1973

Curlew Valley Validation Site Report

David F. Balph

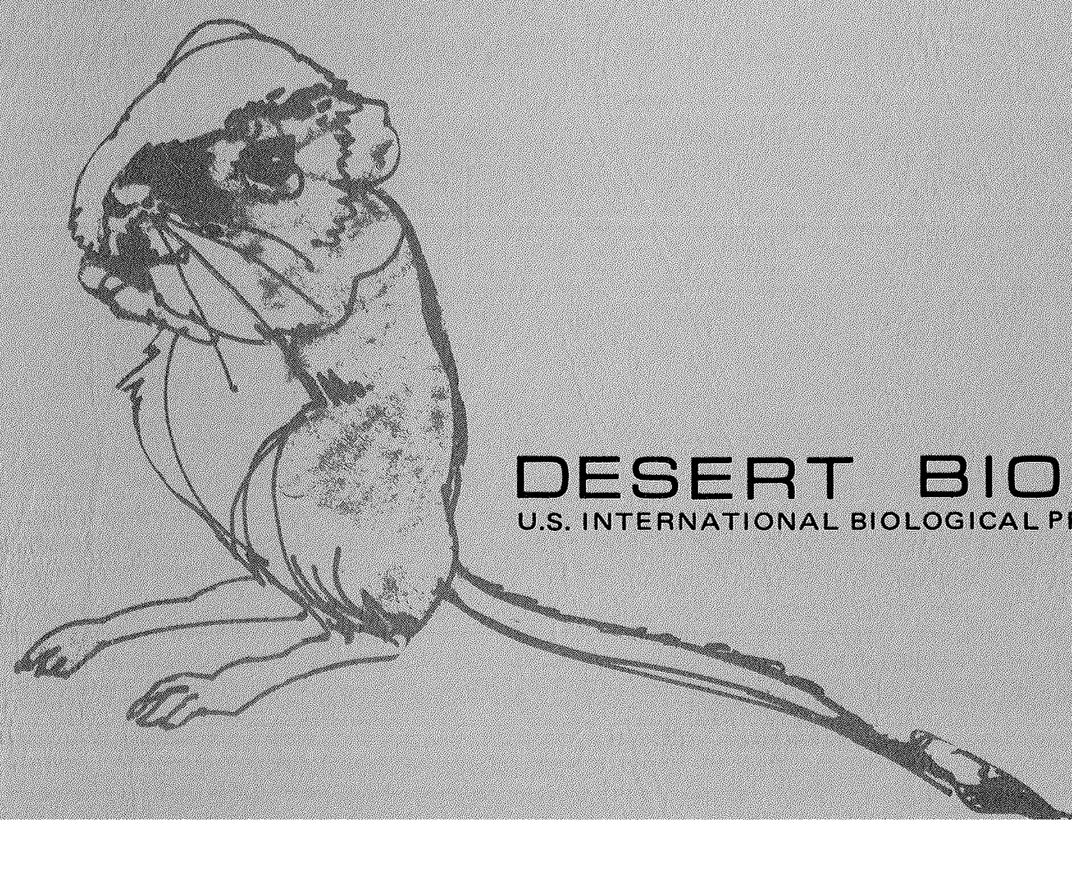
IBP

RESEARCH MEMORANDUM

RM 73-1

CURLEW VALLEY VALIDATION SITE REPORT

Coordinator: David F. Balph



DESERT BIOME

U.S. INTERNATIONAL BIOLOGICAL PROGRAM

1972 PROGRESS REPORT

CURLEW VALLEY VALIDATION SITE REPORT

Coordinator: David F. Balph

Utah State University
Logan, Utah

Research Memorandum 73-1

MAY 1973

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Report Volume 2

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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/ha 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.

ACKNOWLEDGEMENTS

Special acknowledgement is due Robert D. Anderson and Randall S. Shinn who were involved in much of the sampling design, data collection, data analysis, and report preparation for the Curlew Valley validation program. Those who contributed to various sections of this report are as follows:

Abiotic:	R.D. Anderson, J. Hanks, W. Ondrechon, P. Rassmussen, and R. Shinn;
Plants:	G. Adamson, R.D. Anderson, K. Holte, R. Lynn, R. Olson, L. Pearson, M. Perlmutter, R. Shinn, and N. Unhanand;
Invertebrates:	A. Allen, R.C. Anderson, R.D. Anderson, R. Beach, S. Condie, V. Davis, R. Howard, T. Hsiao, G. Knowlton, W. Maibauer, R. Schnell, R. Schwartz, R. Shinn, and G. Tourtlotte;
Vertebrates:	C. Anderson, R.D. Anderson, J. Malechek, R. Olsen, L. Powers, R. Shinn, V. Shinn, B. Smith, L. Stoddart, and C. Trost;
Soils:	S. Cotter, M. Perlmutter, R. Shinn, V. Shinn, A. Southard, J. Skujins, N. Unhanand, G. Utter, and L Wilson;
Data Processing:	K. Marshall, E. Matthews, A. Olsen, and C. Romesburg.

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 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
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	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
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	72	73	North grass 71	72	73	South shrub 71	72	73	South grass 71	72	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	A3UBJX5,6									x			x	--
	(Emergence Traps)														
	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	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
Vertebrates	Number		x	x		x	x		x	x	x	x	x	x	
Birds (Cont.)	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	Biomass - on site	A3UBJH1-4	x	x		x	x		x	x	x	x	x	x	237
Rodents	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	A3UBJ02	x			x			x			x			
	Percent Ground Cover		x			x			x			x			288
	Species Inventory		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
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

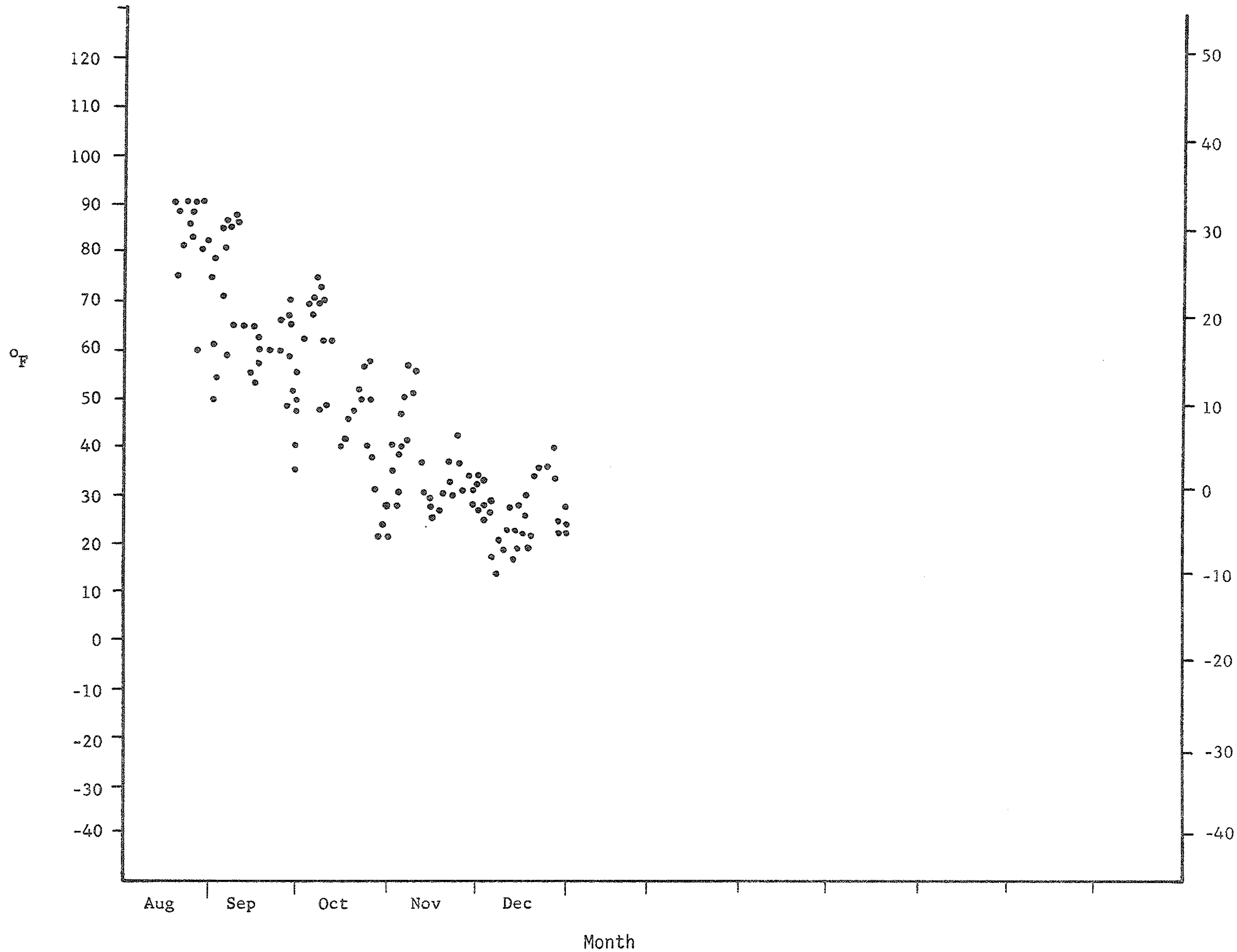

Figure 1. Daily maximum air temperature on northern sites, 1971.

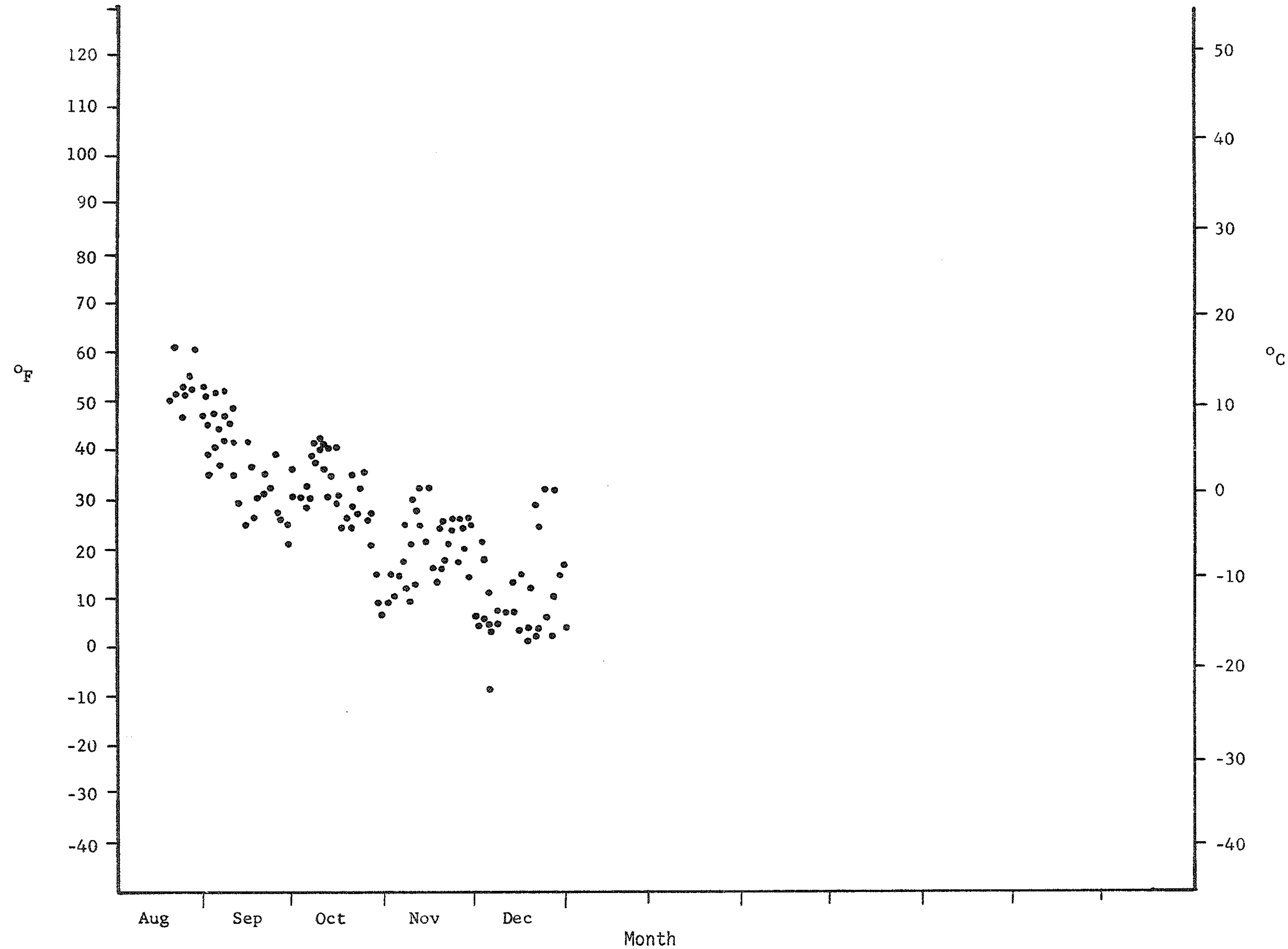

Figure 2. Daily minimum air temperature on northern sites, 1971.

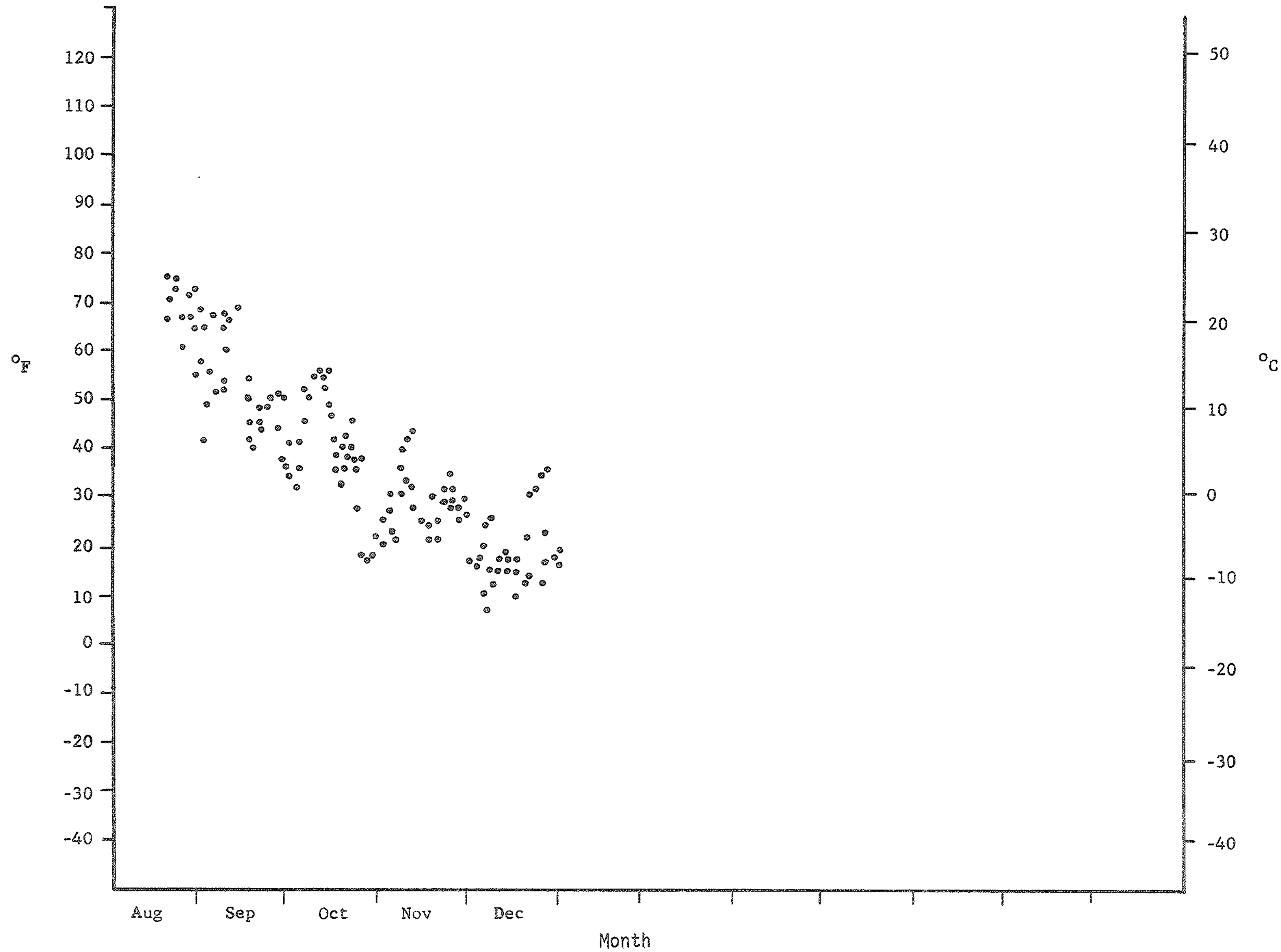

Figure 3. Daily mean air temperature on northern sites, 1971.

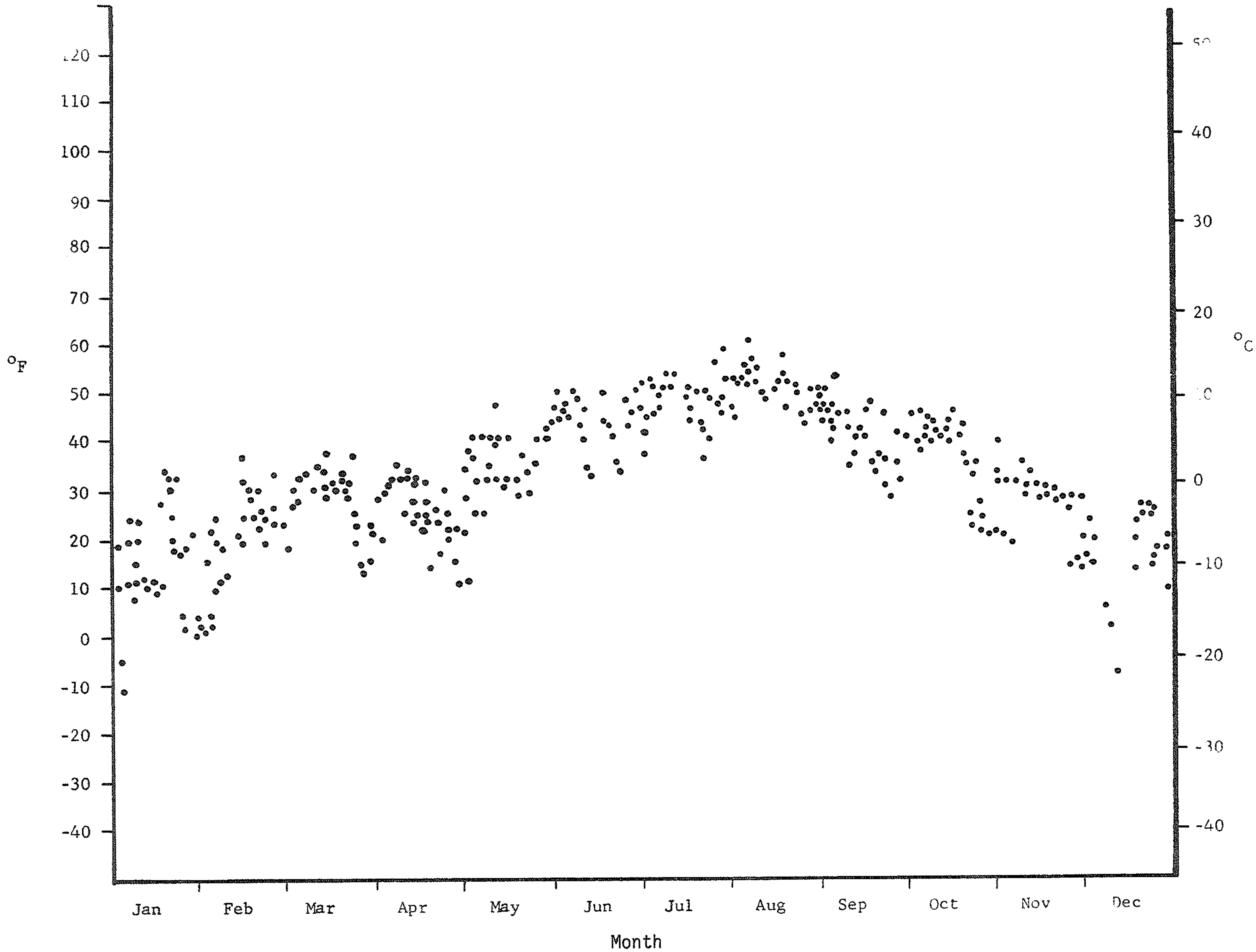

Figure 5. Daily minimum air temperature on northern sites, 1972.

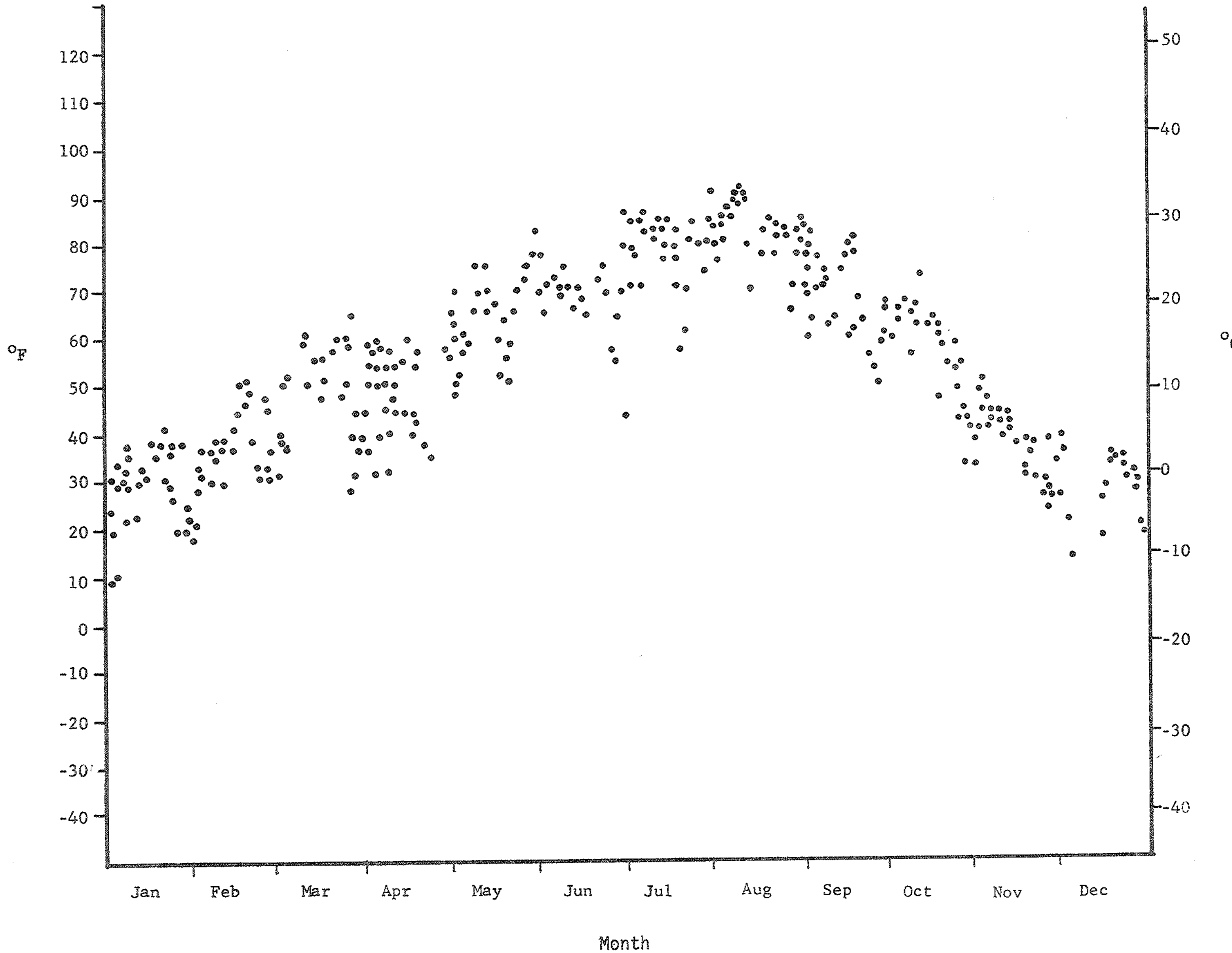

Figure 4. Daily maximum air temperature on northern sites, 1972.

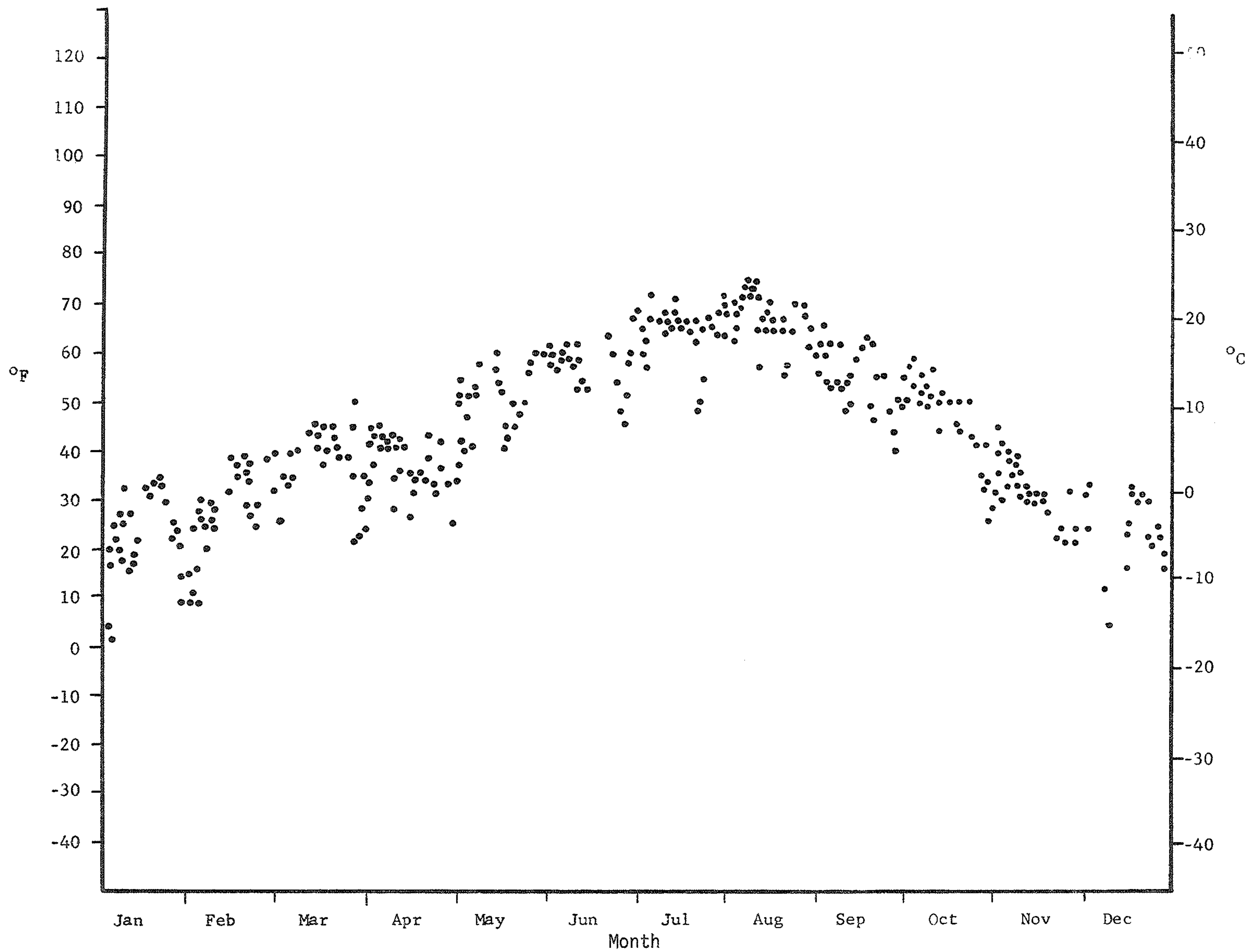

Figure 6. Daily mean air temperature on northern sites, 1971.

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

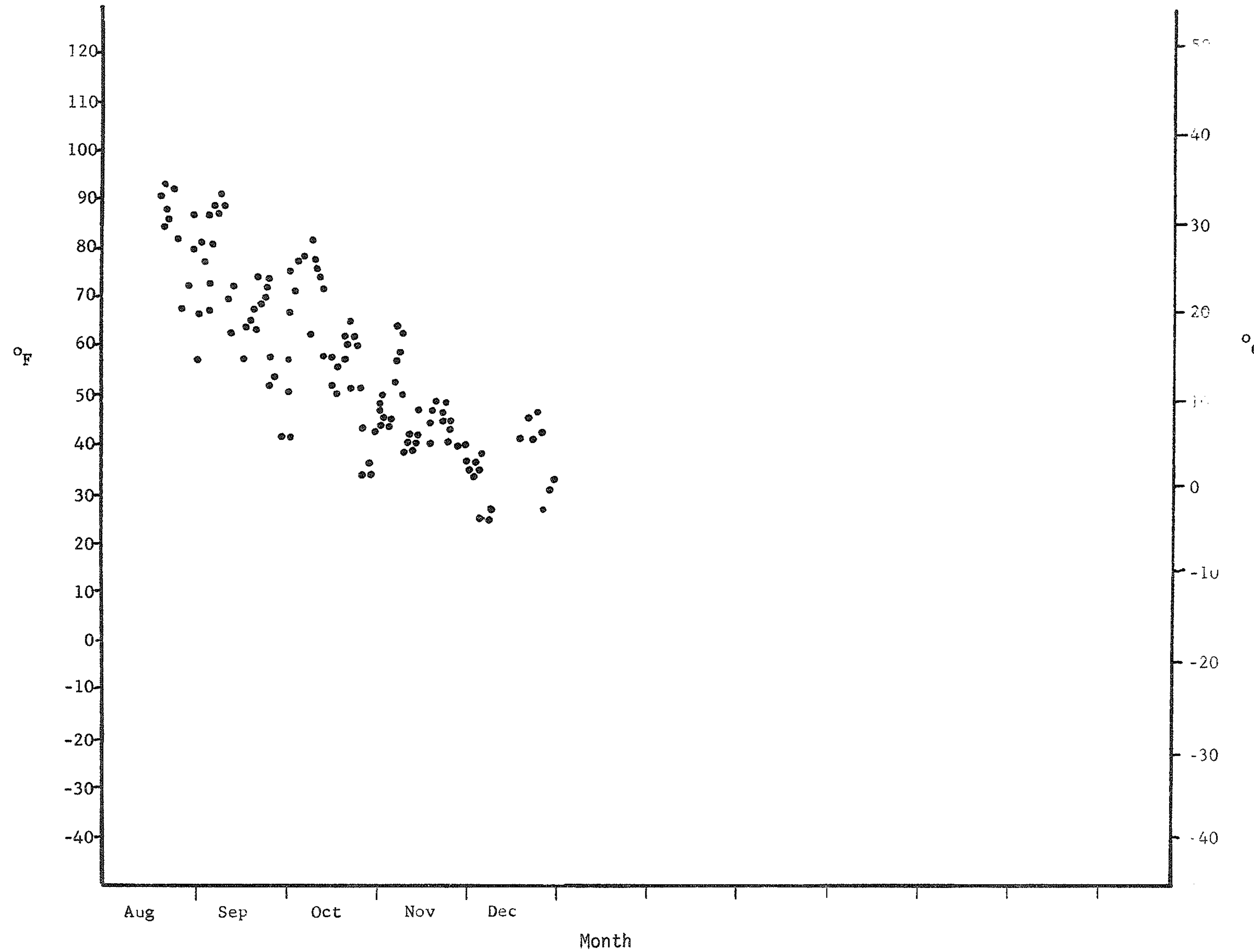

Figure 7. Daily maximum air temperature on southern sites, 1971.

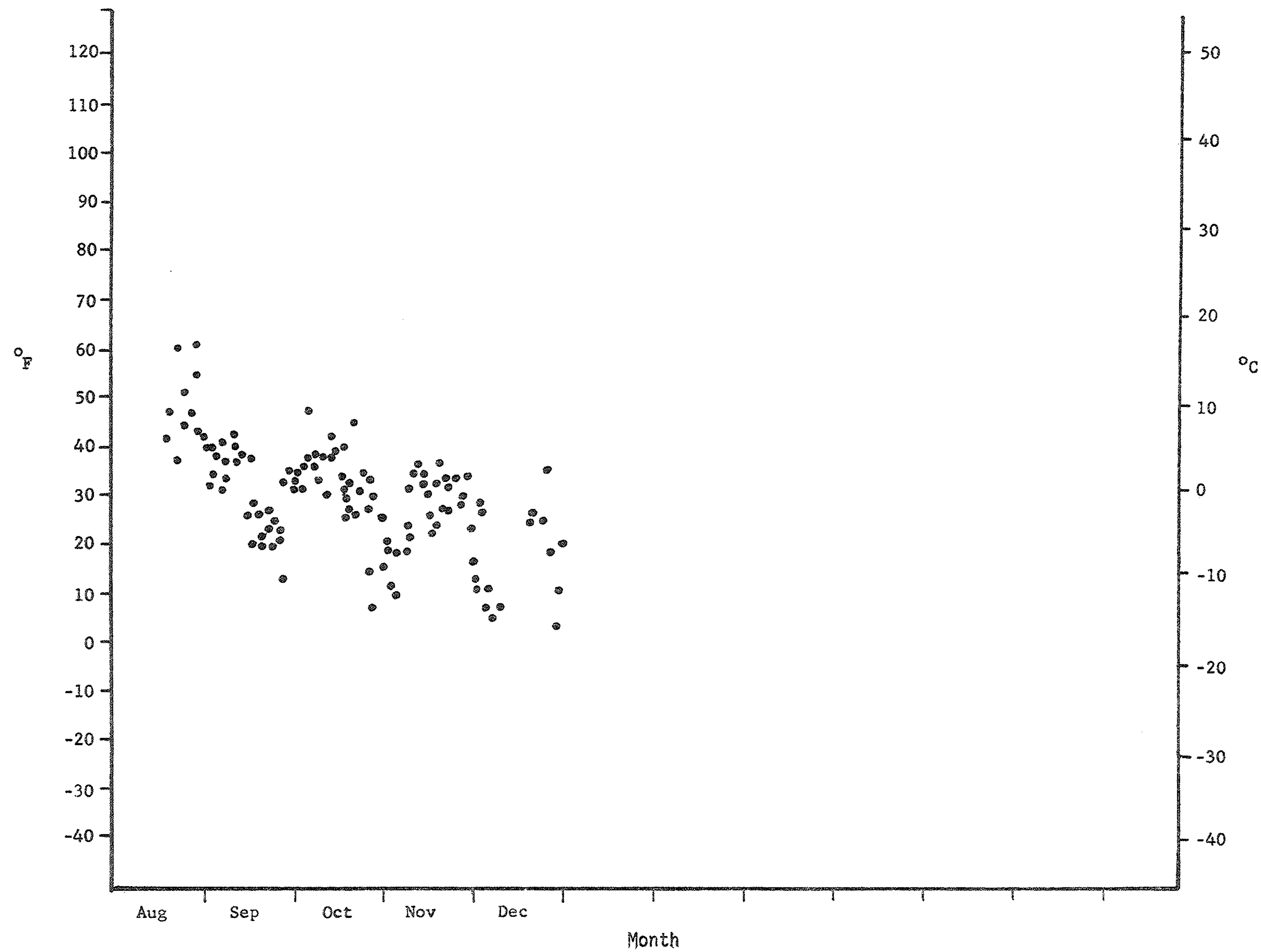

Figure 8. Daily minimum air temperatures on southern sites, 1971.

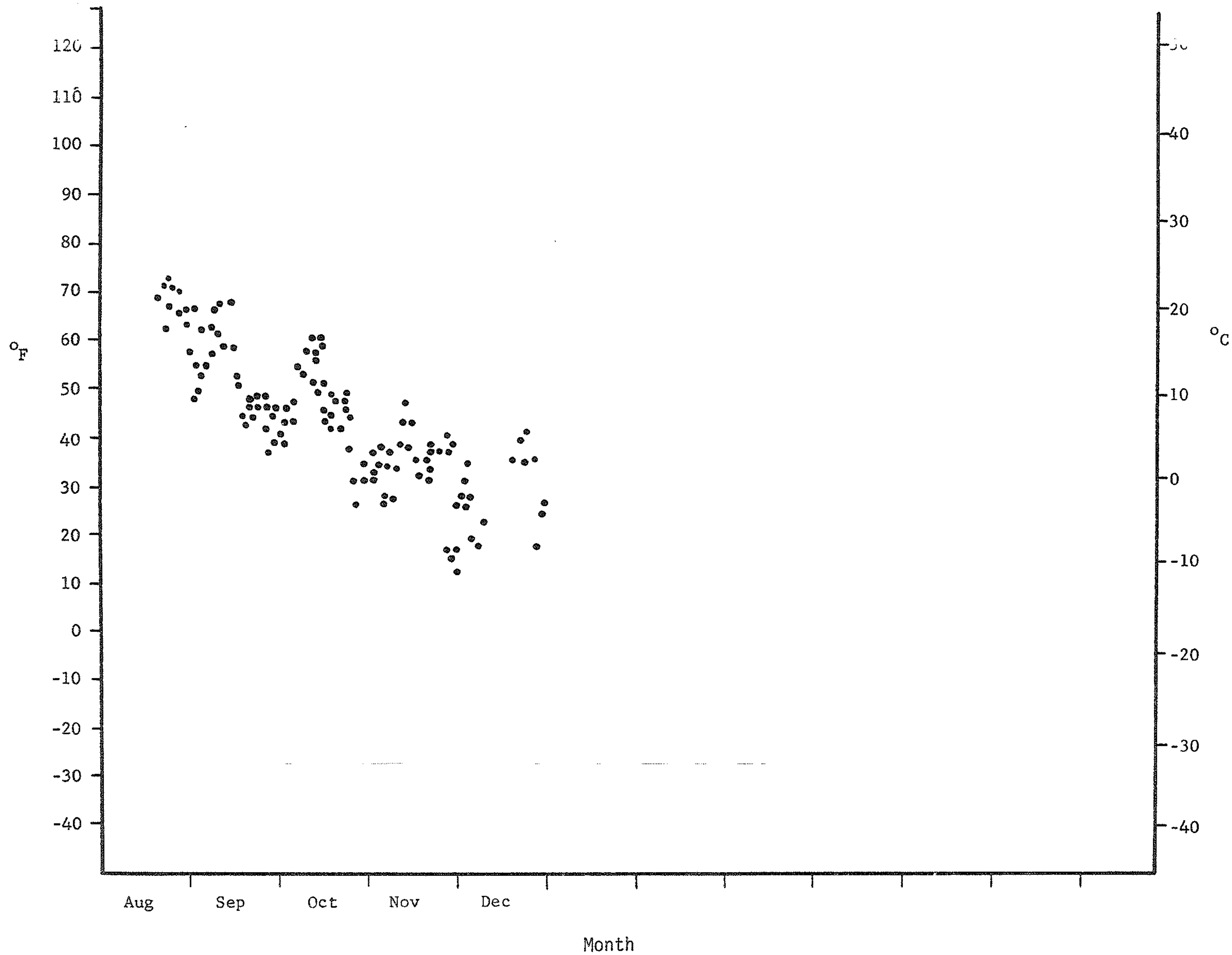

Figure 9. Daily mean air temperature on southern sites, 1971.

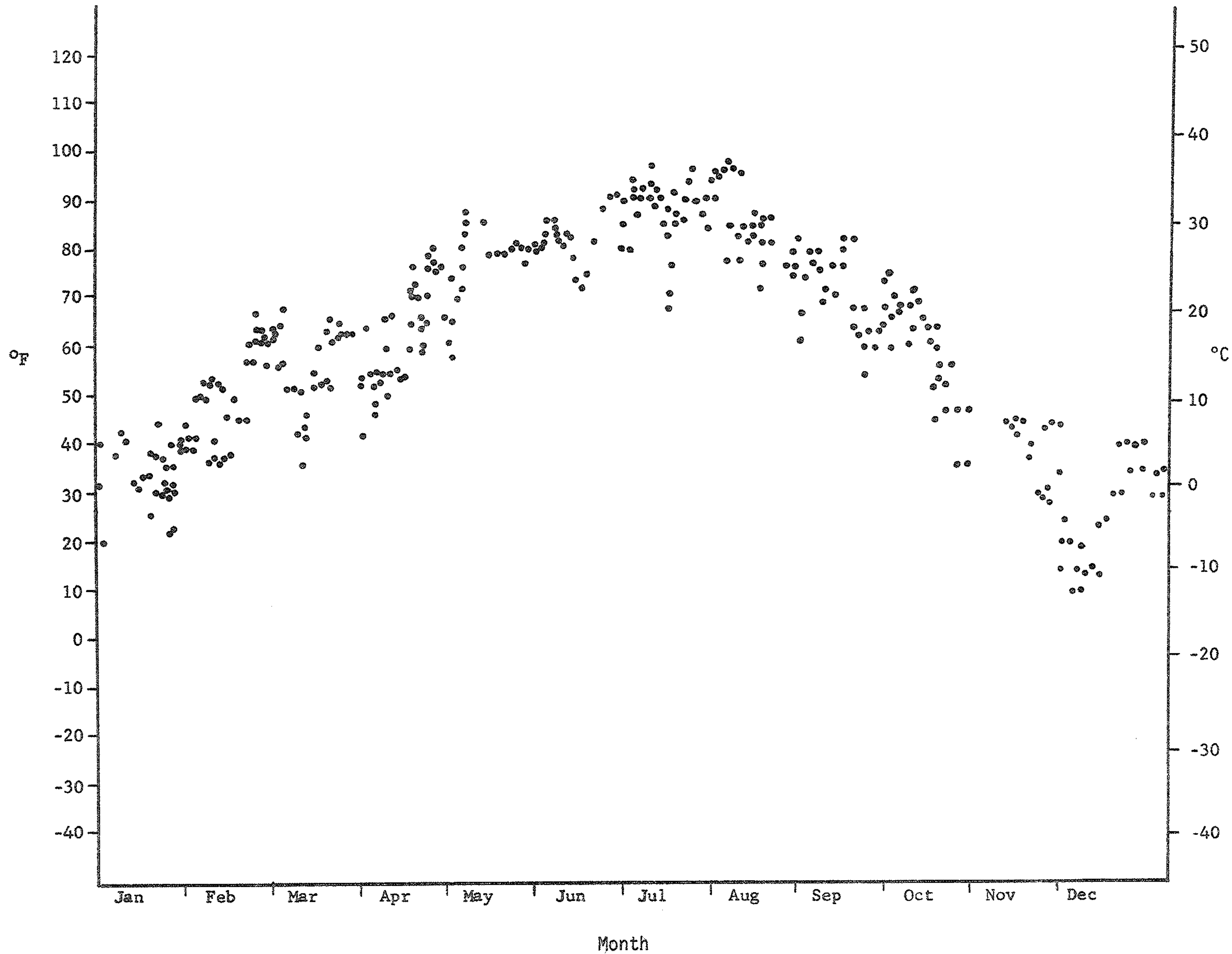

Figure 10. Daily maximum air temperature on southern sites, 1972.

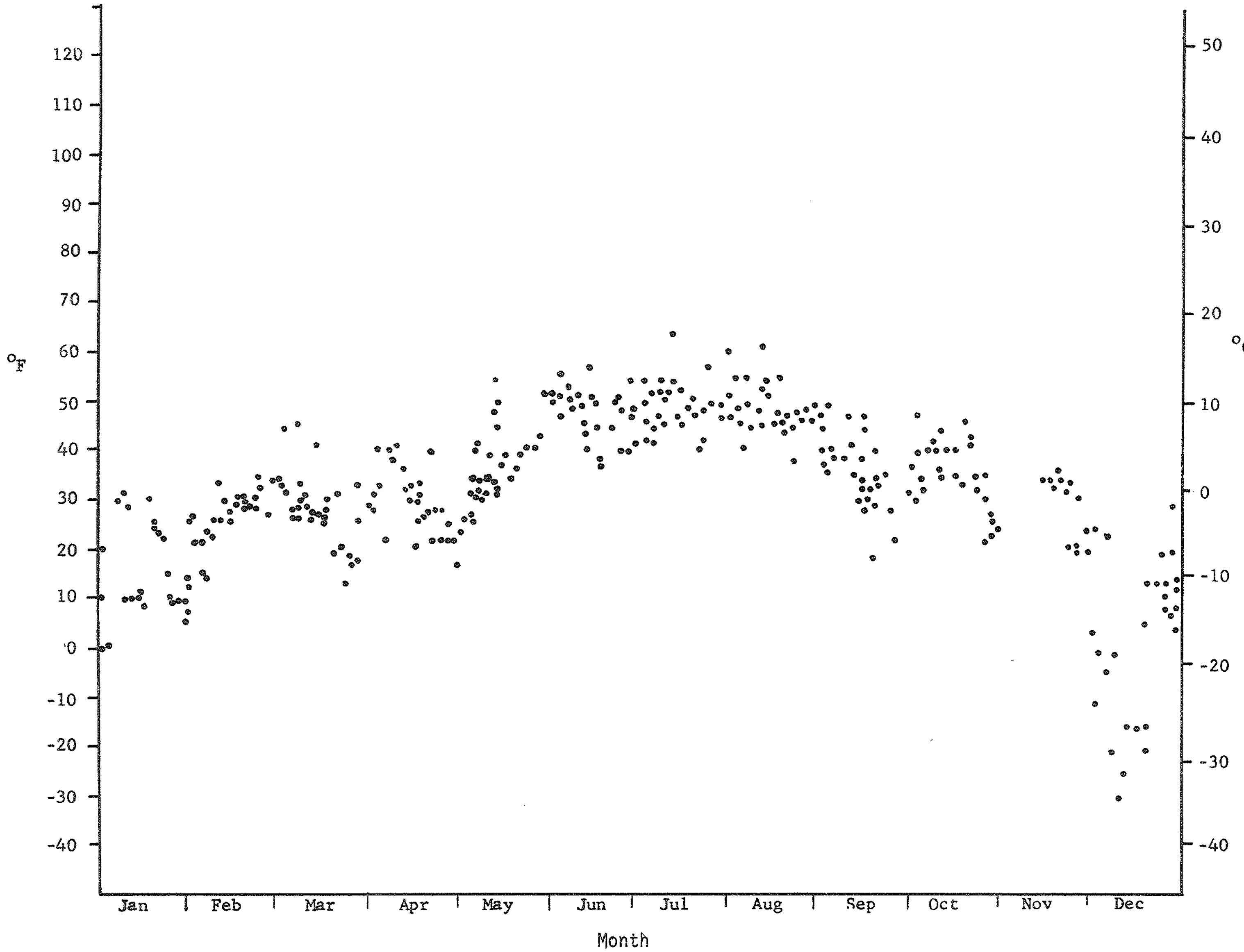

Figure 11. Daily minimum air temperature on southern sites, 1972.

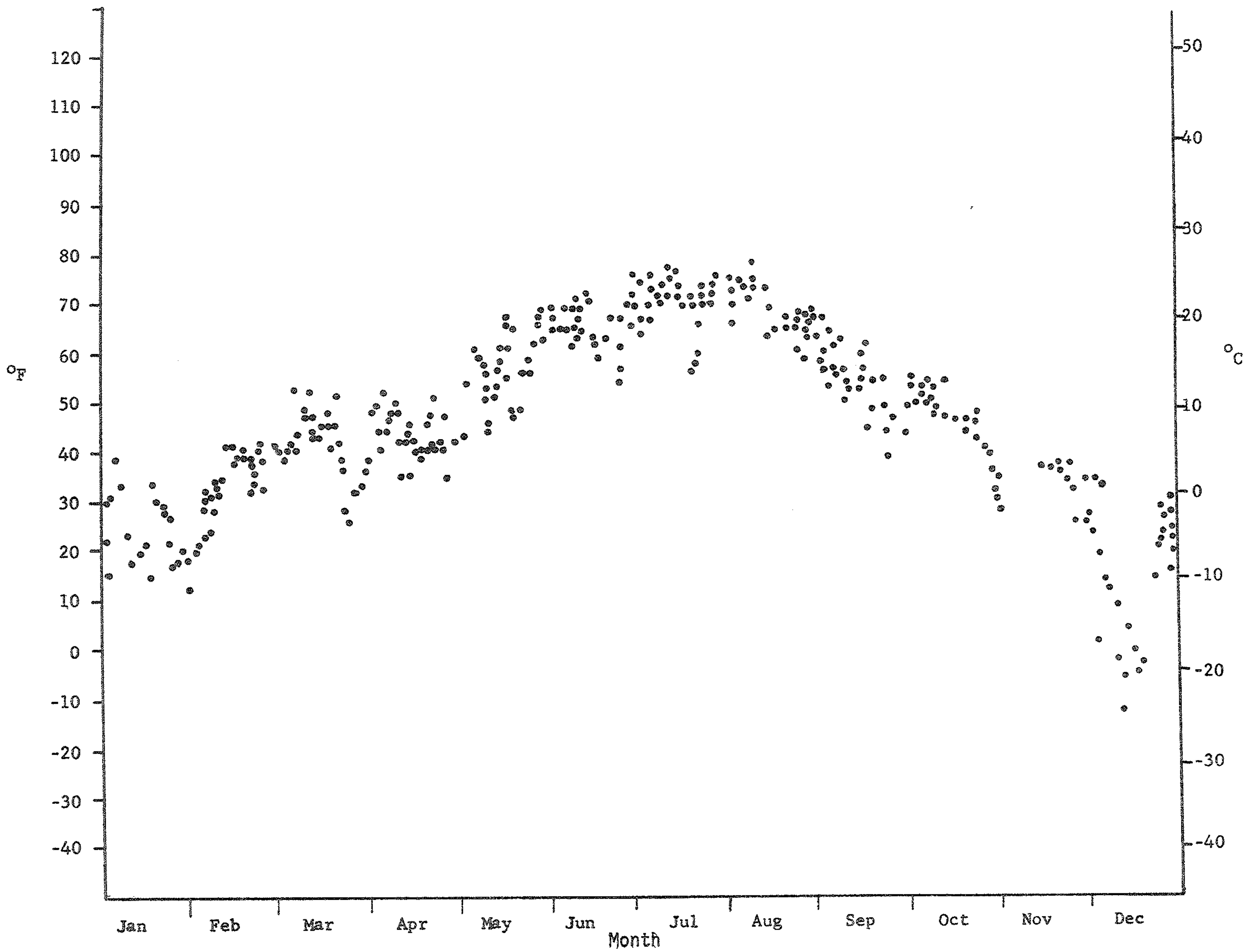

Figure 12. Daily mean air temperature on southern sites, 1972.

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.

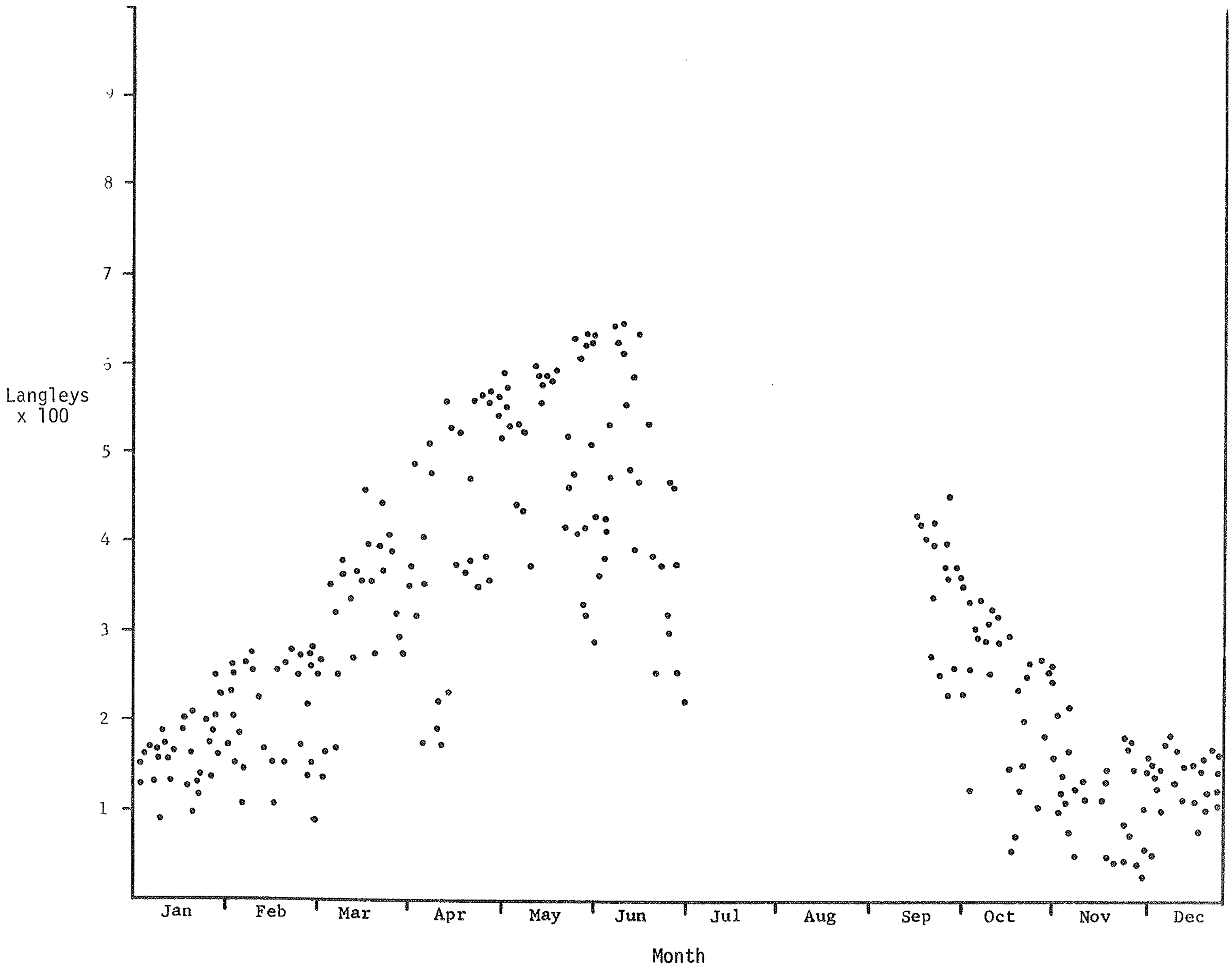

Figure 13. Solar radiation at Snowville, Utah, 1972.

