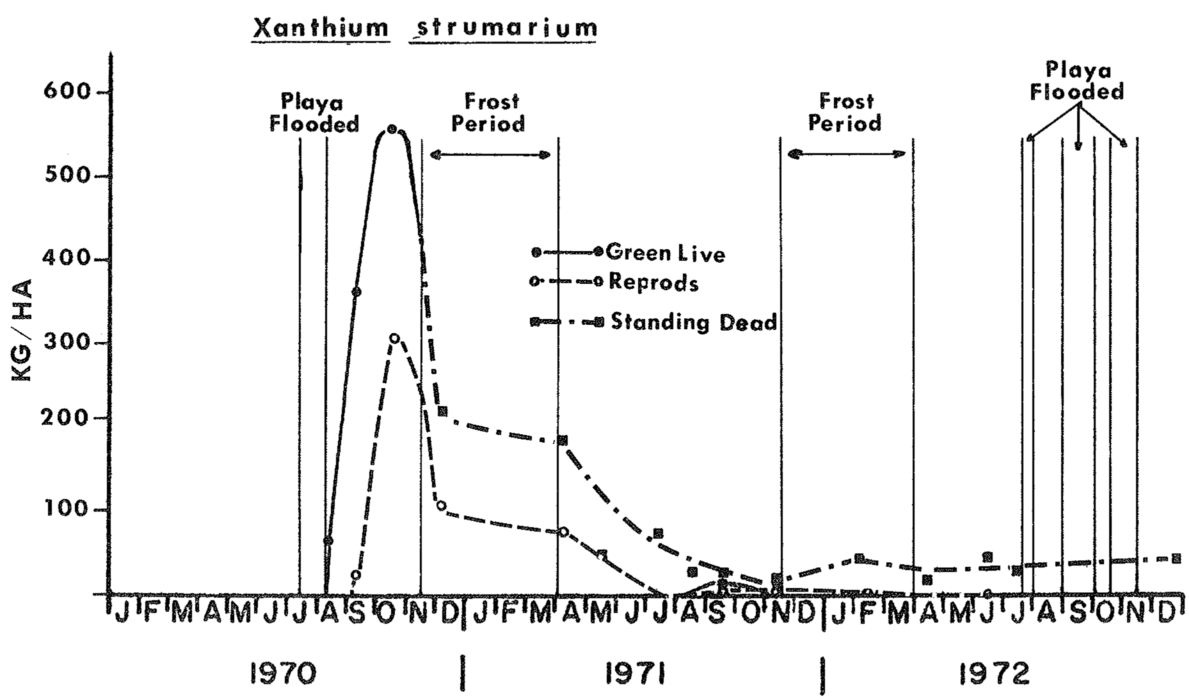

Figure 1. Biomass components of cocklebur (*Xanthium strumarium*) for 1970, 1971 and 1972 on the playa bottom.

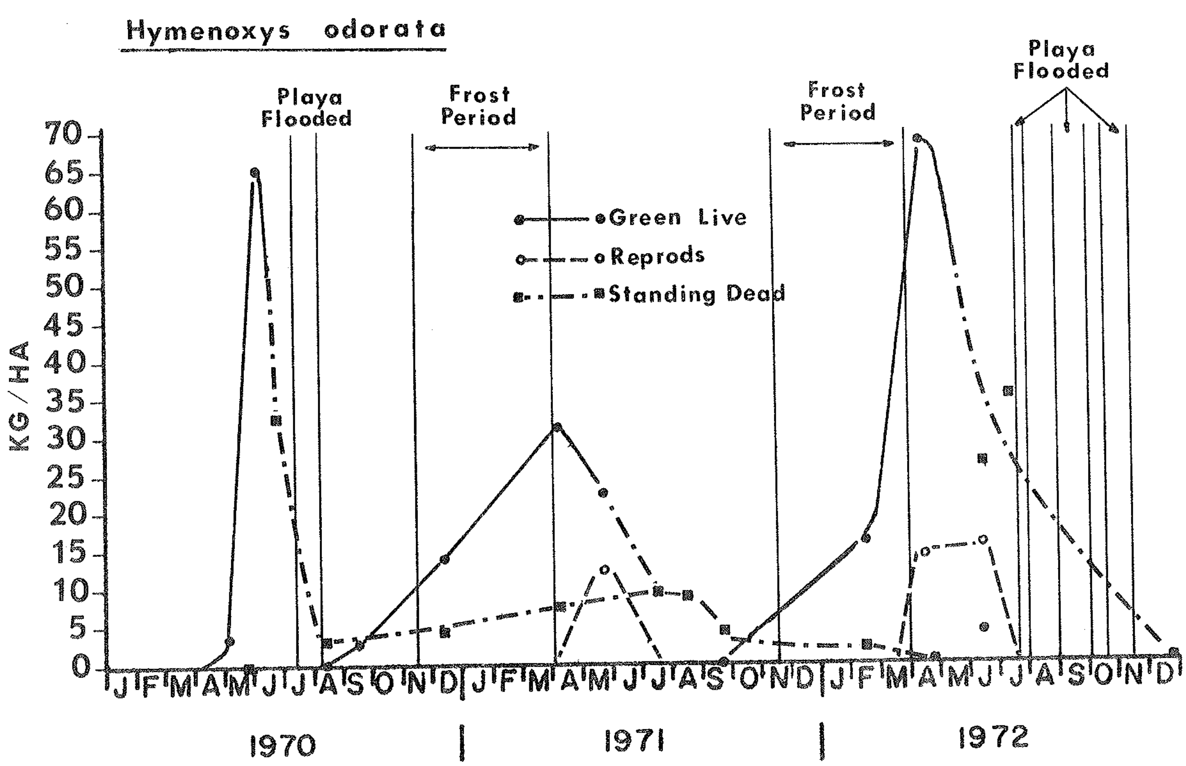

Figure 2. Biomass components of bitterweed (*Hymenoxys odorata*) for 1970, 1971 and 1972 on the playa bottom.

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	27 June	1972 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 10 Jul.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 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.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 26 Oct.
Sporobolus cryptandrus	Vegetative	----	----	----	----	----	294.7
	Reproductive	----	----	----	----	----	15.5
	Total	----	----	----	----	----	310.2
Sporobolus flexuosus	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	1970 2 October	1971 6 October	1971 27 June	1972 22 August	1972 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	27 June	1972 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.	1970 2 Oct.	1971 6 Oct.	1972 27 Jun.	1972 22 Aug.	1972 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	27 June	1972 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 under-estimate 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

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

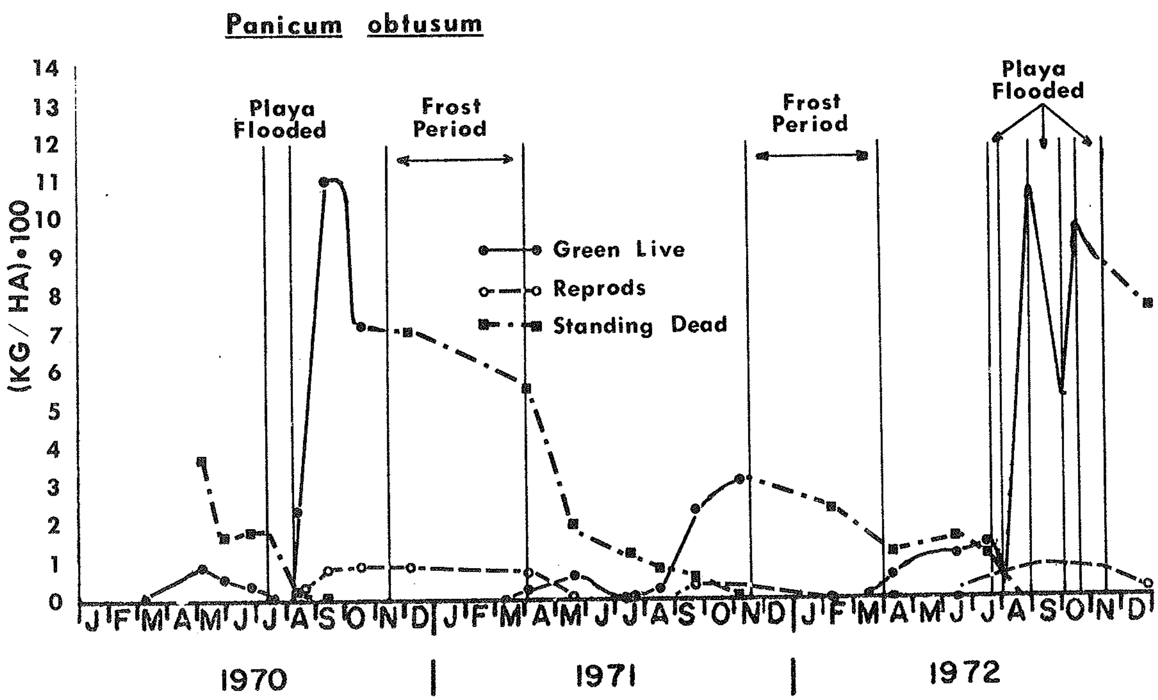

Figure 3. Biomass components of vine-mesquite grass (*Panicum obtusum*) for 1970, 1971 and 1972 on the playa bottom.

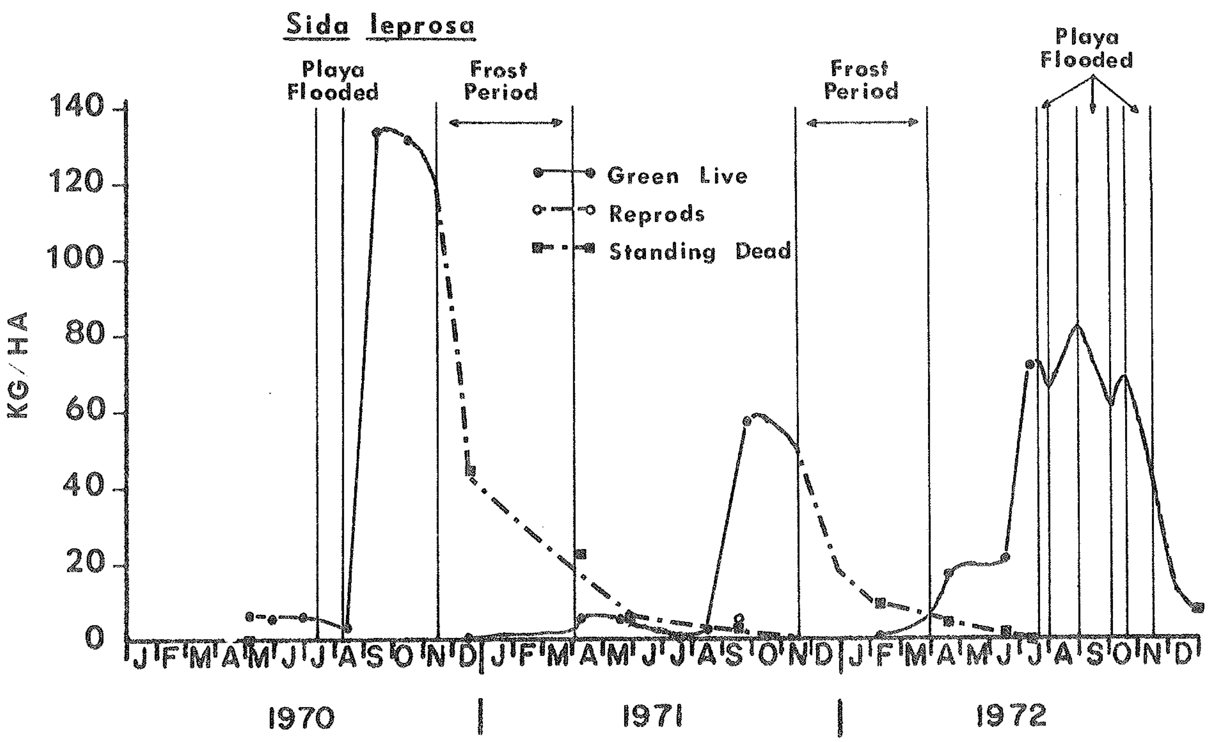

Figure 4. Biomass components of white-flowered mallow (*Sida leprosa*) for 1970, 1971 and 1972 on the playa bottom.

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.

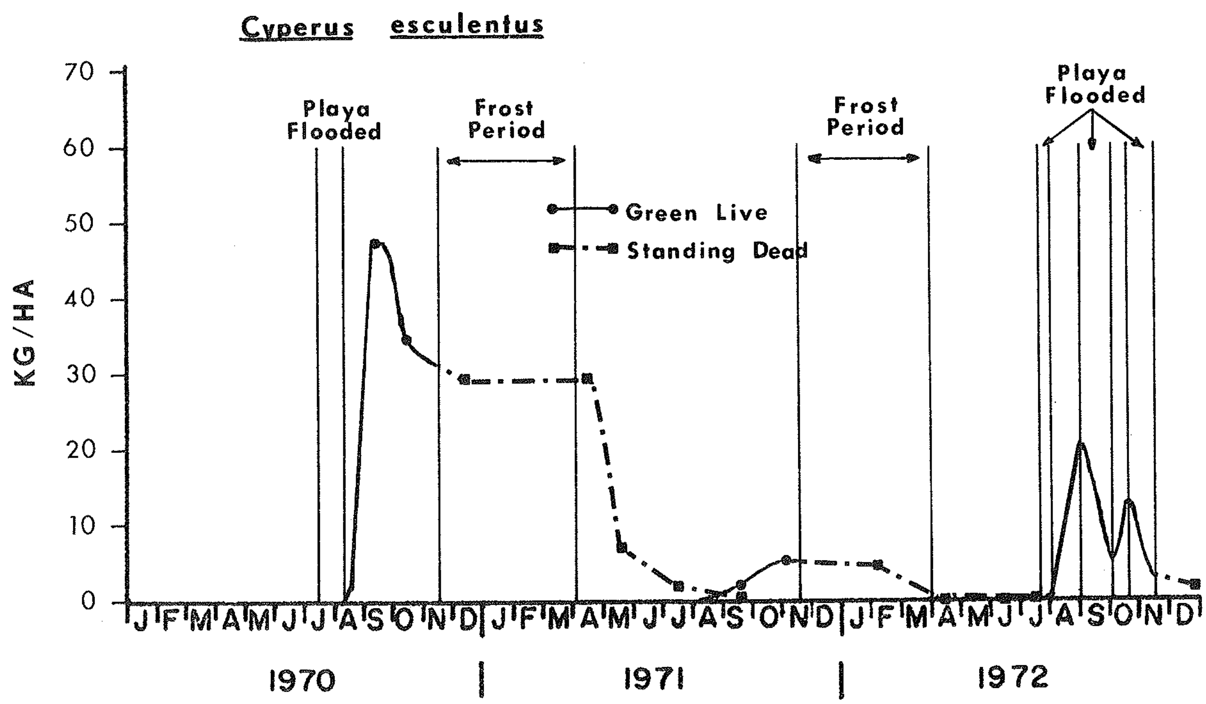

Figure 5. Biomass components of yellow nut grass (*Cyperus esculentus*) for 1970, 1971 and 1972 on the playa bottom.

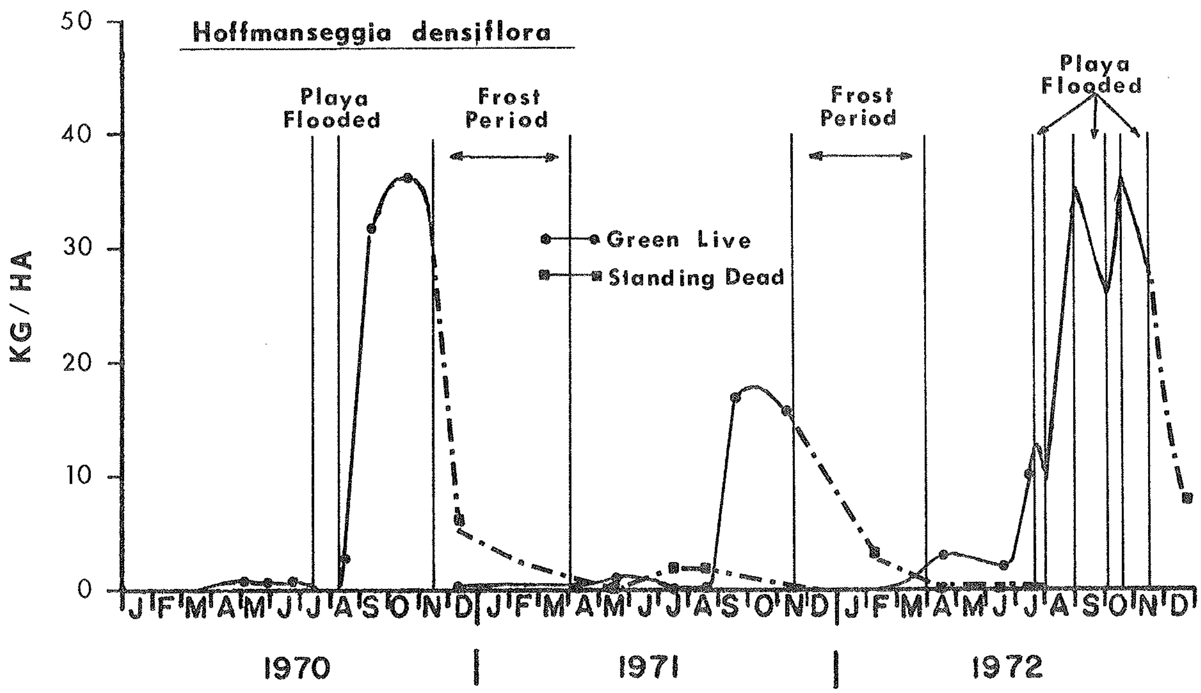

Figure 6. Biomass components of indian rushpea (*Hoffmanseggia densiflora*) for 1970, 1971 and 1972 on the playa bottom.

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 = Calliandra humilis, Hi mu = Hilaria mutica, Pa ob = Panicum obtusum, So el = Solanum elaegnifolium

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

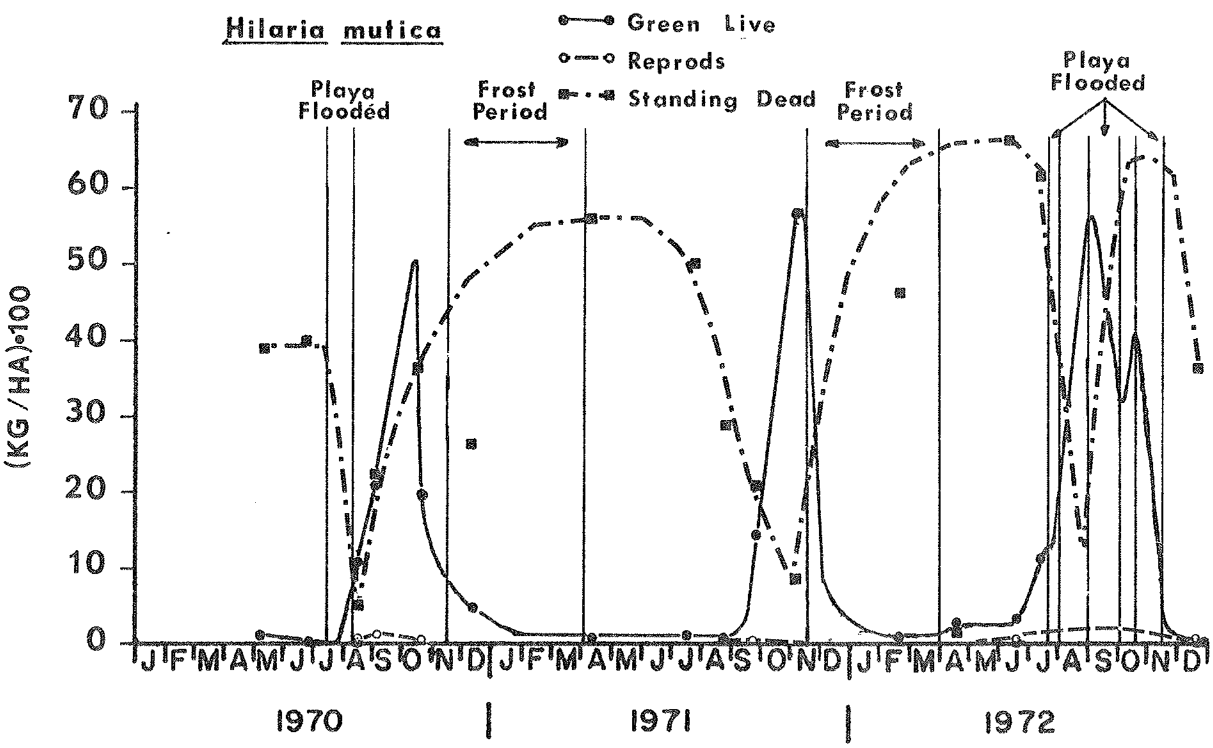

Figure 7. Biomass components of tobosa (*Hilaria mutica*) for 1970, 1971 and 1972 on the playa edge.

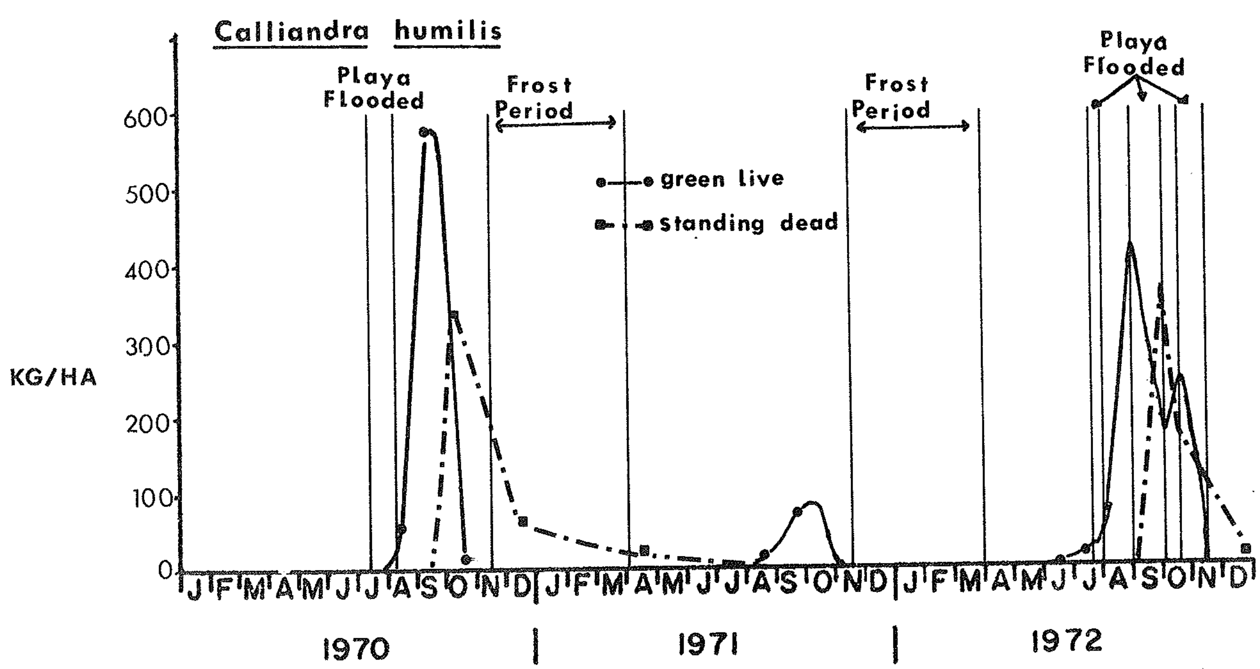

Figure 8. Biomass components of false mesquite (*Calliandra humilis*) for 1970, 1971 and 1972 on the playa edge.

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

*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		$B = 866720.0V + 205.7 \times 10^5V^2$
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.

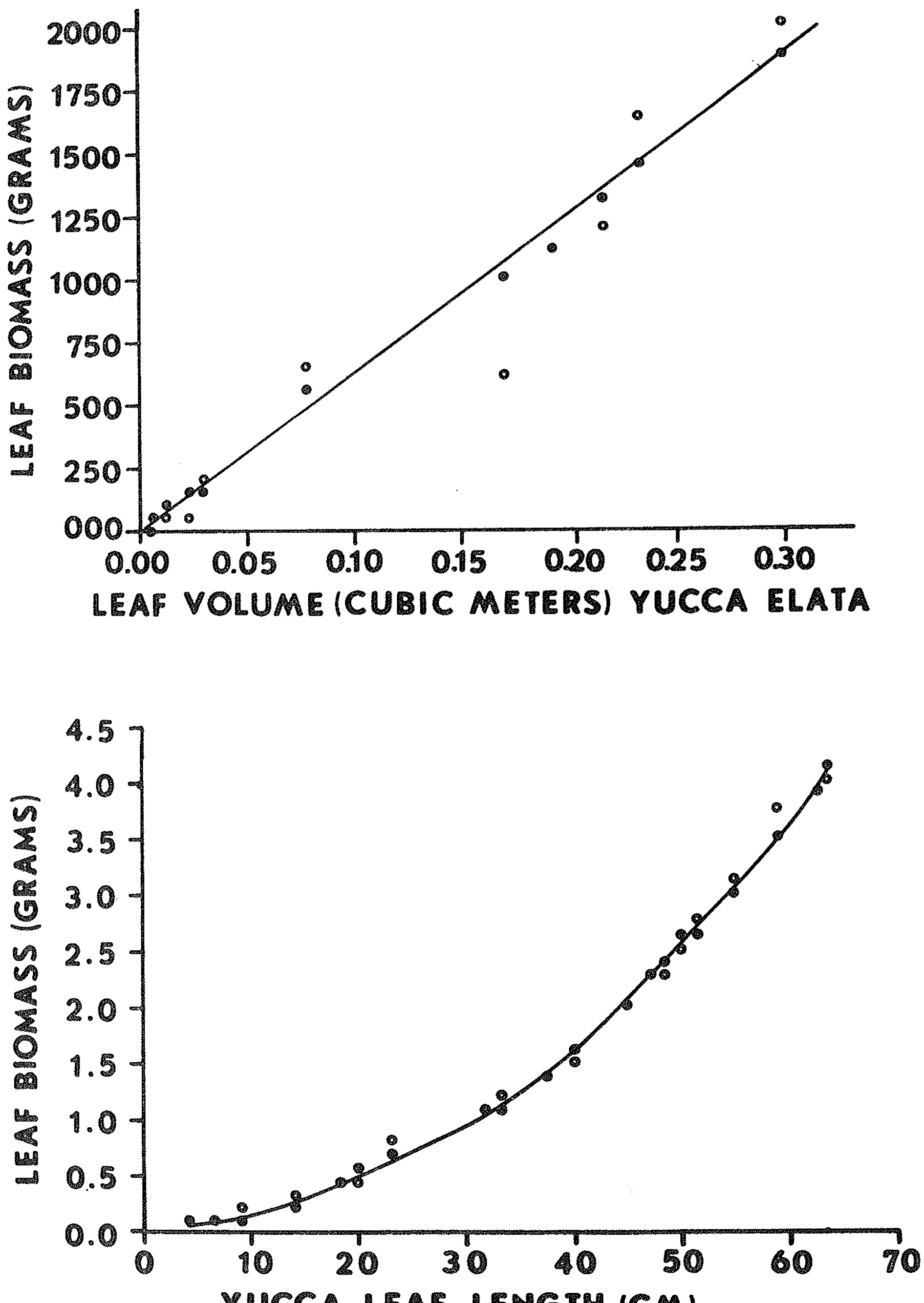

Figure 9. (Top) Regression of leaf biomass (B) onto canopy volume (V) of leaves for *Yucca elata*. The equation of the linear regression line is B = 6218 V.

(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 $B = .0088\ L + .00063\ L^2$.

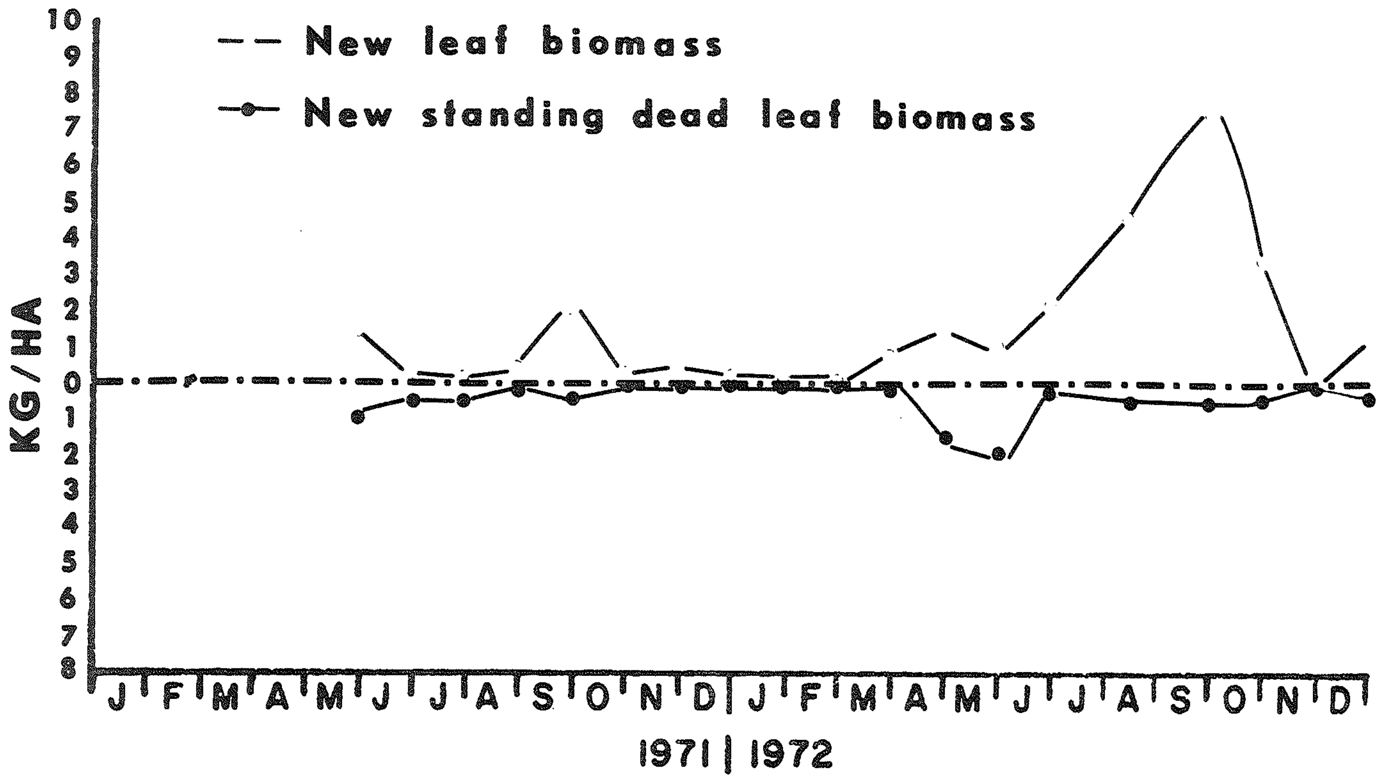

Figure 11. Monthly absolute leaf biomass gains and losses for *Yucca elata* on the playa fringe.

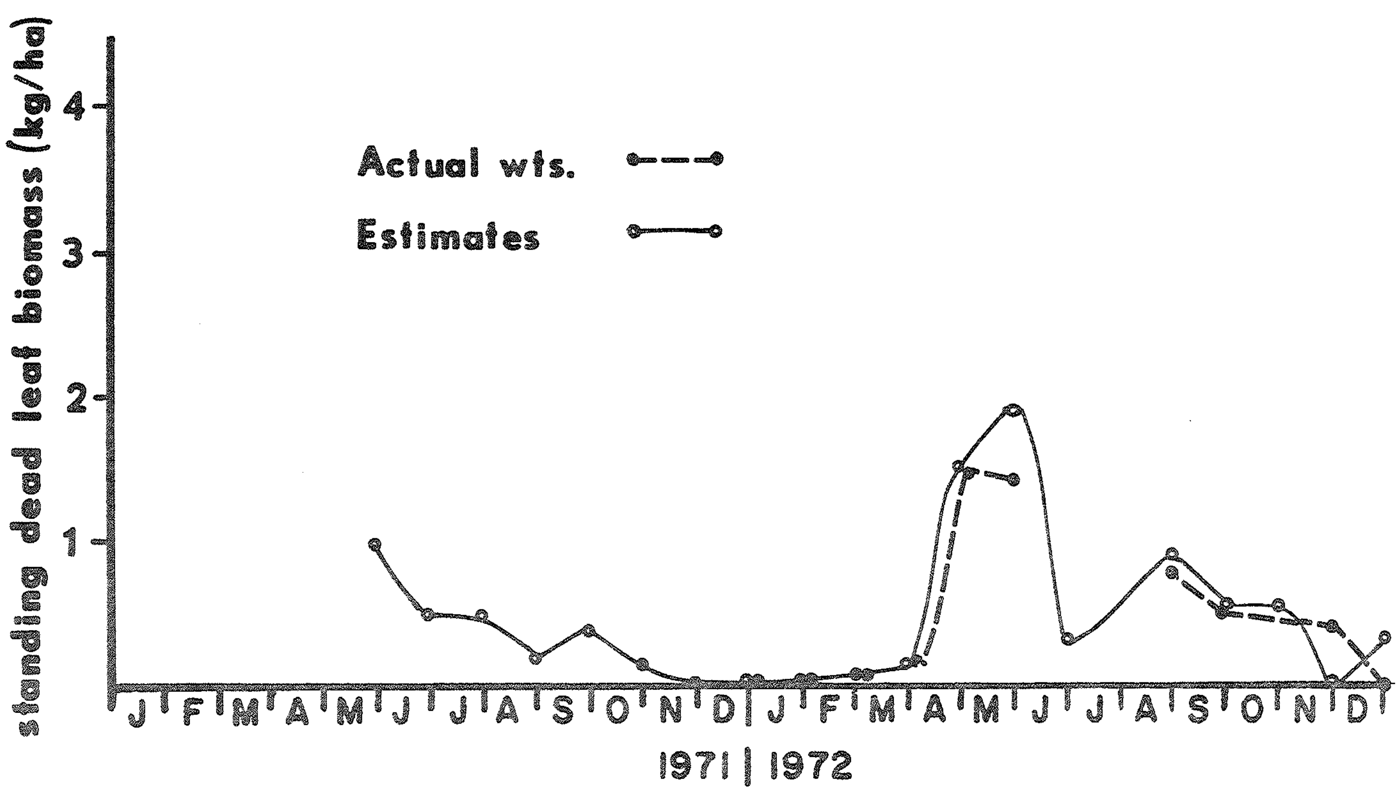

Figure 12. Monthly losses of live leaves to standing dead leaves for *Yucca elata* on the playa fringe. In 1972 the monthly increments of new standing dead leaves were harvested (actual wts.). In both 1971 and 1972, the standing dead leaf increments were estimated from lengths (estimates). The data for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

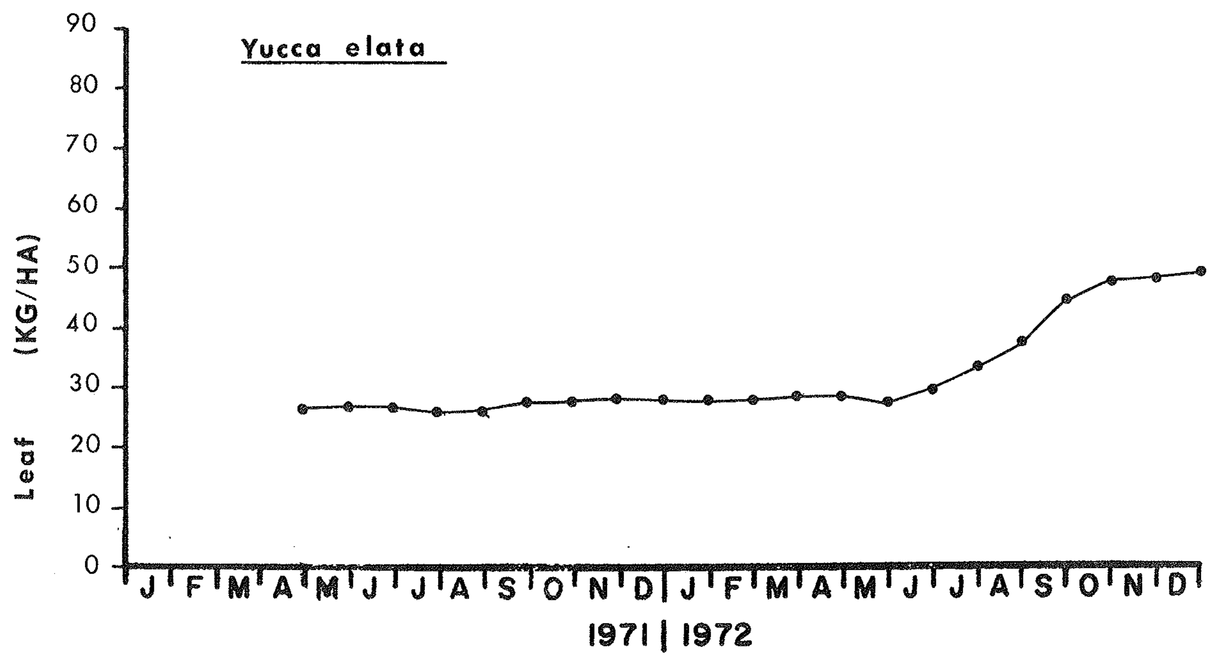

Figure 13. Monthly standing crop of living leaf biomass for *Yucca elata* for 1971 and 1972 on the playa fringe.

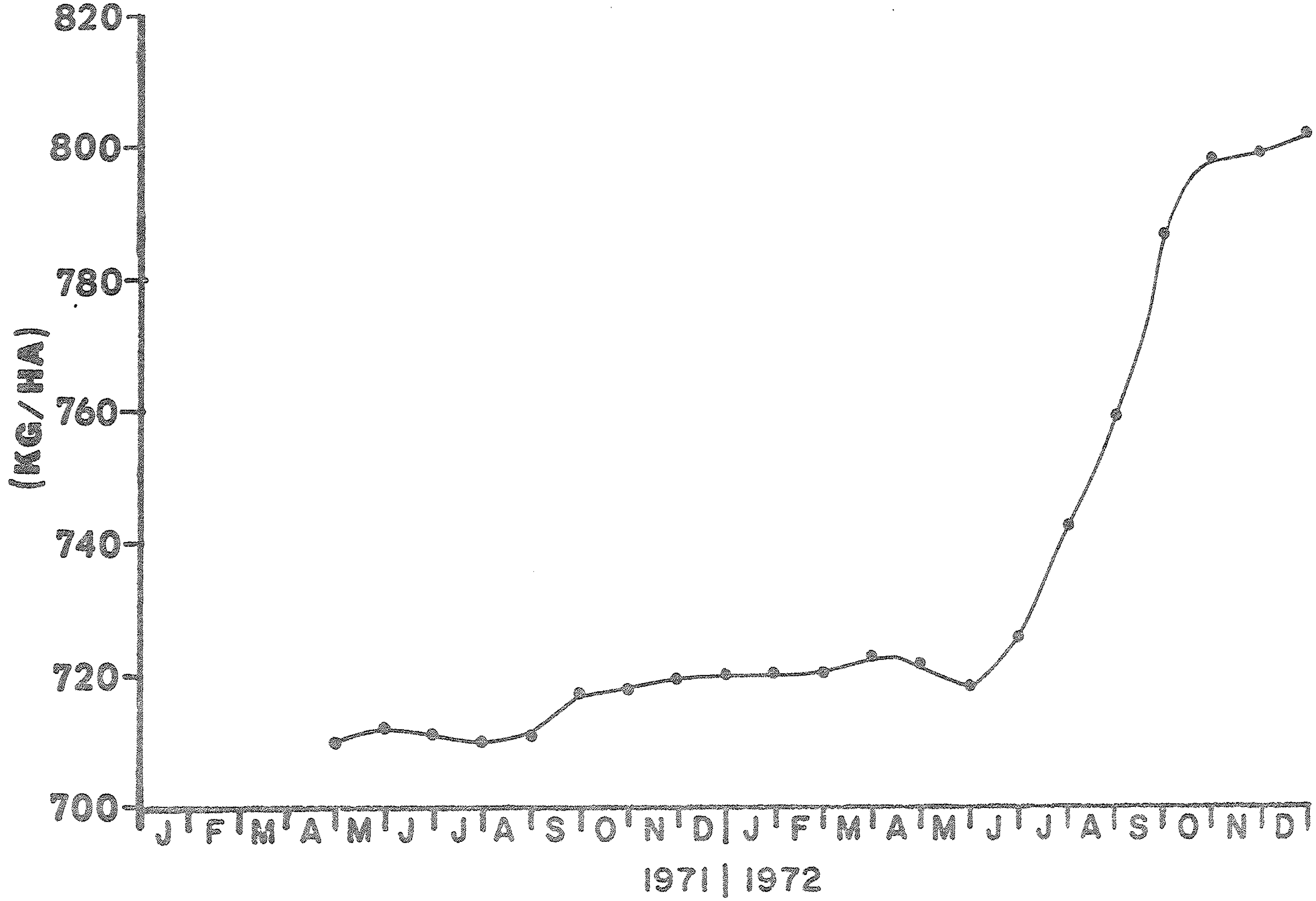

Figure 14. Monthly standing crop of caudex biomass for *Yucca elata* in 1971 and 1972 on the playa fringe.

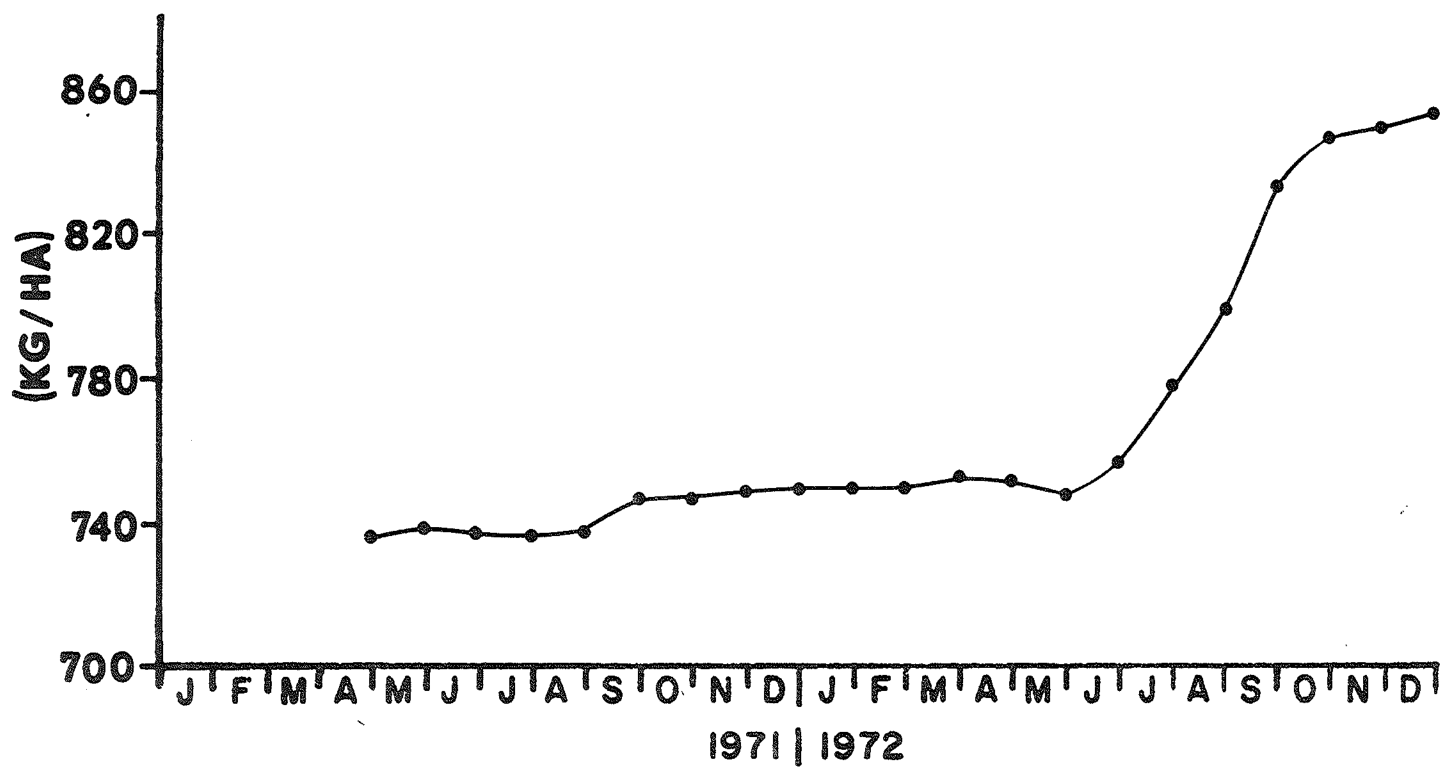

Figure 15. Monthly standing crop of total above-ground biomass for *Yucca elata* in 1971 and 1972 on the playa fringe.

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.

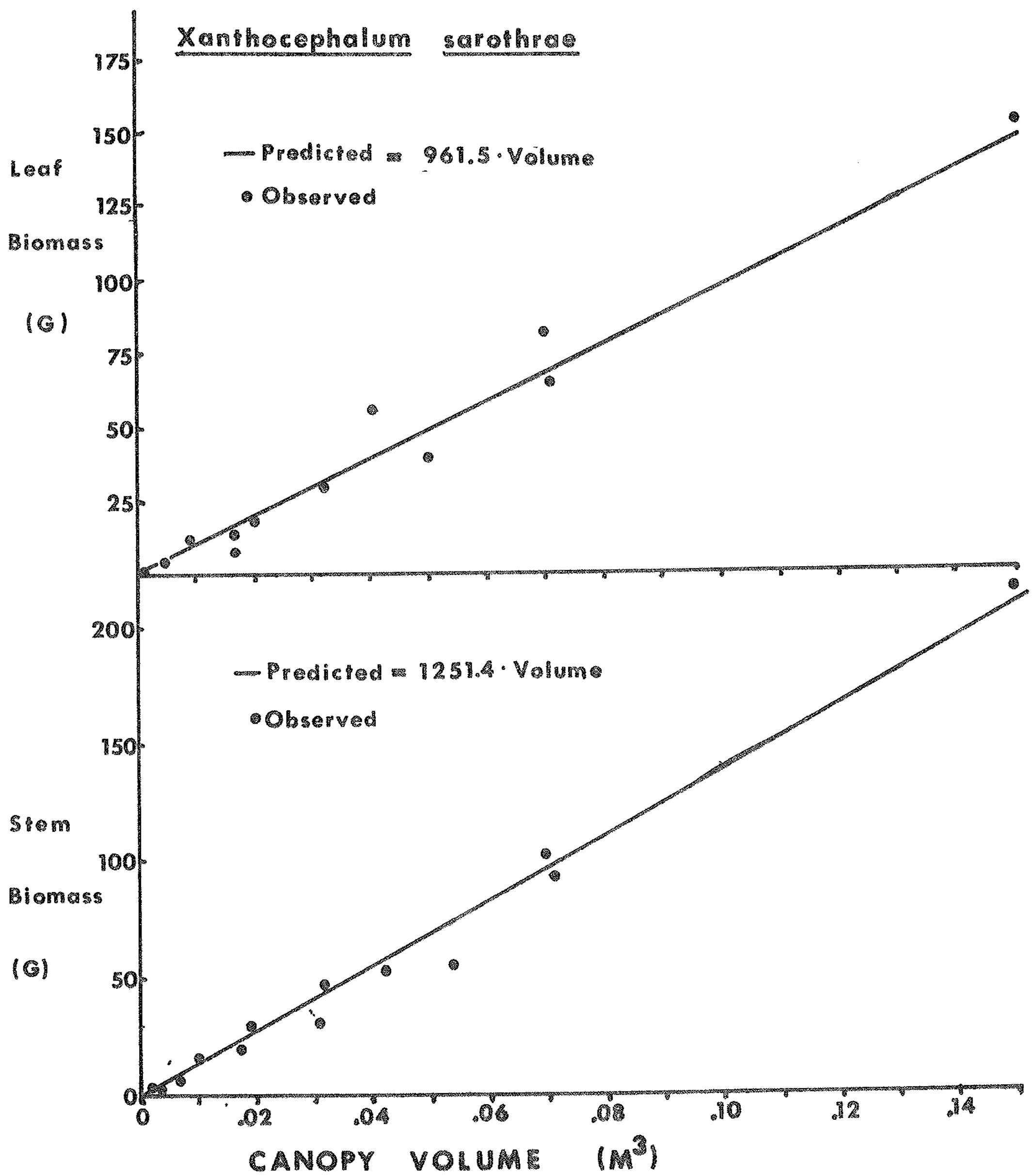

Figure 16. (Top) Regression of leaf biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 961.5 V.

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

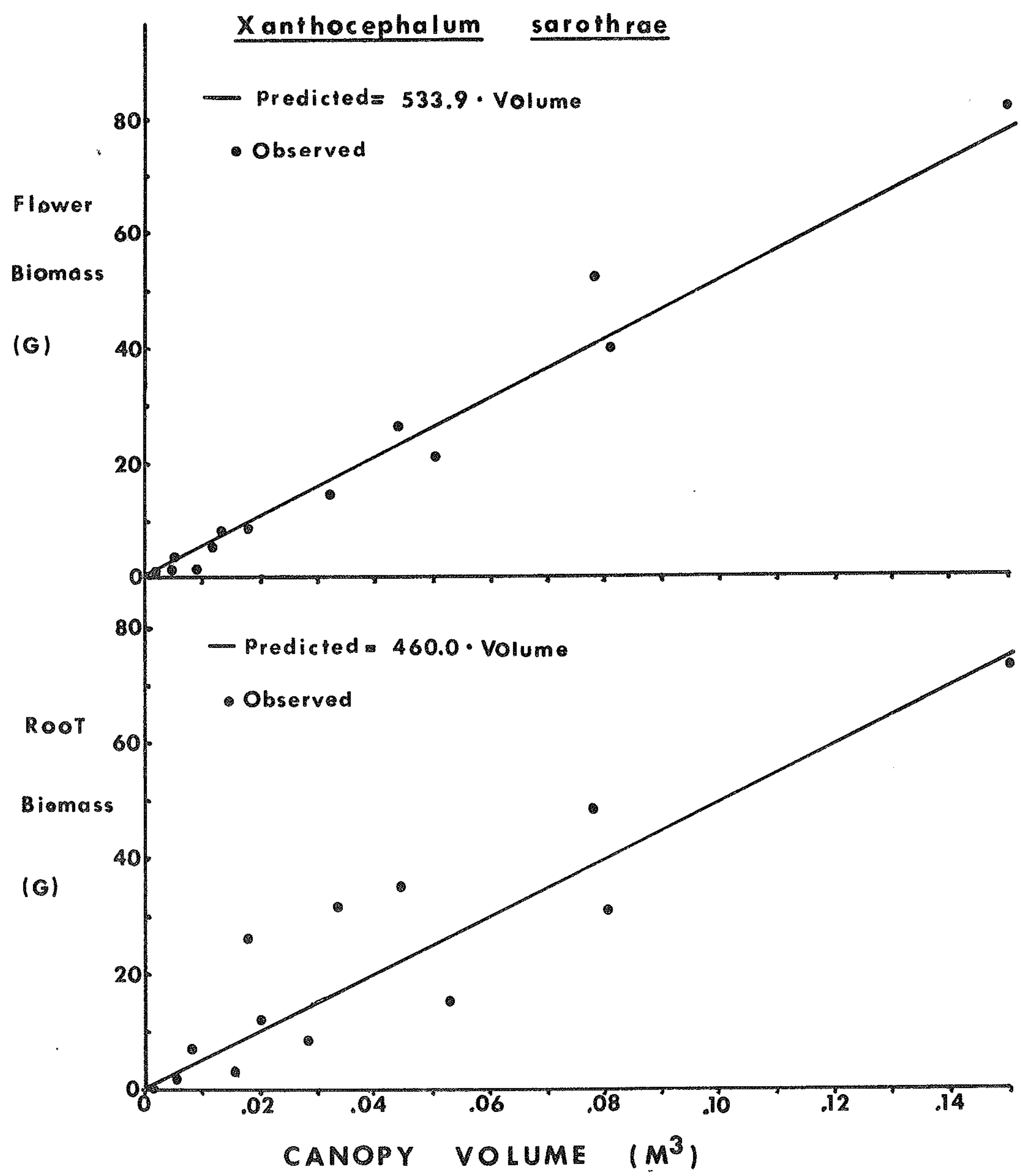

Figure 17. (Top) Regression of flower biomass (B) onto canopy volume (V) for *Xanthocephalum sarothrae*. The equation of the linear regression is B = 533.9 V.

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

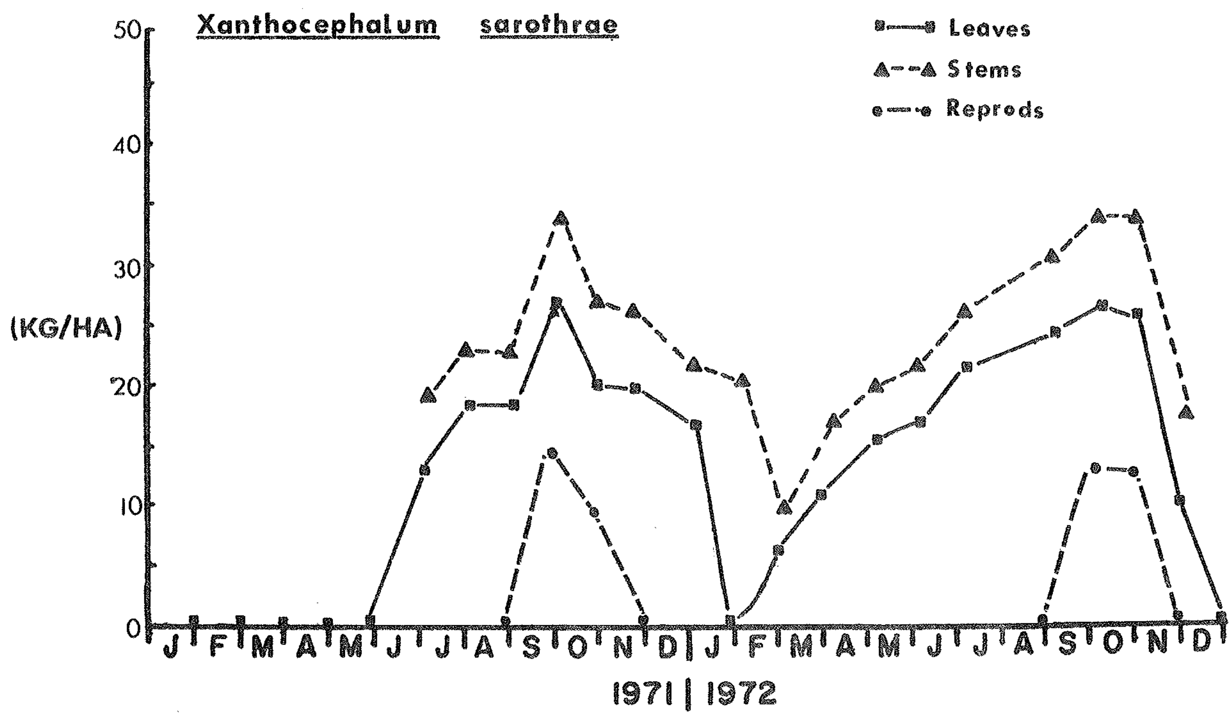

Figure 18. Monthly standing crop of leaf, stem and reproductive biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the playa fringe.

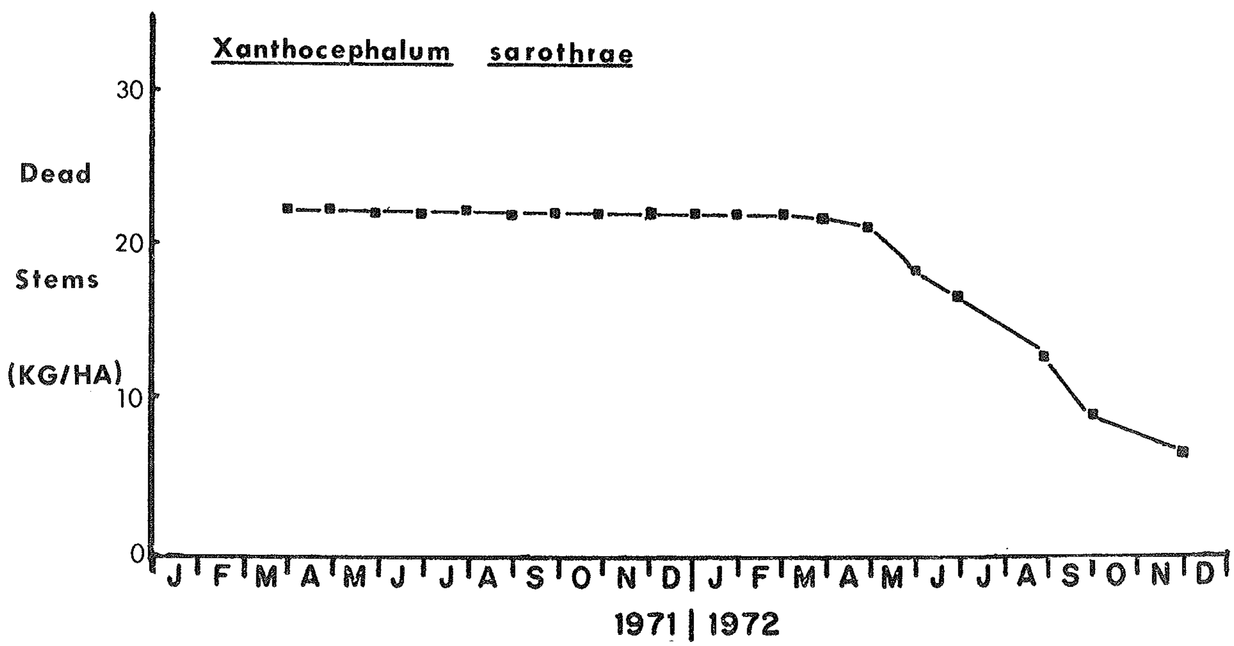

Figure 19. Monthly standing crop of dead stem biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the playa fringe.

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.

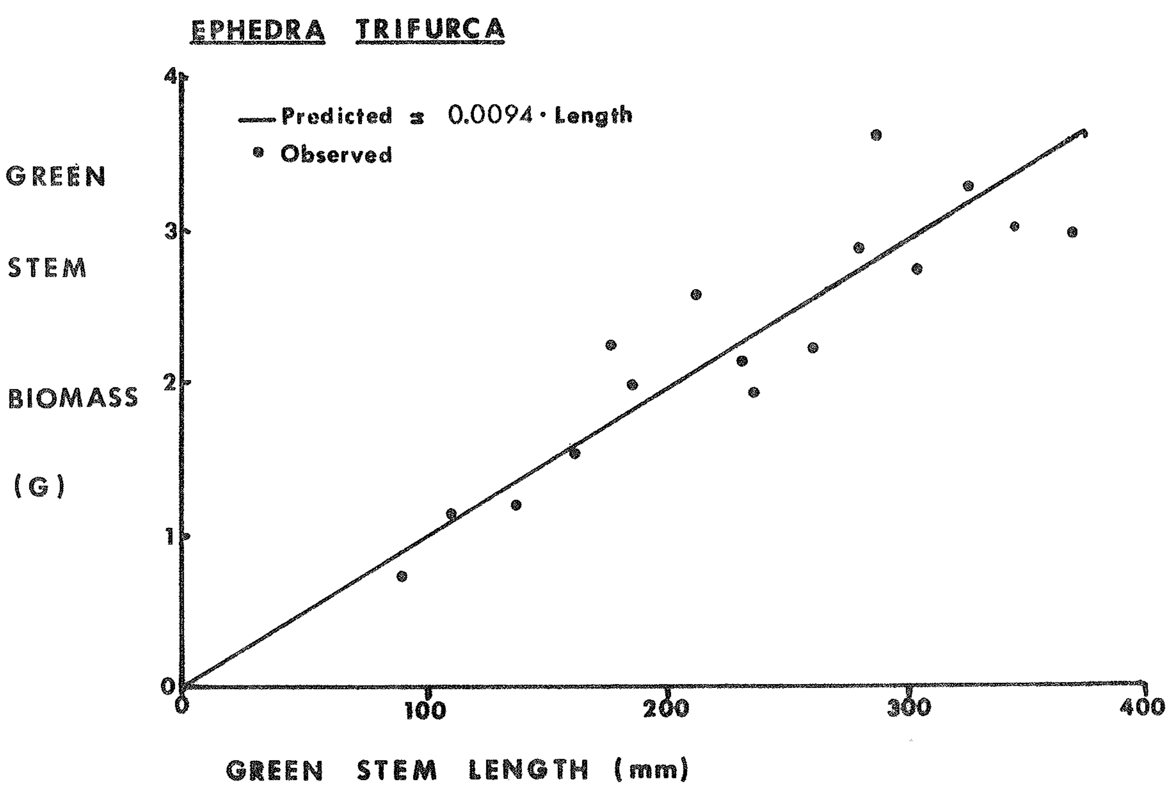

Figure 20. Regression of green leaf biomass (B) onto green leaf length (L) for *Ephedra trifurca*. The equation of the linear regression line is B = 0.0094 L.

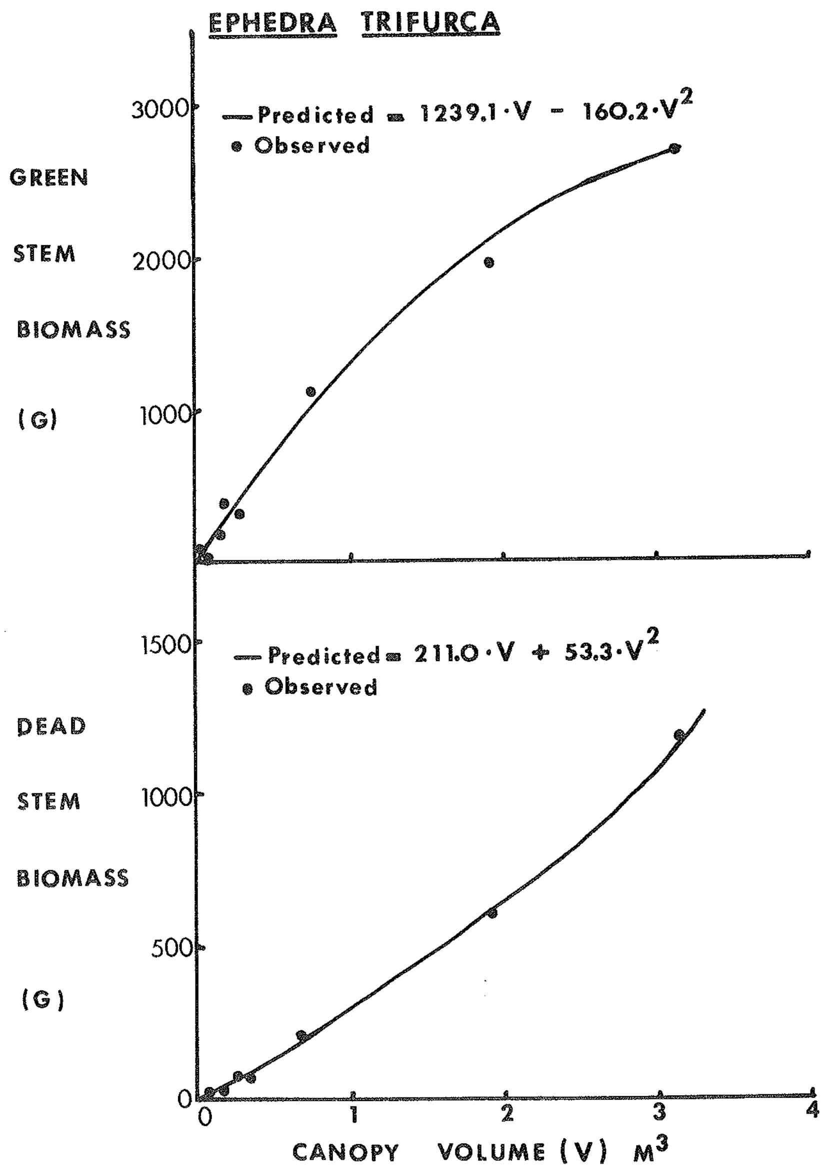

Figure 21. (Top) Regression of green stem biomass (B) onto canopy volume (V) for *Ephedra trifurca*. The equation of the curvilinear regression is $B = 1239.1\ V - 160.2\ V^2$.

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

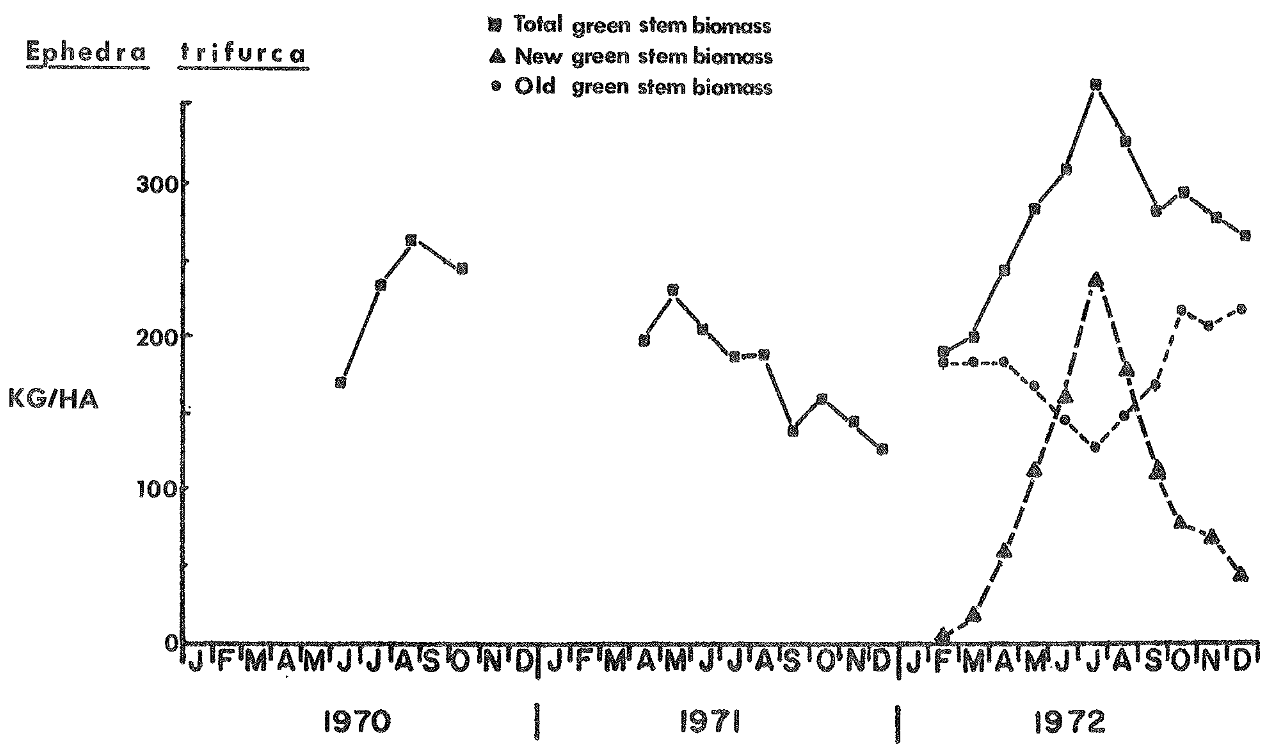

Figure 22. Monthly standing crop of green stem biomass for *Ephedra trifurca* in 1970, 1971 and 1972 on the playa fringe.

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.

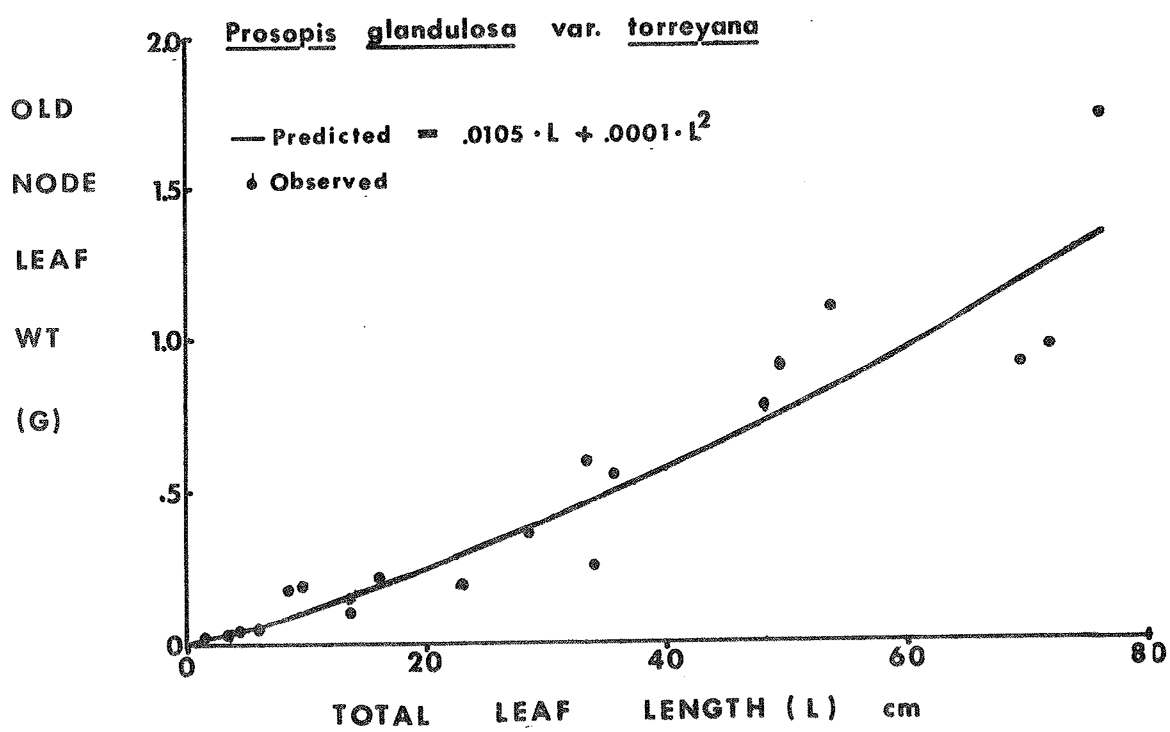

Figure 23. Regression of leaf biomass (B) at a node onto total leaf length (L) at the node for *Prosopis glandulosa* var. *torreyana*. The equation of the curvilinear regression line is $B = 0.0105\ L + .0001\ L^2$

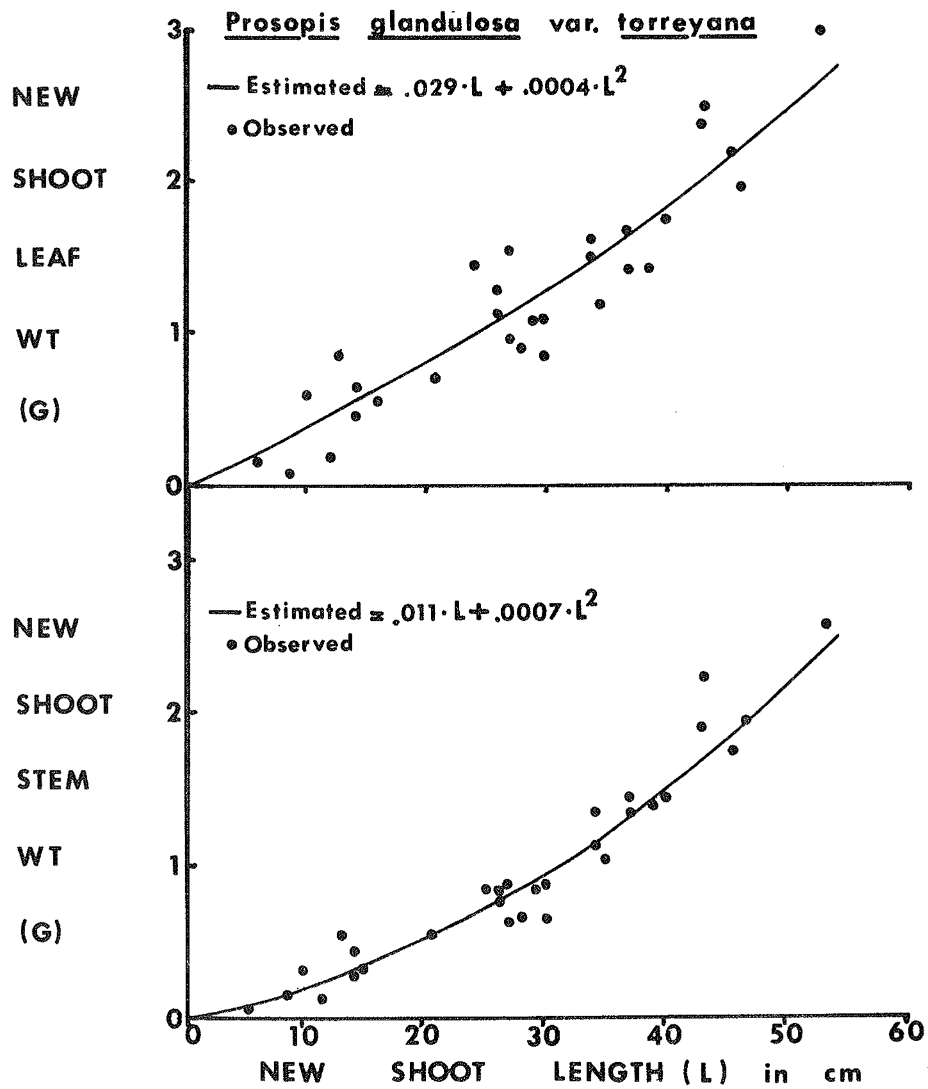

Figure 24. (Top) Regression of leaf biomass (B) of new shoots onto new shoot length (L) for *Prosopis glandulosa* var. *torreyana*. The equation of the curvilinear regression line is $B = .029\ L + .0004\ L^2$.

(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 $B = .011\ L + .0007\ L^2$.

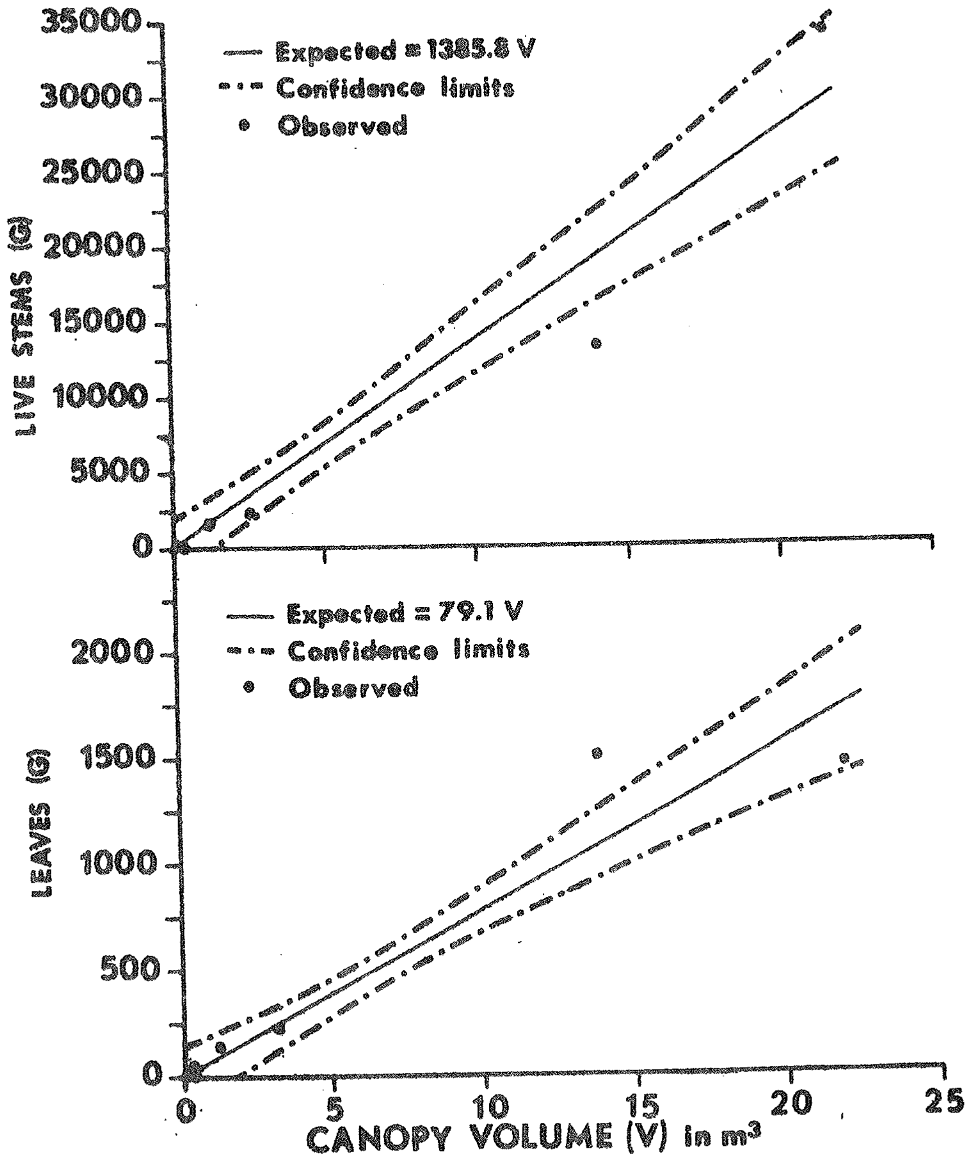

Figure 25. (Top) Regression of live stem biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 1385.8 V.

(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.

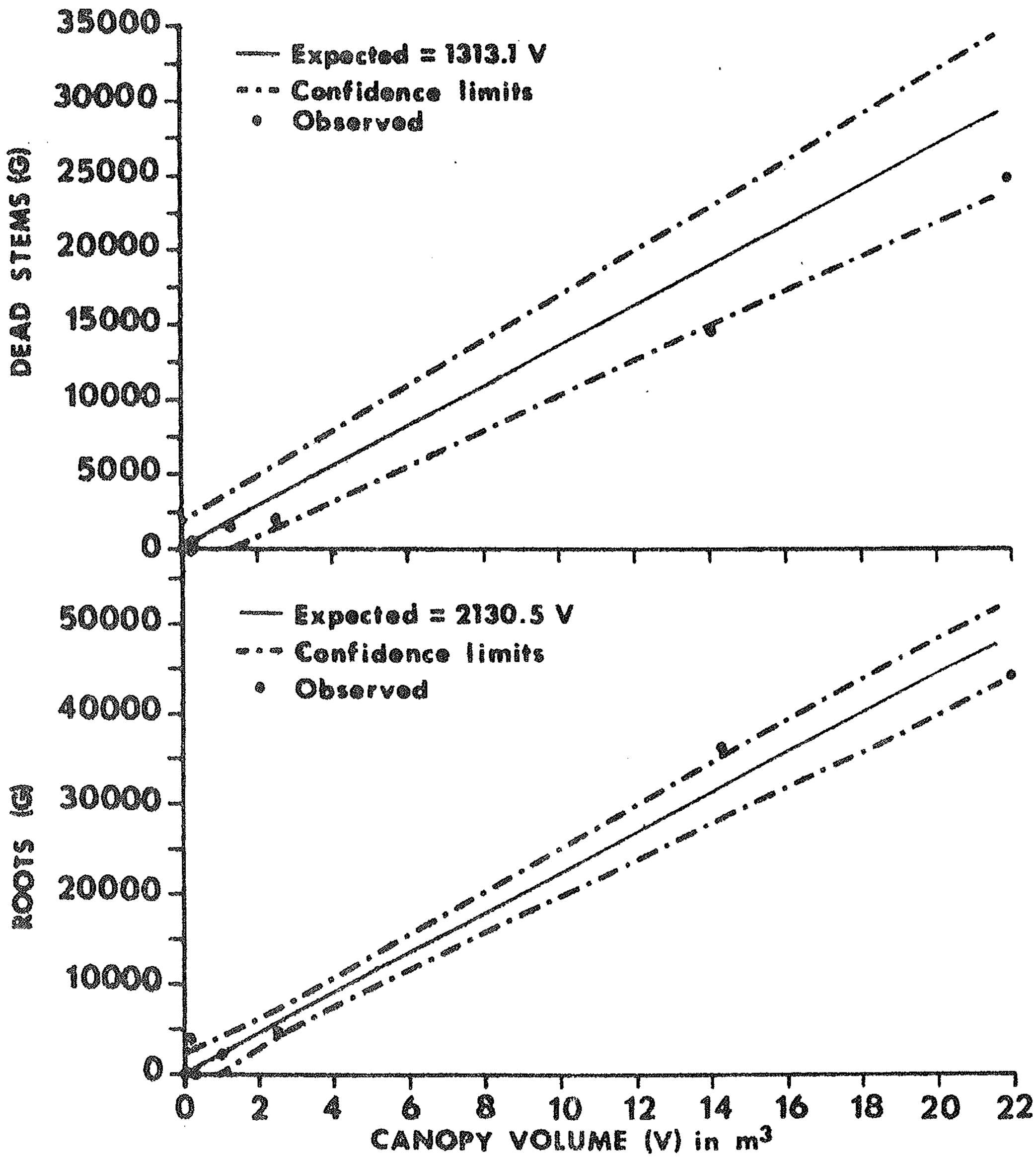

Figure 26. (Top) Regression of dead stem biomass (B) at the end of the growing season onto canopy volume (V) for *Prosopis glandulosa* var. *torreyana*. The equation of the linear regression line is B = 1313.1 V.

(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.

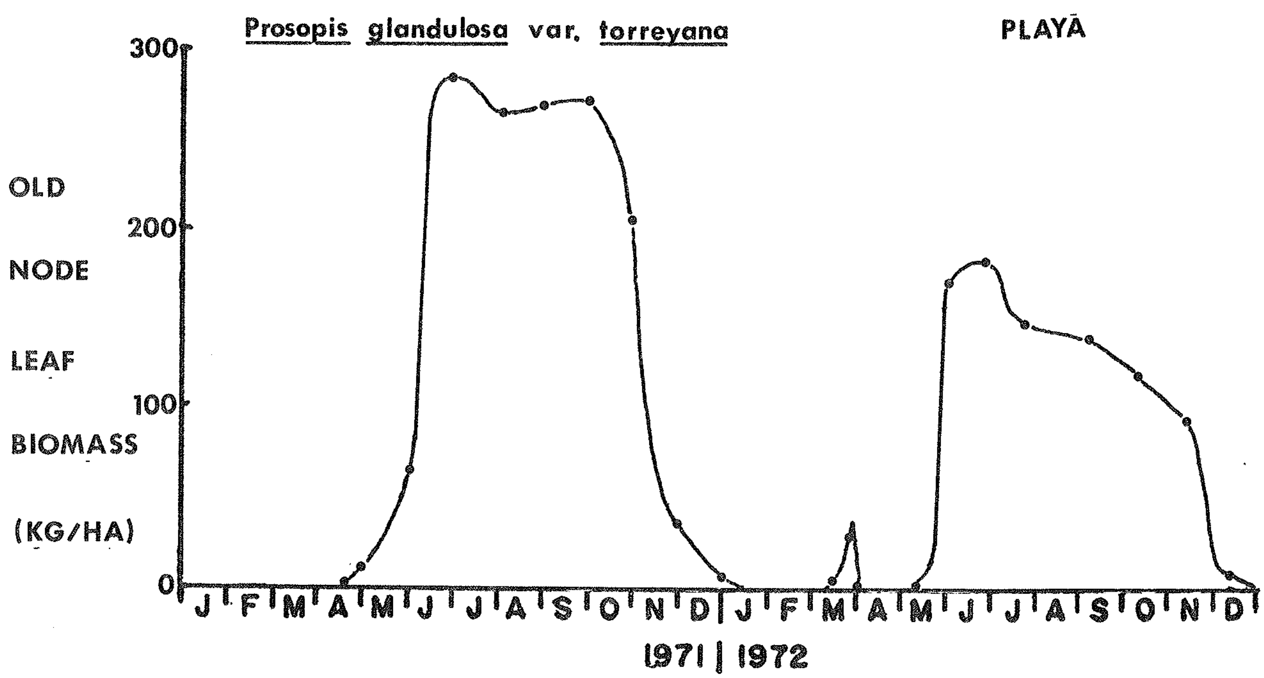

Figure 27. Monthly standing crop of old node leaf biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the playa fringe.

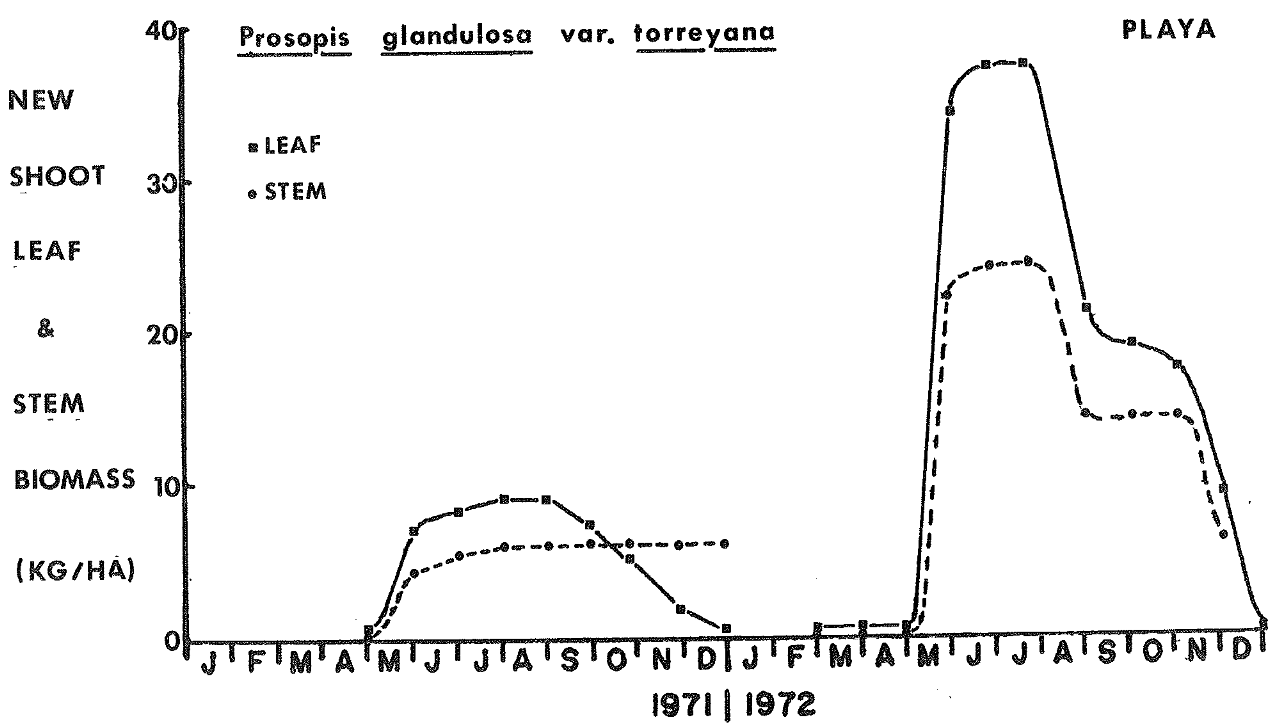

Figure 28. Monthly standing crop of new shoot leaf and stem biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the playa fringe.

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 27	June 15	June 16	June 30	July 13	July 26	August 10	August 11	Sept. 25	Nov. 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 $\pm$ 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 $\pm$ SD	Number of Surface Active Termites/m^2
June 7	4.52 $\pm$ 4.01	0
July 11	14.04 $\pm$ 25.28	2.34
August 1	25.70 $\pm$ 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

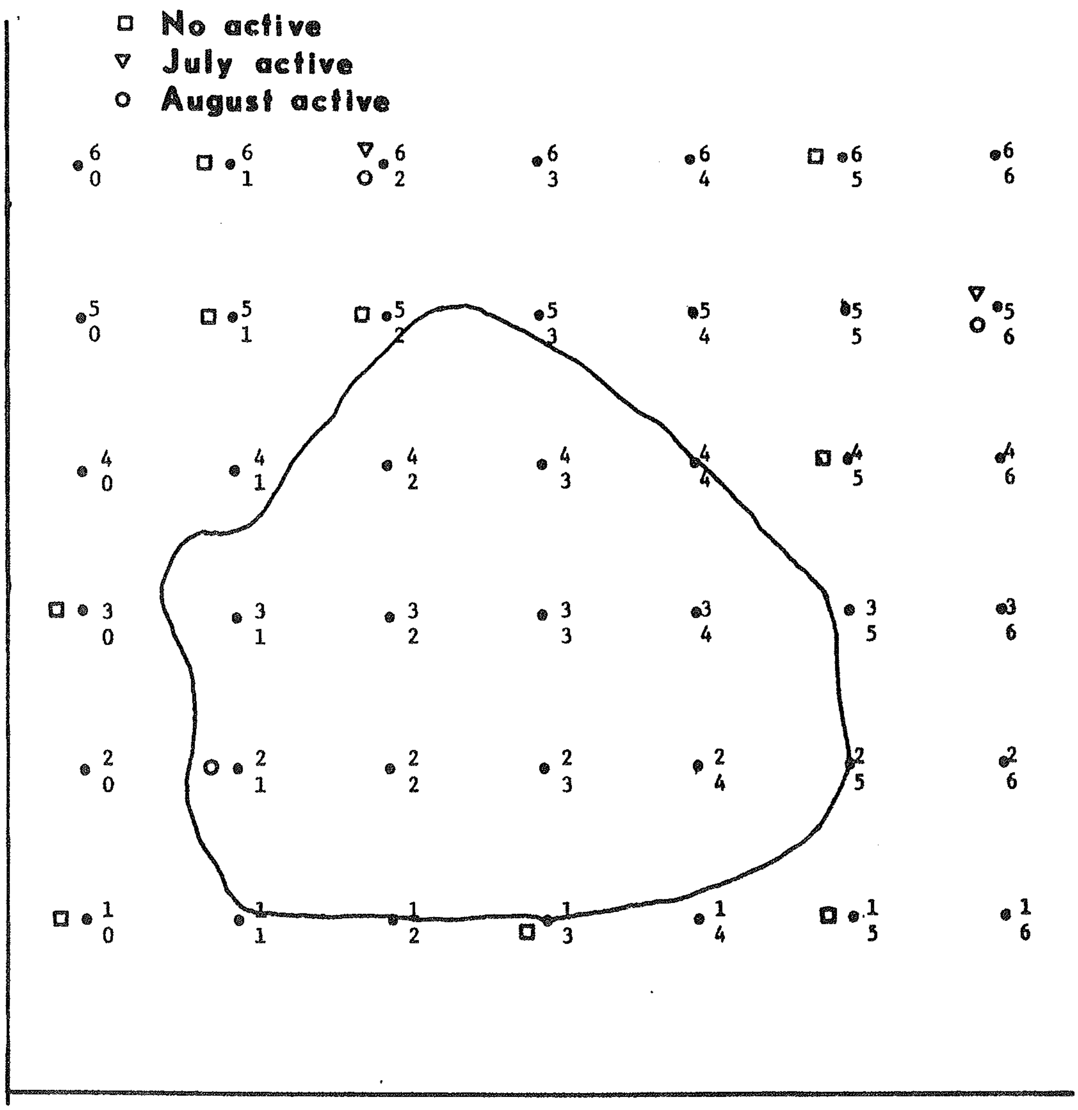

Figure 1. Location of sampling stations for presence of wood and active termite colonies on the playa site, 1972.

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.

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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).

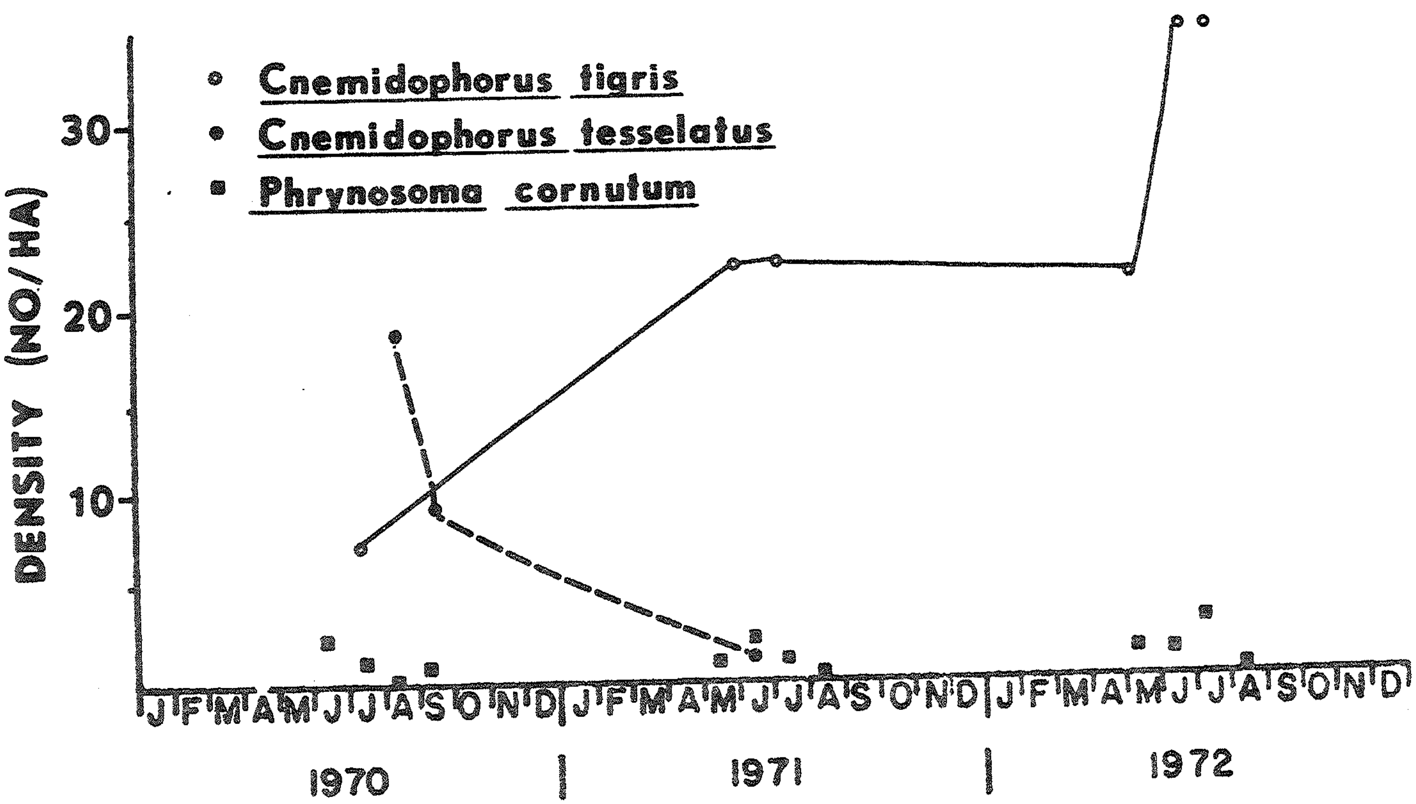

Figure 1. Fluctuation in densities of three species of lizards on the playa site.

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)

	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.[illegible]	.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	1
Crotalus viridis (prairie rattlesnake)	5	5
Pituophis melanoleucus (gopher snake)	3	0
Masticophis sp. (coachwhip snake)	2	0
Salvadora hexalepis (patchnose snake)	2	0
Hysiglena torquata (night snake)	1	0
Heterodon nasicus	1	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.

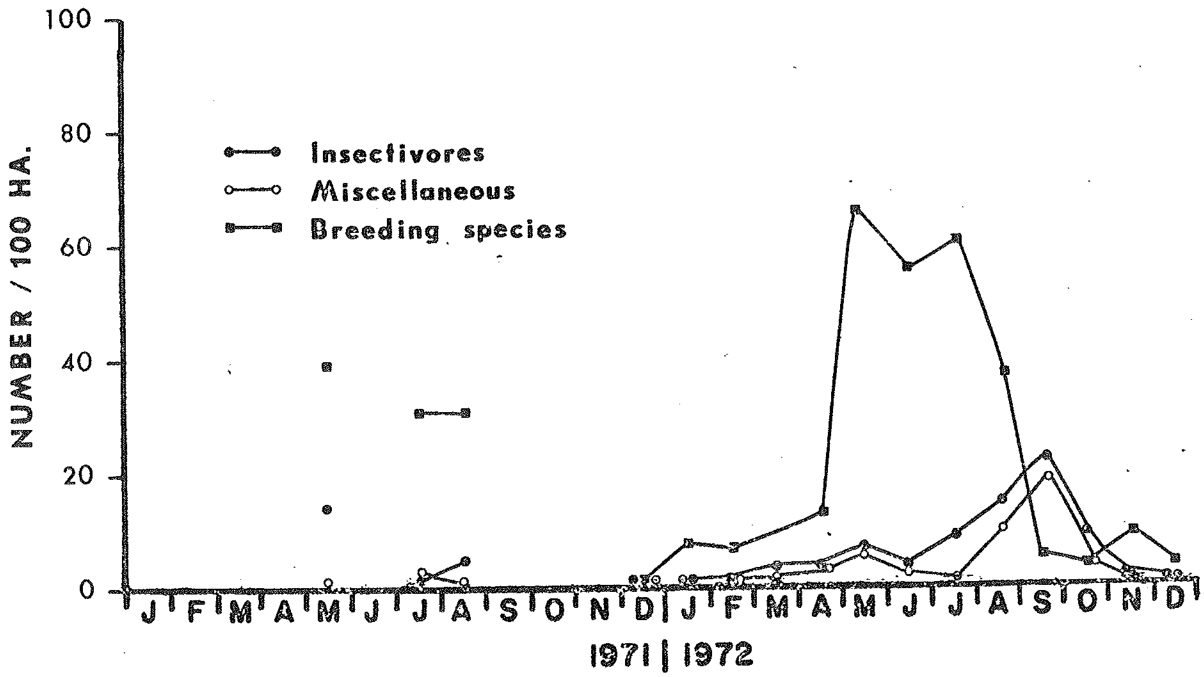

Figure 2. Mean monthly density of breeding species, non-breeding insectivores, and miscellaneous species, playa 1971-1972.

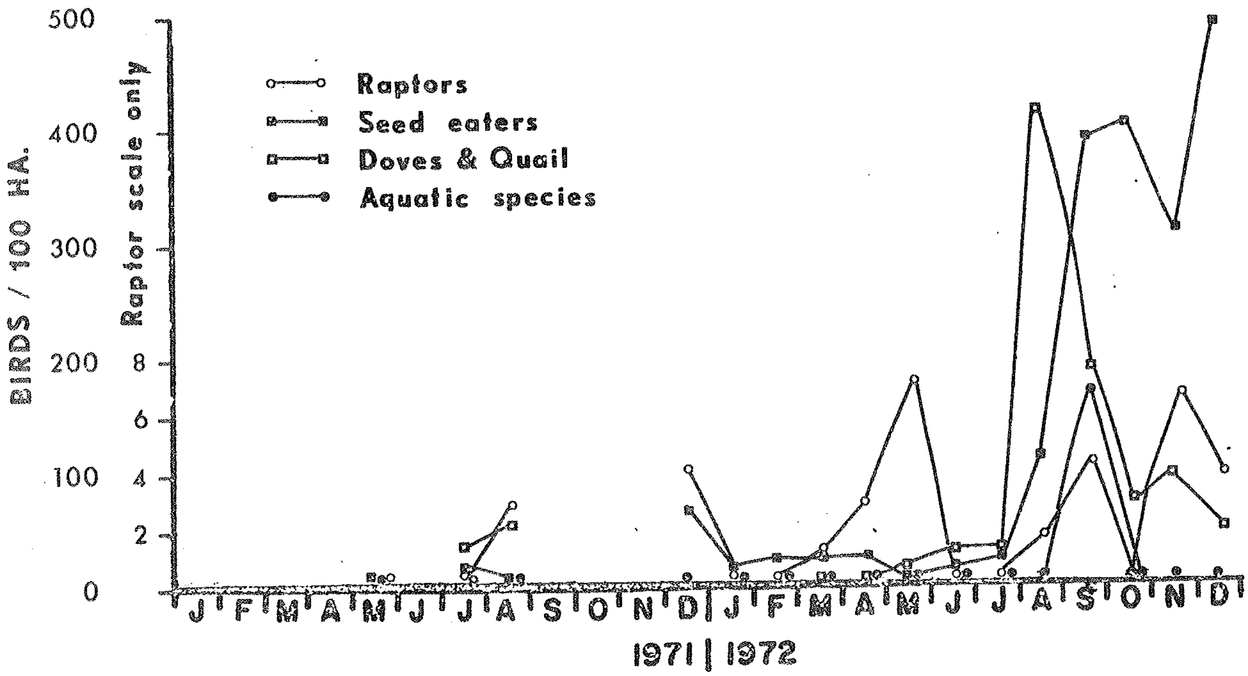

Figure 3. Mean monthly density of doves and quail, non-breeding seed-eaters, aquatic species, and raptors; playa 1971-1972.