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

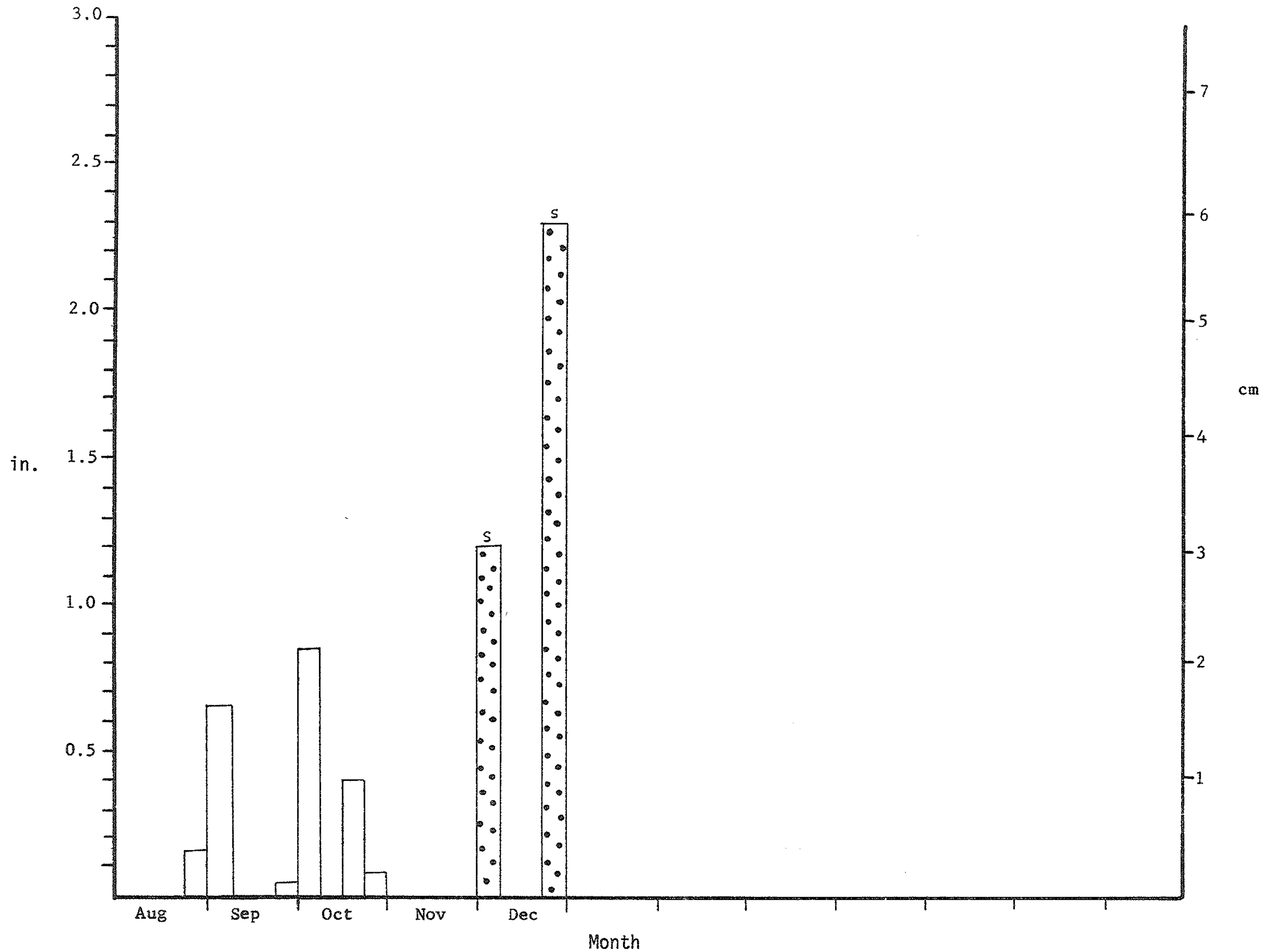

Figure 14. Weekly precipitation on southern sites, 1972.

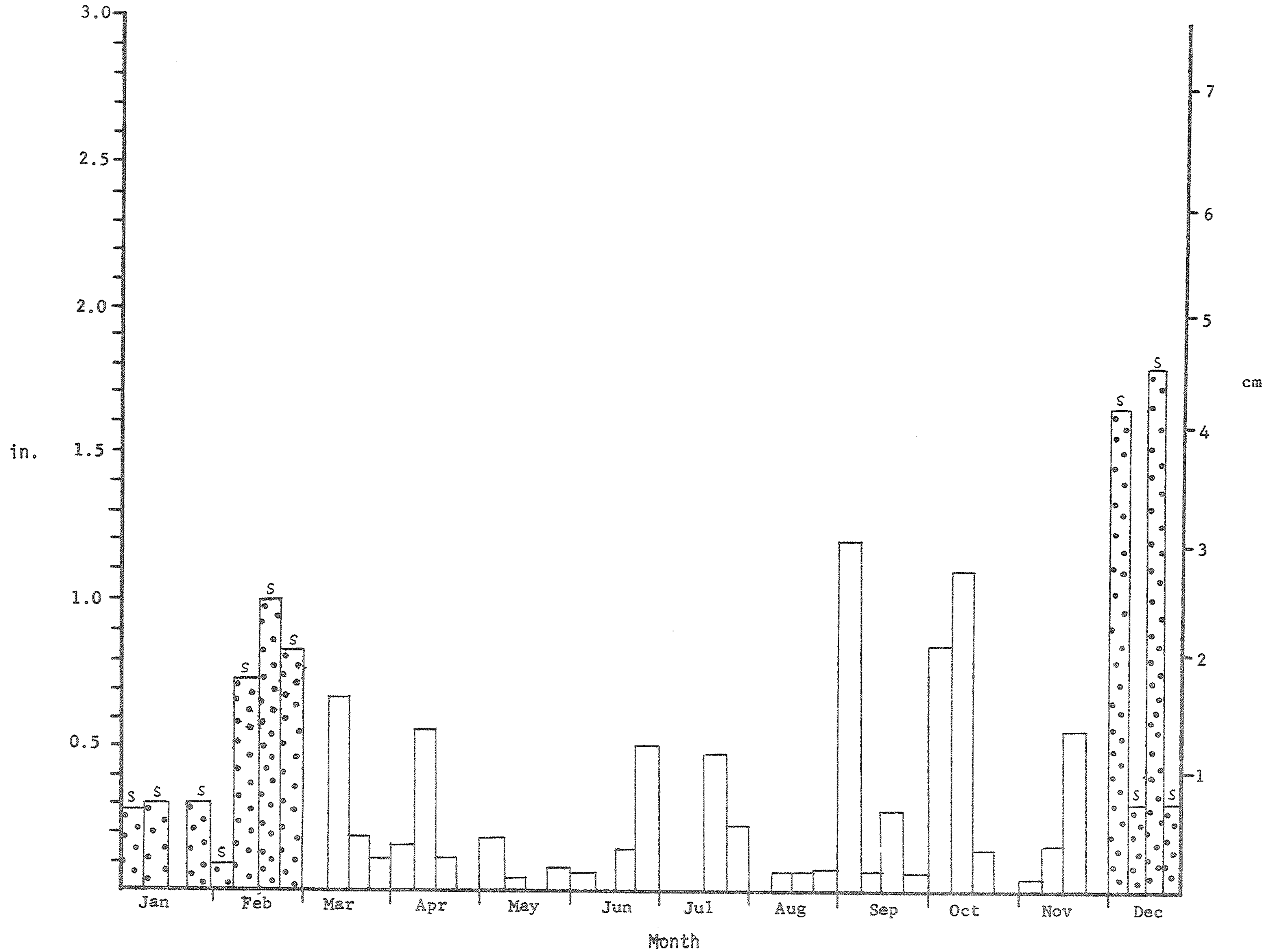

Figure 15. Weekly precipitation on northern sites, 1972.

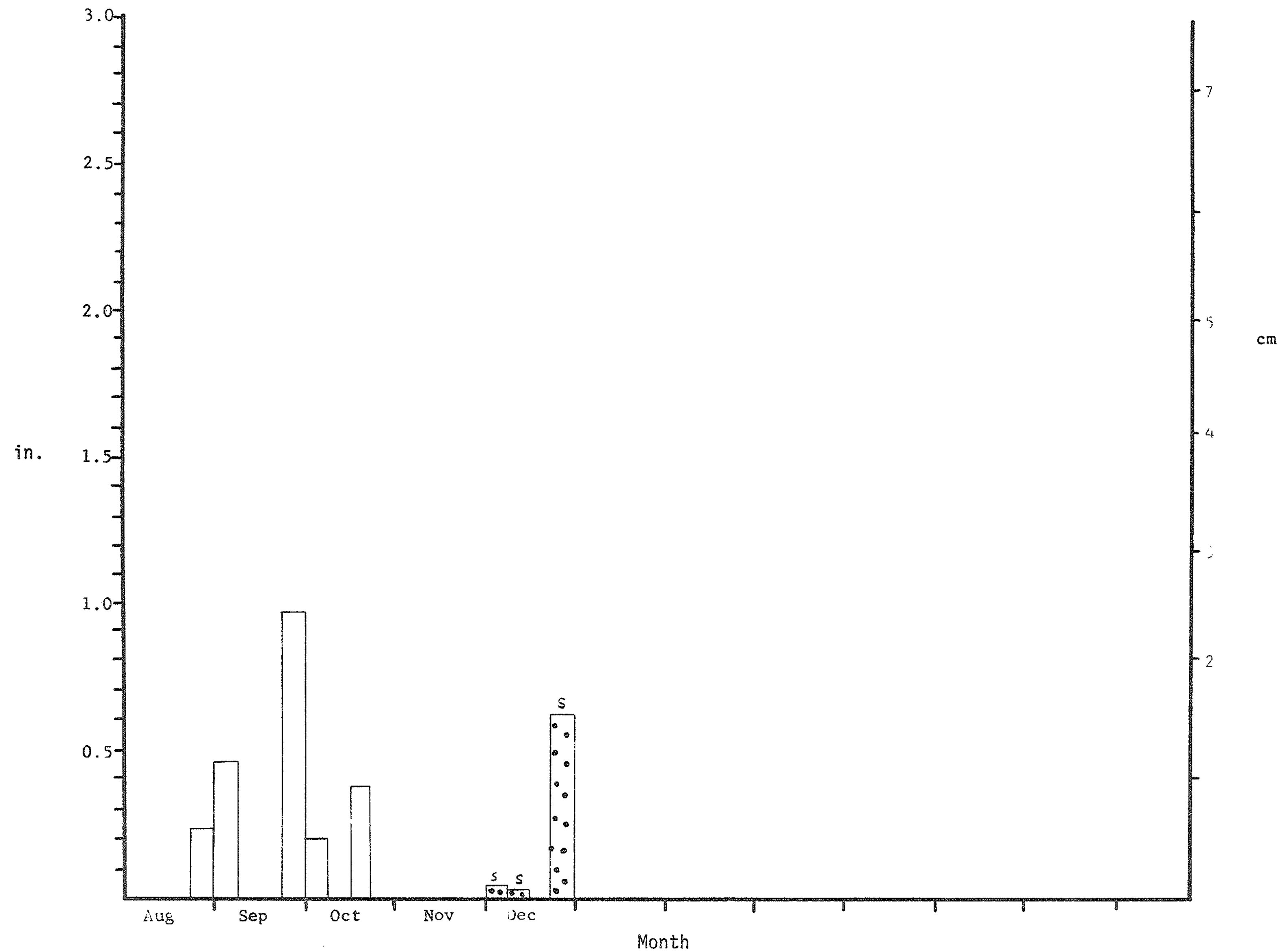

Figure 16. Weekly precipitation on southern sites, 1971.

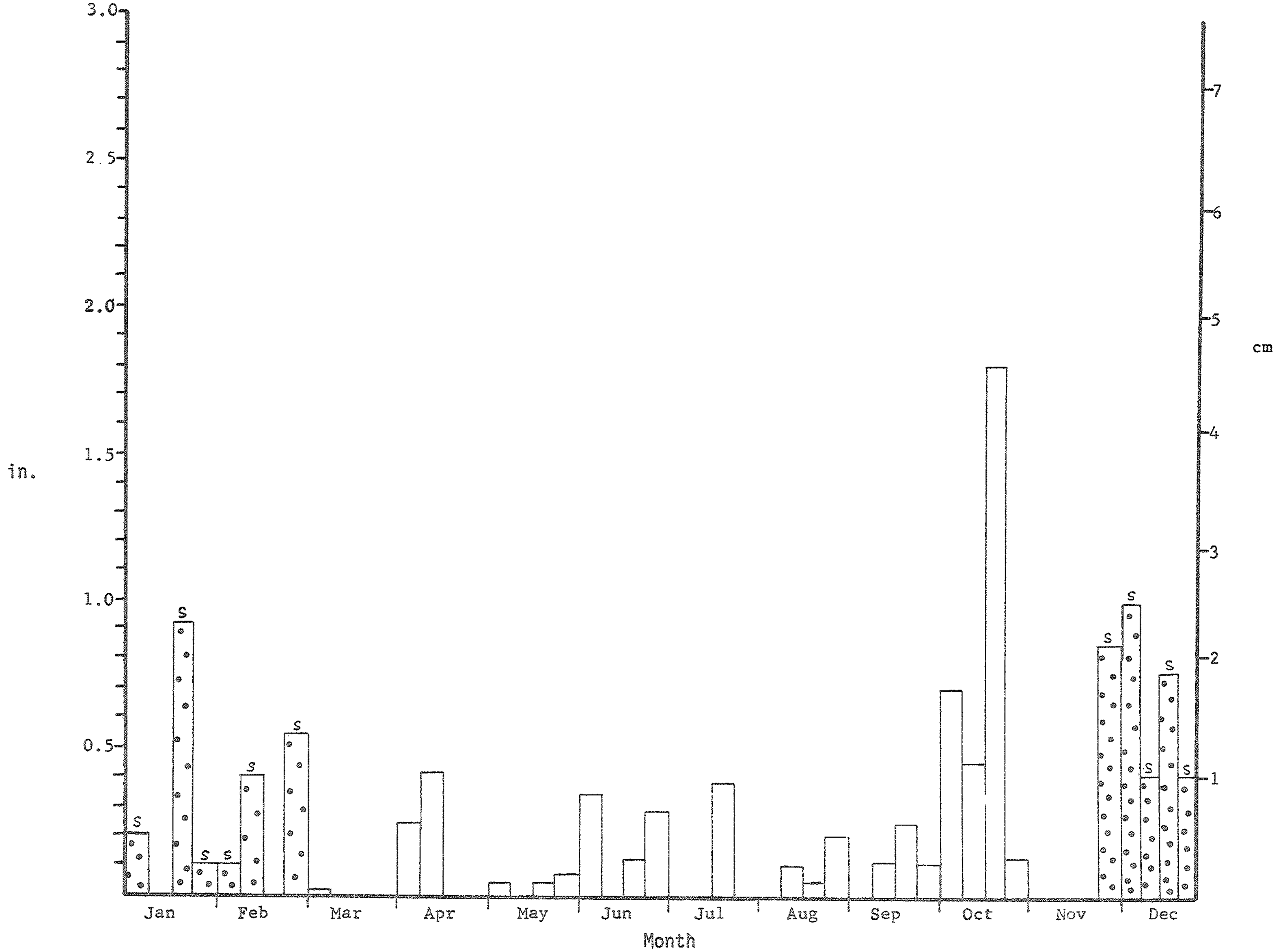

Figure 17. Weekly precipitation on southern sites, 1972.

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.

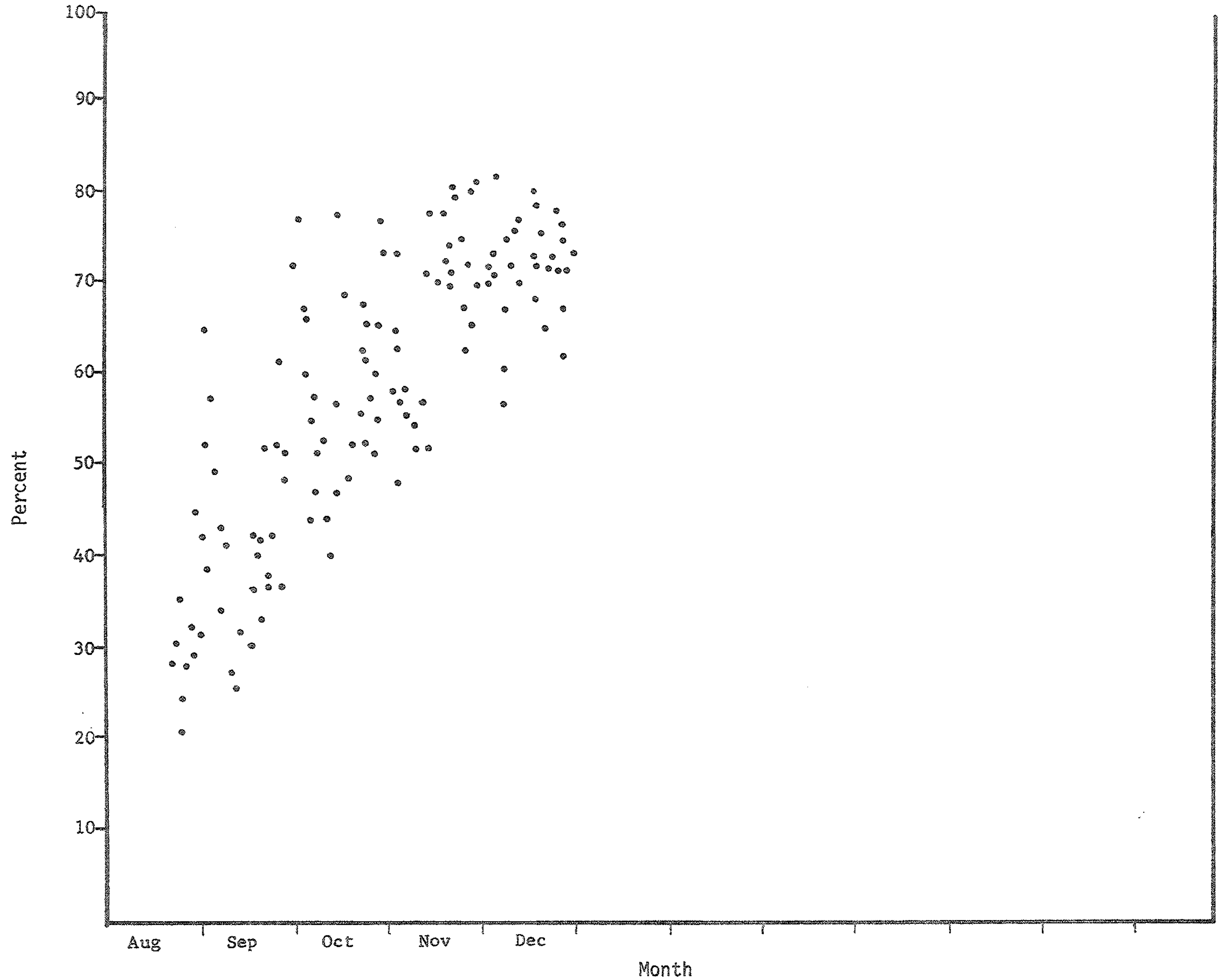

Figure 18. Daily mean relative humidity on northern sites, 1971.

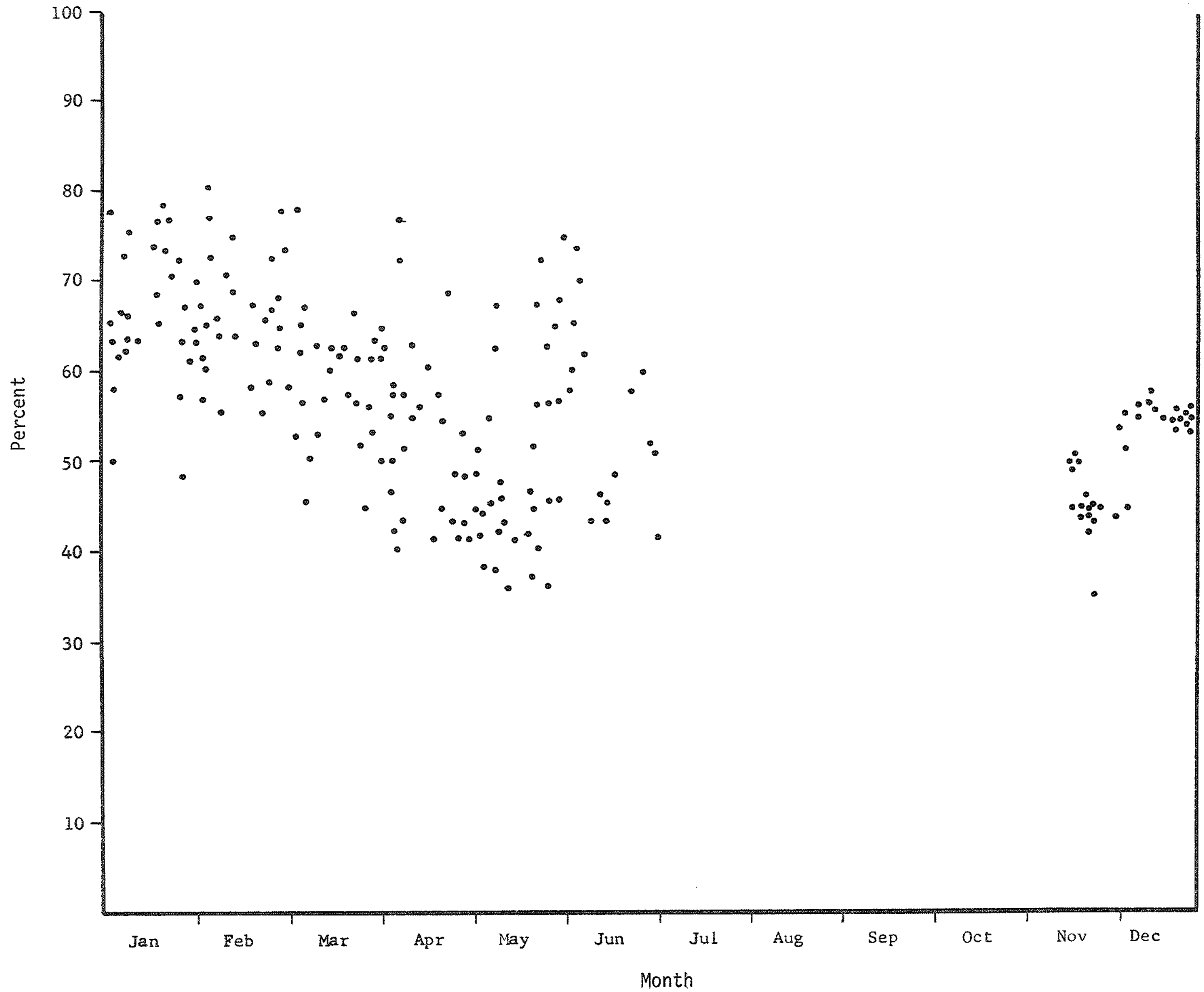

Figure 19. Daily mean relative humidity on northern sites, 1972.

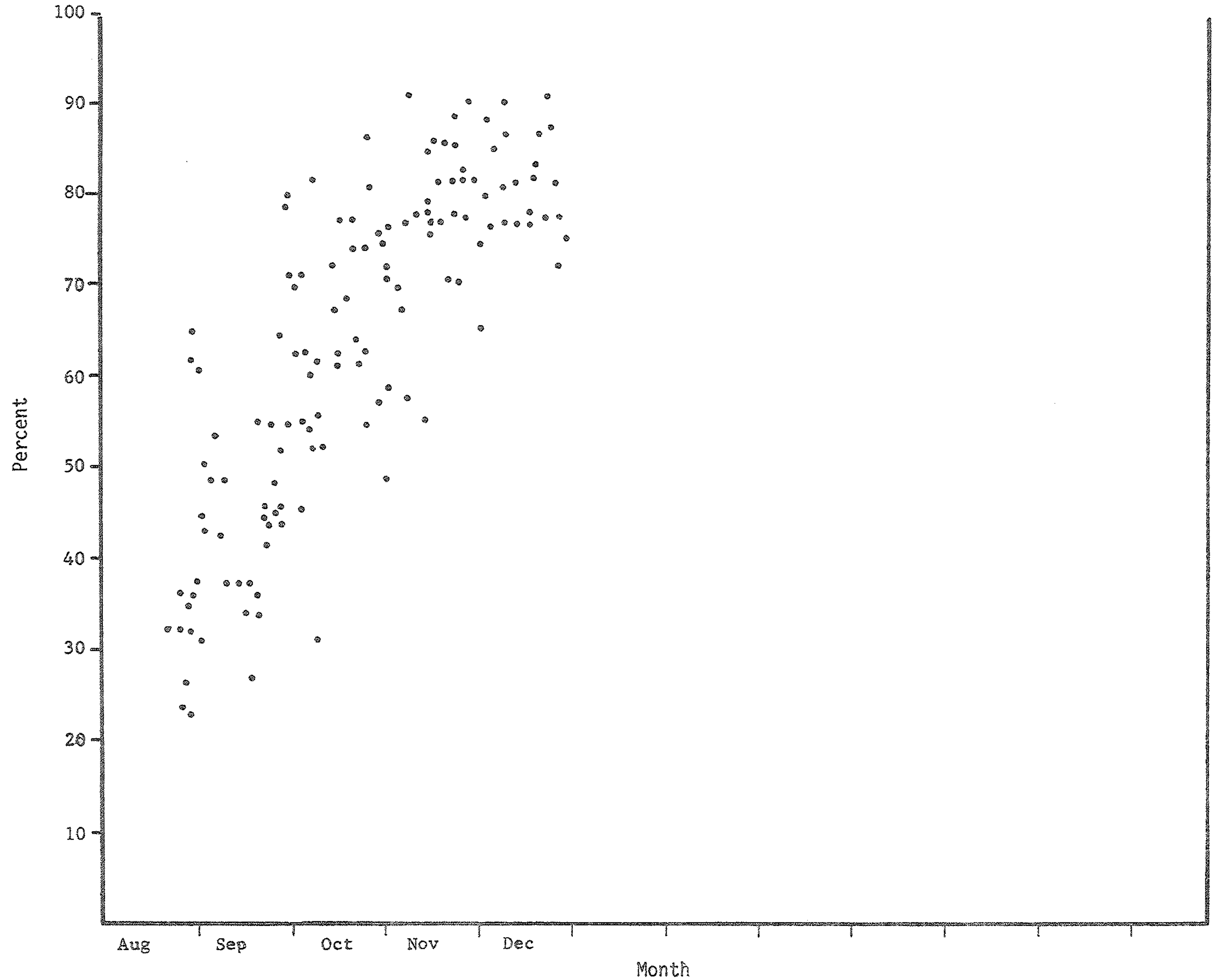

Figure 20. Daily mean relative humdiity on southern sites, 1971.

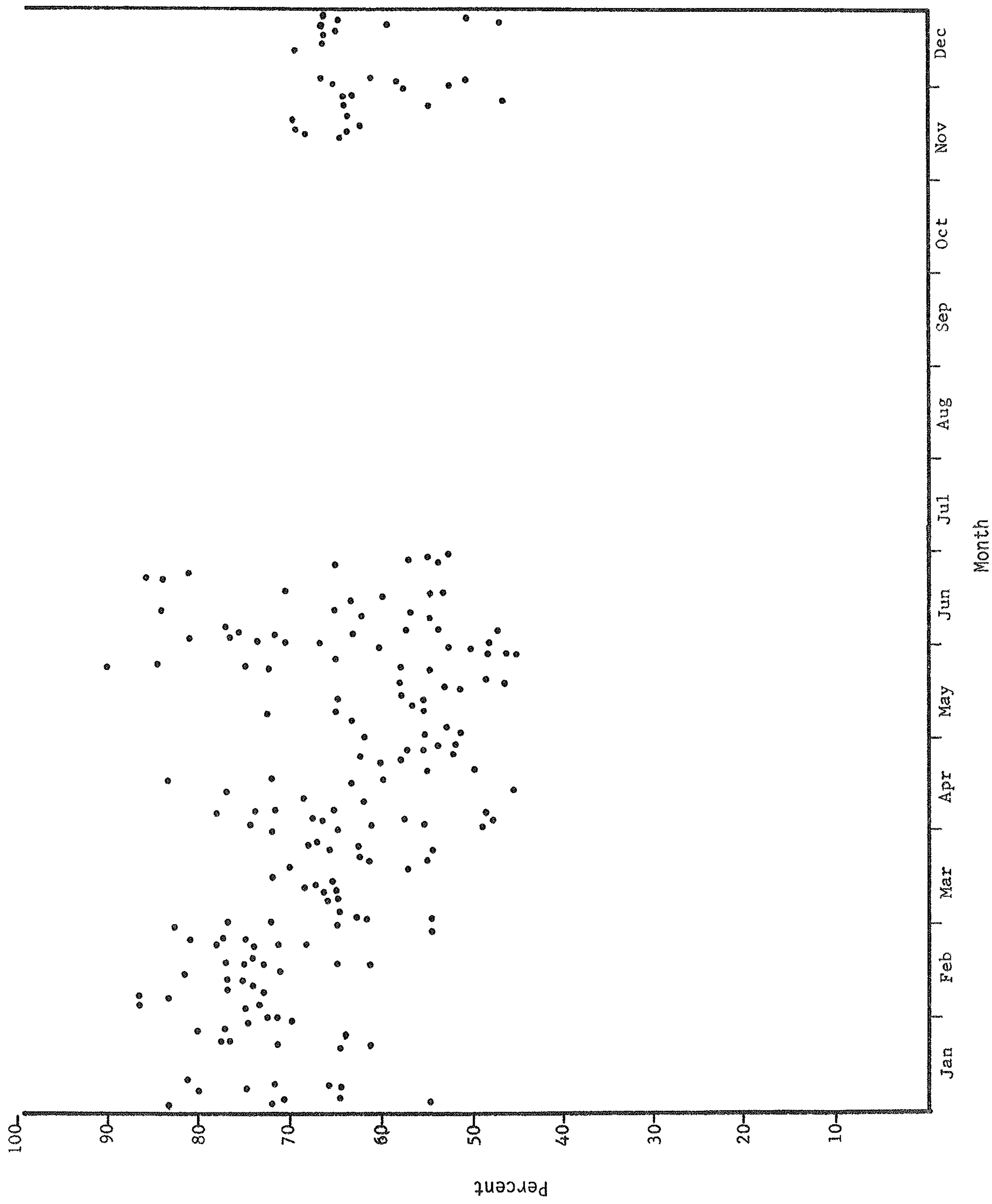

Figure 21. Daily mean relative humidity on southern sites, 1972.

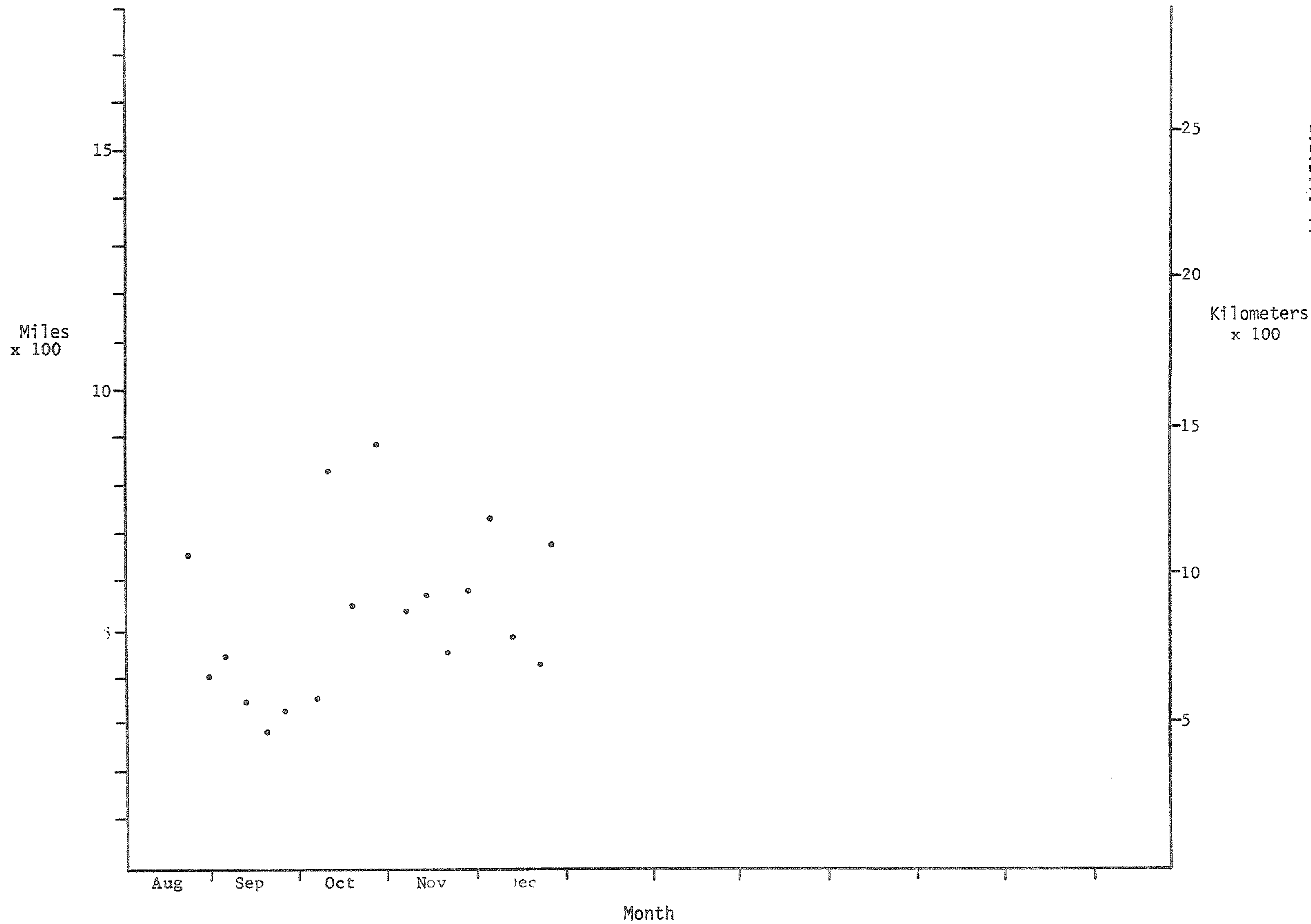

Figure 22. Mean weekly wind velocity (at 2 m) on northern sites, 1971.

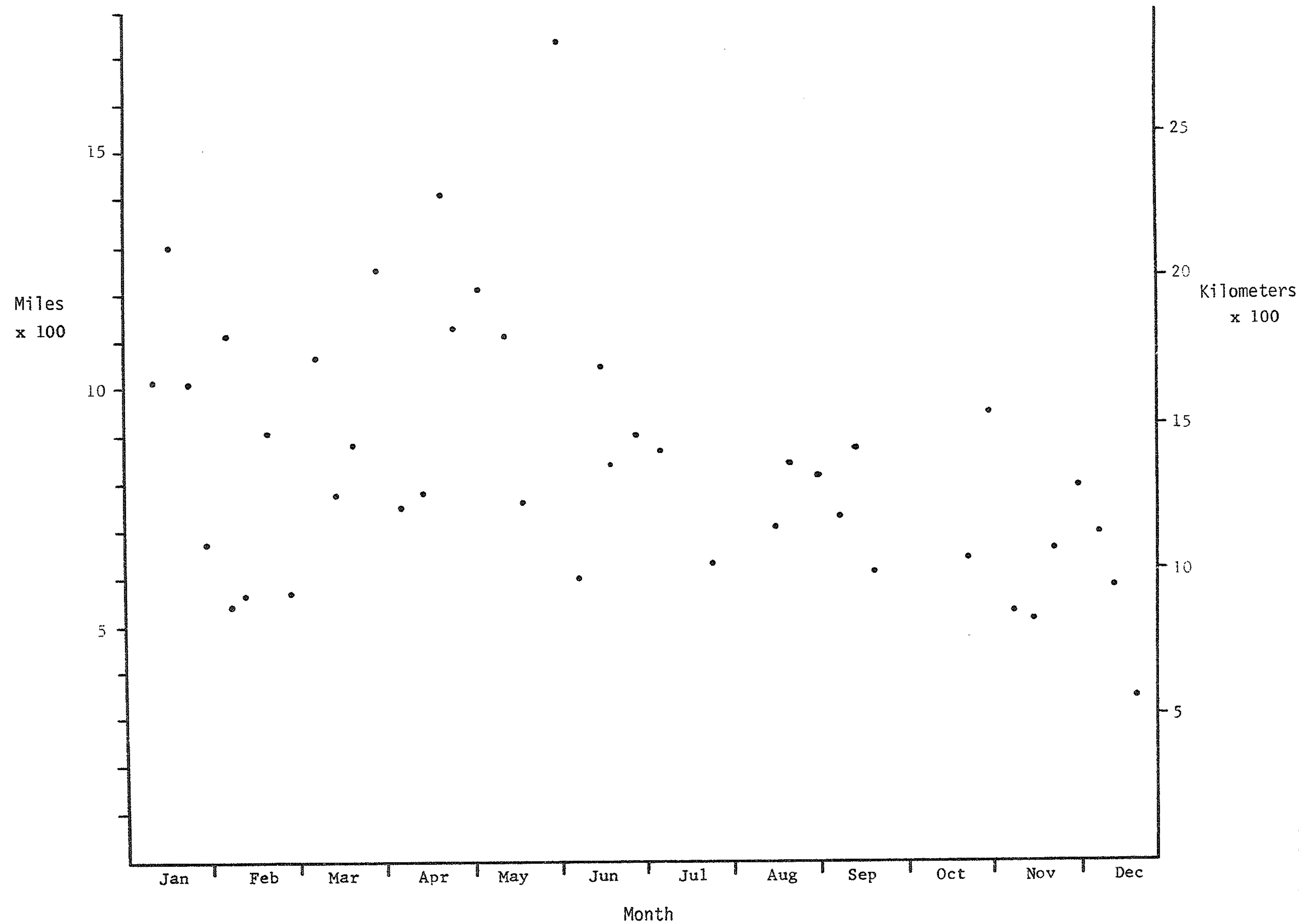

Figure 23. Mean weekly wind velocity (at 2 m) on northern sites, 1972.

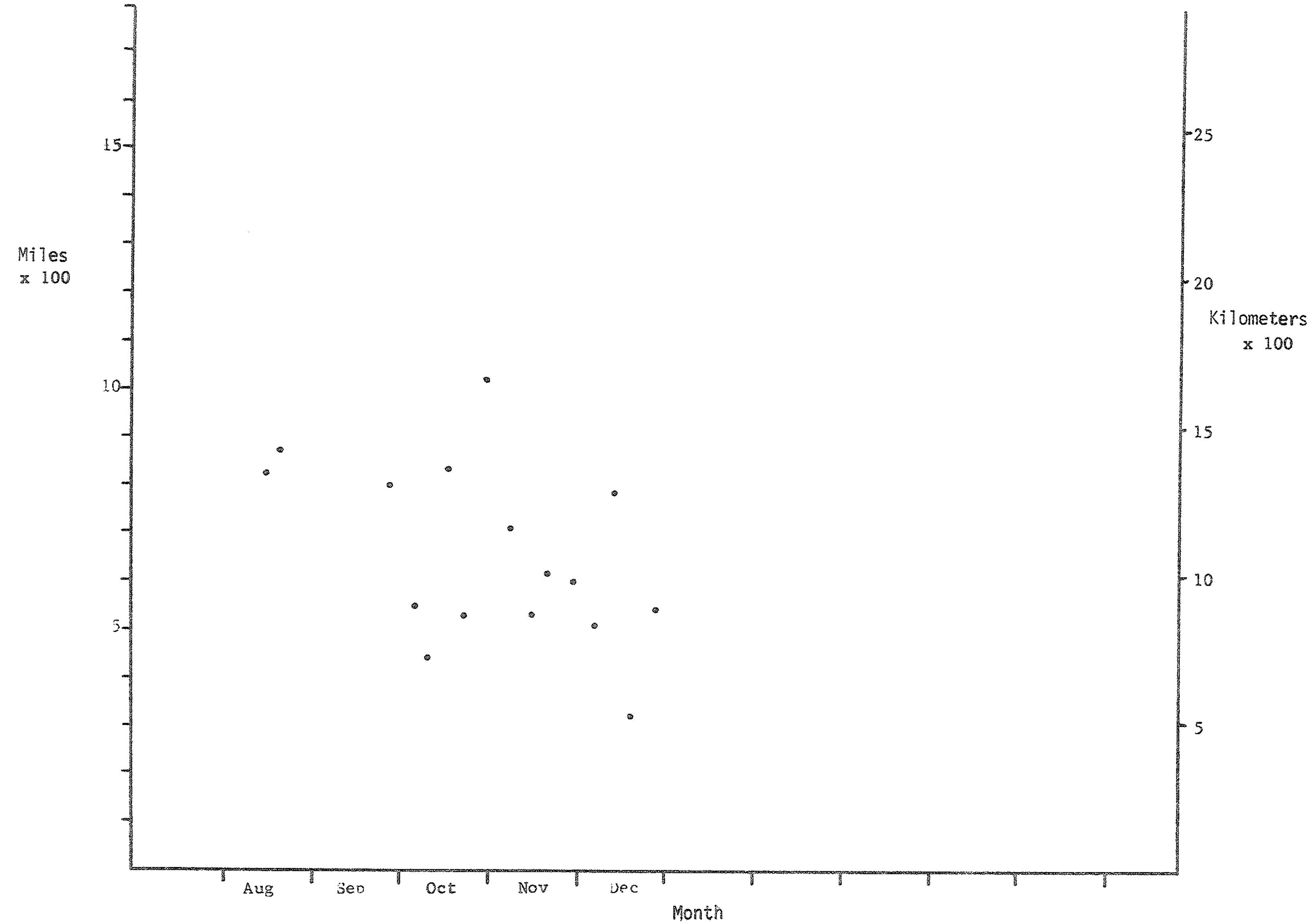

Figure 24. Mean weekly wind velocity (at 2 m) on southern sites, 1971.

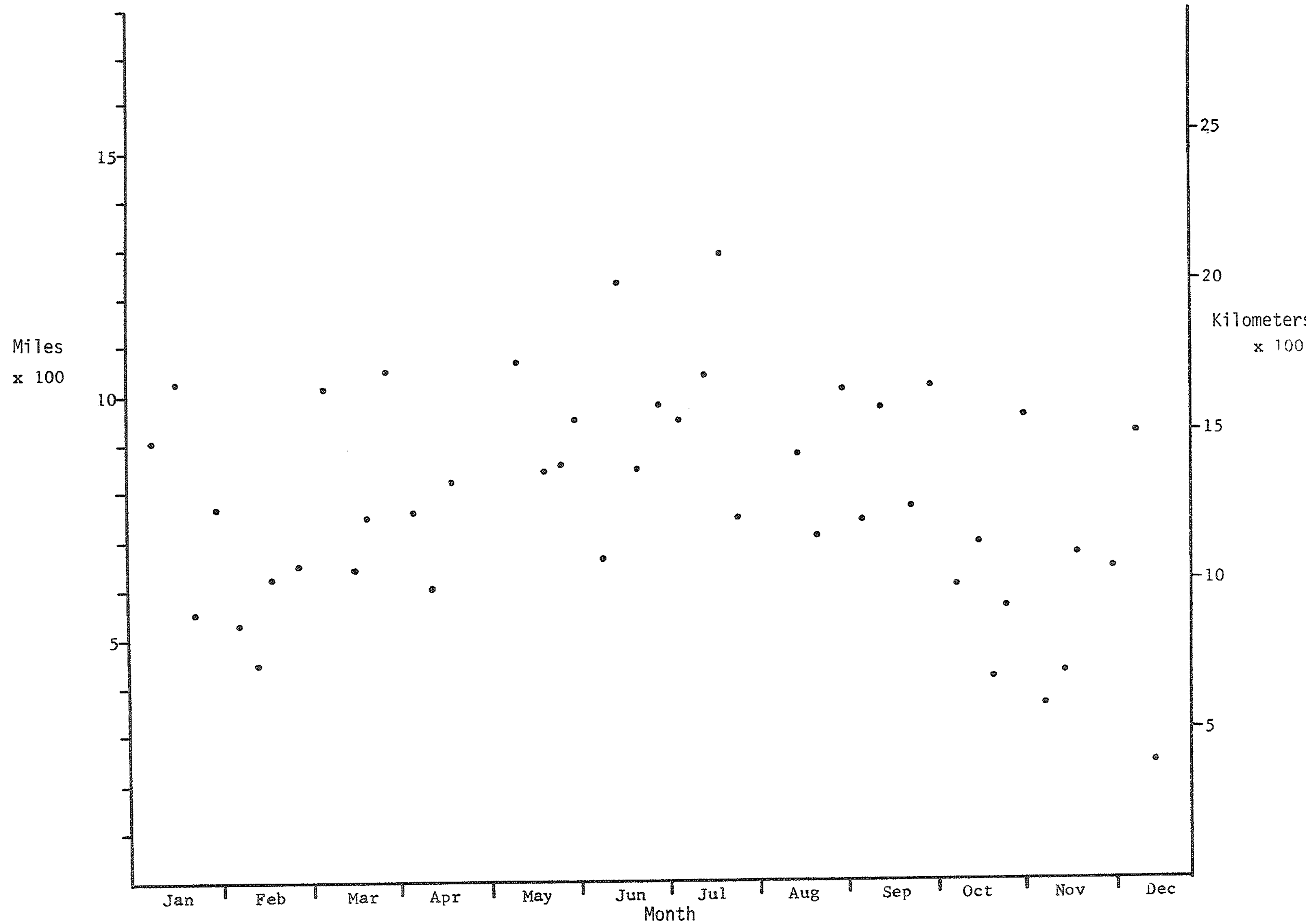

Figure 25. Mean weekly wind velocity (at 2 m) on southern sites, 1972.

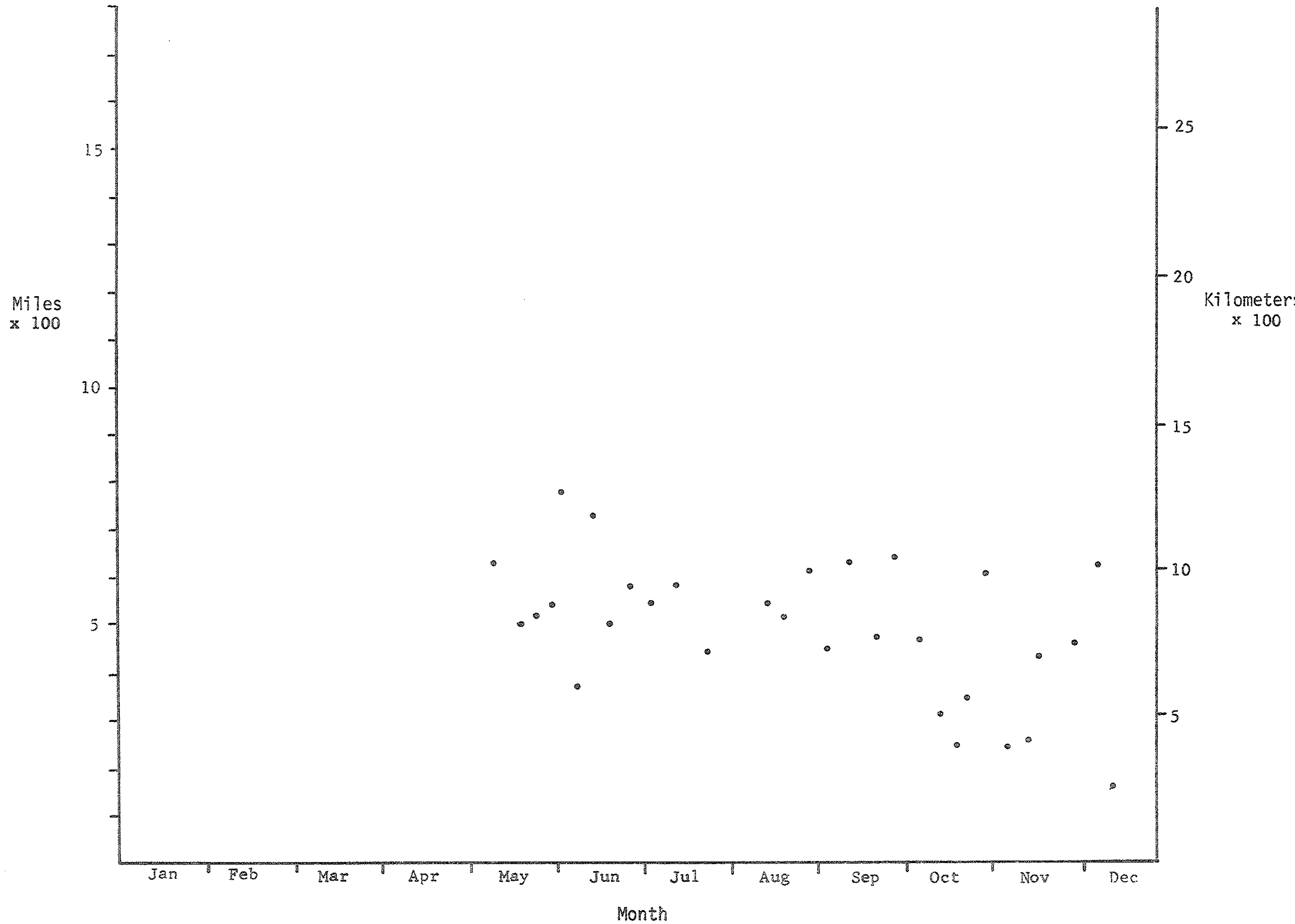

Figure 26. Mean weekly wind velocity (at.5 m) on southern sites, 1972.

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

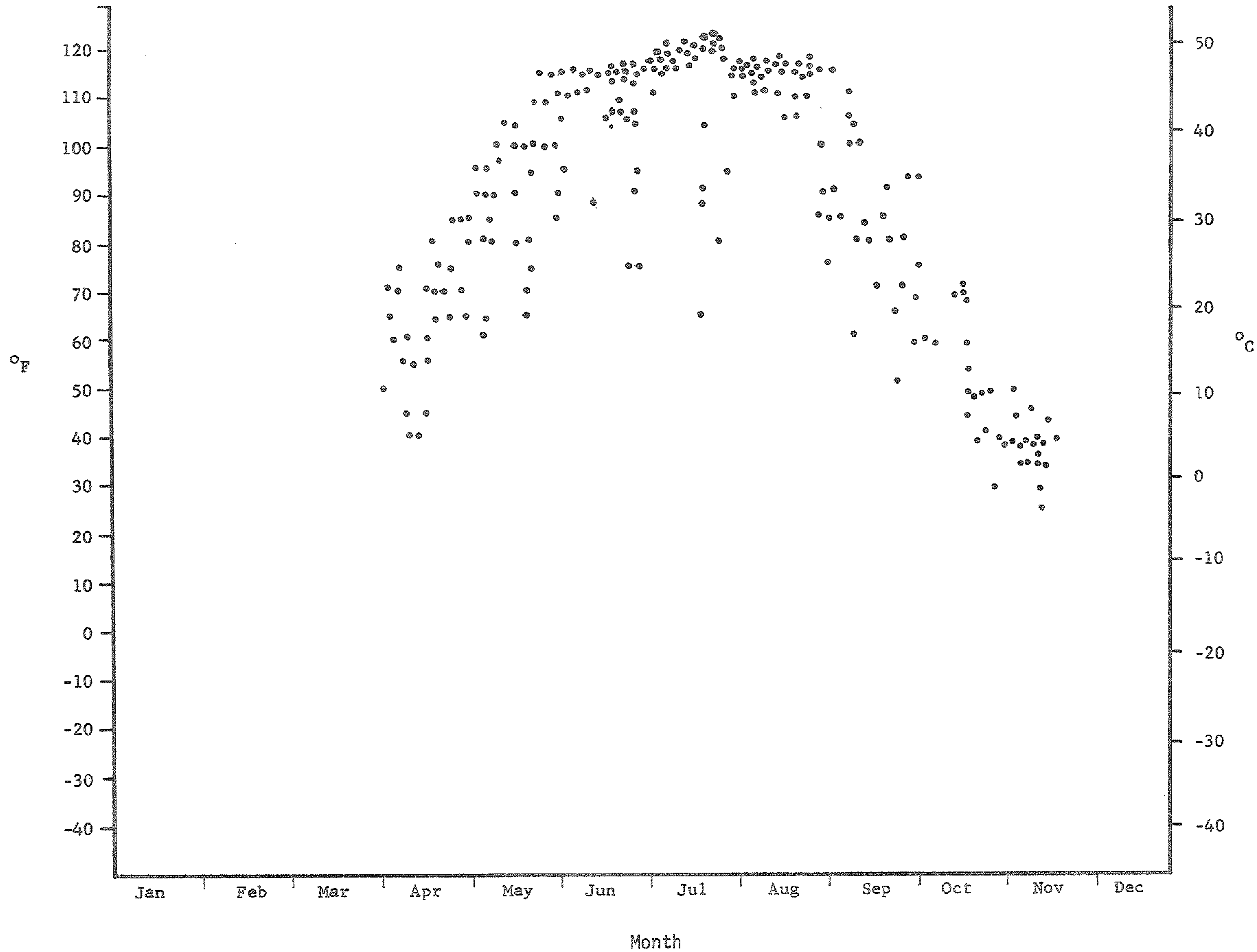

Figure 27. Daily maximum soil surface temperatures on northern sites, 1972.

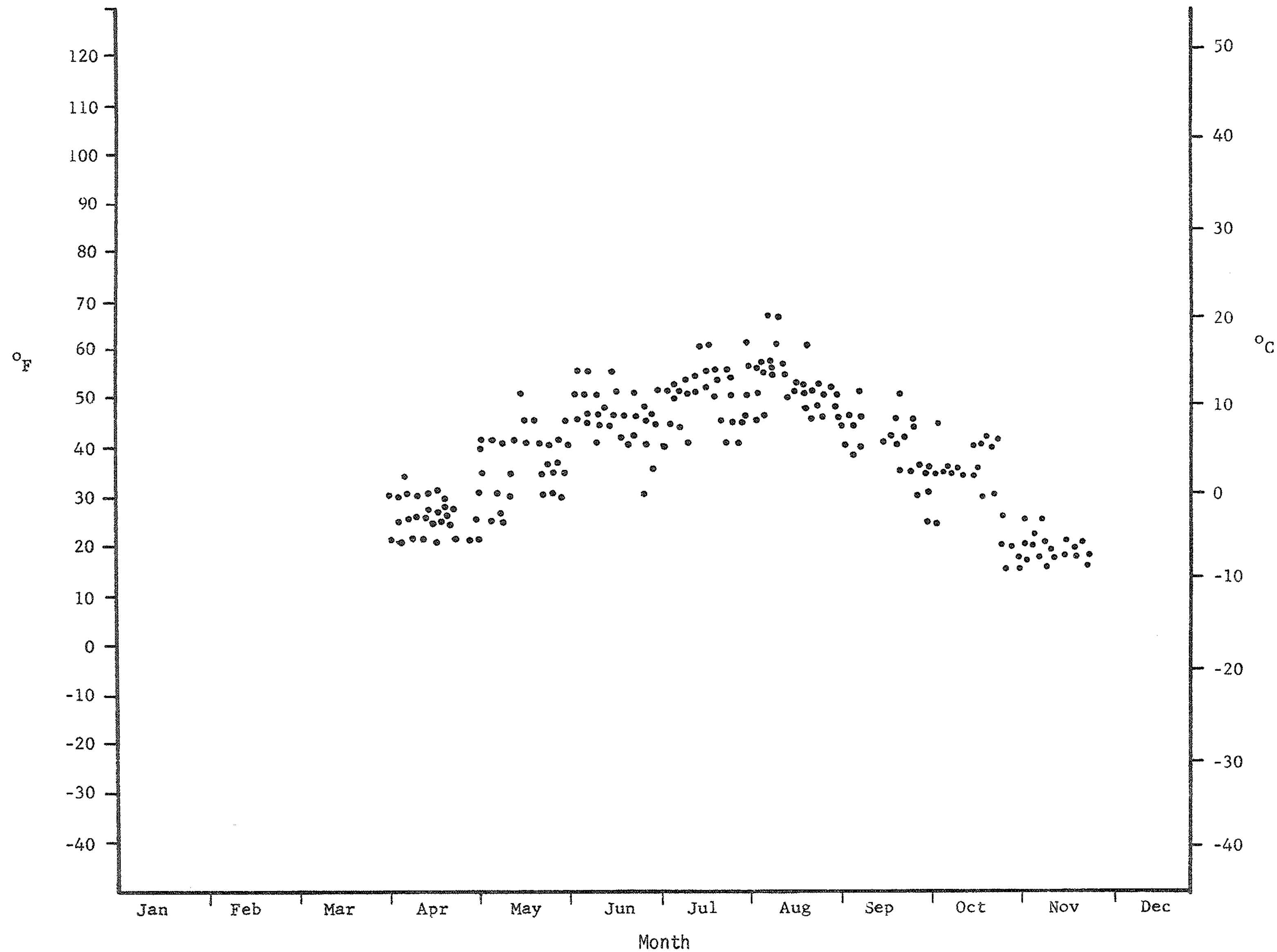

Figure 28. Daily minimum soil surface temperatures on northern sites, 1972.