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
<u>Dipodomys merriami</u>	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
<u>Dipodomys ordii</u>	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	
<u>Perognathus penicillatus</u>	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
<u>Sigmodon hispidis</u>	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
<u>Mus musculus</u>					*1	*1
<u>Neotoma albigula</u>				*5	*5	
<u>Onychomys torridus</u>					*1	
<u>Perognathus flavus</u>			*5	*12	*3	
<u>Perognathus intermedius</u>			*3	*1		
<u>Peromyscus maniculatus</u>				*1	*2	
<u>Reithrodontomys megalotis</u>				*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 Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	1971 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

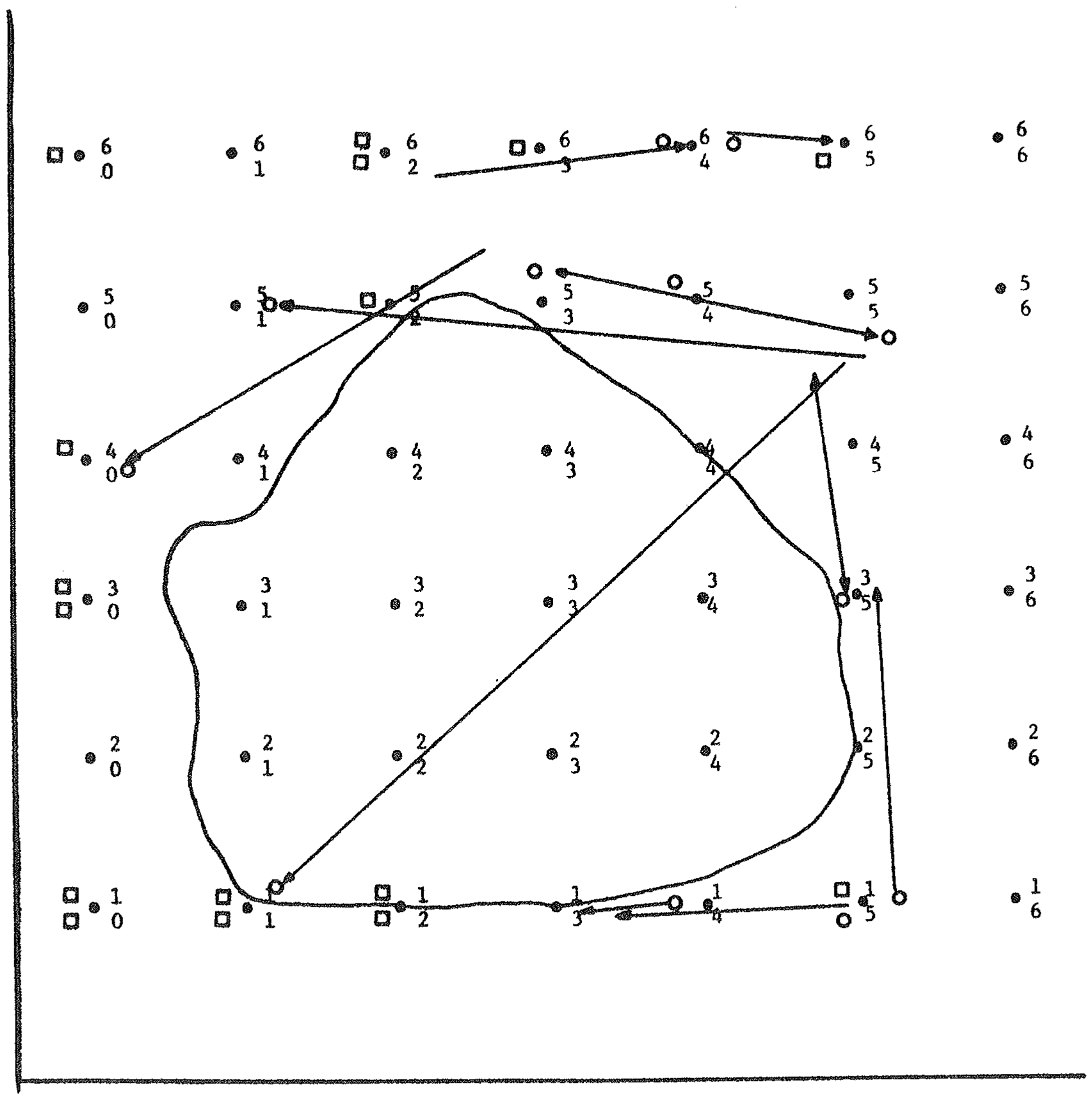

Figure 4. An assessment of movements of individual *Dipodomys merriami* on the playa, June 1972. Circles indicate *D. merriami* making long distance moves; squares represent animals taken at the same hectare marker.

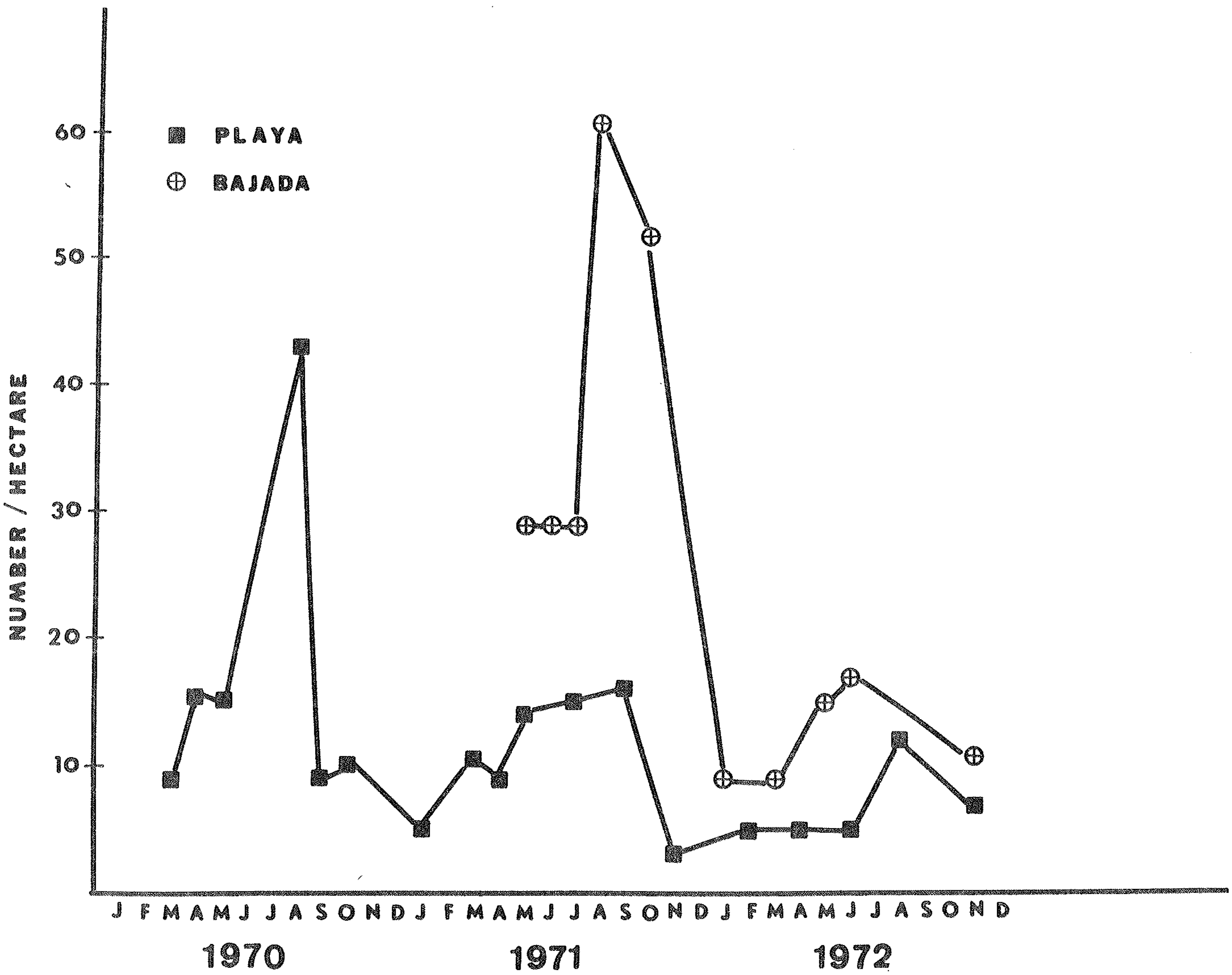

Figure 5. Comparison of fluctuations in the estimated population density of the *Dipodomys merriami* population on the playa and bajada areas, 1970-1972.

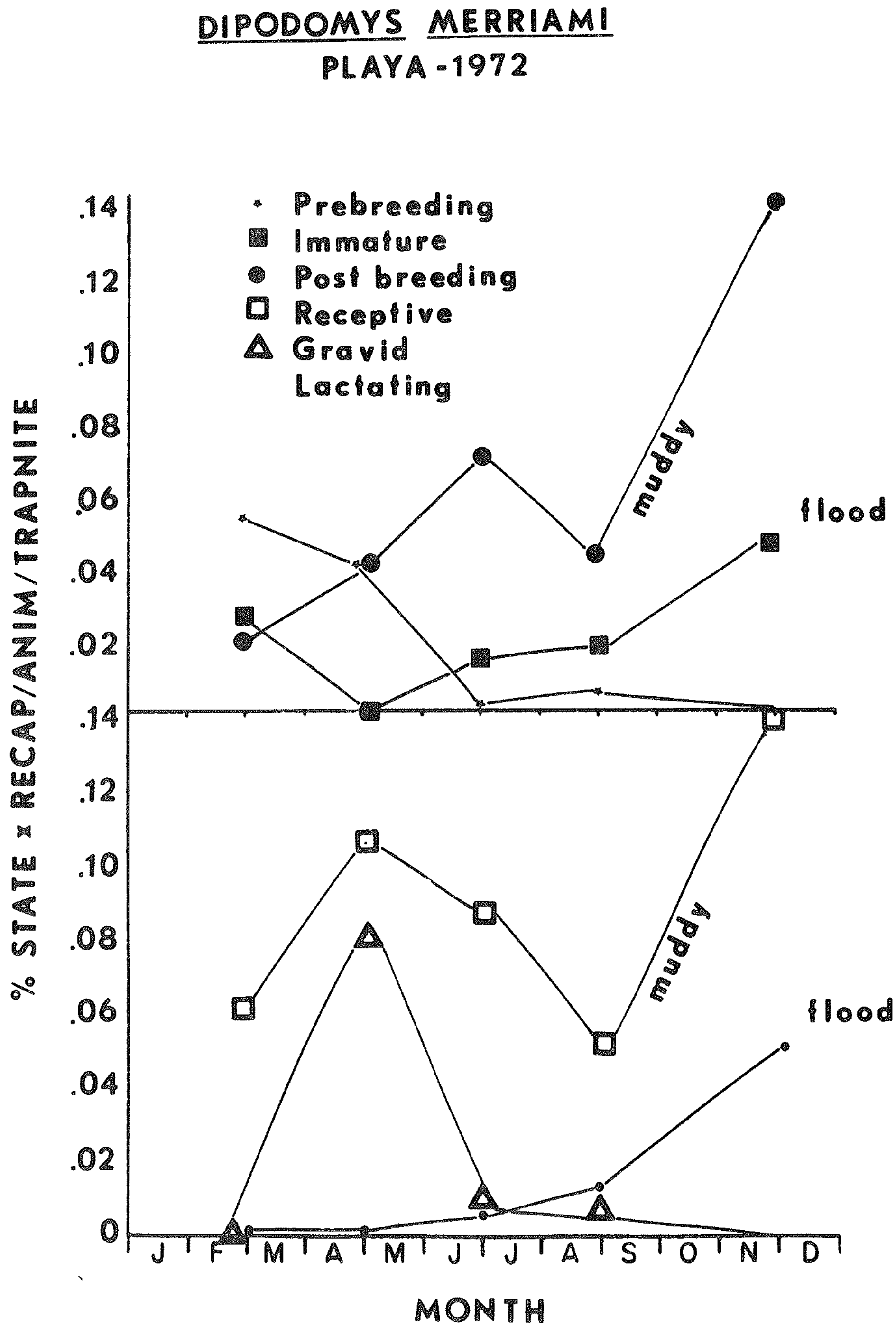

Figure 6. Reproductive characteristics of the *Dipodomys merriami* population on the playa site (1972).

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

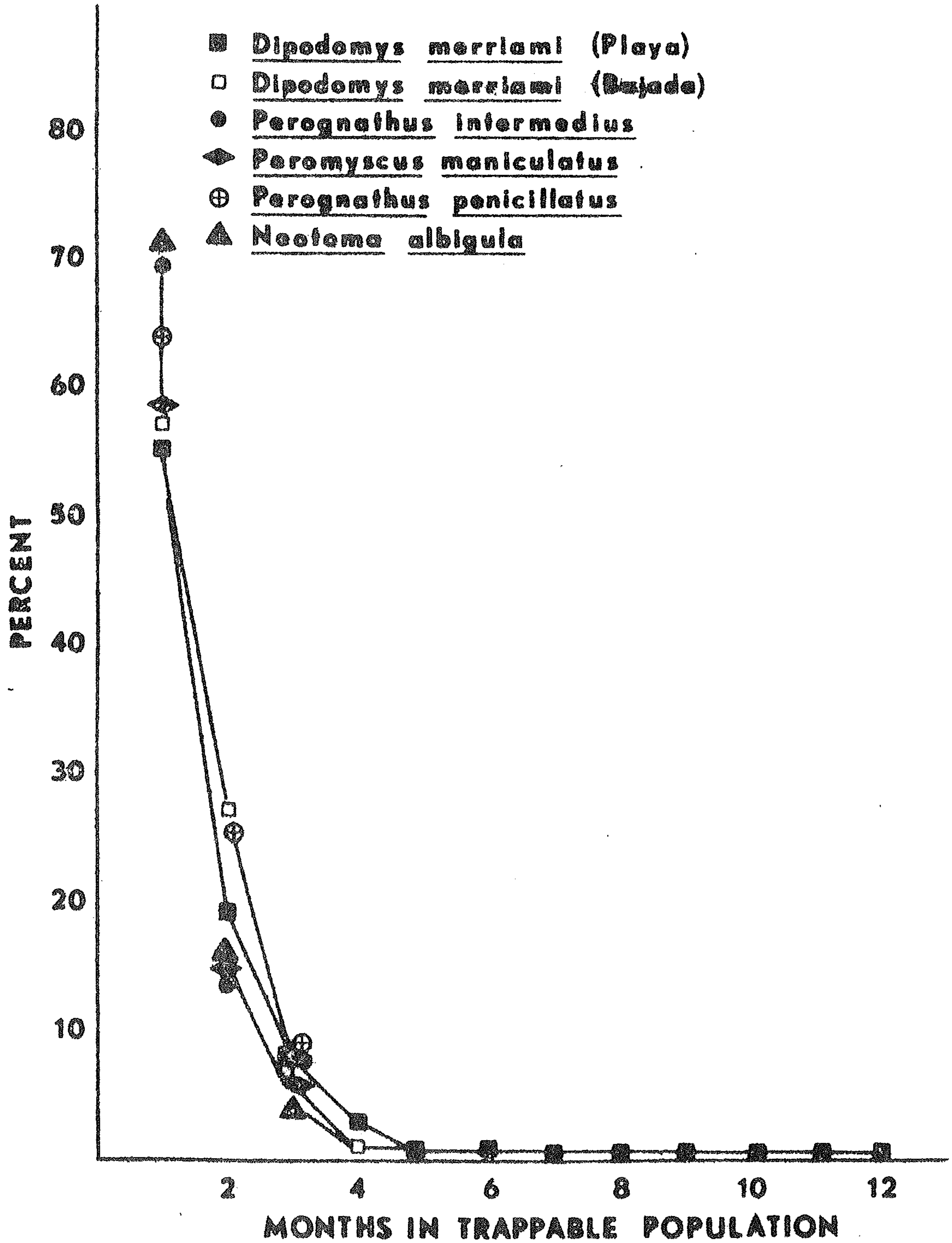

Figure 7. Comparison of survivorship curves for several species of Chihuahuan Desert rodents based on mark-recapture data for playa and bajada sites, 1971-1972.

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.

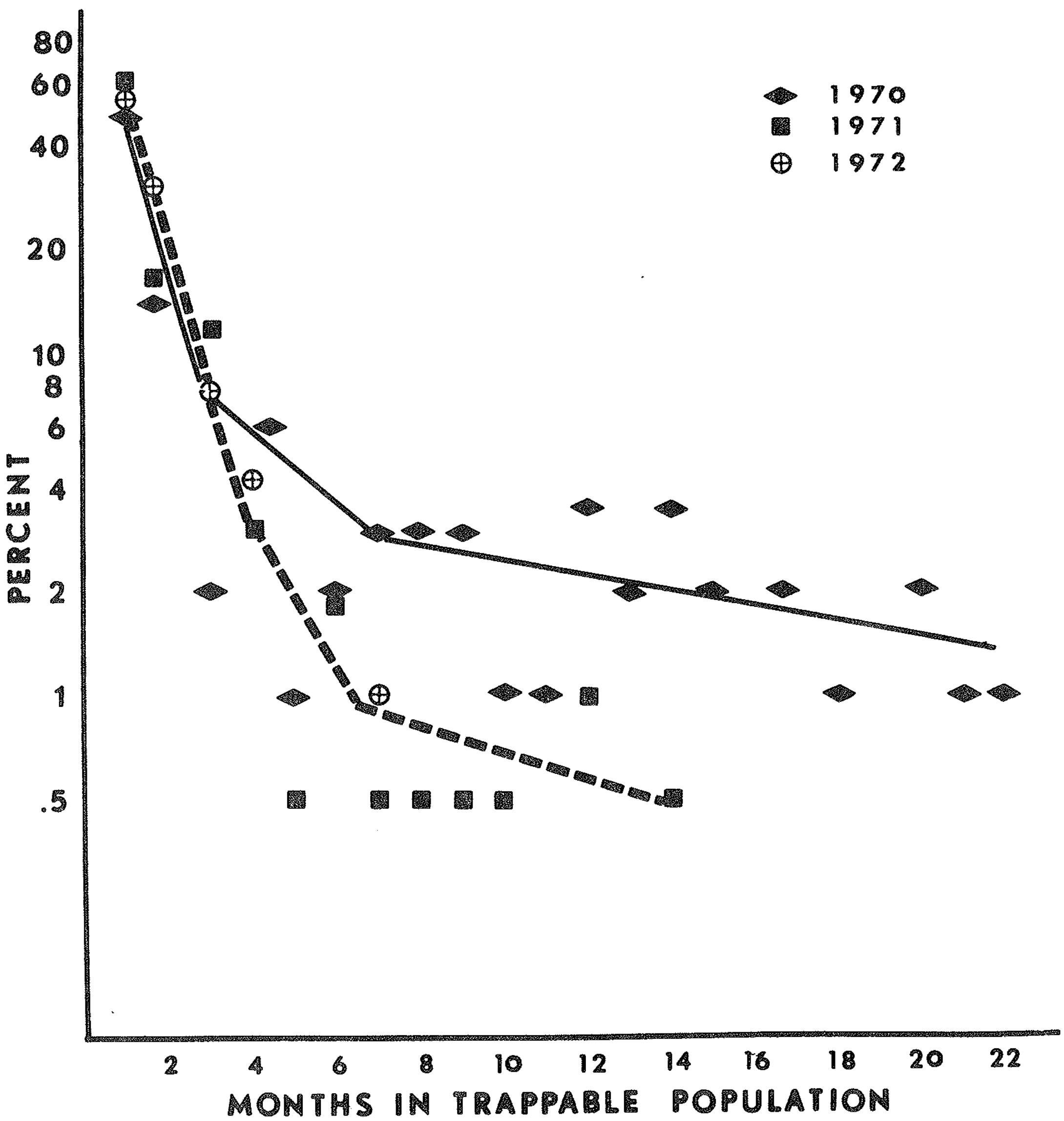

Figure 8. Survivorship in *Dipodomys merriami* population on the playa grid.

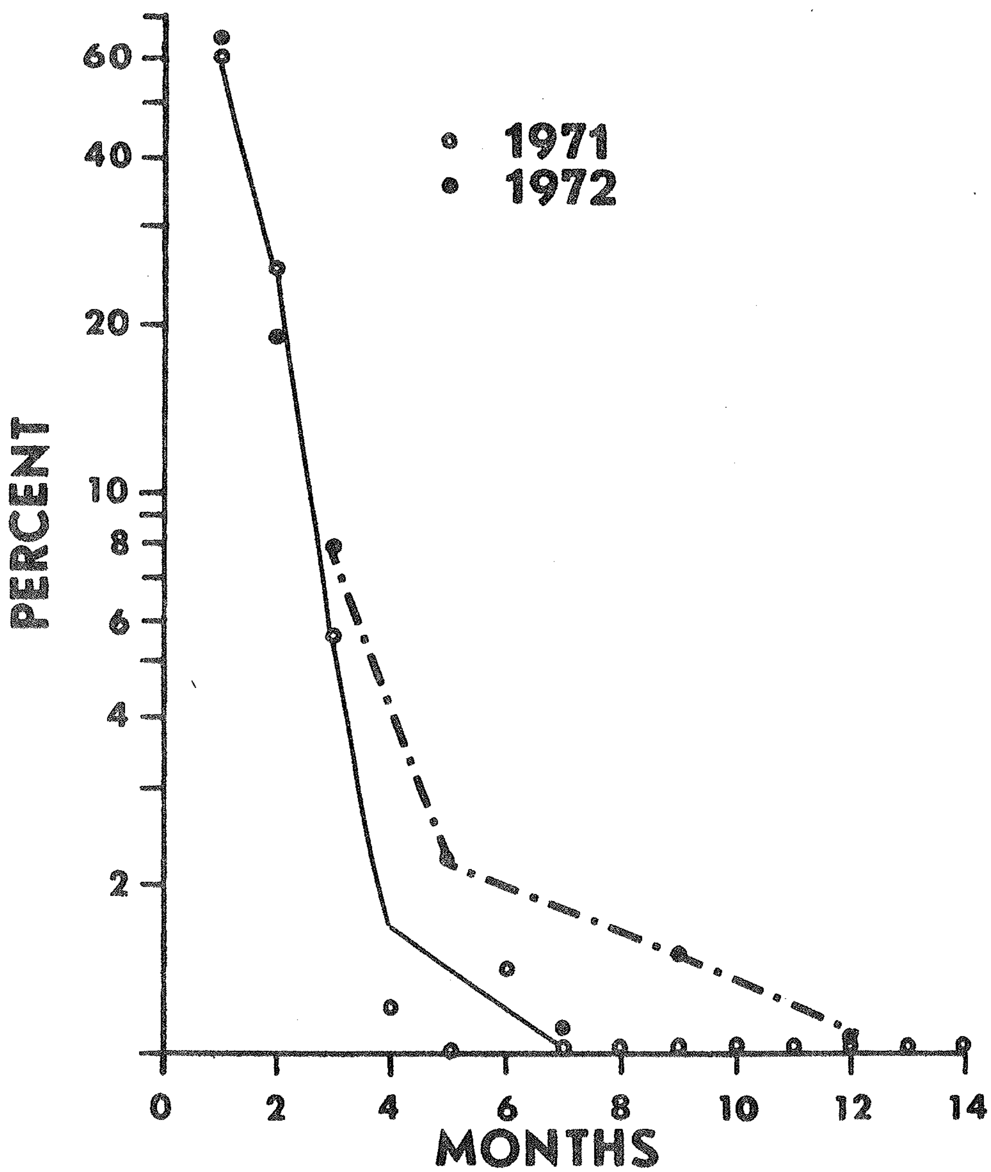

Figure 9. Survivorship in *Dipodomys merriami* population on the bajada grid.

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).

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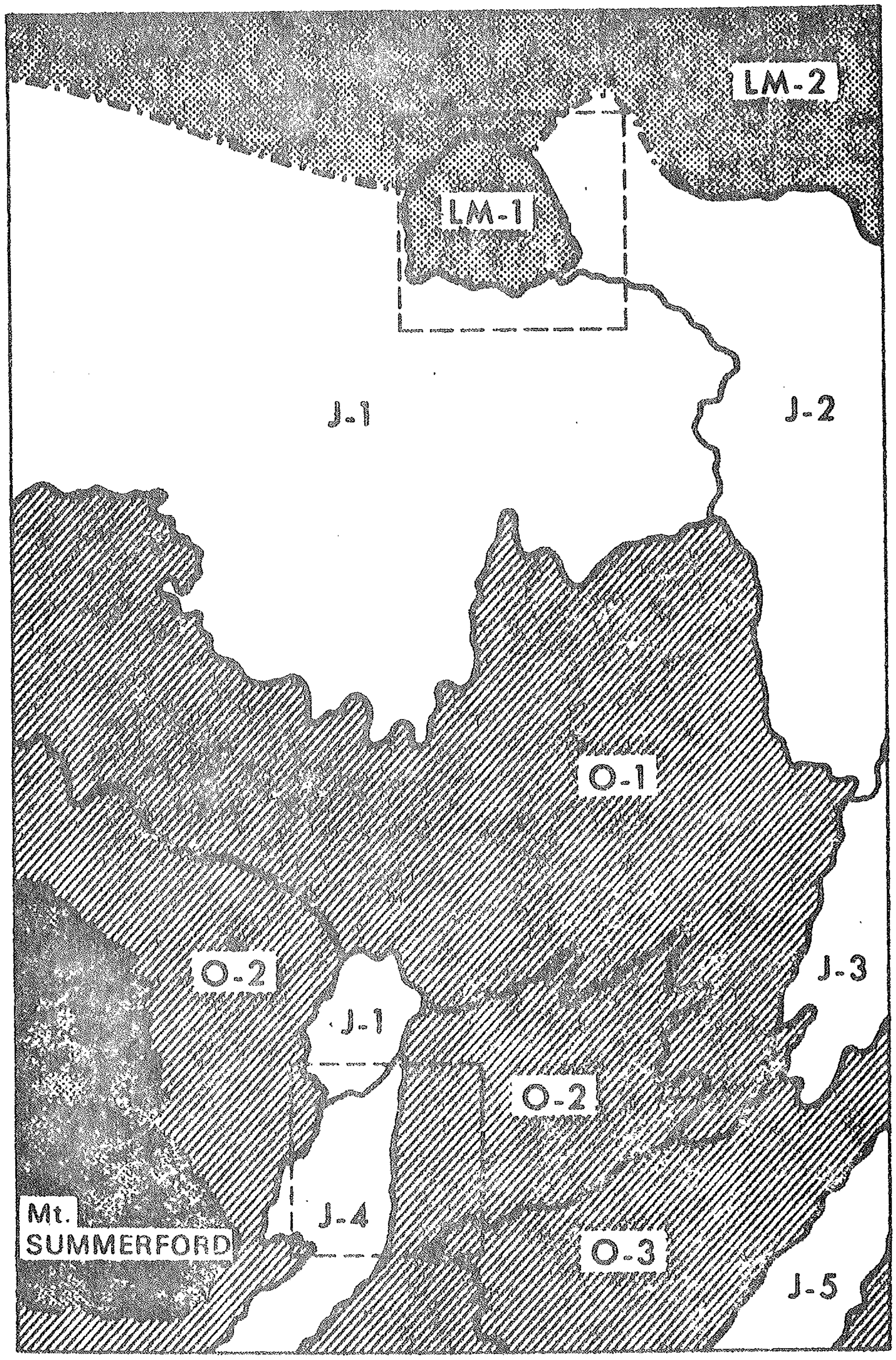

Figure 1. Soil map of the Jornada study area, the playa (upper) site and bajada (lower) site being demarcated. See Table 1 for interpretation of map codes.

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	O-1	Onite	sandy loam	Typic Haplargids, coarse-loamy	Noncalcareous in upper horizons
Organ	O-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	O-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.

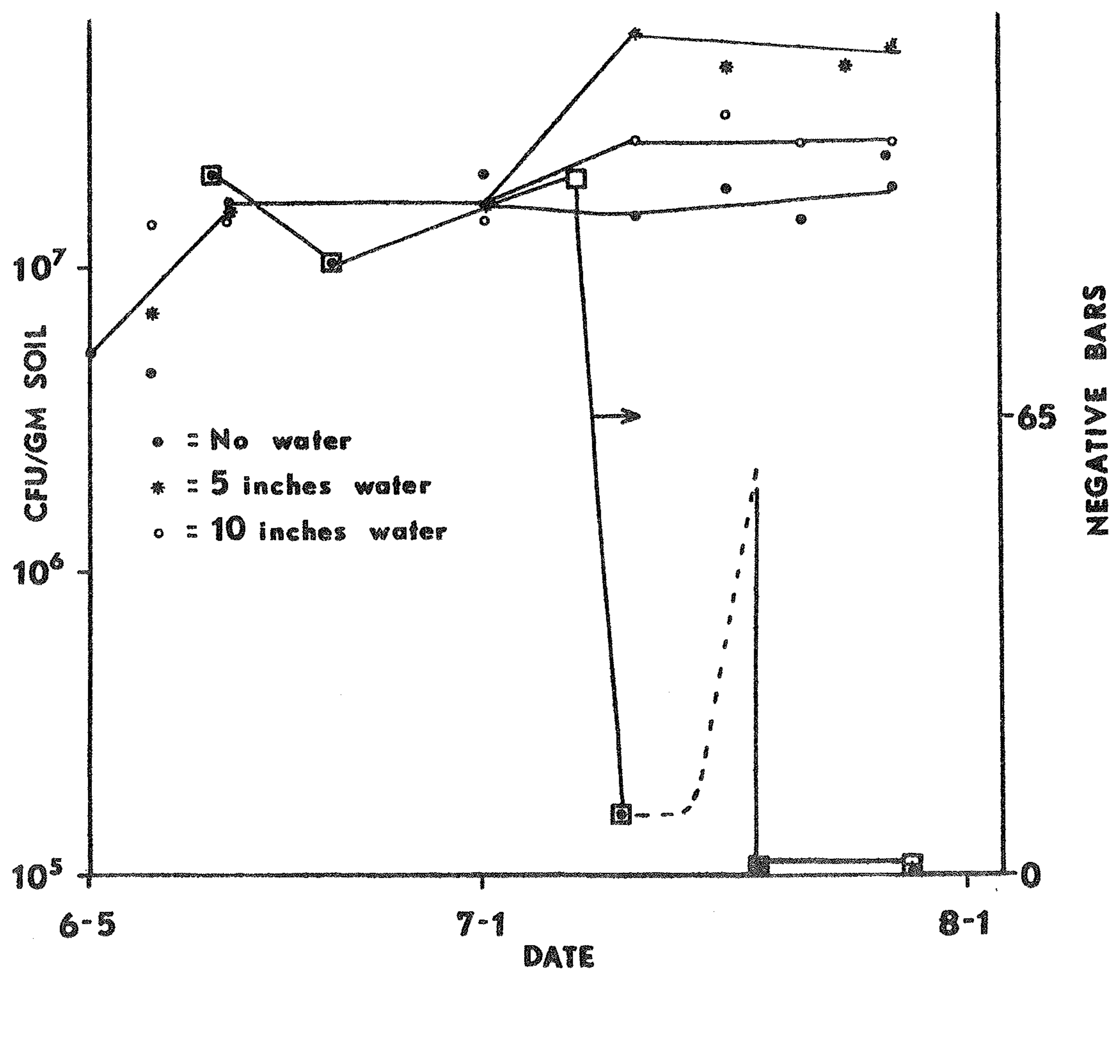

Figure 2. Colony-forming units in playa soil.

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.

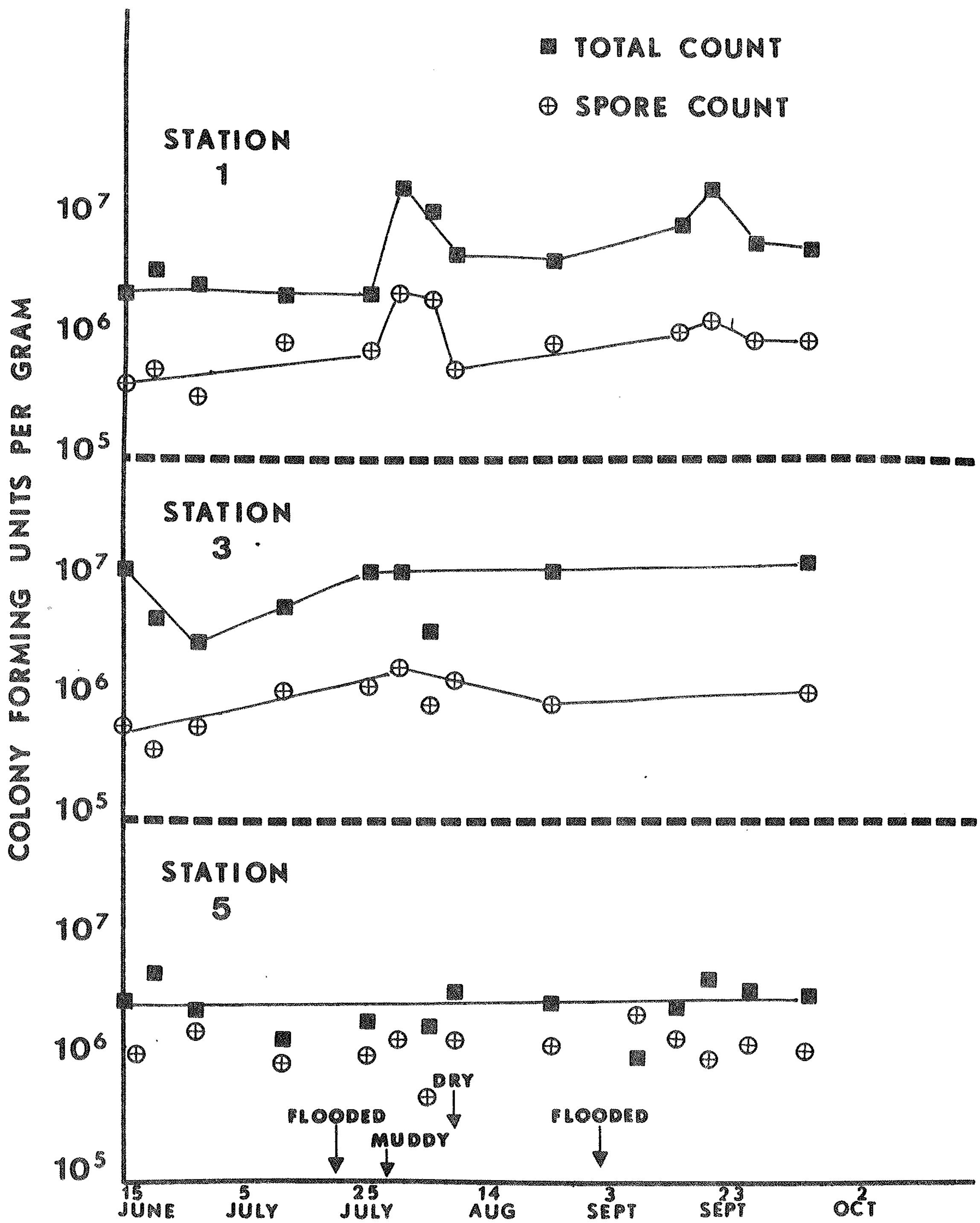

Figure 3. Spore and vegetative cell counts in playa soil.

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 ^3H 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

^{3}H Thymidine uptake

Date	Time	cpm ^{3}H 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

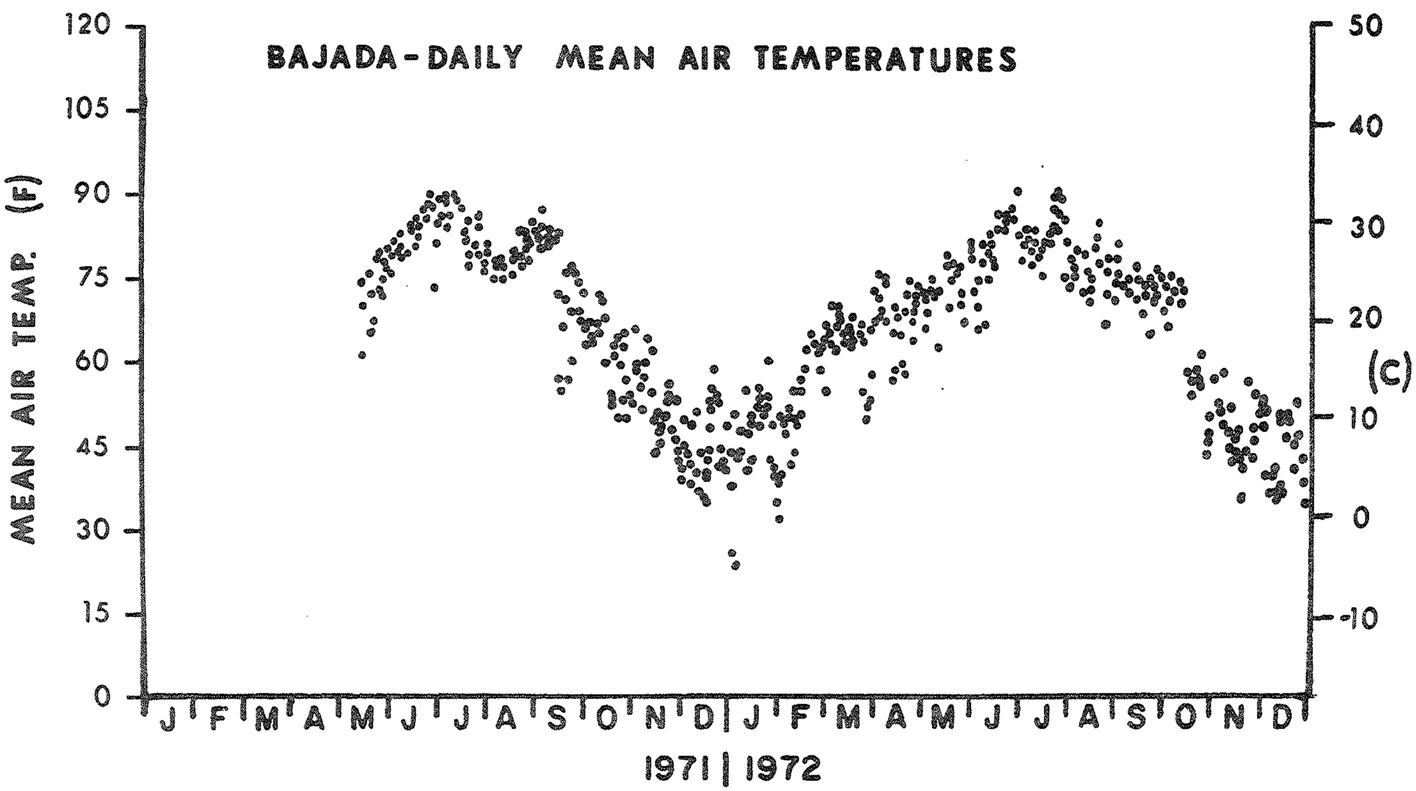

Figure 1. Daily mean air temperatures for 1971 and 1972 at the bajada.

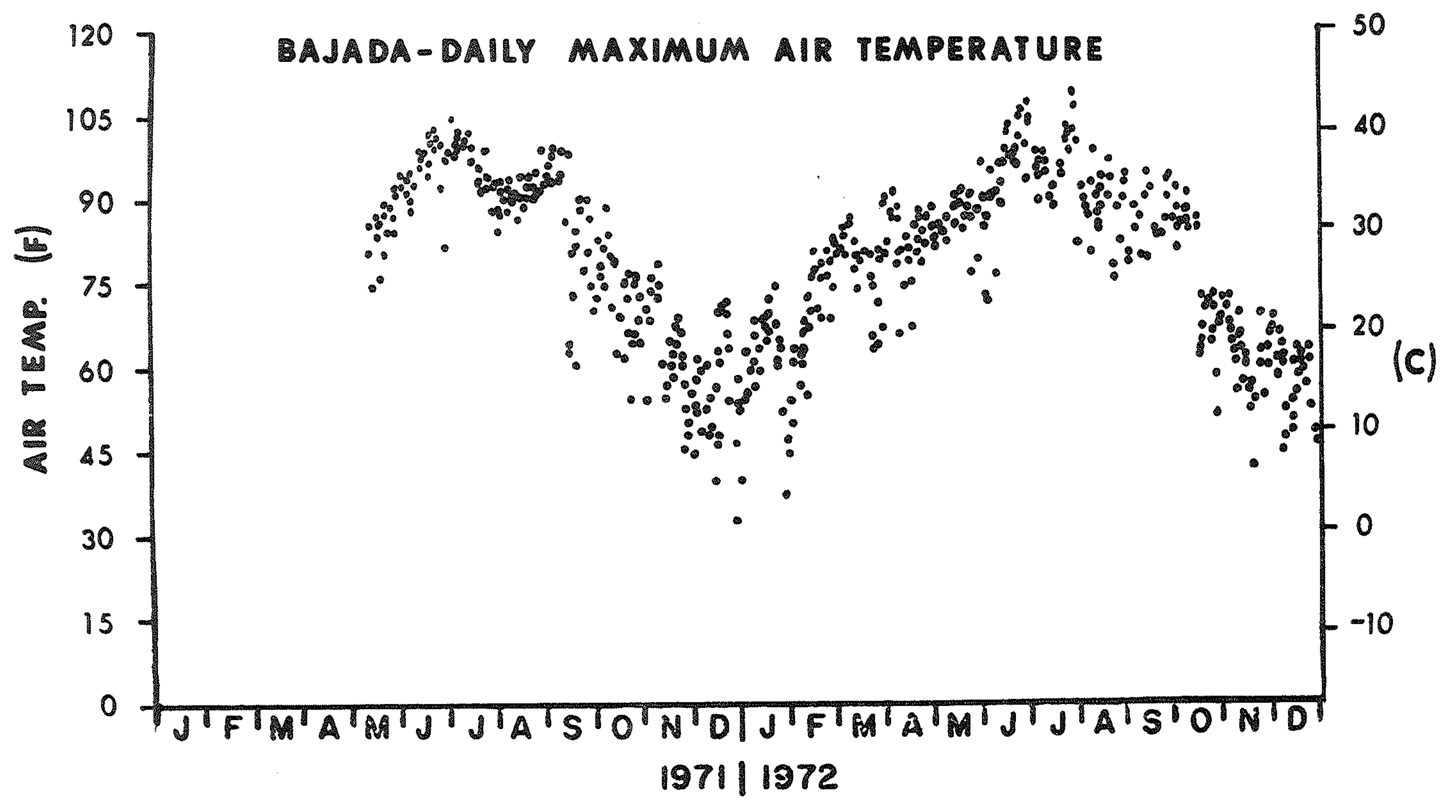

Figure 2. Daily maximum air temperatures for 1971 and 1972 at the bajada.

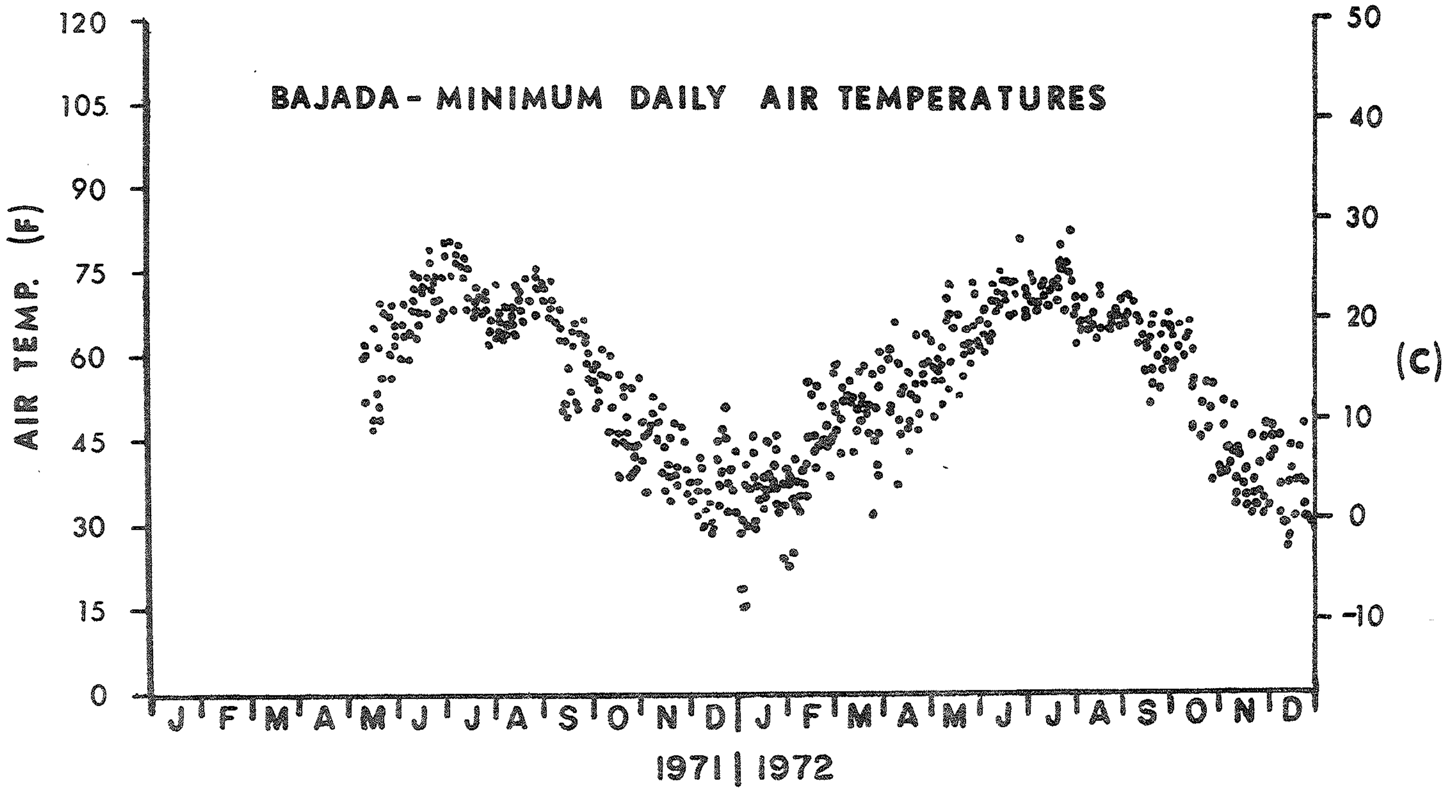

Figure 3. Daily minimum air temperatures for 1971 and 1972 at the bajada.

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.

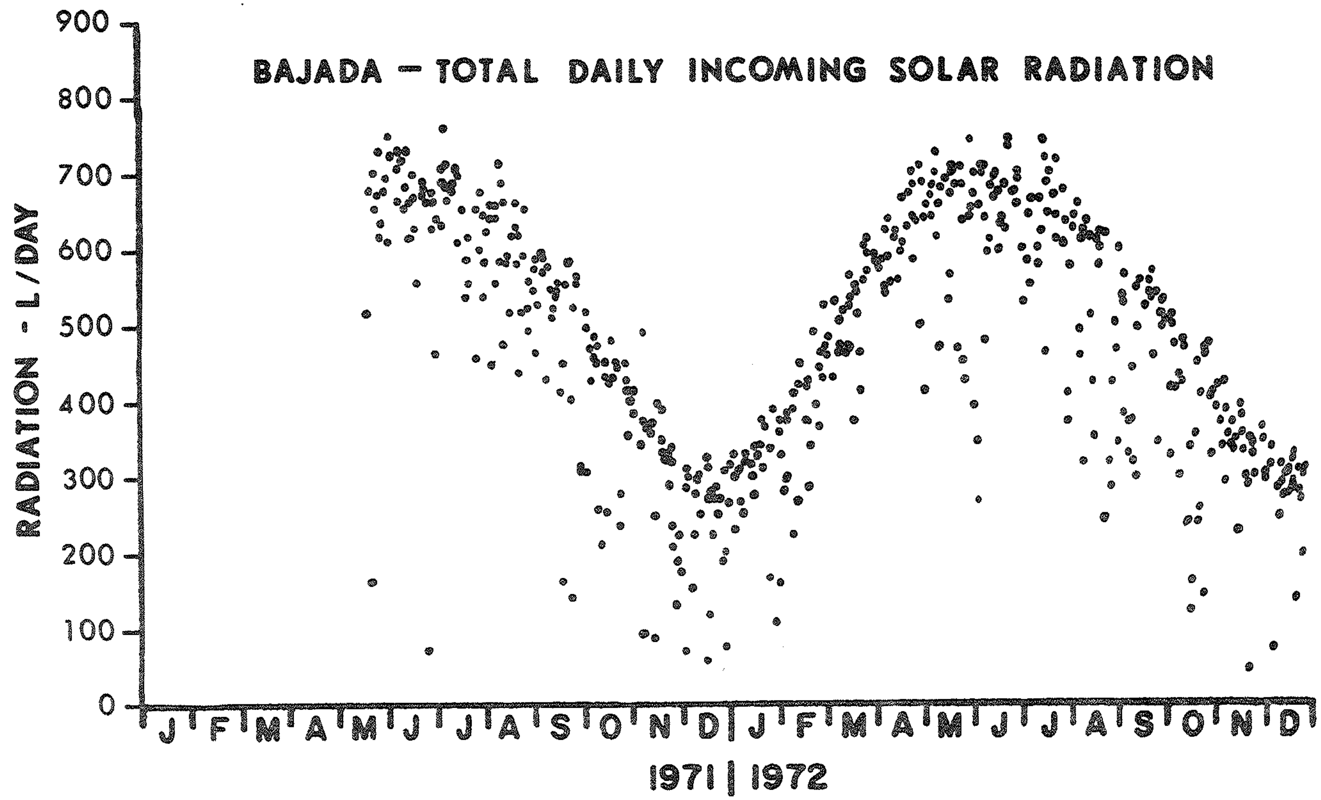

Figure 4. Daily total incoming solar radiation (langleys/day) for 1971 and 1972 at the bajada.

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.