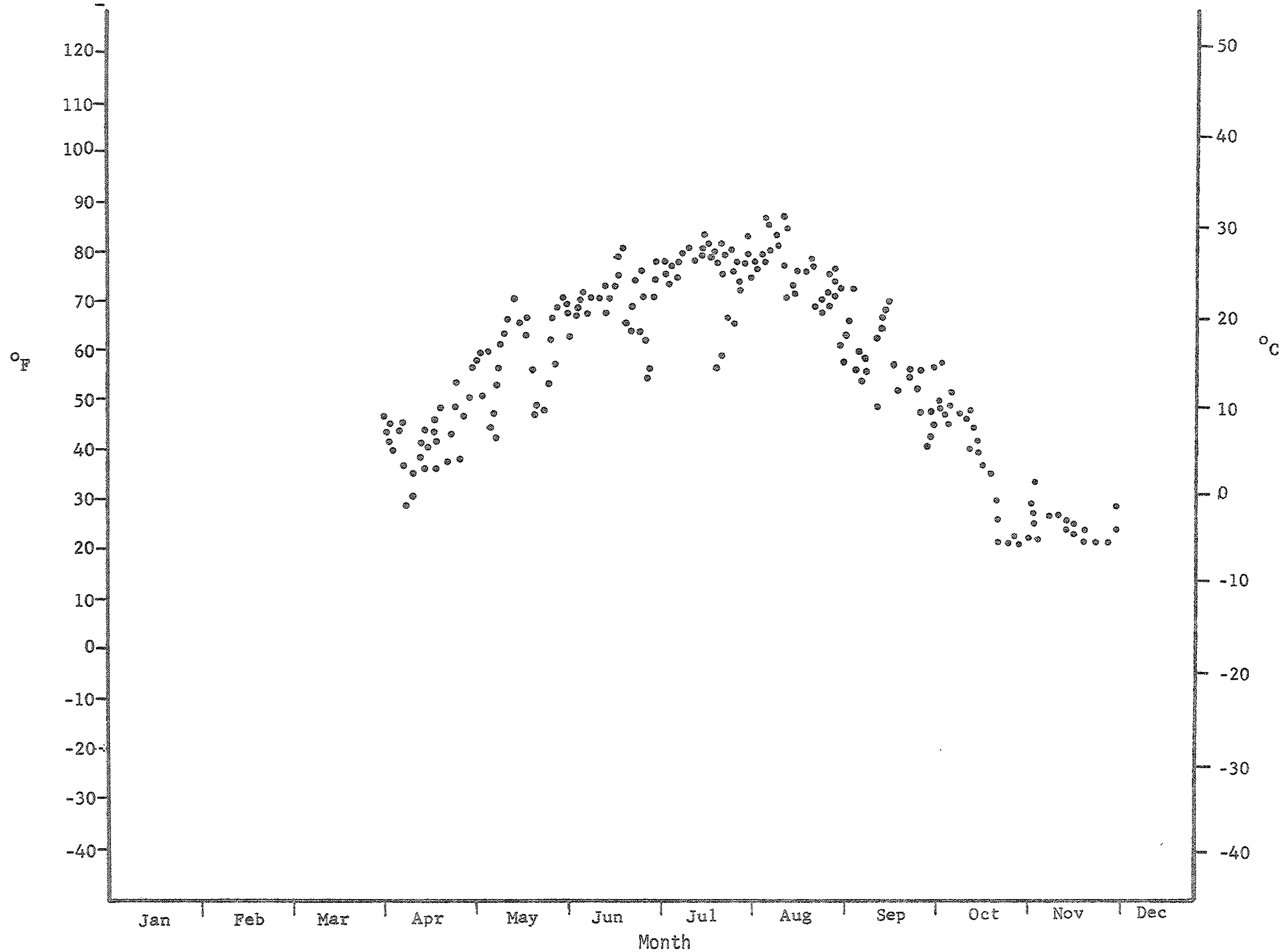

Figure 29. Daily mean soil surface temperatures on northern sites, 1972

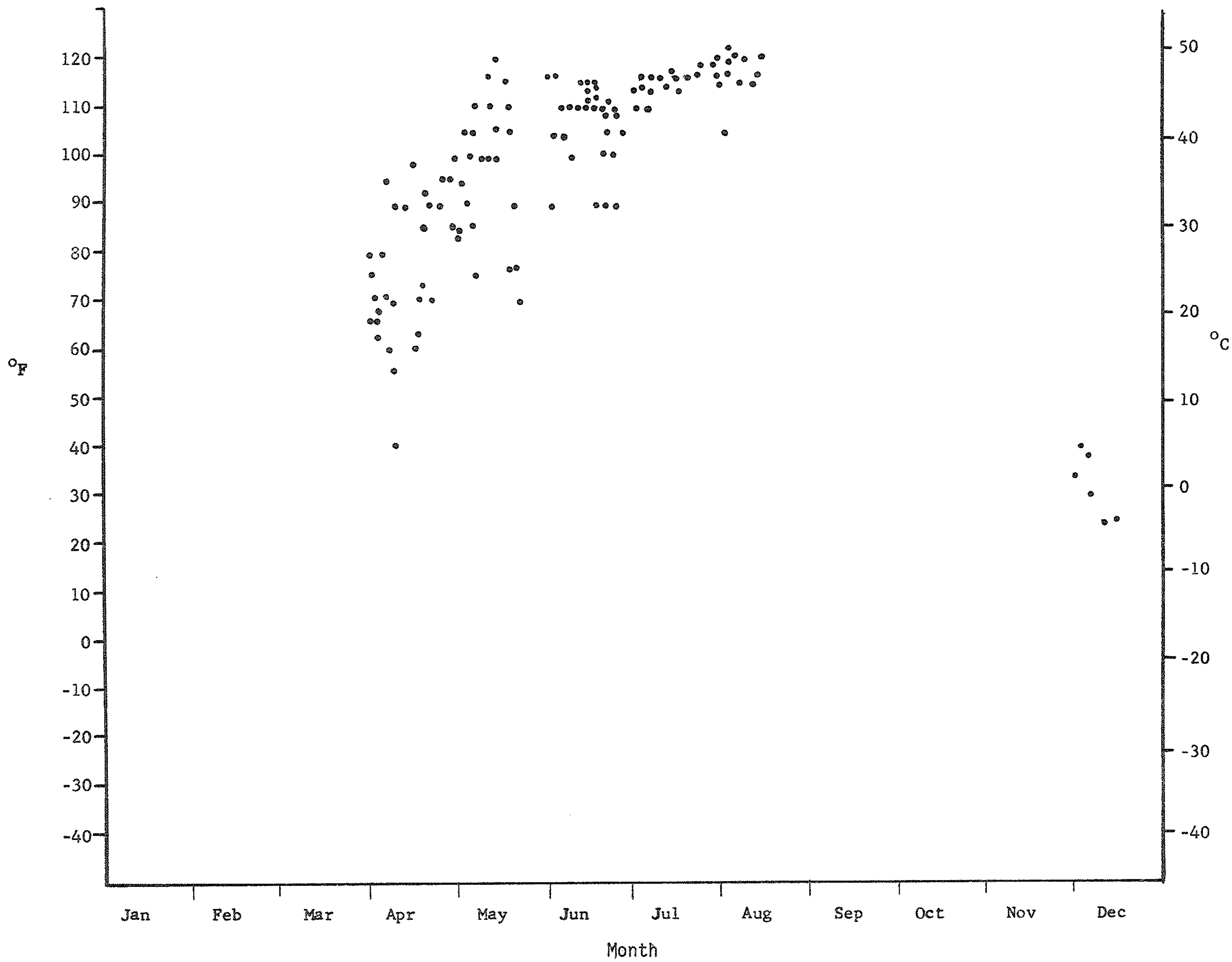

Figure 30. Daily maximum soil surface temperatures on southern sites, 1972.

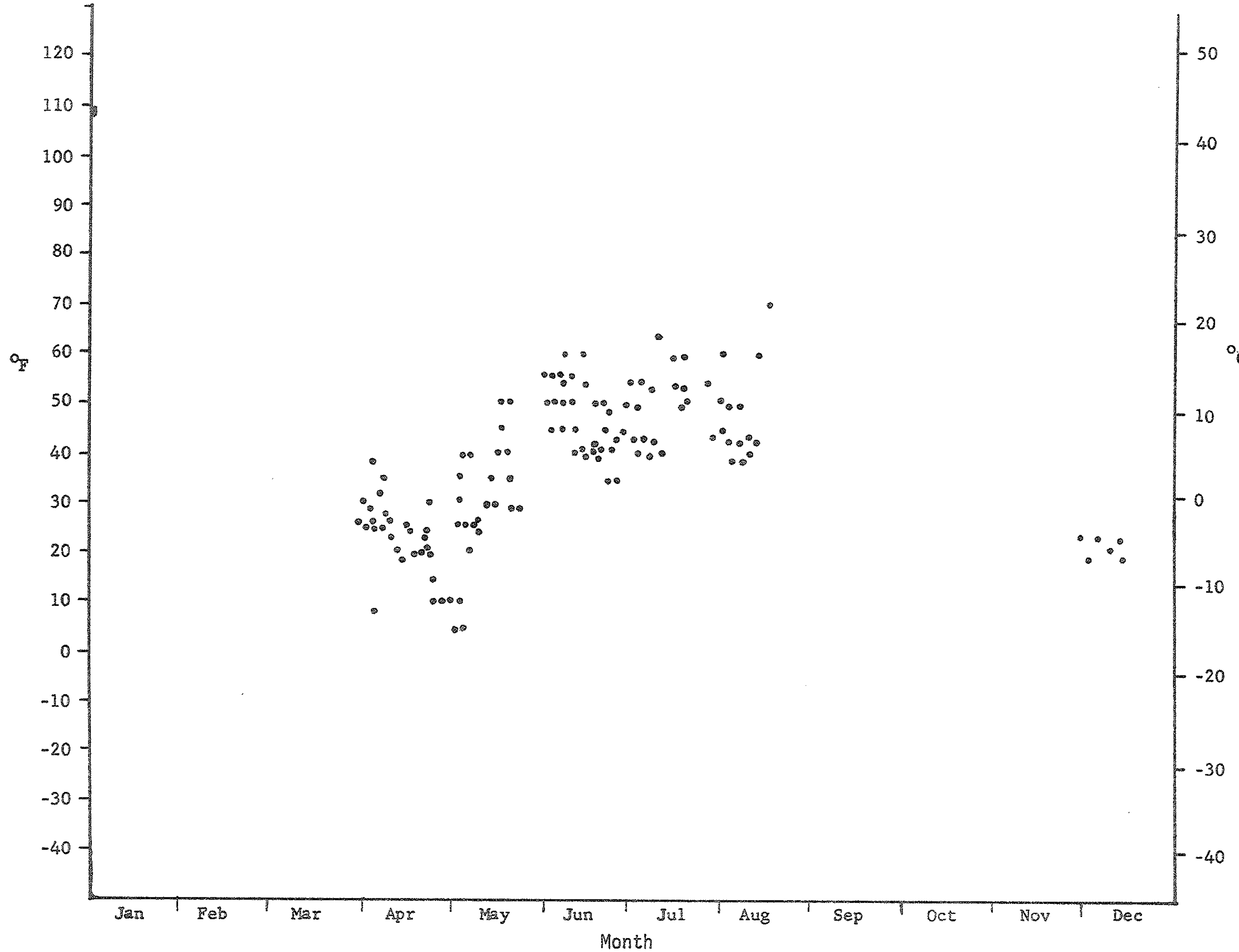

Figure 31. Daily minimum soil surface temperatures on southern sites, 1972.

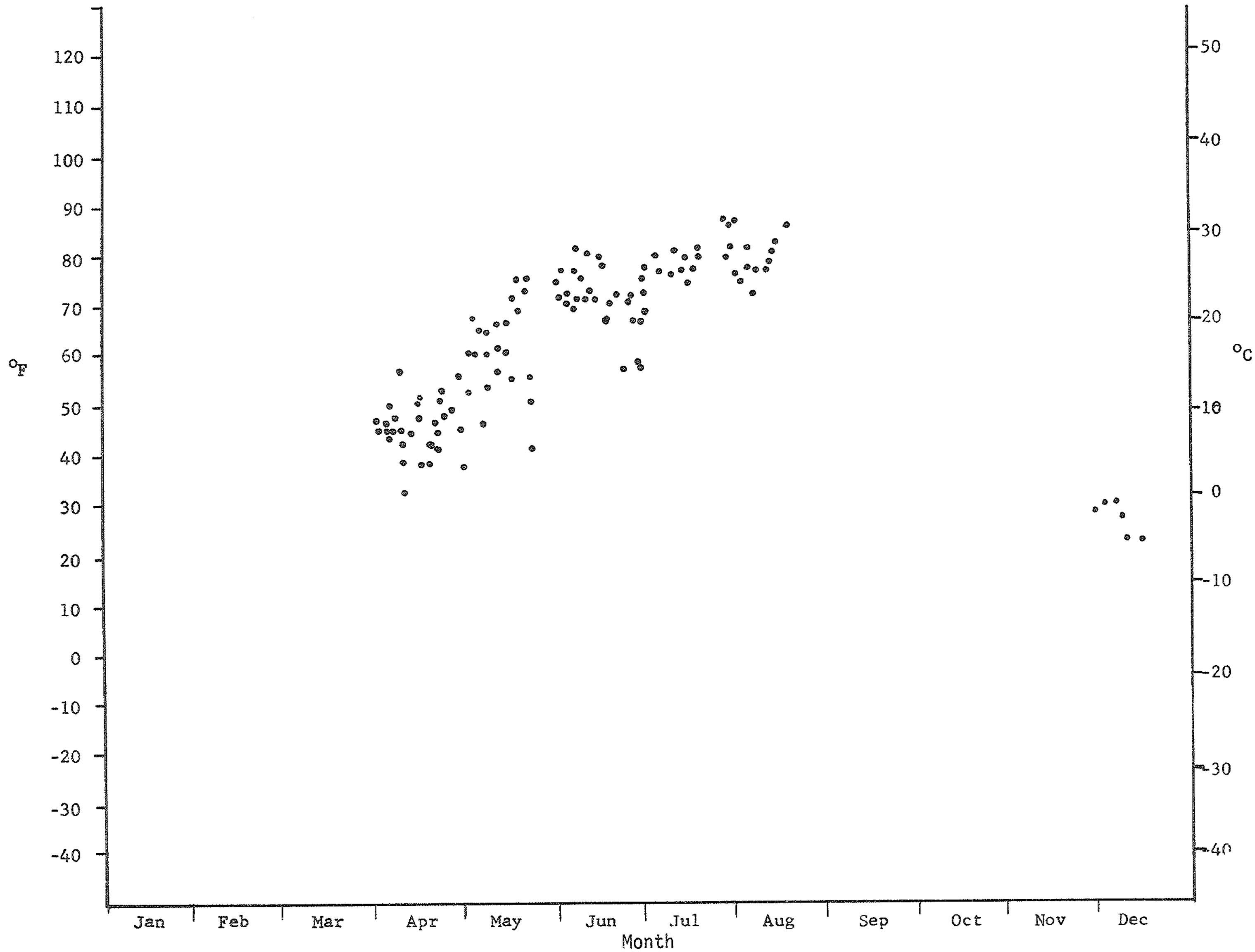

Figure 32. Daily mean soil surface temperatures on southern sites, 1972.

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

Water Content (weight fraction)	Matric Potential (bars)	Total Potential (bars)	Conductivity (cm/min.)
Sample No. 1 - Pressure plate data -- bulk density = 0.87 g/cm^3			
0.48	- .05		4.32×10^{-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			
.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

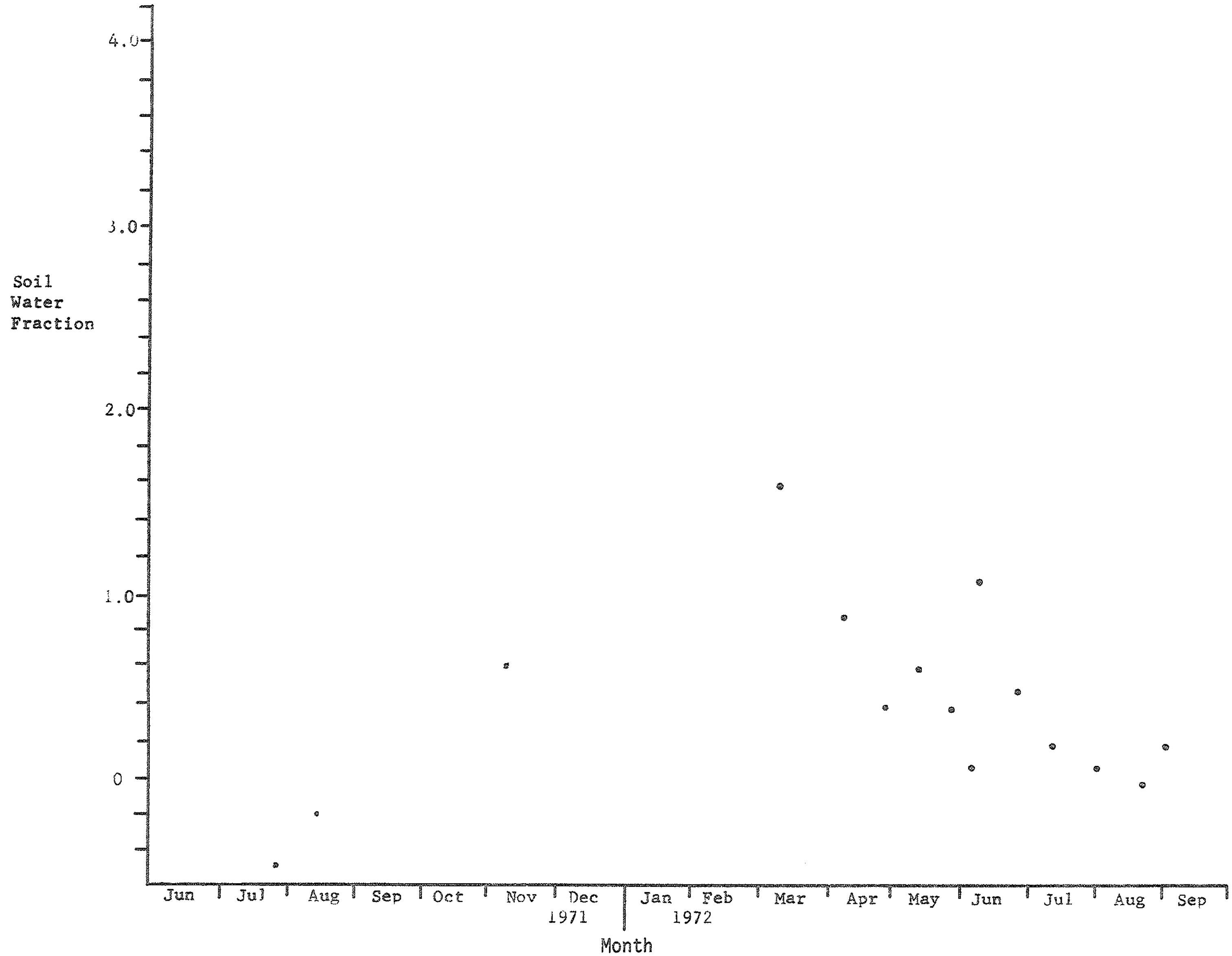

Figure 33. Soil moisture at 2.5 cm depth on southern sites (gamma probe).

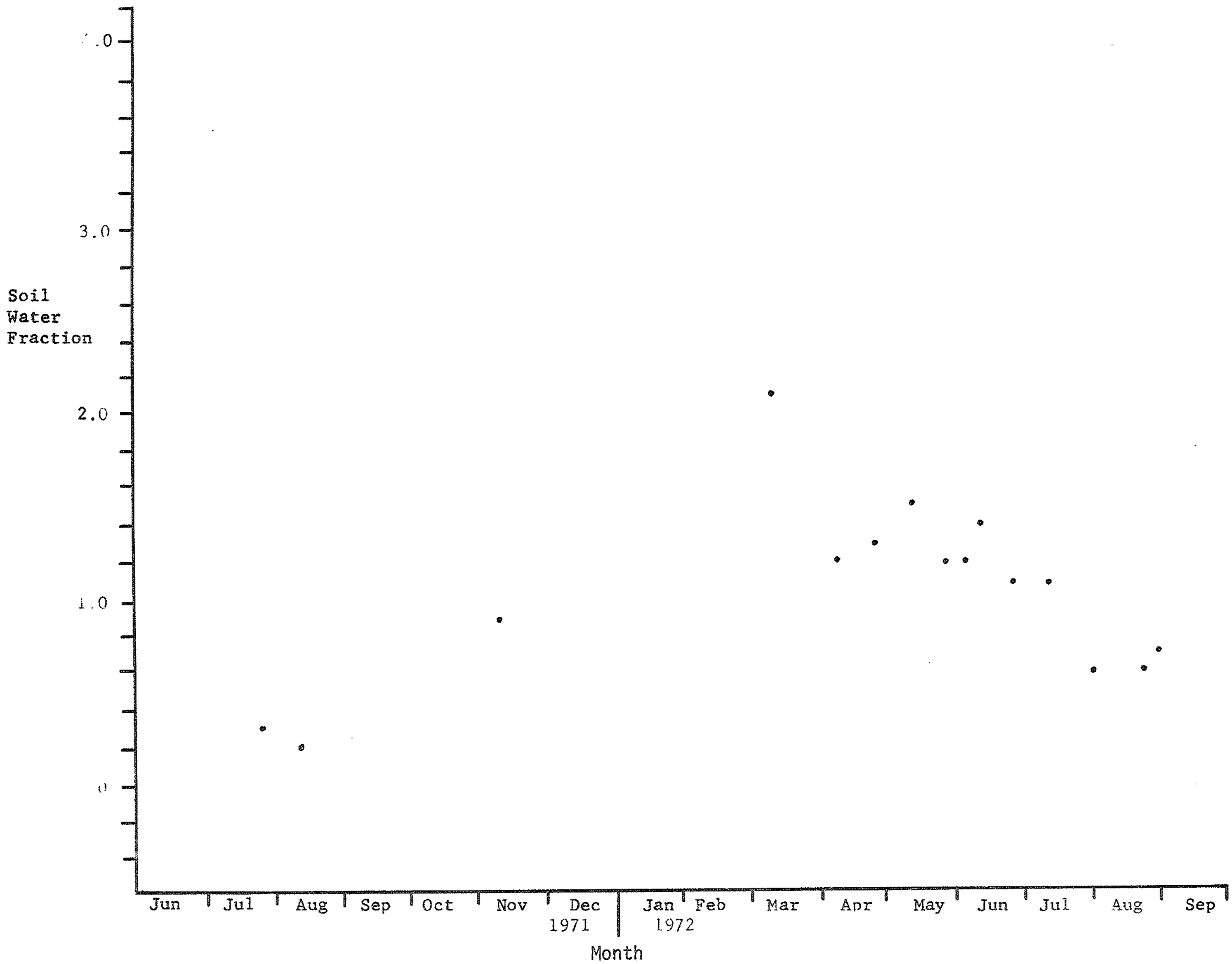

Figure 34. Soil moisture at 5 cm depth on southern sites (gamma probe).

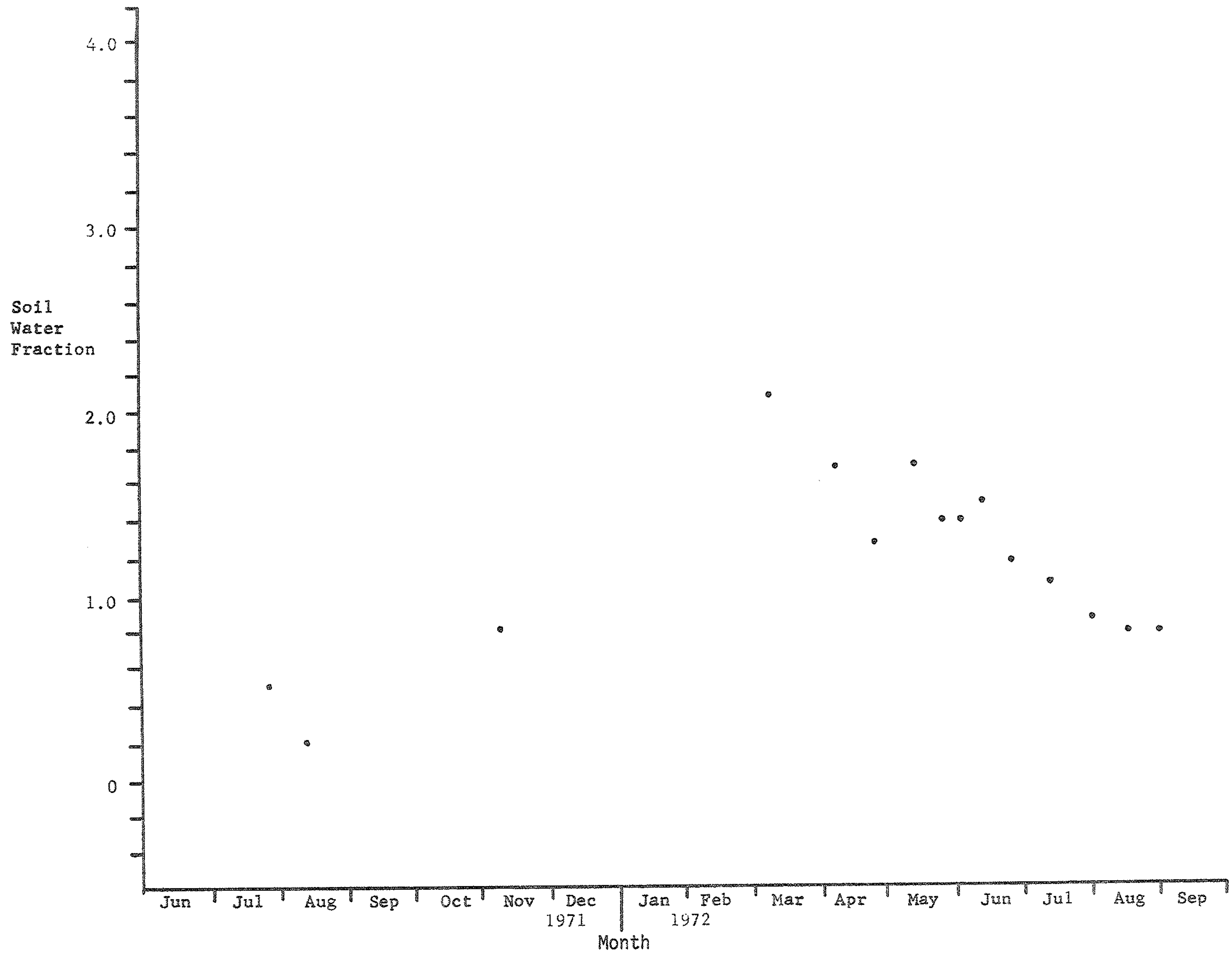

Figure 35. Soil moisture at 13 cm depth on southern sites (gamma probe).

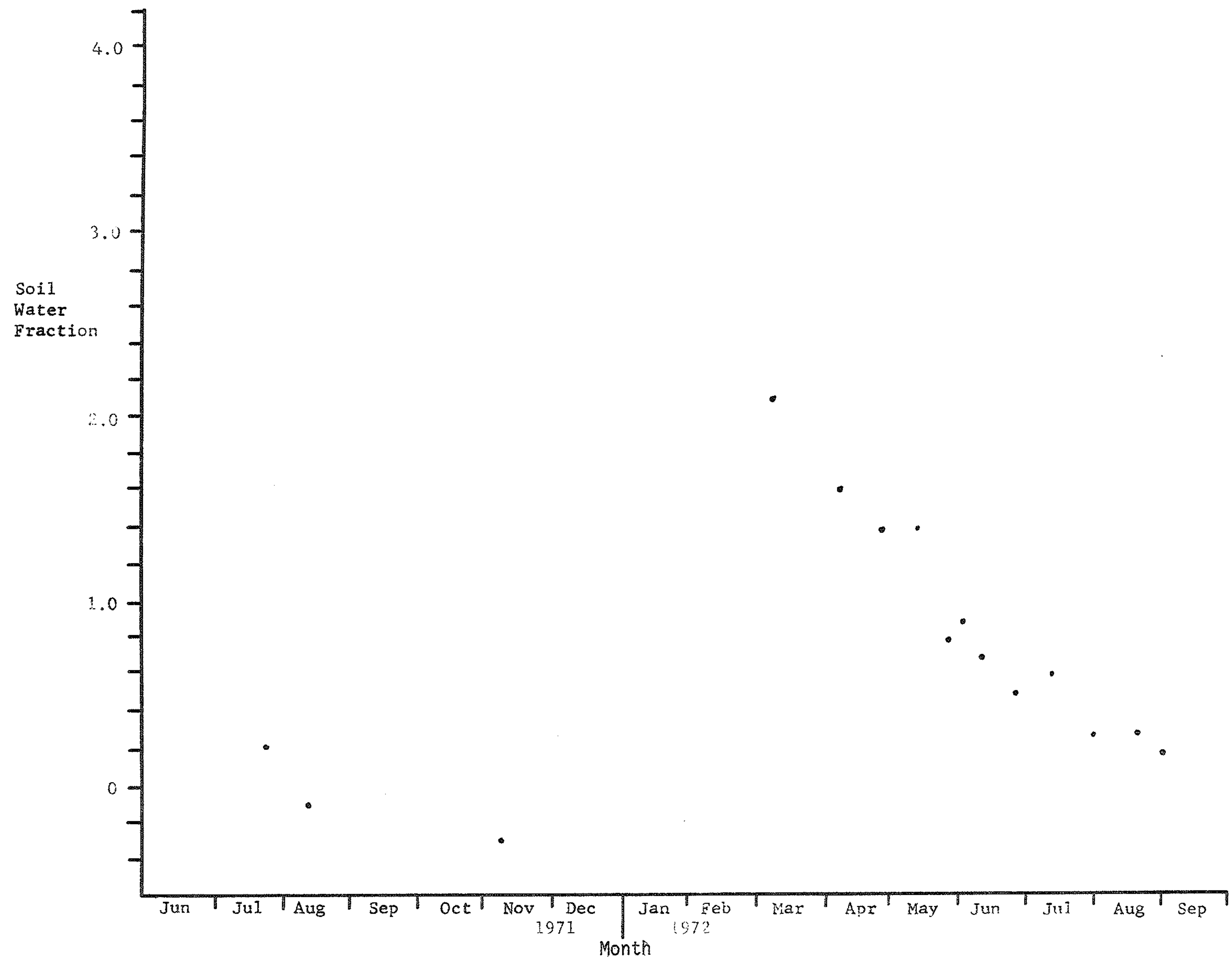

Figure 36. Soil moisture at 20 cm depth on southern sites (gamma probe).

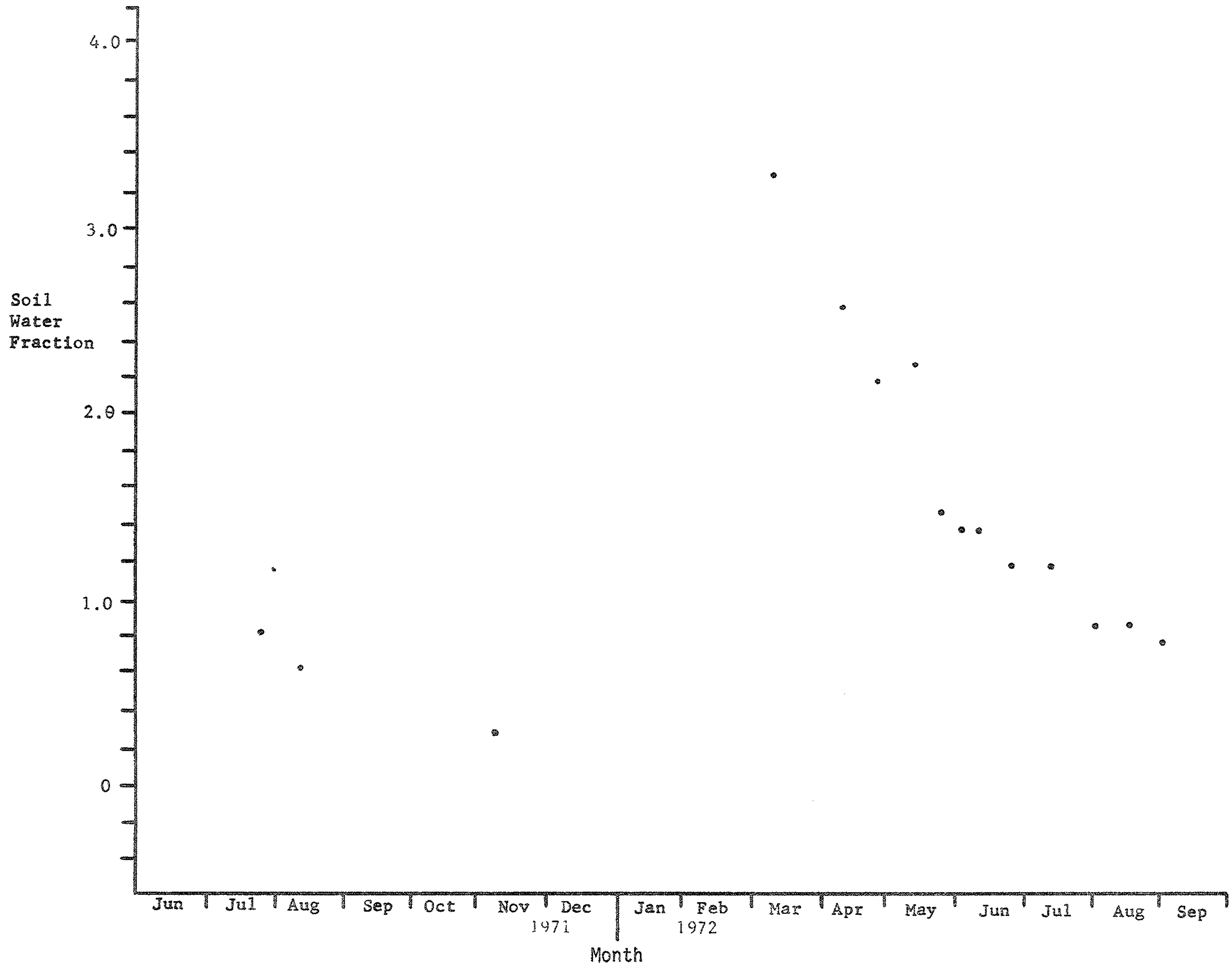

Figure 37. Soil moisture at 2.6 cm depth on southern sites (gamma probe).

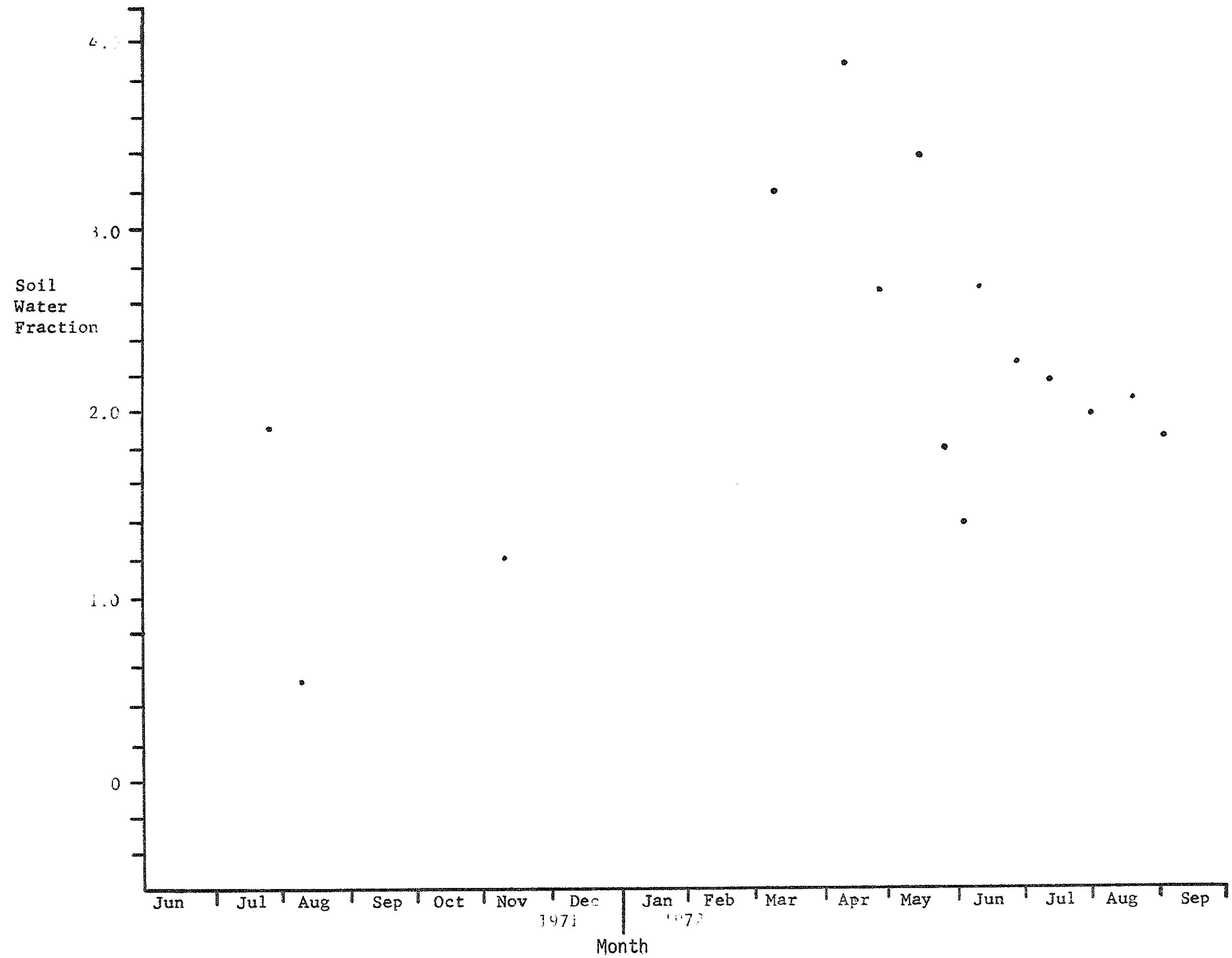

Figure 38. Soil moisture at 36 cm depth on southern sites (gamma probe).

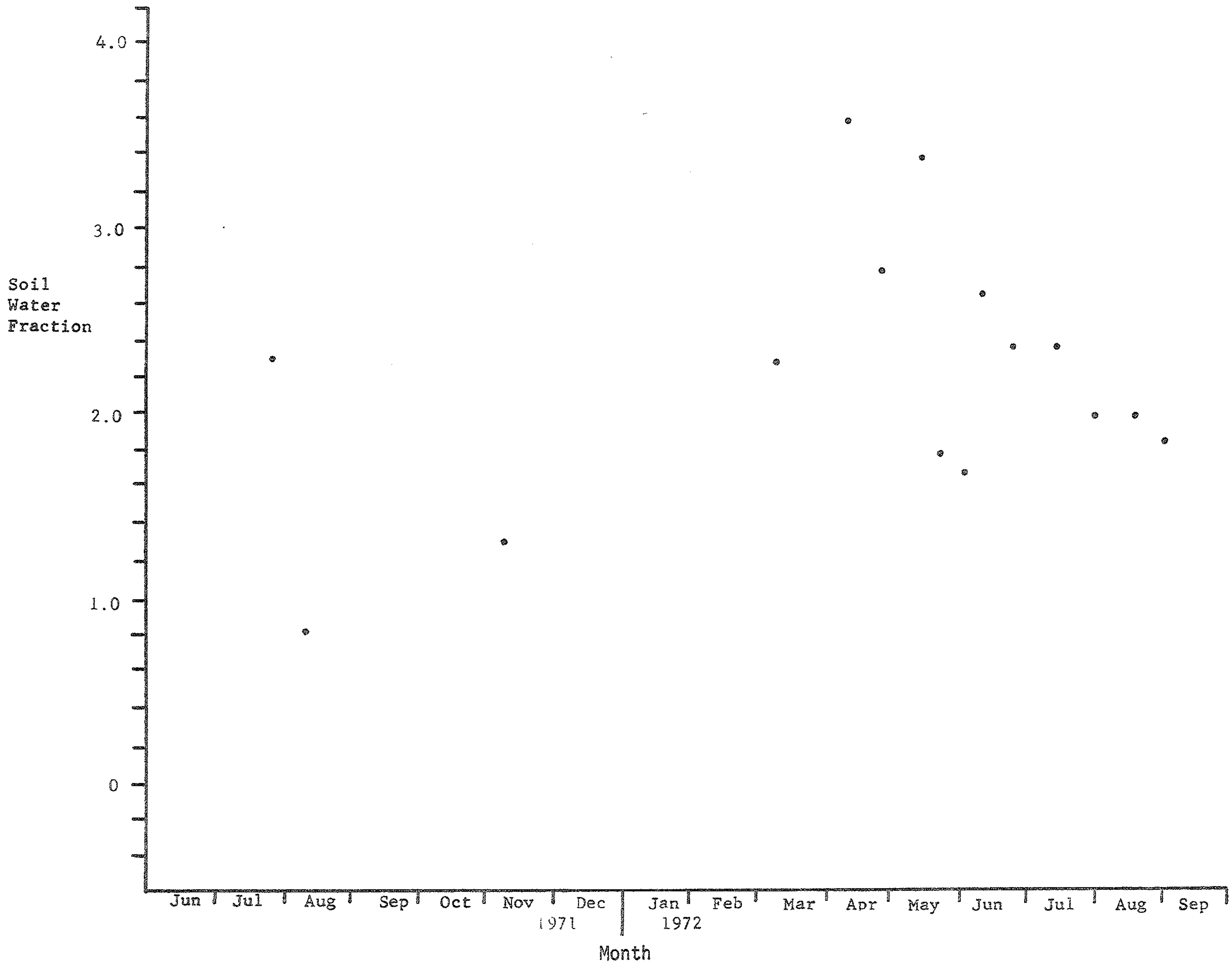

Figure 39. Soil moisture at 43 cm depth on southern sites (gamma probe).

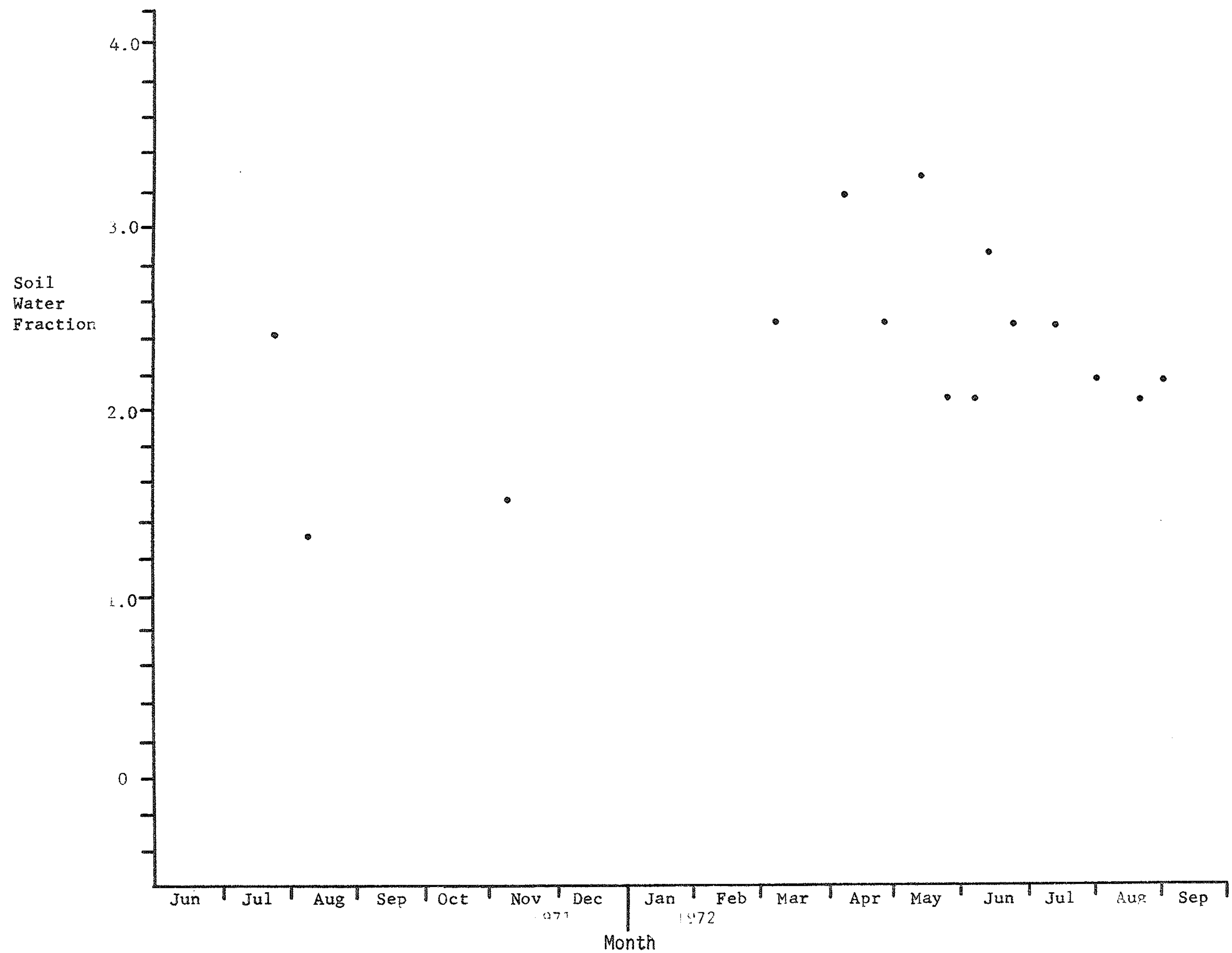

Figure 40. Soil moisture at 51 cm depth on southern sites (gamma probe).

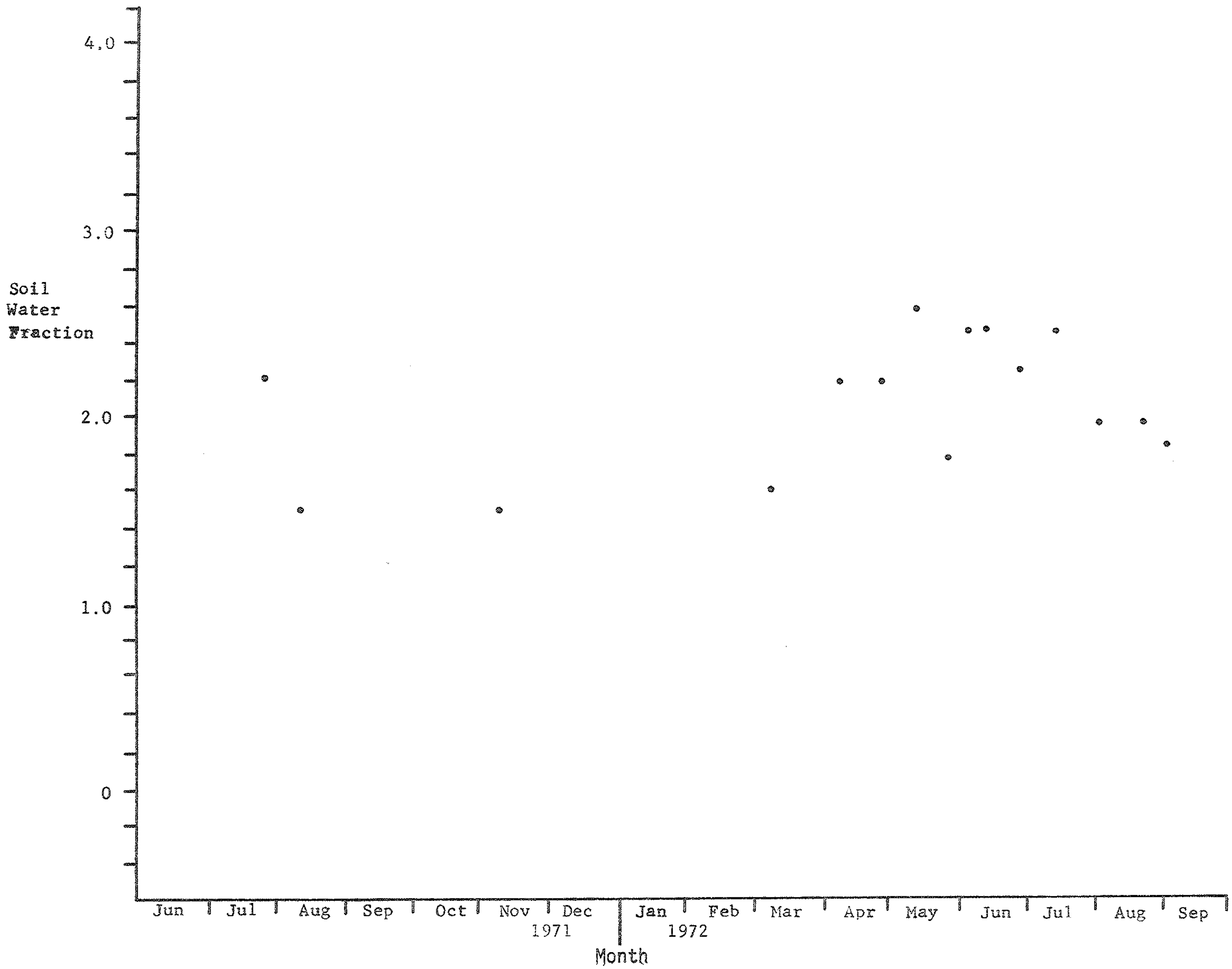

Figure 41. Soil moisture at 58 cm depth on southern sites (gamma probe).

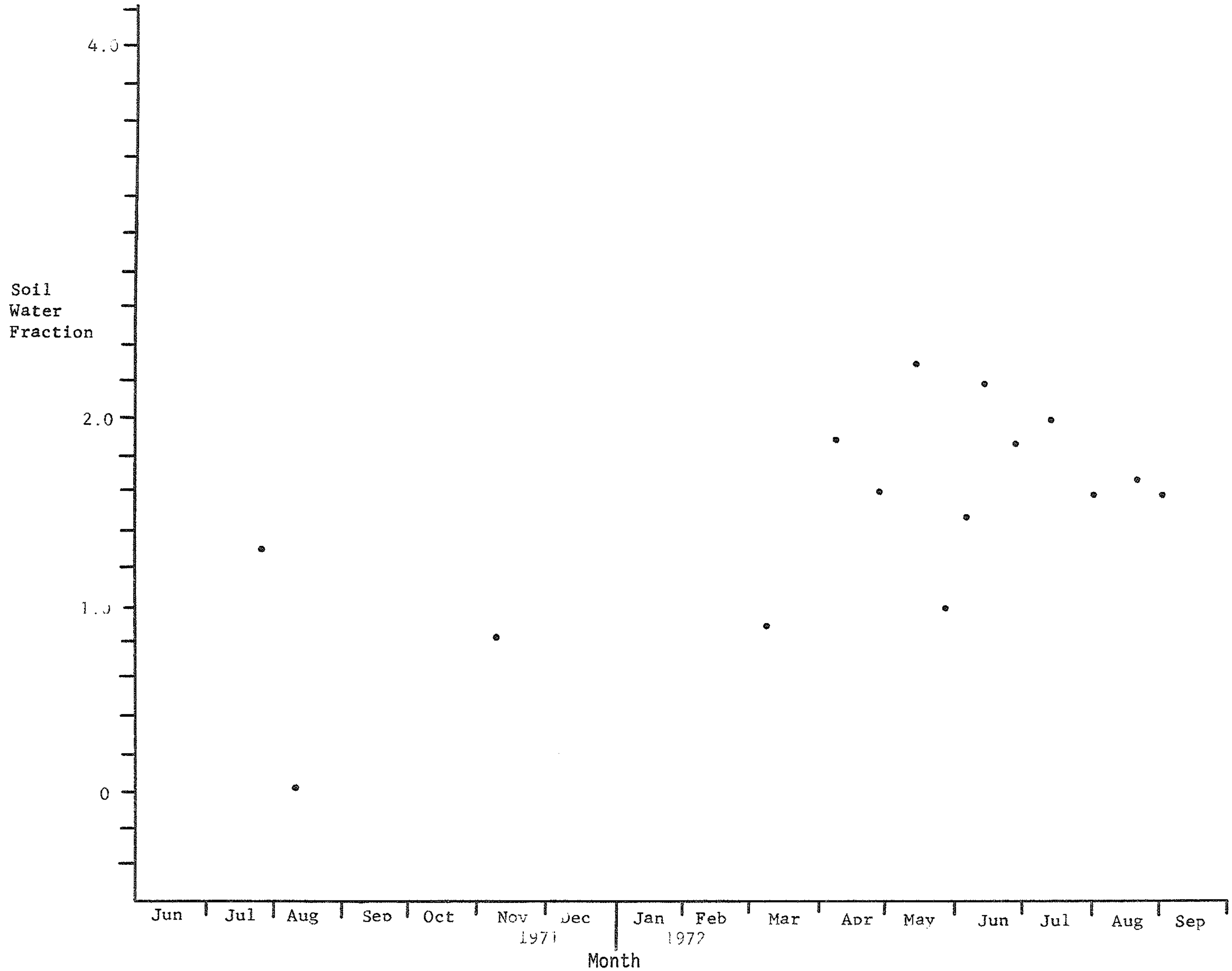

Figure 42. Soil moisture at 66 cm depth on southern sites (gamma probe).

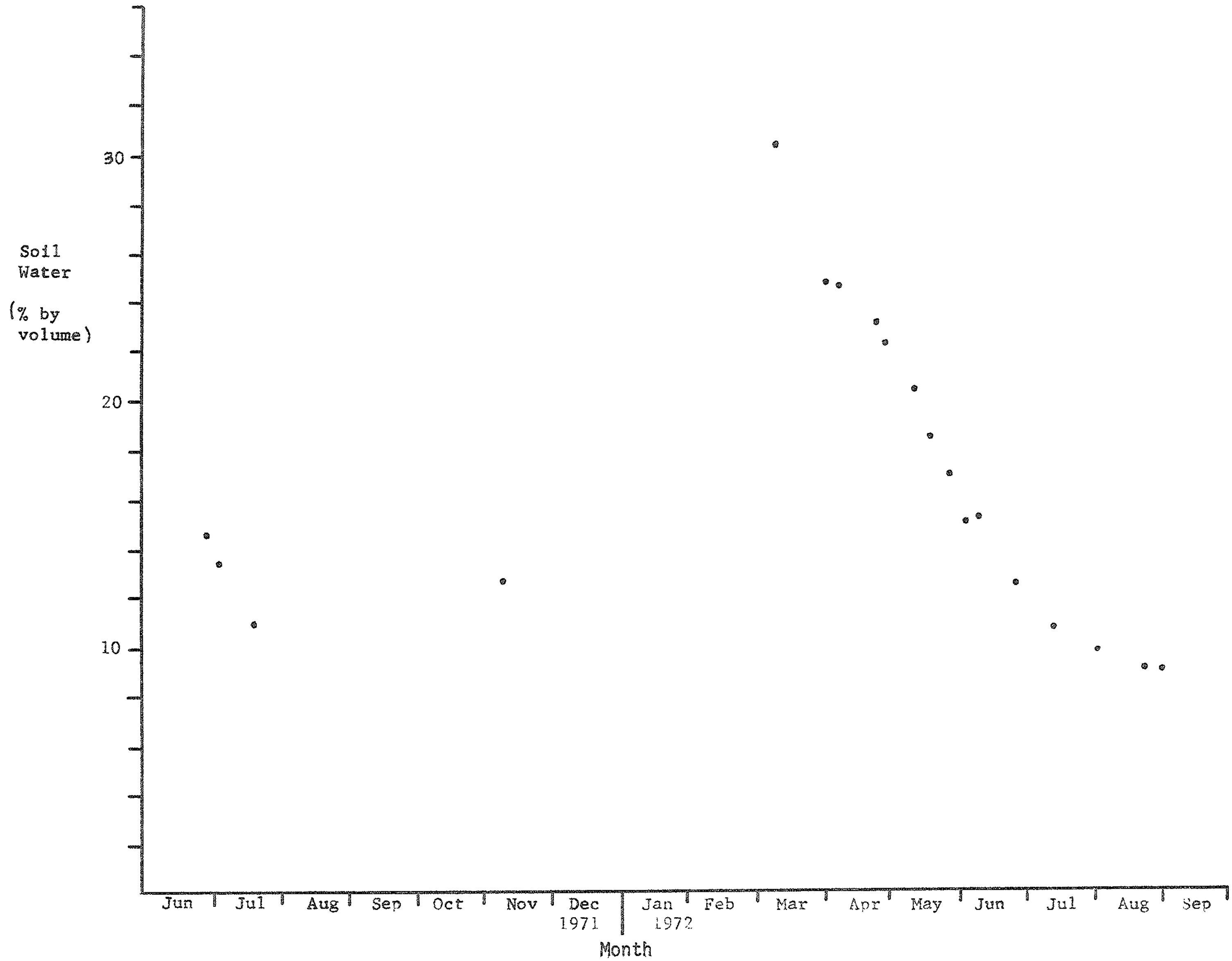

Figure 43. Soil moisture at 31 cm depth on southern sites (neutron probe).

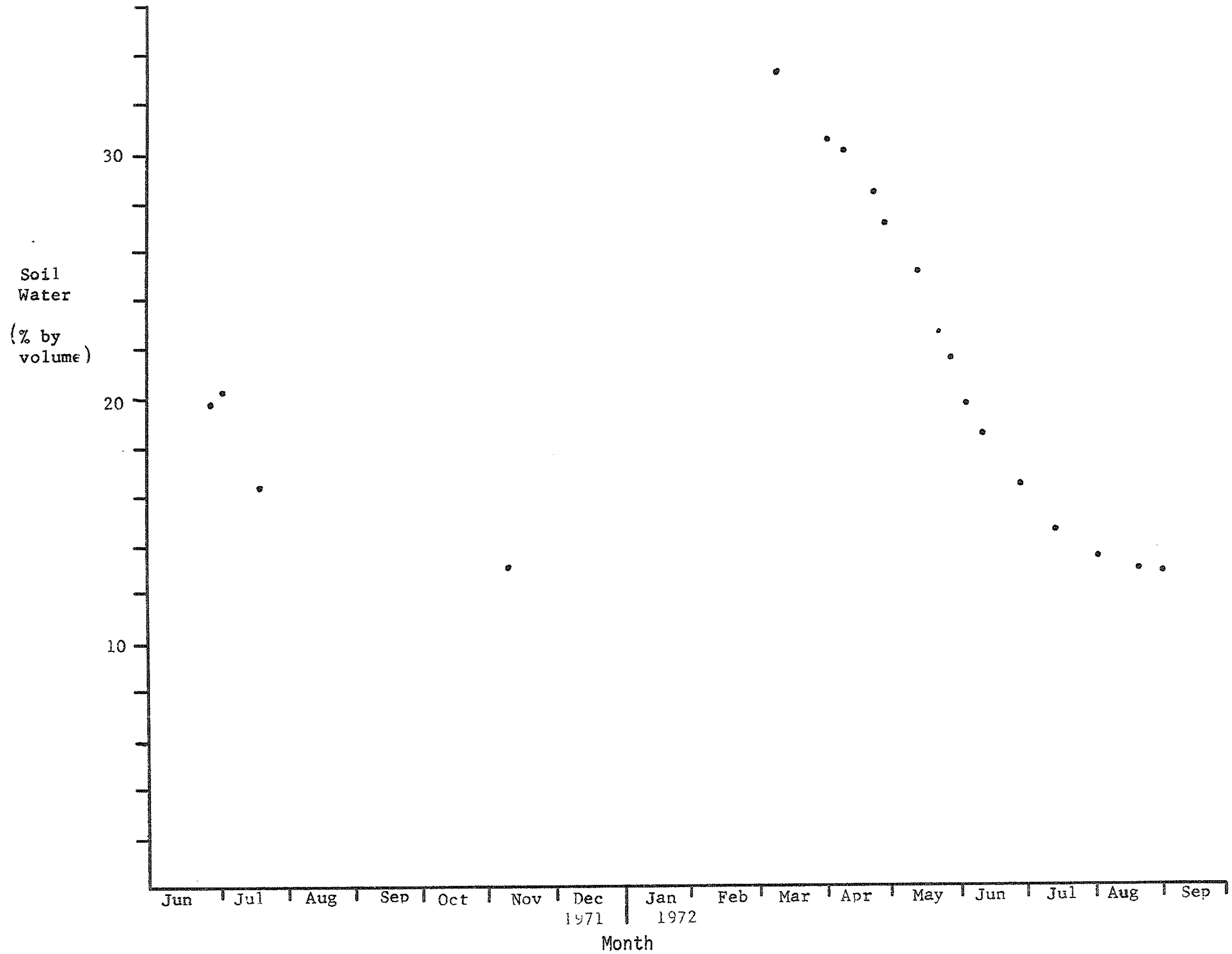

Figure 44. Soil moisture at 46 cm depth on southern sites (neutron probe).

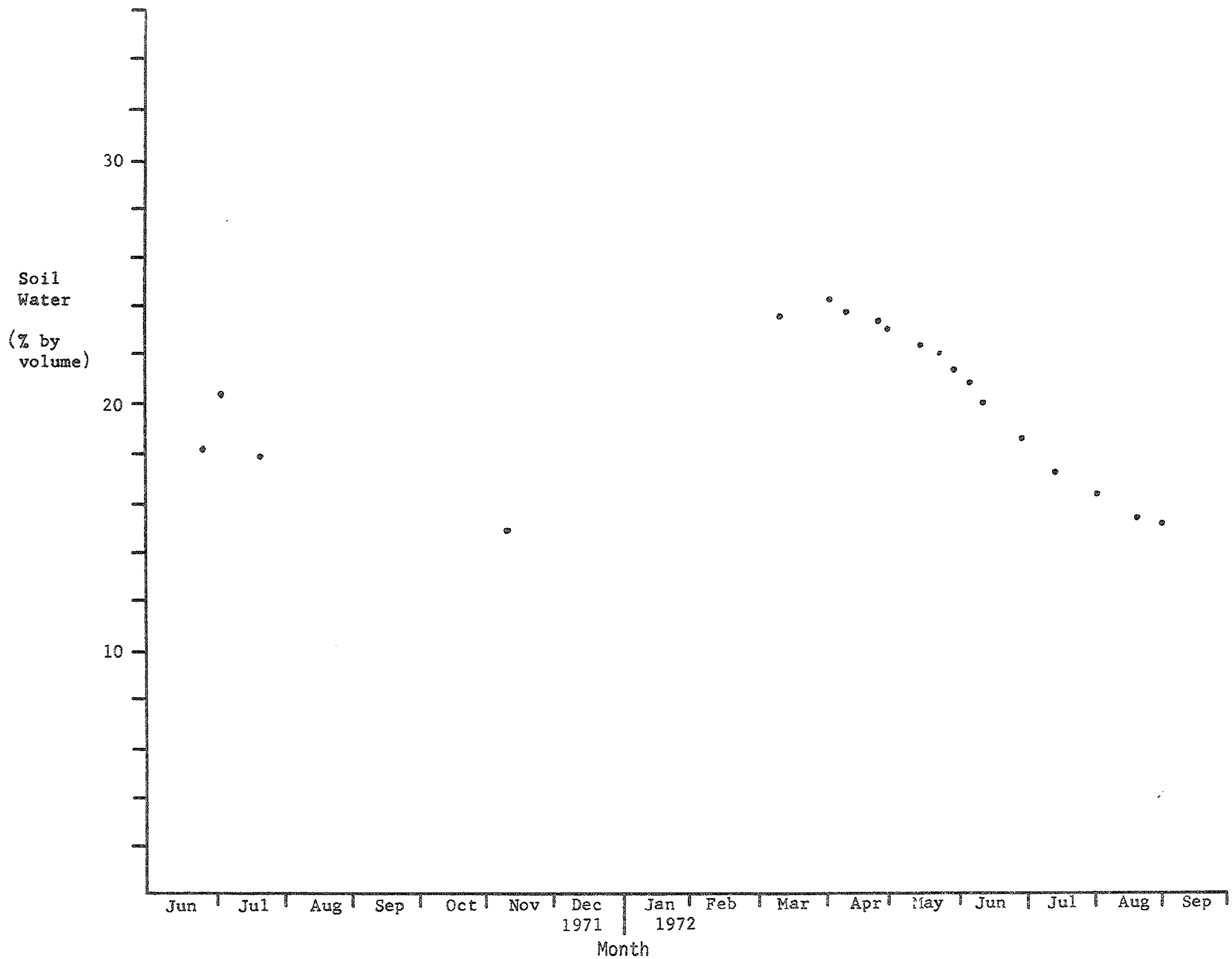

Figure 45. Soil moisture at 61 cm depth on southern sites (neutron probe).

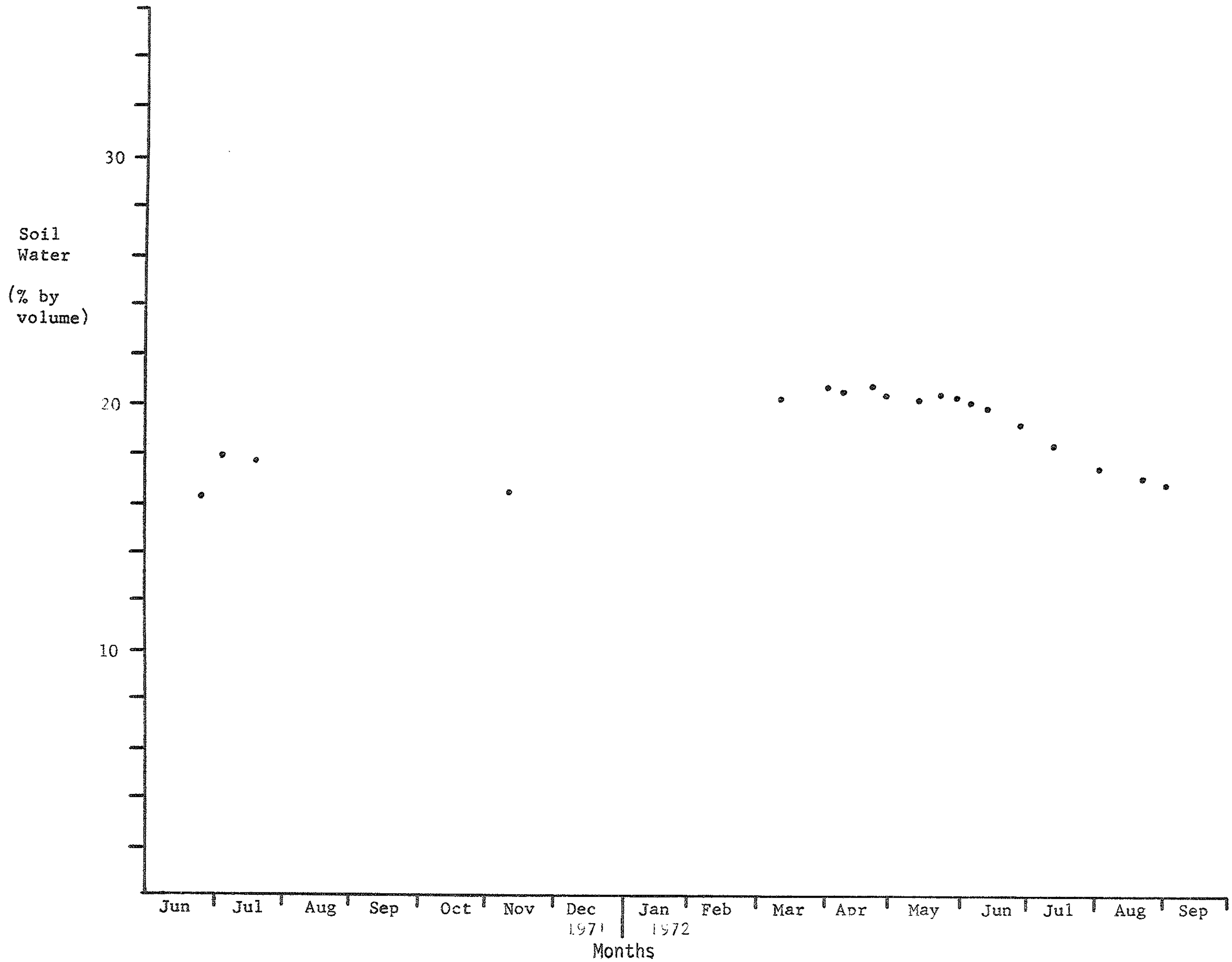

Figure 46. Soil moisture at 76 cm depth on southern sites (neutron probe).

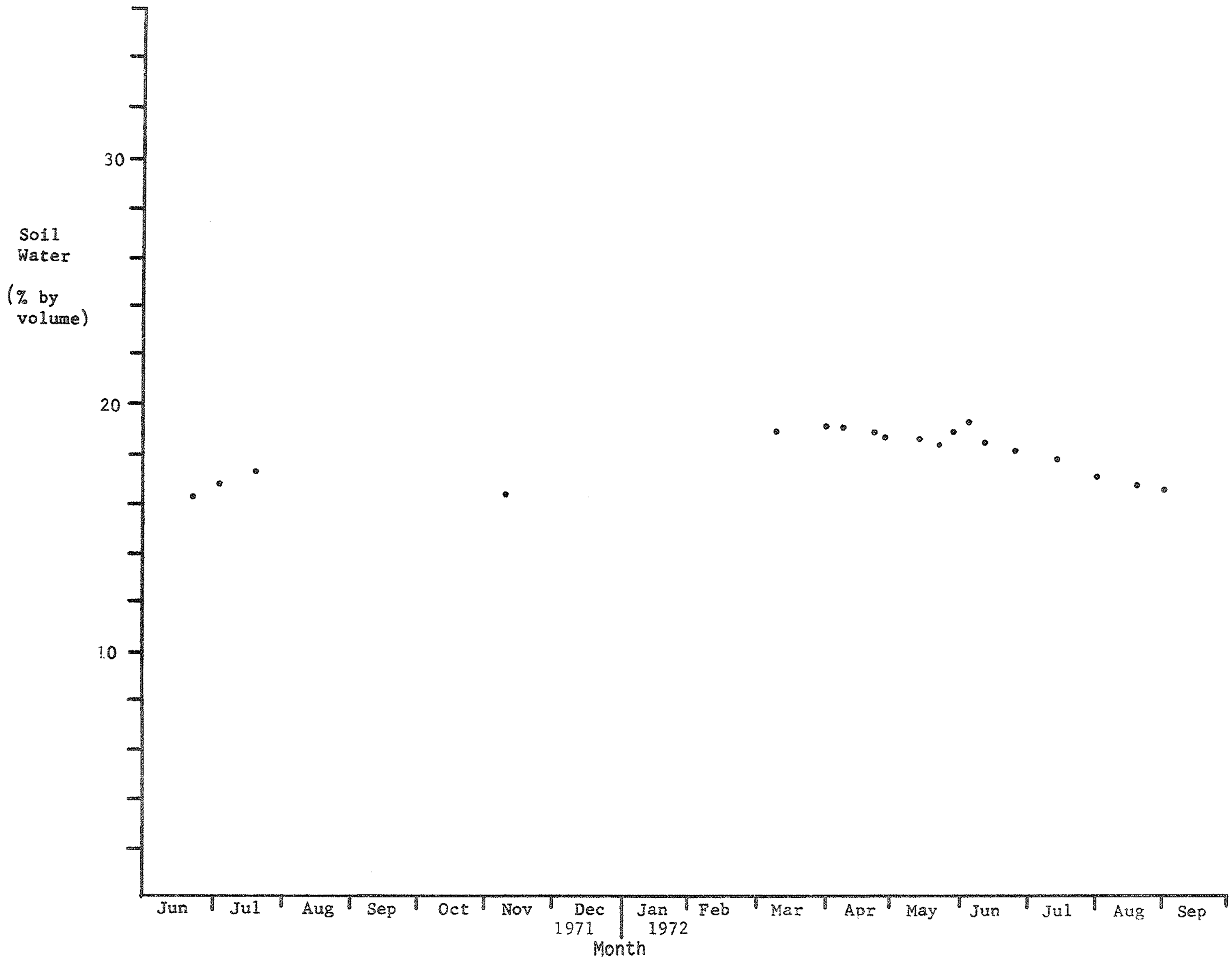

Figure 47. Soil moisture at 91 cm depth on southern sites (neutron probe).

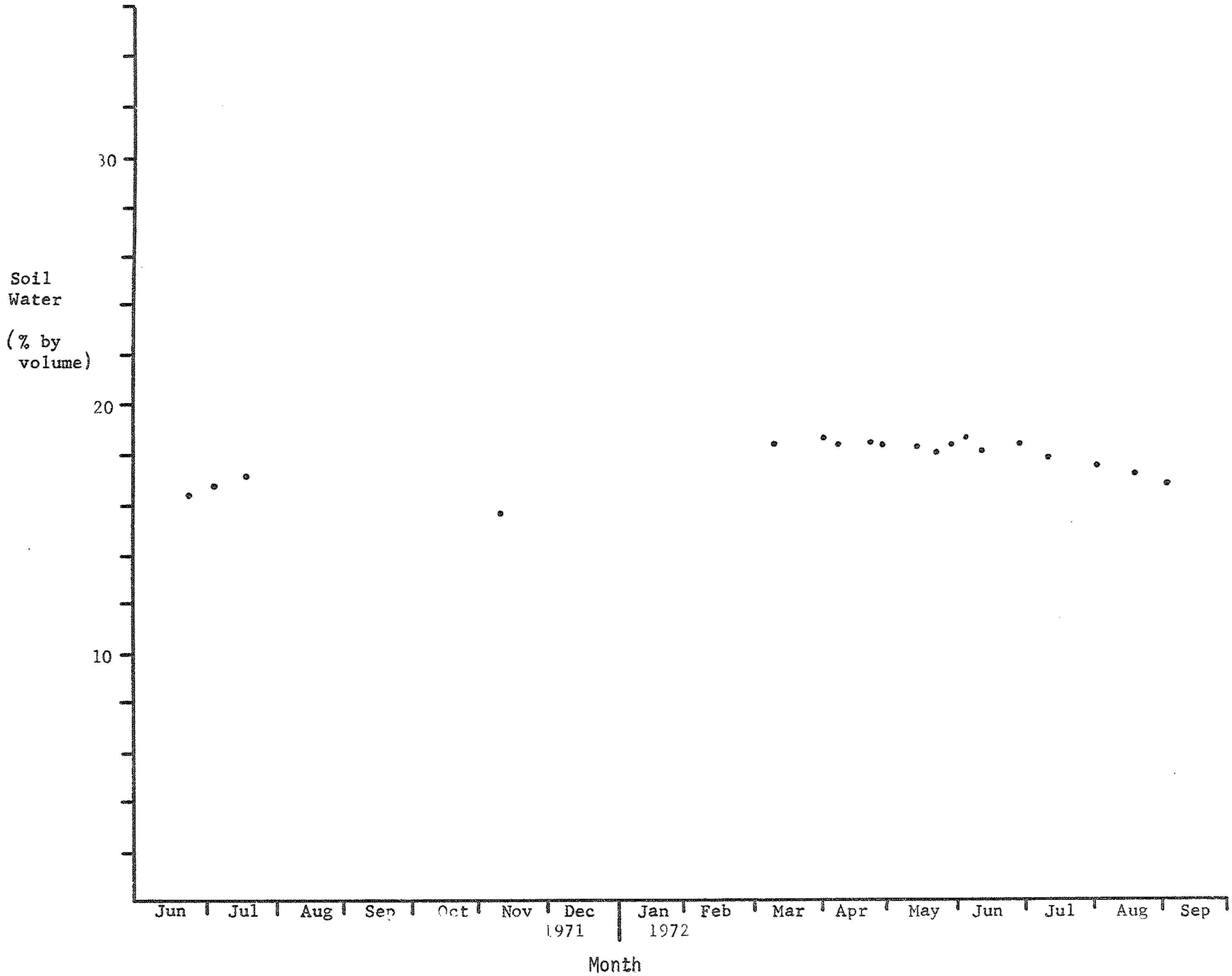

Figure 48. Soil moisture at 107 cm depth on southern sites (neutron probe).

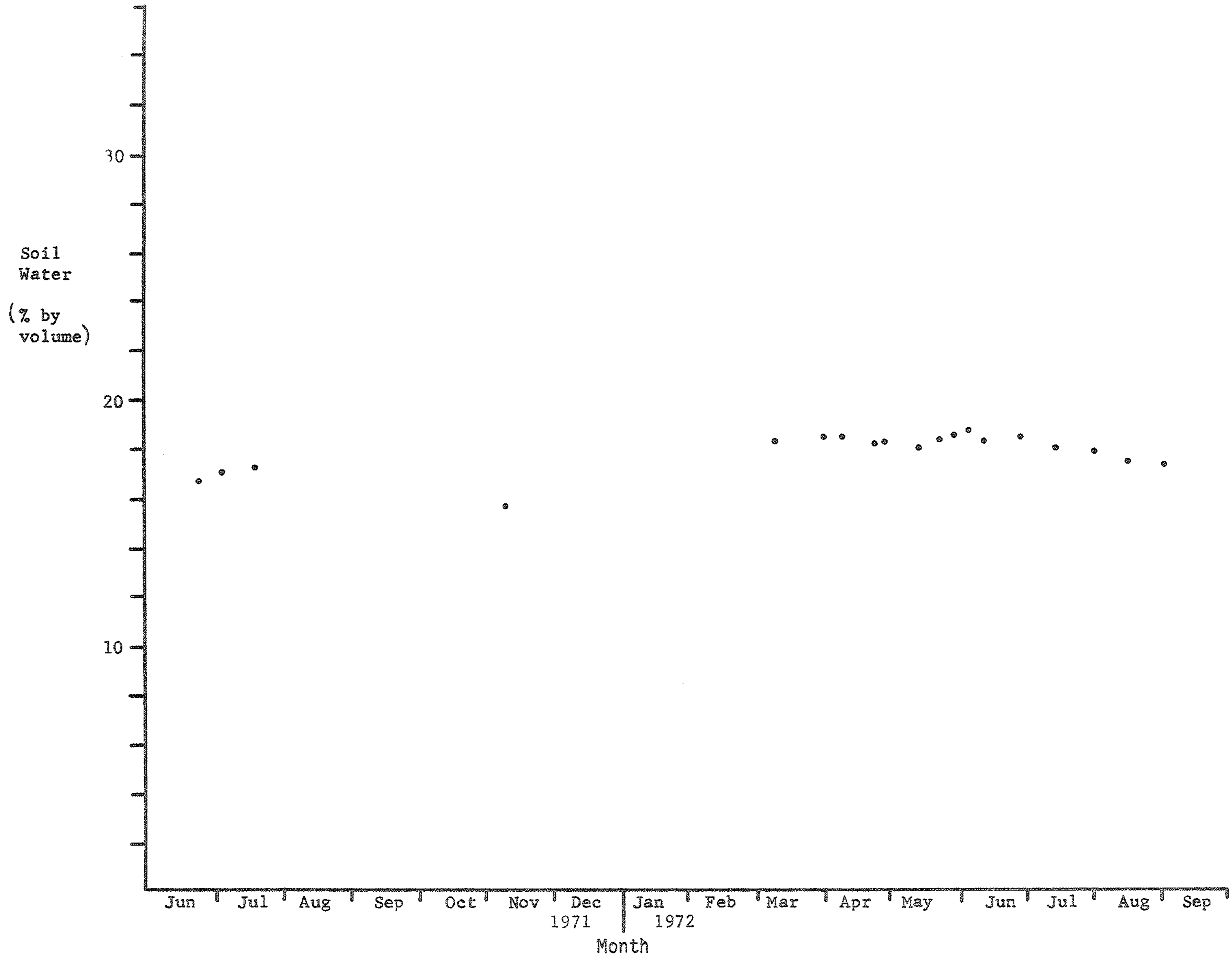

Figure 49. Soil moisture at 122 dm depth on southern sites (neutron probe).

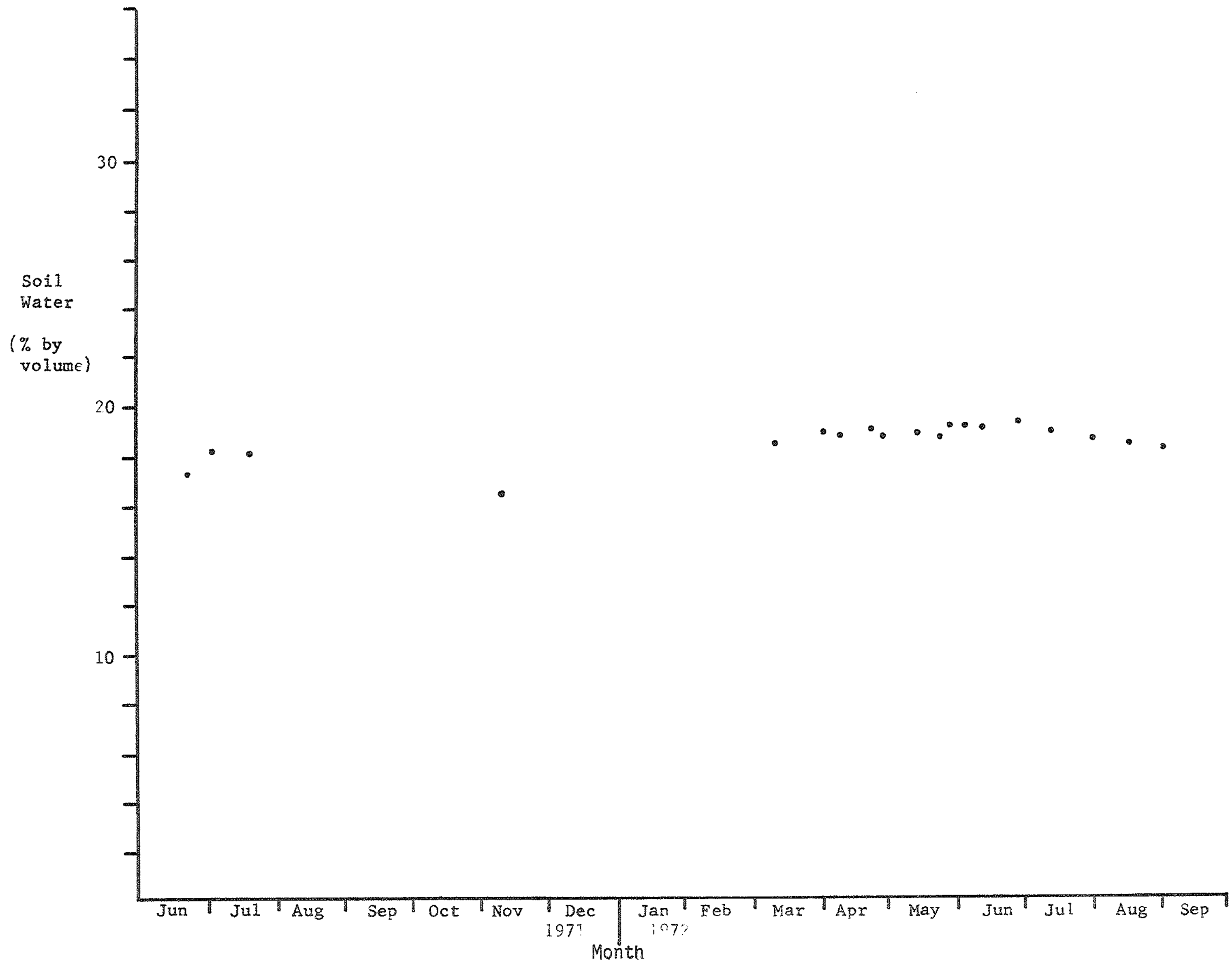

Figure 50. Soil moisture at 137 cm depth on southern sites (neutron probe).

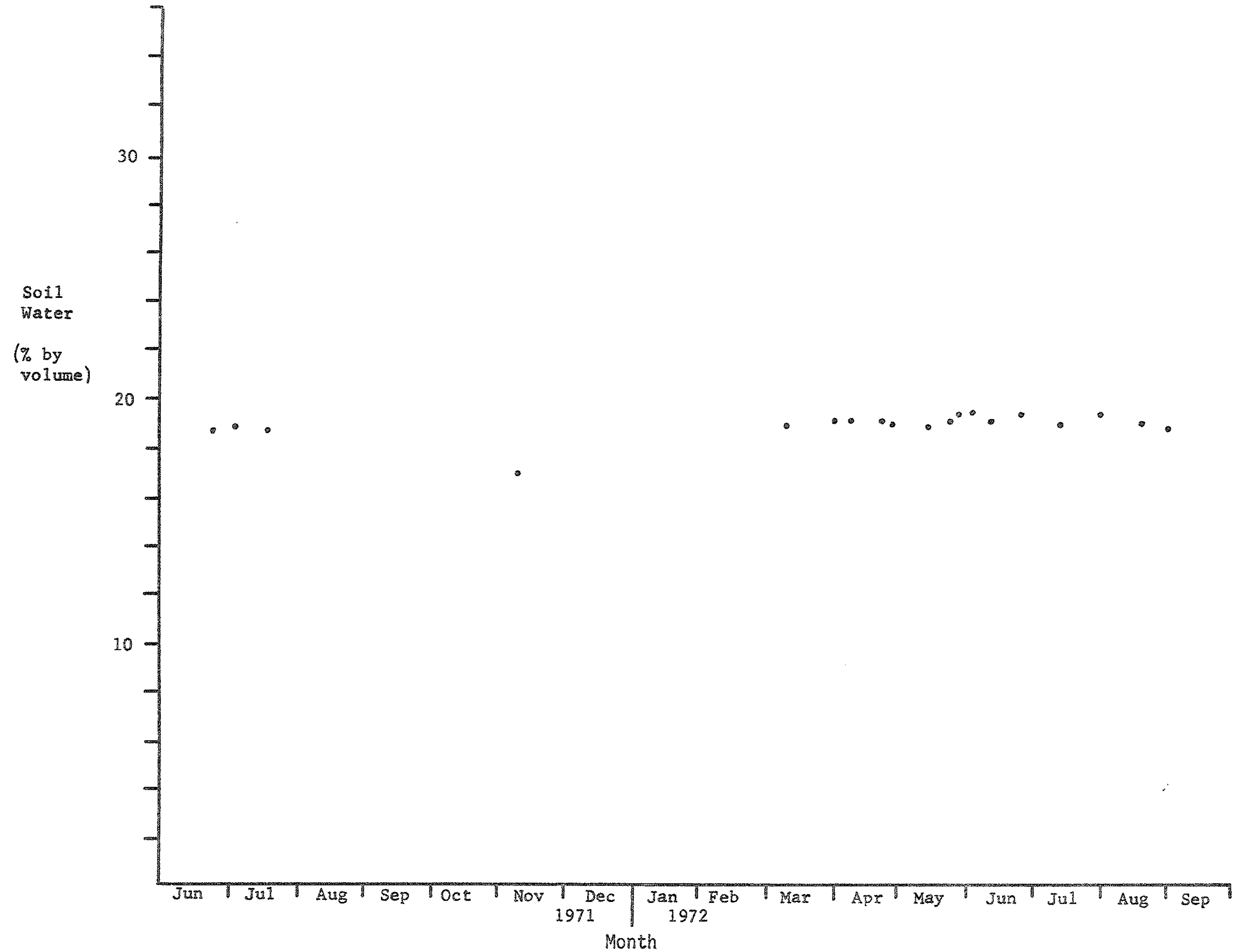

Figure 51. Soil moisture at 152 cm depth on southern sites (neutron probe).

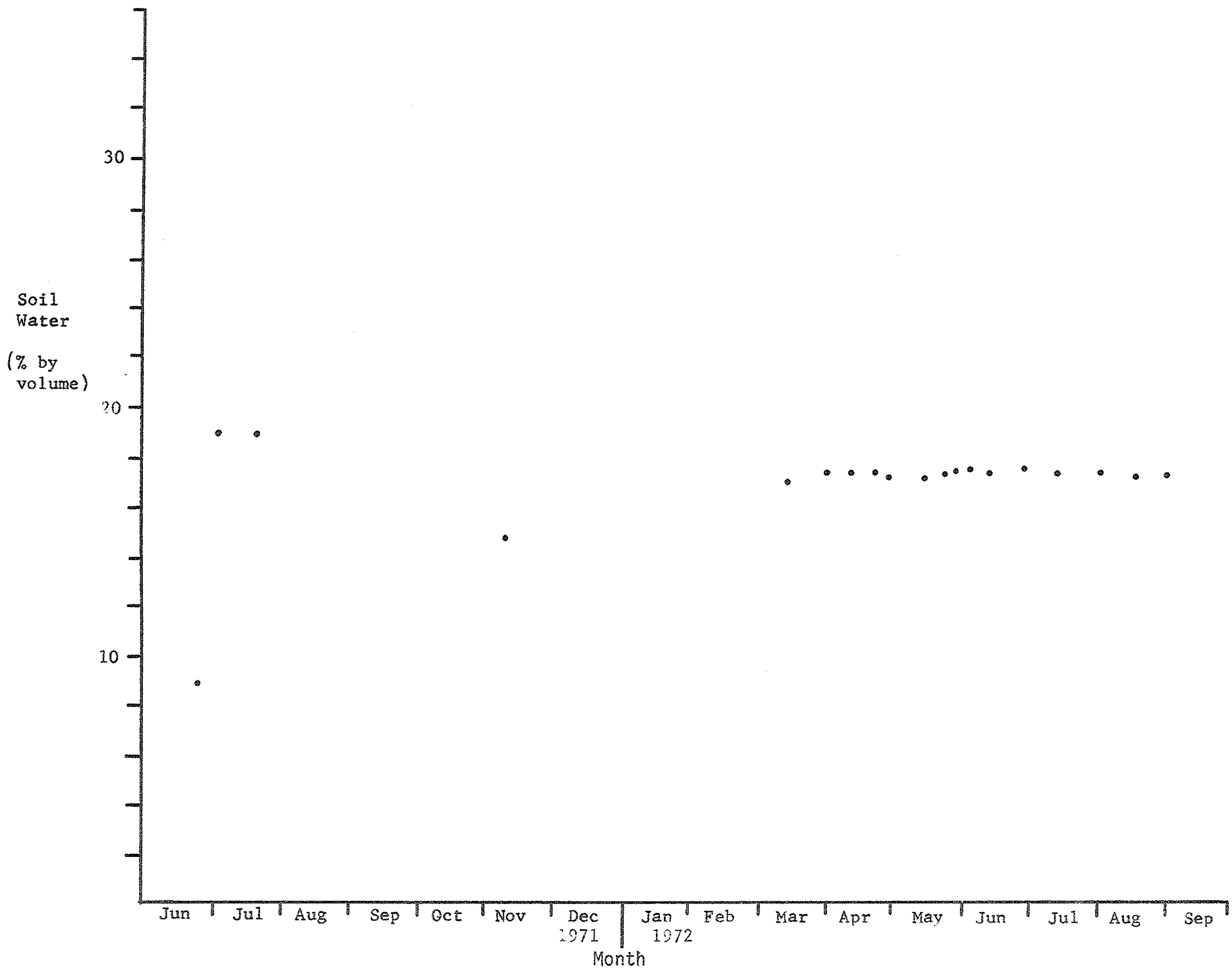

Figure 52. Soil moisture at 169 cm depth on southern sites (neutron probe).

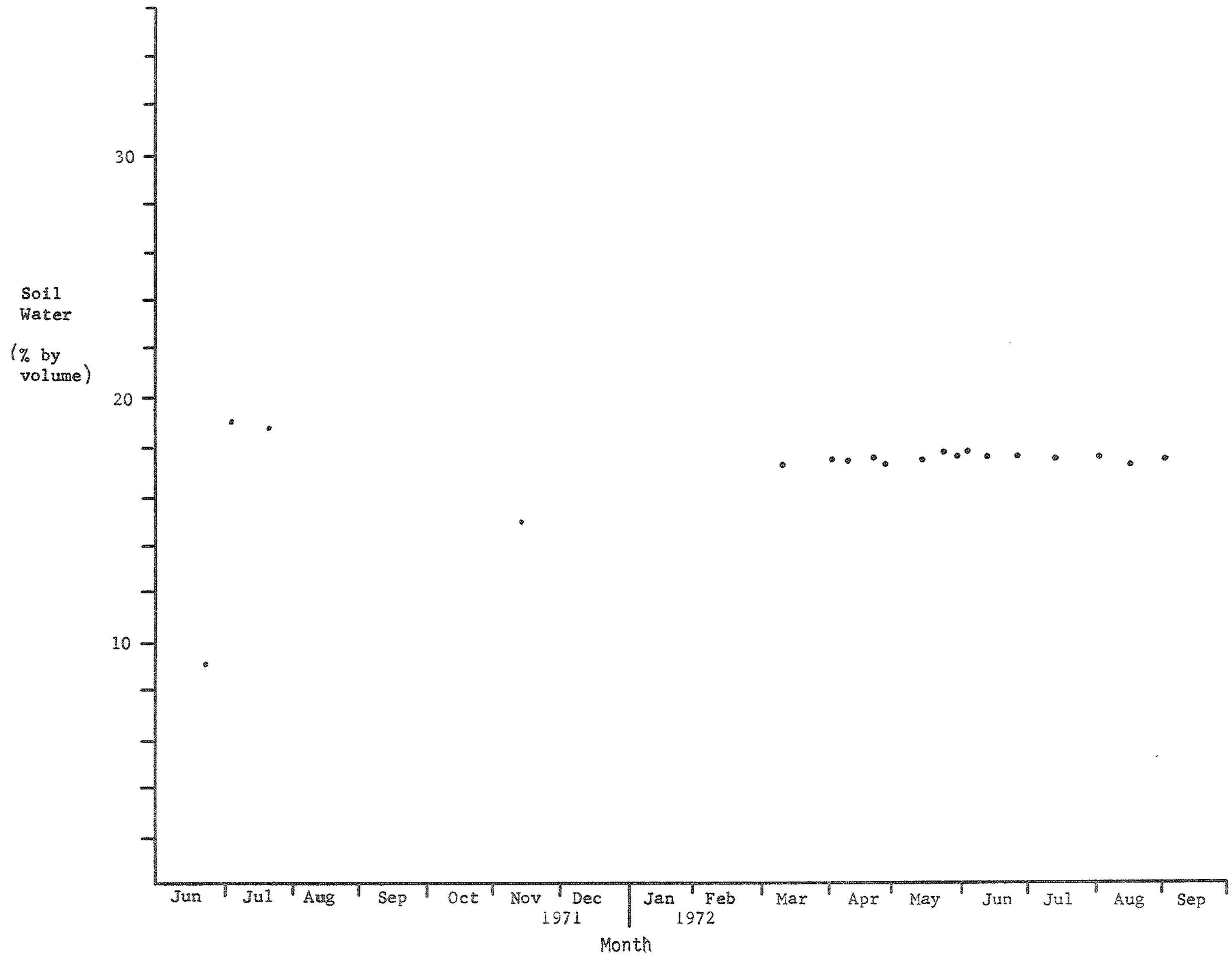

Figure 53. Soil moisture at 183 cm depth on southern sites (neutron probe).

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).

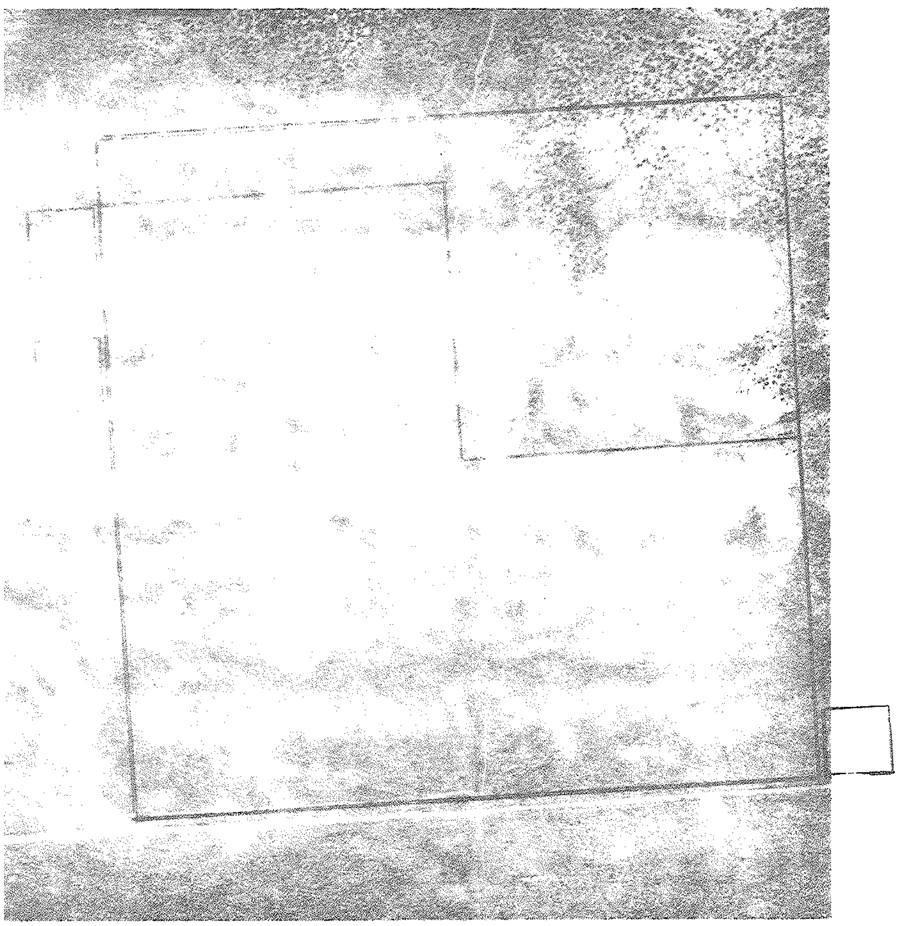

Figure 1. Aerial photo of northern shrub site including off-site destructive sampling areas (small squares).

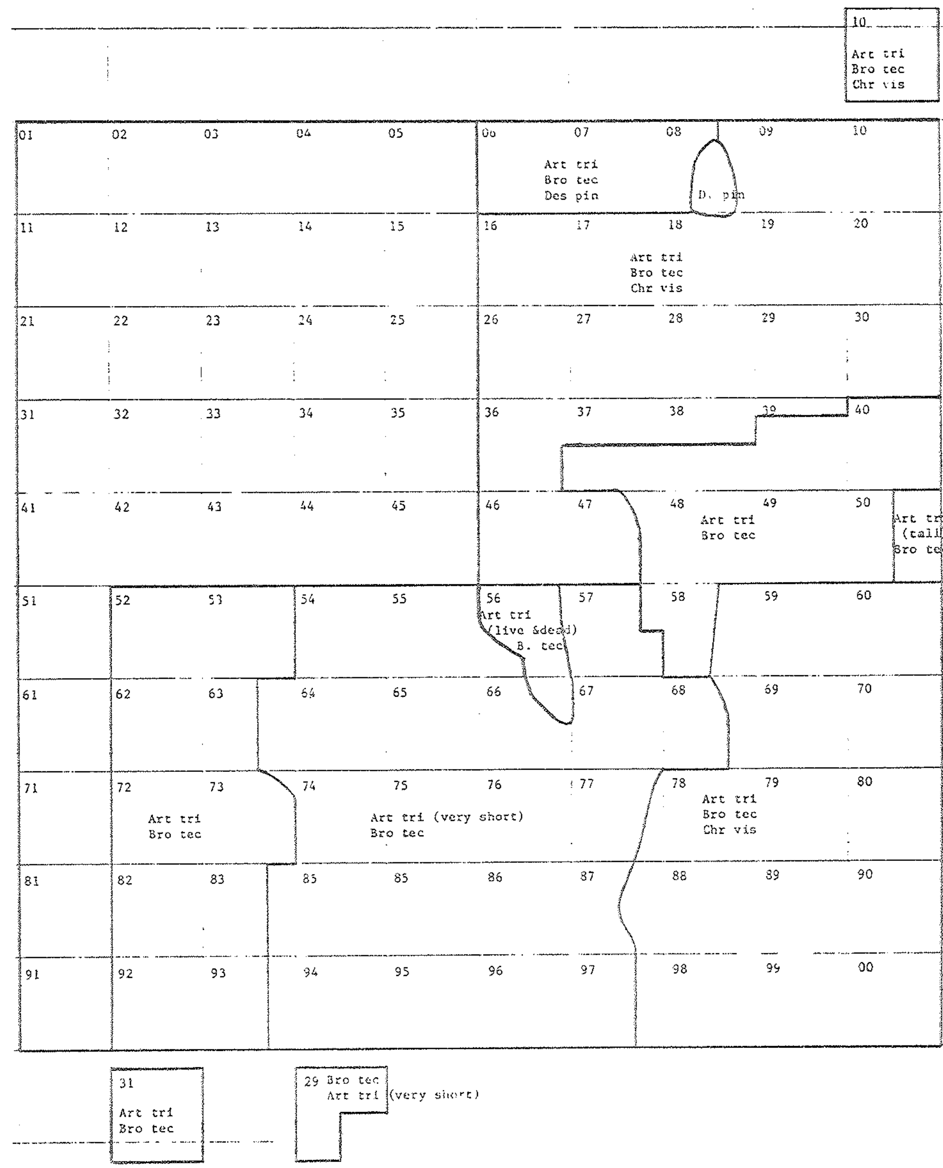

Figure 2. Hectare grid, dominant vegetation, and off-site sampling areas of northern shrub site.

Figure 3. Vegetation types of northern shrub site.

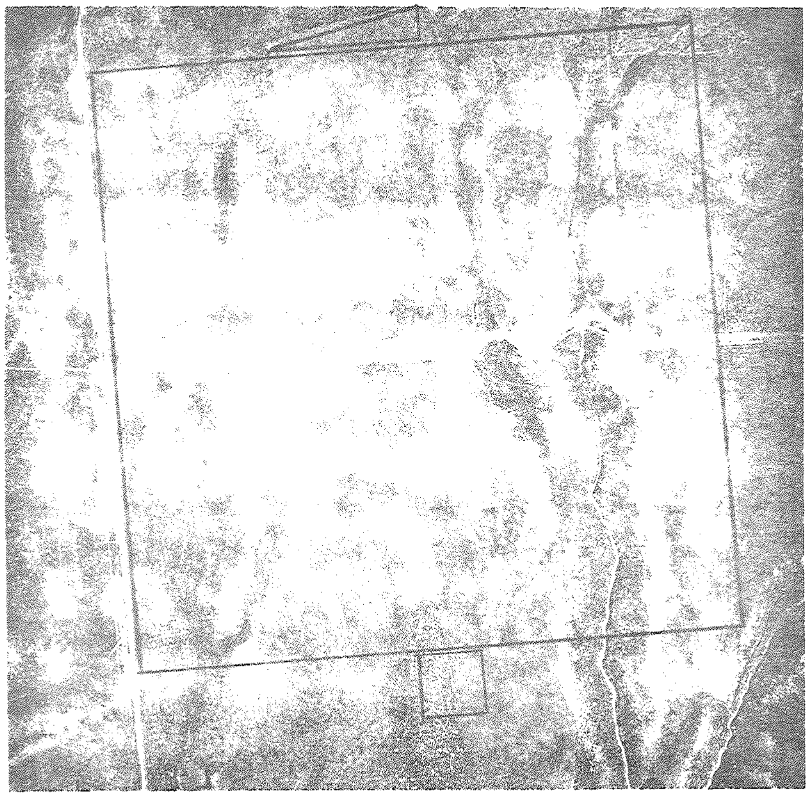

Figure 4. Aerial photo of northern crested wheatgrass site including off-site destructive sampling areas (small plots).

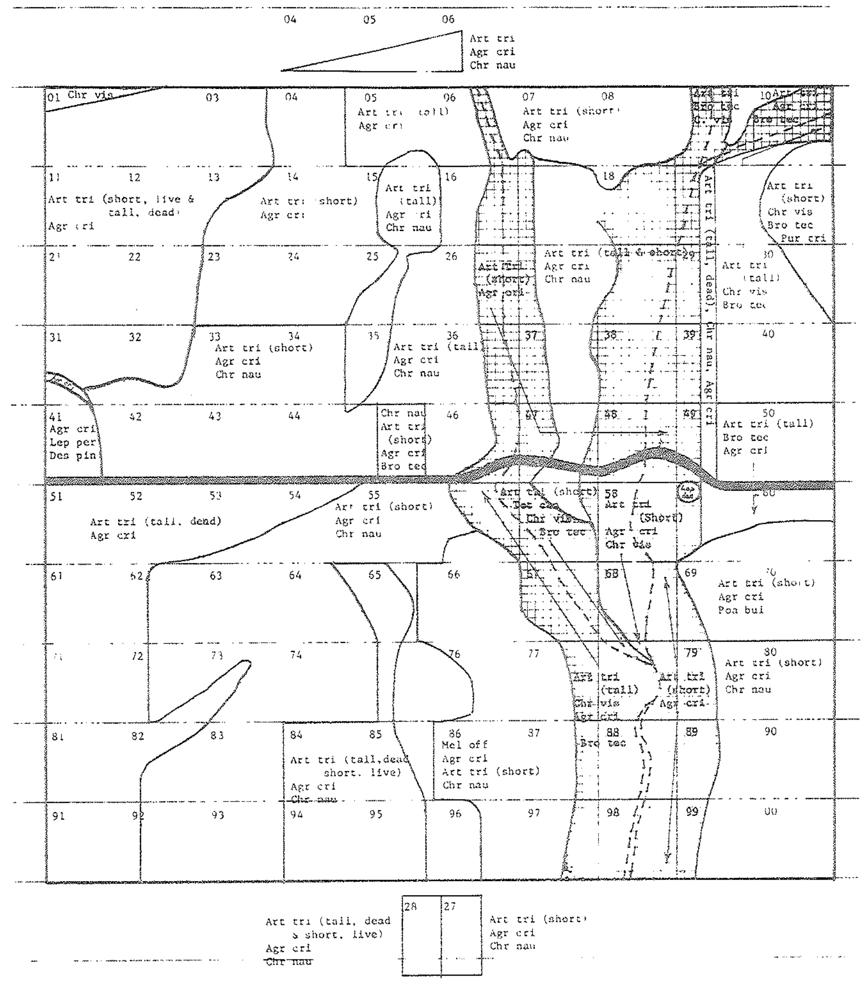

Figure 5. Hectare grid, dominant vegetation and off-site sampling of northern crested wheatgrass site. Area of gullies show in hatching.

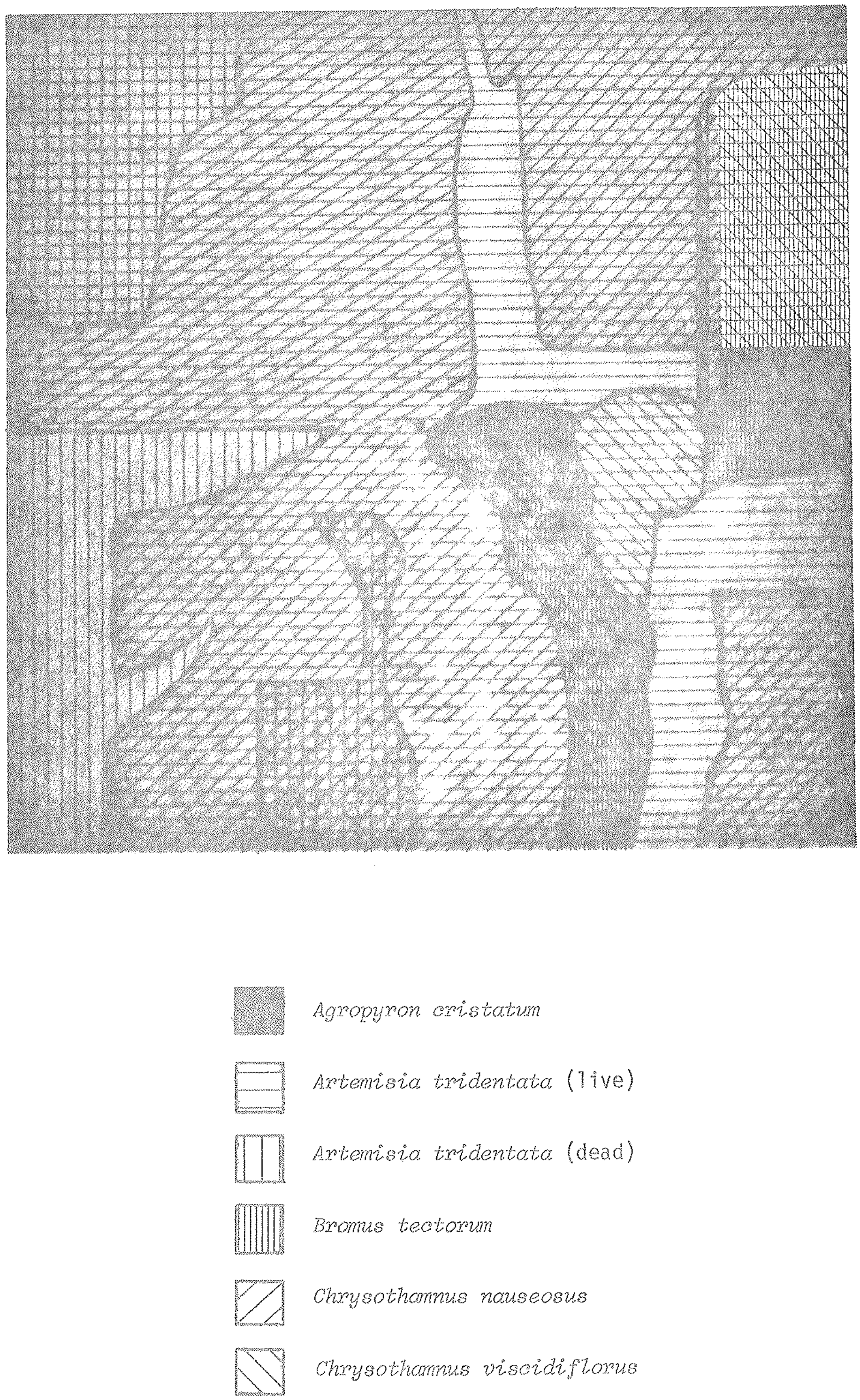

Figure 6. Dominant vegetation on the northern crested wheatgrass site.

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).