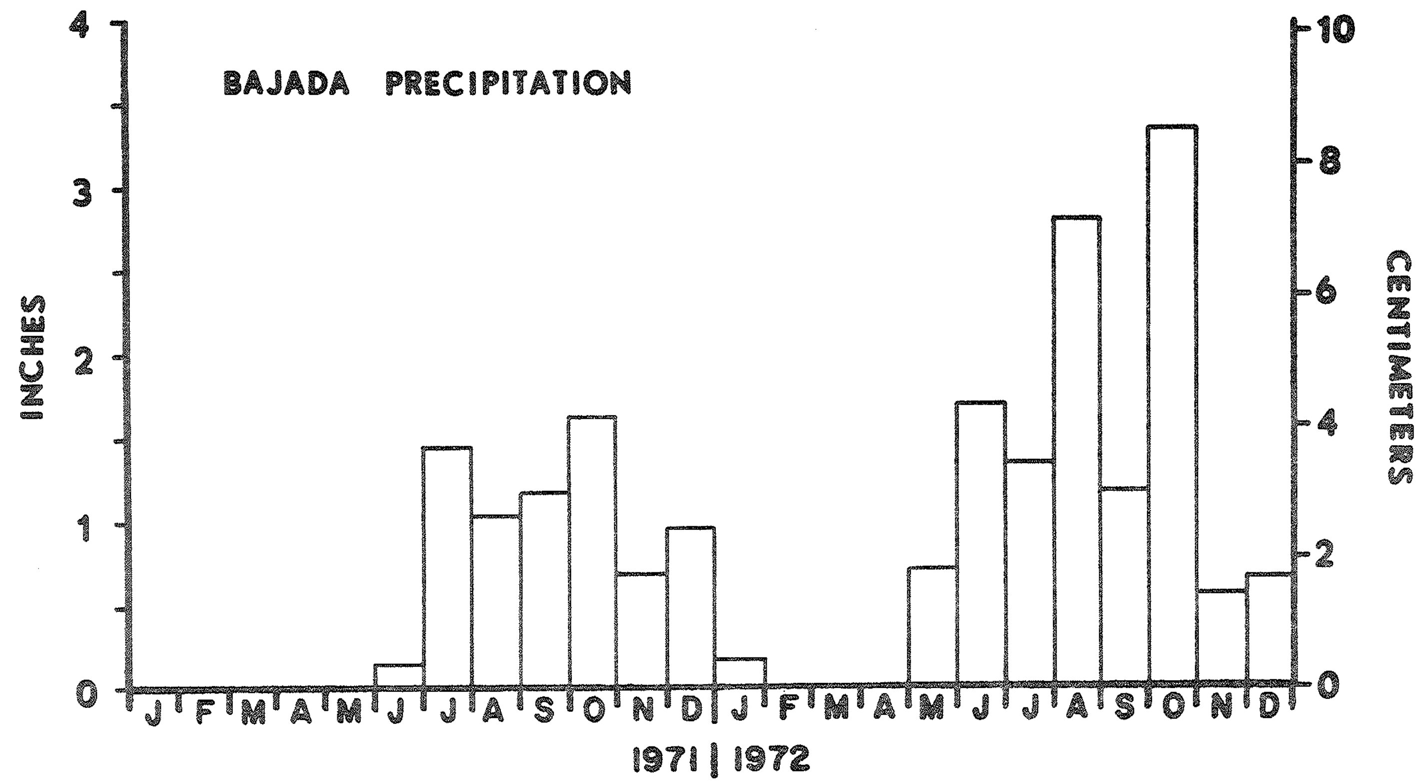

Figure 5. Monthly total precipitation patterns for 1971 and 1972 at the bajada.

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.

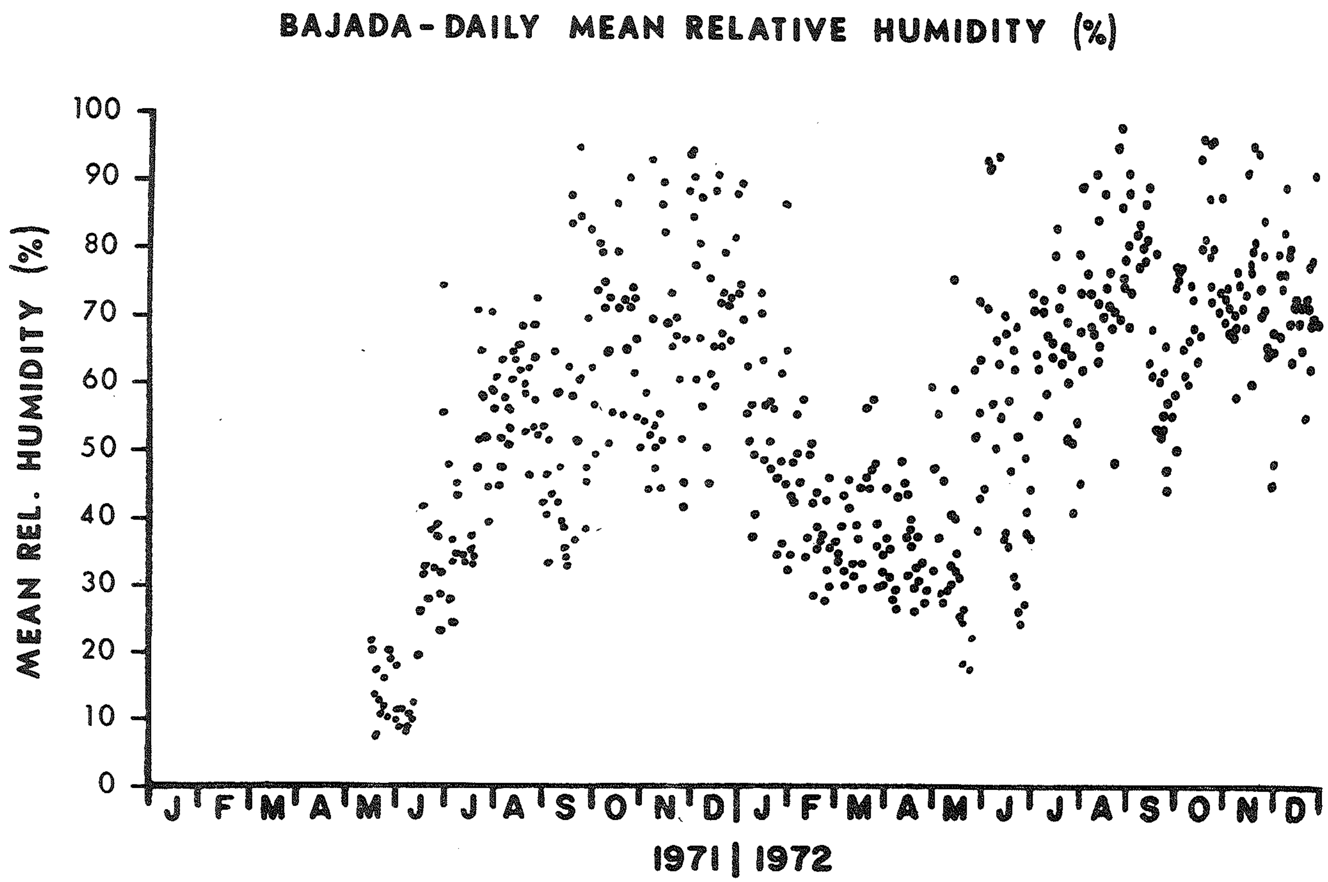

Figure 6. Daily mean relative humidities for 1971 and 1972 at the bajada site.

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.

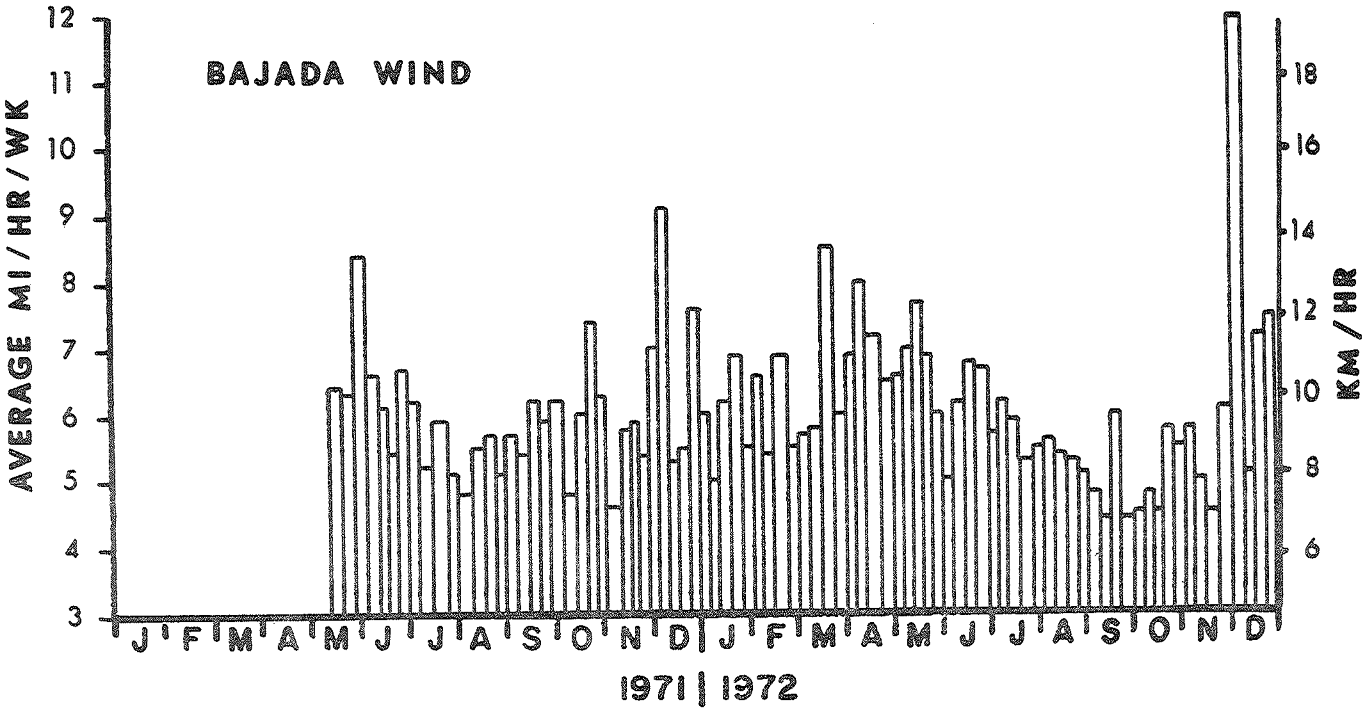

Figure 7. Average wind speed (miles/hr/week) on the bajada site in 1971 and 1972.

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).

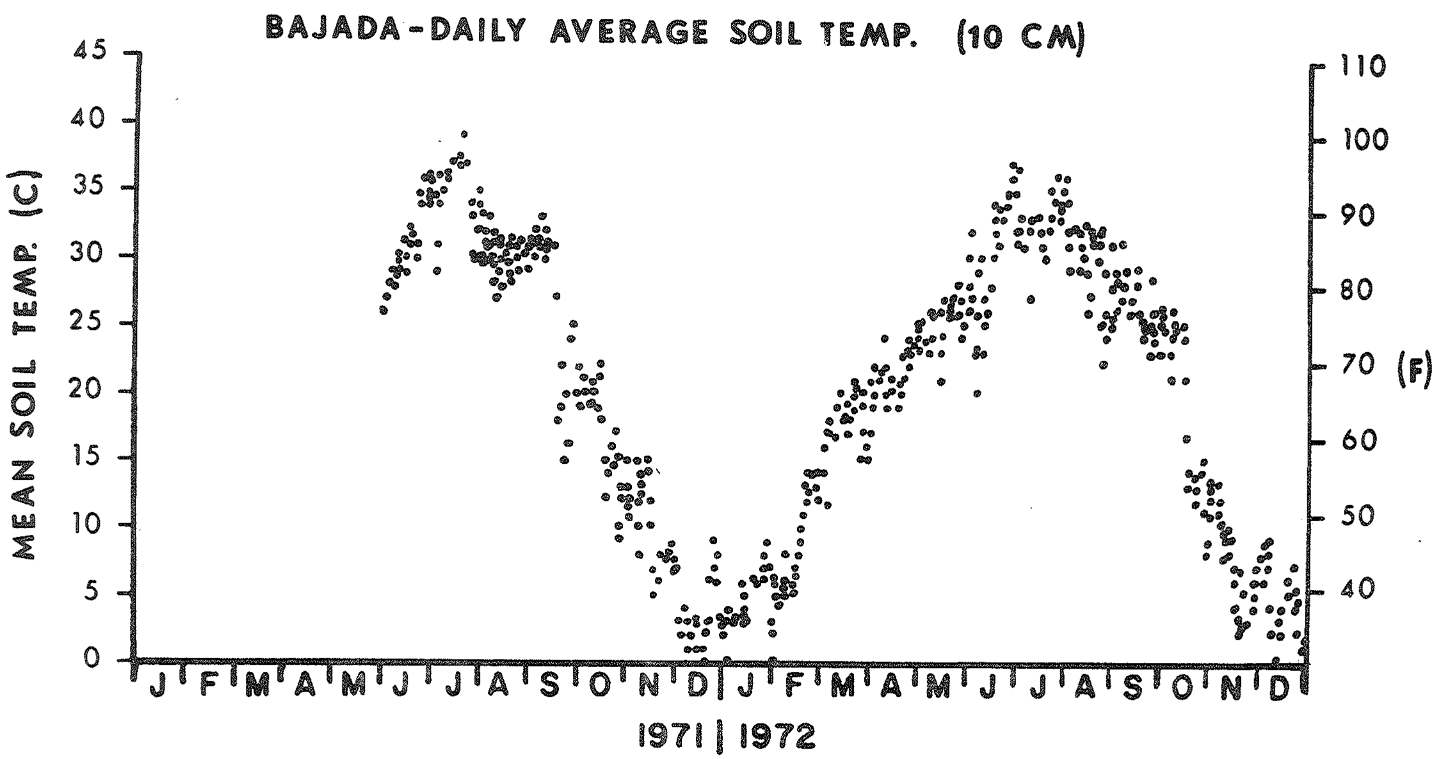

Figure 8. Daily mean soil temperatures at 10 cm for 1971 and 1972 at the bajada site.

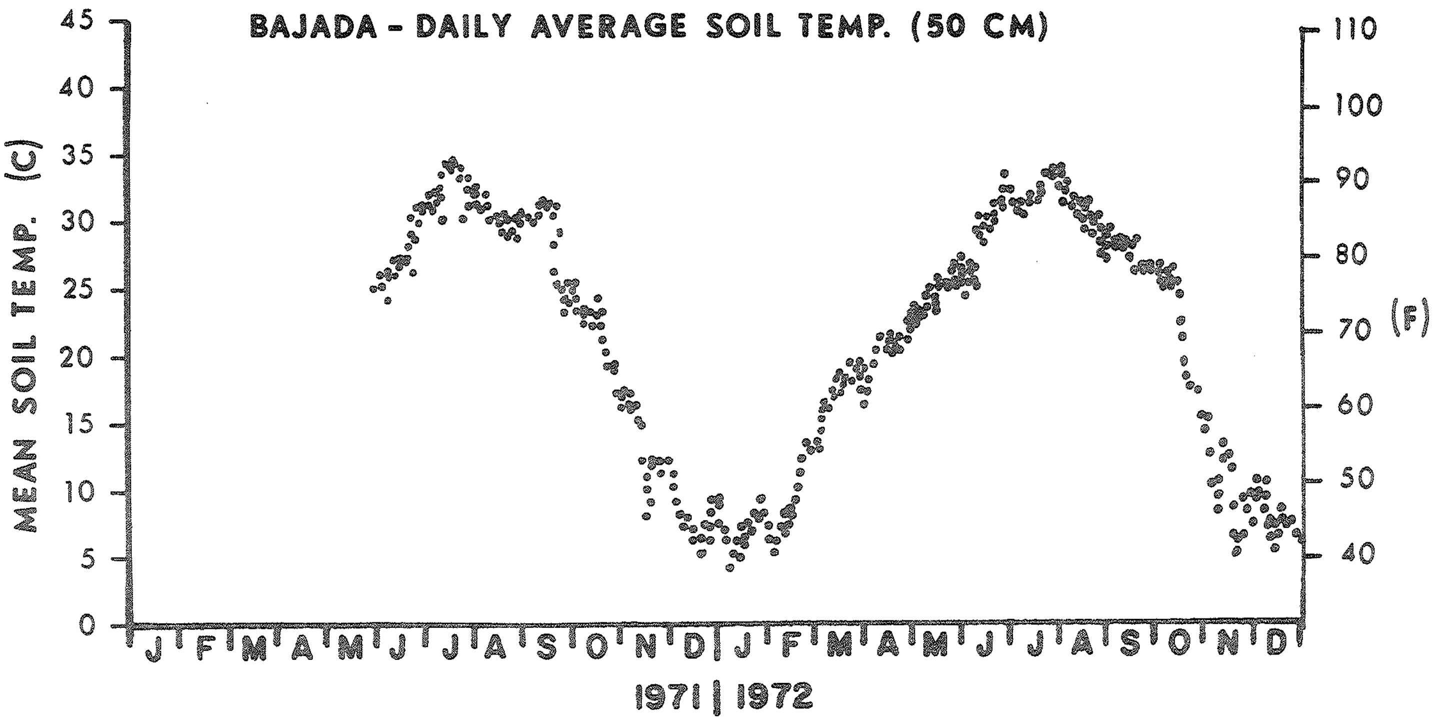

Figure 9. Daily mean soil temperatures at 50 cm for 1971 and 1972 at the bajada site.

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.

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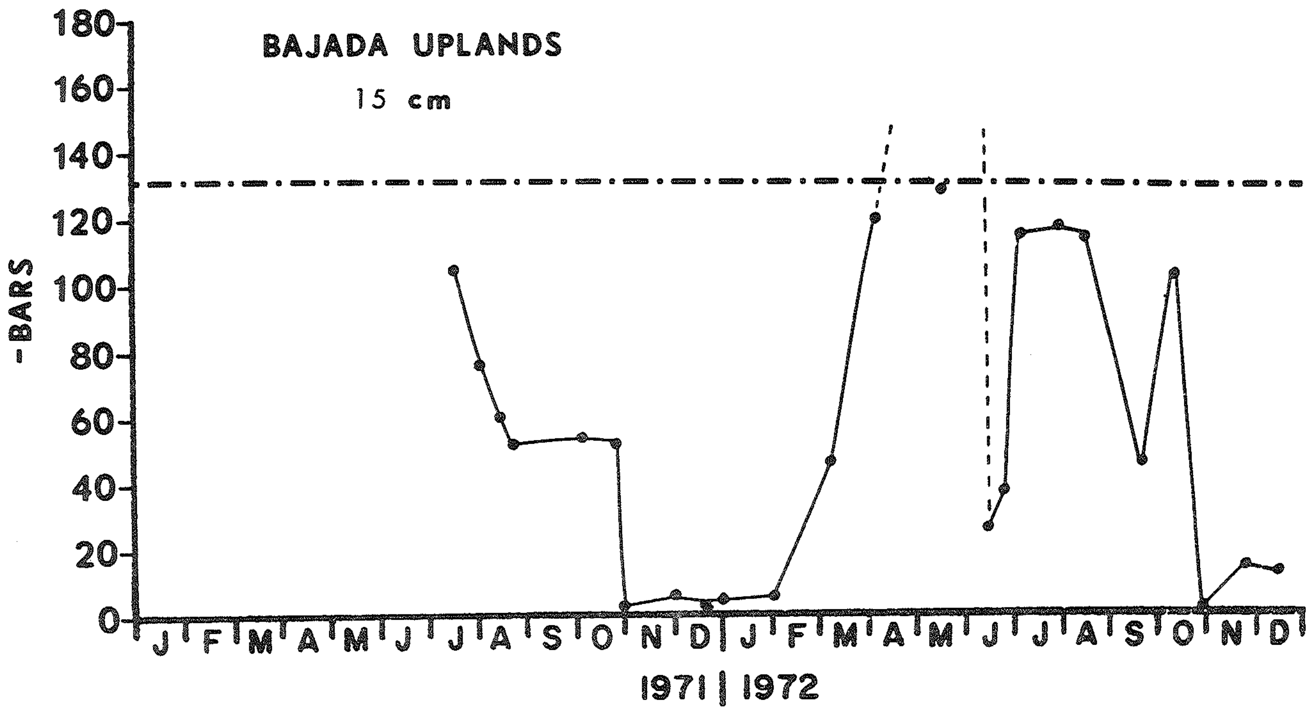

Figure 10. Soil water potentials at 15 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

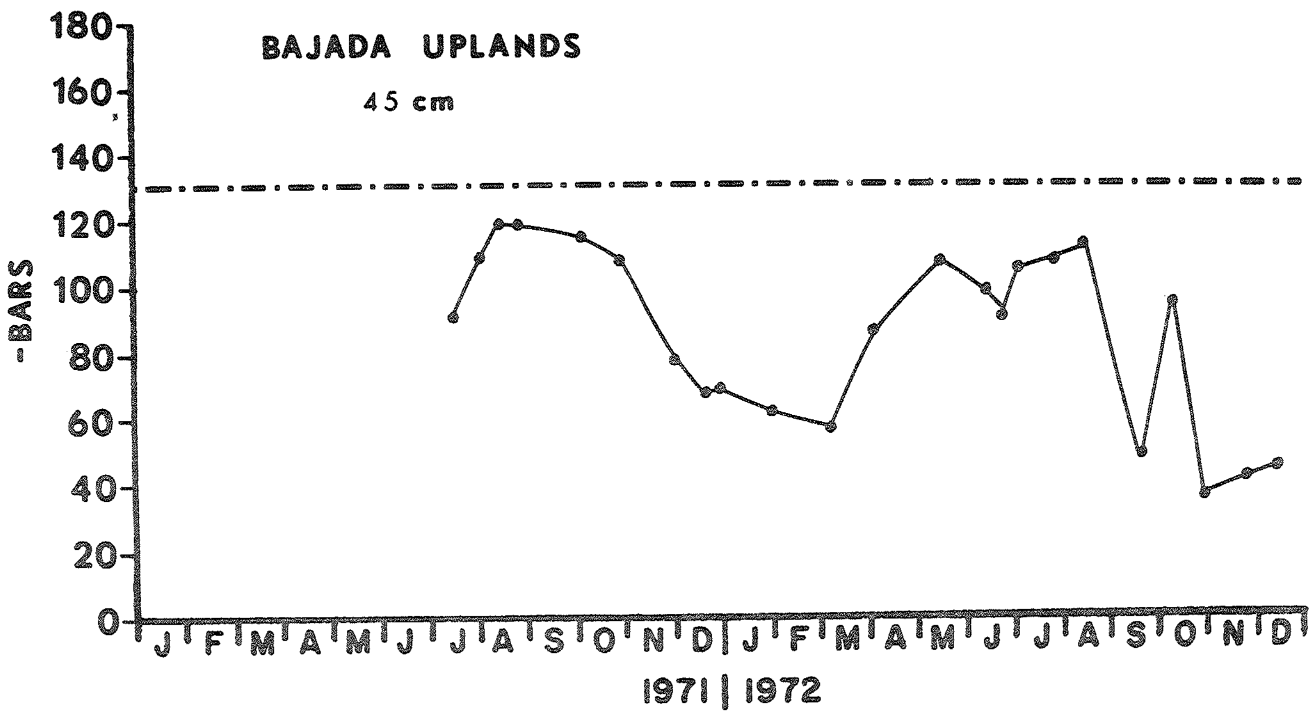

Figure 11. Soil water potentials at 45 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

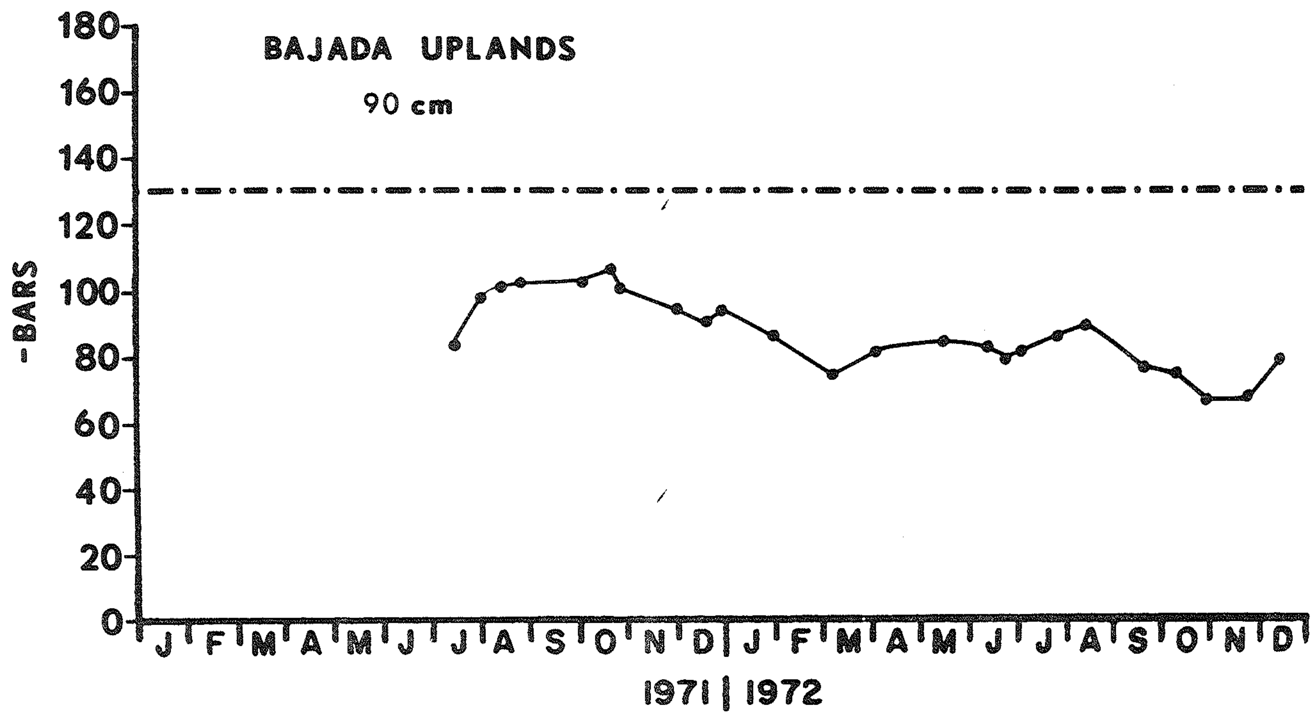

Figure 12. Soil water potentials at 90 cm for 1971 and 1972 on the bajada uplands (creosote bush area).

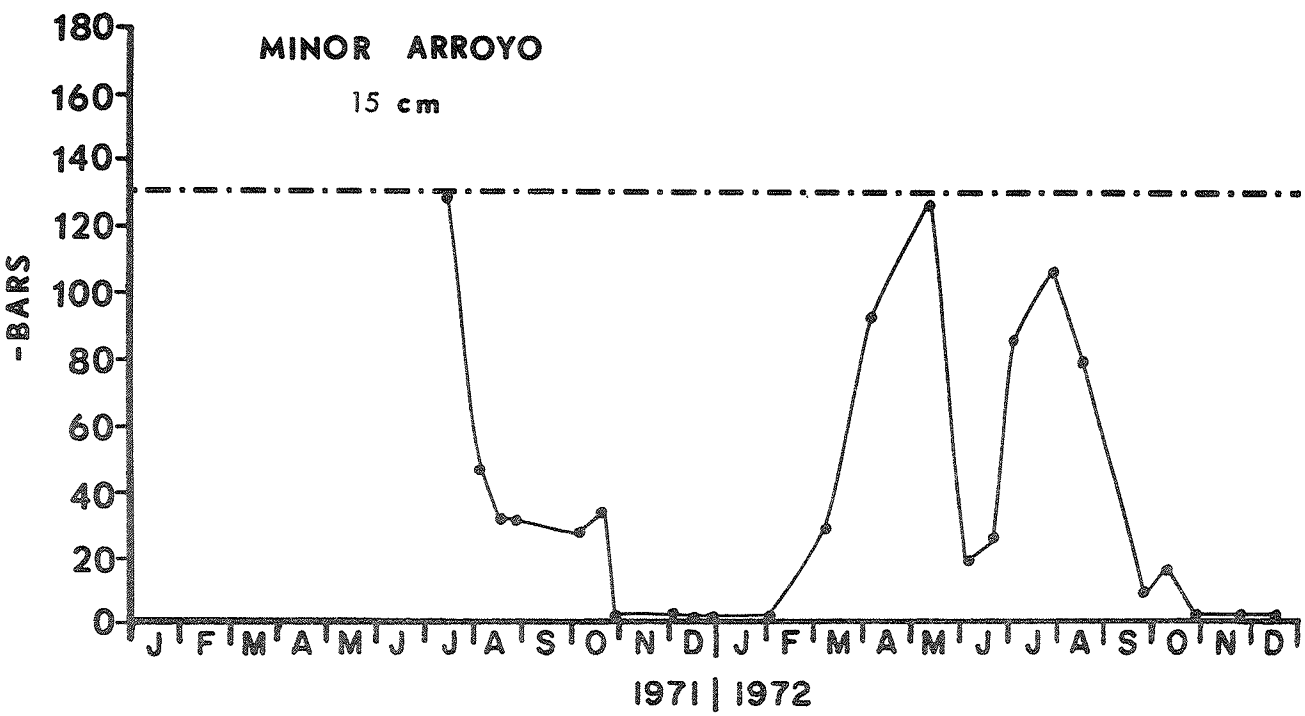

Figure 13. Soil water potentials at 15 cm for 1971 and 1972 in the bajada minor arroyos.

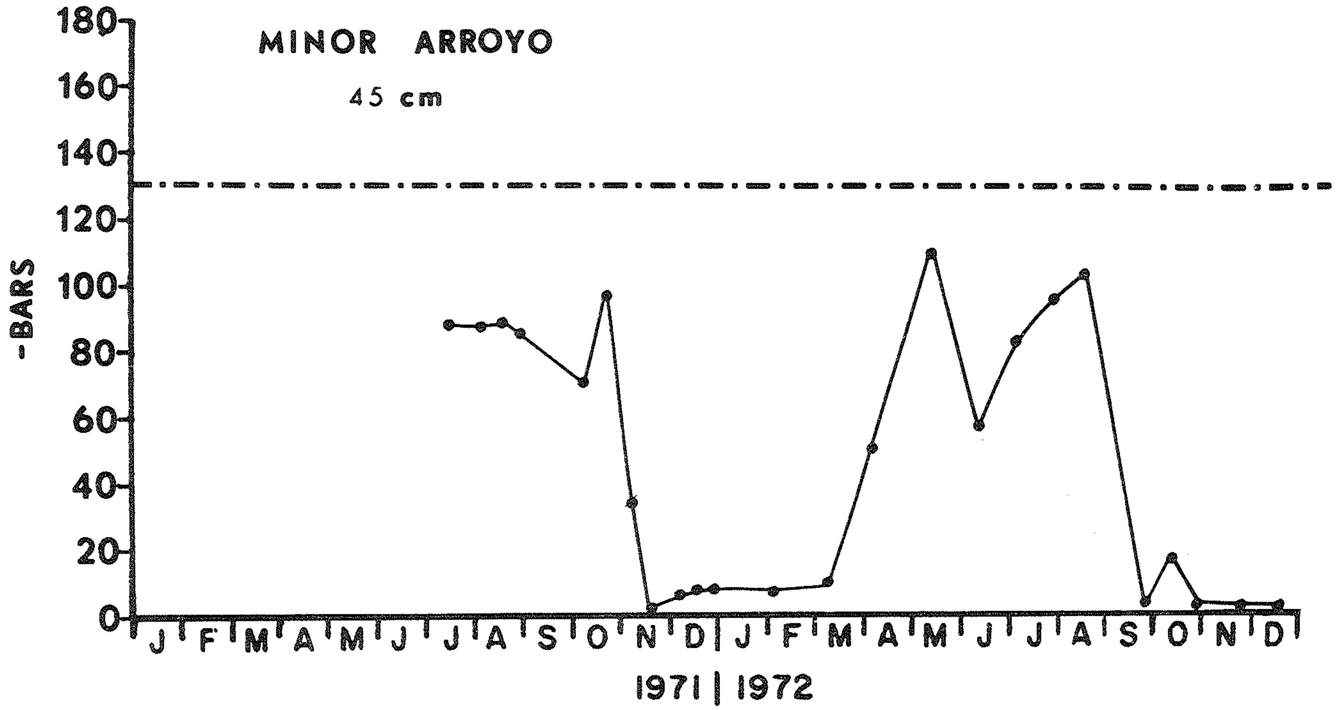

Figure 14. Soil water potentials at 45 cm for 1971 and 1972 in the bajada minor arroyos.

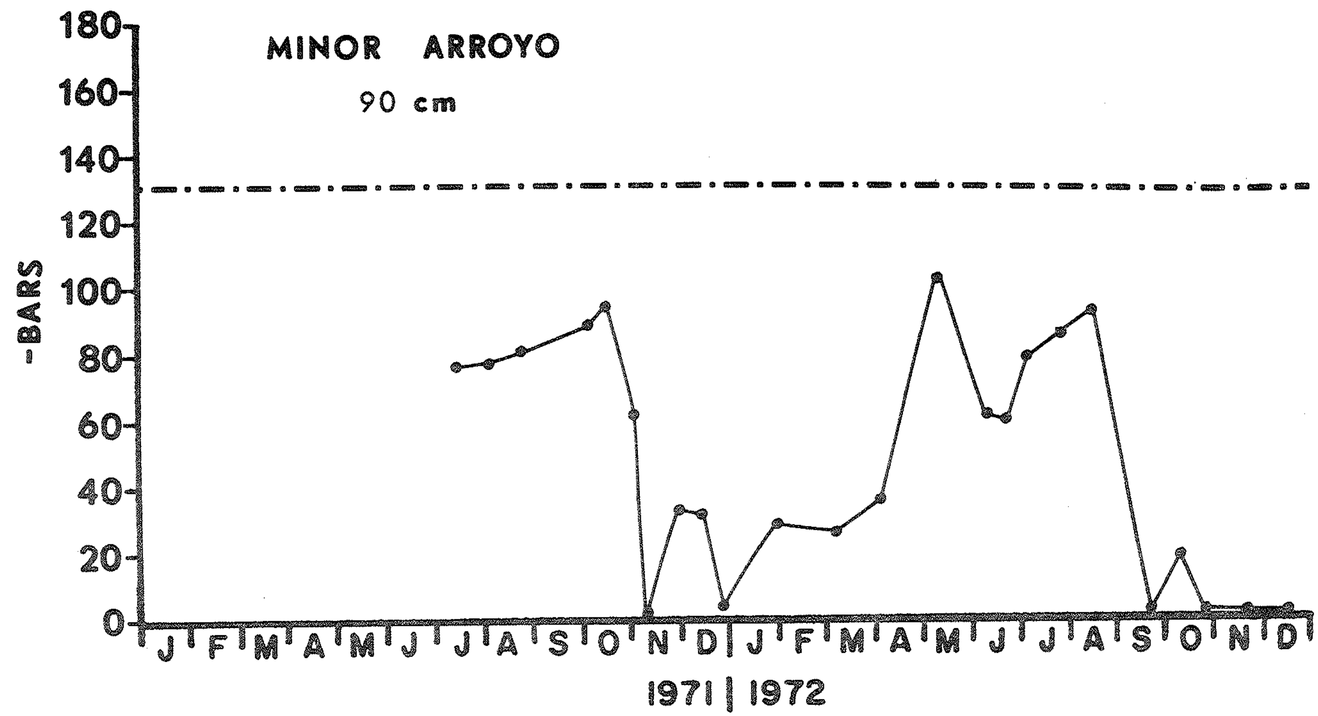

Figure 15. Soil water potentials at 90 cm for 1971 and 1972 in the bajada minor arroyos.

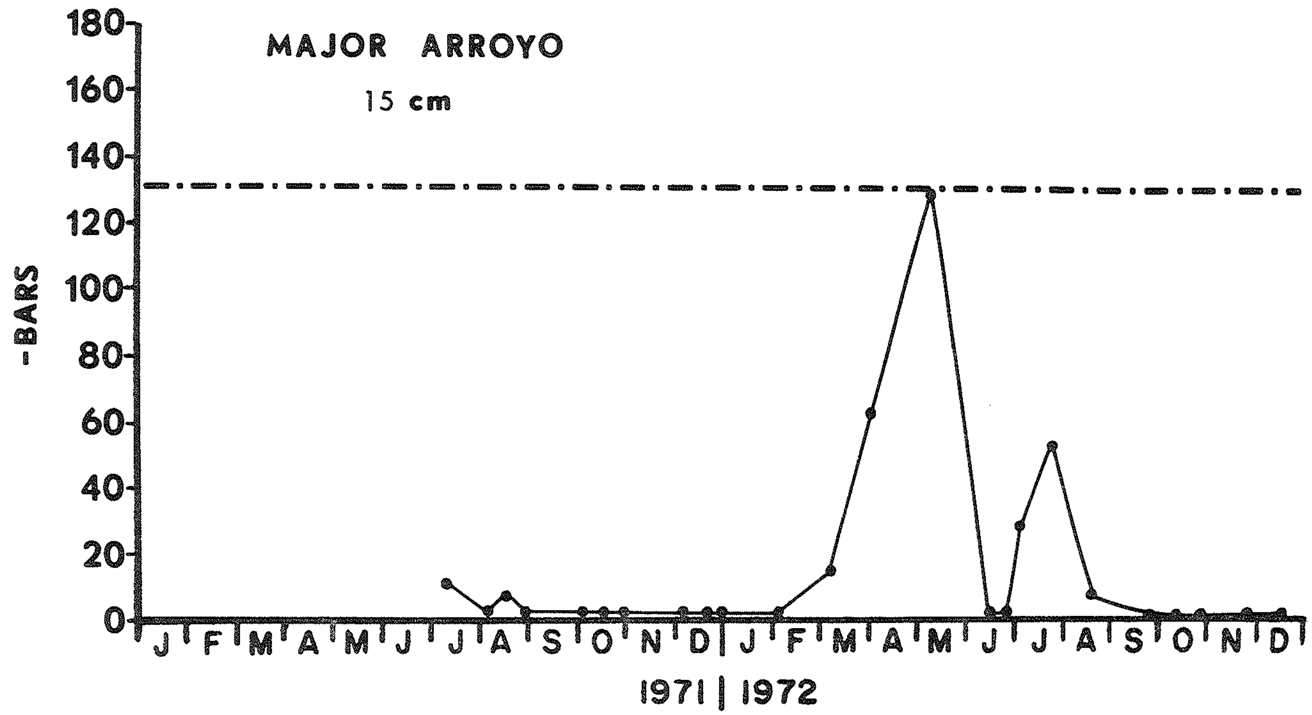

Figure 16. Soil water potentials at 15 cm for 1971 and 1972 in the bajada major arroyo.

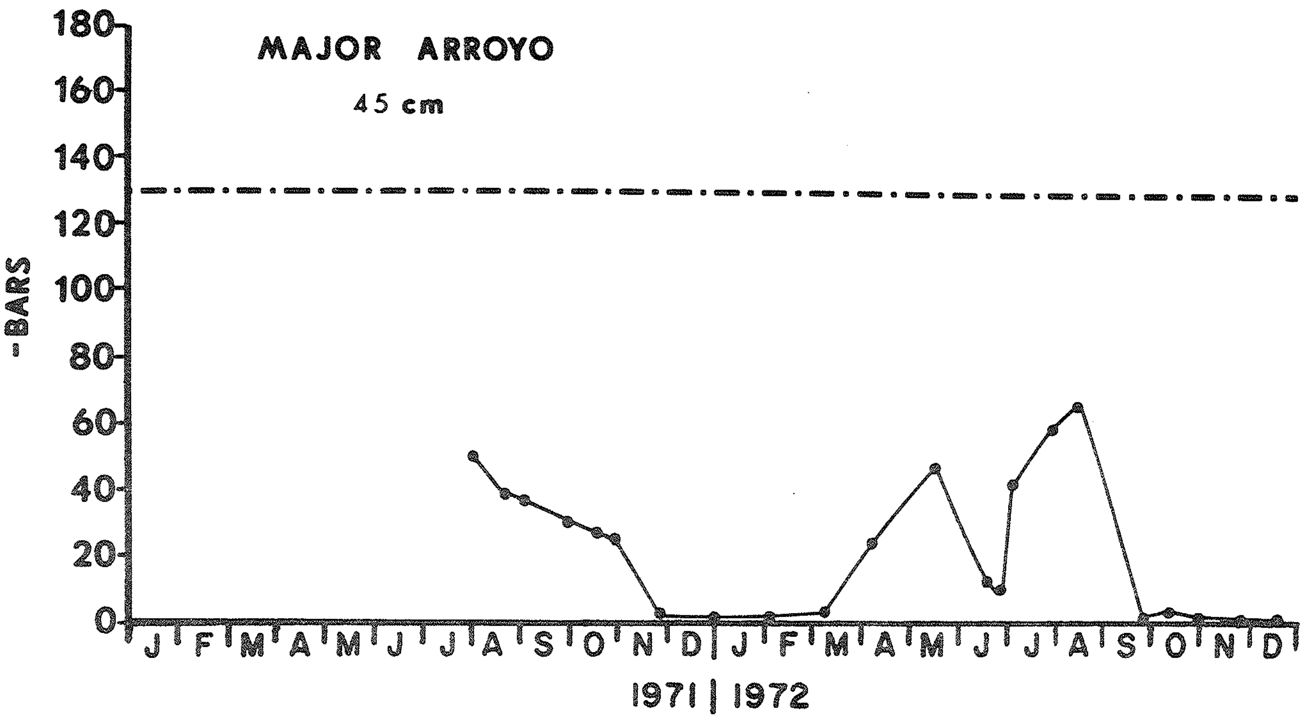

Figure 17. Soil water potentials at 45 cm for 1971 and 1972 in the bajada major arroyo.

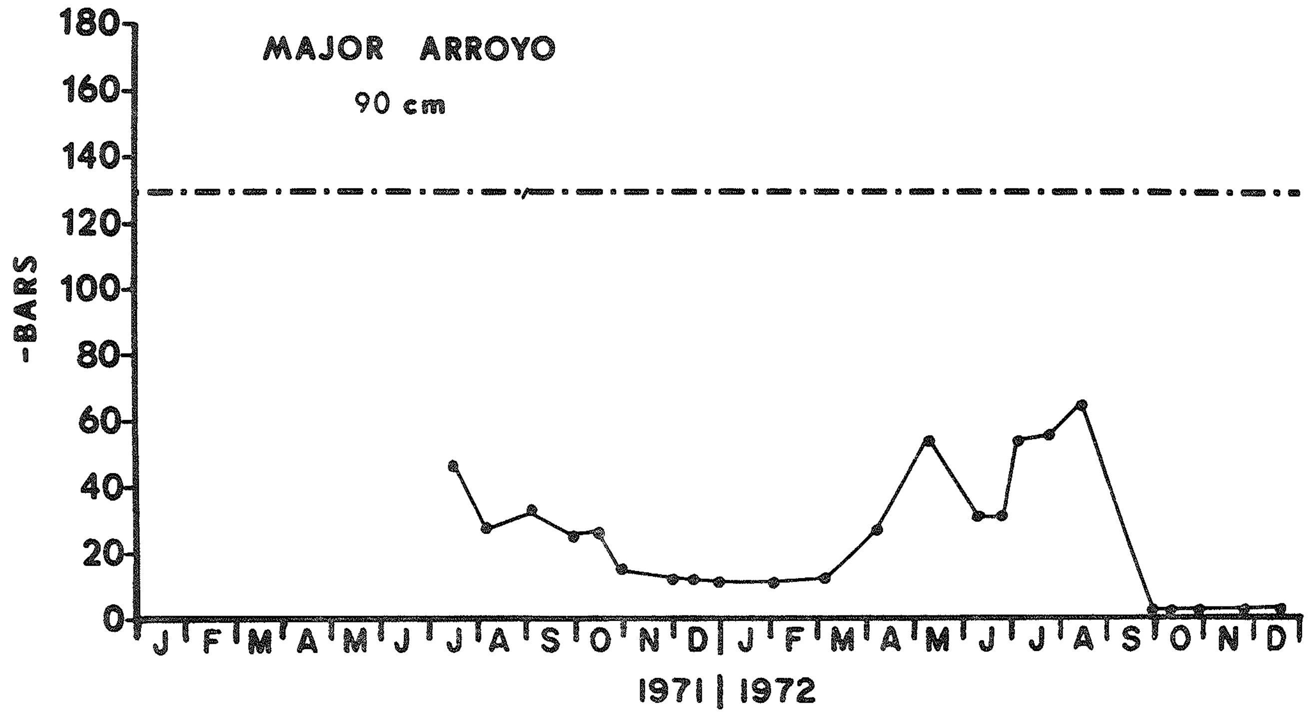

Figure 18. Soil water potentials at 90 cm for 1971 and 1972 in the bajada major arroyo.

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 Total	Vegetative	1.5	7.6	.45	0
	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	1972 4 April	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	1972 4 April	1972 28 June	1972 19 October
<u>Amaranthus fimbriatus</u>	Vegetative	1.0	----	----	----
	Reproductive	0.1	----	----	----
	Total	1.1	----	----	----
<u>Astragalus nuttallianus</u>	Vegetative	----	15.2	----	----
	Reproductive	----	15.2	----	----
	Total	----	30.4	----	----
<u>Boerhaavia spicata</u>	Vegetative	1.2	----	----	53.2
	Reproductive	0	----	----	2.1
	Total	1.2	----	----	55.3
<u>Chaenactis stevioides</u>	Vegetative	----	6.1	----	----
	Reproductive	----	3.0	----	----
	Total	----	9.1	----	----
<u>Cryptantha angustifolia</u>	Vegetative	----	914.4	----	----
	Reproductive	----	914.4	----	----
	Total	----	1,828.8	----	----
<u>Cryptantha crassisepala</u>	Vegetative	----	15.2	----	----
	Reproductive	----	4.6	----	----
	Total	----	19.8	----	----
<u>Cryptantha micrantha</u>	Vegetative	----	27.4	----	----
	Reproductive	----	27.4	----	----
	Total	----	54.8	----	----
<u>Descurainia pinnata</u>	Vegetative	----	195.1	----	2.1
	Reproductive	----	146.3	----	0
	Total	----	341.4	----	2.1
<u>Dithyrea wislizeni</u>	Vegetative	----	----	2.2	----
	Reproductive	----	----	0	----
	Total	----	----	2.2	----

Table 5. (cont.)

Species	Plant Component	1971 9 September	4 April	1972 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)

Species	1971 9 September	1972 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)

Species	1971 9 September	1972 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 Component	1971 9 September	1972 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	1972 4 April	1972 28 June	1972 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	1972 4 April	1972 28 June	1972 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 specie. 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.	mean	U.L.	Estimated by Equation
<u>Yucca elata</u>	Green Leaves		55		V
	Caudex		853		V
	Dead Leaves		326		V
	Total Above Grnd		1234		V
	Tuber		3341		V
<u>Yucca baccata</u>	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.

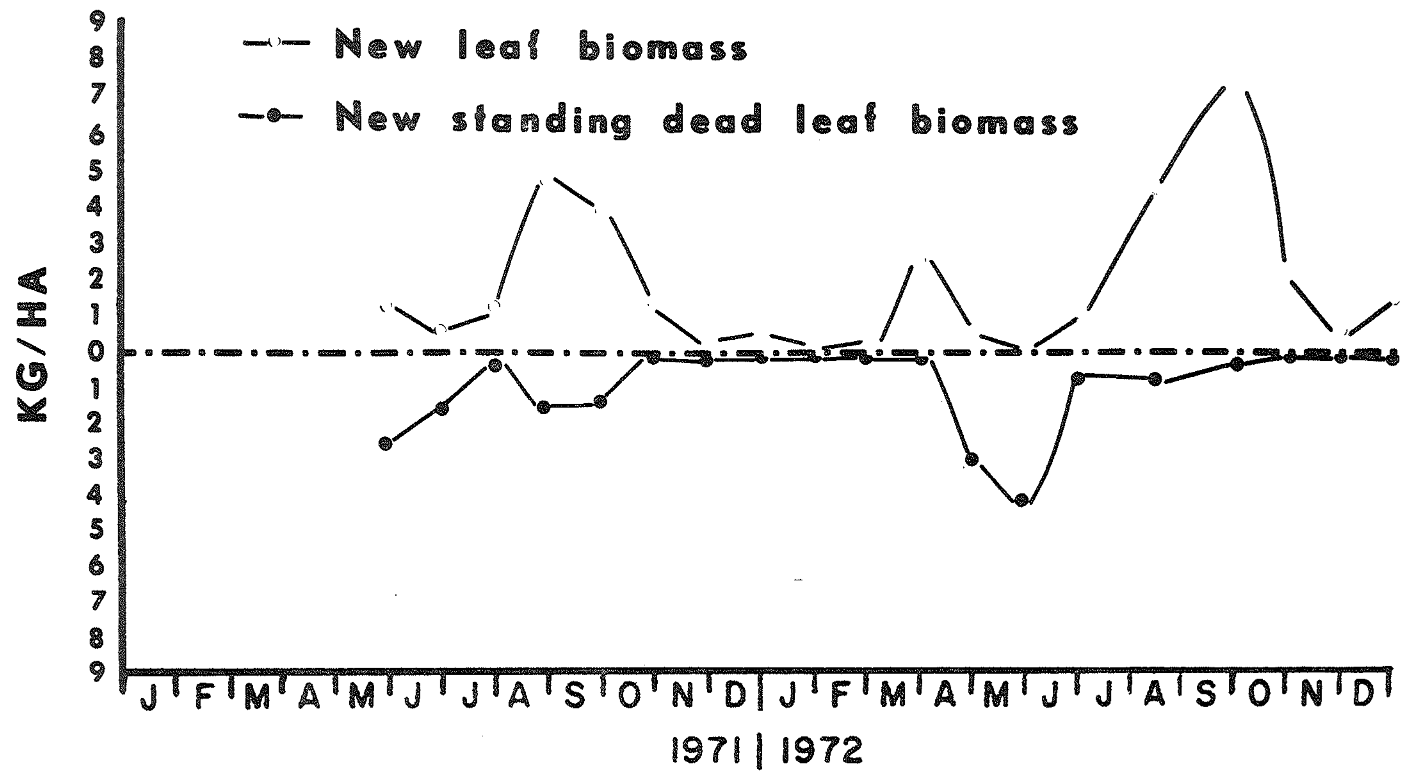

Figure 1. Monthly changes in new leaf and standing dead-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada.

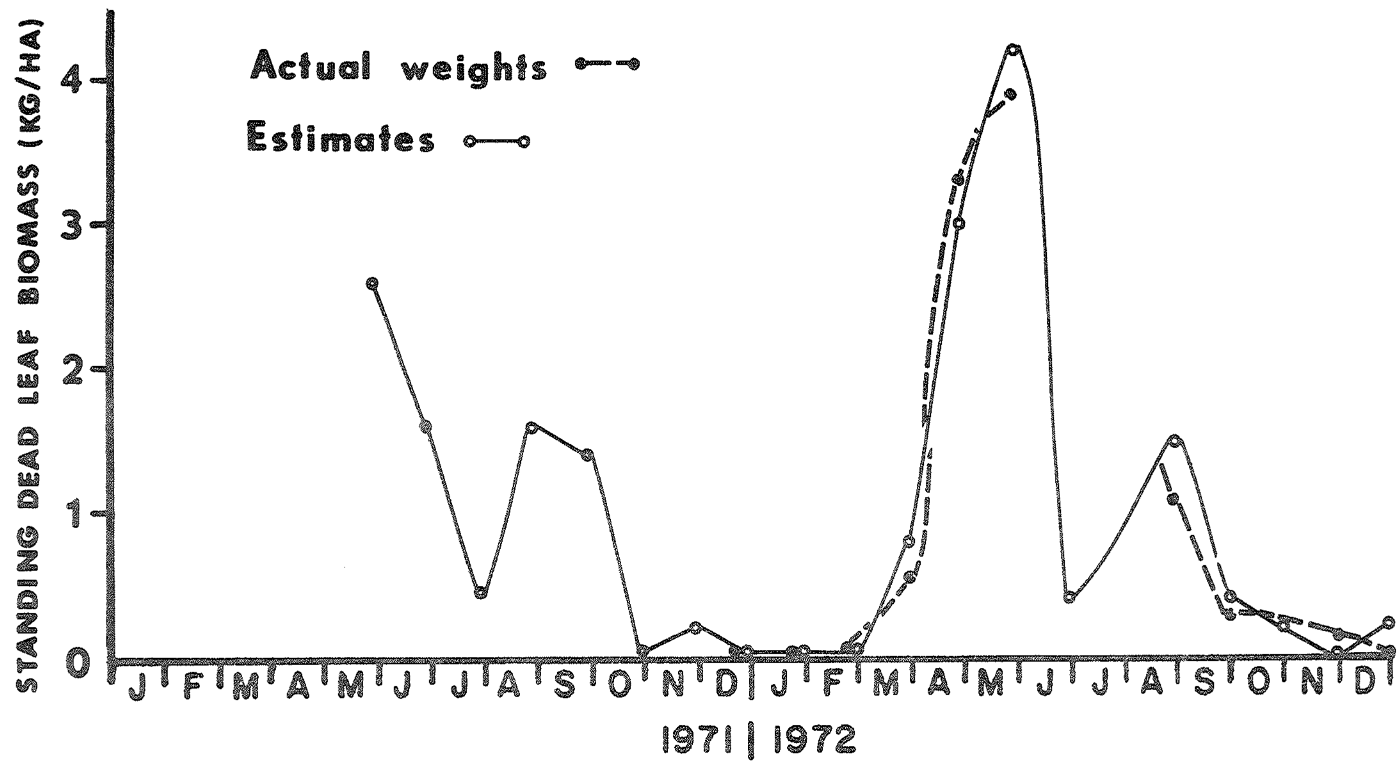

Figure 2. Monthly changes in standing dead-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada. Estimates based on a regression equation relating dead-leaf biomass to dead-leaf length are given along with actual weights determined from harvest of dead leaves.