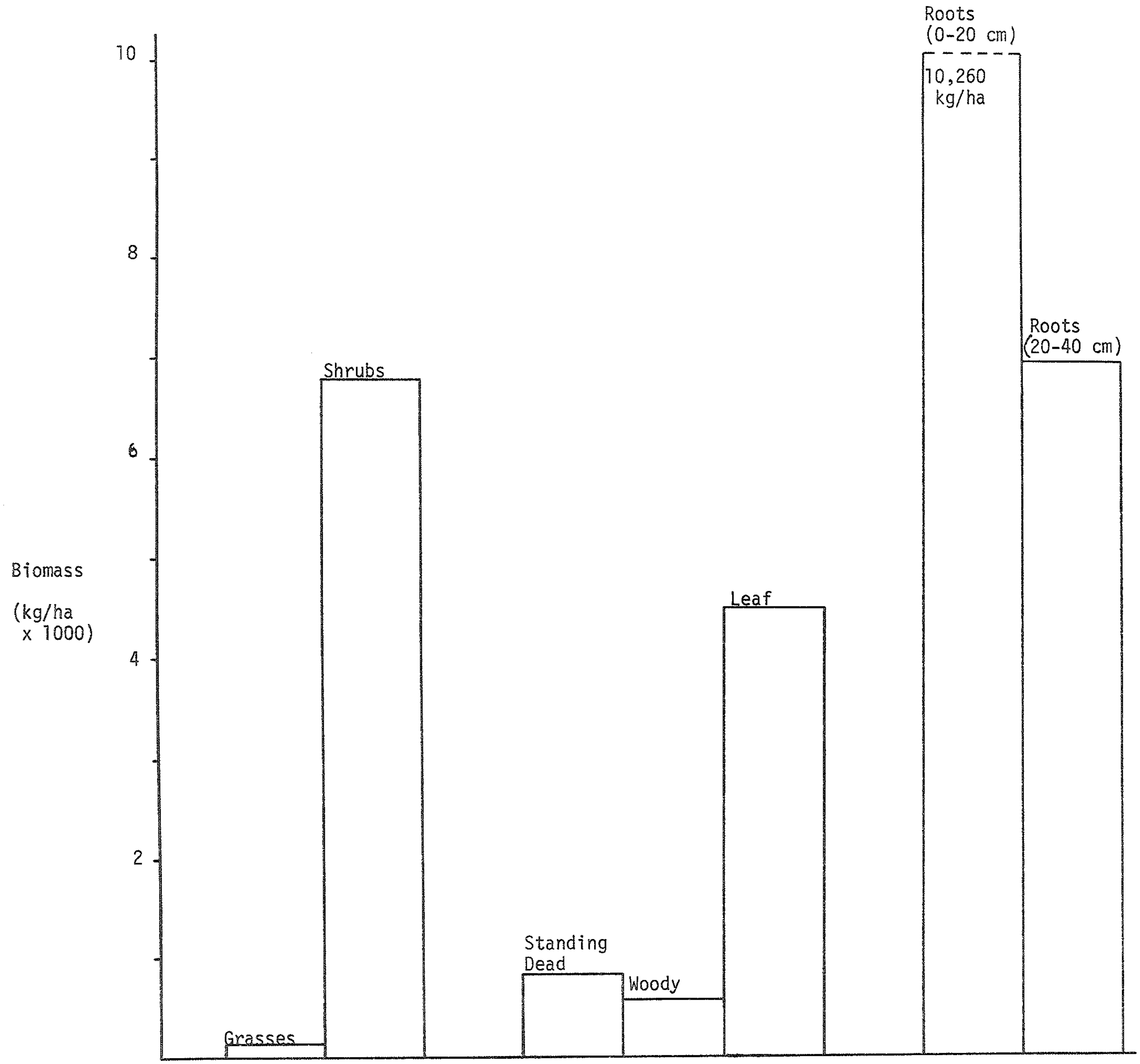

Figure 7. Biomass of plant components, northern shrub site, August 1971.

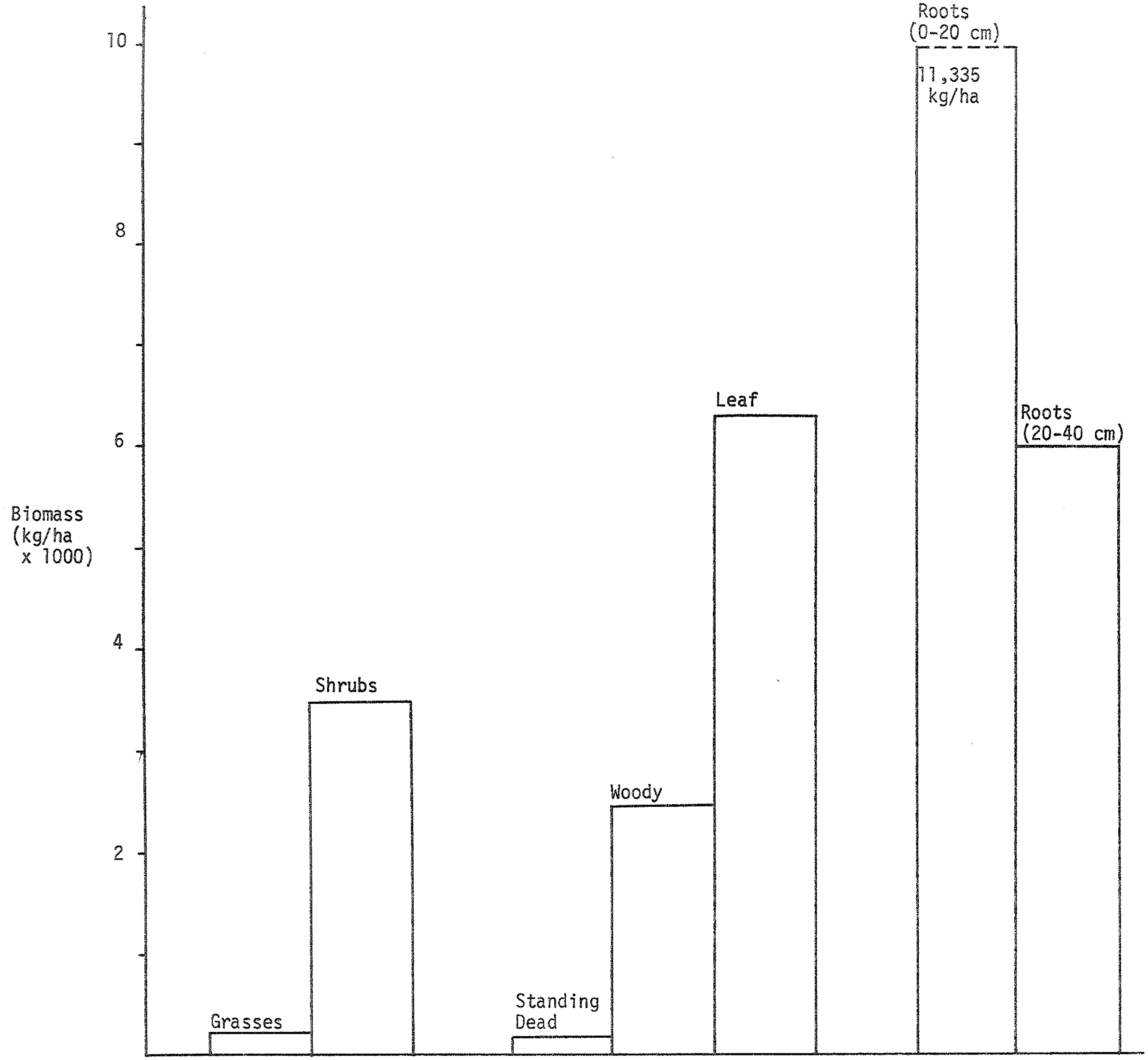

Figure 8. Biomass of plant components, nrothern crested wheat grass site, August 1971.

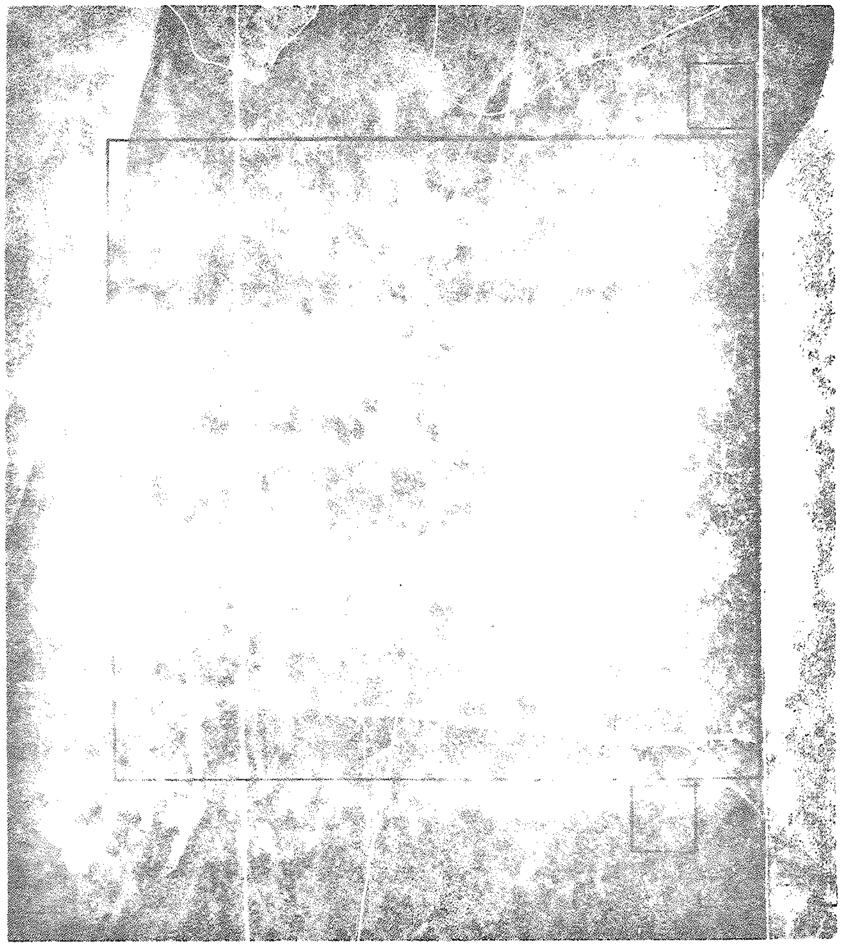

Figure 9. Aerial photo of southern shrub site including off-site destructive sampling areas (small squares).

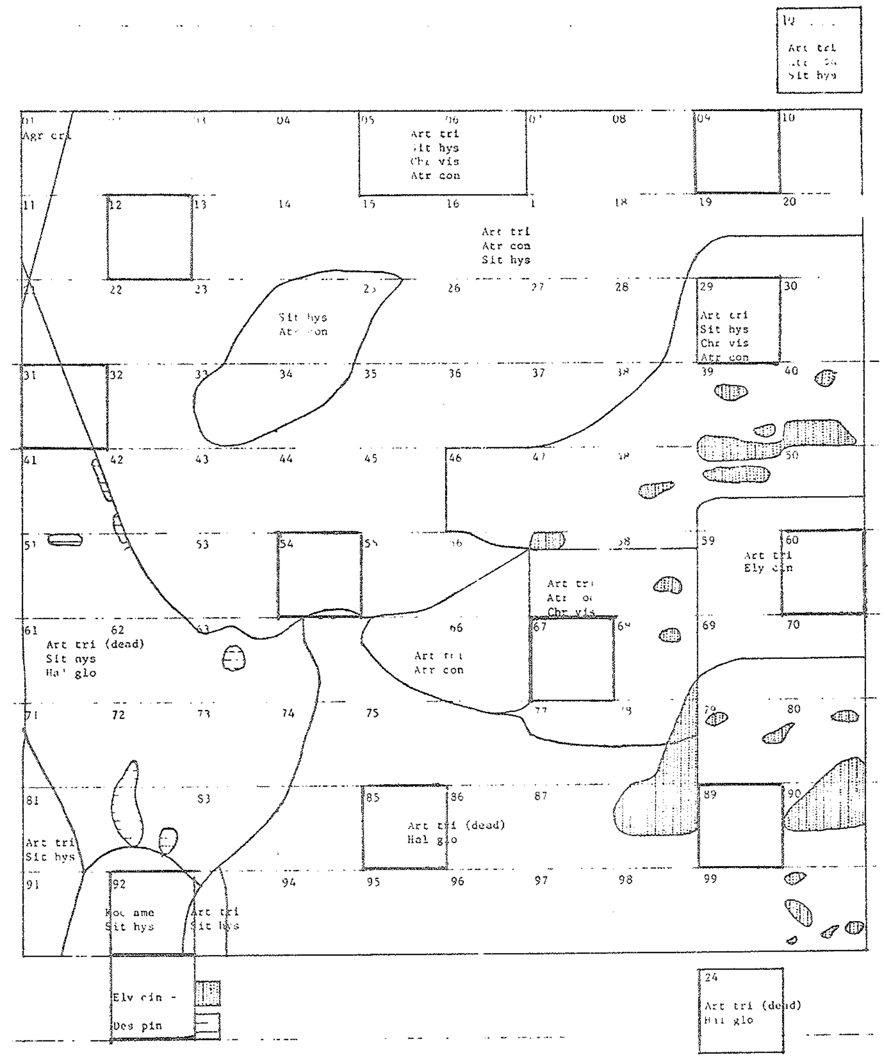

Figure 10. Hectare grid, dominant vegetation and sampling areas, southern shrub site.

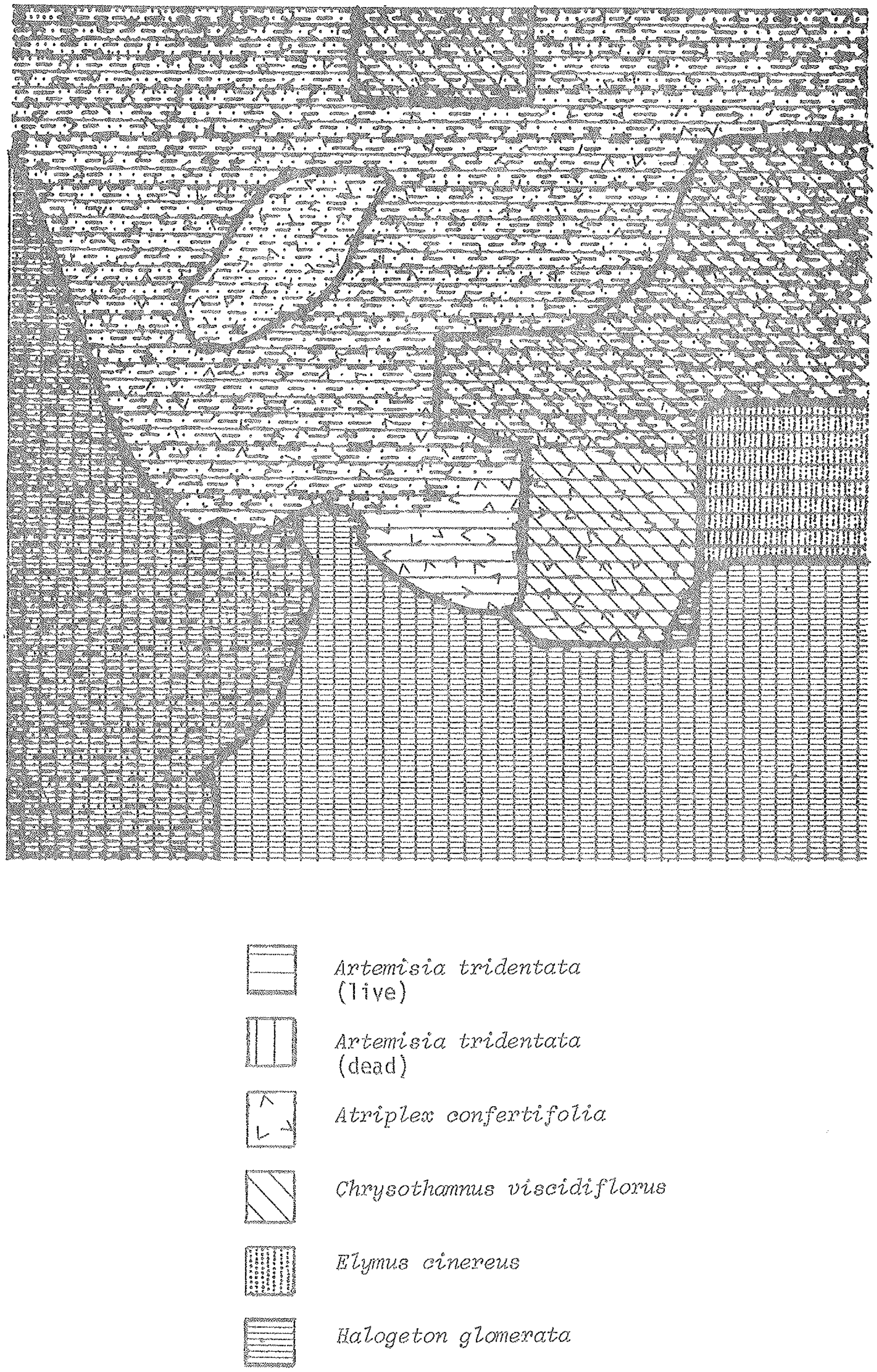

Figure 11. Dominant plants on the southern shrub site.

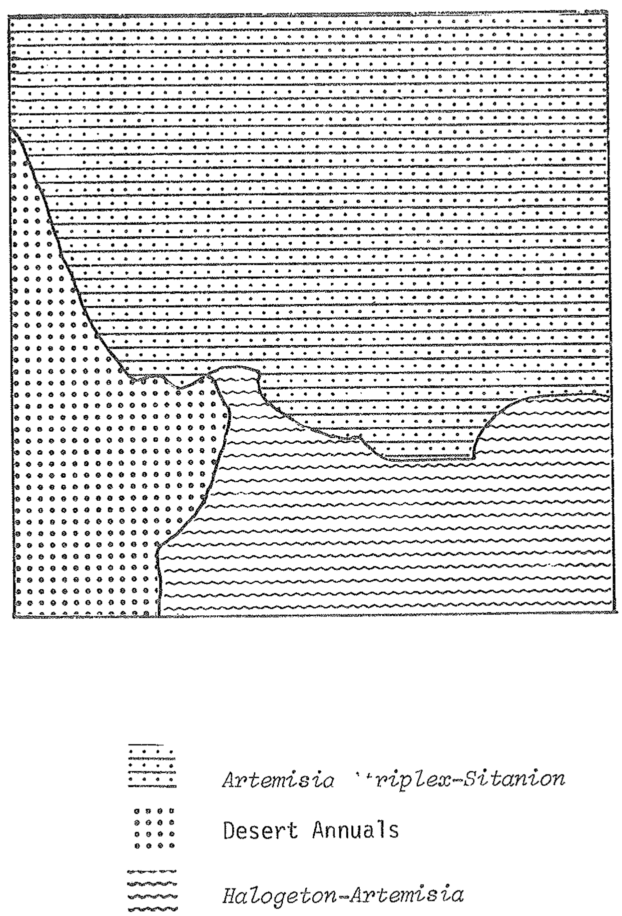

Figure 12. Vegetation map of the major vegetation types on the southern shrub site.

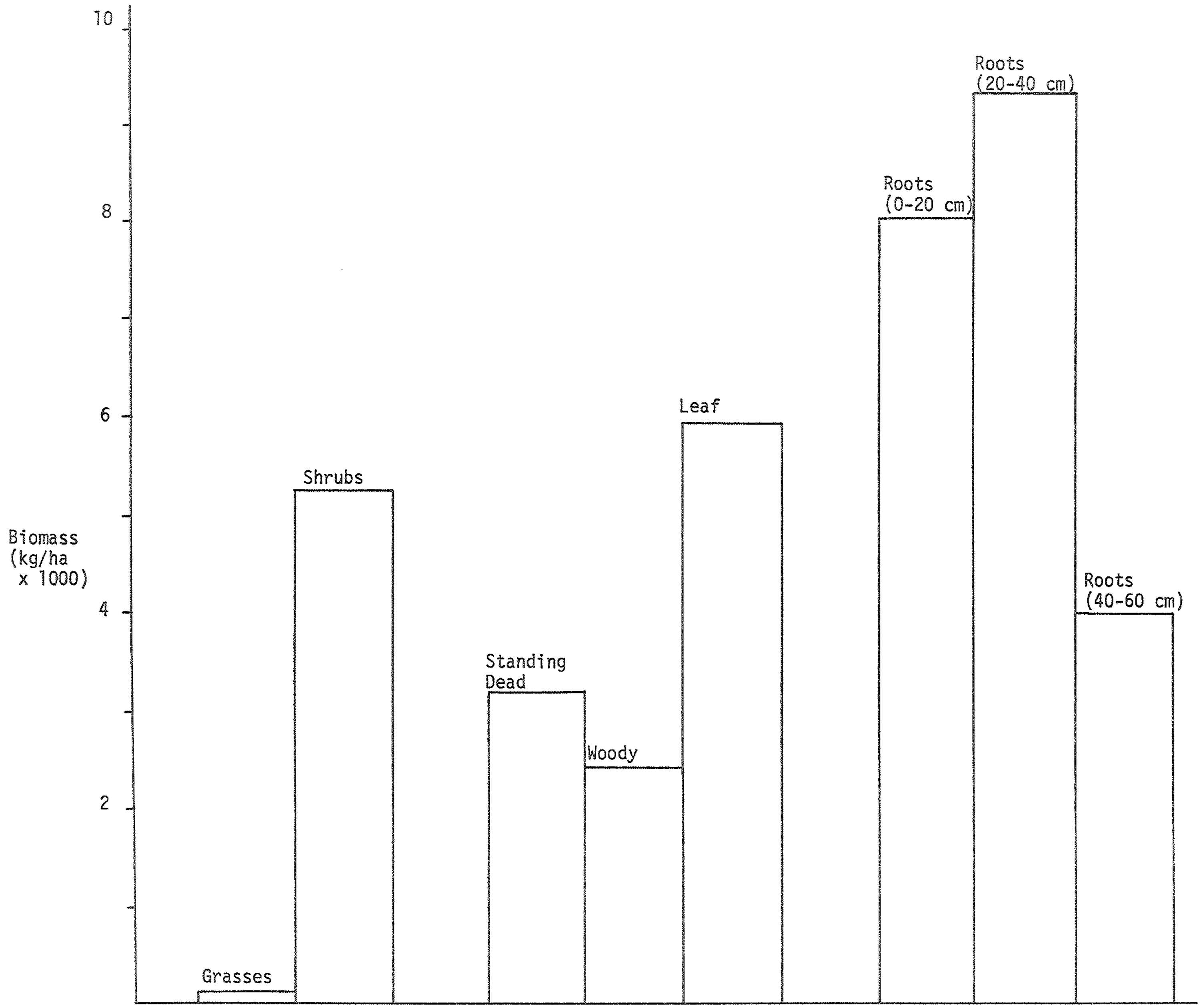

Figure 13. Components of plant biomass in the Art-Atr-Sit vegetation type of shrub site, August 1971.

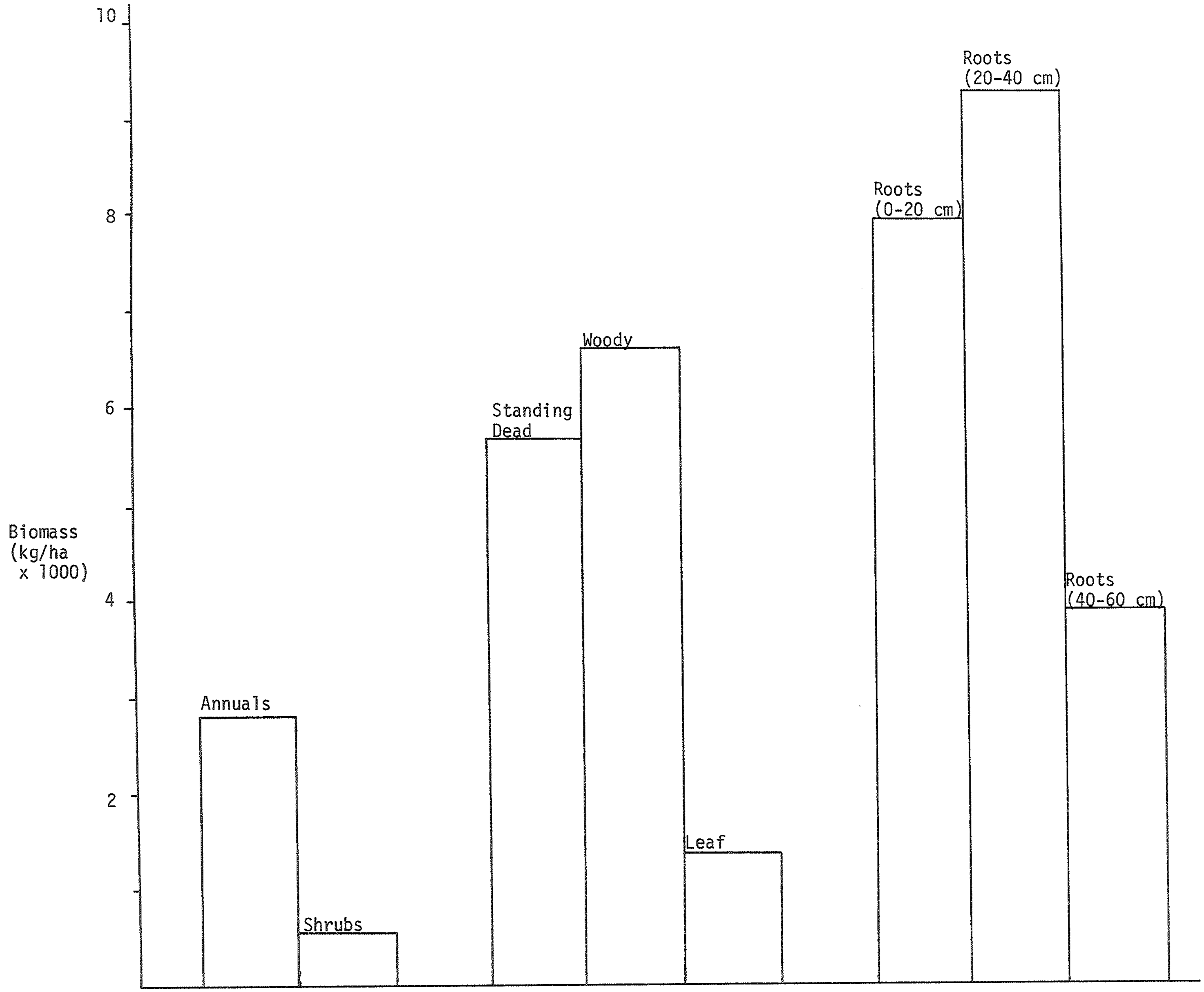

Figure 14. Components of plant biomass in Hal-Art vegetation type of southern shrub site, August 1971.

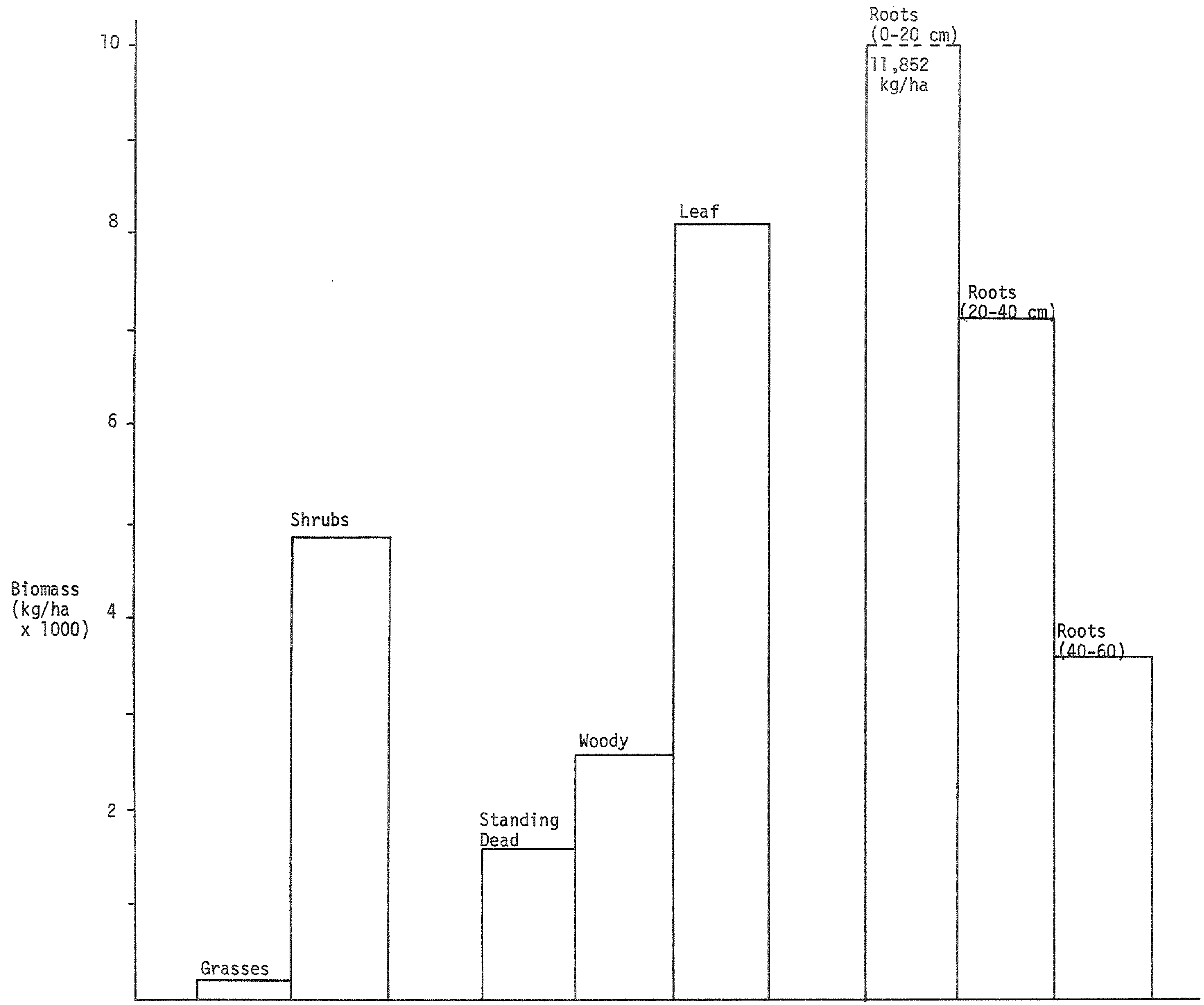

Figure 15. Components of plant biomass in Art-Atr-Sit vegetation type, southern shrub site, August 1972.

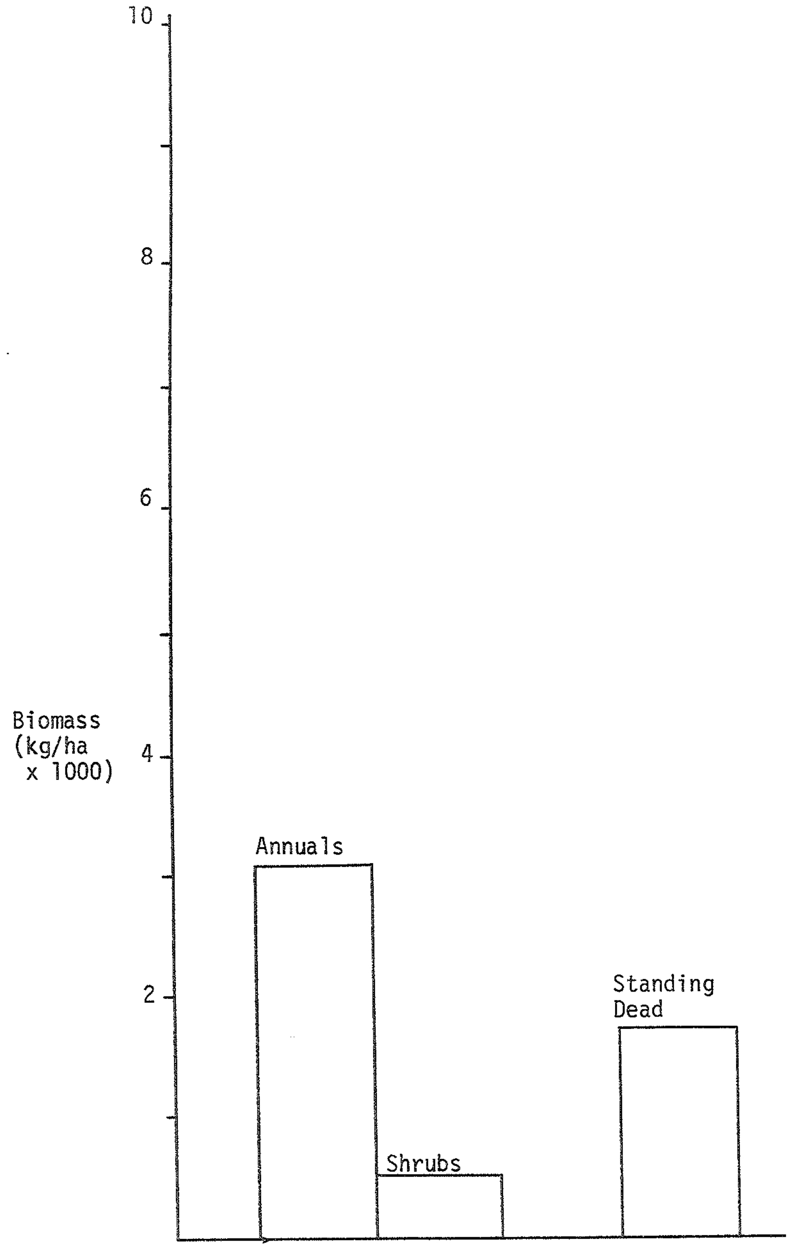

Figure 16. Components of plant biomass in Hal-Art vegetation type, southern shrub site, August 1972.

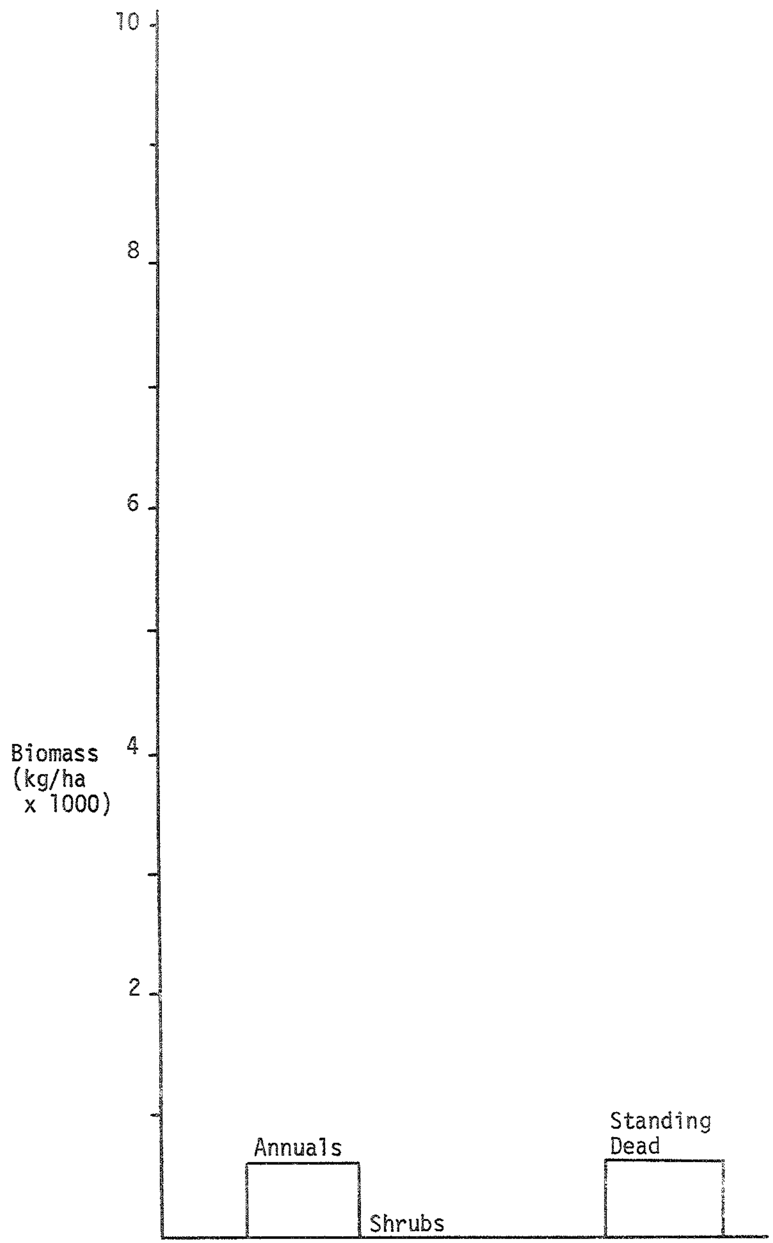

Figure 17. Components of plant biomass in Annuals vegetation type, southern shrub site, August, 1972.

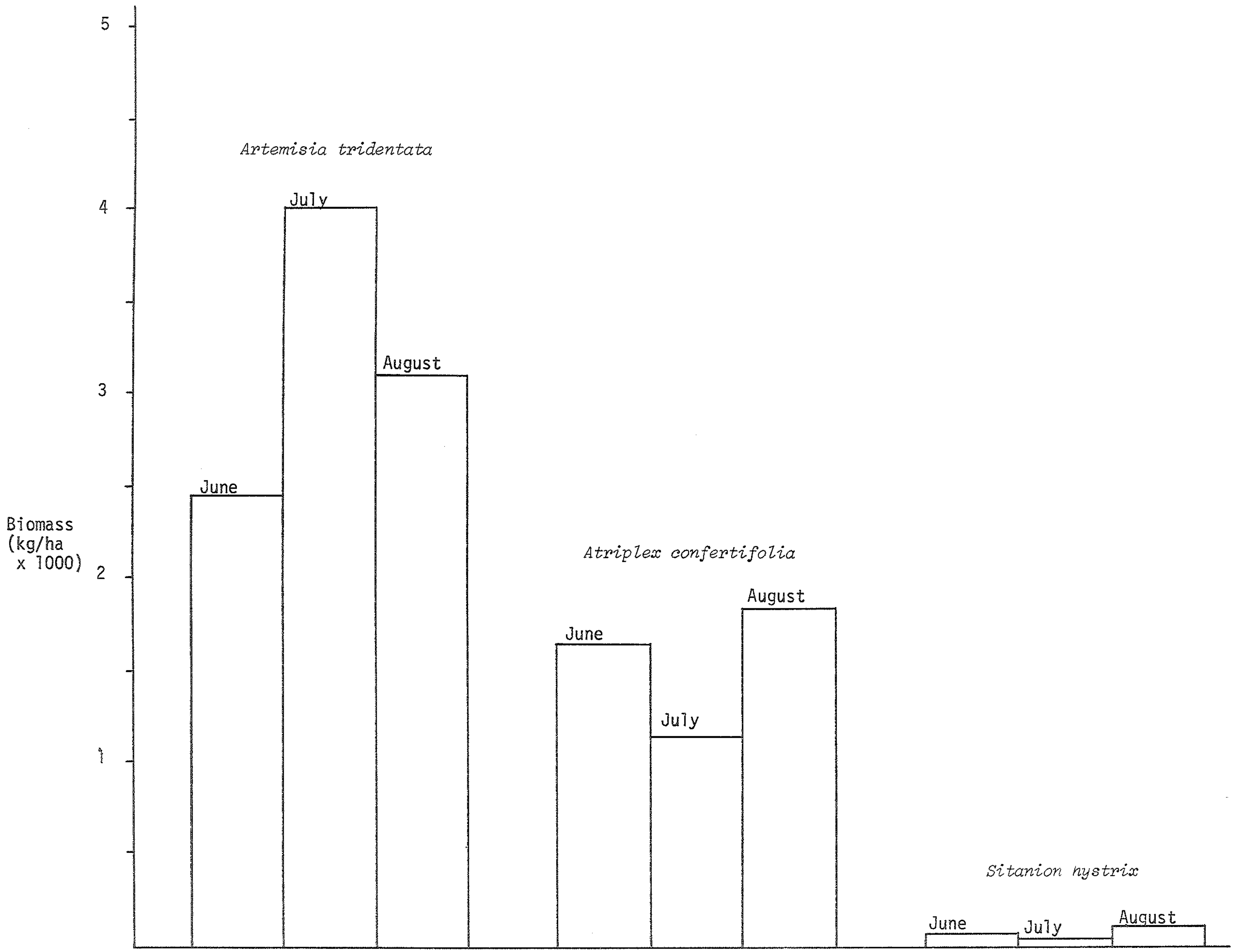

Figure 18. Above ground plant biomass in Art-Atr-Sit vegetation type, southern shrub site, June, July, and August, 1972.

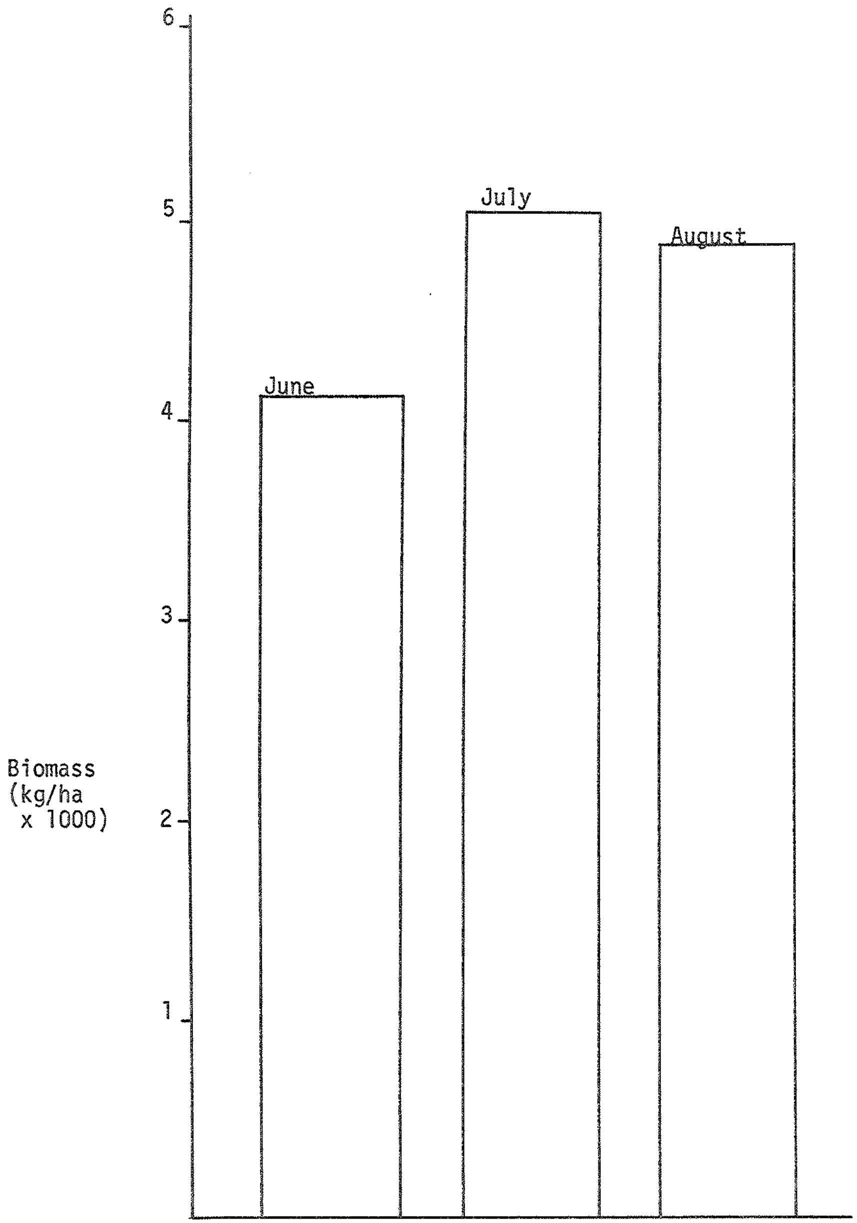

Figure 19. Total above ground biomass in Art-Atr-Sit vegetation type, southern shrub site, June, July, and August, 1972.

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).

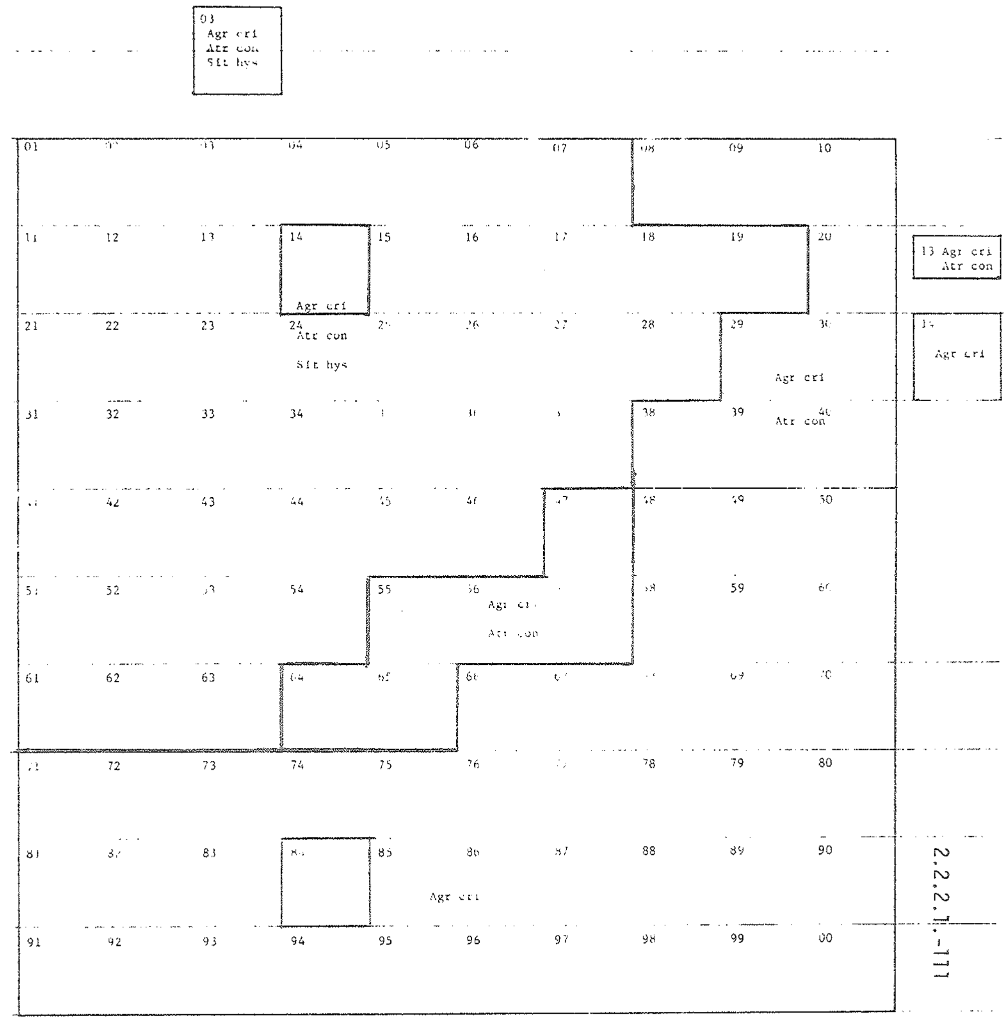

Figure 21. Hectare grid, dominant vegetation of southern sites.

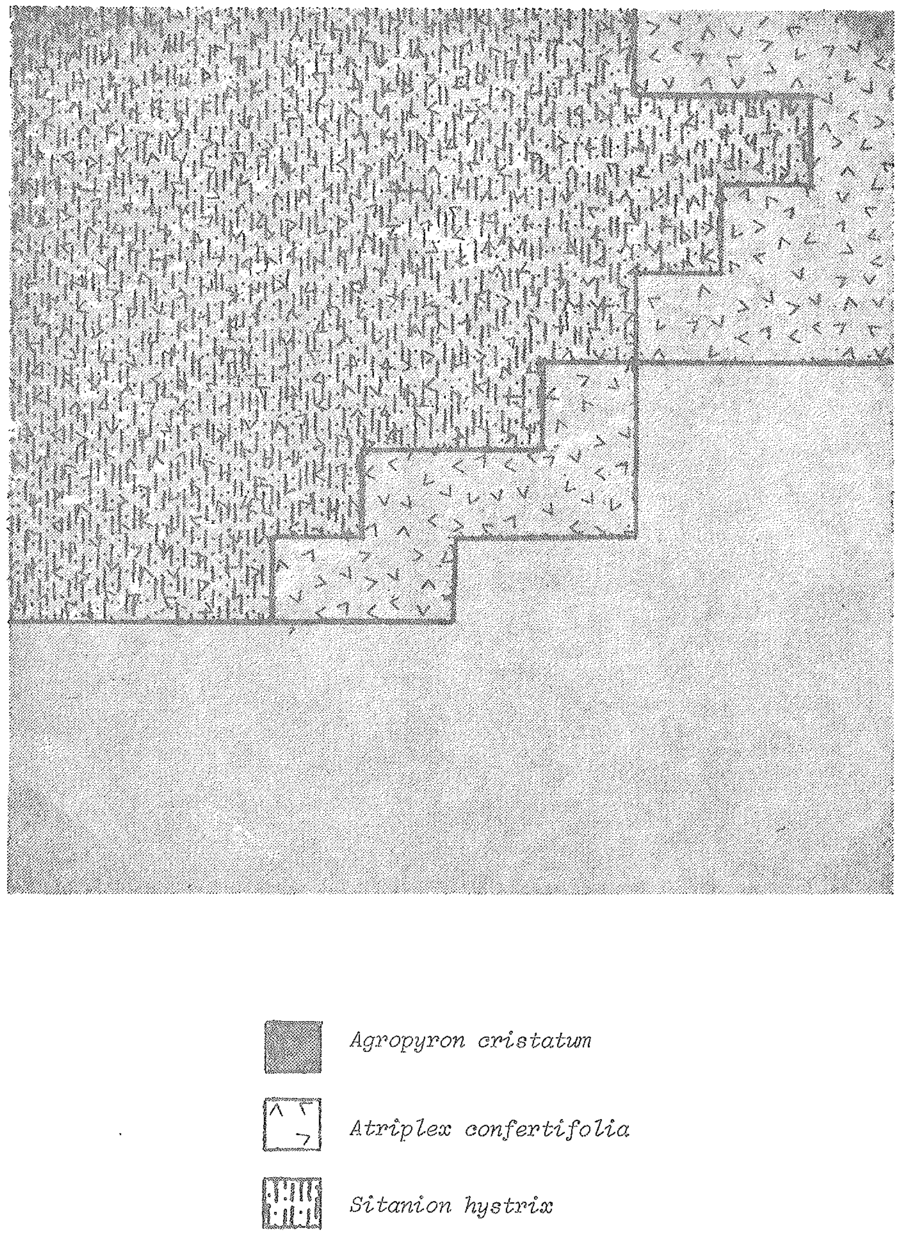

Figure 22. Dominant plants on the southern grass site.

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

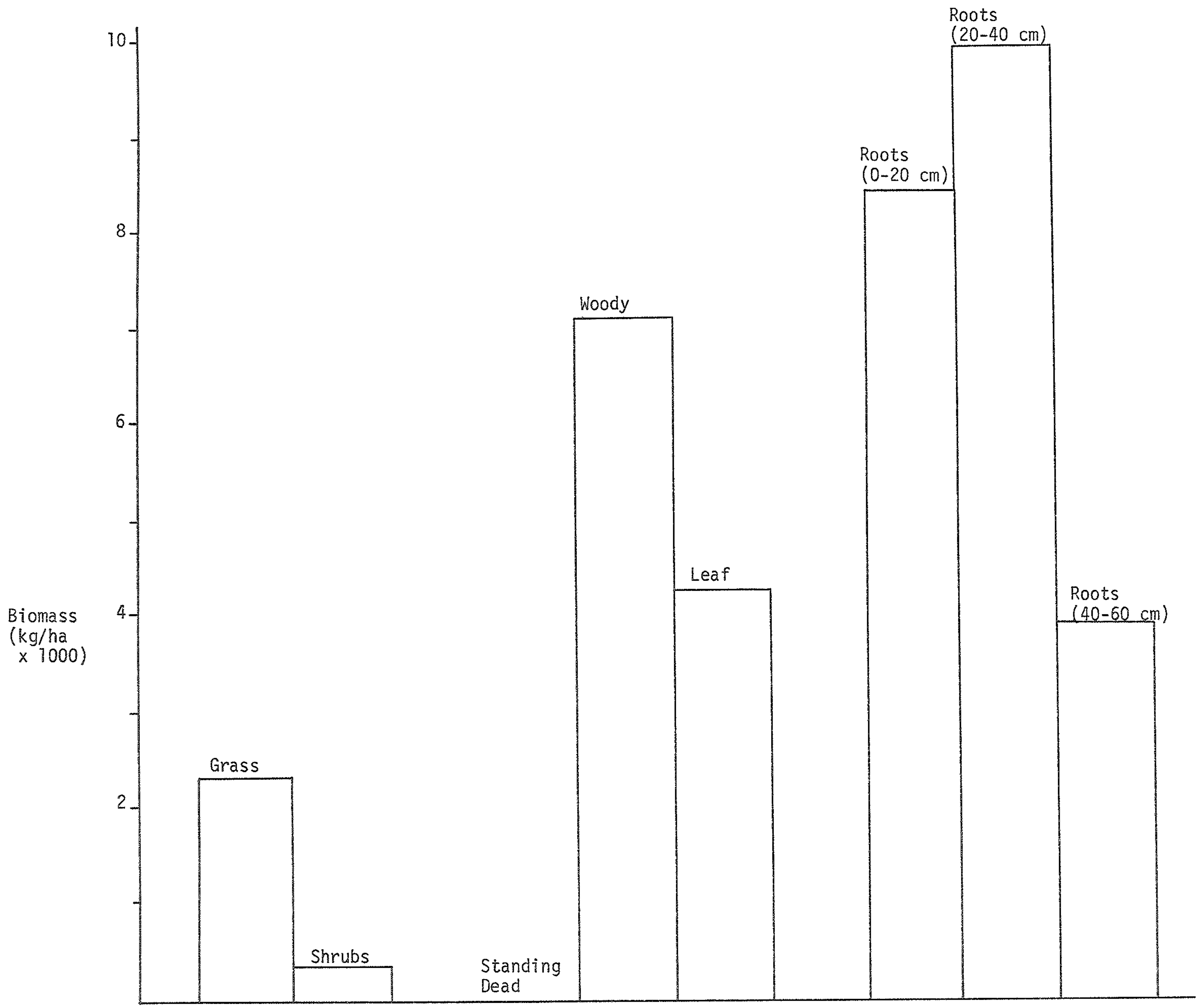

Figure 23. Components of plant biomass, southern grass site, August, 1971.

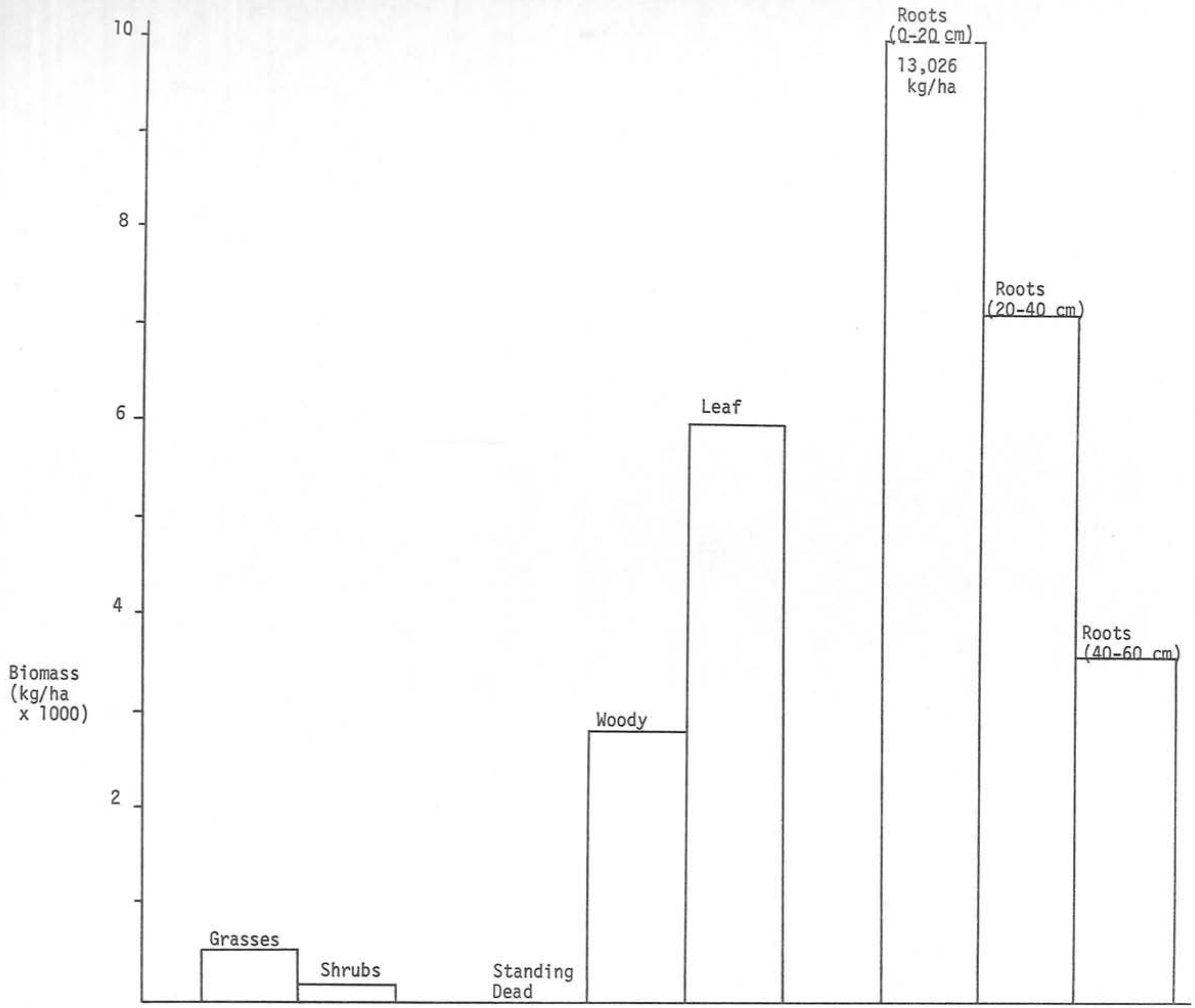

Figure 24. Components of plant biomass on southern grass site, August, 1972.

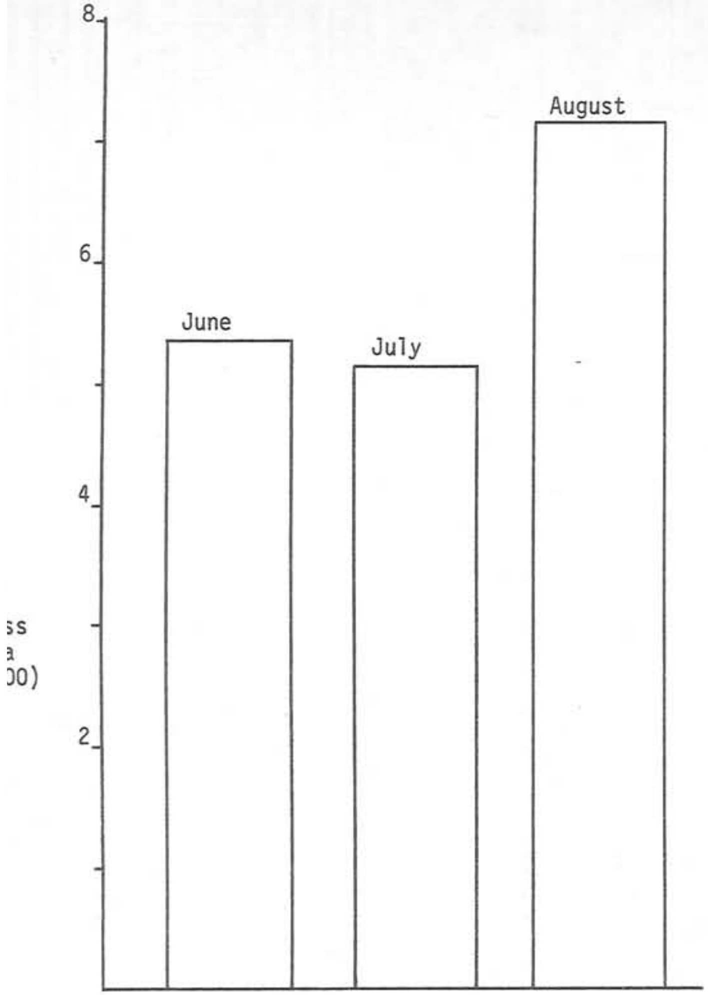

Figure 25. Above ground plant biomass on southern grass site in June, July, and August, 1972.

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

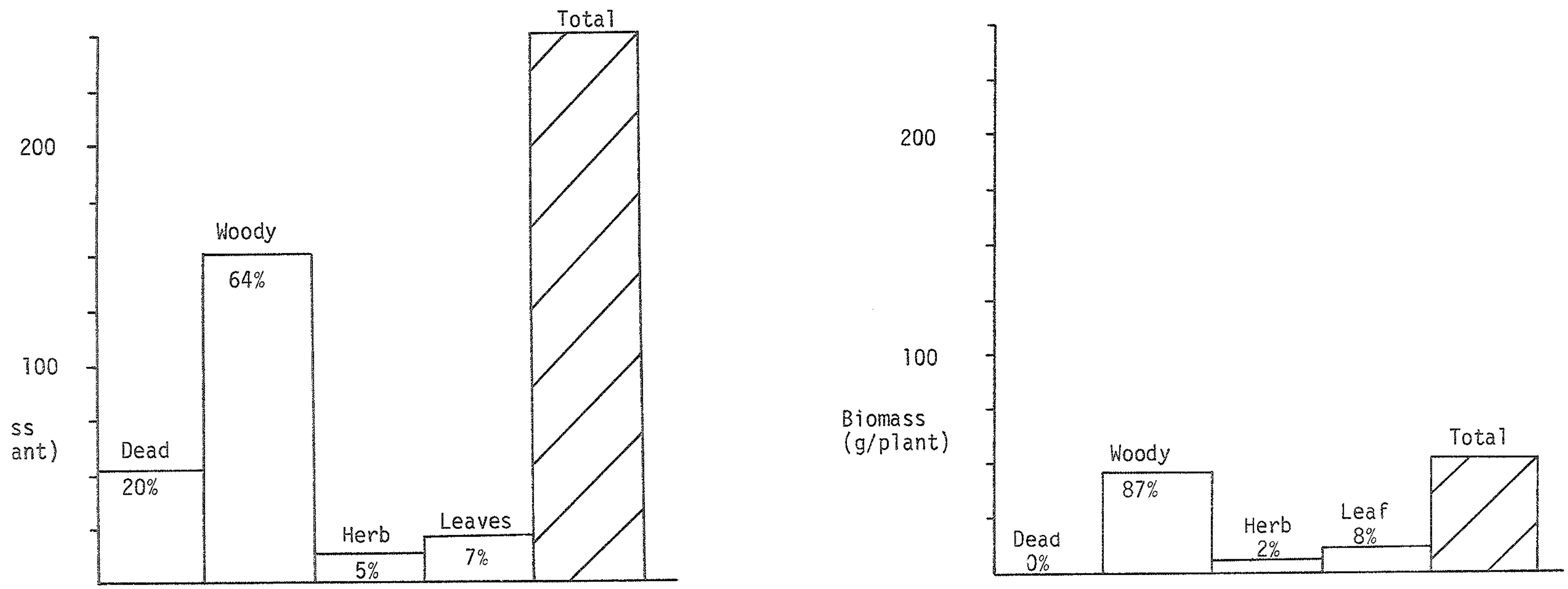

Figure 26. Measurements taken from 100 *Artemisia tridentata* and 300 *Atriplex confertifolia* plants on southern shrub site. (samples taken from off-site hectare 10, summer, 1972).

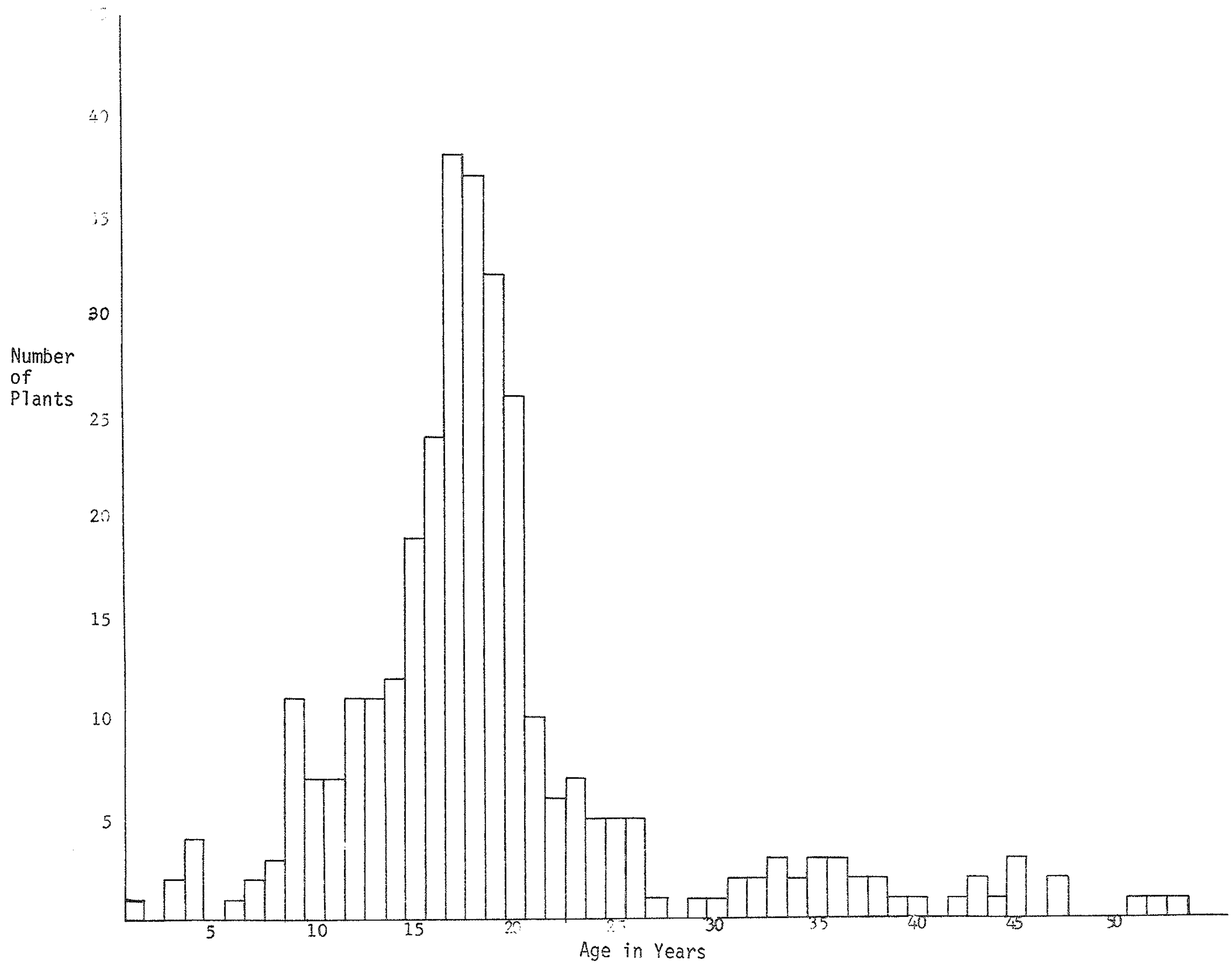

Figure 27. Age distribution of 100 *Artemisia tridentata* plants, southern shrub site (samples taken from off-site hectare 10, summer, 1972.

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 utahense 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

	Density (1,000/ha)		Biomass (g/ha)	
Hour	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

	Density (1,000/ha)		Biomass (g/ha)	
Hour	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

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	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

Date of Sample	Density (1,000/ha) D-Vac	Density (1,000/ha) Soil	Biomass (g/ha) D-Vac	Biomass (g/ha) 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)		Biomass (g/ha)	
	D-Vac	Soil	D-Vac	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)			Biomass (g/ha)		
	Artemisia	*Halogeton*	*Agropyron*	*Artemisia*	*Halogeton*	*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

Month and Method	Biomass (g/ha)			Density (1,000/ha)		
	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

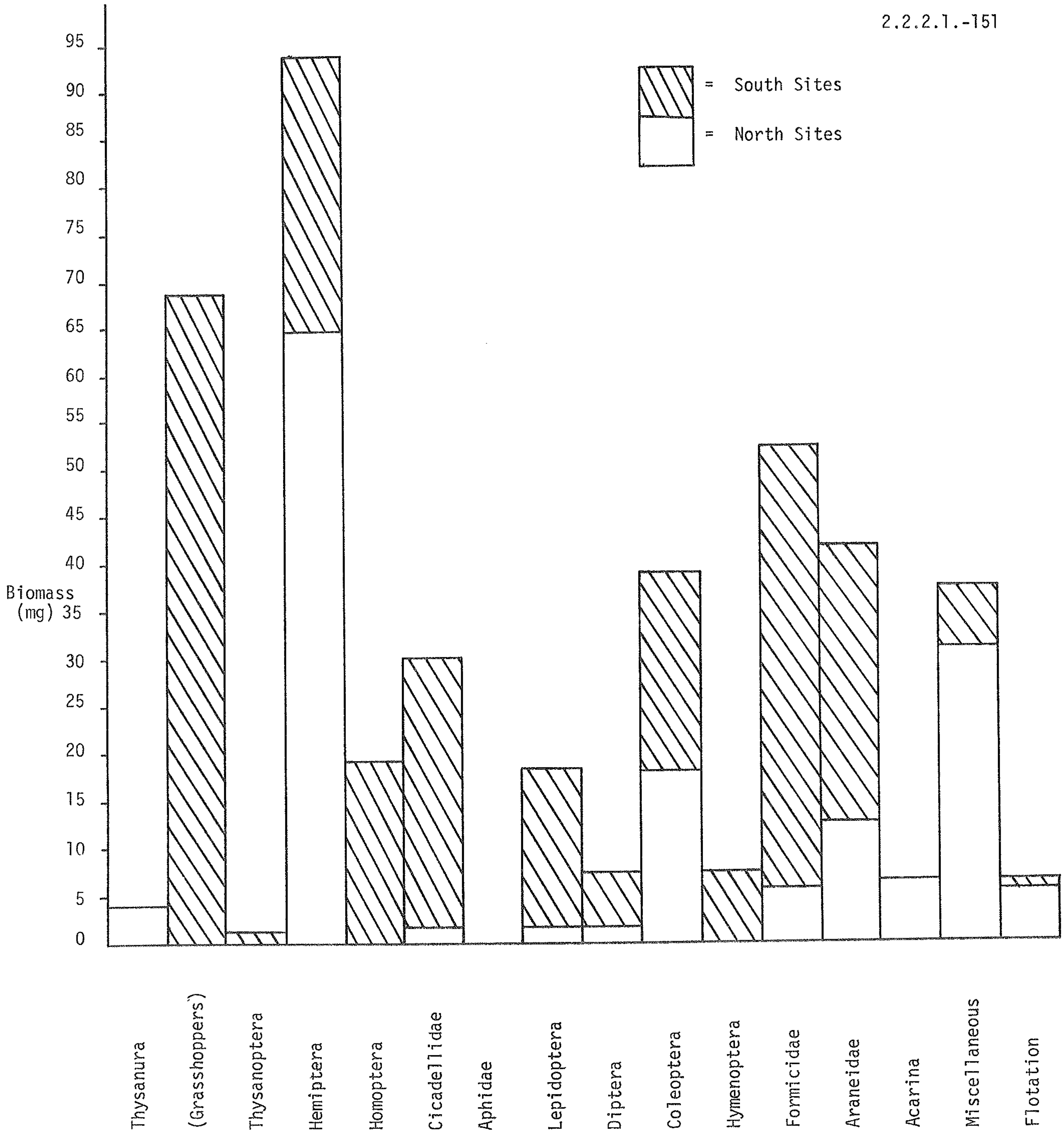

Figure 1. Biomass of the major invertebrate groups collected on 21 plants of *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, September 11, 1971.

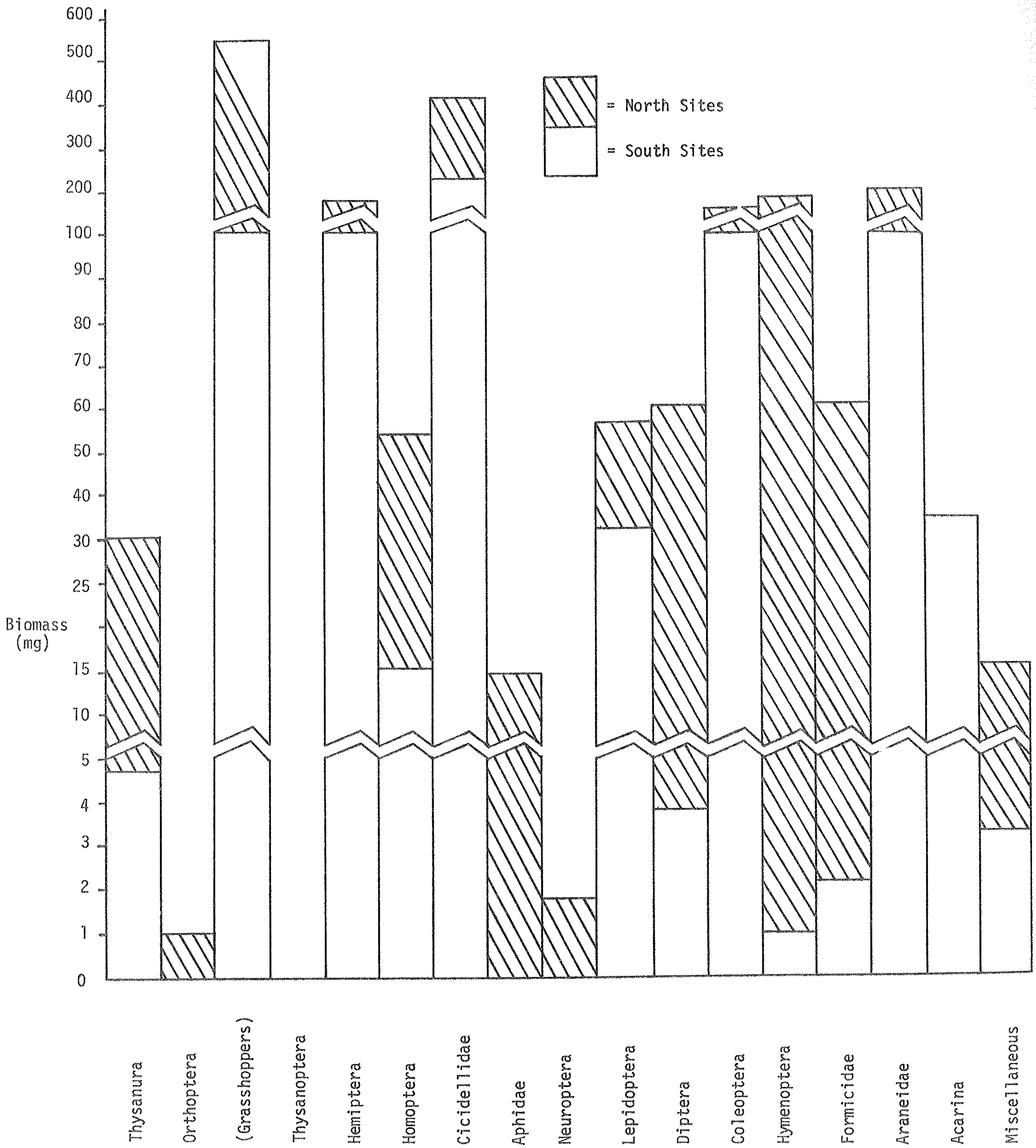

Figure 2. Total invertebrate biomass collected on 21 plants of *Atriplex*, *Sitanion*, *Agropyron*, and *Chrysothamnus* on sites in Curlew Valley, June 1971.

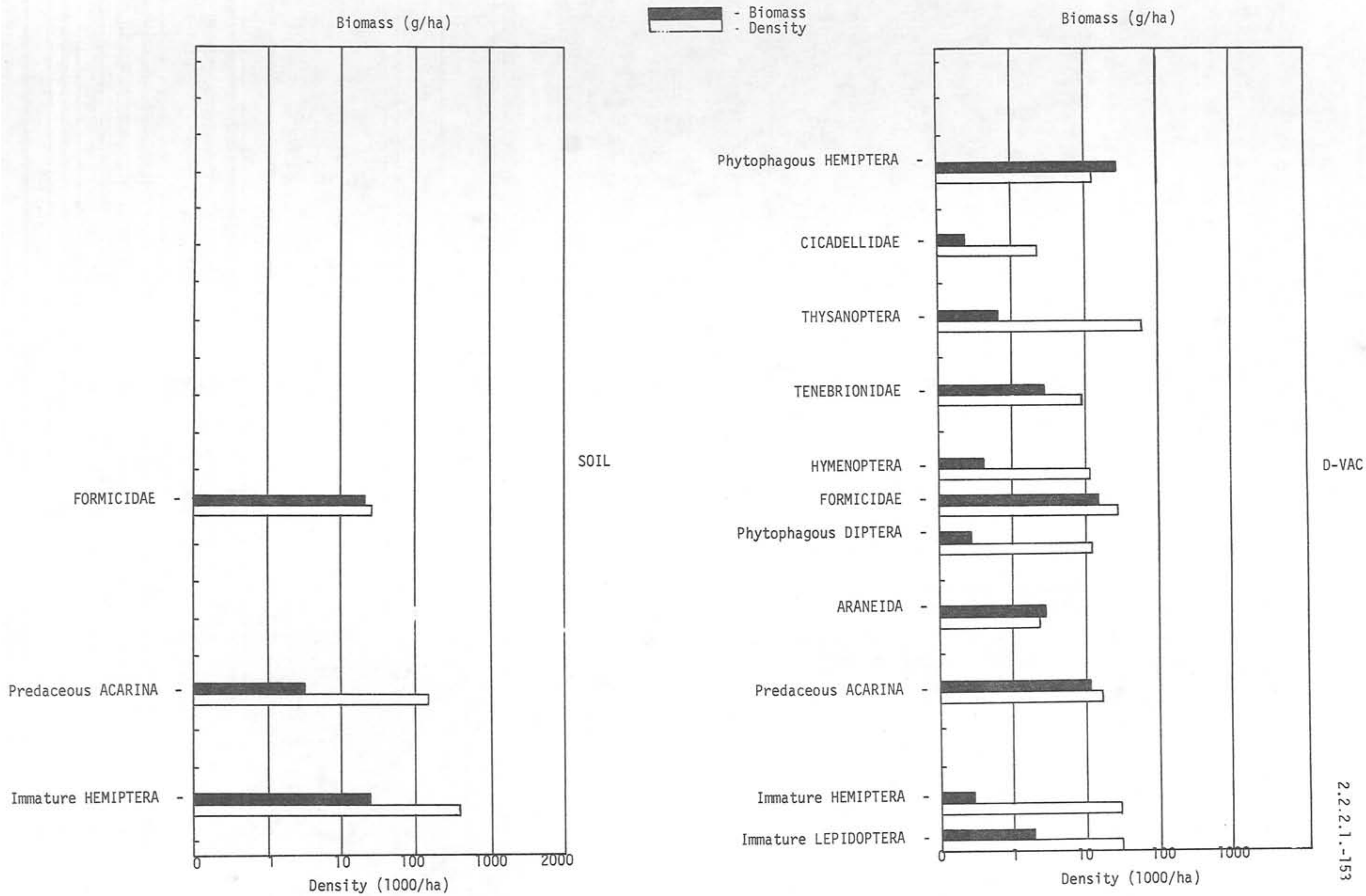

Figure 3. Biomass of invertebrates in Art-Atr-Sit vegetation type by D-Vac and soil extraction, June 15, 1972 (Predominant vegetation: *Atriplex*, *Sitanion*, *Artemisia*)

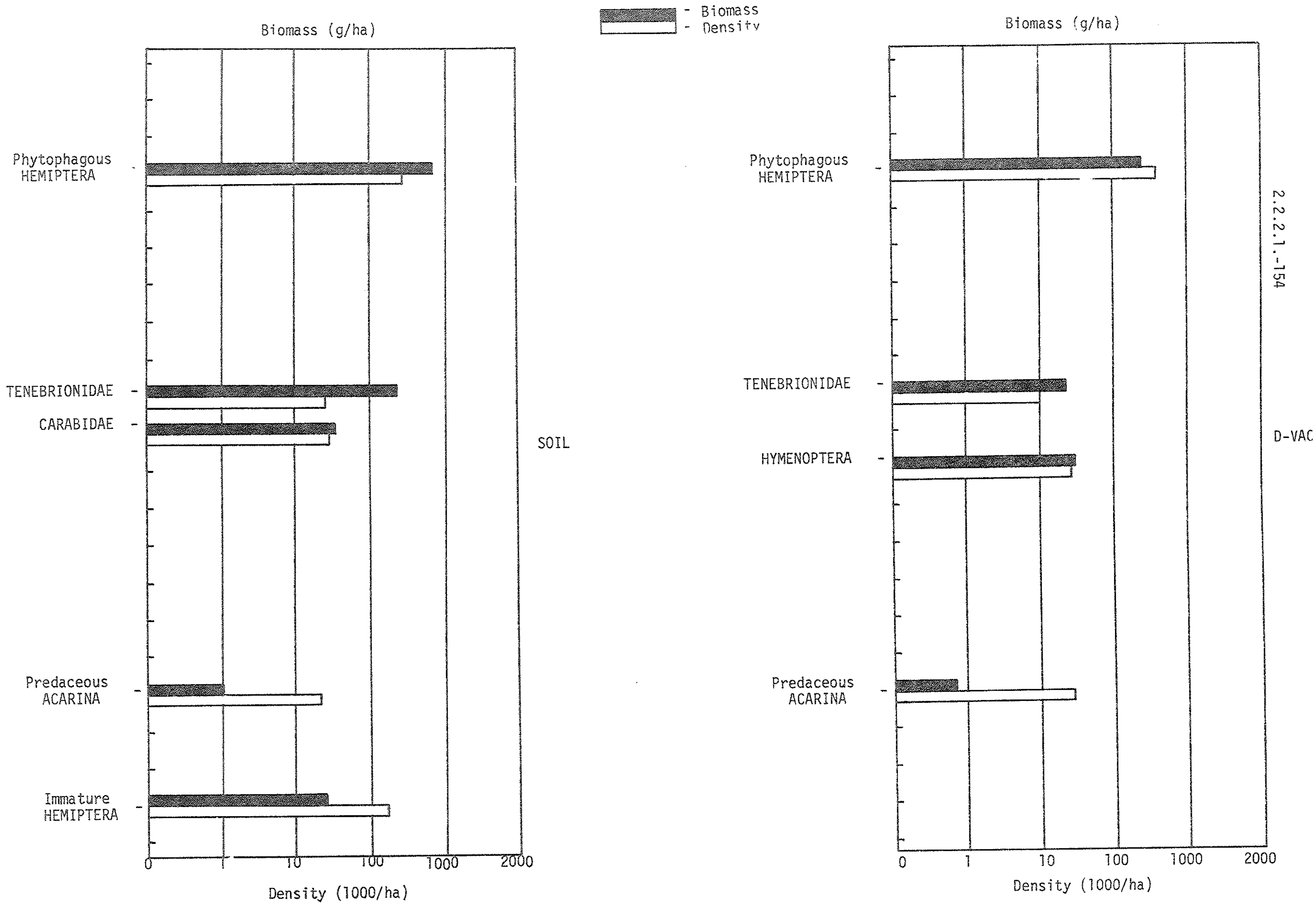

Figure 4. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 13, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Sitanion*)

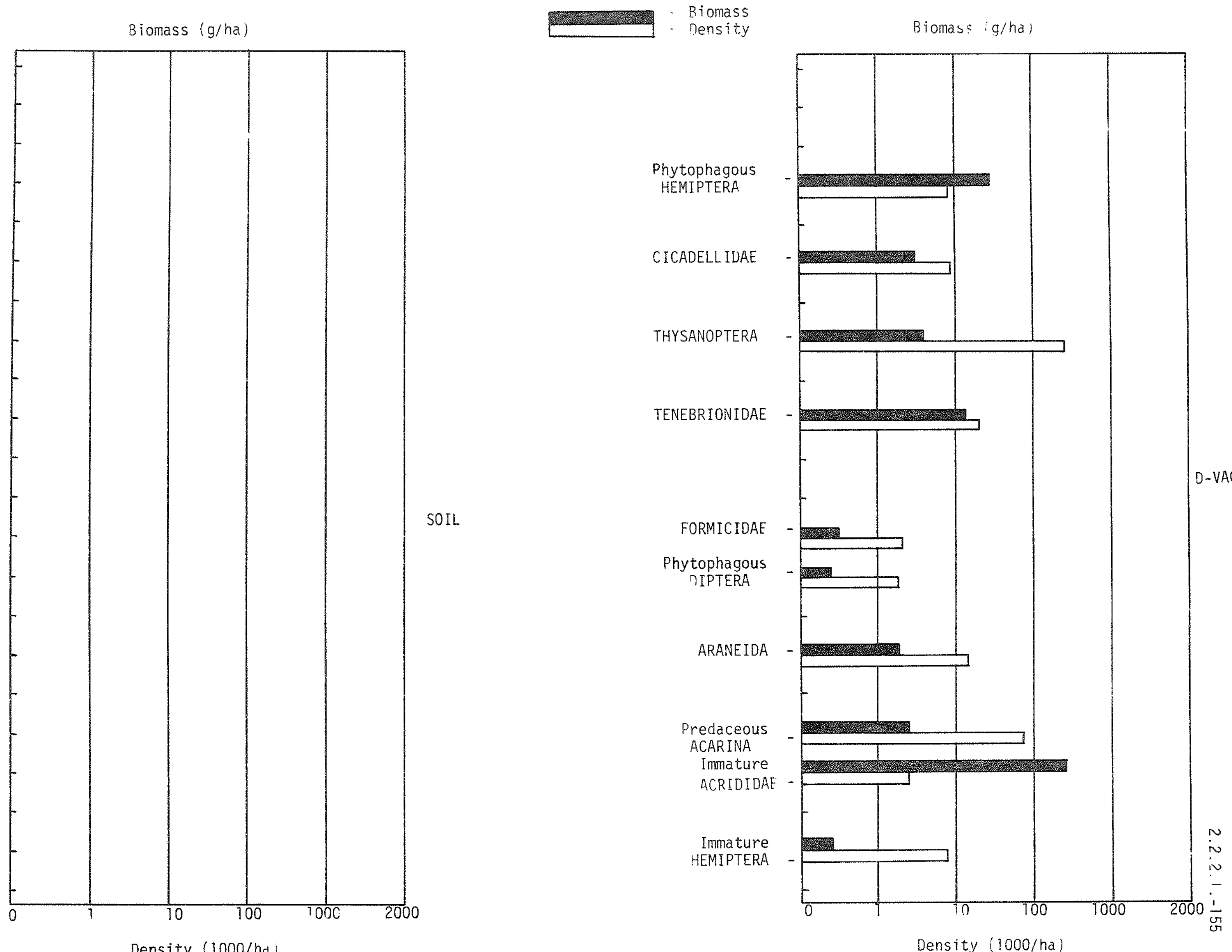

Figure 5. Biomass of invertebrates collected in Agr Vegetation type by D-Vac and soil extraction, June 15, 1972 (Predominant vegetation: *Agropyron*, *Atriplex*, [illegible])

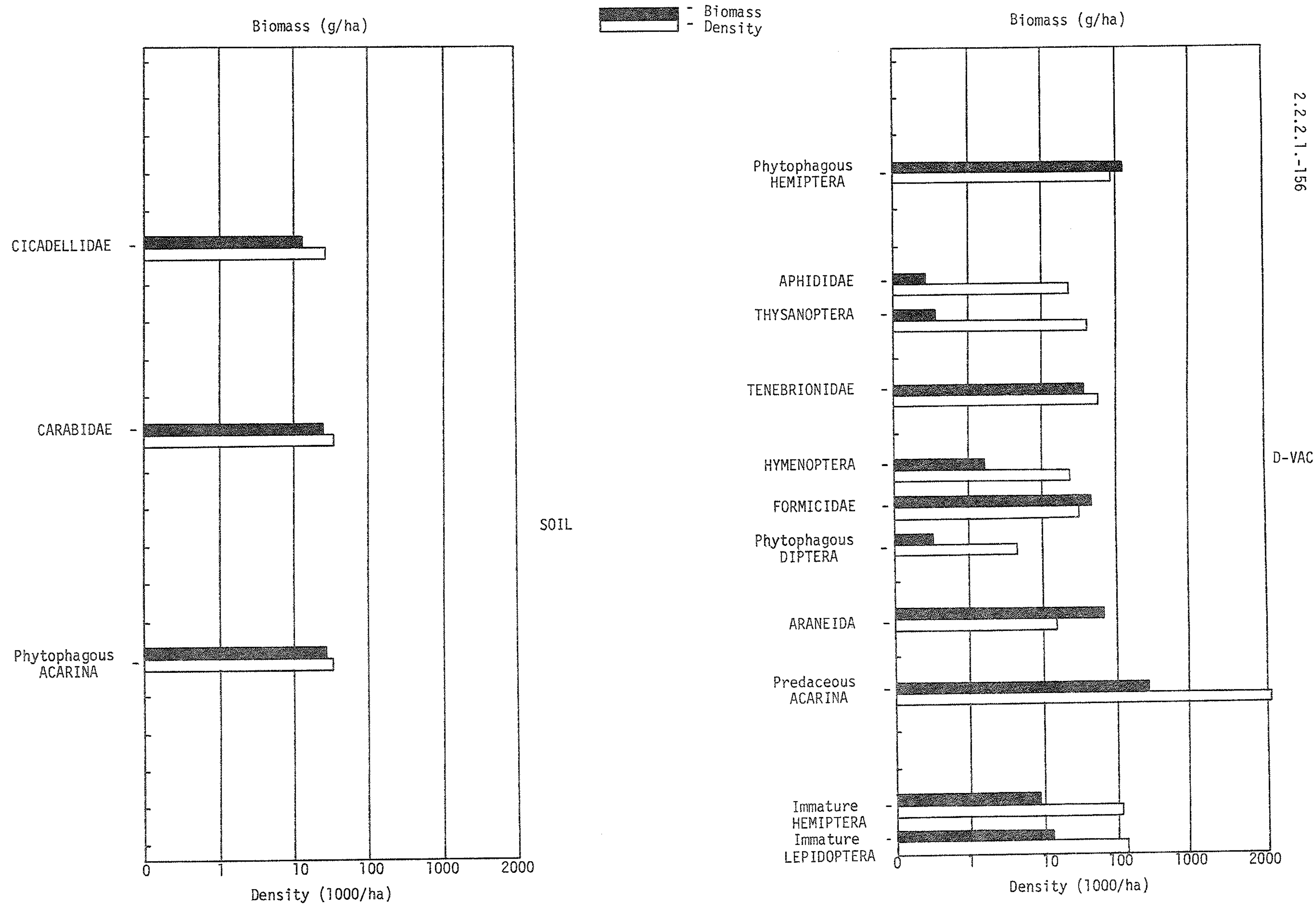

Figure 6. Biomass of invertebrates collected in Art-Atr-Sit vegetation type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Atriplex, Chrysothamus, Artemisia, Sitanion*)

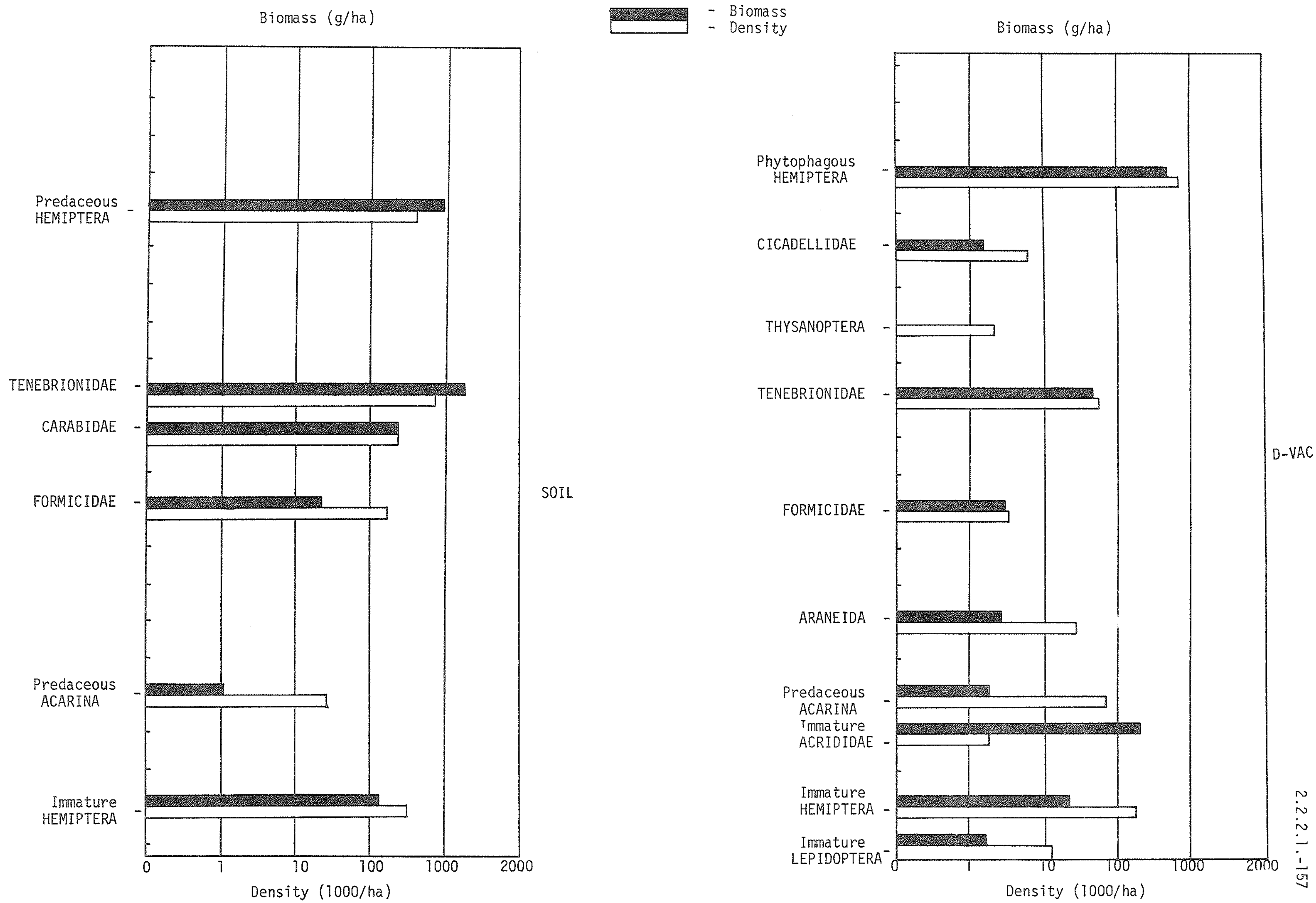

Figure 7. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Halogeton, Bassia, Descurainia, Atriplex, Artemisia, Sitanion*)

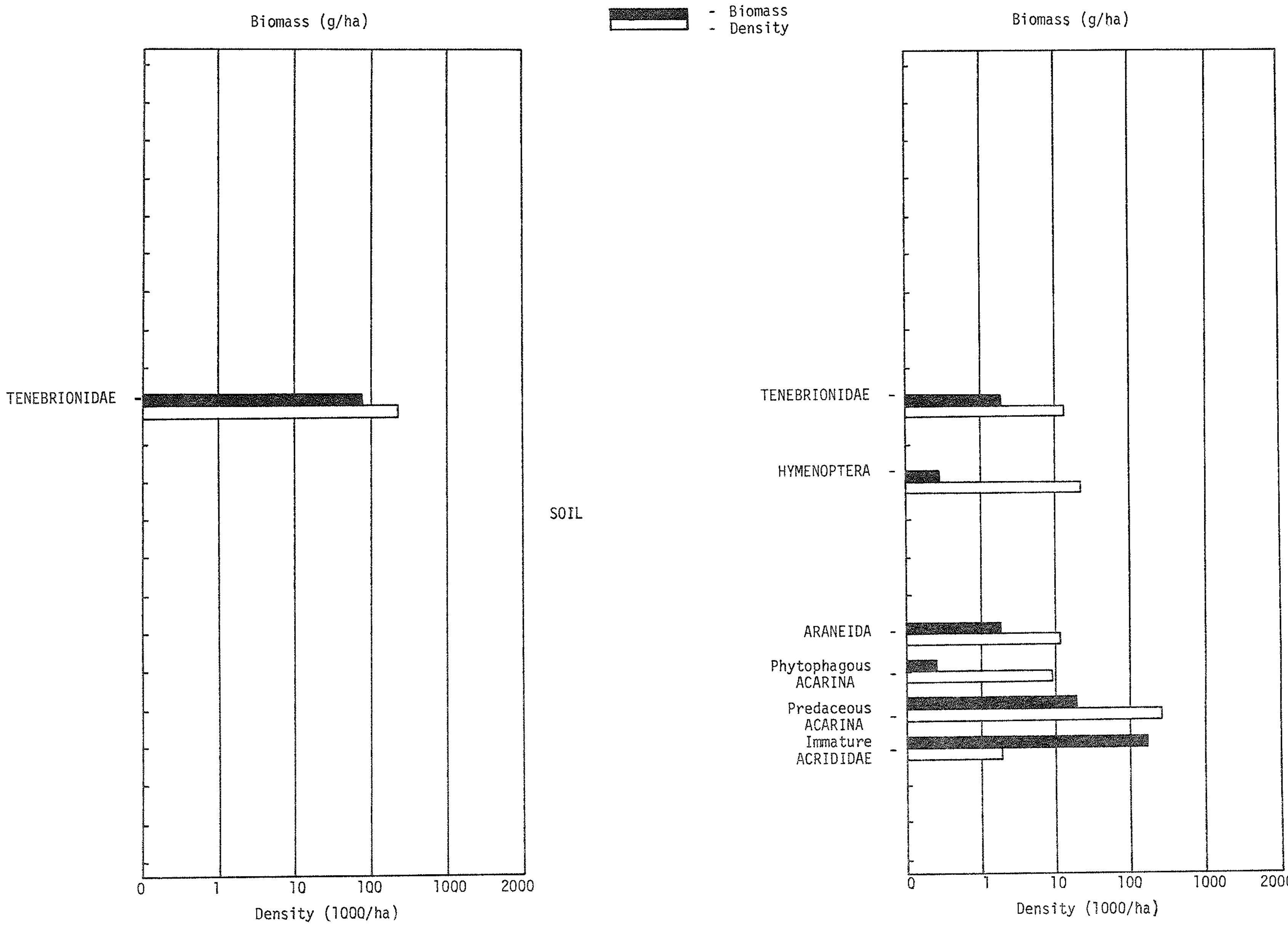

Figure 8. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, June 20, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*)

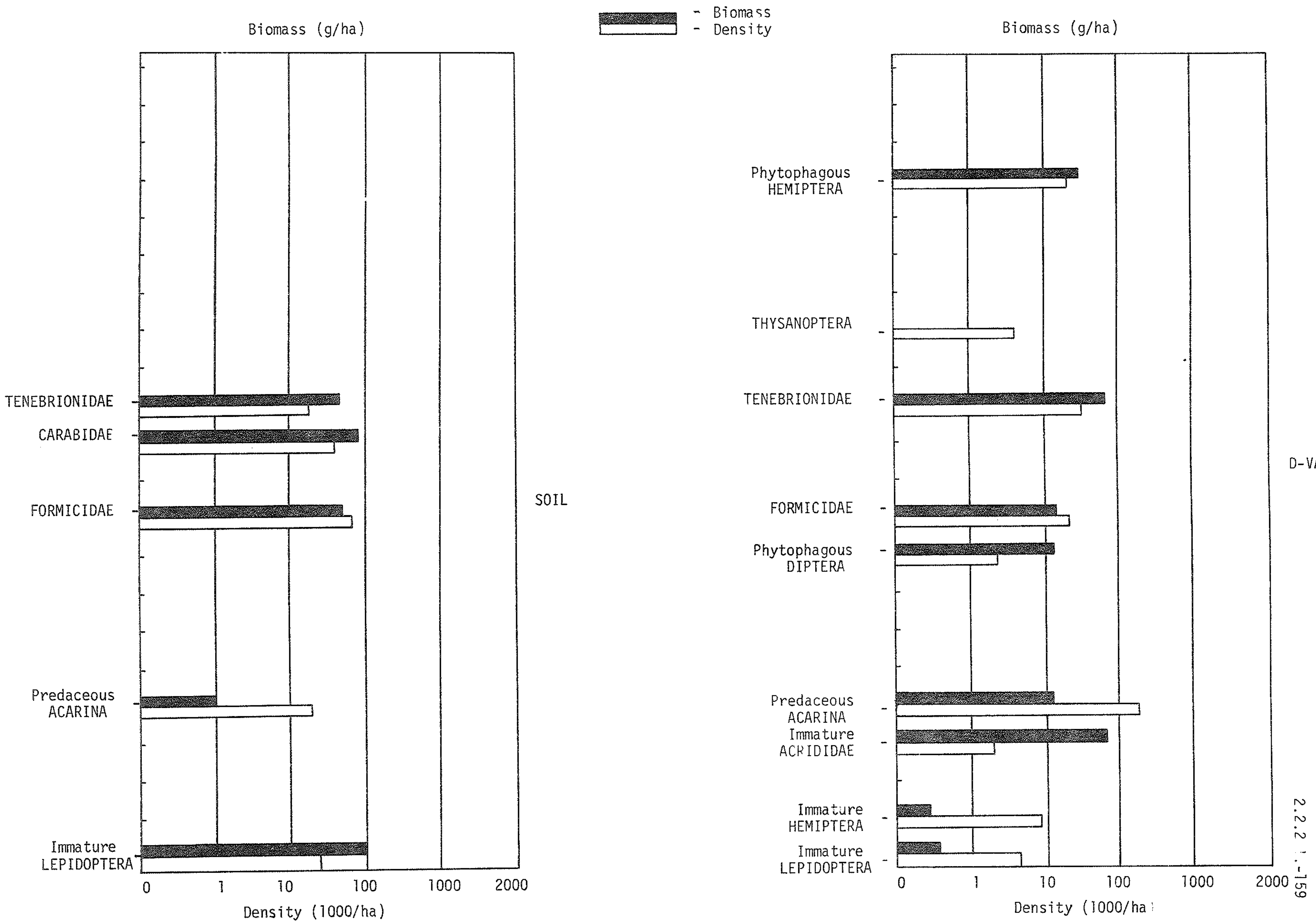

Figure 9. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Artemisia, Atriplex, Sitanion, Halogeton*)

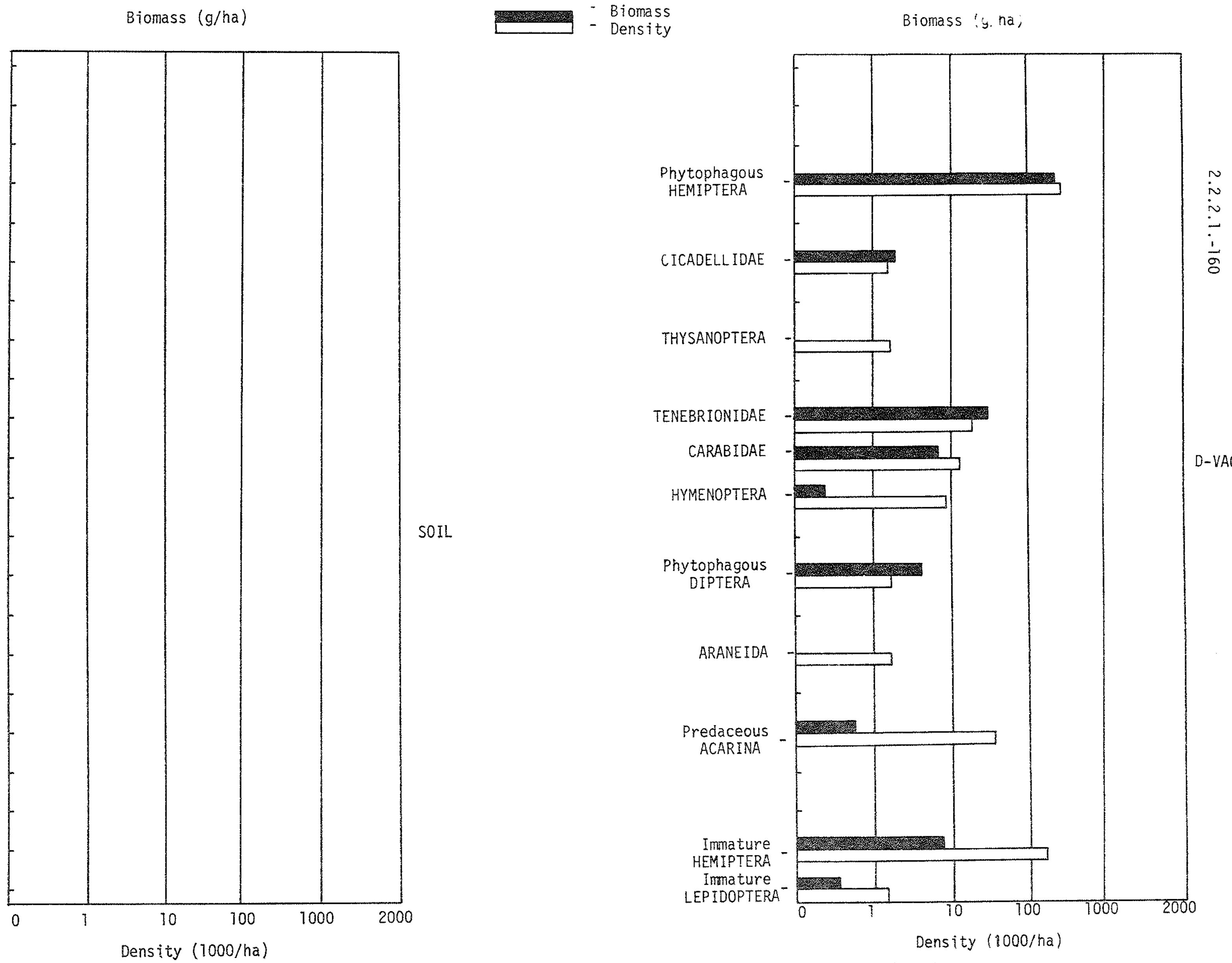

Figure 10. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Halogeton, Salsola, Lepidium, Descurainia*)

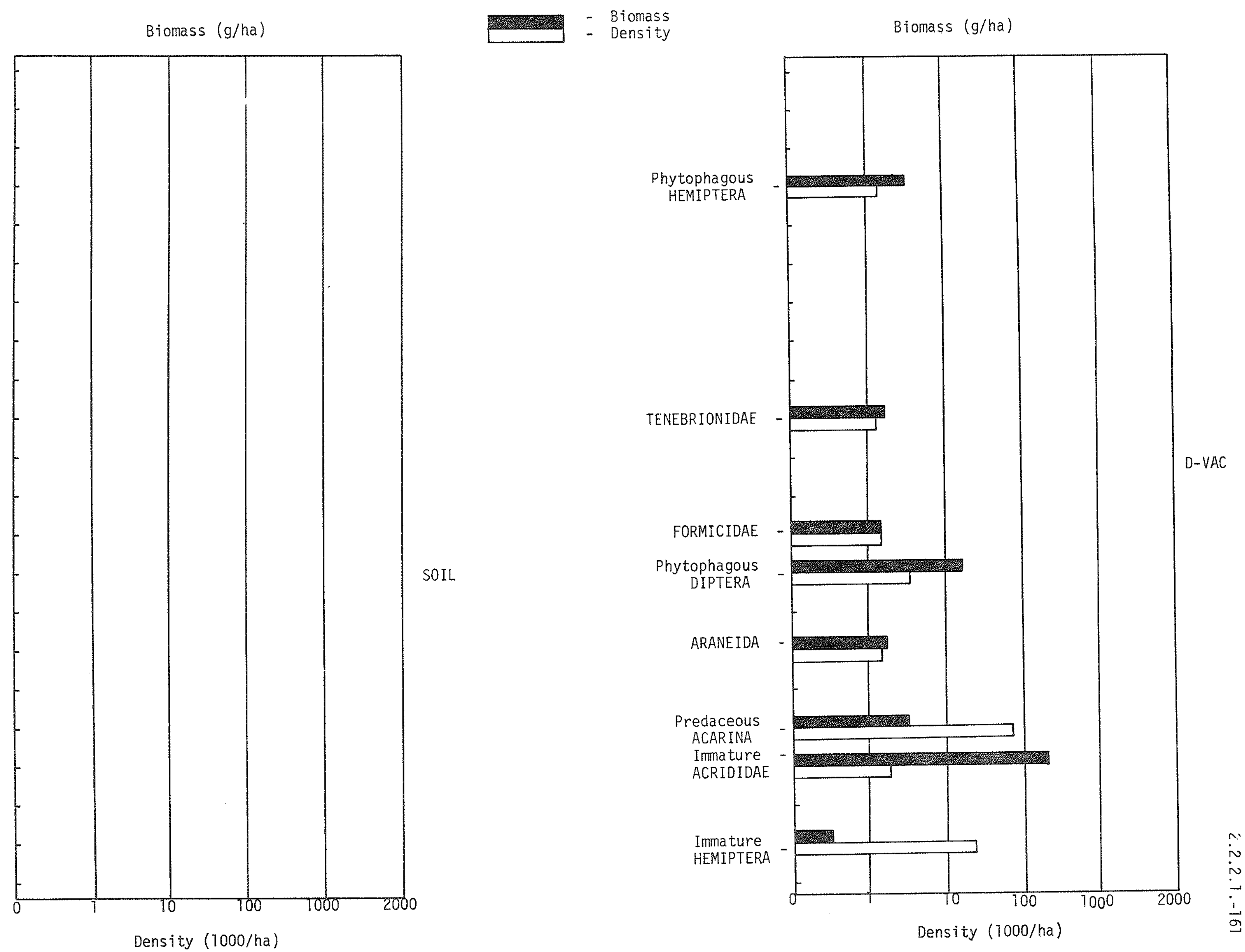

Figure 11. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, June 27, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*, *Sitanion*, *Halogeton*)