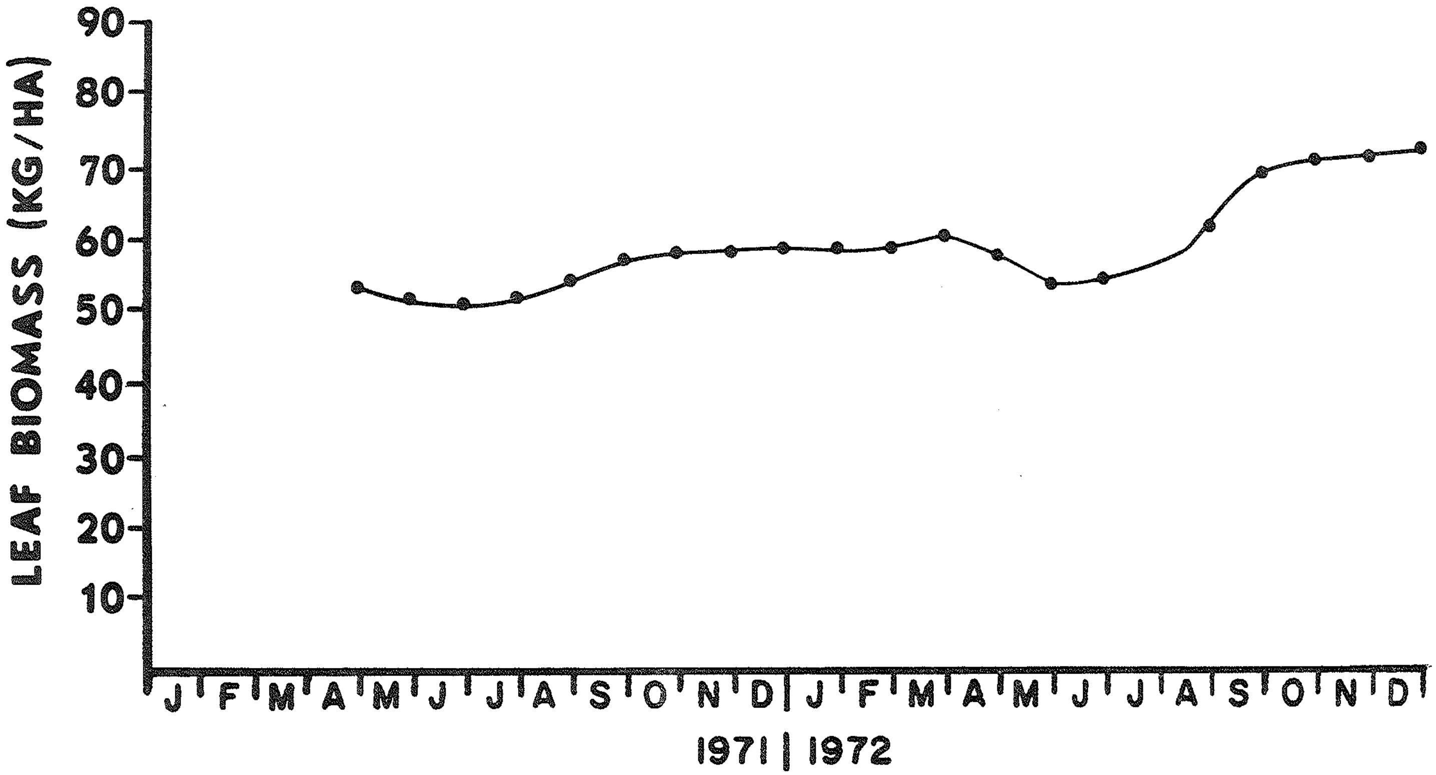

Figure 3. Monthly net standing crop of green-leaf biomass for *Yucca elata* in 1971 and 1972 on the bajada.

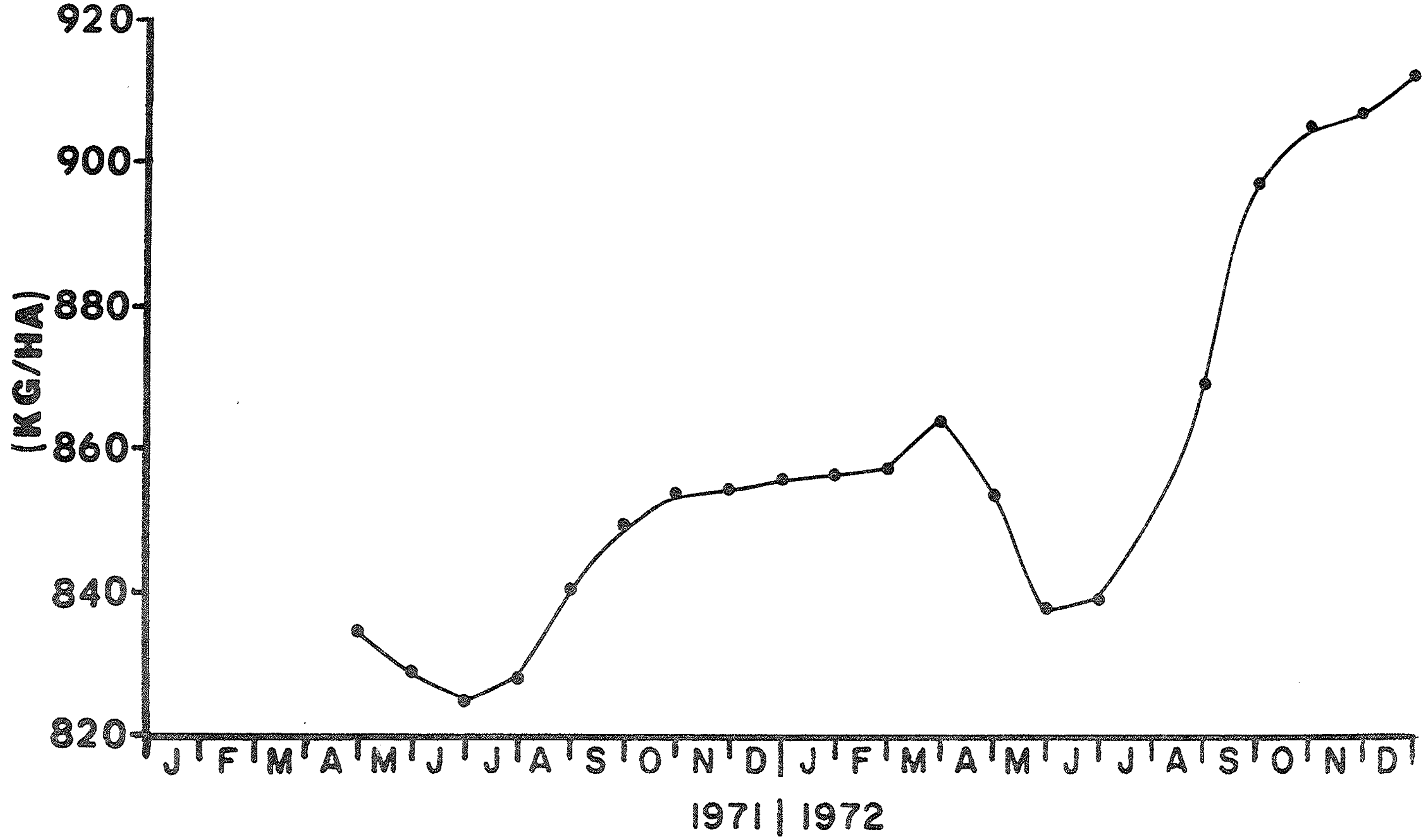

Figure 4. Monthly standing crop of caudex biomass for *Yucca elata* in 1971 and 1972 on the bajada.

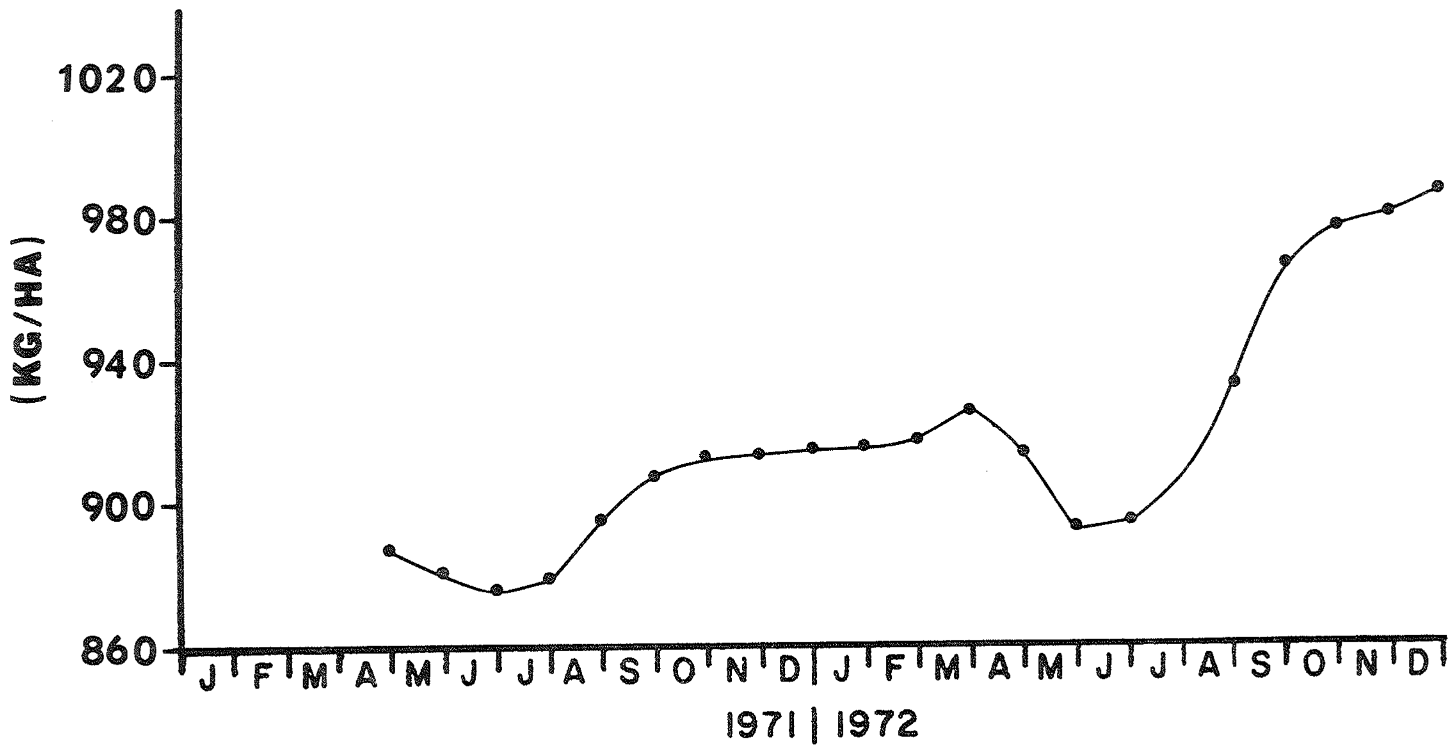

Figure 5. Monthly standing crop of total above-ground biomass for *Yucca elata* in 1971 and 1972 on the bajada.

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.

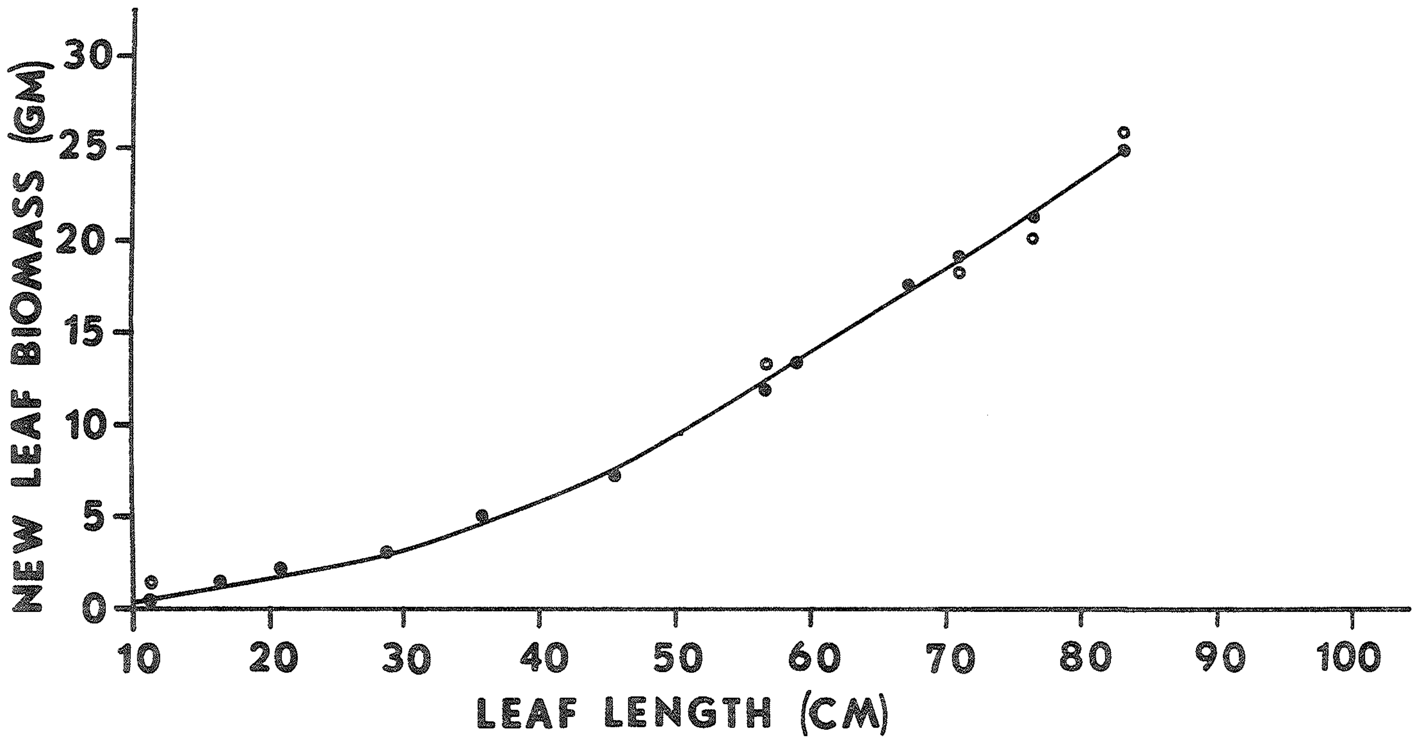

Figure 6. Regression of live-leaf biomass (B) onto live-leaf length (L) for *Yucca baccata*. The equation of the curvilinear regression line is $B = -0.0021\ L + 0.0038\ L^2$.

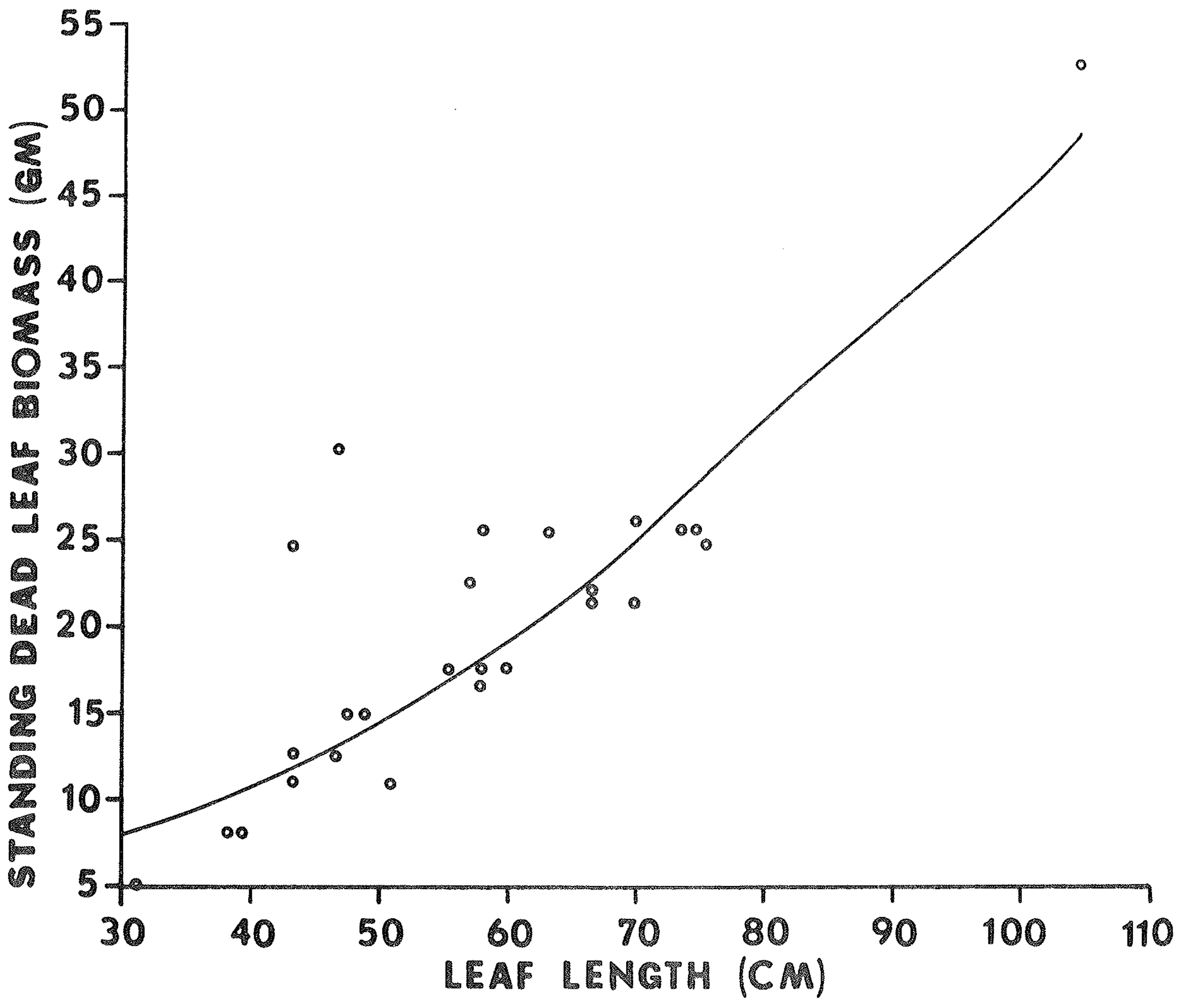

Figure 7. Regression of standing dead-leaf biomass onto dead-leaf length (L) for *Yucca baccata*. The equation of the curvilinear regression line is $B = 0.207\ L + 0.0023\ L^2$.

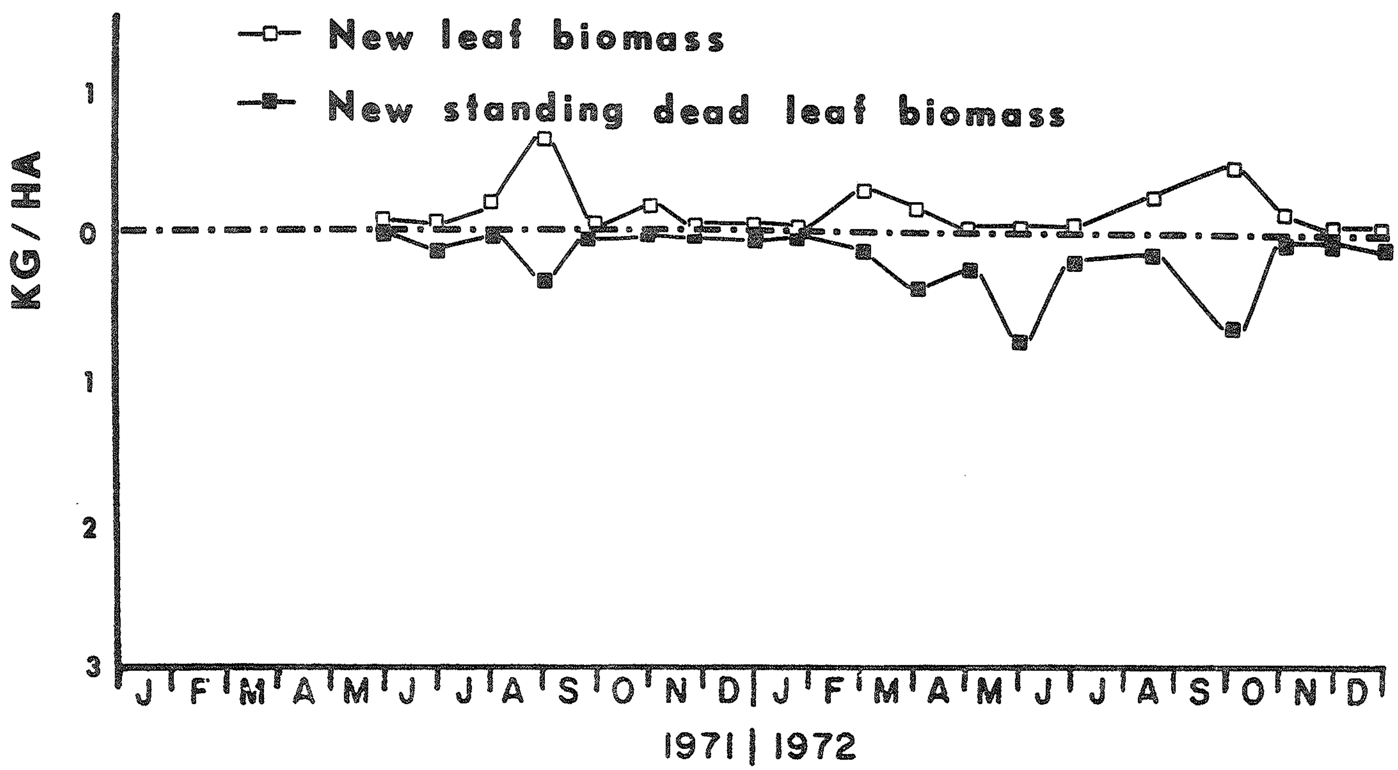

Figure 8. Monthly absolute leaf biomass gains and losses for *Yucca baccata* in 1971 and 1972 on the bajada.

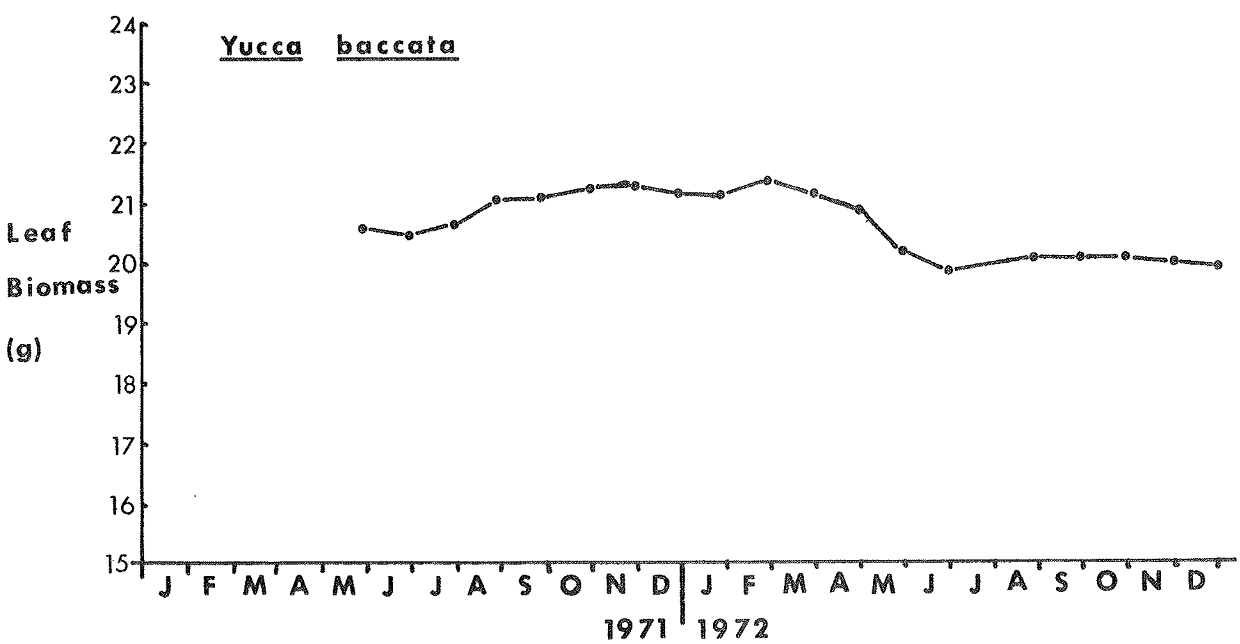

Figure 9. Monthly standing crop of live-leaf biomass for *Yucca baccata* in 1971 and 1972 on the bajada.

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.

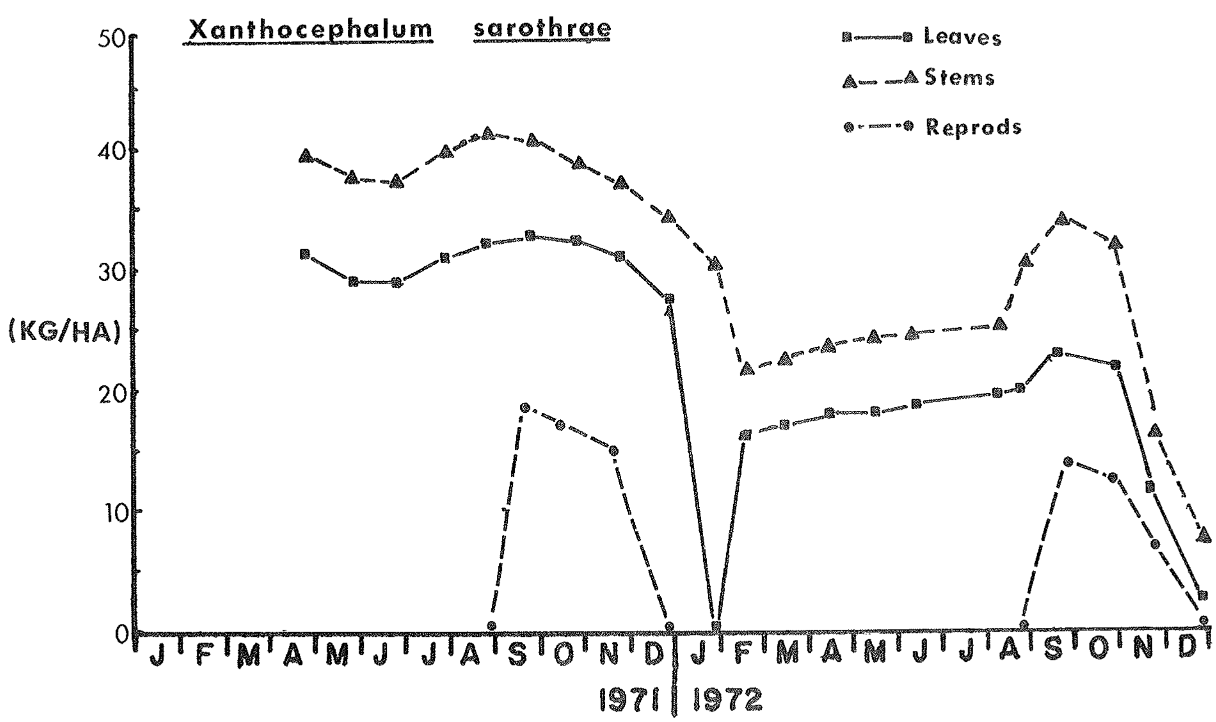

Figure 10. Monthly standing crop of leaf, stem and reproductive biomass for *Xanthocephalum sarothrae* in 1971 and 1972 on the bajada.

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

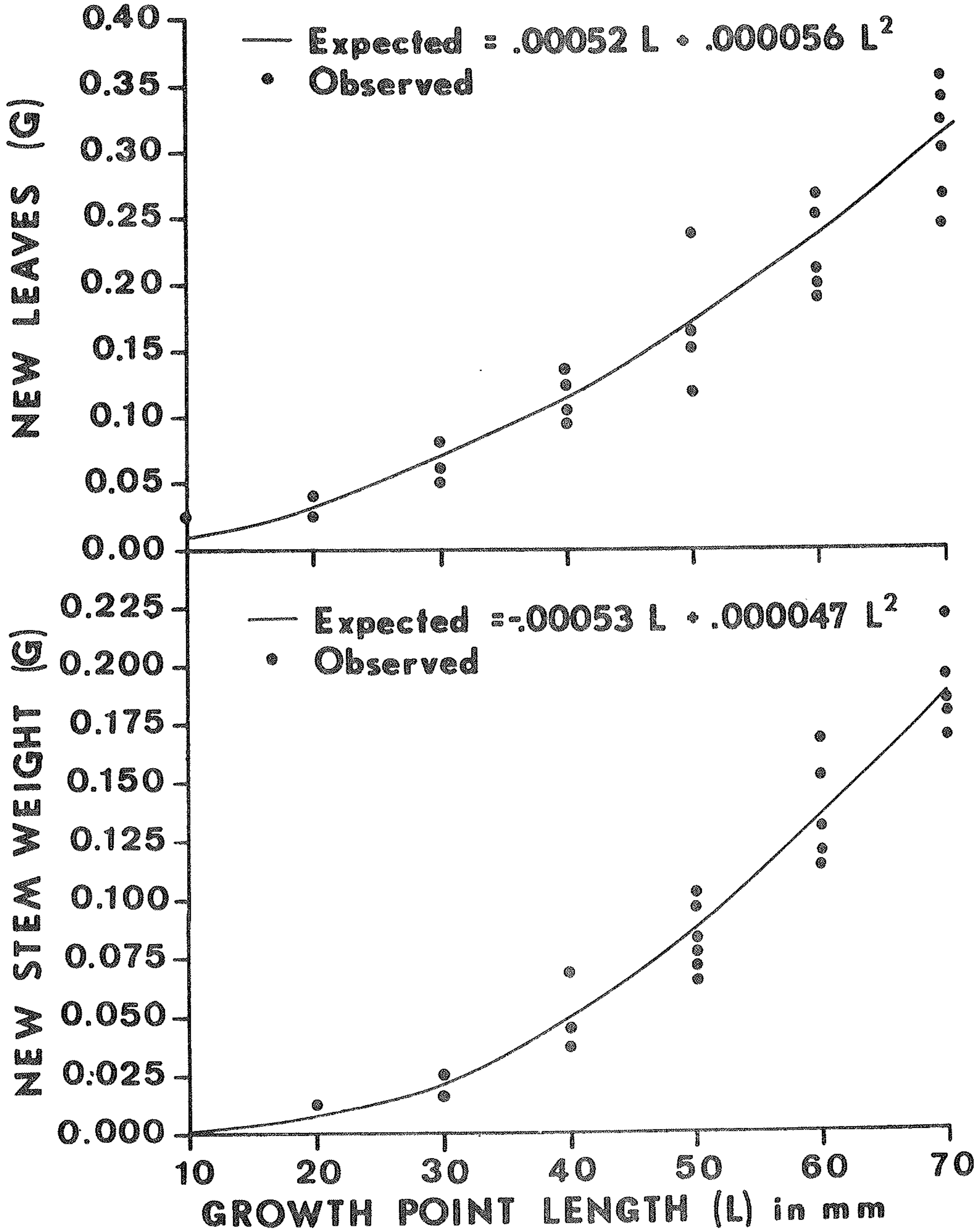

Figure 11. (Top) Regression of leaf biomass (B) onto growth point length (L) for *Larrea divaricata*. The equation of the curvilinear regression line is $B = 0.00052\ L + 0.000056\ L^2$.

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

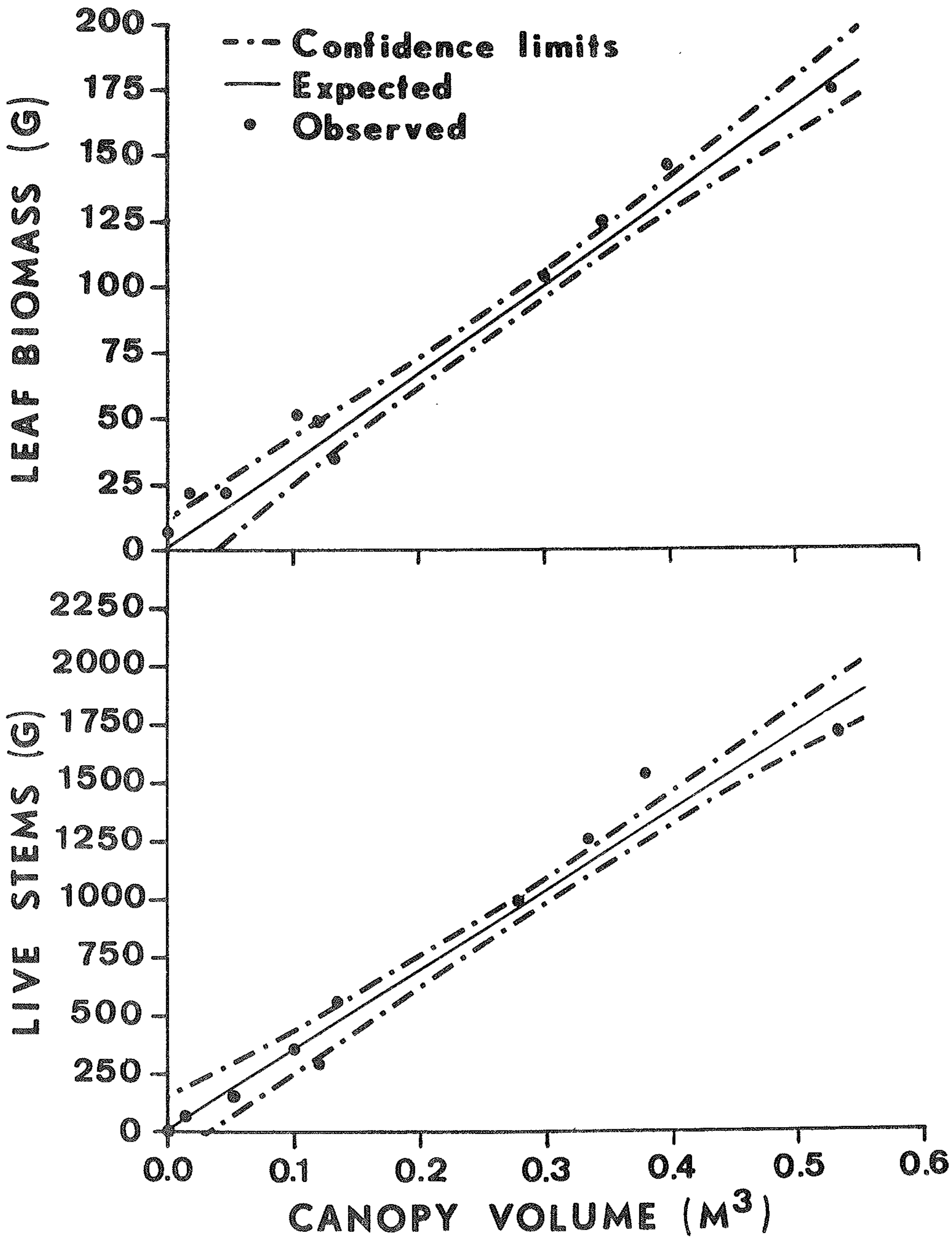

Figure 12. (Top) Regression of total leaf biomass (B) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 345.8 V.

(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

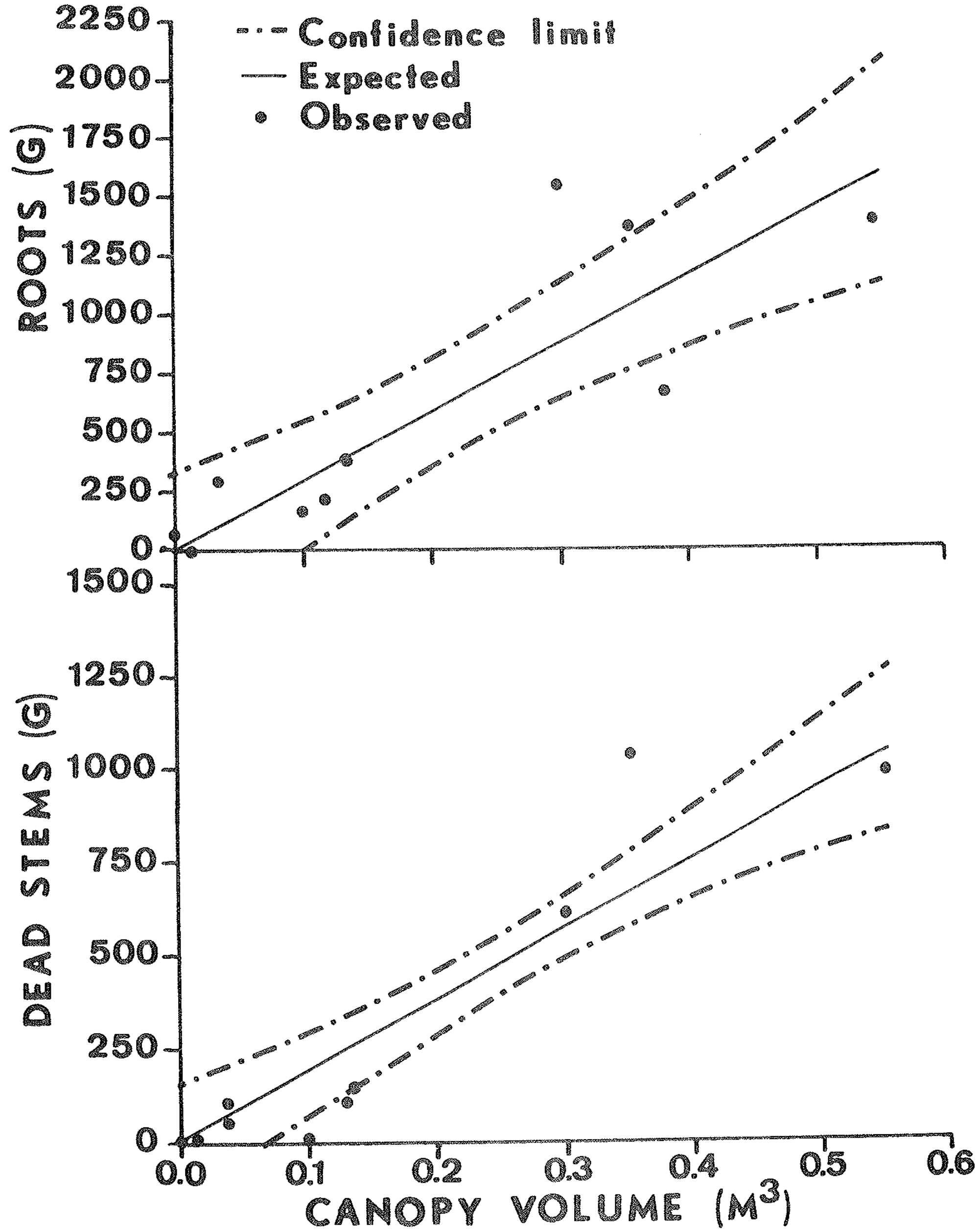

Figure 13. (Top) Regression of total root biomass (B) at the end of the growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 2919.1 V.

(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.

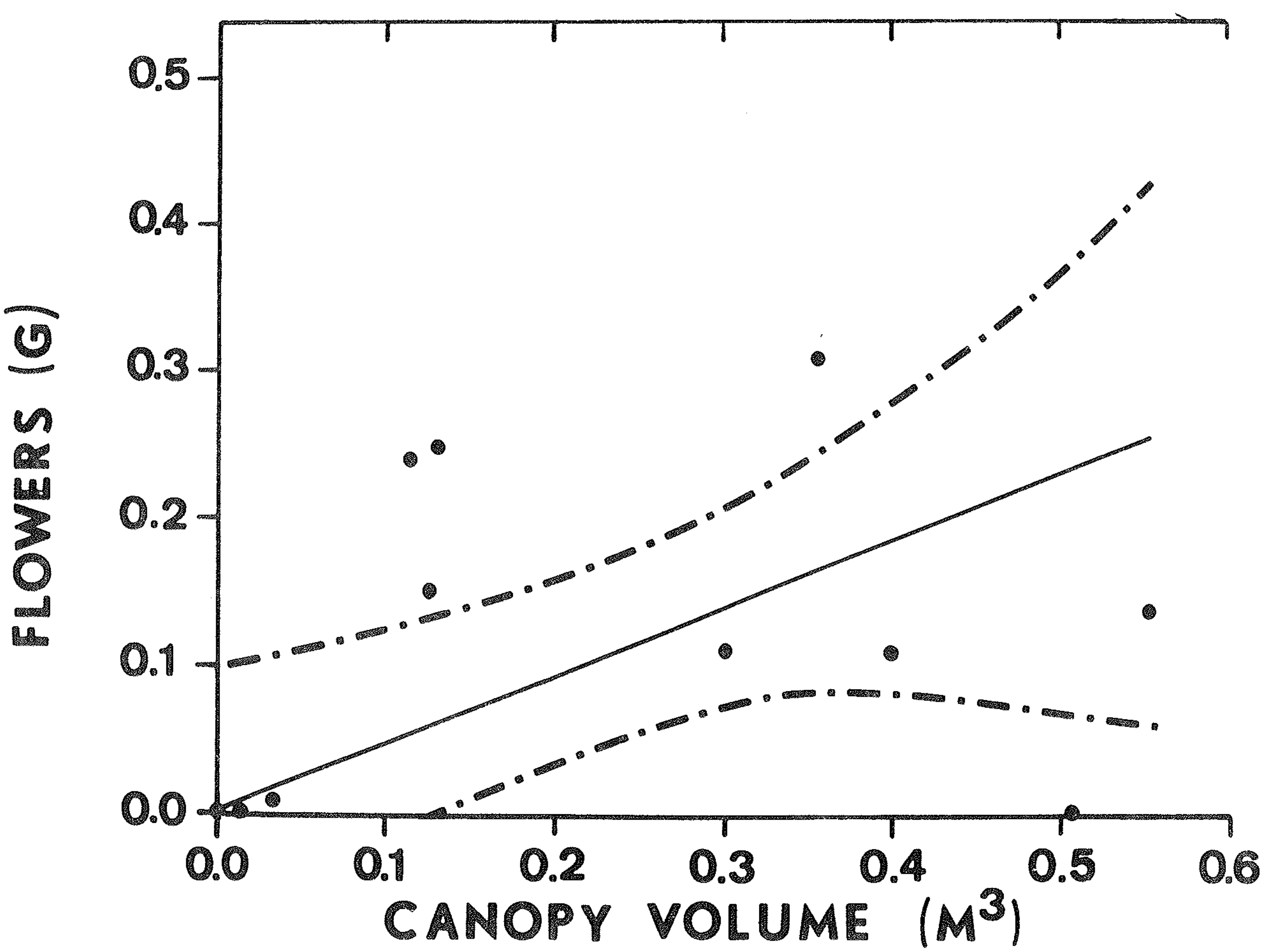

Figure 14. Regression of flower biomass (B) at the end of the 1971 growing season onto canopy volume (V) for *Larrea divaricata*. The equation of the linear regression line is B = 0.436 V, with confidence limits shown by the broken lines. Observed

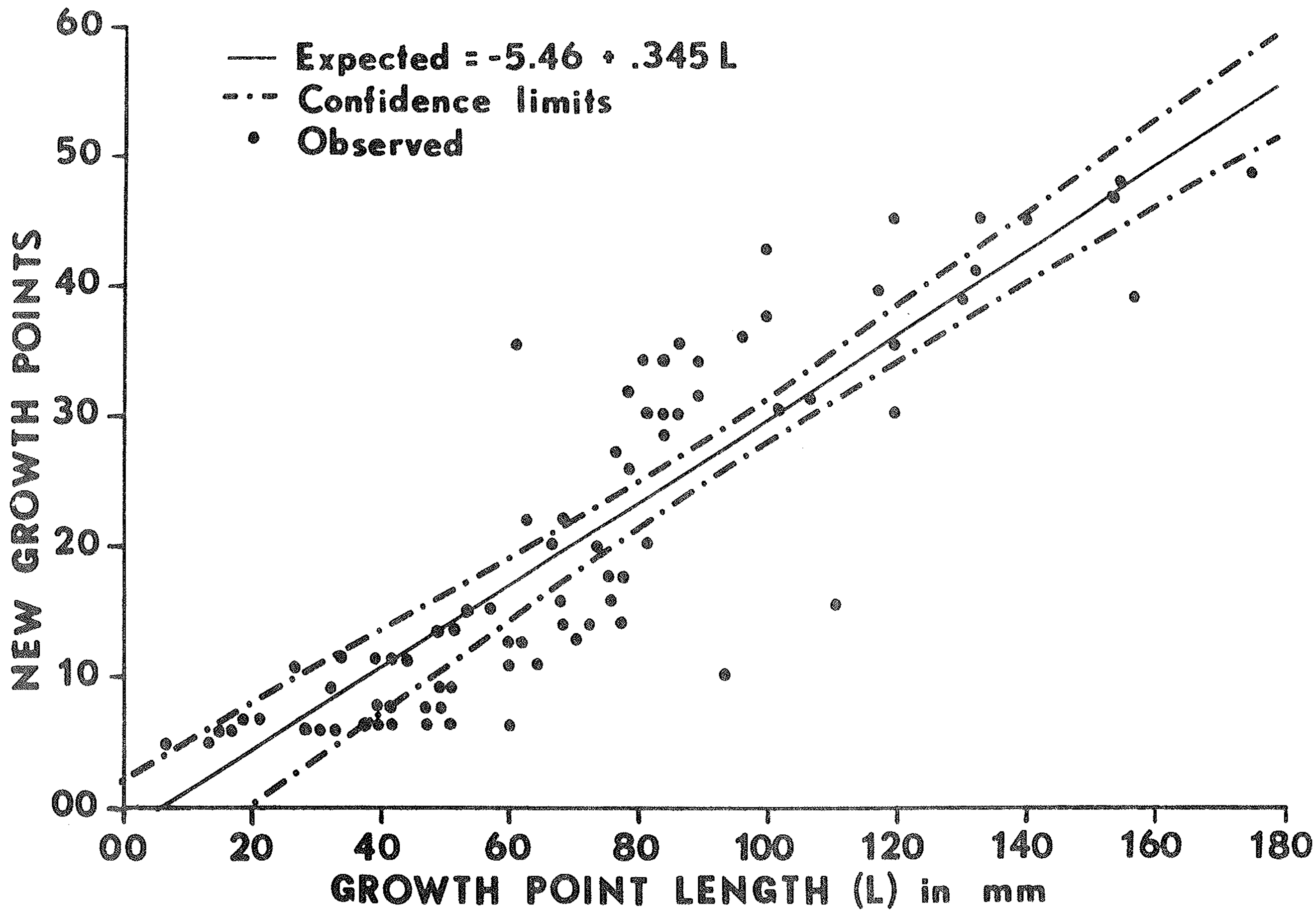

Figure 15. Regression of new growth points (P) onto growth point length (L) for *Larrea divaricata*. The equation of the linear regression line is P = -5.46 + 0.345 L.

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.

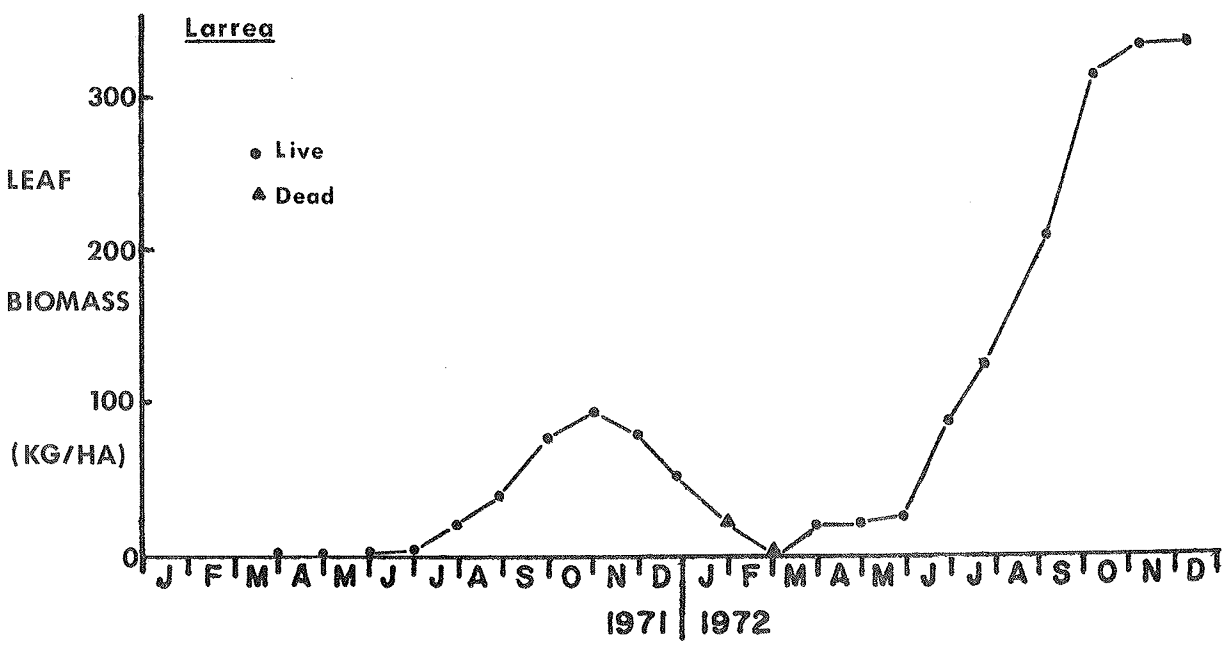

Figure 16. Monthly standing crop of leaf biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

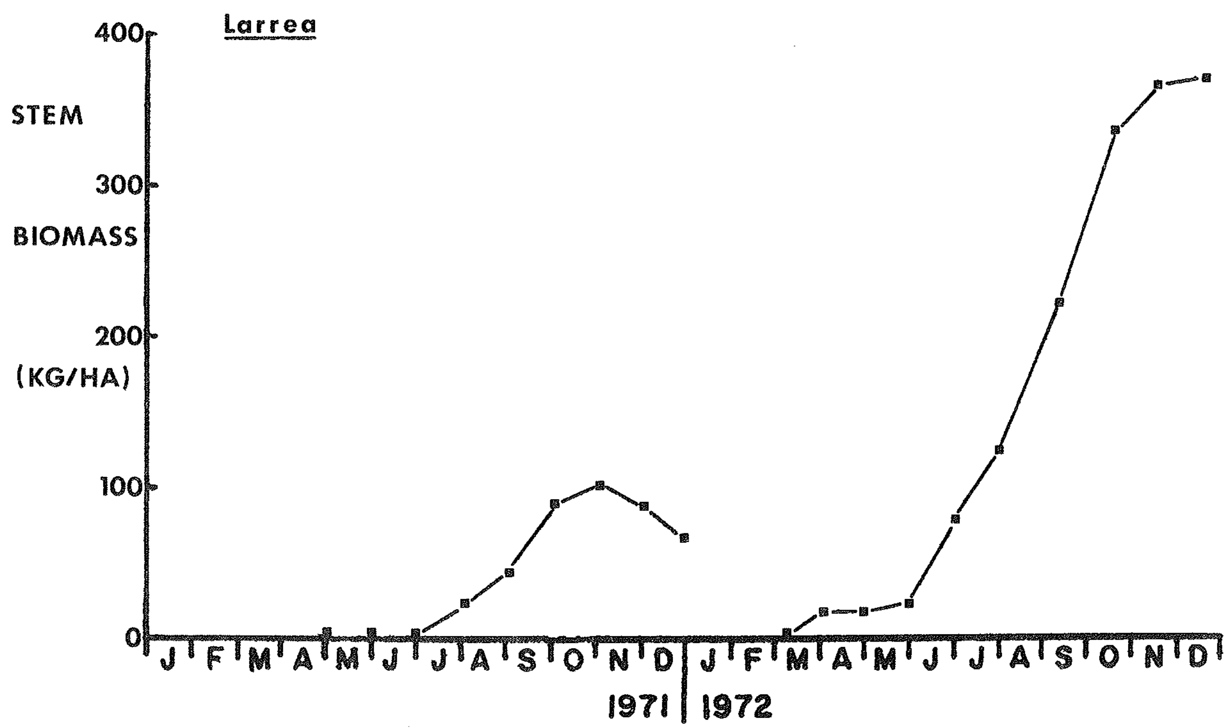

Figure 17. Monthly standing crop of new stem biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

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	

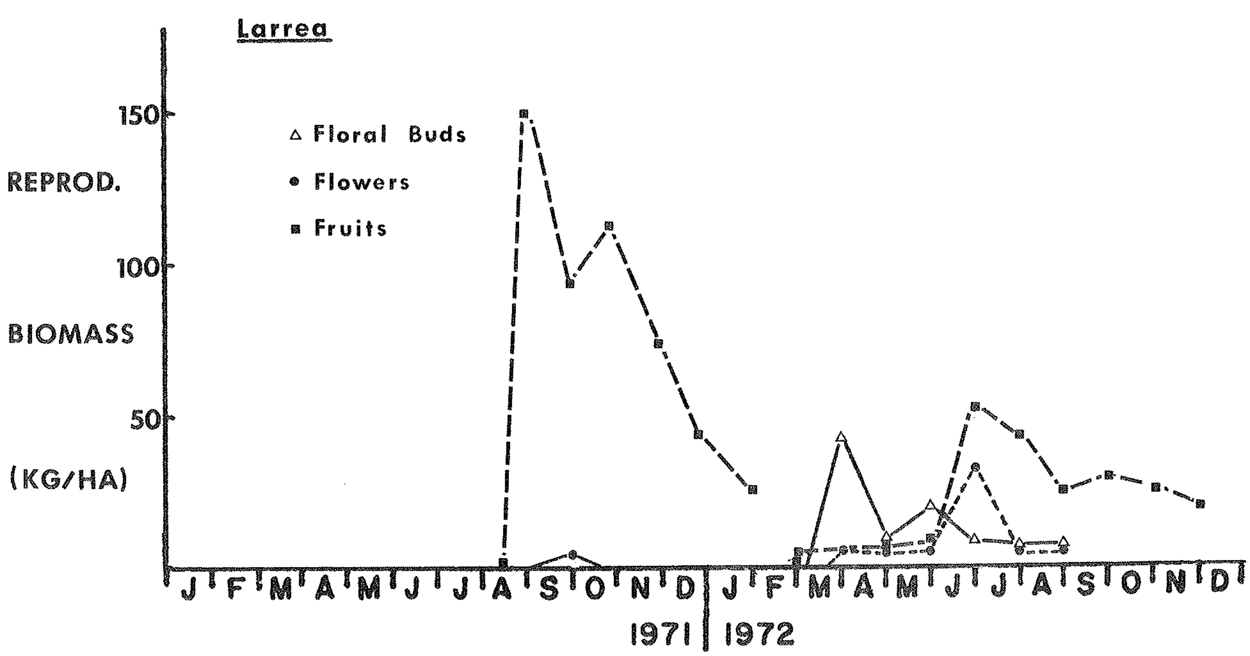

Figure 18. Monthly standing crop of reproductive structures biomass for *Larrea divaricata* in 1971 and 1972 on the bajada.

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%.

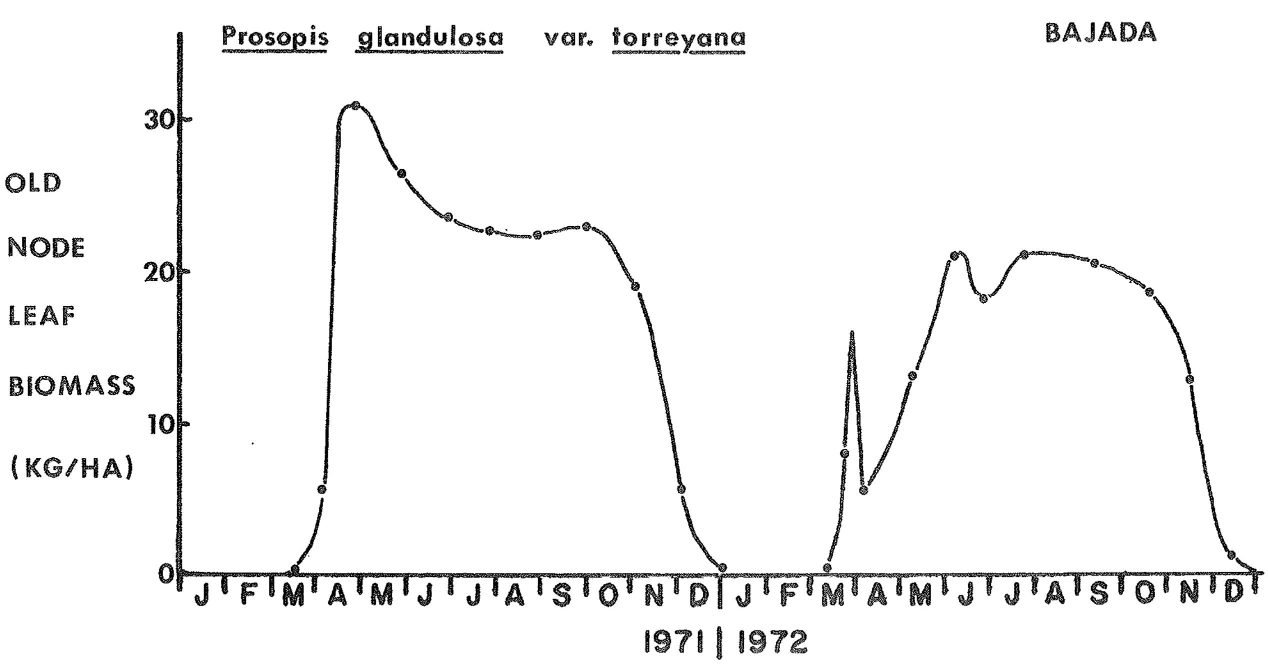

Figure 19. Monthly standing crop of old node leaf biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the bajada.

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	

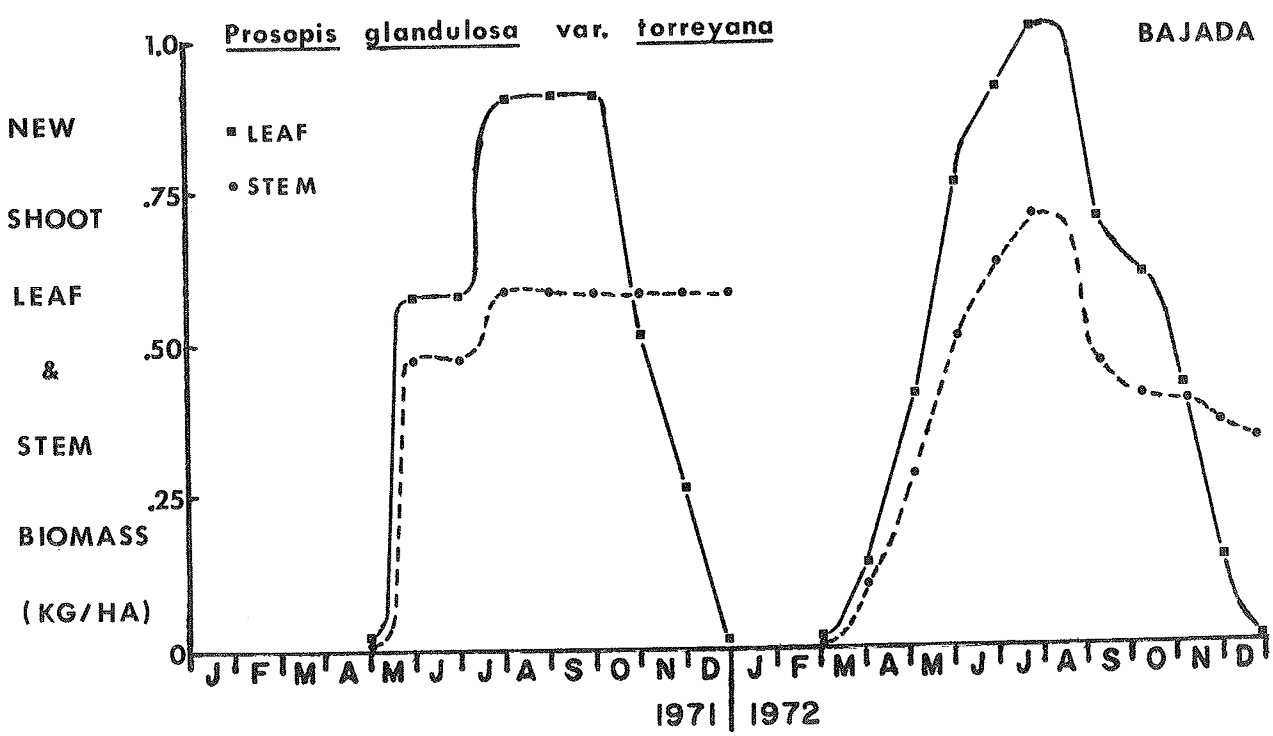

Figure 20. Monthly standing crop of new shoot leaf and stem biomass for *Prosopis glandulosa* var. *torreyana* in 1971 and 1972 on the bajada.

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.

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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.
<u>Parthenium incanum</u>	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)		
<u>Guterrezia sarothrae</u>	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.

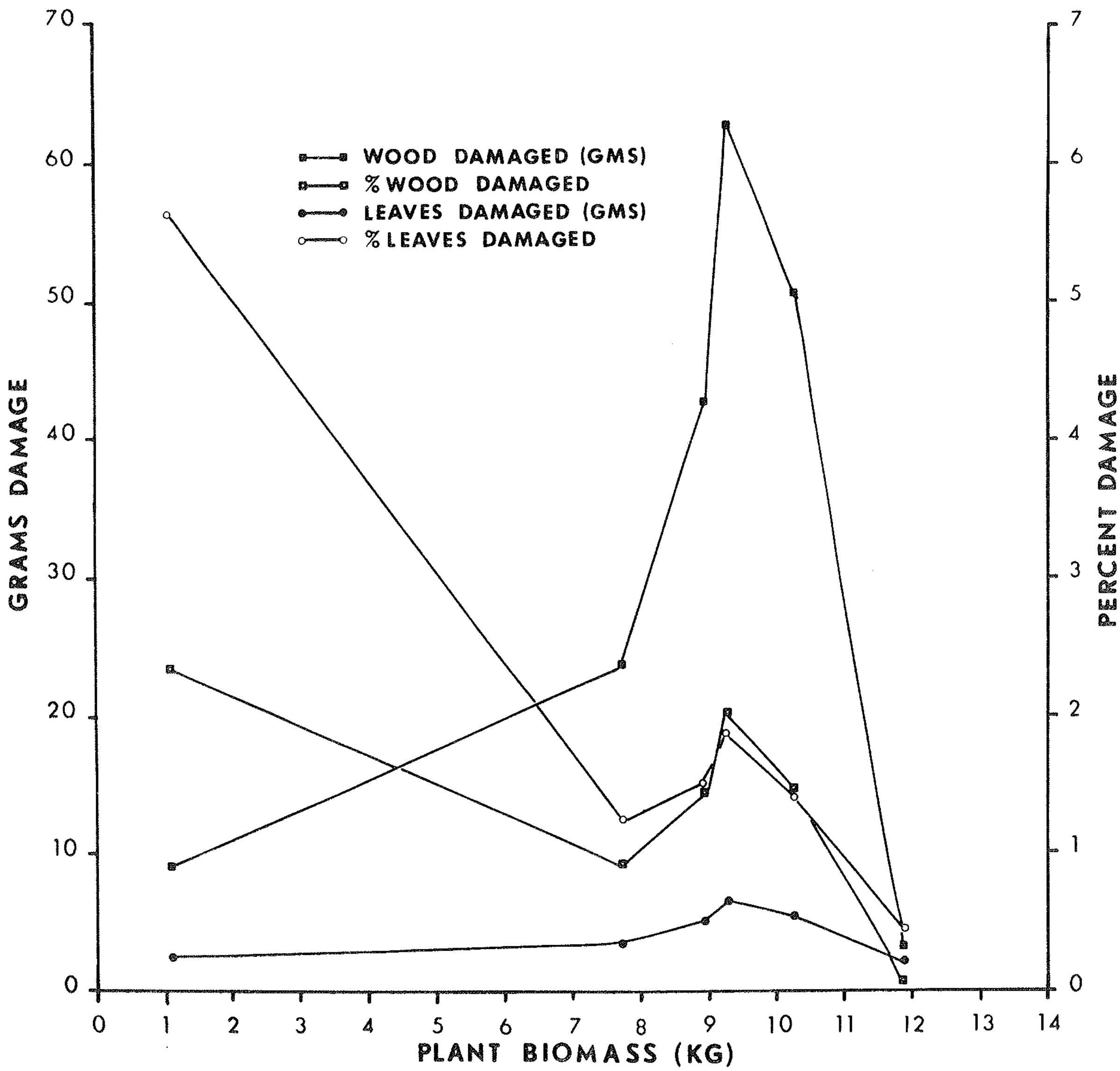

Figure 1. The relationship between wood and leaf mortality and plant biomass of *Prosopis glandulosa*, 1972. Damage caused by node borers, Bostrichidae.

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	6.5	1.0	14.0	35.4	54.5
	Predators	9.6	10.8	3.7	3.8	2.4	2.2	6.1	3.2
	Detritivores	0	0	0	0	0	0	0	0
Ephedra trifurca	Herbivores	.38			.07				
	Predators	.10			0				
	Detritivores	0			0				
Flourensia cernua	Herbivores		6.97	2.16	3.7	.03	19.3	53.7	
	Predators		.48	0	.03	.04	1.5	.4	
	Detritivores		0	0	0	0	0	0	
Prosopis glandulosa	Herbivores	4.8	1.45		.08	1.9	.78	.64	.14
	Predators	.18	1.0		.04	.02	.25	.04	.02
	Detritivores	0	.006		0	0	0	0	0

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
Fallugia paradoxa	Herbivores	.82	.33	6.4	.013	.02
	Predators	.38	.06	.16	.03	3.6
	Detritivores	0	0	0	0	0
Larrea divaricata	Herbivores	122.8		109.2		
	Predators	19.4		11.9		
	Detritivores	0		0		
Prosopis glandulosa	Herbivores		2.0			
	Predators		.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.

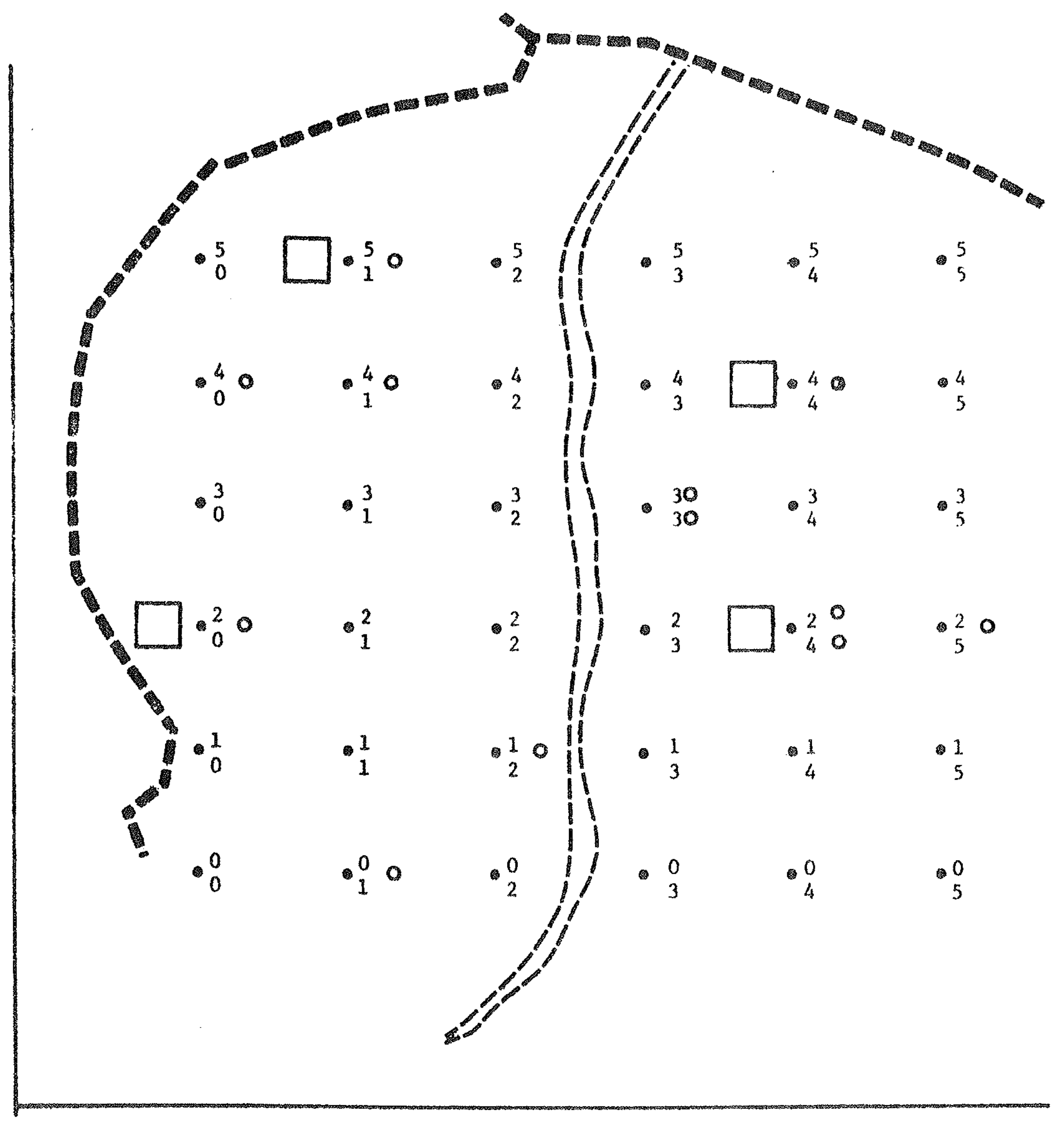

Figure 2. Locations of wood sampling areas and toilet paper grids on the bajada for monitoring termite activity.

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 $\cong$ 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

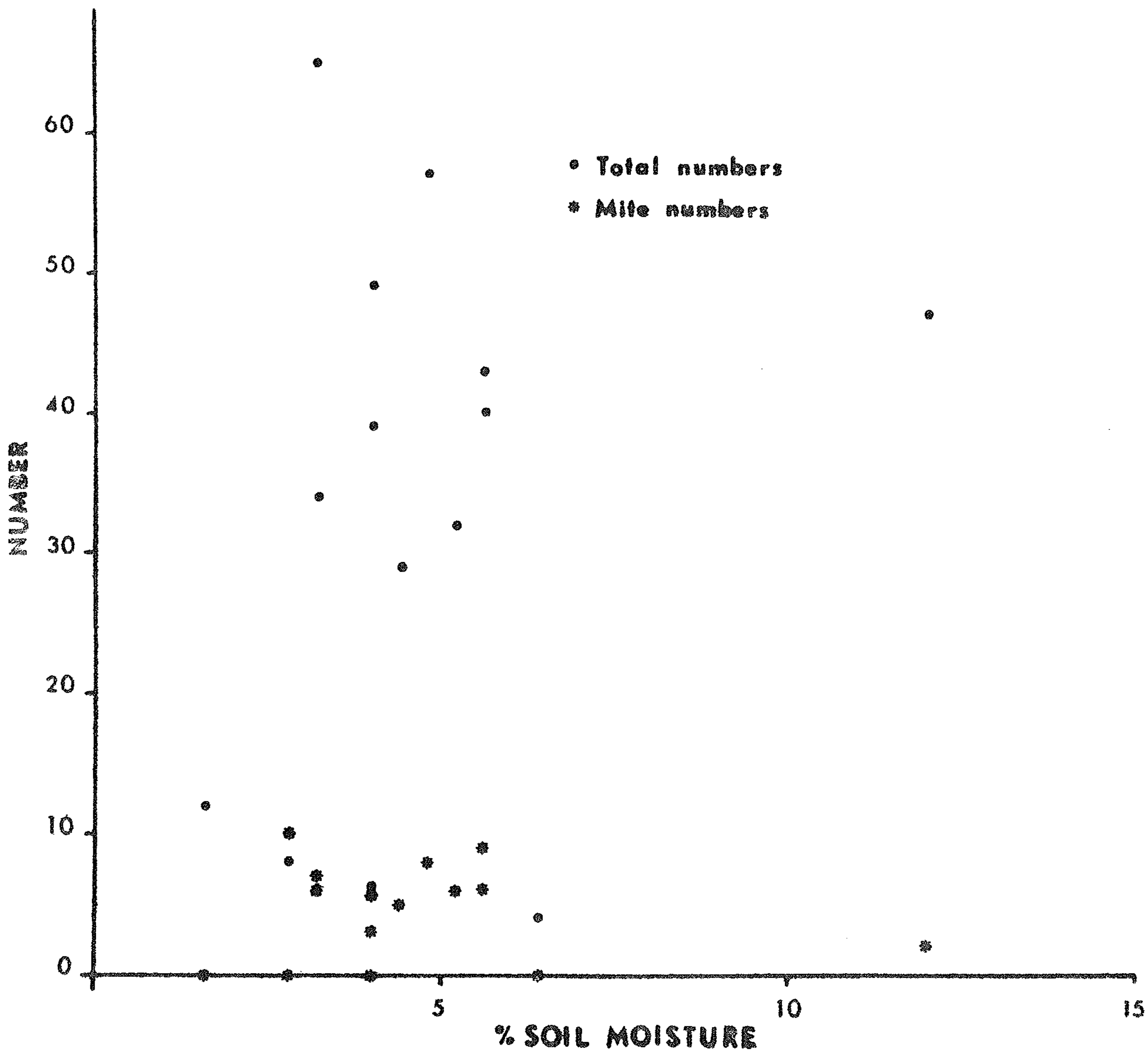

Figure 3. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled in an arroyo area under *Fallugia paradoxa*.

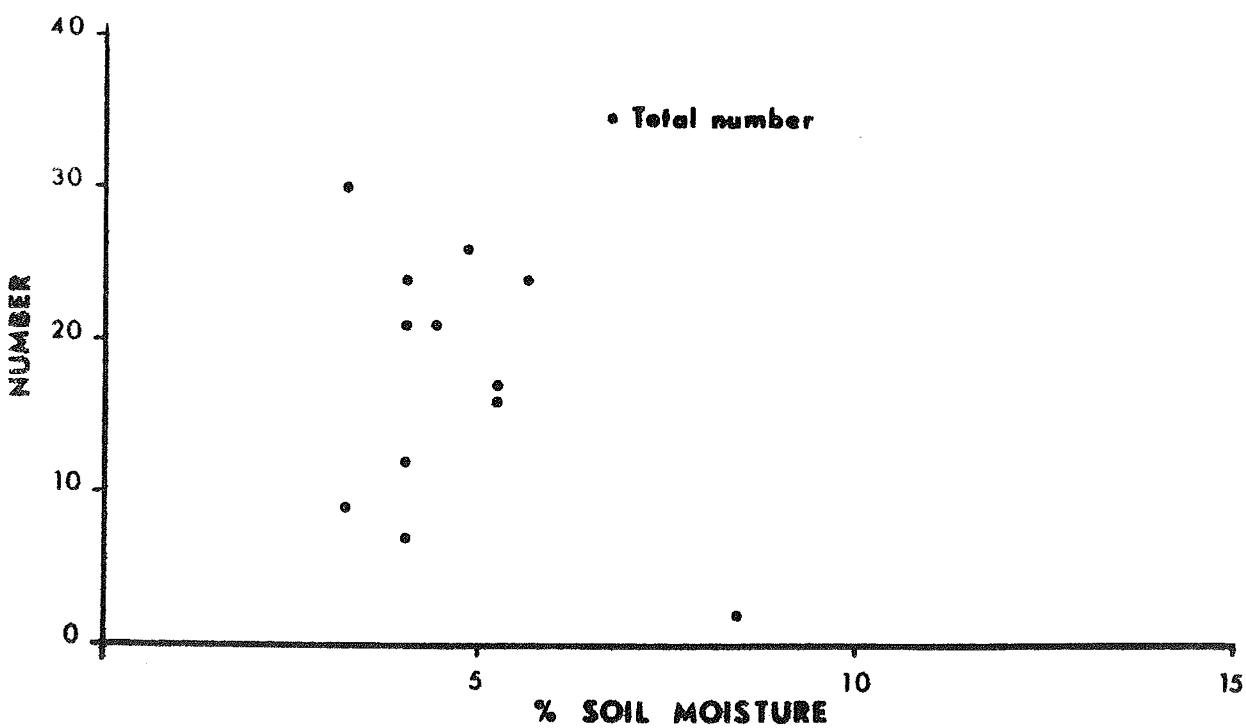

Figure 4. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled in an unvegetated portion of arroyo bottom.

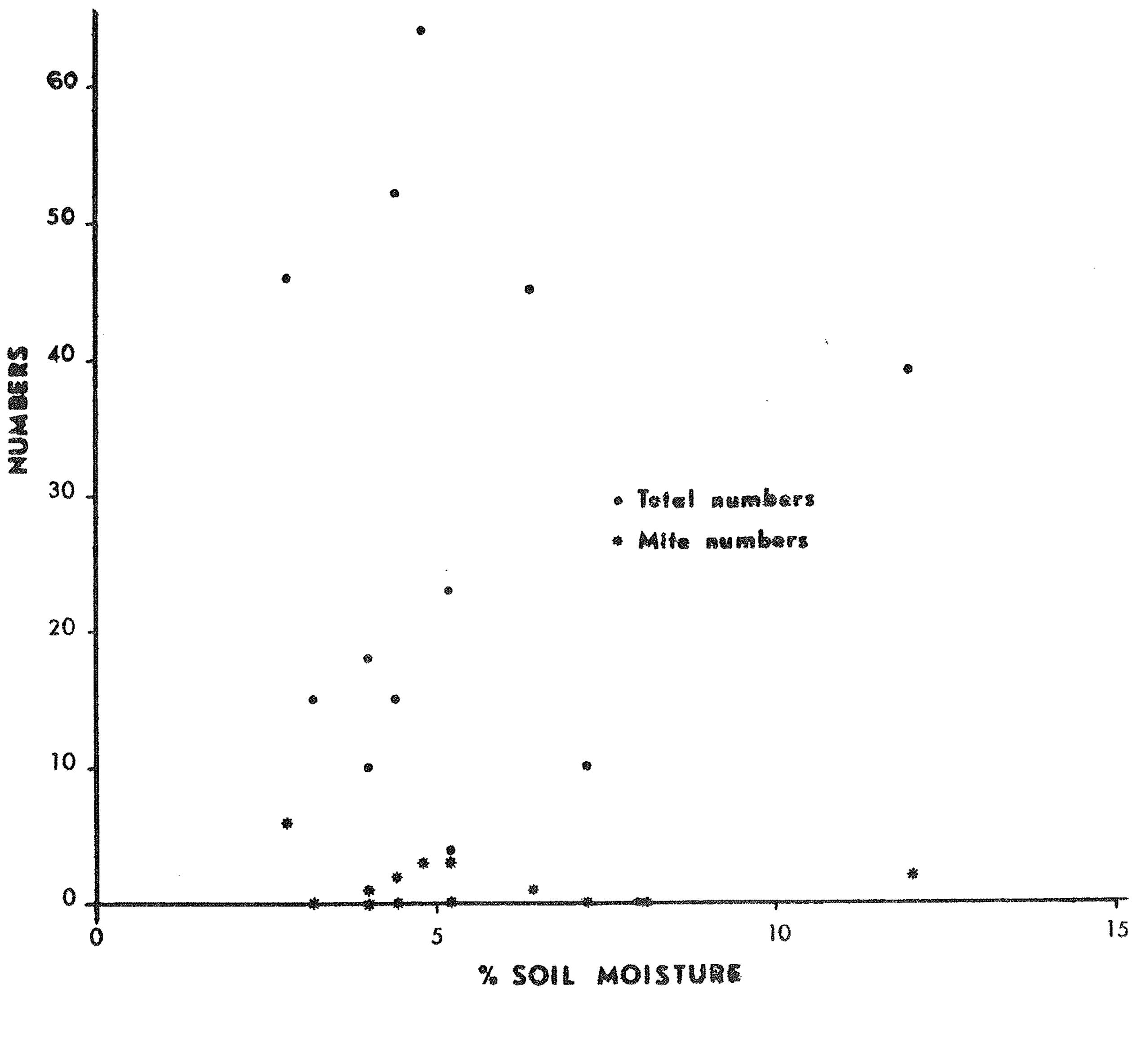

Figure 5. The effect of soil moisture on total numbers of soil microarthropods and soil mites sampled under mixed vegetation in the bajada arroyo.

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*

Months	1971 May	1971 Jun	1971 Jul	1971 Aug	1971 Sep	1972 May	1972 Jun	1972 Jul	1972 Aug	1972 Sep	1972 Oct
Cnemidophorus tigris											
Density ($No \cdot ha^{-1}$)		31.7	25.1	25.8	31.5	32.5	42.8	20.7	58.0	66.7	
$\bar{x}$ wt/lizard (gms)		16.1	14.0		11.3	18.3	17.2	16.1	10.4	2.6	
biomass (LW)		510.4	351.4		356.0	594.8	736.2	333.3	603.2	173.4	
biomass (DW)		153.1	105.4		106.8	178.4	220.9	100.0	181.0	52.0	
Holbrookia texana											
Density		2+	1+			6+	9.7	1+	5.2	3+	
$\bar{x}$ wt/lizard (gms)		5.4	6.0			8.4	8.0	8.8		.9	
Uta stansburiana											
Density		3.5	1+			3+	3+	12+	18+	4+	
$\bar{x}$ wt/lizard (gms)		3.0	1.0			4.7	4.2	1.2	.85	.95	
Phrynosoma modestum											
Density			2+			1+	.31	7+	0	1+	

* 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.

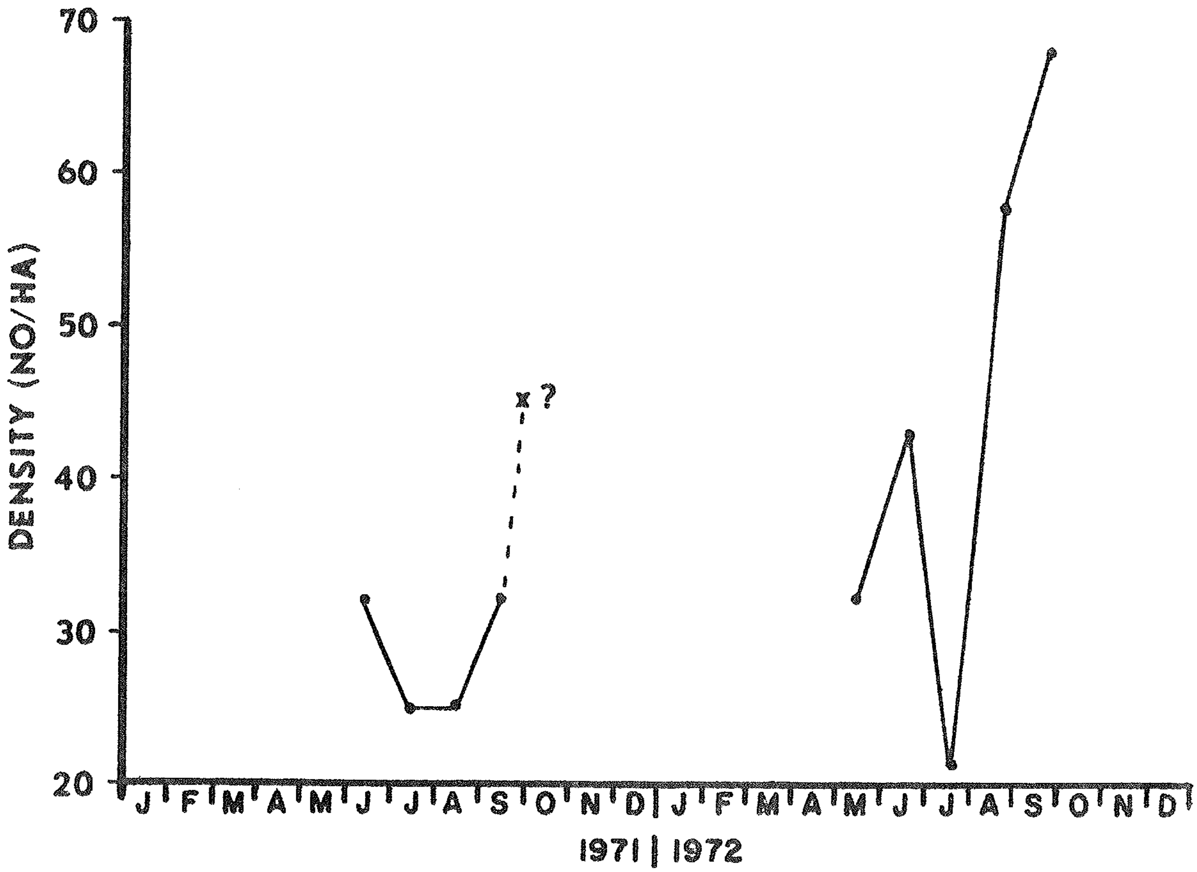

Figure 1. Fluctuations in estimated *Cnemidophorus tigris* populations on the bajada.

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.

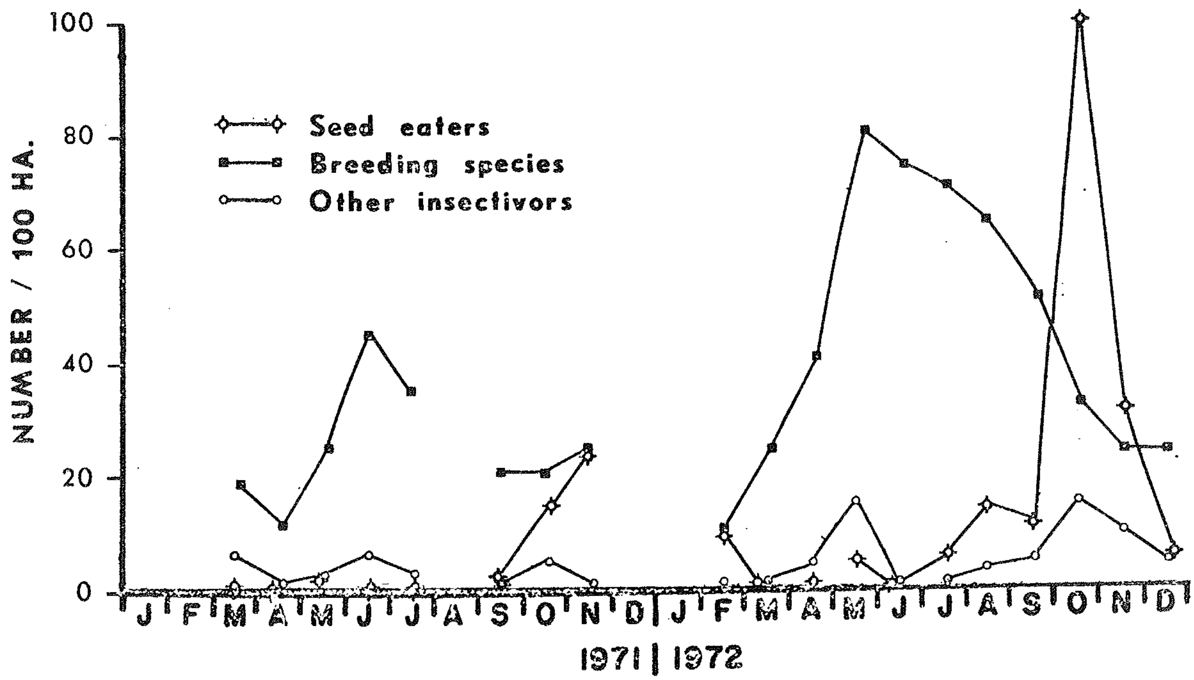

Figure 2. Mean monthly density of breeding species, non-breeding insectivores and non-breeding seed-eaters, bajada, 1971-1972.

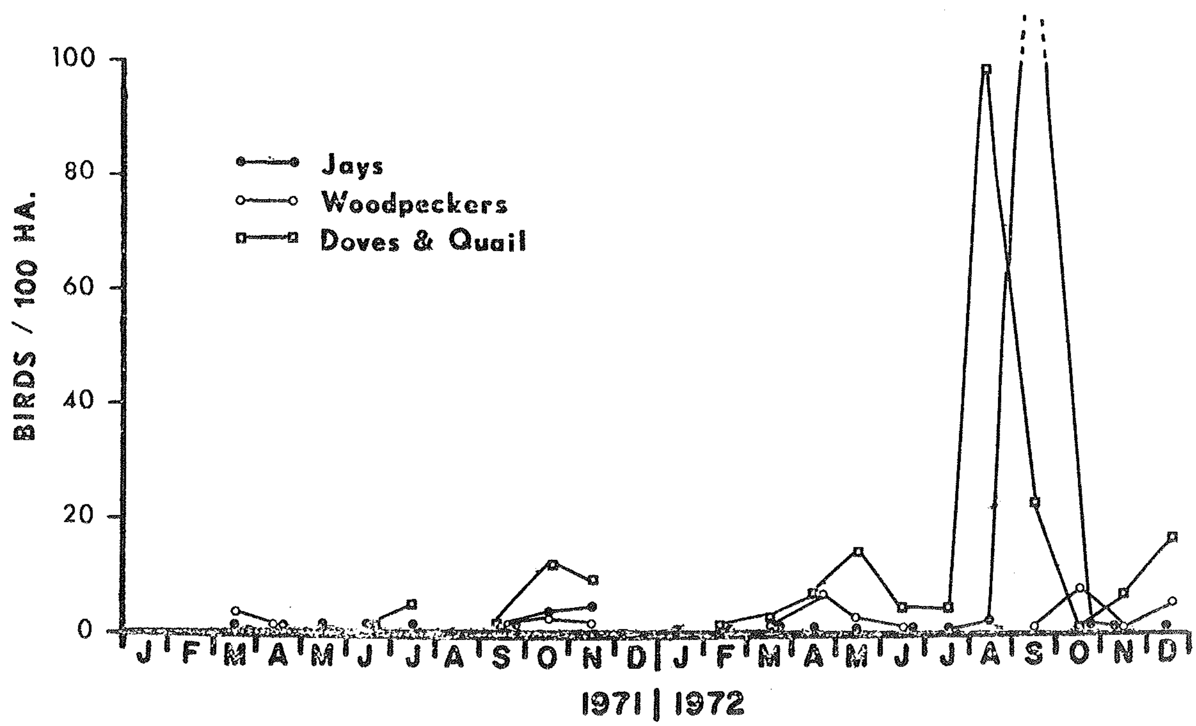

Figure 3. Mean monthly density of doves, quail, woodpeckers, and jays, bajada, 1971-1972

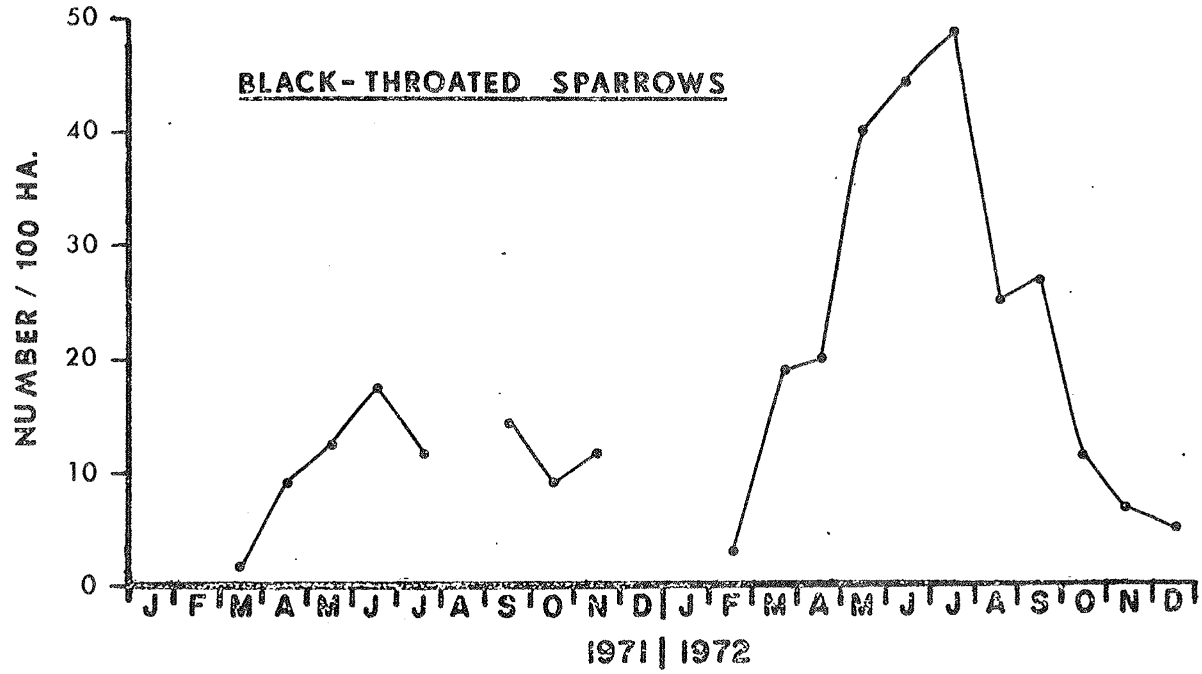

Figure 4. Mean monthly density of Black-throated Sparrows, bajada, 1971-1972.

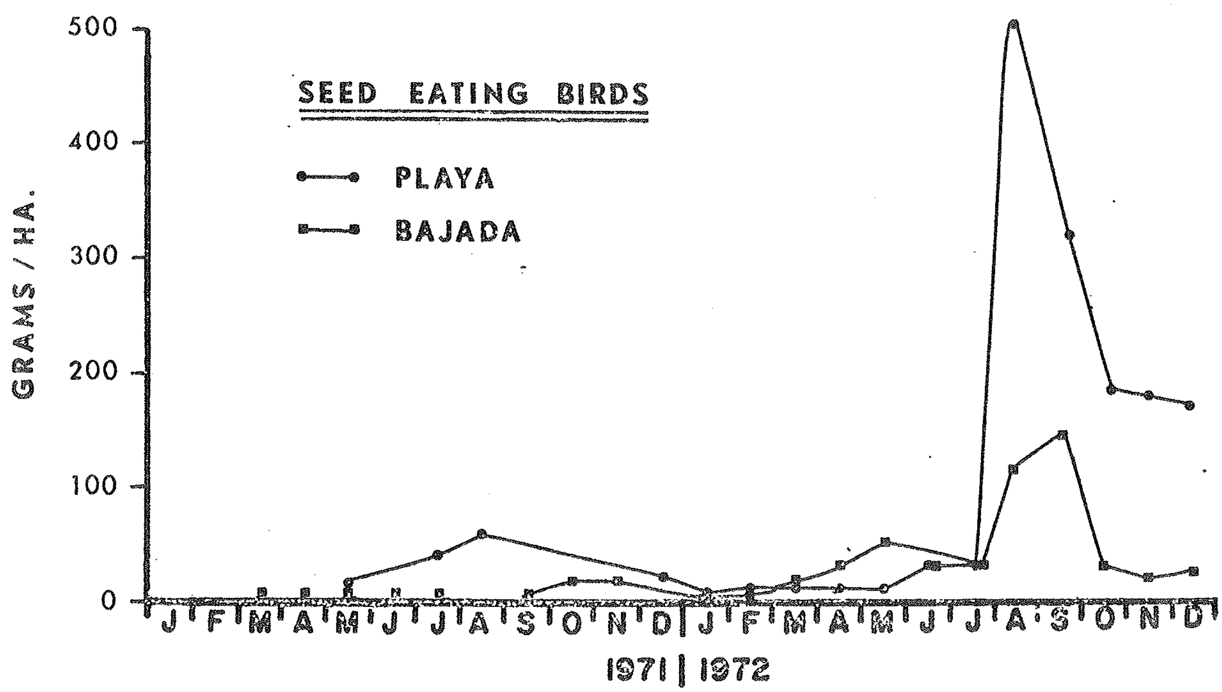

Figure 5. Comparison of biomass of all seed-eating birds on playa and bajada, 1971-1972.

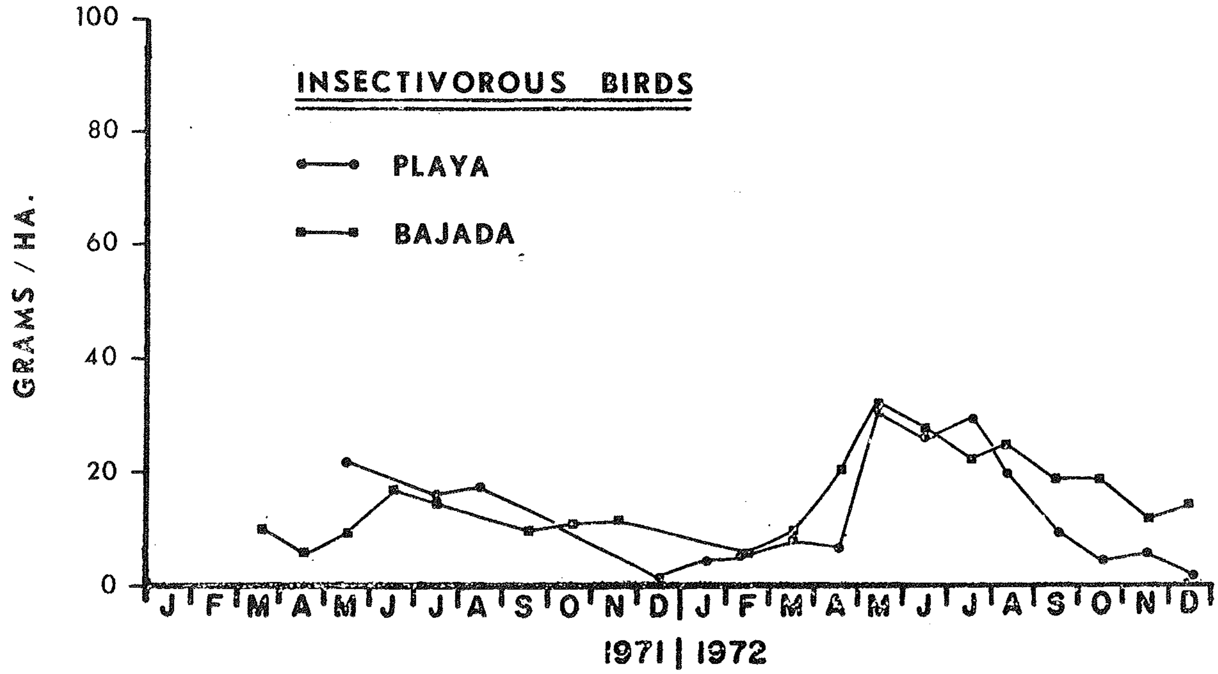

Figure 6. Comparison of biomass of all insectivorous birds on playa and bajada, 1971-1972.