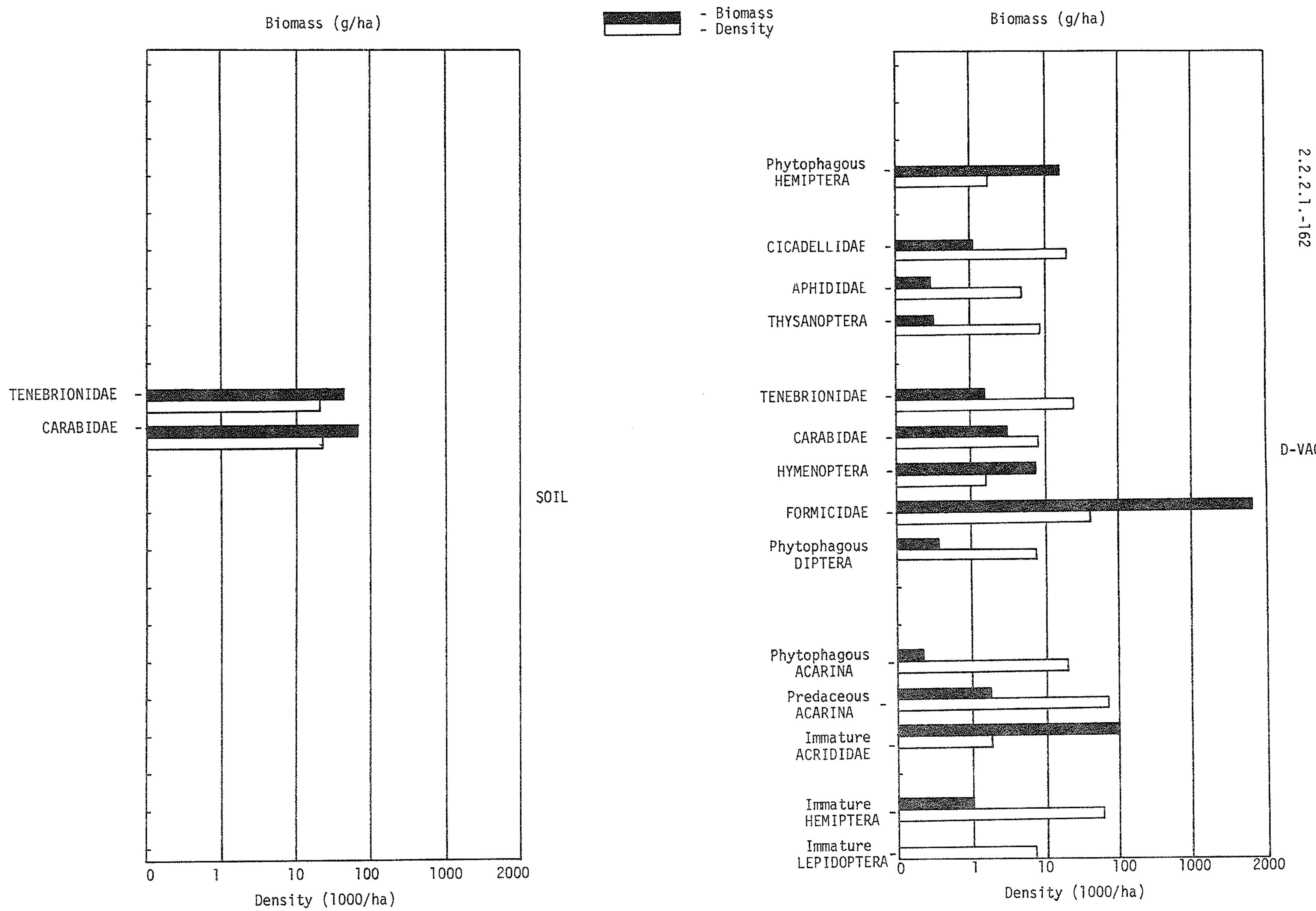

Figure 12. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation: *Atriplex*, *Artemisia*, *Sitanion*, *Chrysothamnus*)

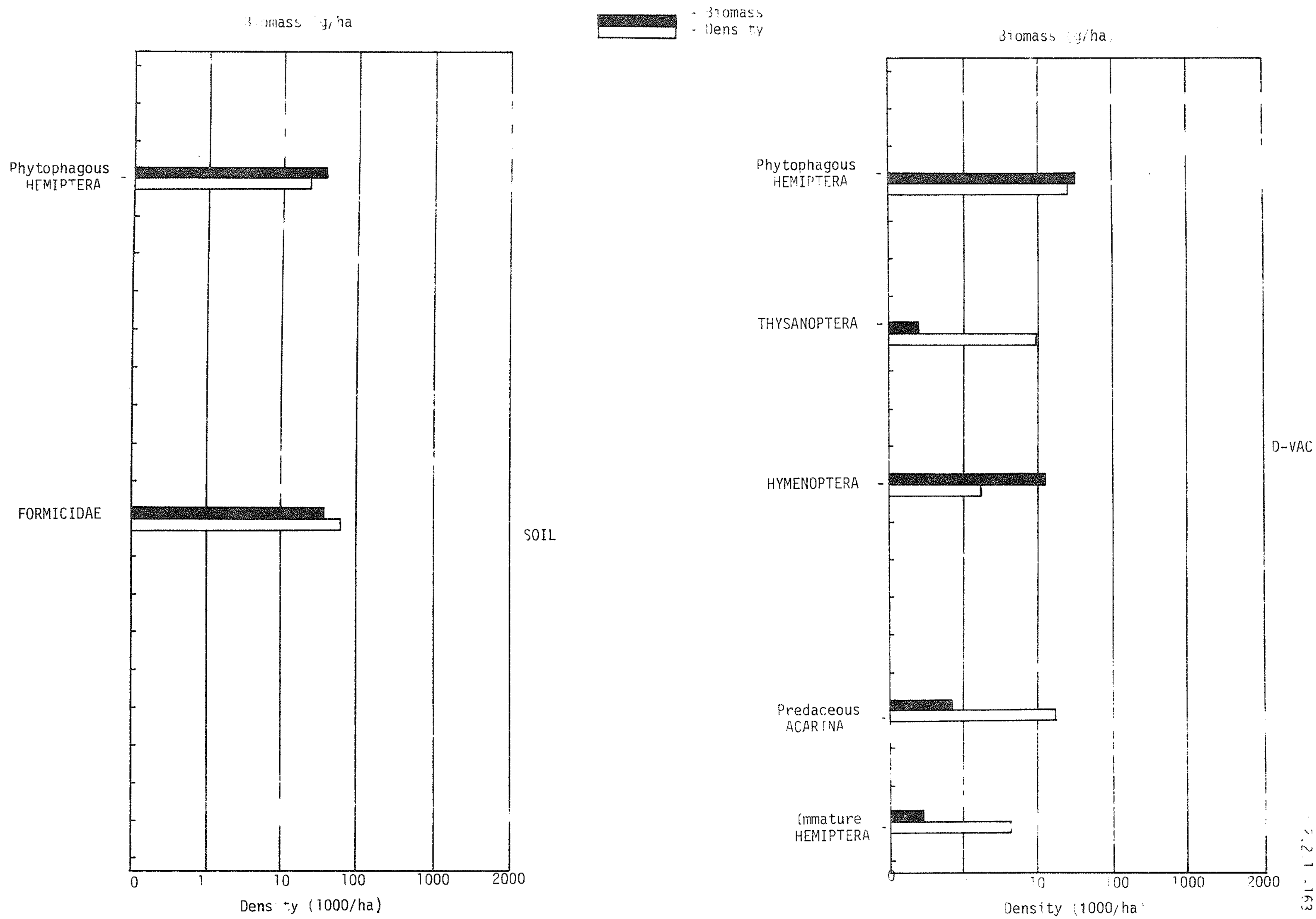

Figure 13 Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation. *la... n, ...*)

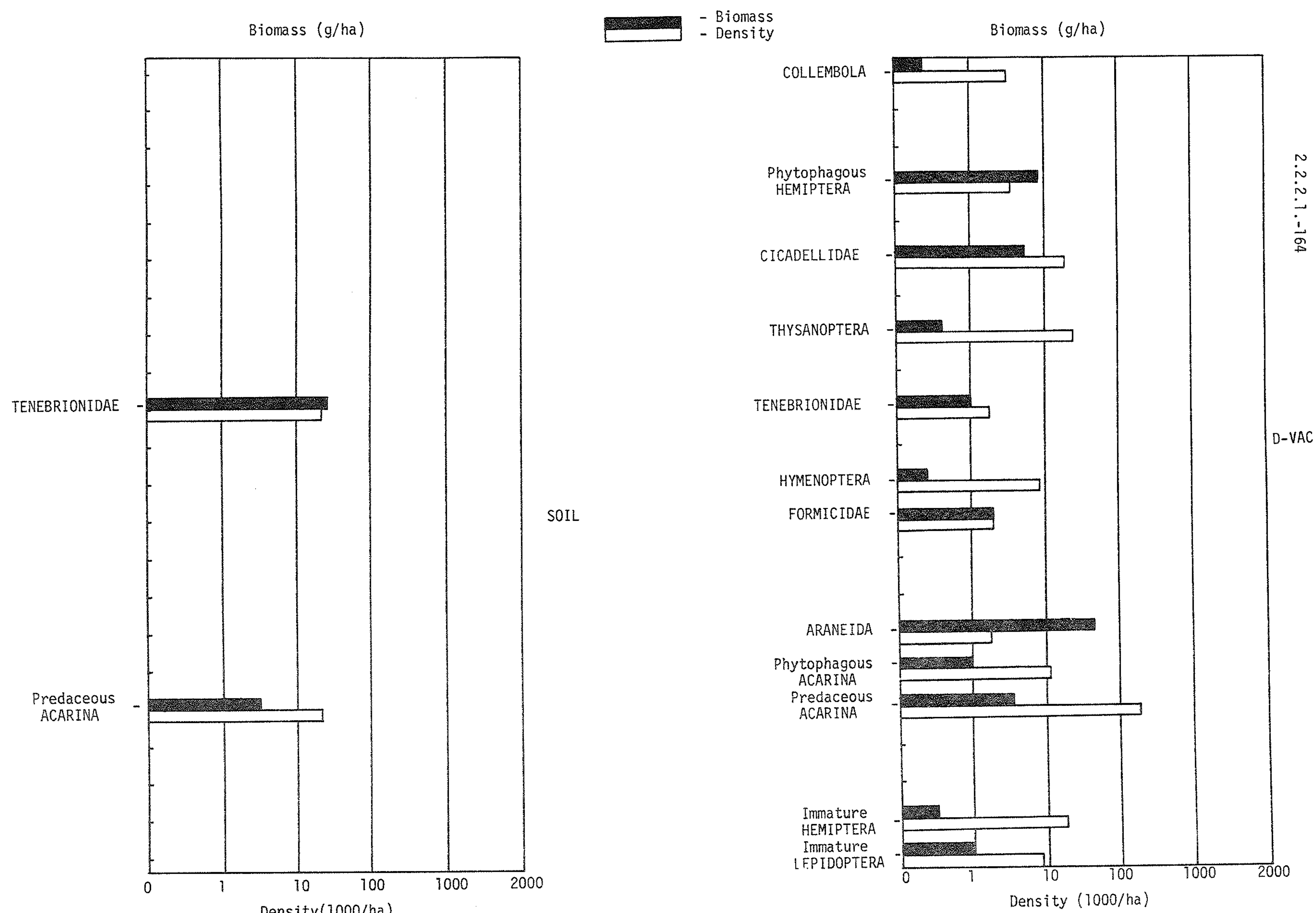

Figure 14. Histogram analysis of invertegrates collected in Agr Vegetation Type by D-Vac and soil extraction, July 5, 1972 (Predominant Vegetation: *Agropyron, Atriplex*)

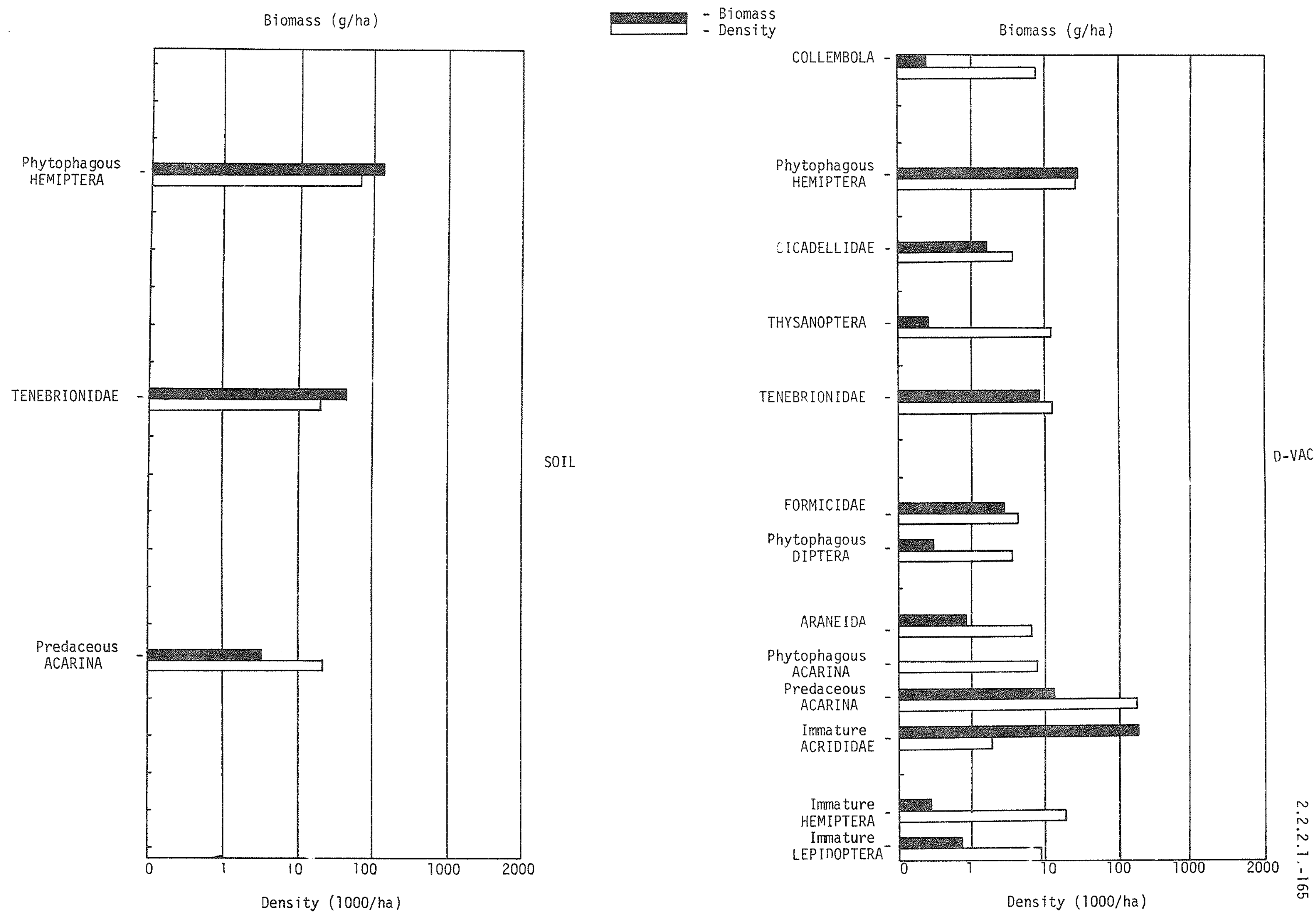

Figure 15. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac or soil extraction, July 11, 1972 (Predominant Vegetation: *Atriplex*, *Artemisia*, *Sitanion*)

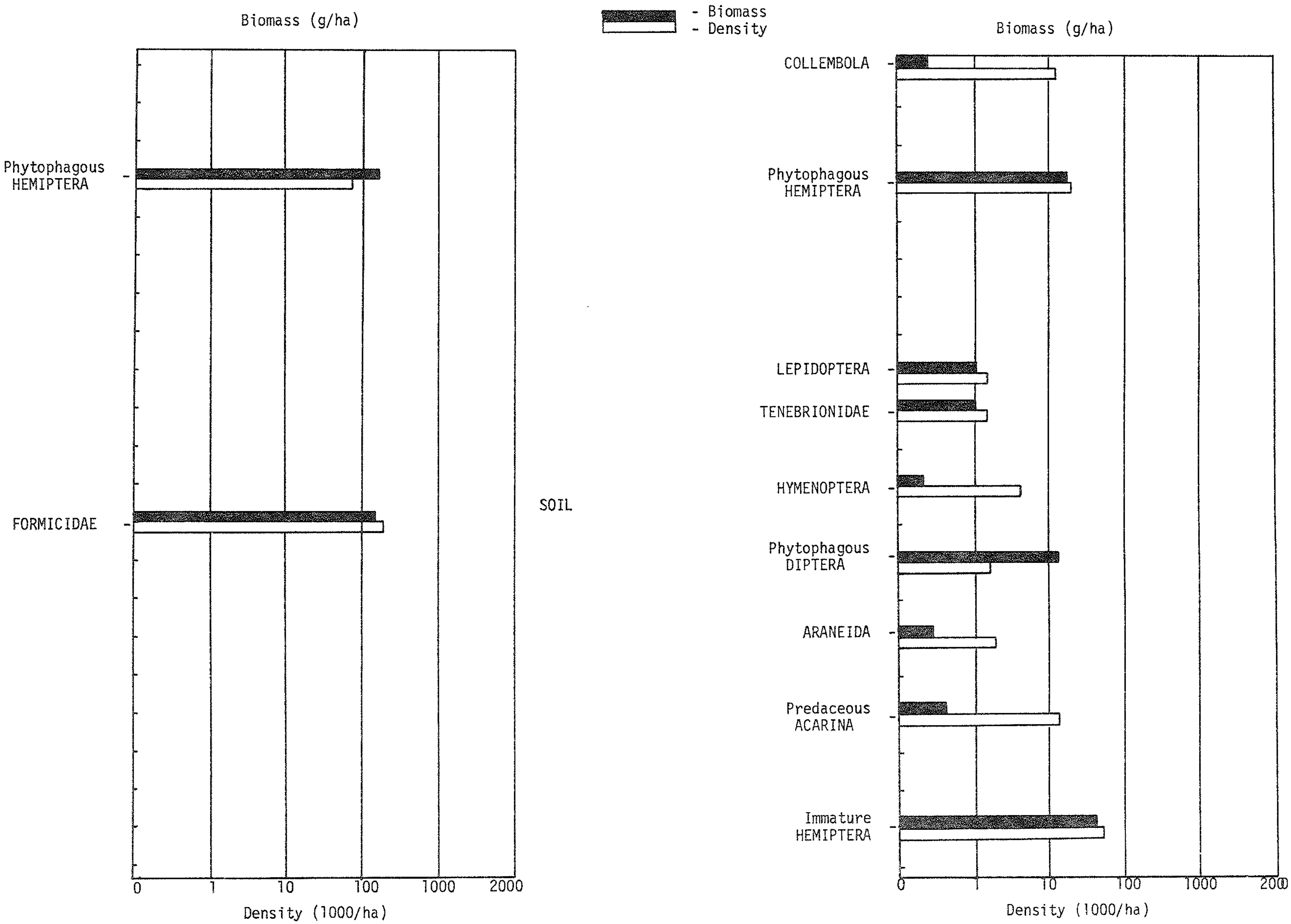

Figure 16. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 11, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Artemisia*)

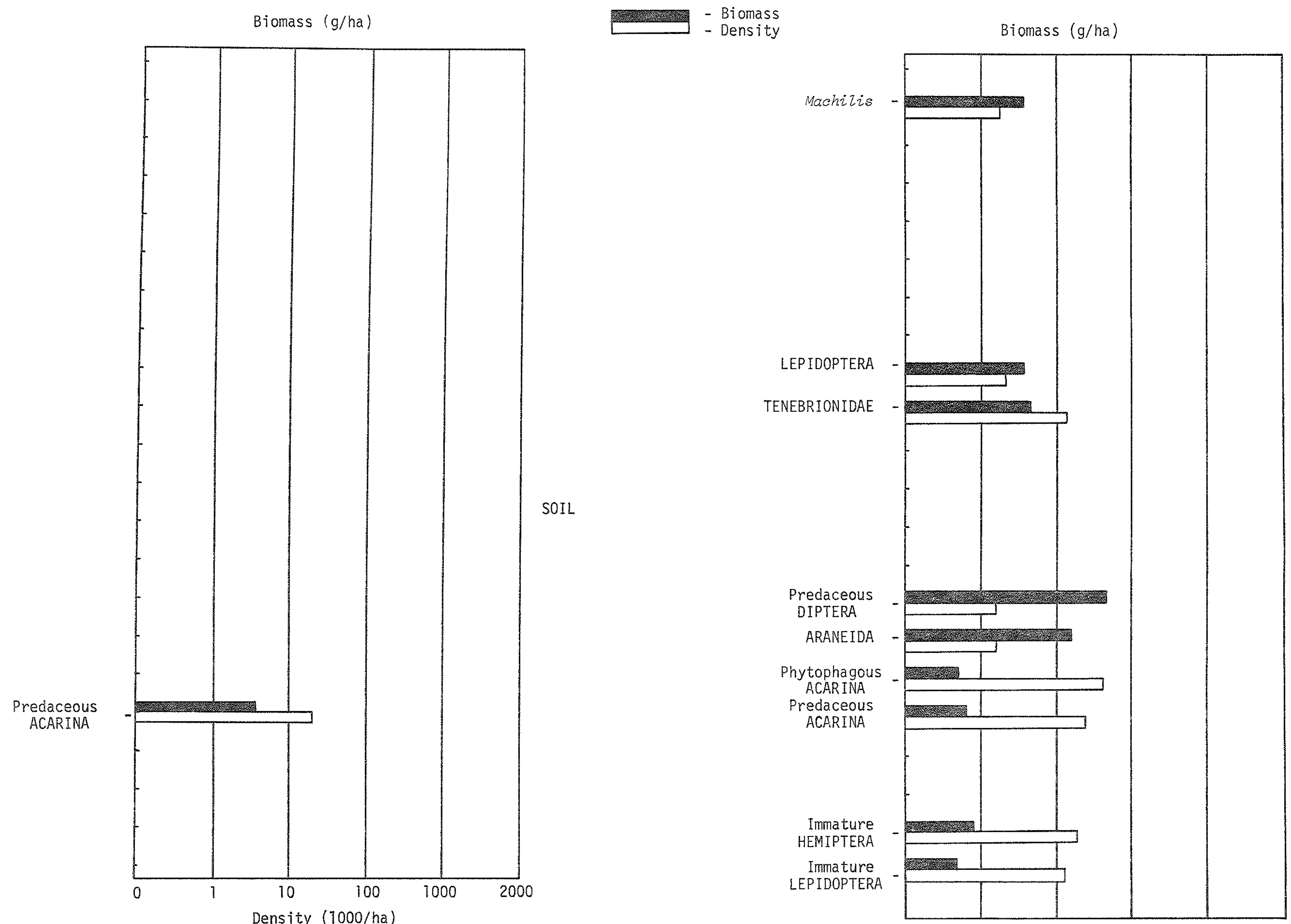

Figure 17. Biomass of invertebrates collected in Agr Vegetation Type, by D-Vac and soil extraction (Predominant Vegetation: *Agropyron, Atriplex*)

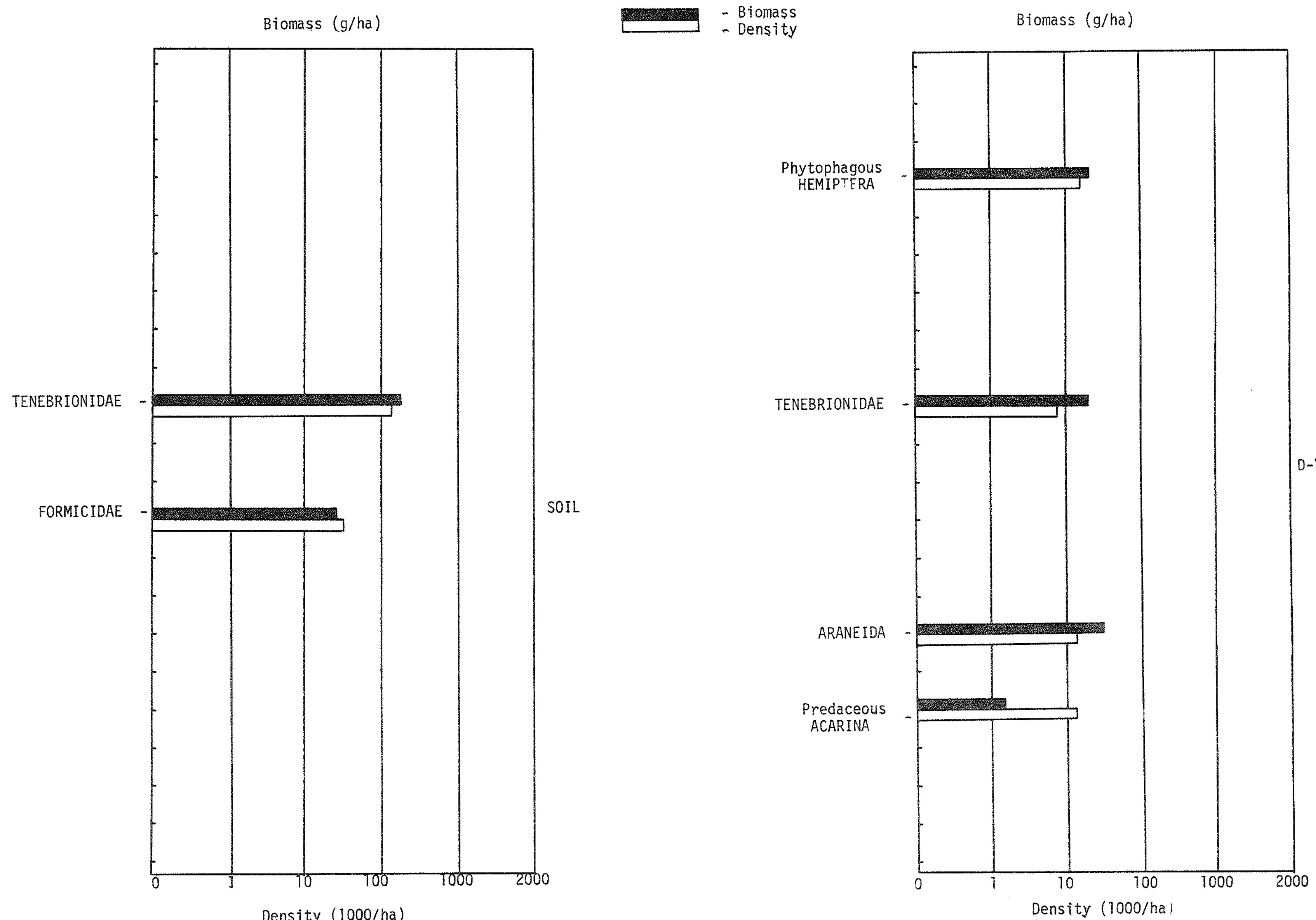

Figure 18. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Atriplex*, dead *Artemisia*, *Artemisia*)

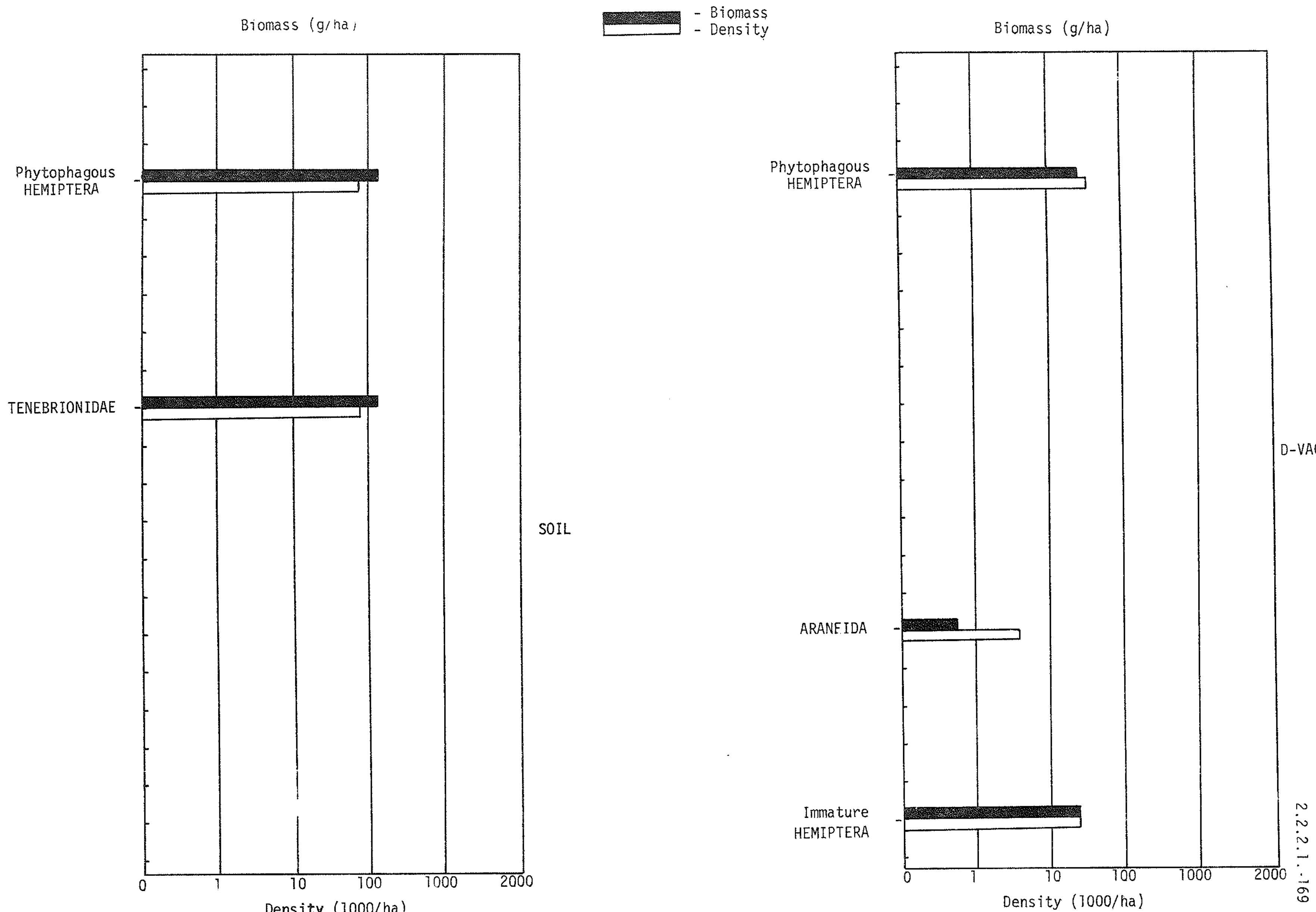

Figure 19. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Halogeton*, *Bassia*, *Bassia* dead)

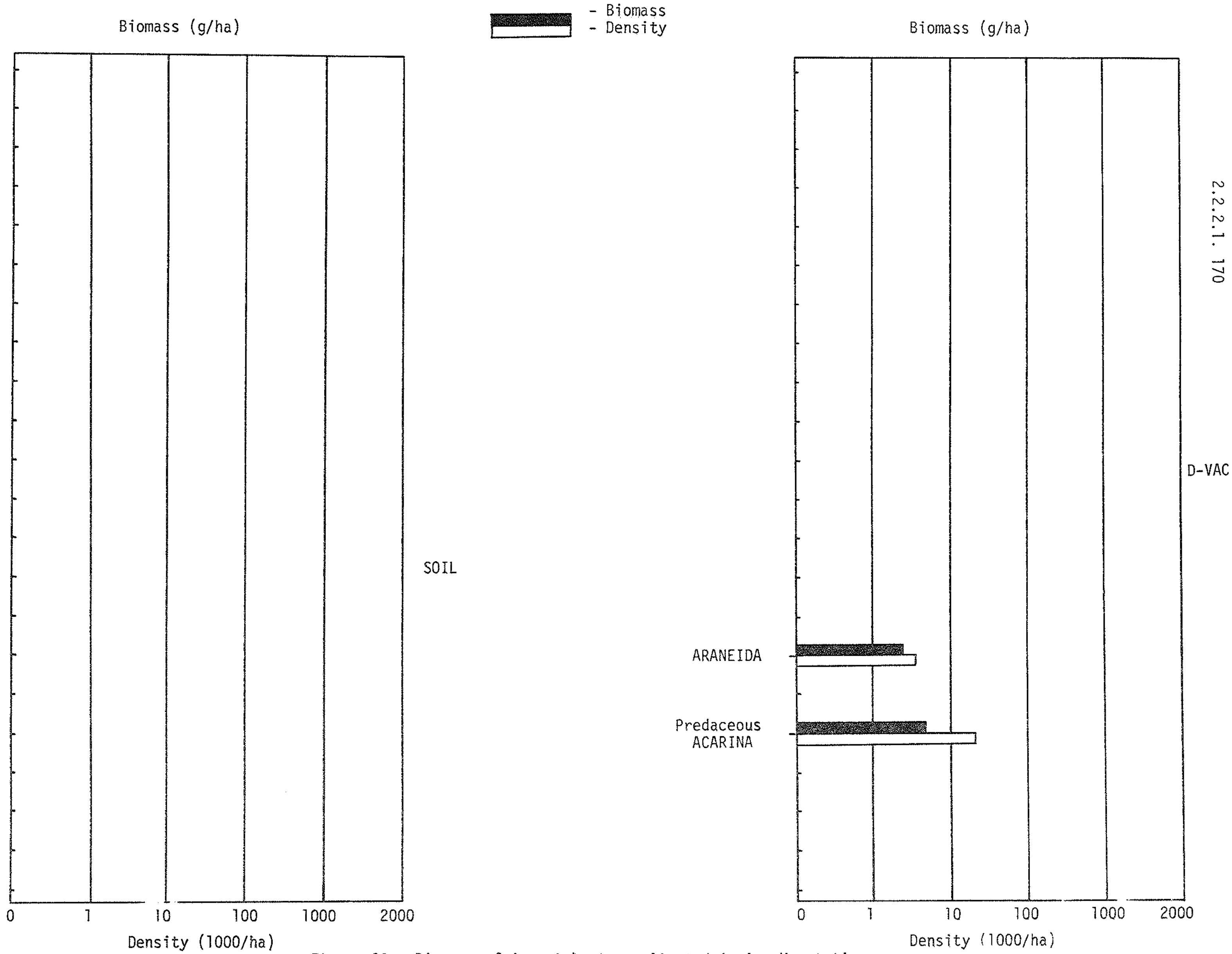

Figure 20. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, July 18, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*)

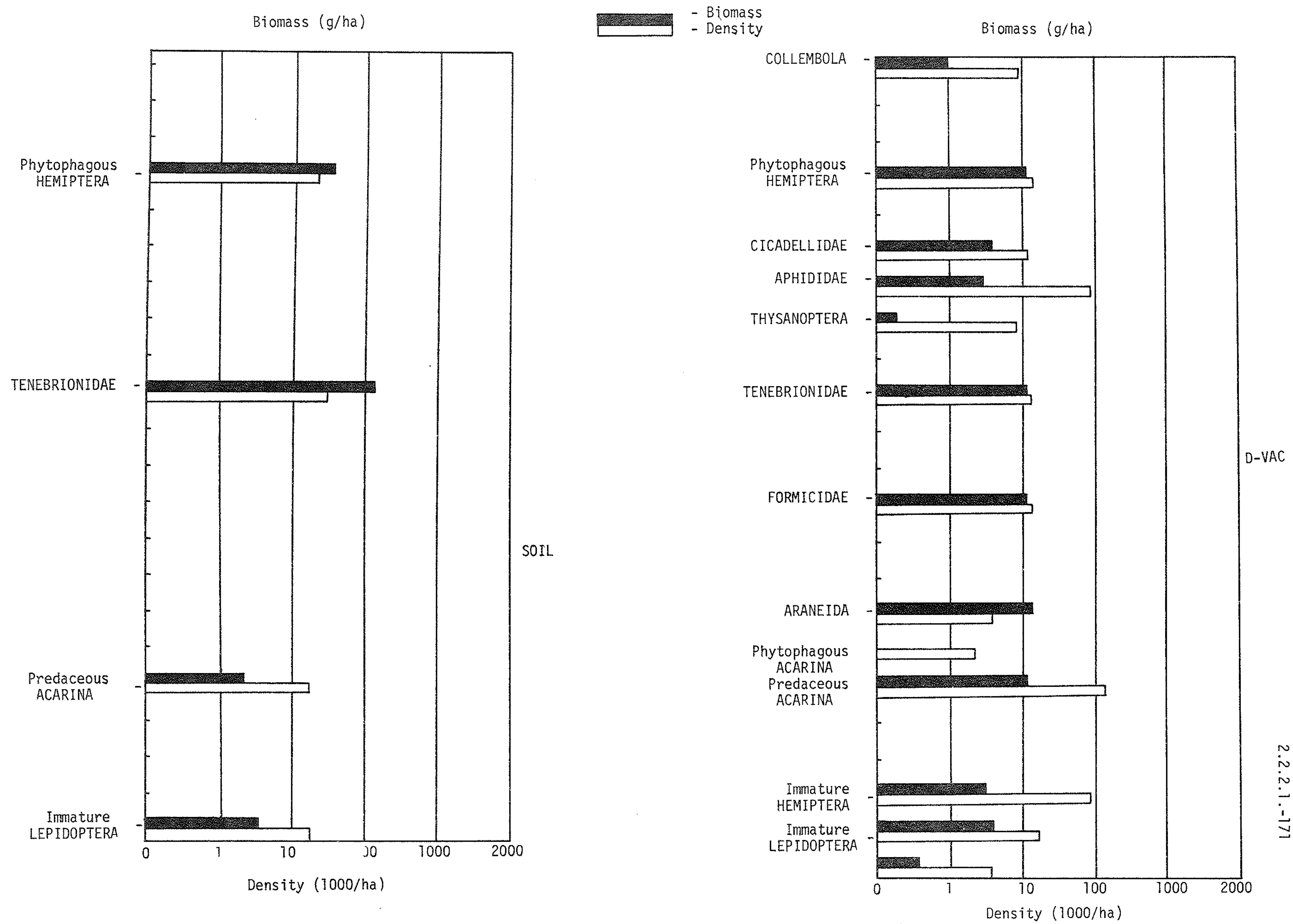

Figure 21. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Atriplex*, *Artemisia*, *Sitanion*, *Chrysothamnus*)

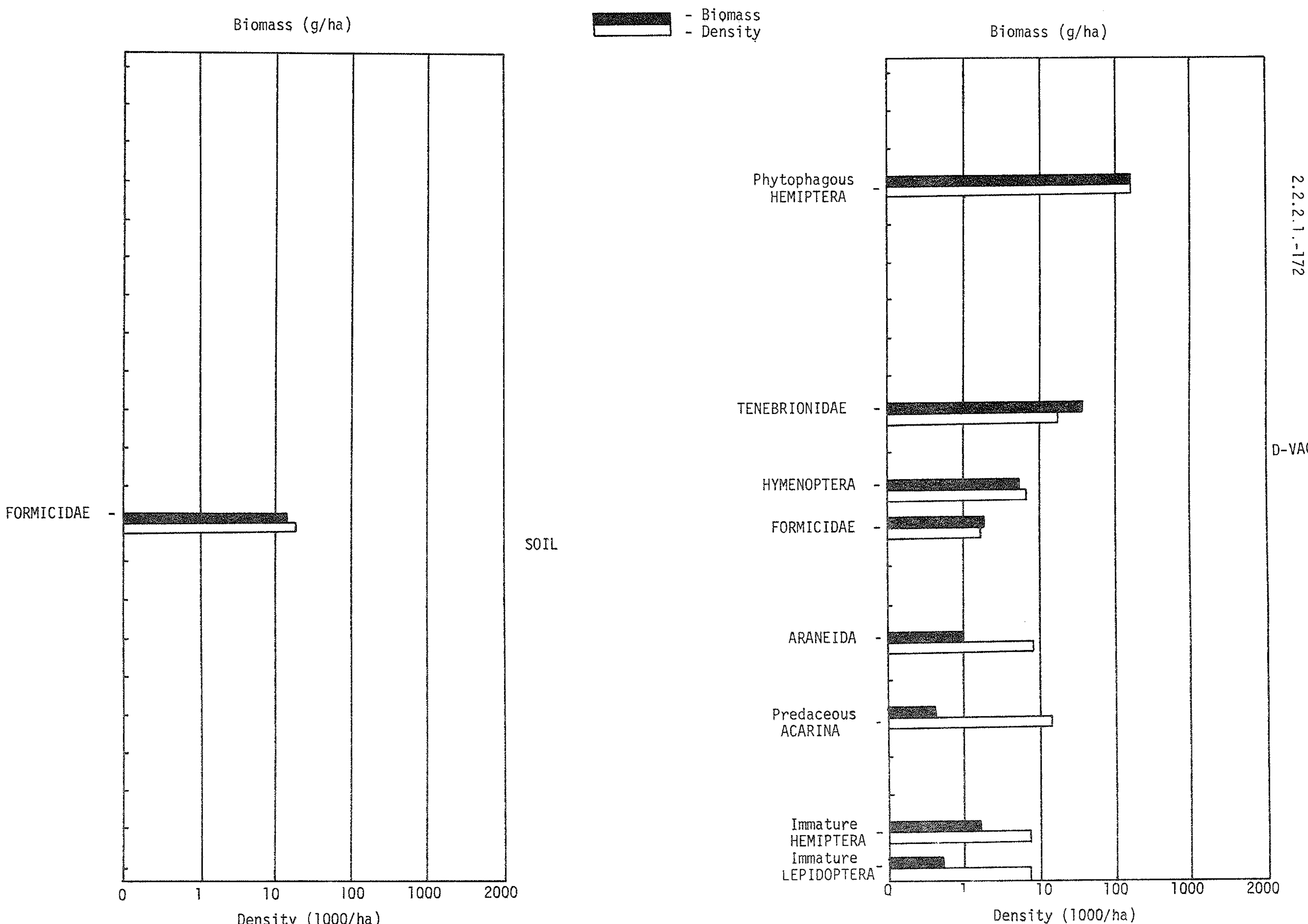

Figure 22. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Halogeton, Sitanion, Descurainia, Descurainia* dead)

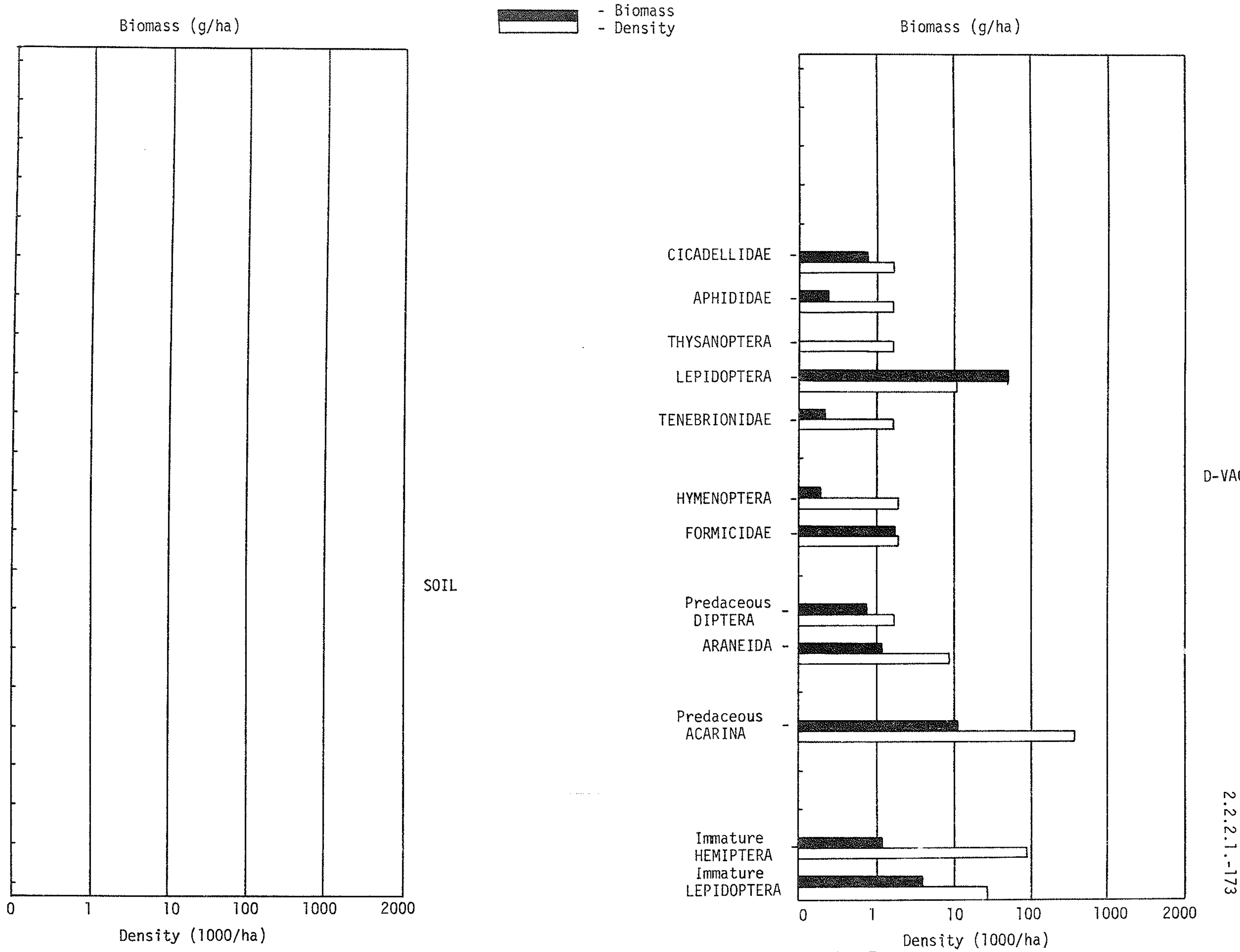

Figure 23. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 25 July, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Artemisia*)

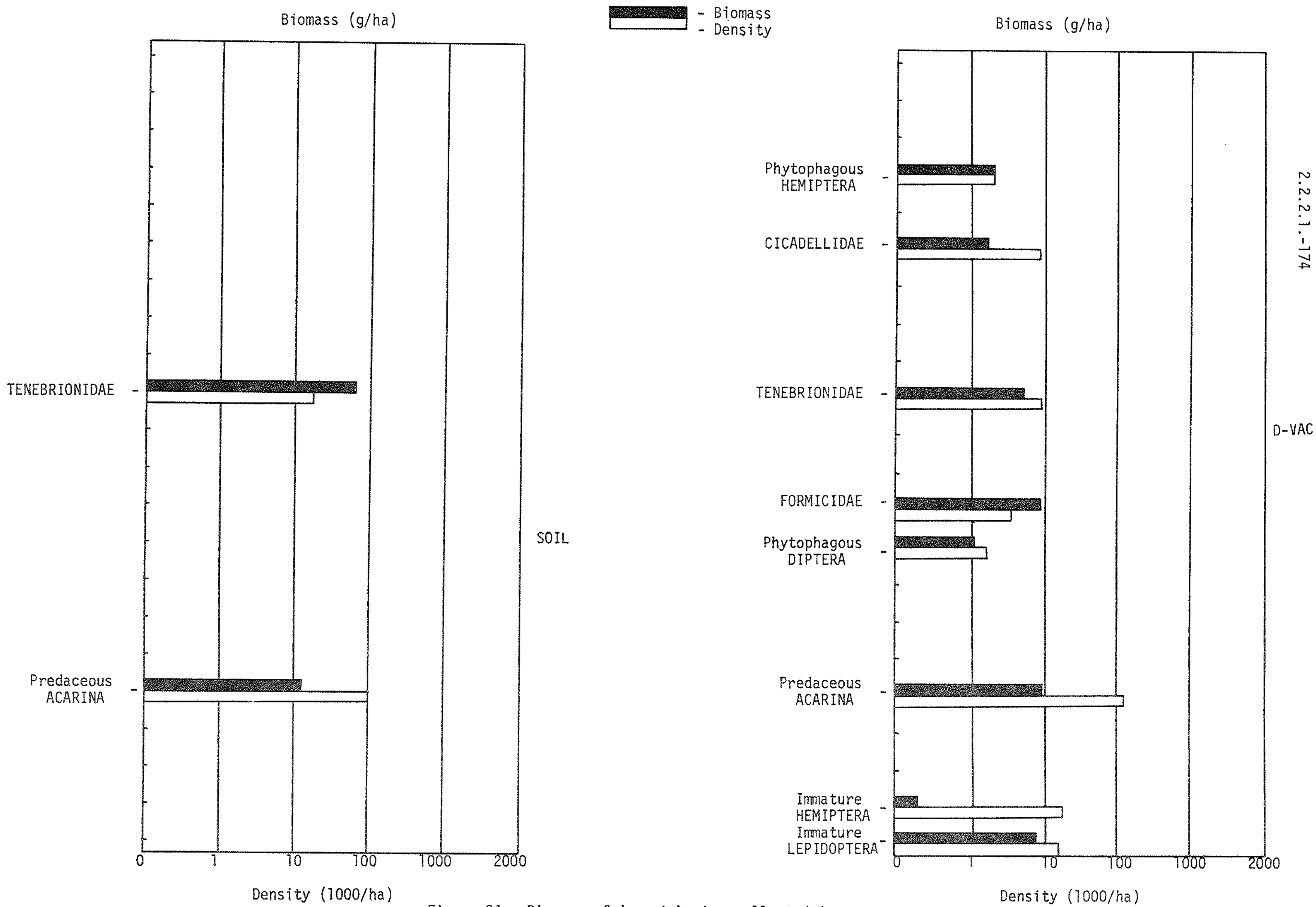

Figure 24. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 1 August, 1972 (Predominant Vegetation: *Artemisia*, *Sitanion*, *Atriplex*)

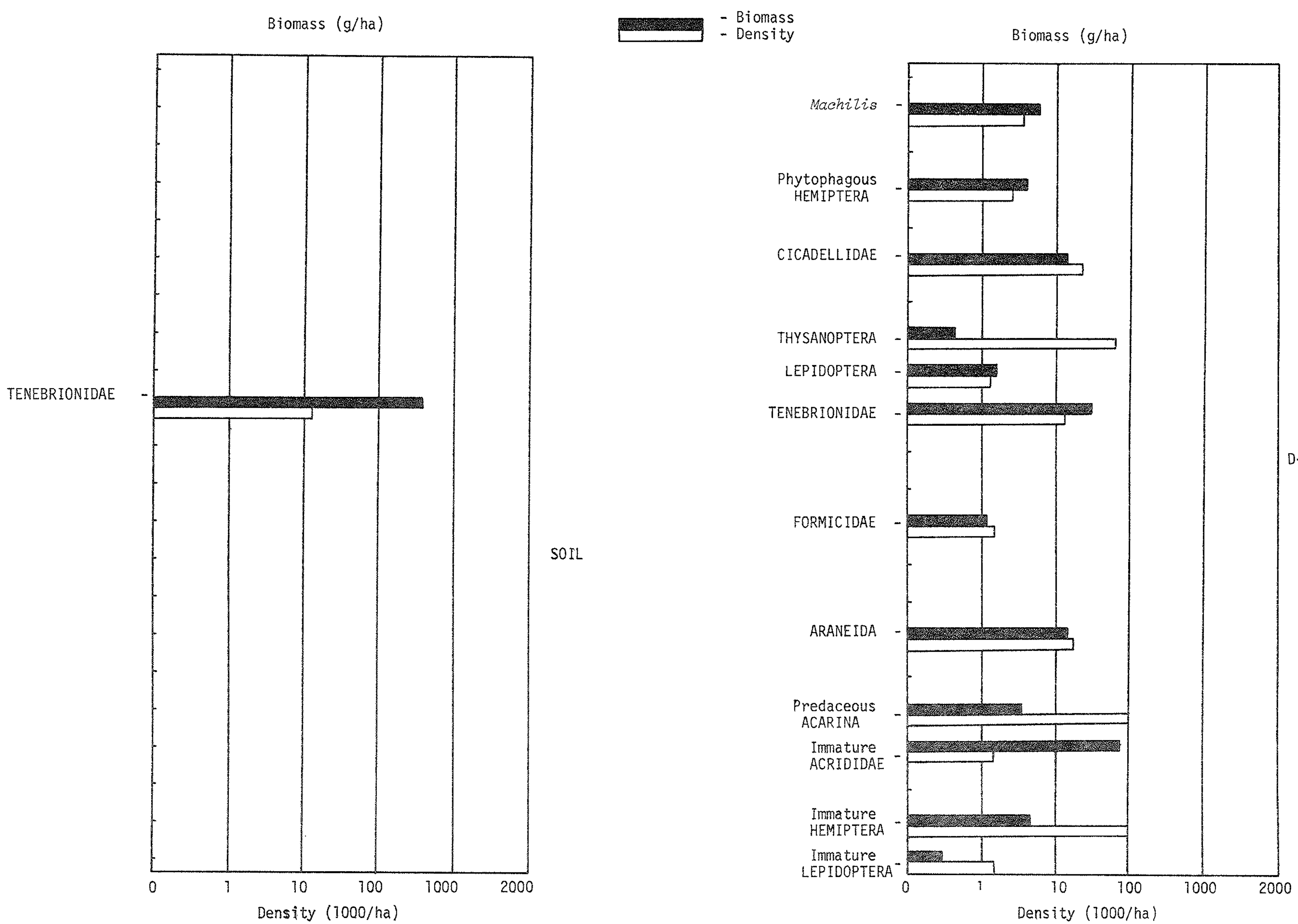

Figure 26. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 1 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Halogeton*)

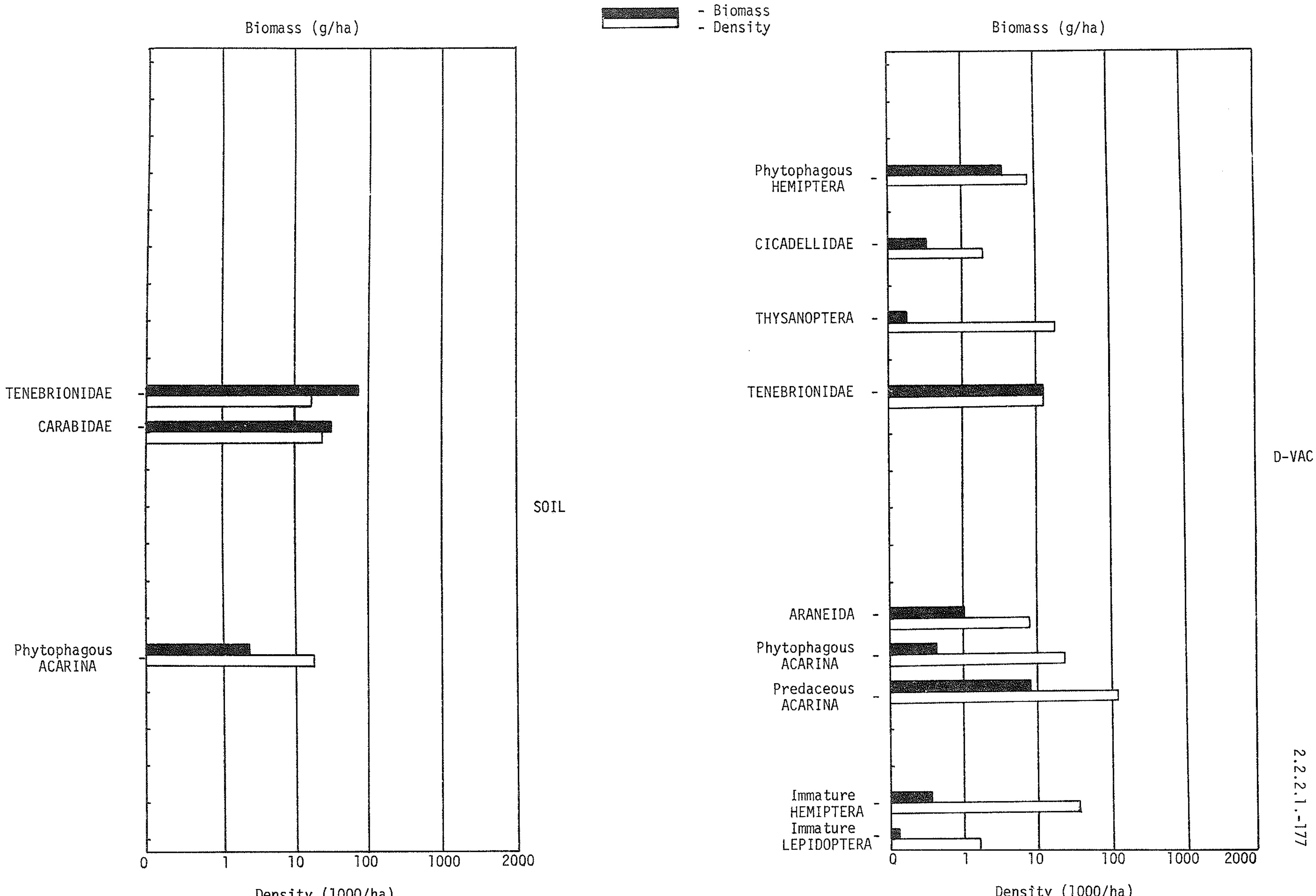

Figure 27. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Sitanion, Artemisia, Atriplex*)