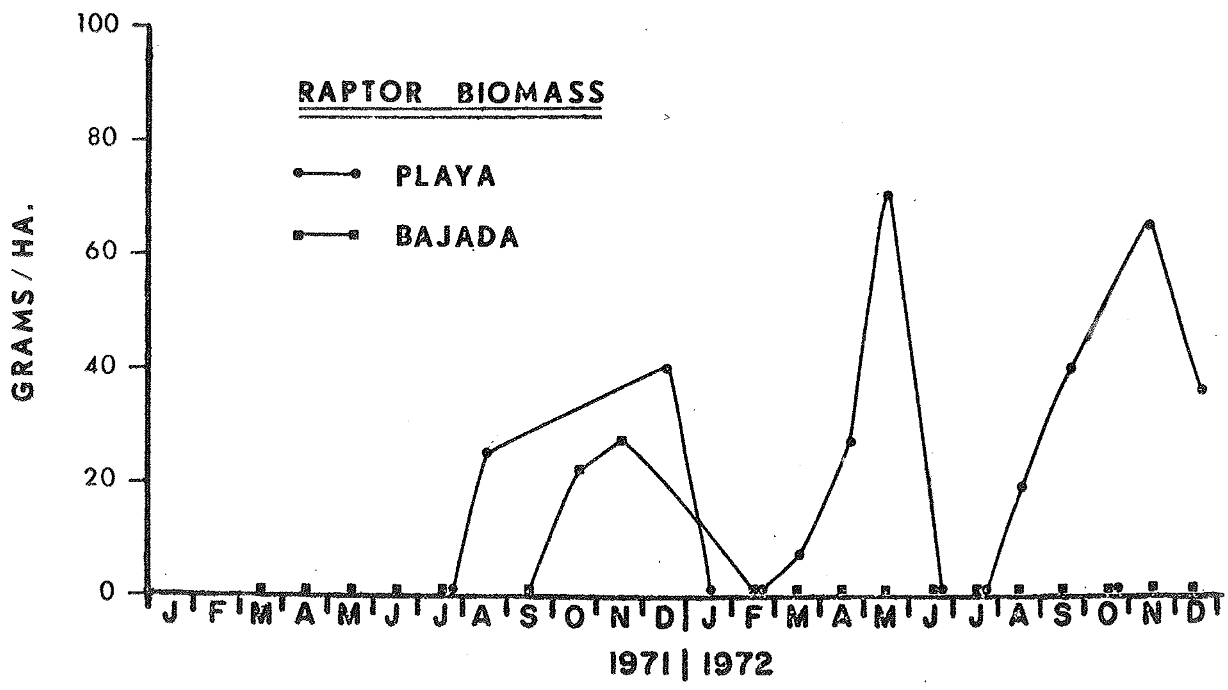

Figure 7. Comparison of biomass of raptors on playa and bajada, 1971-1972.

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.

		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.

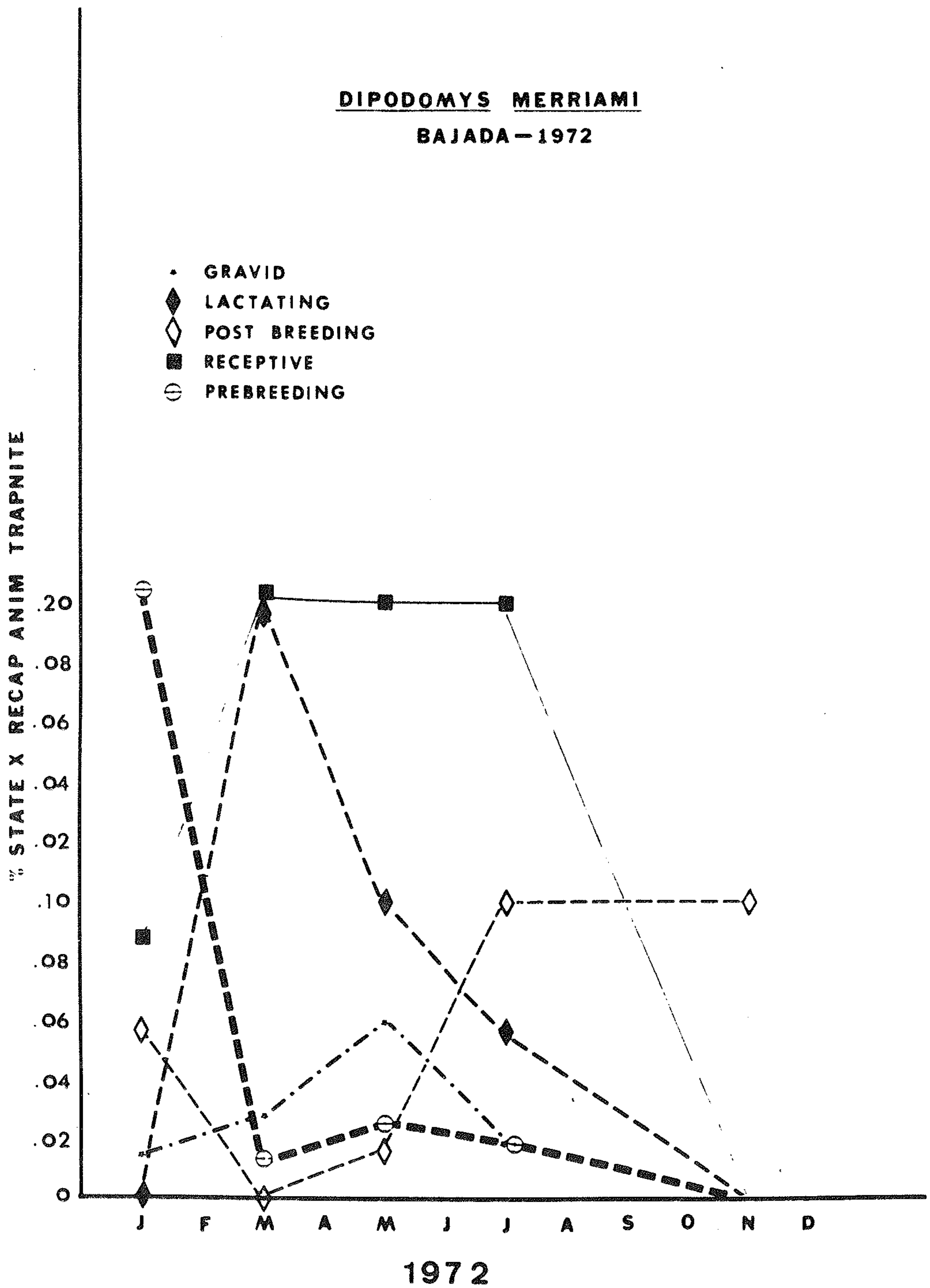

Figure 8. Reproduction condition of the population of *Dipodomys merriami* on the bajada.

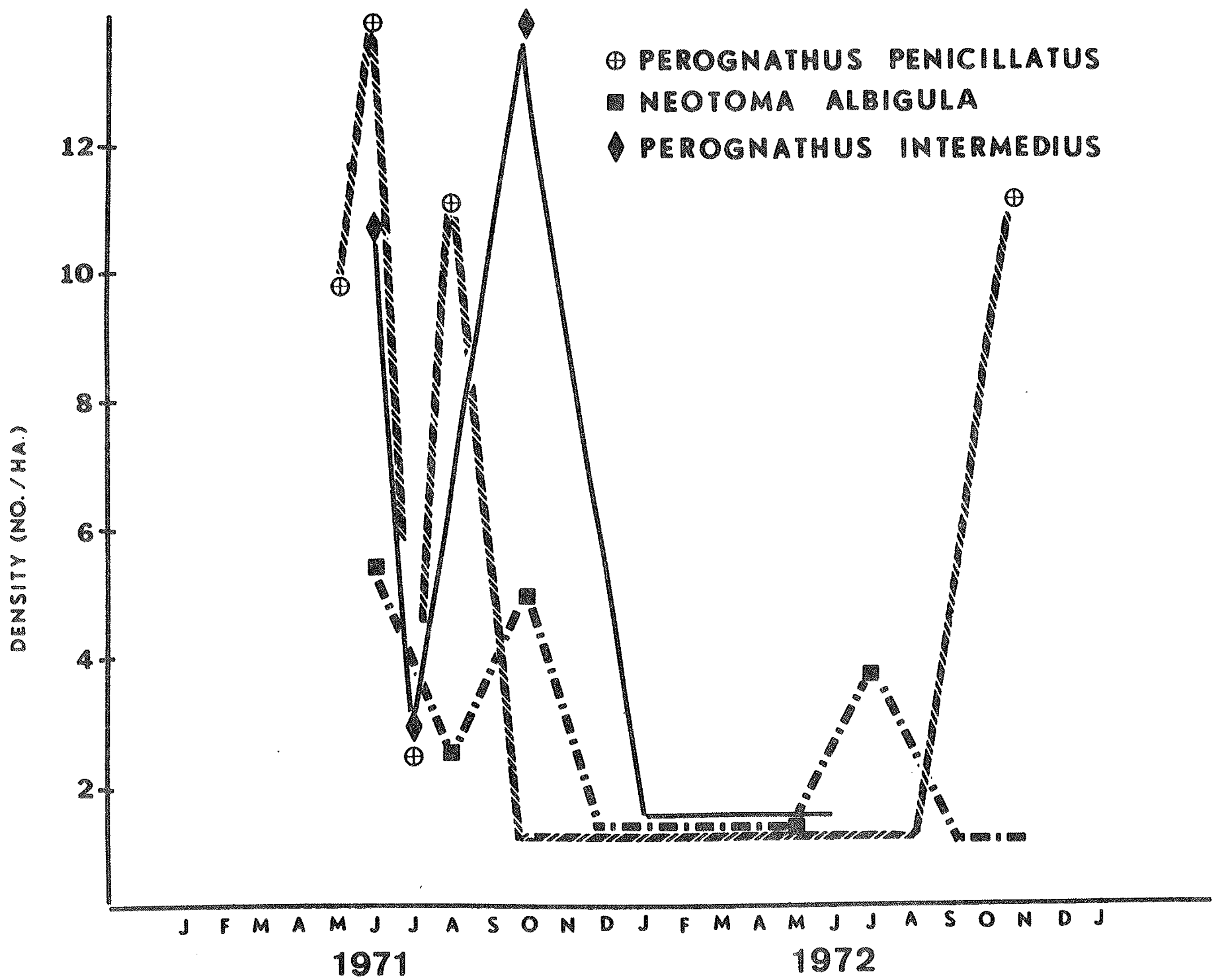

Figure 9. Population fluctuation of rodent species on the bajada.

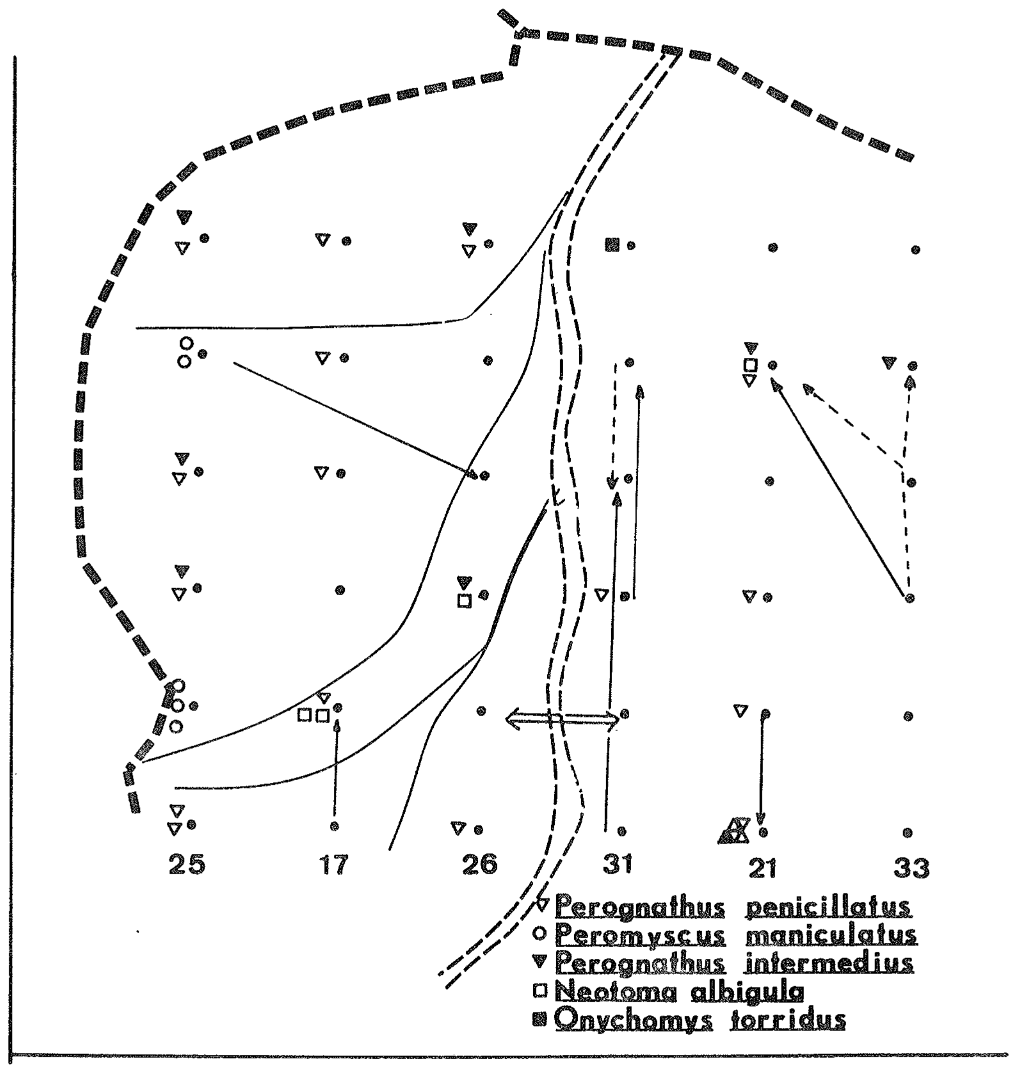

Figure 10. Long distance moves of *Dipodomys merriami* and trapping stations where other species were captured May-June 1972. Numbers at bottom of figure indicate numbers of animals captured on that line of the grid.

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

Group	1971		1972	
	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.

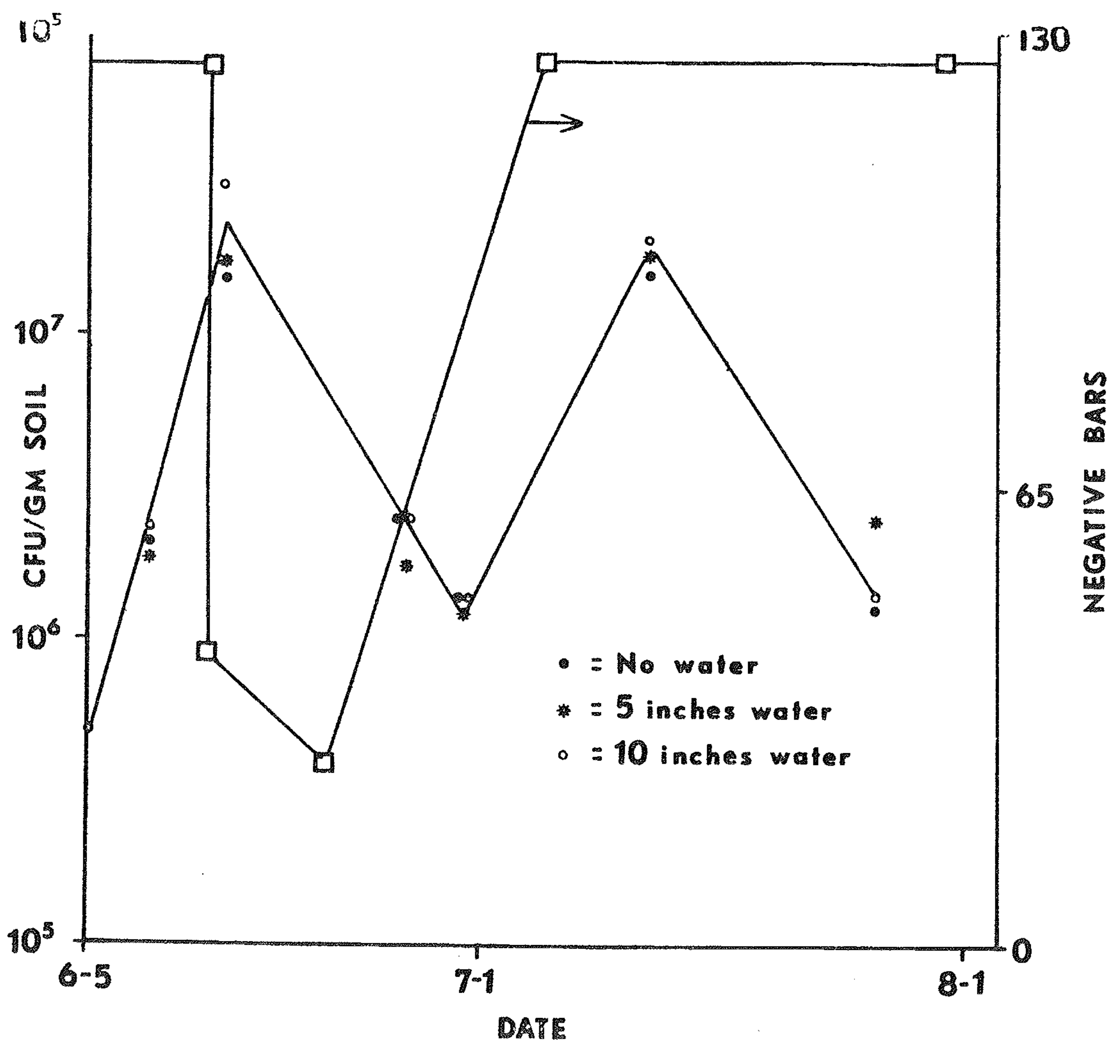

Figure 1. The effect of moisture amendment on colony forming units in bajada soil.

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)		Canopy Cover %		Leaf (kg/ha)		Live Stems (kg/ha)	
	1971	1972	1971	1972	1971	1972	1971	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.

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

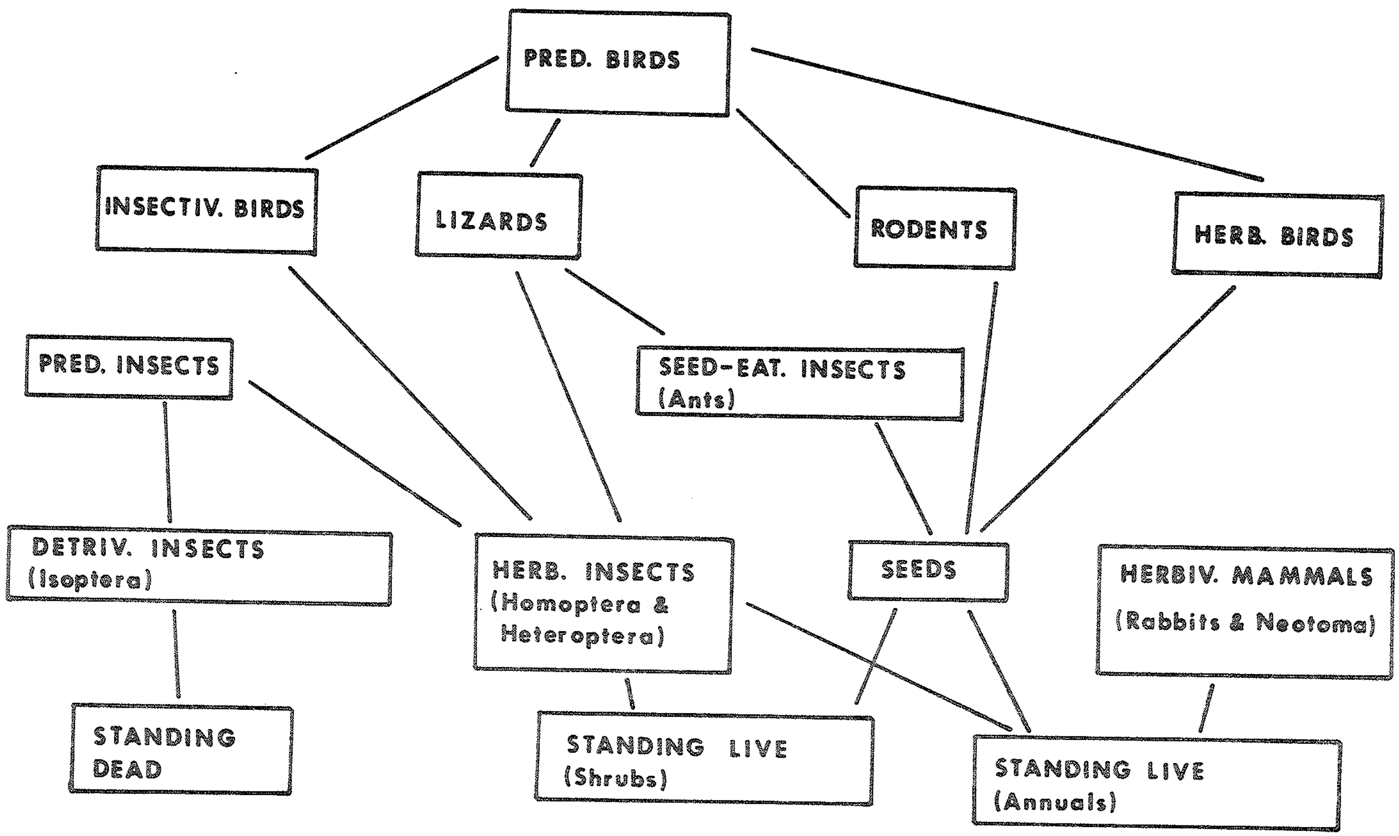

Figure 1. Consumer compartments in a desert ecosystem based on Jornada Validation Site data.

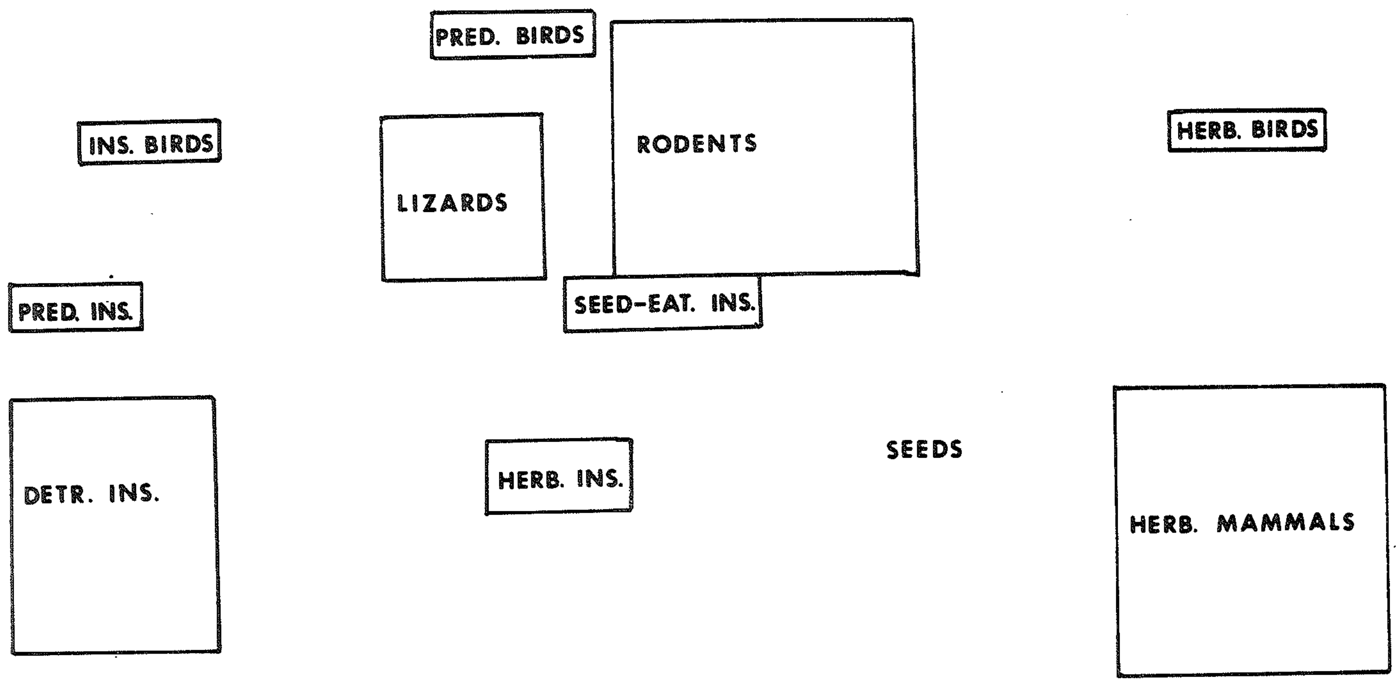

Figure 2. Relative biomass of consumer compartments in a desert ecosystem. Sizes of boxes represent relative biomass.

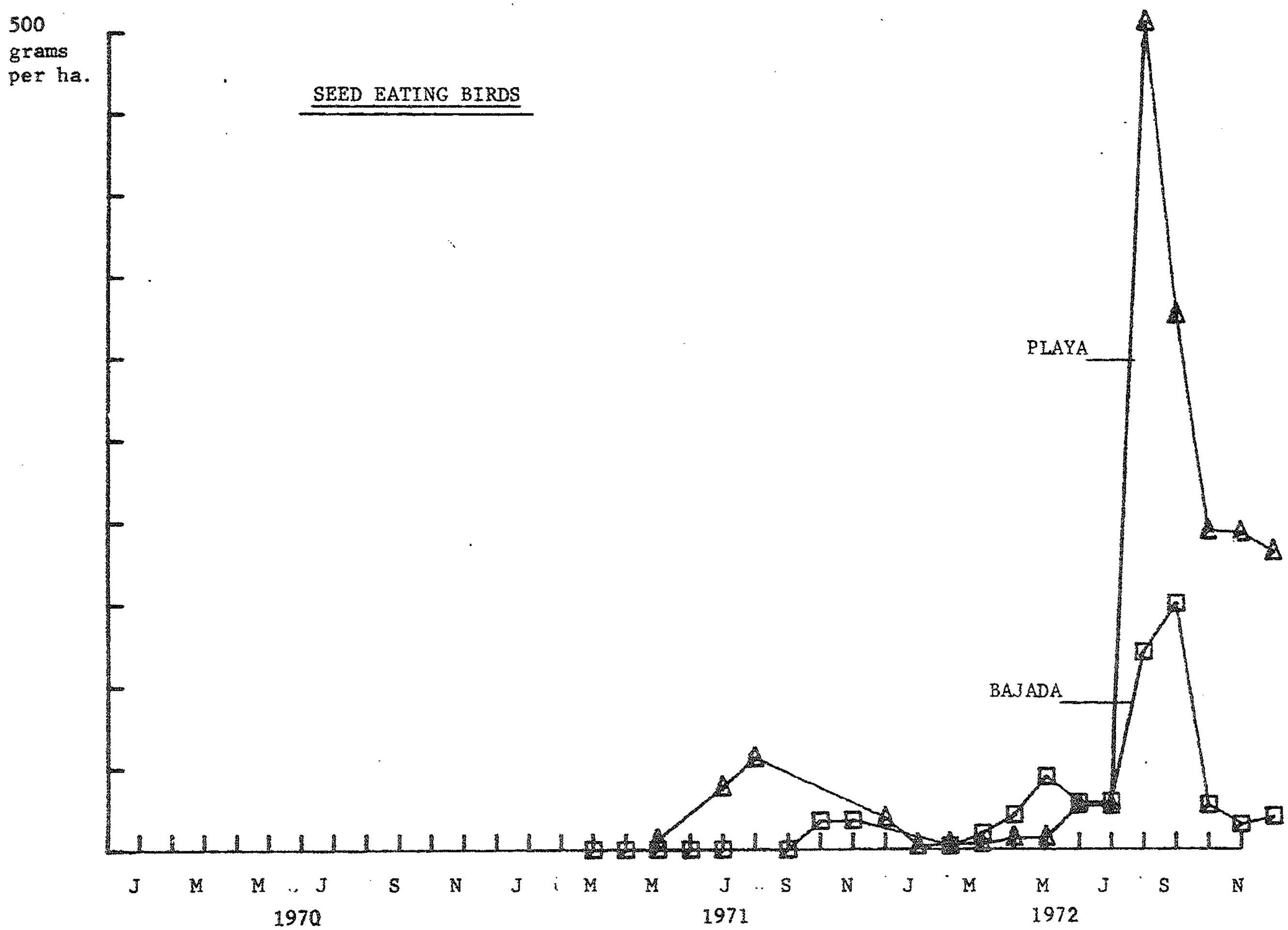

Figure 3. Fluctuations in biomass of seed-eating birds, Jornada Validation Site.

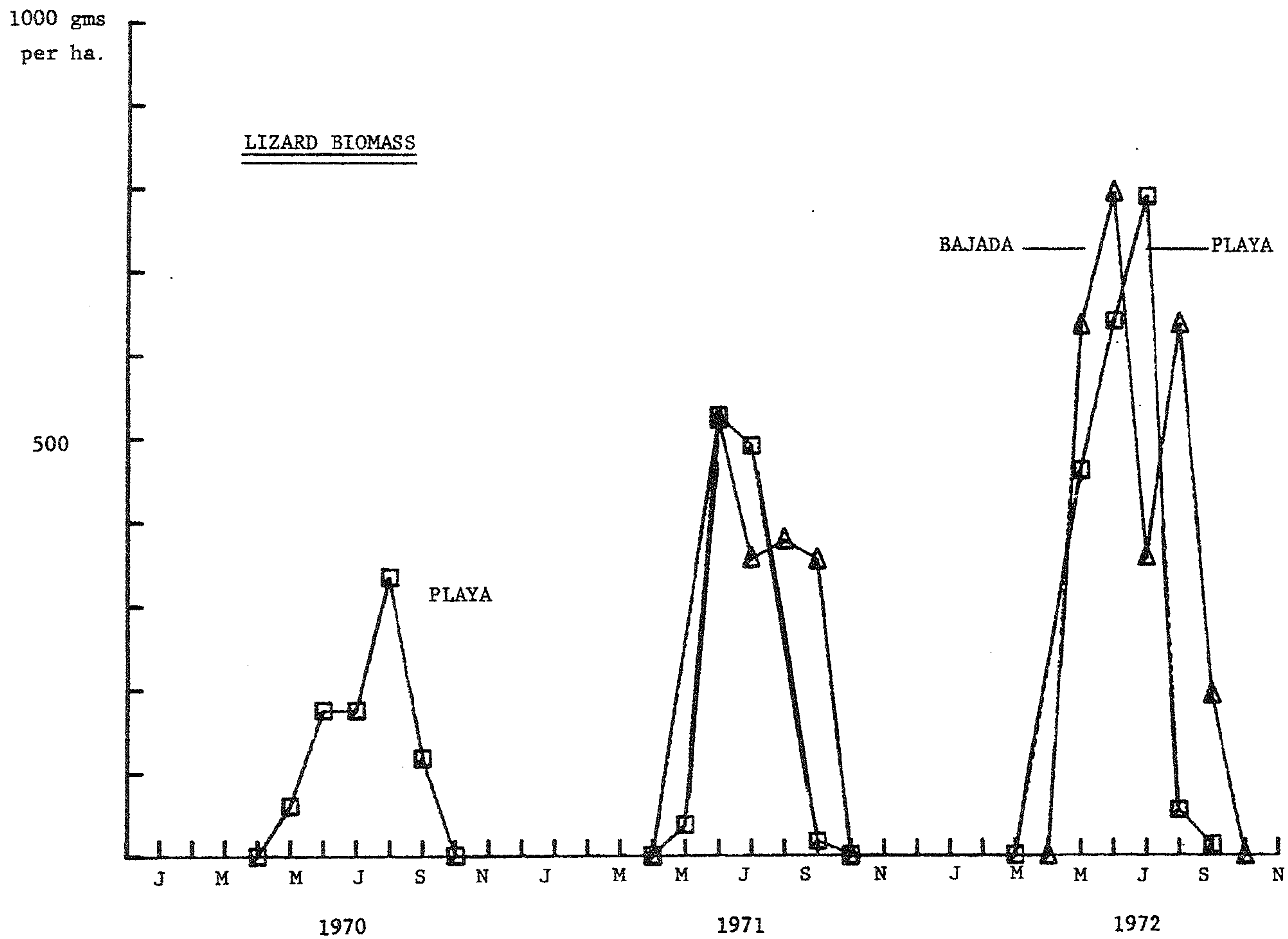

Figure 4. Fluctuations in biomass of lizards, Jornada Validation Site.

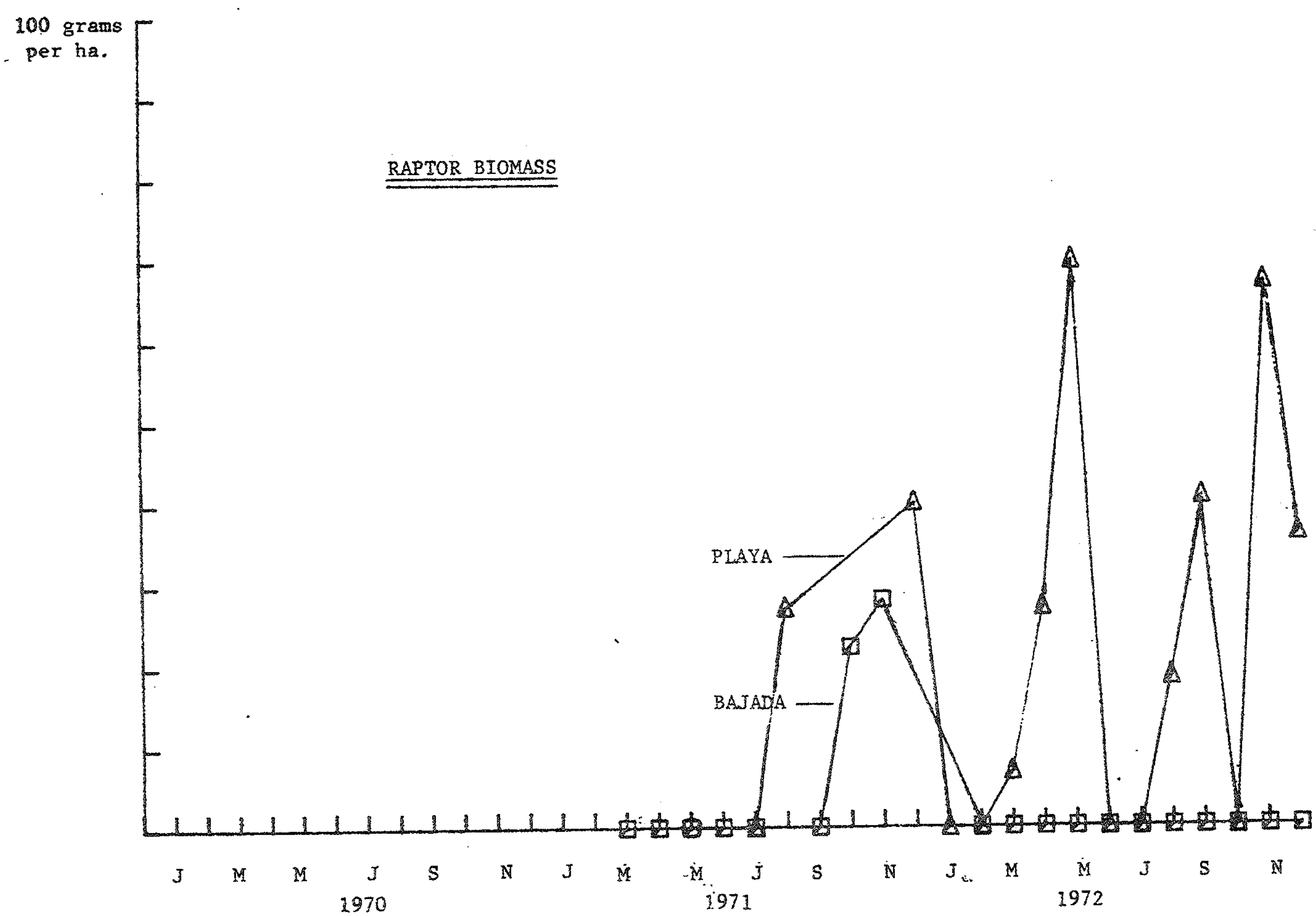

Figure 5. Fluctuations in biomass of raptors, Jornada Validation Site.

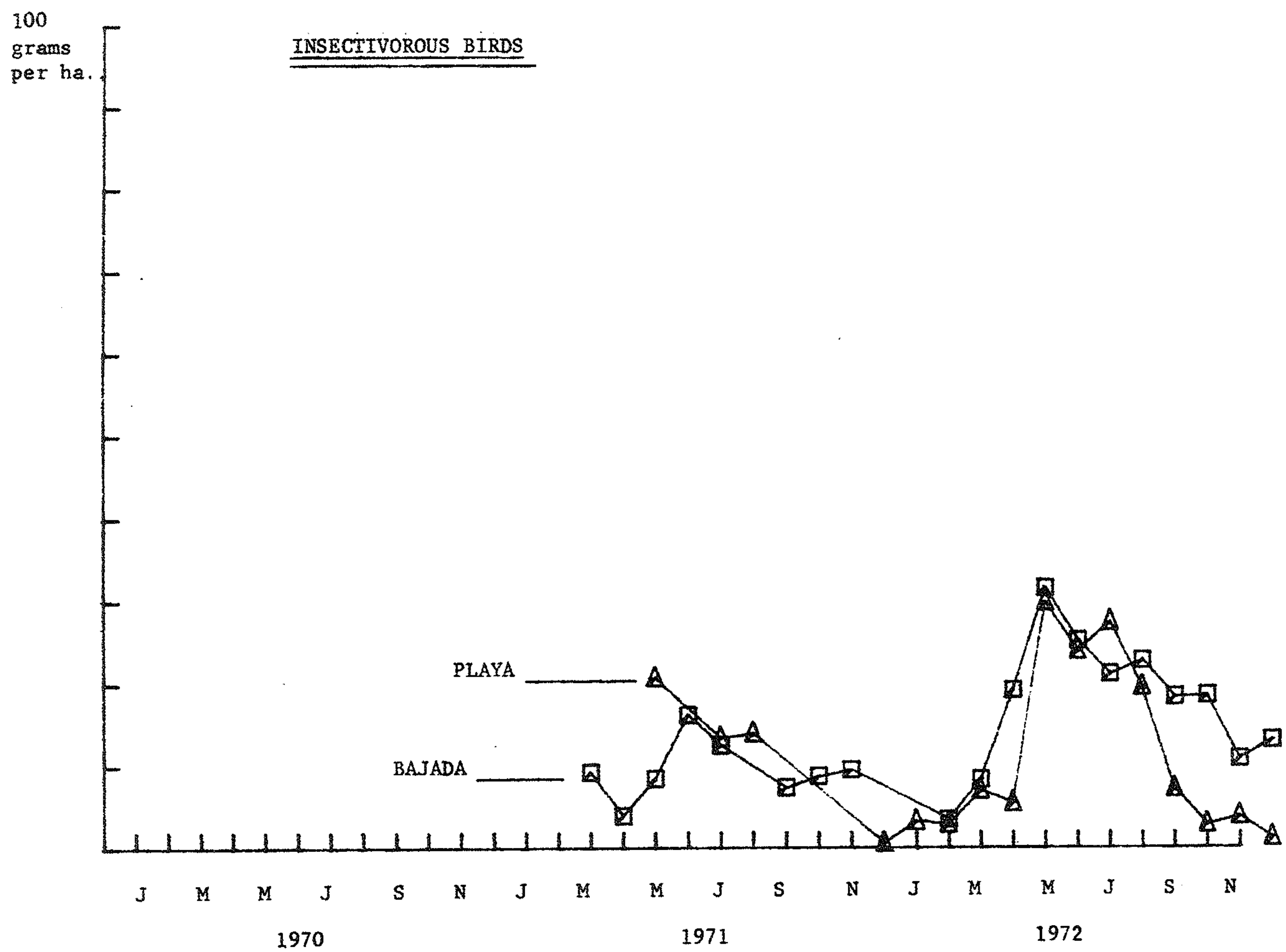

Figure 6. Fluctuations in biomass of insectivorous birds, Jornada Validation Site.

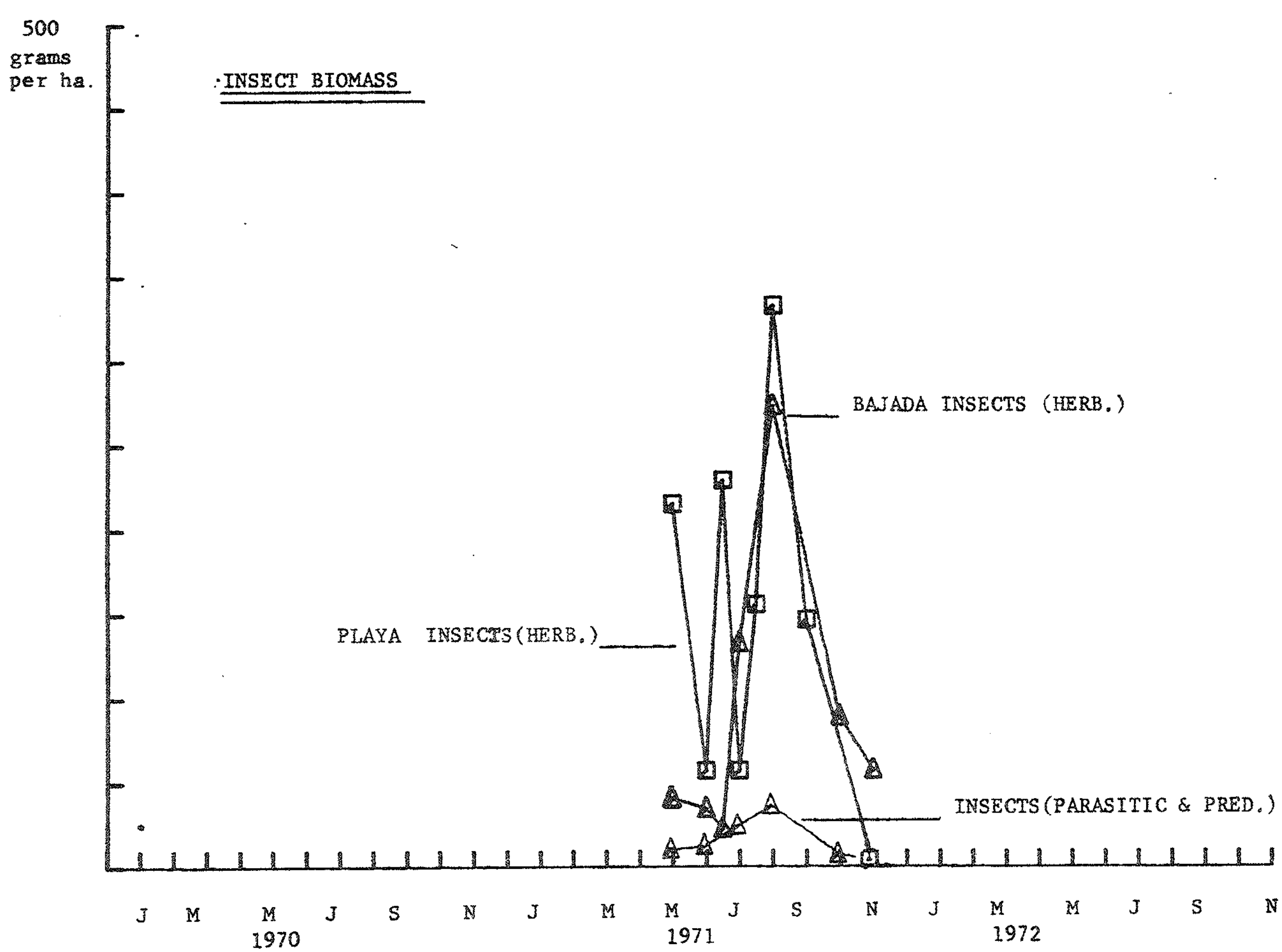

Figure 7. Fluctuations in biomass of insects, Jornada Validation Site.

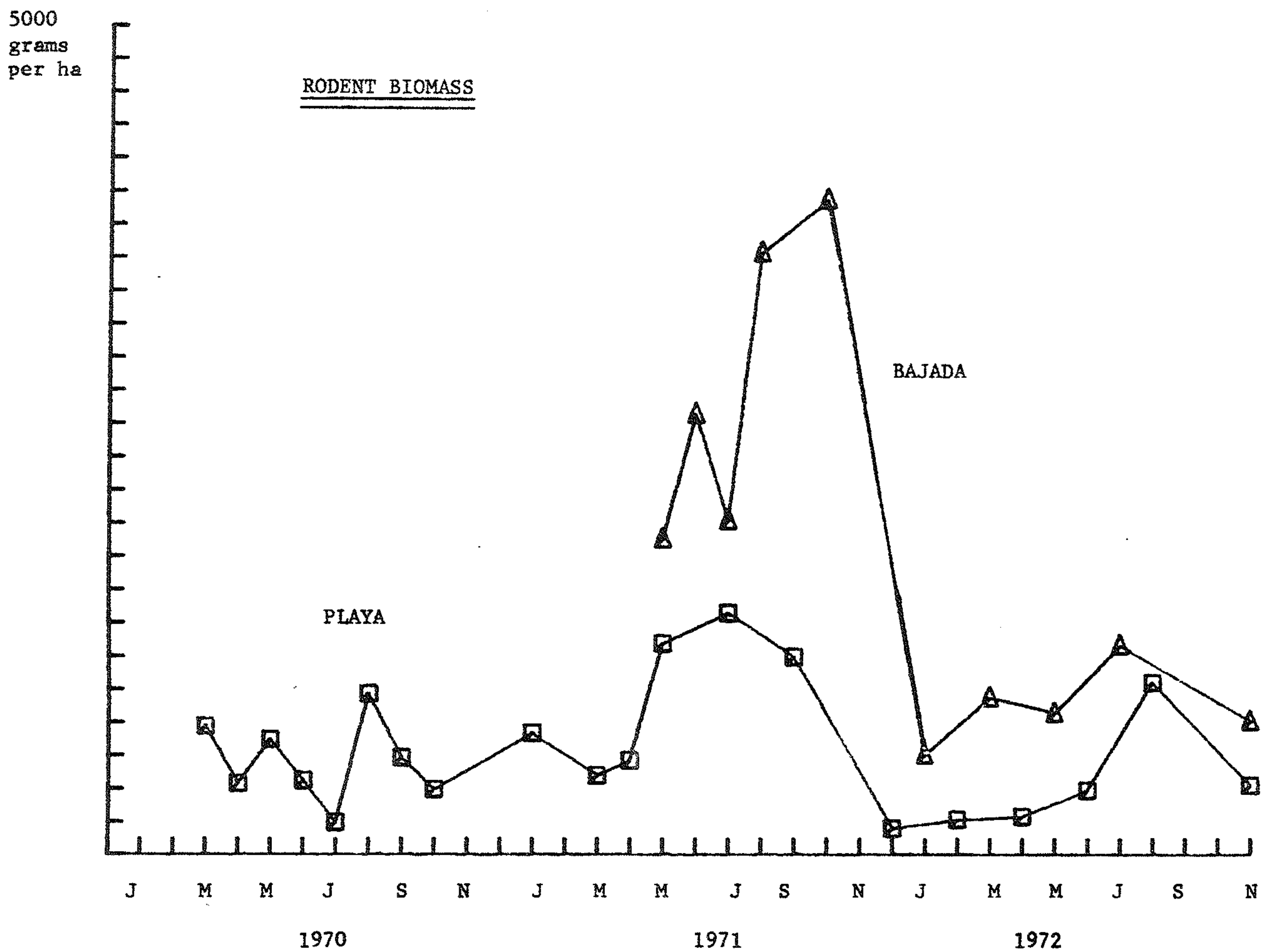

Figure 8. Fluctuations in biomass of rodents, Jornada Validation Site.

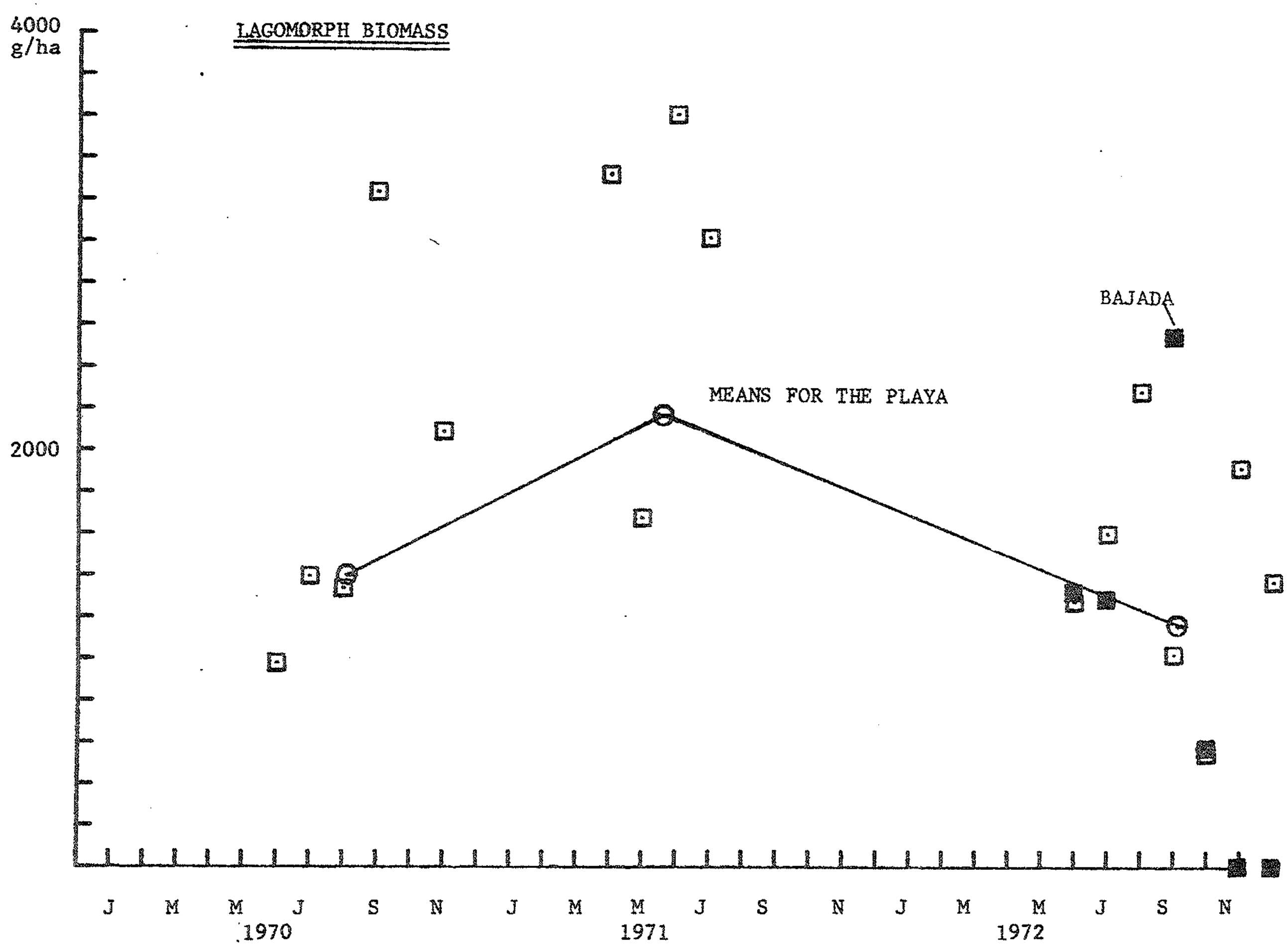

Figure 9. Fluctuations in biomass of lagomorphs, Jornada Validation Site.

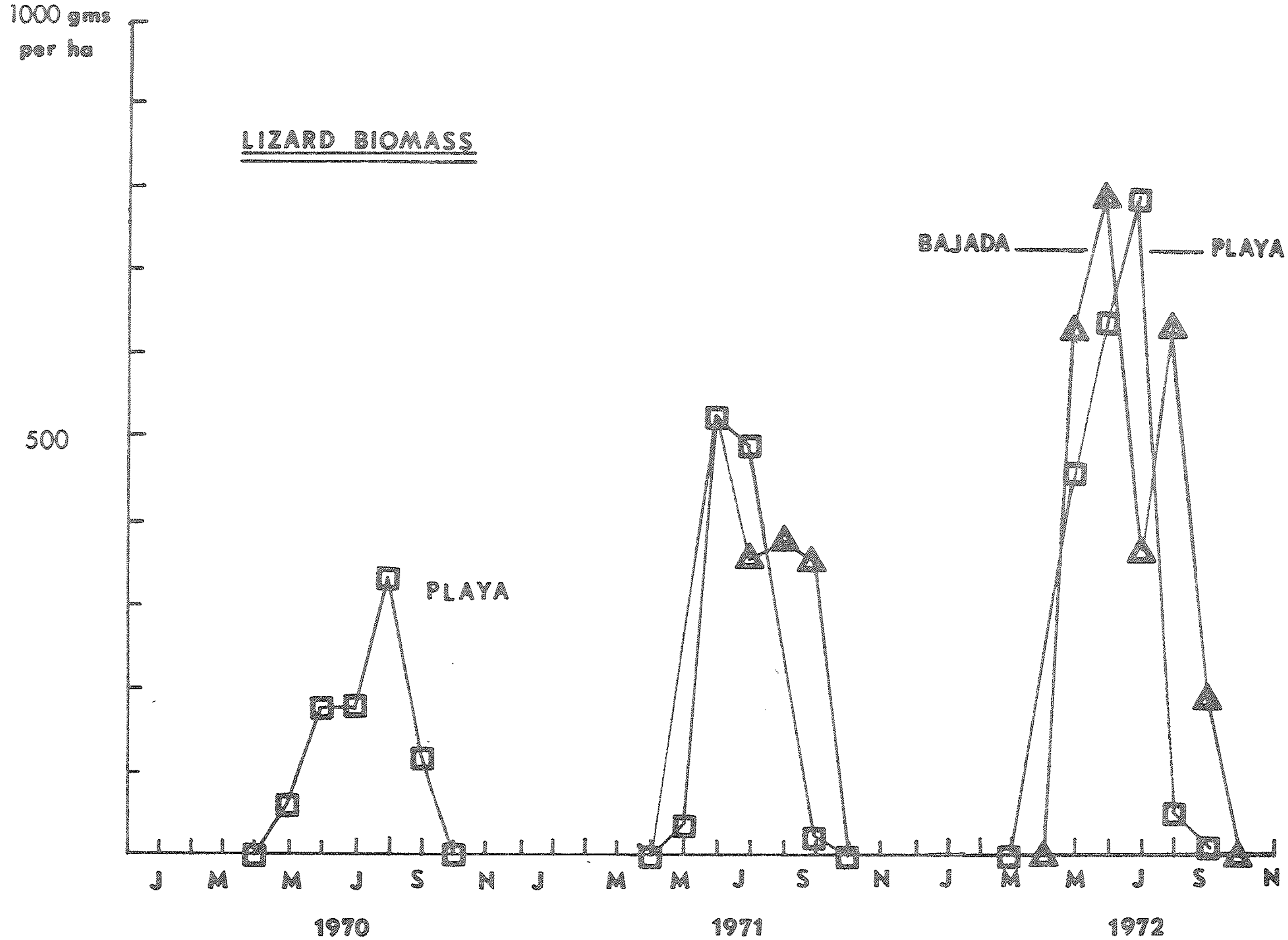

Figure 10. Density estimates of lizards on playa site, 1970-1972.

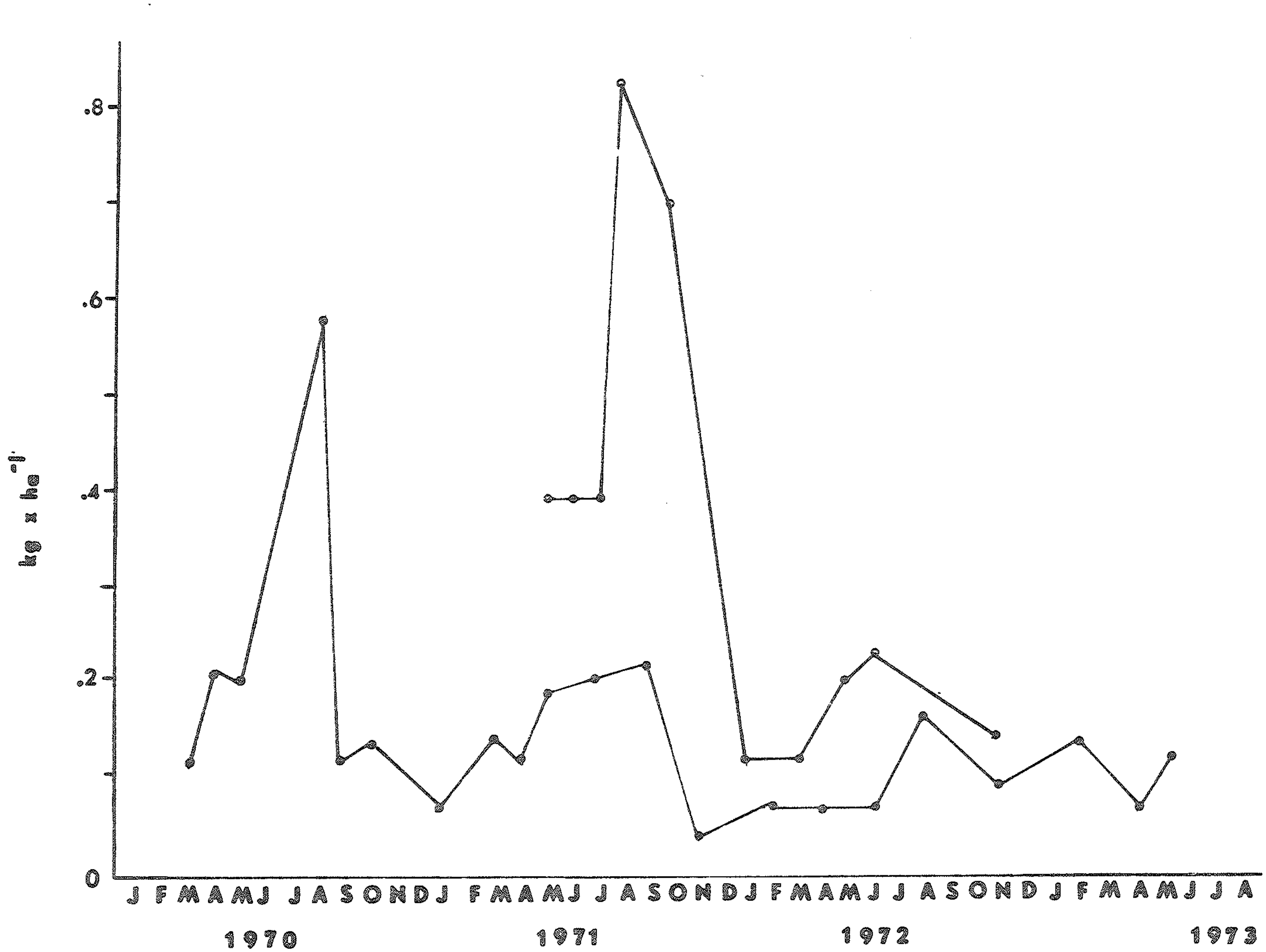

Figure 11 and 12. Survivorship of *D. merriami* 1970 - 1973 on the playa and bajada respectively.

1972 PROGRESS REPORT

SEED RESERVES OF DESERT SOILS

Stuart Childs and

David W. Goodall, Project Leader

Utah State University

Research Memorandum, RM 73-5

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ABSTRACT

Soil and litter samples from Rock Valley and Silverbell were analyzed for their seed content with special attention to spatial distribution. In both sites, the seed content of the soil fell off sharply from the surface downwards; at the time of sampling, however, the surface 1 cm of soil contained more seeds of most species than were in the loose litter on the soil surface. At Silverbell, 18% of all seeds occurred below 5 cm; in Rock Valley the corresponding figure was 3%.

At Rock Valley most seeds were found under shrubs. At Silverbell this difference was less marked, and was reversed for two species of *Bouteloua*. Under certain shrub species at both sites, there was a significant reduction in seed population as one proceeded from the center to the periphery of shrub canopy.

Total seed populations are estimated at 427 m^{-2} in Rock Valley and 33097 m^{-2} in Silverbell, with biomasses of 5 kg. ha^{-1} and 83 kg. ha^{-1}, respectively.

INTRODUCTION

Numerous studies have been made of the seed reserves in arable soils and in improved grassland, but very little information is available on reserves in desert soils, either in North America or elsewhere. This project was initiated in 1971 to develop methods for estimating seed reserves, and to inventory the seed reserves of validation sites.

OBJECTIVES

This project has as its purpose to obtain estimates of the seed populations in the Desert Biome Validation Sites, and also to provide information on their spatial distribution.

METHODS

Fieldwork

The Jornada Validation Site and the Silverbell Validation Site were sampled for seed reserves in June, 1972, in order to test depth stratification, and seed distribution under different species of shrub and in open ground.

At the Jornada Validation Site, samples were taken from the playa, the playa fringe and the bajada zones. Replicate samples were taken in the open and under the canopies of *Prosopis glandulosa, Larrea divaricata, Ephedra trifurca, Yucca elata, Fallugia paradoxa,* and *Hilaria mutica.* At the Silverbell Validation Site, samples were taken in the open and under the canopies of *Larrea divaricata, Cercidium microphyllum, Ambrosia dumosa, Acacia constricta* and *Olneya tesota.* While approximately four replicates of the above samples were made, only one series of samples was made at Silverbell under the canopies of *Opuntia spinosa, Opuntia fulgida, Fouqueria splendens,* and *Cereus giganteus.* In November, 1971, samples were taken at Rock Valley in the open and under the canopies of *Lycium pallidum, Lycium andersonii, Ambrosia dumosa, Krameria parvifolia, Larrea divaricata,* and *Ephedra nevadensis,* representing the Mohave Desert.

In June, 1972, samples were collected at the Curlew Valley Validation Sites. Because the variables of depth, canopy type, and distance from canopy center were dealt with adequately in 1971, it was felt that elimination of sampling procedures

providing this type of information would increase project efficiency. To that end, replicate samples were collected under canopies of tussock grasses, *Artemisia tridentata, Atriplex confertifolia* and *Chrysothamnus nauseosus*, as well as in open sites at both the northern and southern sites in Curlew Valley. Each sample was a cubic decimeter in volume and was taken midway between the canopy center and its periphery.

Laboratory techniques

The laboratory techniques used in 1971, and described in the Progress Report for the year (Goodall, 1972), proved satisfactory, and were in the main continued in 1972, although minor adaptations were used for different soil types. Soaking in Calgon was not so necessary for coarse textured soils, because few aggregates were present. The soaking period was not eliminated, however, it was merely shortened.

Another feature of coarse textured soil was that a large quantity of mineral particles was retained in the flotation solution. Because a large amount of mineral particles increased the chance of trapping seeds and thereby causing them to sink, two successive flotations were used to reduce this potential source of error.

An additional flotation in zinc chloride solution of specific gravity 1.9 was applied to one half of the samples from each test site in order to check on the efficiency of flotation by the potassium carbonate solution normally used. No seeds were found in this additional flotation.

Tests of seed recovery for species occurring in Rock Valley showed that total seed recovery remained well over 90%. Because adequate supply of test seeds of plants occurring at Silverbell was not available to test their recovery, similar tests could not be run. However, seeds of the same genus, or otherwise similar to those found at Silverbell, were tested successfully, indicating that poor recovery is probably not a serious source of error in seed counts.

Seed identification

Field collections of additional seed species from Curlew Valley have been labeled and added to the seed herbarium. This collection is now virtually complete for Curlew Valley seeds. In addition, seeds of *Phlox gracilis* and *Veronica biloba* were obtained from plants grown from Curlew Valley soil taken undisturbed from the field and placed in a greenhouse.

The Rock Valley herbarium has grown from the addition of field samples collected and identified by Dr. S. Bamberg. James Nelson at the University of Southern California has also contributed some seed samples.

Although the seed herbarium at Logan is poorly supplied with seeds of plants at Silverbell, identifications of many seeds from that site have been made. James Reichman at Northern Arizona University helped greatly in these identifications by permitting use of his seed herbarium, as well as making several personal identifications.

Dr. W. G. Whitford has sent a preliminary collection of identified seeds from Jornada Validation Site.

Determination of bulk density

In order to extrapolate from actual seed counts of soil samples to seed reserves on an area basis, a determination of the bulk density of the surface 10 cm of soil at each site was necessary. These measurements were made on clods from soil samples. The clods were weighed, then dipped in paraffin. The volumes of the clods were determined by displacing water and correcting for the volume of the paraffin coating. The average bulk densities are:

Curlew Valley	1.68
Rock Valley	1.58
Silverbell	1.60

RESULTS AND DISCUSSION

Only the results of analysis of samples taken in 1971 in Rock Valley and in 1972 at Silverbell are included in this report. Analysis of the samples taken in 1972 at Jornada and in Curlew Valley are still incomplete.

Rock Valley

Depth distribution: The distribution of seeds with depth (to 10 cm) is shown in Table 1. It will be noted that four species have no identification, while two others are identified only to genus. It is hoped that germination tests will enable these uncertainties to be reduced. In Table 1, for each depth, both the number of samples in which seed of the species in question was found, and the total number of seeds counted, are recorded. In the case of the surface litter samples, the whole was analyzed, and hence the counts refer to 100 cm^2 per sample. In the deeper samples,

a sub-sample of 100 g of air-dry soil was analyzed; hence the count must be multiplied by the bulk density and by the thickness (in cm) of the soil layer in order to arrive at an area estimate. The last two columns of the Table give the number of samples to 10 cm in which the seeds were recorded at one or more depths, and an estimate of the mean number of seeds in these samples in an area of 1 dm^2. Only samples which were complete for all depths have been included in these calculations. The total number of such samples was 71.

Table 1 suggests strongly a marked difference in seed concentration with depth, and this indication was confirmed by statistical tests. In Table 2, seed counts for eight of the more abundant species are recorded for all complete sets of samples (i.e., those where figures were available for all four depths of soil). In each case, a X^2 test showed great heterogeneity. Furthermore, the depth distribution for the different species does seem to follow the same pattern; the 8 x 4 table including all these data gives a X^2 value of 34.88 with 21 degrees of freedom, with $P<.05$ This heterogeneity derives from the fact that, unlike other species, no seeds of *Oryzopsis hymenoides* were found below 1 cm; without this species, the X^2 value becomes 20.33 with 18 degrees of freedom, so that the attenuation of seed concentration with depth can be regarded as uniform for the other species.

The surface litter, even where present, fairly consistently contained fewer seeds than the top 1 cm of soil. Table 3 shows the number of sample pairs in which this relation holds, for each of the more abundant species. The only exception seems to be *Larrea divaricata*; seeds of which were usually more numerous in the litter.

In Table 4, the overall distribution of seeds by depth is given for the more abundant species, and for the whole seed population. It will be seen that three quarters of the total seed population are found within 1 cm of the surface, and only 3% are deeper than 5 cm.

Sample Location: Comparisons of samples taken in the interspaces between shrubs and under canopies of different shrub species, are presented in Table 5. The number of shrubs or interspace areas in each category where seeds of the species in question were recorded is shown, and also the number of 100 cm^2 samples (to 10 cm depth, including litter). The seed quantities recorded are estimates of those contained in such a 1-litre volume of soil, obtained by multiplying the numbers actually found in subsamples of 100 g by the bulk density and thickness of the soil layer represented.

Table 1. Seed distribution depth at Rock Valley DSCODE—A3UGE22

Species	Surface Litter		0-1 cm		1-2 cm		2-5 cm		5-10 cm		All Depths	
	Sample where present	Seeds counted	Sample where present	Seeds counted	Sample where present	Seeds counted	Sample where present	Seeds counted	Sample where present	Seeds counted	Sample where present	Seeds counted
Amsinckia tesselata	2	4	3	3	0	0	2	2	0	0	6	3.0
Astragalus lentiginosus	0	0	4	5	4	8	2	6	3	3	6	12.1
Chaenactis carphoclinia	4	6	11	16	1	1	0	0	1	1	15	2.7
Chorizanthe rigida	0	0	1	2	0	0	0	0	0	0	1	3.2
Cryptantha circumscissa	4	16	7	17	2	5	1	2	0	0	8	7.5
C. micrantha	0	0	0	0	1	1	0	0	0	0	1	1.6
C. nevadensis	1	1	1	3	0	0	0	0	0	0	2	2.9
C. pterocarya	1	1	0	0	1	1	0	0	0	0	2	1.3
C. recurvata	4	9	3	5	1	2	1	2	0	0	6	4.9
Descurainia pinnata	5	8	17	43	10	18	5	7	1	1	22	6.6
Eriogonum maculatum	0	0	0	0	0	0	1	1	0	0	1	4.7
E. trichipes	1	1	4	4	1	1	0	0	0	0	6	0.7
E. spp.	0	0	1	1	0	0	0	0	0	0	1	1.6
Euphorbia spp.	0	0	2	2	1	1	2	2	2	2	3	10.0
Festuca octoflora	6	23	26	42	11	29	6	14	5	7	36	7.1
Gilia spp.	0	0	2	2	0	0	0	0	0	0	2	1.6
Grayia spinosa	0	0	2	2	0	0	0	0	0	0	2	1.6
Ipomopsis polycladon	2	2	2	2	2	2	0	0	1	1	7	1.9
Krameria parvifolia	0	0	1	1	0	0	0	0	0	0	1	1.6
Larrea divaricata	12	67	6	22	3	4	3	3	3	3	14	10.4
Lycium andersonii	3	30	8	27	1	1	2	3	0	0	10	8.8
L. pallidum	1	1	0	0	0	0	0	0	0	0	1	1.0
Mentzelia obscura	0	0	3	4	2	11	1	1	2	2	3	14.7
Oryzopsis hymenoides	1	1	4	30	0	0	0	0	0	0	5	9.7
Pectocarya spp.	5	10	3	10	0	0	0	0	0	0	8	3.8
Phacelia fremontii	0	0	1	1	1	1	1	1	0	0	3	2.6
Phacelia vallis-mortae	2	3	5	9	3	5	0	0	0	0	7	3.6
Stephanomeria exigua	0	0	0	0	0	0	1	1	0	0		4.7
Streptanthella longiros.	3	15	3	14	2	3	2	3	0	0	6	9.3
Stylocline microporoides	1	1	0	0	0	0	0	0	1	1	2	4.5
Tridens pulchellus	1	2	0	0	0	0	0	0	0	0	1	2.0
Species A	1	1	2	2	0	0	0	0	0	0	3	1.4
Species B	1	4	1	6	0	0	0	0	0	0	1	13.5
Species C	0	0	1	1	0	0	0	0	0	0	1	1.0
Species D	1	2	2	11	1	4	2	3	0	0	2	19.5

Table 2. Seed Distribution by Depth at Rock Valley.

Species	Number of Seeds in Samples of Equivalent Weight				
	0-1 cm	1-2 cm	2-5 cm	5-10 cm	X^2 *
Chaenactis carphoclinia	14	4	0	1	25.84
Cryptantha circumscissa	17	5	2	0	29.0
Descurainea pinnata	41	17	7	1	56.42
Festuca octoflora	79	27	13	6	104.60
Larrea divaricata	22	4	3	3	53.38
Lycium andersonii	27	1	3	0	64.61
Oryzopsis hymenoides	30	0	0	0	90.00
Streptanthella longirostris	14	3	3	0	22.80

* Significance limit of X^2 for $P = .01$ is 12.84

Table 3. Distribution of Seeds in Litter and Surface Soil at Rock Valley

Species	Number of Samples Without Litter but with Seeds in the Surface Soil	Samples with Litter	
		More seeds in surface soil than in litter	Fewer seeds in surface soil than in litter
Chaenactis carphoclinia	3	7	2
Cryptantha circumscissa	-	4	3
Descurainia pinnata	5	10	2
Festuca octoflora	7	18	3
Larrea divaricata	2	2	10
Lycium andersonii	1	5	1
Oryzopsis hymenoides	2	2	1
Streptanthella longirostris	1	1	2

Table 4. Proportion of seeds at different depths at Rock Valley

Species	Percentage of total seeds at: Surface	0-1 cm	1-2 cm	2-5 cm	5-10 cm
Astragalus lentiginosus	0	22	28	33	17
Chaenactis carphoclinia	24	56	16	0	4
Cryptantha circumscissa	40	43	12	5	0
C. recurvata	56	19	13	12	0
Descurainia pinnata	12	55	23	9	1
Festuca octoflora	11	56	20	9	4
Larrea divaricata	68	22	4	3	3
Lycium andersonii	49	44	2	5	0
Mentzelia obscura	0	13	69	6	12
Oryzopsis hymenoides	3	97	0	0	0
Pectocarya spp.	48	48	0	4	0
Phacelia vallis-mortae	18	53	29	0	0
Streptanthella longirostris	43	40	9	8	0
Species D	10	58	20	15	0
All species	29	46	14	8	3

Table 5. Estimates of seed numbers per sq. dm under different shrub species, Rock Valley

Canopy Species:	Between shrubs	*Ephedra nevadensis*	*Lycium andersonii*	*Lycium pallidum*	*Ambrosia dumosa*	*Krameria parvifolia*	*Larrea divaricata*
No. of canopy individuals:	5	1	3	4	4	2	5
No. of 1 sq. dm samples:	5	4	9	12	12	5	19
Seed species							
Chaenaetis carphoclinia	0	0	0	0.7	0.3	0.2	2.5
Cryptantha circumscissa	0	0.4	0	0	0	0.3	2.7
Descurainia pinnata	0.3	0	5.2	3.9	1.1	0.3	4.3
Festuca octoflora	0.3	1.8	3.6	1.6	3.0	15.9	6.9
Larrea divaricata	0	0	0	0	1.5	0	6.5
Lycium andersonii	0	0	6.7	2.5	0.3	0	0.2
Oryzopsis hymenoides	0	0	0	0	1.1	2.6	1.2
Streptanthella longirostris	0	0	0	0.2	0.1	1.0	2.5
Other species	0.4	0.5	3.2	3.1	4.7	12.8	2.1
Total, all species	1.0	2.7	18.7	12.0	12.1	33.1	28.9

The density of seeds of all species in the soil under different types of canopy was compared for the more abundant seed species by analysis of variance. Only sample sets in which all soil depths were represented were included in the analysis. The estimates of seeds dm^{-2} at different soil depths were summed; these figures were subjected to a square-root transformation, and the variance due to canopy type was separated from that between different canopies of the same type.

The results are reported in Table 6. In the five areas sampled outside shrub canopies, only four seeds were found in a total of 500 cm^2. Under shrub canopies the average number in this area would have been 72. This difference is highly significant. There is some evidence that certain shrub species are more likely than others to have high seed concentration beneath them -- the figures range from 1.25 seeds per 100 cm^2, in one shrub of *Ephedra nevadensis* studied, to 10.57 as an average for four shrubs of *Larrea divaricata*. The differences between individual shrubs, however, are such that these differences in average seed population did not reach significance. Similar analyses were performed for the different seed species but no significant effects emerged -- doubtless because of the small numbers in most cases.

Table 6. Total seed population per sq. dm under different shrub canopies, Rock Valley*

Source of variation	d.l.	SS	MS	F	P
Bare ground vs. shrubs	1	50.6160	50.616	10.60	<.05
Between shrub species	6	28.6384	4.773	1.47	>.05
Within canopy types	18	58.2765	3.2375		
Total	25	137.5309			

*Analysis of variance (after square root transformation)

Position under shrub canopy: Comparisons were also made between the seed populations (totalled over all depths) in soil at different distances from the center of a shrub canopy. Samples were taken within 10 cm of the center, between 20 and 30 cm from it, and so forth at intervals of 20 cm between sample centers. The results are tabulated in Table 7.

Table 7. Total seed population at different distances from the center of a shrub canopy, Rock Valley

Canopy Species	0-10 cm.		20-30 cm		40-50 cm		60-70 cm	
	No.of Samples	Seeds per sq. dm.	No.of Samples	Seeds per sq. dm.	No.of Samples	Seeds per sq. dm.	No.of Samples	Seeds per sq. dm.
Ephedra nevadensis	1	4.6	1	0	1	0	1	6.3
Lycium andersonii	3	19.87	3	23.57	2	10.63	1	7.9
L. pallidum	4	24.95	3	7.87	4	5.15	1	0
Ambrosia dumosa	4	22.93	4	3.18	3	12.43	1	9.4
Krameria parvifolia	2	12.15	1	15.8	1	53.1	1	76.2
Larrea divaricata	6	38.67	5	41.64	4	31.63	4	19.45

The very patchy distribution found seemed to call for a non-parametric test in this case, to ascertain whether there were common patterns in the distribution of particular seed species in relation to the shrub base. Rank-sum tests were used, applied to the rank order of samples at different distances from the canopy center. The samples could be ranked, of course, only where the species occurred in at least one of the series, and consequently the number of rankings available differed from species to species; moreover, the number of samples in the series depended on the size of the shrub under which it was taken. The data are consequently very irregular. The results of these tests are shown in Table 8, where data for seed of a given species have been combined for all shrub canopies, irrespective of species. Since the number of samples under a canopy varied, it was necessary to treat series of three samples and series of four samples separately, which accounts for the partial overlap between the upper and lower parts of the Table. The penultimate column shows $\underline{W}$, the coefficient of concordance between the rankings (Kendall, 1962). None of these values of $\underline{W}$ reaches significance according to Kendall's tables; the results consequently fail to support the view that the order of seed quantities, in samples taken from the canopy center outwards, follows a common pattern. However, possibly more interesting than concordance among the different rankings for a species is the question whether all seed species under a given shrub tend to be concentrated towards the base; agreement between rankings would seem less biologically meaningful than a test of trend in this sense. To answer this question, it would be valuable to combine data for sample series of different numbers, which cannot well be done when the coefficient of concordance is employed. For this purpose a different type of non-parametric test was used.

Table 8. Tests of concordance: Rankings of seed populations at different distances from the center of a shrub canopy, Rock Valley

Seed Species	No. of Canopy Individuals	No. of Samples Per Canopy	W	P
Descurainea pinnata	4	4	.133	.80
Festuca octoflora	5	4	.080	.88
Chaenactis carphoclinia	2	4	.633	.65
Cryptantha circumscissa	3	4	.778	.22
Streptanthella longirostris	2	4	.900	.04
Oryzopsis hymenoides	3	4	.651	.31
Larrea divaricata	4	3	.214	.65
Descurainea pinnata	9	3	.004	.99
Lycium andersonii	2	3	3.500	.65
Festuca octoflora	9	3	.159	.36
Chaenactis carphoclinia	4	3	.019	.98
Cryptantha circumscissa	4	3	.250	.65
Oryzopsis hymenoides	4	3	.438	.37

For each sequence of samples at different distances from a shrub center, the estimated seed densities were ranked. The probability of each possible ranking was calculated on the assumption of random distribution, and these probabilities were summed for all rankings which, on the alternative hypothesis of a decreasing density from the center outwards, were not more improbable than that observed. These probabilities, P_i, derived from different sample sequences, were then combined. Where the number of possible values of the probability for each set is large (where it can be treated as continuous), the appropriate method for doing this, due to Fisher (1963), is to calculate:

$$\chi^2 = -2 \sum_{i}^{n} \ln P_i$$

which is distributed as a χ^2 variable with n degrees of freedom on the null hypothesis of no trend. In the present instance, however, the probabilities may take only a small number of values, and as shown elsewhere (Goodall, 1966) the Fisher method then over-estimates the combined probability. Accordingly, an exact combinatorial method was used. This method enabled data sets with different numbers of samples, and many ties, to be combined without loss of information. The results are given in Table 9. It is clear that under *Larrea divaricata* and *Lycium pallidum* there is a definite tendency for seeds to be concentrated towards the shrub base, but that this does not apply to the other shrub species.

Table 9. Effect of position under a shrub canopy on seed density, Rock Valley

Shrub Species	Number of Canopy Individuals	Number of 1 sq.dm. Samples	Number of Rankings	Significance*
Ambrosia dumosa	4	12	19	.25
Krameria parvifolia	1	4	14	.82
Larrea divaricata	5	19	25	.03
Lycium andersonii	3	9	14	.50
Lycium pallidum	4	12	18	.015

*Probability of observed rankings on the null hypothesis, against the alternative hypothesis of a trend from the center outwards.

Estimate of total seed population: In order to obtain an estimate of the total seed population of the area we should have estimates of the proportion of the area under shrub canopies, and the proportion at different distances from the shrub center. These estimates could then be combined with the estimate of seed population density to give figures for quantity of seed in the area as a whole. Data on numbers of shrubs of different sizes have been collected in the course of the Rock Valley study, but are not available in the requisite form at the time of writing.

Meanwhile, approximate figures may be derived from the cover estimates given in the progress report for the Rock Valley Validation Site for 1971 (Turner, 1972). Taking the total shrub cover of 19.3% from this report, and the populations of seed of different species found under shrubs and in bare areas, overall estimates of population may be obtained on the assumption that the shrub species do not differ in the seed populations they harbor.

Conversion of these population figures to biomass estimates requires values for the average weight of a seed. These are given in Table 10. Many of these figures were based on a very small number of seeds -- sometimes only a single seed -- so they are not to be regarded as highly accurate.

Population and biomass estimates for each of the more important species are combined in Table 11. In view of the way these estimates were derived, no error figures are attached to them; better estimates with errors will be available at a later stage. The total mass of seeds estimated amounts to 5 kg. ha^{-1}.

Table 10. Mean weight of individual seeds: Rock Valley DSCODE---A3UGE21

Species	Seed Weight (mg)	Species	Seed Weight (mg)
Amsinckia tesselata	1.99	*Larrea divaricata*	6.63
Astragalus lentiginosus	3.17	*Lycium andersonii*	2.21
Chaenactic carphoclinia	0.32	*L. pallidum*	14.00
Chorizanthe rigida	0.57	*Mentzelia obscura*	0.30
Cryptantha circumscissa	0.14	*Oryzopsis hymenoides*	1.72
C. micrantha	0.02	*Pectocarya* spp.	0.41
C. nevadensis	0.24	*Phacelia fremontii*	0.22
C. recurvata	0.37	*P. vallis-mortae*	0.64
Descurainia pinnata	0.15	*Streptanthella longirostris*	0.24
Erigonum maculatum	0.39	*Stylocline micropoides*	0.21
E. trichopes	0.10	*Tridens pulchellus*	1.00
Festuca octoflora	0.37	Species A	0.27
Gilia spp.	0.98	Species B	0.10
Grayia spinosa	0.25	Species C	0.05
Ipomopsis polycladon	0.75	Species D	0.02
Krameria parvifolia	97.10		

Table 11. Seed reserves in Rock Valley

Species	Per sq. m Population	Per sq. m Biomass (mg. air-dry weight)
Chaenactis carphoclinia	12.0	3.84
Cryptantha circumscissa	11.0	1.54
Descurainia pinnata	71.9	10.79
Festuca octoflora	129.8	48.03
Larrea divaricata	25.7	170.39
Lycium andersonii	31.3	69.17
Oryzopsis hymenoides	15.8	21.18
Streptanthella longirostris	12.2	2.93
Other species	117.2	171.11*
Total	426.9	498.98

*For this figure a mean seed weight of 1.46 mg was used, derived by weighting the figures in Table 10 for different species with their relative overall abundance.

Silverbell

Depth distribution: As at Rock Valley, samples were taken to test the distribution of seeds with depth on the Silverbell site. Table 12 gives the counts of seeds found, presented in the same way as Table 1 for Rock Valley. The number of unidentified seeds is much greater here than in the Rock Valley samples, but again it is hoped that germination tests during 1973 will enable many of these uncertainties to be resolved. Again, the last two columns of Table 12 give the numbers of samples, complete to 10 cm, in which each seed species was found (out of a total of 71 such samples), together with the mean quantity in such samples. It will immediately be noted that seeds are very much more abundant at this site than in Rock Valley.

The variation in seed density with depth is presented in Table 13. In all species there are significant differences with depth, and in most a progressive decline in deeper soil layers. *Euphorbia chamaesyce* appeared at first to be an exception, for one of the samples included no fewer than 344 seeds of this species between 2 and 5 cm. This large number appears to be due to the chance inclusion of a cache of seeds collected by a rodent or insect. If this exceptional sample is excluded the decrease in density with depth is continuous in this species, as in most of the others. Even with this correction, however, the depth distribution differs from species to species. If the data in Table 13 are analyzed as a contingency table, the X^2 value is 613 for 39 degrees of freedom, with a very high significance. This is in contrast with the results for Rock Valley, where only one species (*Oryzopsis hymenoides*) deviated from the norm by not appearing below the immediate sub-surface. At Silverbell, on the other hand, several species--*Astragalus nuttalliana,* both *Ferocactus* species, and the unidentified species designated as C -- all occur in quantity below 5 cm.

As in Rock Valley, a good proportion of samples are bare of litter, and where litter is present it usually contains fewer seeds of most species than does the surface 1 cm of soil (Table 14). This comparison would doubtless vary greatly with the time of year, these samples having been collected in June.

The distribution of seeds with depth is further illustrated in Table 15, in terms of proportions. For the four aberrant species mentioned above (*Ferrocactus* and *Astragalus nuttalliana,* and Species C), over 25% of the total seed population are to be found below 5 cm, whereas the figure for the other species averages 5%, and almost half the buried seeds occur in the top 1 cm of soil.

Sample location: Comparisons of samples taken in inter-shrub areas, and under shrub canopies, are presented in Table 16, in the same fashion as for Rock Valley in Table 5.

Table 12. Estimated seed distribution by depth, Silverbell DSCODE——A3UGE42

Species	Litter		0-1 cm			1-3 cm			2-5 cm			5-10 cm			All depths	
	Sample	Seeds.	Sample	Seeds.	Seeds per sq. dm	Sample	Seeds	Seeds per sq. dm	Sample	Seeds.	Seeds per sq. dm	Sample	Seeds	Seeds per sq. dm	Sample where present	Estimated mean seeds per sq. dm
Amsinckia tesselata	2	2	1	1	1.6	1	1	1.6	0	0	0	0	0	0	4	1.3
Astragalus nuttalliana	1	1	11	13	1.9	16	18	1.8	9	11	5.85	4	4	8	27	5.01
Boerhaavia spp.	10	39	11	26	3.78	5	7	2.24	3	3	4.8	2	2	8	22	5.55
Bouteloua aristidoides	17	451	28	967	55.25	20	73	5.84	8	55	32.98	8	16	16	43	58.30
B. barbata	15	193	39	492	20.18	17	63	5.92	11	73	31.82	16	28	14	40	41.38
B. sp.	0	0	2	2	1.6	1	1	1.6	0	0	0	0	0	0	3	1.60
Crytantha sp. 1	1	1	2	2	1.6	1	1	1.6	2	2	4.8	1	1	8	5	4.68
C. sp. 2	0	0	2	4	3.2	0	0	0	1	2	9.6	1	1	8	4	6.00
Eriochloa spp.	2	2	0	0	0	0	0	0	1	1	4.8	0	0	0	3	2.27
Euphorbia chamaesyce	6	8	23	68	4.72	16	38	3.79	11	361	157.49	2	2	8	33	58.38
E. hyssopifolia	0	0	3	20	10.66	3	10	5.32	2	3	7.2	1	1	8	3	23.47
Ferocactus sp. 1 = sp. A	2	7	12	31	4.13	11	15	2.18	6	11	8.78	4	6	12	19	9.55
Ferocactus sp. 2 + sp. B	4	43	6	99	26.4	7	64	14.62	6	67	53.57	7	60	6856	11	100.49
Franseria spp.	11	18	2	3	2.13	3	3	1.6	1	1	4.8	1	1	8	16	2.53
Larrea divaricata	3	3	2	3	2.13	0	0	0	0	0	0	0	0	0	5	1.56
Lepidium medium	0	0	1	1	1.6	0	0	0	0	0	0	0	0	0	1	1.60
Lesquerella gordoni	0	0	0	0	0	0	0	0	1	1	4.8	0	0	0	1	4.80
Pectocarya spp.	17	45	40	111	4.43	17	25	2.35	5	6	5.76	5	6	96	50	6.79
Phacelia spp.	0	0	0	0	0	1	1	1.6	0	0	0	0	0	0	1	1.60
Plantago insularis	0	0	2	3	2.4	0	0	0	0	0	0	0	0	0	4	1.20
Sphaeralcea spp.	0	0	2	2	1.6	1	1	1.6	0	0	0	0	0	0	3	1.60
Strephanomeria spp.	0	0	1	1	1.6	0	0	0	0	0	0	0	0	0	1	1.60
Thelypodium lasiophyllum	0	0	1	1	1.6	0	0	0	0	0	0	0	0	0	1	1.60
Species C	4	5	28	58	3.31	31	48	2.46	16	28	8.4	13	16	9.84	47	9.30
Species D	0	0	15	32	3.41	16	18	1.79	5	5	4.8	5	5	8	25	5.76
Species E	2	52	10	54	8.46	9	46	8.18	10	67	32.16	1	1	8	19	28.51
Species F	2	8	15	18	5.76	3	5	2.66	2	4	9.6	1	1	8	5	14.40
Species G	0	0	5	12	3.84	3	3	1.6	2	4	9.6	0	0	0	4	10.80
Species H	0	0	1	1	1.6	0	0	0	0	0	0	0	0	0	1	1.60

Table 12. Continued

Species	Litter		0-1 cm			1-3 cm			2-5 cm			5-10 cm			All depths	
	Sample	Seeds	Sample	Seeds	Seeds per sq. dm	Sample	Seeds	Seeds per sq. dm	Sample	Seeds	Seeds per sq. dm	Sample	Seeds	Seeds per sq. dm	Sample where present	Estimated mean seeds per sq. dm
Species I	0	0	2	2	1.6	0	0	0	0	0	0	0	0	0	2	1.60
Species J	0	0	1	1	1.6	0	0	0	0	0	0	0	0	0	2	1.60
Species K	0	0	0	0	0	0	0	0	1	1	4.8	0	0	0	1	4.80
Species L	0	0	0	0	0	0	0	0	1	1	4.8	1	1	8	2	6.40
Species M	0	0	0	0	0	0	0	0	0	0	0	1	1	8	1	8.00
Species N	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1.00
Species O	0	0	2	2	1.6	1	1	1.6	0	0	0	0	0	0	2	2.40
Species P	1	1	0	0	0	1	1	1.6	0	0	0	0	0	0	1	2.60
Species Q	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1.00
Species R	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1.00
Species S	1	1	0	0	0	0	0	0	0	0	0	0	0	0	1	1.00
Species T	0	0	0	0	0	1	1	1.6	0	0	0	0	0	0	1	1.60
Species U	0	0	0	0	0	1	1	1.6	0	0	0	0	0	0	1	1.60

Table 13. Seed distribution with depth, Silverbell

Species	Number of seeds at depth 0-1 cm	1-2 cm	2-5 cm	5-10 cm	χ^2 (*)
Astragalus nuttalliana	13	18	3	4	10.35
Boerhaavia spp.	26	7	3	2	38.79
Bouteloua aristidoides	694	71	49	16	2637.34
B. barbata	313	66	26	26	863.25
Euphorbia chamaesyce†	67	34	17	1	78.55
E. sp.	5	9	1	1	26.00
Ferocactus sp. A	33	15	10	6	26.63
Ferocactus sp. B	99	63	69	59	13.61
Pectocarya spp.	103	20	5	7	201.83
Species C	44	46	27	16	19.76
Species D	29	16	5	5	31.66
Species E	55	49	64	2	52.67
Species F	18	5	4	1	24.43
Species G	37	13	3	-	75.42

*At .01 Significance level χ^2 = 11.34
At .001 Significance level χ^2 = 16.27

†Without one sample area which included a cache of 344 seeds at 2-5 cm

Table 14. Distribution of seeds in litter and surface soil, Silverbell

Species	No. of samples without Litter but with seeds in the surface soil	Samples with litter: More seeds in surface soil than in litter	Fewer seeds in surface soil than in litter
Astragalus nuttalliana	4	7	--
Boerhaavia spp.	5	3	8
Bouteloua aristidoides	15	12	13
B. barbata	19	13	6
Euphorbia chamaesyce	11	12	2
E. hyssopifolia	3	--	--
Ferocactus sp. A	5	5	2
F. sp. B	--	7	--
Pectocarya spp.	11	22	6
Species C	7	8	1
Species D	10	18	1
Species E	5	3	1
Species F	--	4	--
Species G	3	--	--

Table 15. Proportion of seeds at different depths, Silverbell

Species	Percentage of total seeds at				
	Surface	0-1 cm	1-2 cm	2-5 cm	5-10 cm
Astragalus nuttalliana	1	16	23	36	24
Boerhaavia spp.	32	34	9	12	13
Bouteloua aristidoides	17	62	5	11	5
Bouteloua barbata	11	48	6	21	14
Euphorbia chamaesyce	3	41	21	32*	3
Euphorbia hyssopifolia	0	45	23	11	21
Ferocactus sp. A	4	29	13	27	27
Ferocactus sp. B	4	14	9	30	43
Pectocarya spp.	14	52	10	7	17
Species C	1	18	17	33	30
Species D	1	35	19	17	28
Species E	9	18	17	53	4
Species F	11	40	11	27	11
Species G	0	61	18	21	0
All species	13	37	11	21	18

*Sample with cache of these seeds omitted

Seeds of the two *Bouteloua* species are significantly more abundant in the open areas than under shrubs (though the one specimen of *Opuntia fulgida* sampled harbored a large number), but for other seed species the tendency is in the opposite direction. In Table 17 are analyses of variance separately for *Bouteloua* and for other seed species.

Position under shrub canopy: As in Rock Valley, comparisons were made between the total seed population per unit area (combining all depths) at different distances from the center of a shrub canopy. The results will be found in Table 18. They were subjected to concordance tests, as shown in Table 19, series of three, four and five samples from the shrub center being combined for each species of seed where that species occurred somewhere in the series.

As at Rock Valley, these tests showed no significant agreement between the rankings for a given seed species under different canopies, and the exact test of trend was applied, combining different seed species under a given canopy species. The results are shown in Table 20.

Under *Ambrosia dumosa*, *Larrea divaricata*, and *Olneya tesota*, a significant trend was shown, but under *Cercidium microphyllum* there was none.

Table 16. Estimates of seed numbers per sq. dm under shrub species, Silverbell

Canopy Species	Open	*Ambros. dumosa*	*Larrea divar.*	*Cercid. microph.*	*Olneya tesota*	*Opunt. spino.*	*Cereus gigan.*	*Fouqueria splendens*	*Acacia constr.*	*Opuntia fulgida*
No. of canopy Individuals	4	3	4	3	3	1	1	1	1	1
No. of 1 sq. dm samples	4	8	14	15	14	3	3	4	3	3
Seed species										
Astragalus nuttalliana	1.2	2.4	1.4	1.5	0.7	3.7	0.5	3.9	2.1	8.5
Boerhaavia spp.	2.8	3.1	1.0	3.5	1.4	0	0	0	0	0
Bouteloua aristidoid.	250.5	46.0	20.1	2.7	1.1	1.1	34.1	0	2.1	215.0
B. barbata	96.8	36.7	21.0	5.4	1.3	1.6	1.1	2.4	5.7	17.8
Euphorbia chamaesyce	5.6	8.7	0	.8	2.7	1.1	3.2	1.2	8.3	661.1
E. hyssopifolia	0	0	7.8	0	0	0	0	0	0	23.5
Ferocactus sp. A	0.4	0.2	0.8	.4	5.0	19.9	1.6	0.8	3.2	0
Ferocactus sp. B	0	0	1.9	.2	74.6	0	0	4.8	0	2.7
Pectocarya sp.	2.8	7.3	4.9	5.2	6.5	4.3	1.1	0	1.6	6.9
Species C	1.6	0.6	1.7	1.7	2.3	2.7	3.7	1.5	1.6	6.4
Species D	4.0	1.6	4.2	7.4	4.7	21.9	16.0	0.8	3.2	14.4
Species E	2.4	0	1.9	15.3	22.8	0	0	0	0	8.0
Species F	0	0	0	0	5.1	0	0	0	0	0
Species G	0	0	0.5	0	0	0	0	0	0	36.8
Other species	0.8	38.9	1.0	1.8	2.6	0.4	5.9	5.0	25.8	67.3
Total, all species	368.8	145.5	68.2	42.9	130.8	56.7	67.2	19.6	53.6	1068.3

Table 17. Analysis of variance, total seed populations per sq. dm, under different canopies

Species	D.F.	S.S.	M.S.	F.
Bouteloua spp				
Bare ground vs. shrubs	1	334.30	334.30	7.30*
Treatments: Bare ground	1	126.67	126.67	
Treatments: Under shrubs	1	2.21	2.21	
Between different shrubs				
Untreated area	8	236.21	29.53	
Treated area	3	222.37	74.12	
Within same canopy type and treatment	7	320.63	45.80	
Other species				
Bare ground vs. shrubs	1	29.36	29.36	
Treatments: Bare ground	1	12.92	12.92	
Treatments: Under shrubs	1	5.00	5.00	
Between different shrubs				
Untreated area	8	417.80	52.23	3.25
Treated area	3	65.02	21.67	
Within same canopy type	7	112.41	16.06	

*P < 0.05

Table 18. Total seed population at different distances from the center of a shrub canopy, Silverbell

Canopy Species	0-10 cm		20-30 cm		40-50 cm		60-70 cm		80-90 cm	
	No. of Samples	Seeds per sq. dm	No. of Samples	Seeds per sq. dm	No. of Samples	Seeds per sq. dm	No. of Samples	Seeds per sq. dm	No. of Samples	Seeds per sq. dm
Cercidium microphyllum	3	45.57	3	35.53	3	52.35	3	34.13	3	47.24
Larrea divaricata	4	75.2	3	37.13	4	64.75	3	94.73	0	--
Ambrosia dumosa	3	151.87	3	88.53	2	52.00	0	--	0	--
Olneya tesota	3	177.8	3	145.4	3	112.93	3	140.93	2	49.9
Opuntia spinosior	1	68.8	1	75.6	1	25.6	1	0	0	--
Cereus giganteus	1	76.8	1	46.4	1	78.4	1	0	0	--
Fouqueria splendens	1	19.2	1	11.2	1	20.8	1	27.2	0	--
Acacia constricta	1	40.4	1	61.6	1	52.8	1	0	0	--
Opuntia fulgida	1	251.6	1	163.2	1	2764.8	1	0	0	--

Table 19. Tests of concordance: Rankings of seed populations at different distances from the center of a shrub canopy, Silverbell

Species	No. of canopy Individuals	No. of samples Per canopy	W
Astragalus nuttalliana	5	5	.218
Boerhaavia sp.	3	5	.305
Bouteloua aristidoides	5	5	.107
Bouteloua barbata	3	5	.281
Euphorbia chamaesyce	2	5	.338
Ferocactus sp. A	2	5	.417
Ferocactus sp. B	2	5	.321
Pectocarya sp.	5	5	.210
Species C	5	5	.293
Species D	4	5	.153
Species E	3	5	.544
Astragalus nuttalliana	7	4	.125.
Boerhaavia sp.	5	4	.021
Bouteloua aristidoides	6	4	.297
Bouteloua barbata	4	4	.172
Euphorbia chamaesyce	5	4	.091
Ferocactus sp. A	4	4	.083
Ferocactus sp. B	4	4	.017
Pectocarya sp.	7	4	.214
Species C	8	4	.246
Species D	5	4	.078
Species E	3	4	.573
Astragalus nuttalliana	12	3	.002
Boerhaavia sp.	5	3	.031
Bouteloua aristidoides	10	3	.085
Bouteloua barbata	8	3	.014
Euphorbia chamaesyce	10	3	.009
Ferocactus sp. A	7	3	.354
Ferocactus sp. B	3	3	.636
Pectocarya sp.	12	3	.022
Species C	12	3	.292
Species D	8	3	.094
Species E	4	3	.250

Total seed populations on the Silverbell site: Again, as with Rock Valley, estimates of areas of different annuli under shrub canopies, and areas between shrub canopies, would be needed for combining with estimates of the seed populations in these categories of area to obtain accurate estimates of the seed population of the site as a whole, in view of the fact that the population densities often decrease from the center of a shrub outwards. Data for numbers of shrubs of different sizes were not available at the time of writing, so use was made of data for shrub cover included in the 1972 Progress Report for the Silverbell Validation Site (Thames, 1972). Seed weights are given in Table 21. Table 22 estimates the reserves of seeds in the untreated area as a whole at 33,091 m^{-2}, weighing 8.1311 g.

Table 20. Effect of position under a shrub canopy on seed density, Silverbell

Shrub Species	Number of Canopy Individuals	Number of 1 sq. dm Samples	Number of Rankings	Significance*
Ambrosia dumosa	3	8	9	.005
Cercidium microphyllum	3	15	24	.50
Larrea divaricata	4	14	29	.025
Olneya tesota	3	14	26	.004

*Probability of observed rankings on the null hypothesis, against the alternative hypothesis of a trend from the center outwards.

Table 21. Mean weight of individual seeds, Silverbell DSCODE A3UGE41

Species	Seed Weight (mg)	Species	Seed Weight (mg)
Amsinckia tesselata	1.99	*Thelypodium lasiophyllum*	0.10
Astragalus nuttalliana	1.20	Species C	1.50
Boerhaavia spp.	0.60	Species D	1.33
Bouteloua aristidoides	0.24	Species E	0.11
B. barbata	0.12	Species F	0.40
B. spp.	0.80	Species G	0.93
Cryptantha spp. 1	0.18	Species H	0.10
C. spp.2	0.07	Species I	0.10
Eriochloa spp.	1.90	Species J	0.40
Euphorbia chamaesyce	0.12	Species K	0.40
E. hyssopifolia	2.28	Species L	0.65
Ferocactus spp. 1=species A	0.46	Species M	0.40
Ferocactus spp. 2=species B	1.26	Species N	1.83
Franseria spp.	1.70	Species O	0.30
Larrea divaricata	6.63	Species P	0.10
Lepidium medium	0.10	Species Q	14.10
Pectocarya spp.	0.41	Species R	1.10
Phacelia spp.	0.50	Species S	1.00
Plantago insularis	1.27	Species T	1.40
Sphaeralcea spp.	0.50	Species U	1.10
Stephanomeria spp.	0.31		

Table 22. Seed reserves at Silverbell

Species	Per sq. m Population	Biomass (mg)
Astragalus nuttalliana	130	157
Boerhaavia sp.	268	161
Bouteloua aristidoides	21,805	5,233
B. barbata	8,583	1,030
Euphorbia chamaesyce	521	63
E. hyssopifolia	21	48
Ferocactus sp. A	88	40
Ferocactus sp. B	213	268
Pectocarya sp.	311	127
Species C	167	250
Species D	422	562
Species E	325	36
Species F	14	6
Species G	23	21
Other Species	206	309*
Total	33,097	8,311

*For this figure a mean seed weight of 1.50 mg was used, derived by weighting the figures in Table 12 for the different species with their relative overall abundance.

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