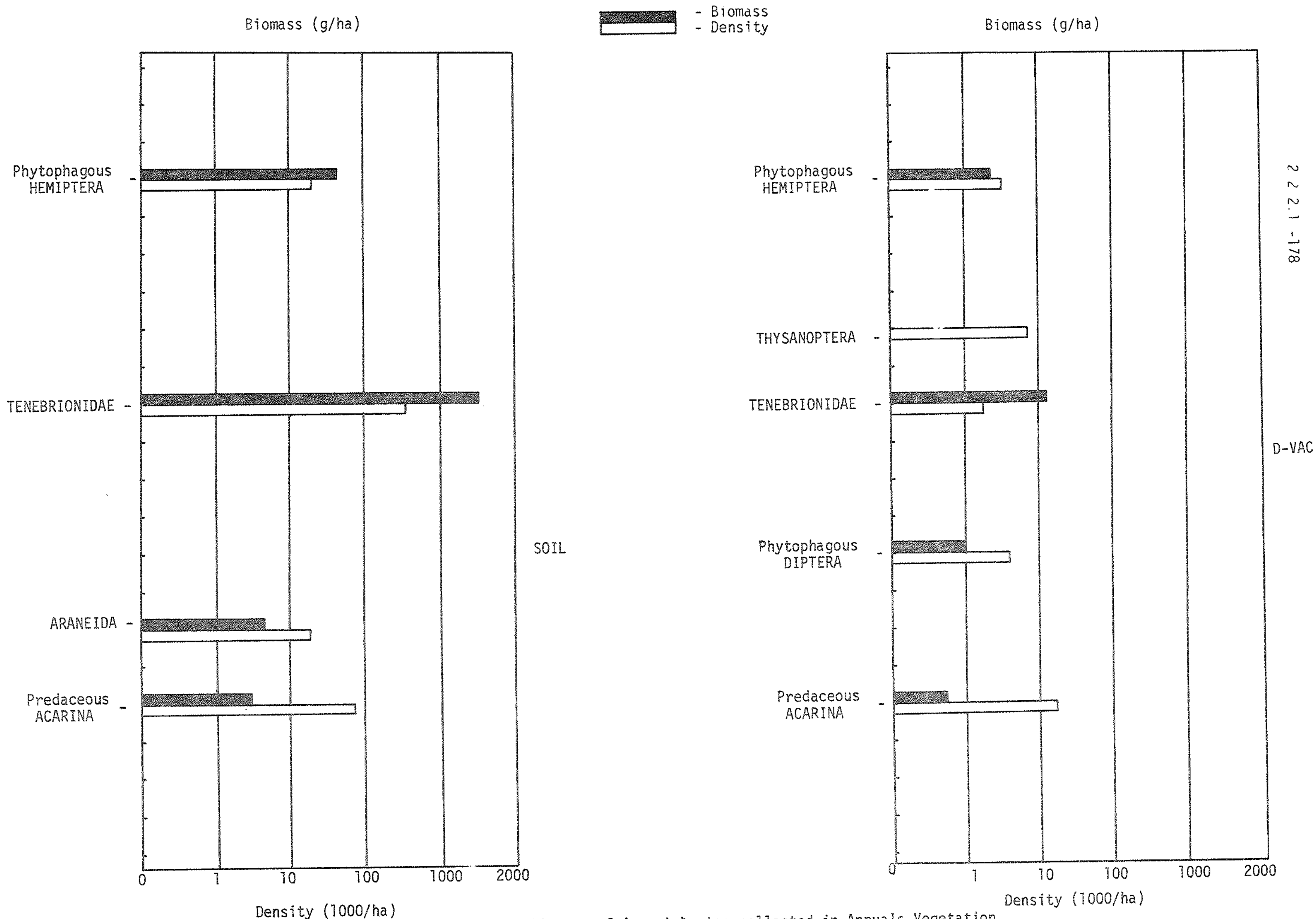

Figure 28. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Halogeton, Bassia, Descurainia* dead, *Artemisia* dead)

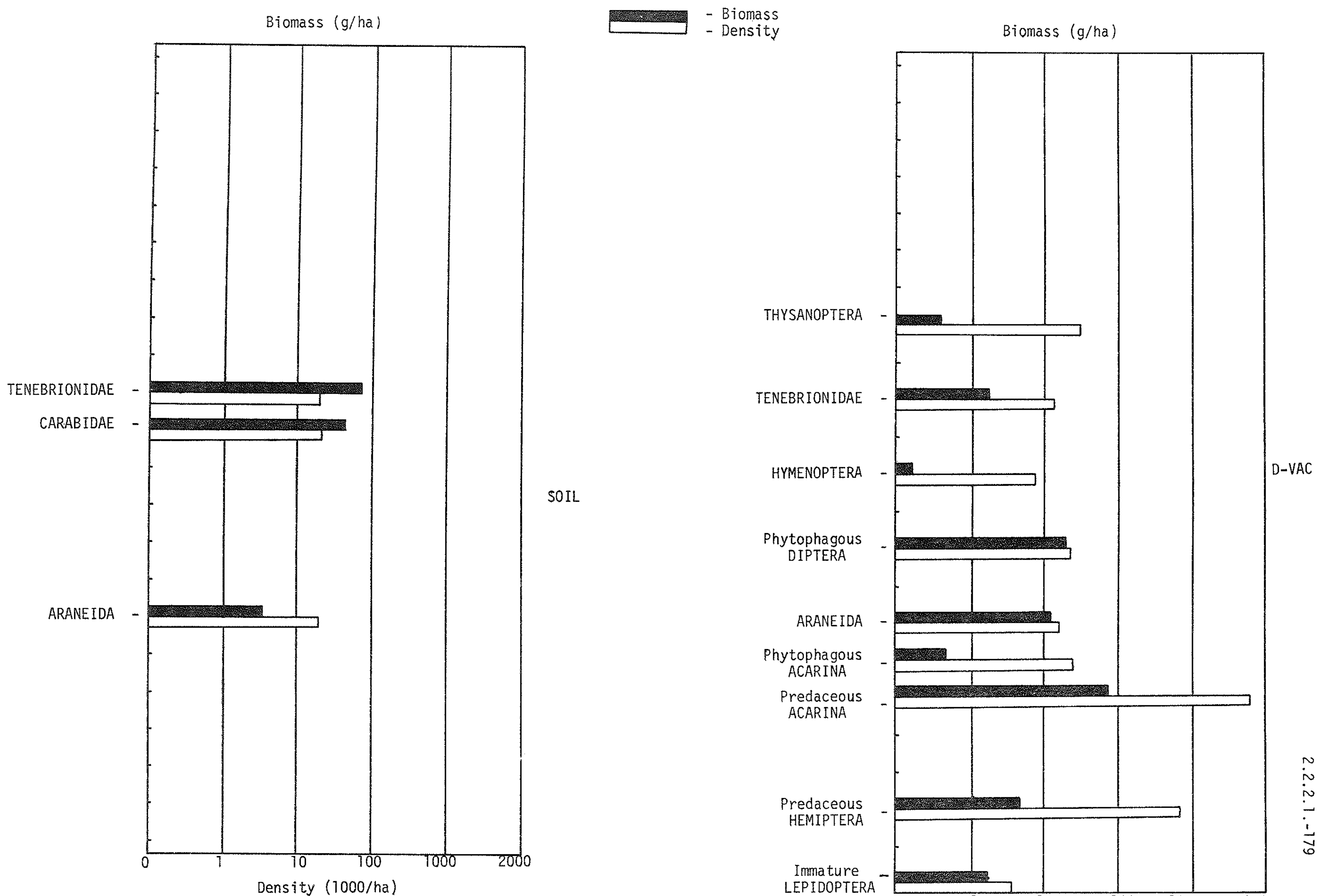

Figure 29. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 8 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Chrysothamnus*)

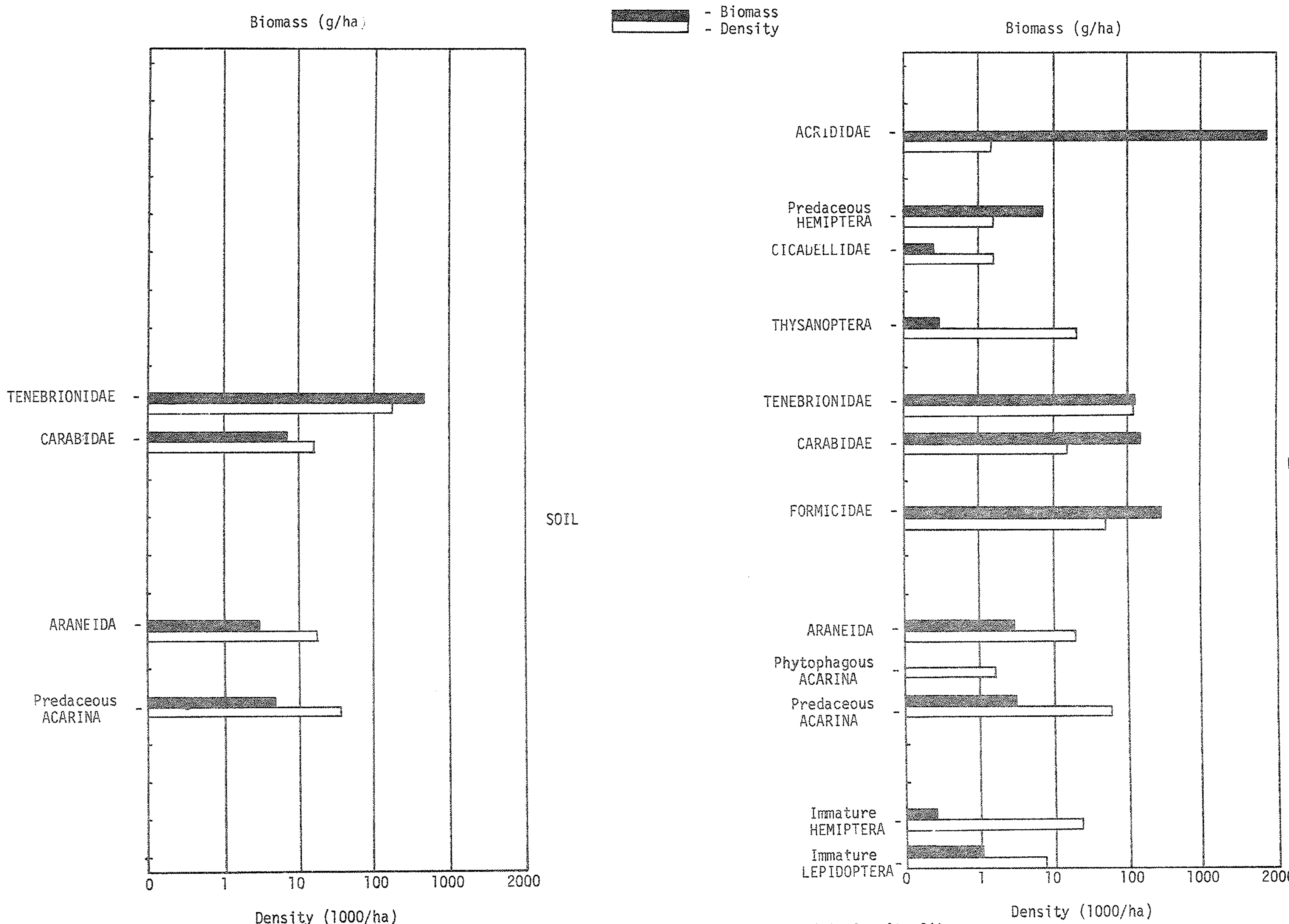

Figure 30. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 15 August, 1972, (Predominant Vegetation: *Atriplex*, *Artemisia* dead *Sitanion*, *Halogeton*, *Chrysothamus*)

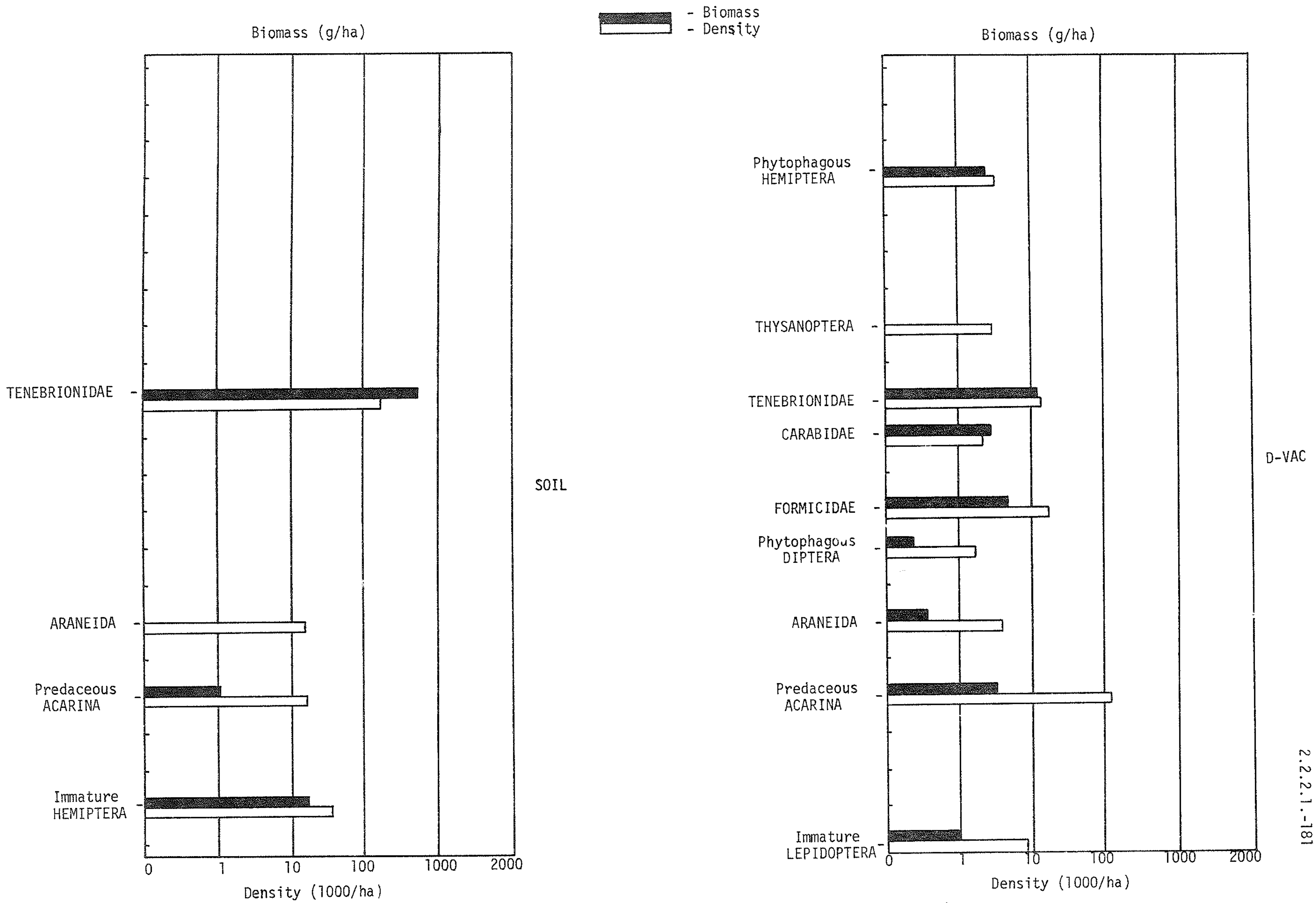

Figure 31. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 15 August, 1972 (Predominant Vegetation: *Halogeton, Bassia, Artemisia* dead, *Sitanion*)

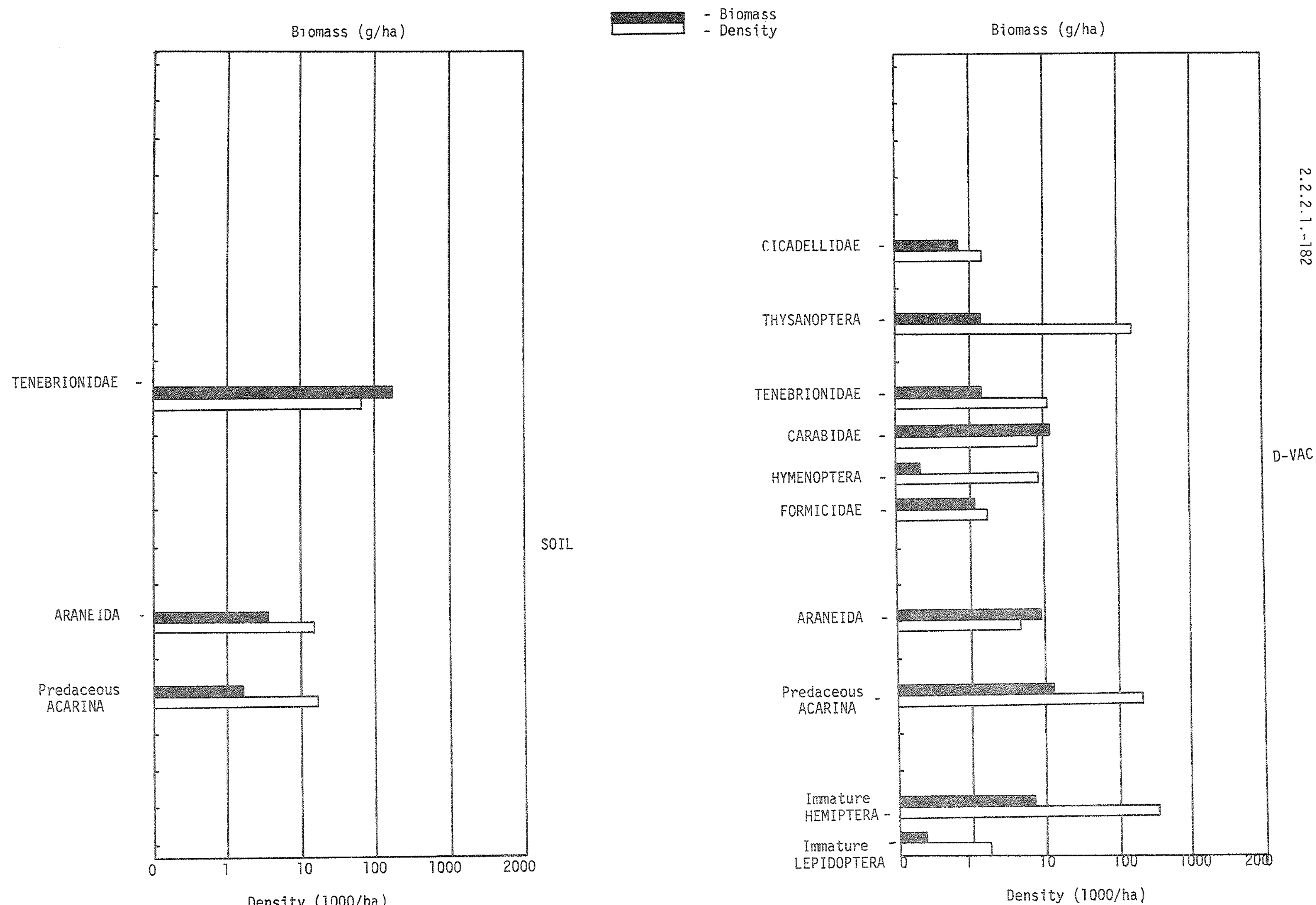

Figure 32. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 25 August, 1972 (Predominant Vegetation: *Agropyron*, *Atriplex*, *Artemisia* dead)

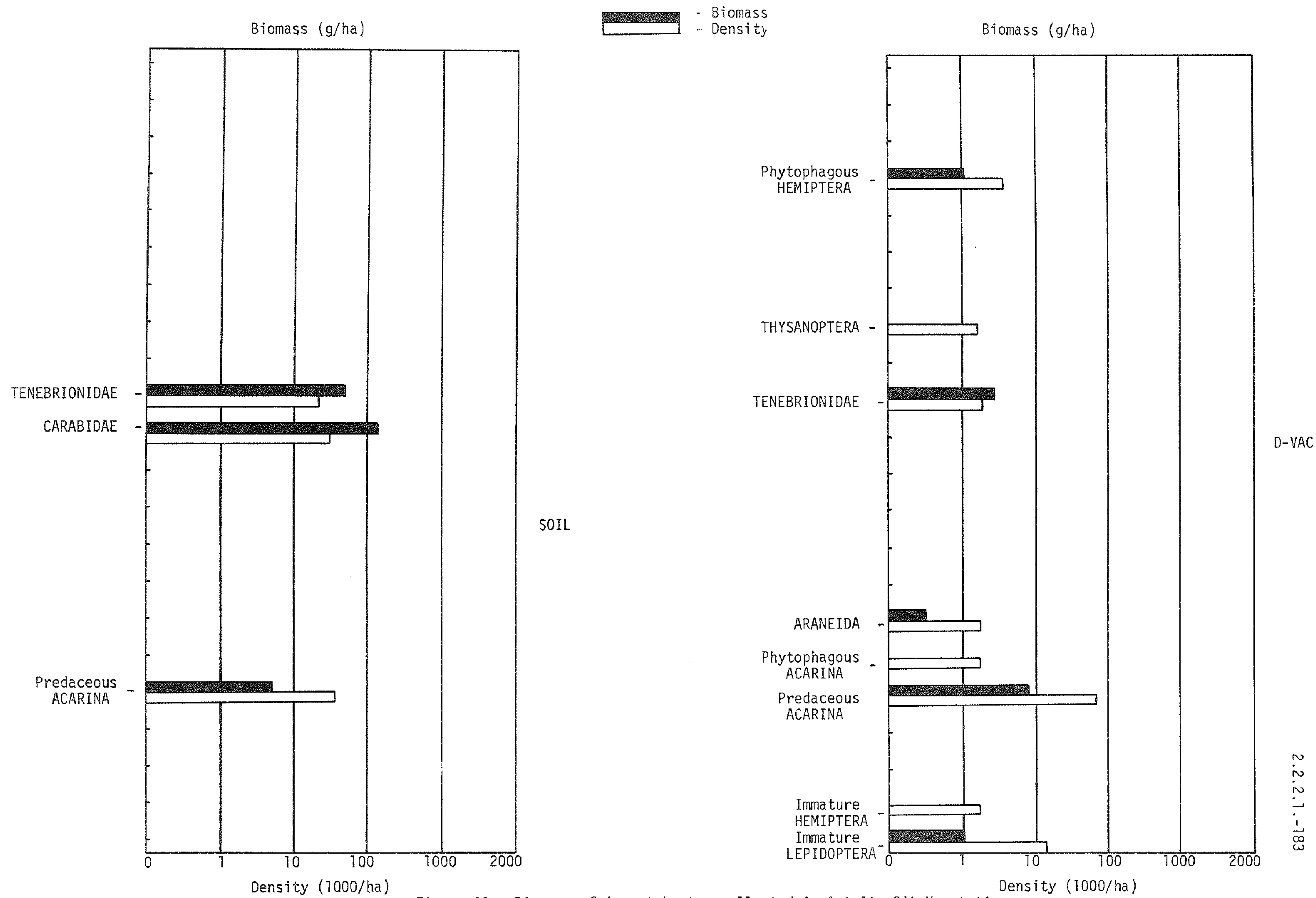

Figure 33. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Artemisia, Atriplex, Sitanion, Chrysothamus, Elymus*)

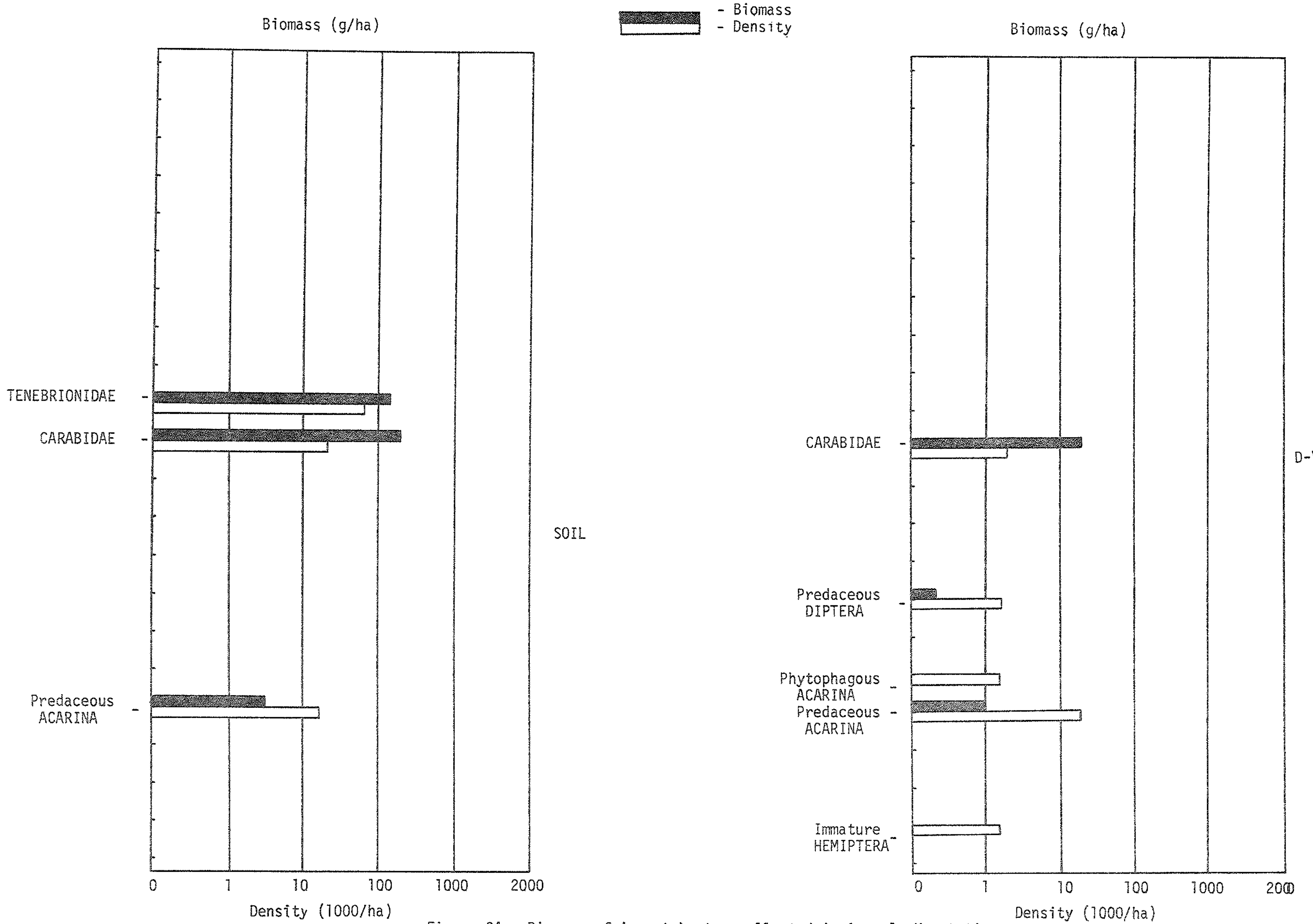

Figure 34. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Halogeton*, *Artemisia* dead, *Bassia*)

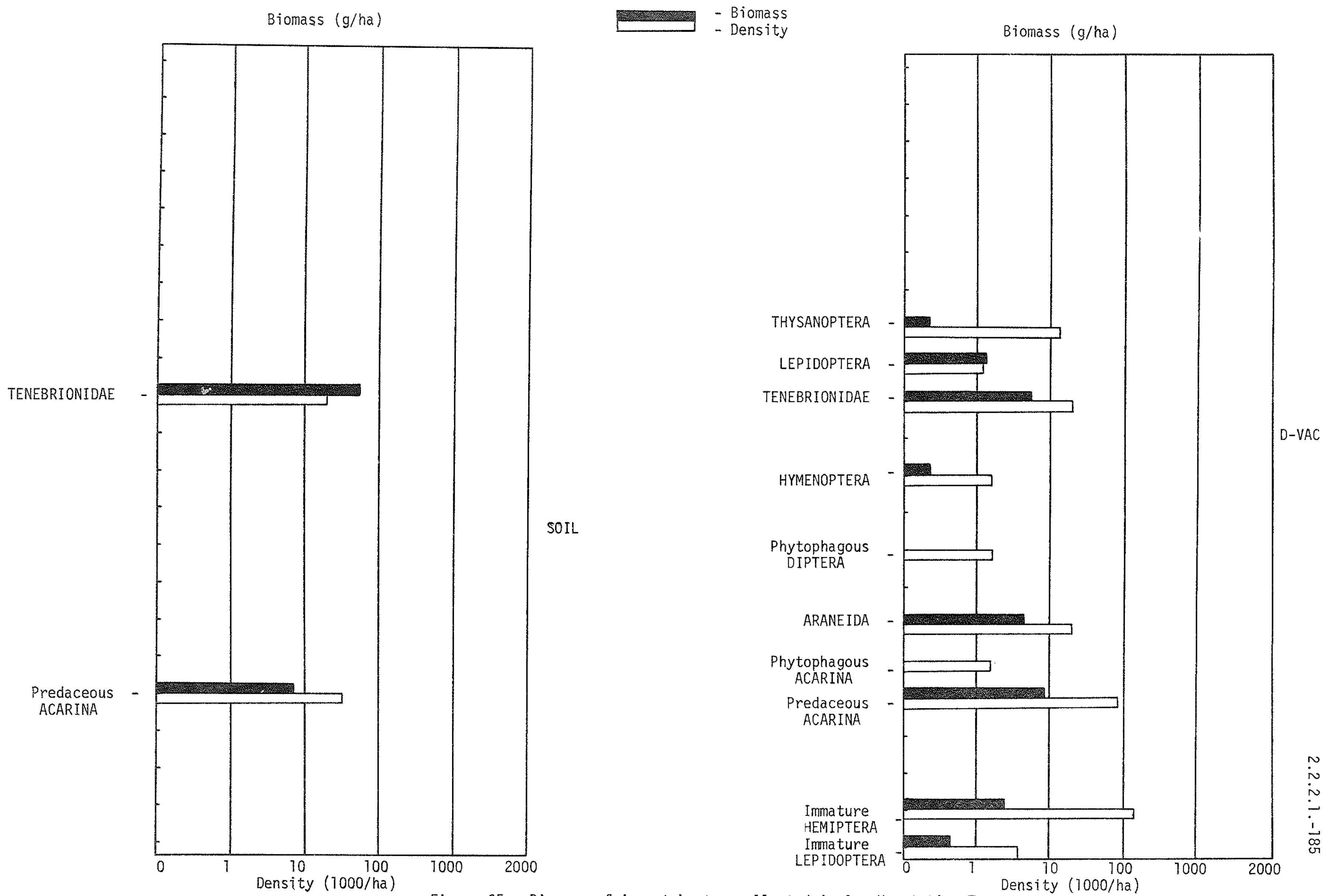

Figure 35. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 22 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Artemisia*)

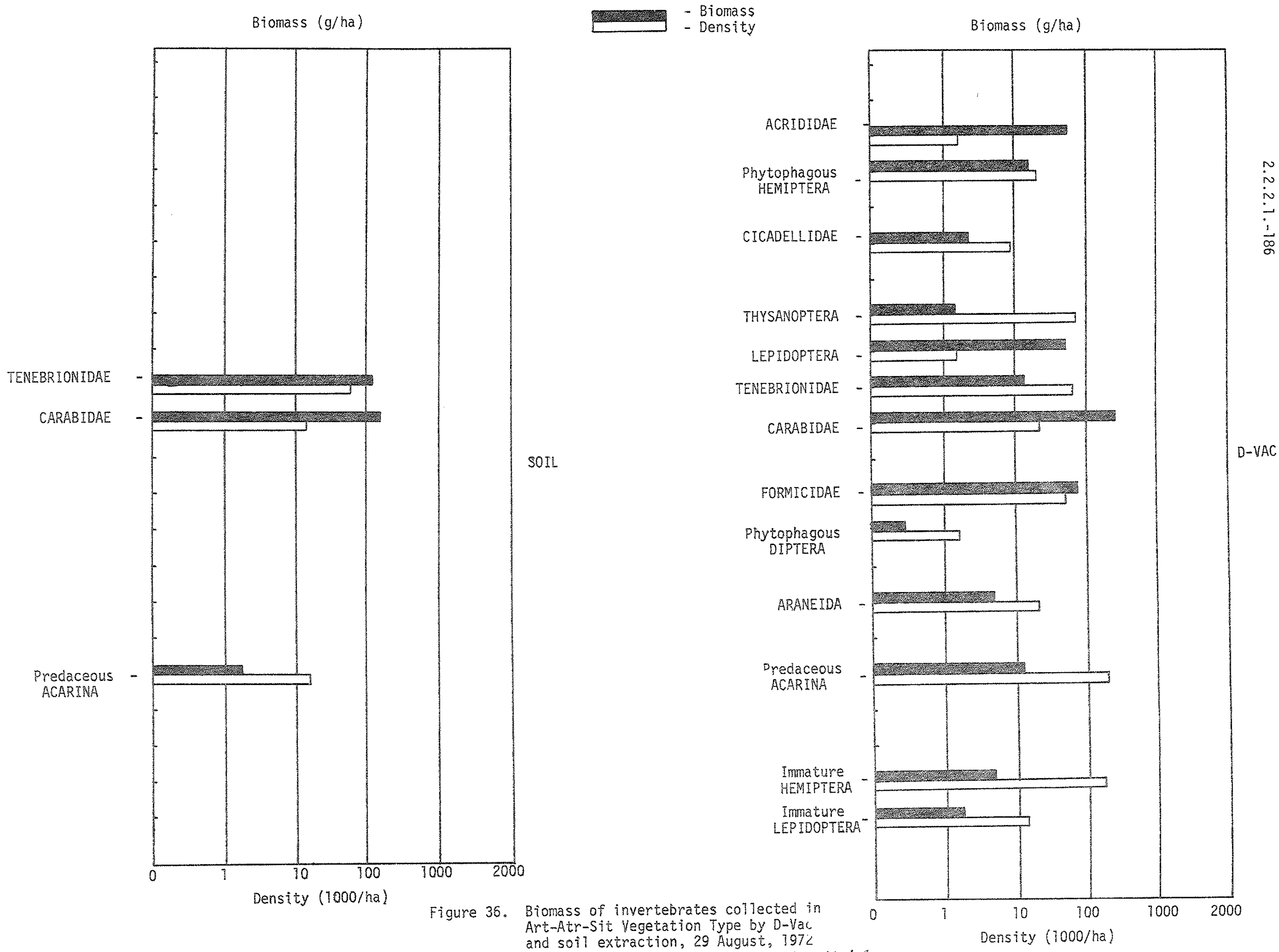

Figure 36. Biomass of invertebrates collected in Art-Atr-Sit Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Artemisia*, *Atriplex*, *Sitanion*, *Chrysothamus*, *Artemisia* dead)

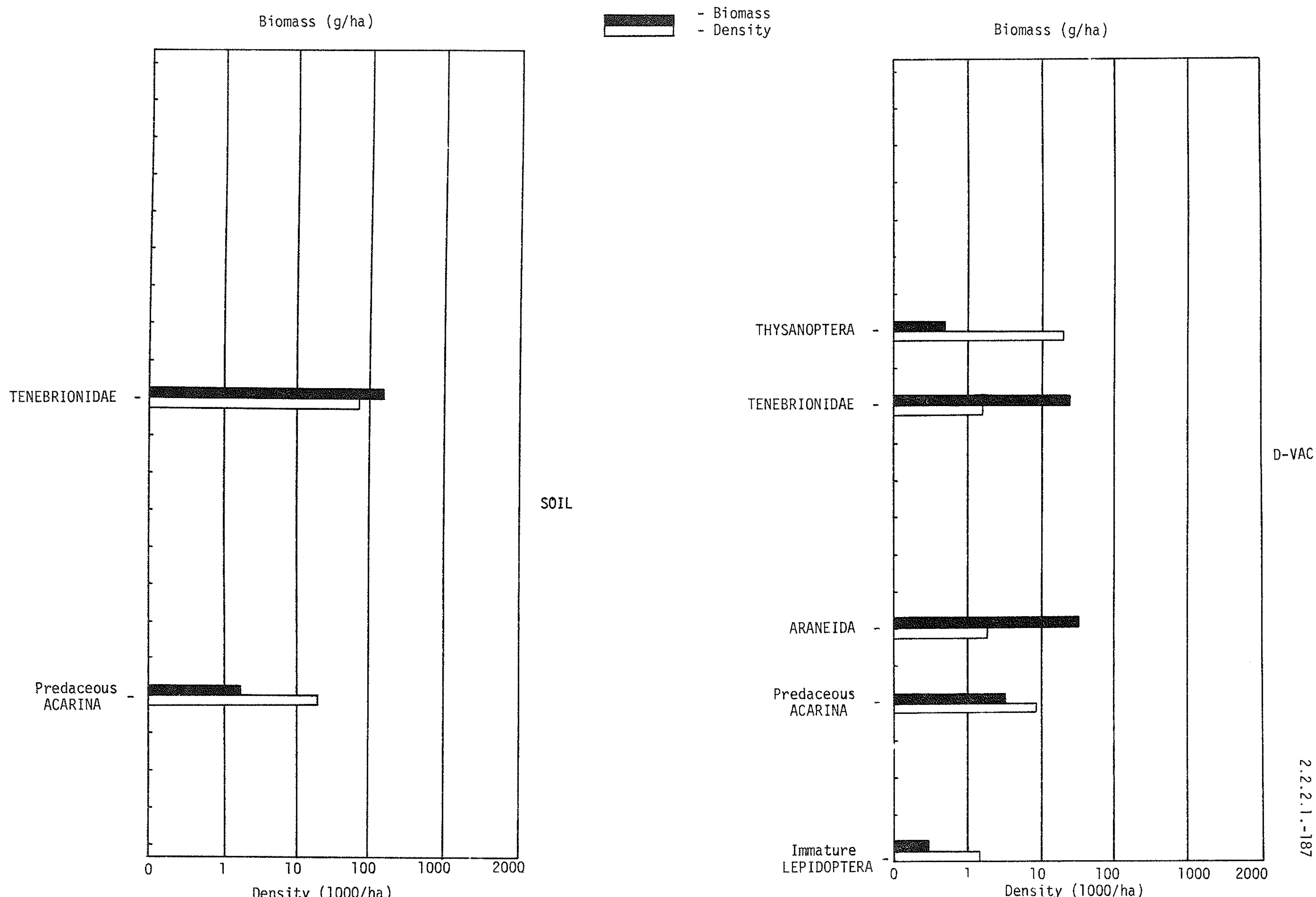

Figure 37. Biomass of invertebrates collected in Annuals Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Halogeton*)

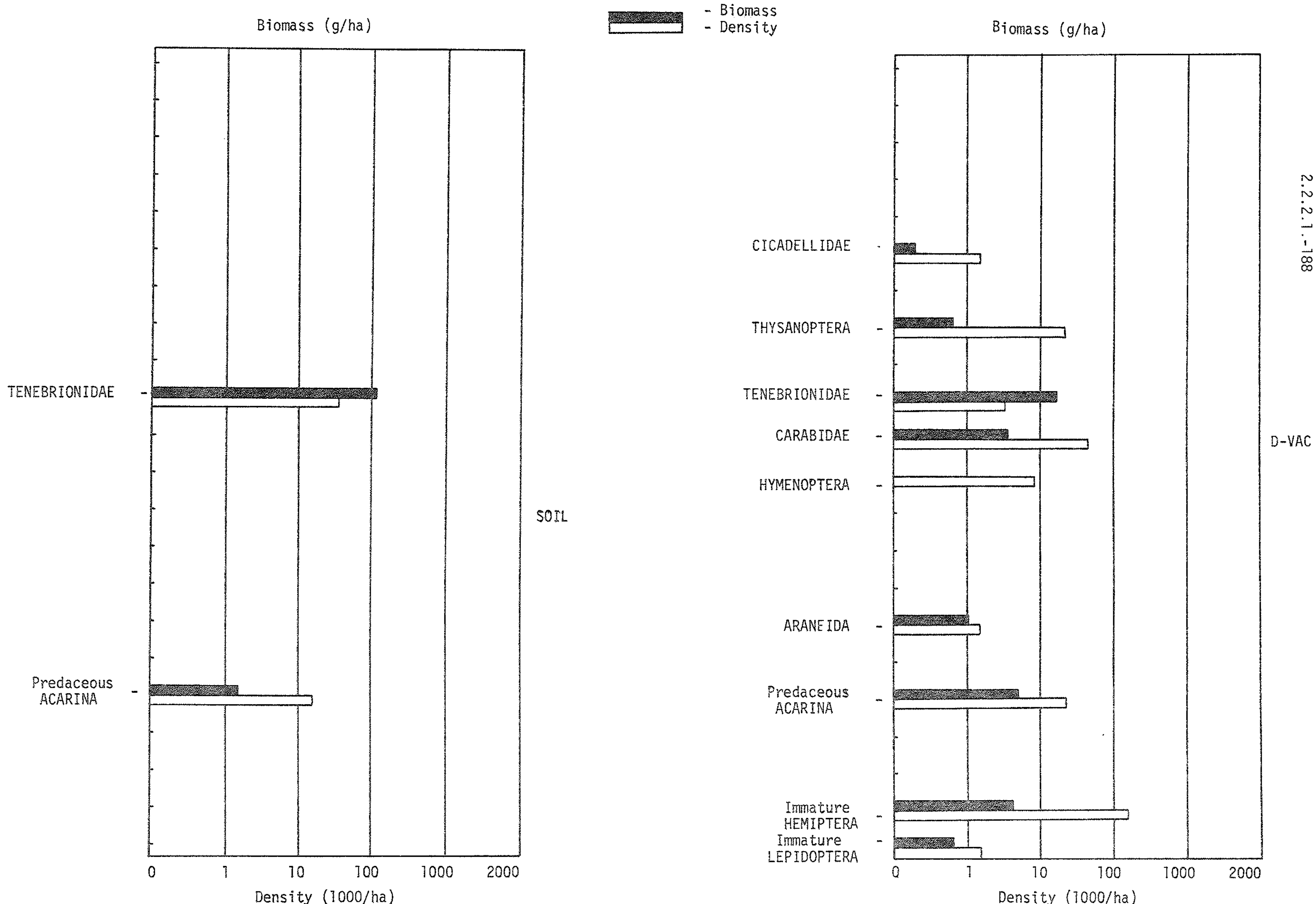

Figure 38. Biomass of invertebrates collected in Agr Vegetation Type by D-Vac and soil extraction, 29 August, 1972 (Predominant Vegetation: *Agropyron, Atriplex, Chrysothamnus*)

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

Taxon	Biomass (g/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		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

	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		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

Taxon	Biomass (g/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	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

	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	.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

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	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			July 17-19			July 24-28			July 31-August 4		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	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			August 14-18			August 21-25			August 28-September 1		
	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	Agr	Art	Annuals	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]r[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
Hayhurstia 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 Buprestid 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 Anthrophoridae
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

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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 xuxiliaris* (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	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	-	-	-	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	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	-	-	-	.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	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	-	.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	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	-	.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	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	-	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.

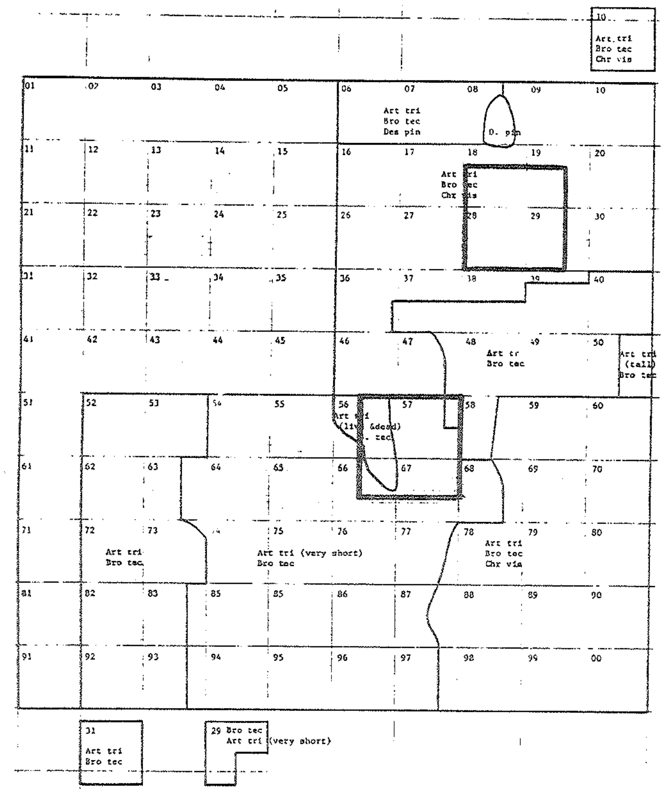


Figure 1. Location of 12 x 12 trapping grids on northern shrub site.

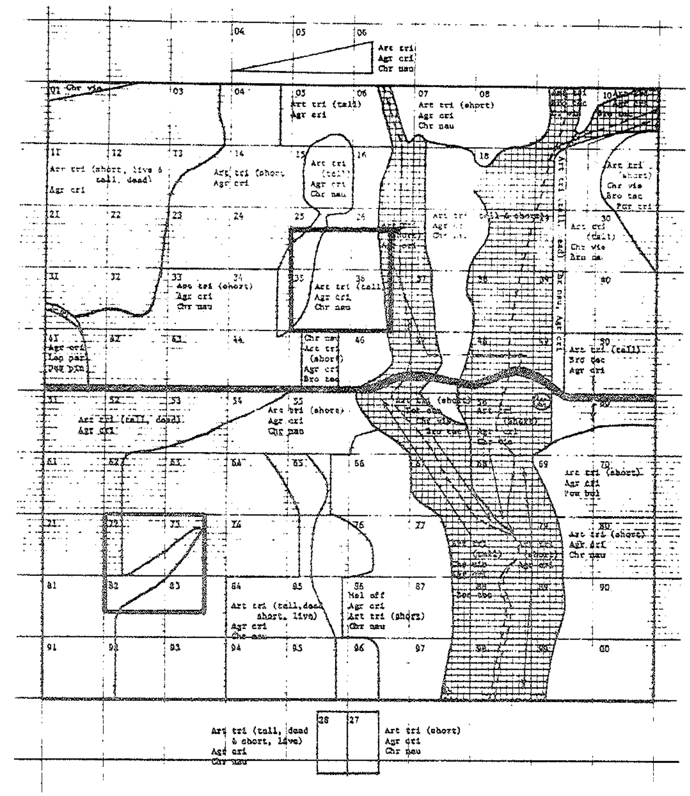


Figure 2. Location of 12 x 12 trapping grids on northern grass site.

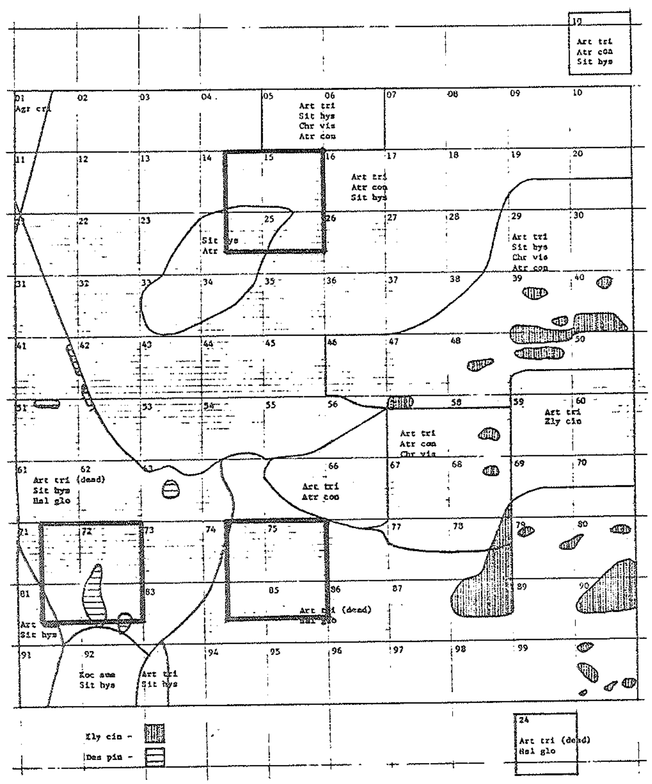


Figure 3. Location of 12 x 12 trapping grids on the southern shrub site.

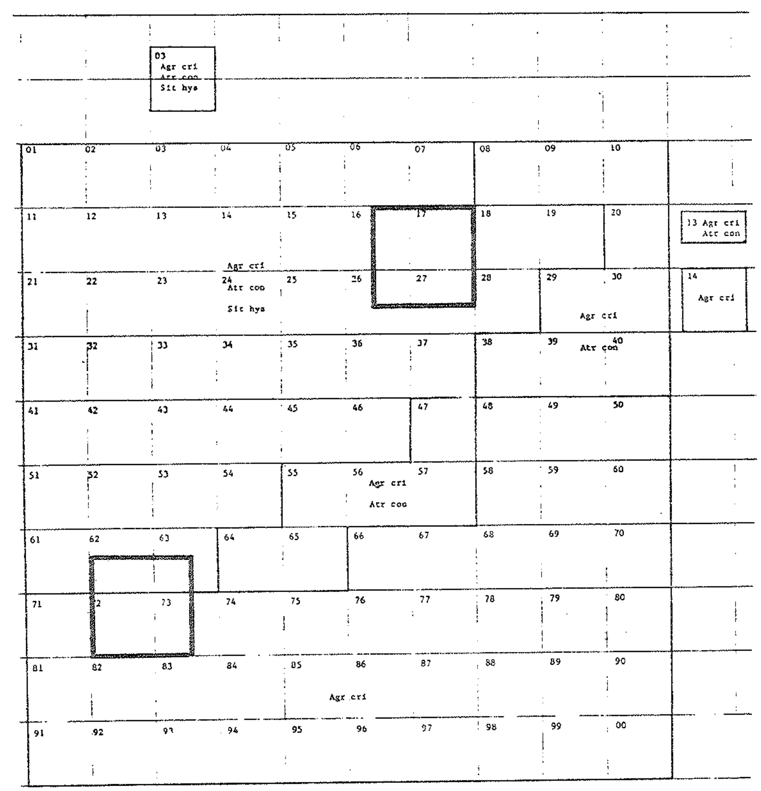


Figure 4. Location of 12 x 12 trapping grid on the southern grass site.

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,

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

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).

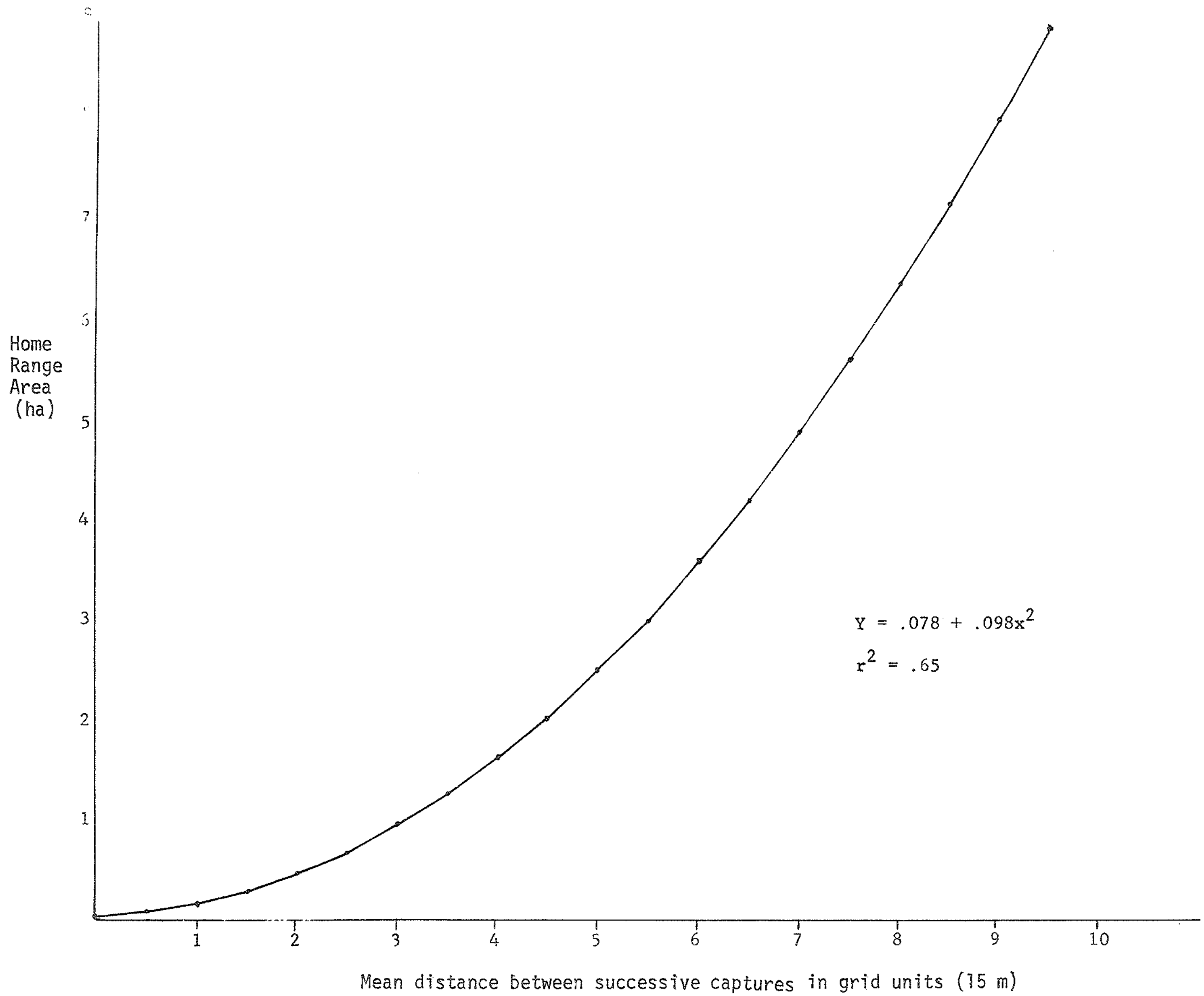


Figure 5. Regression equation for predicting home range area from movement data.

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 Density 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.

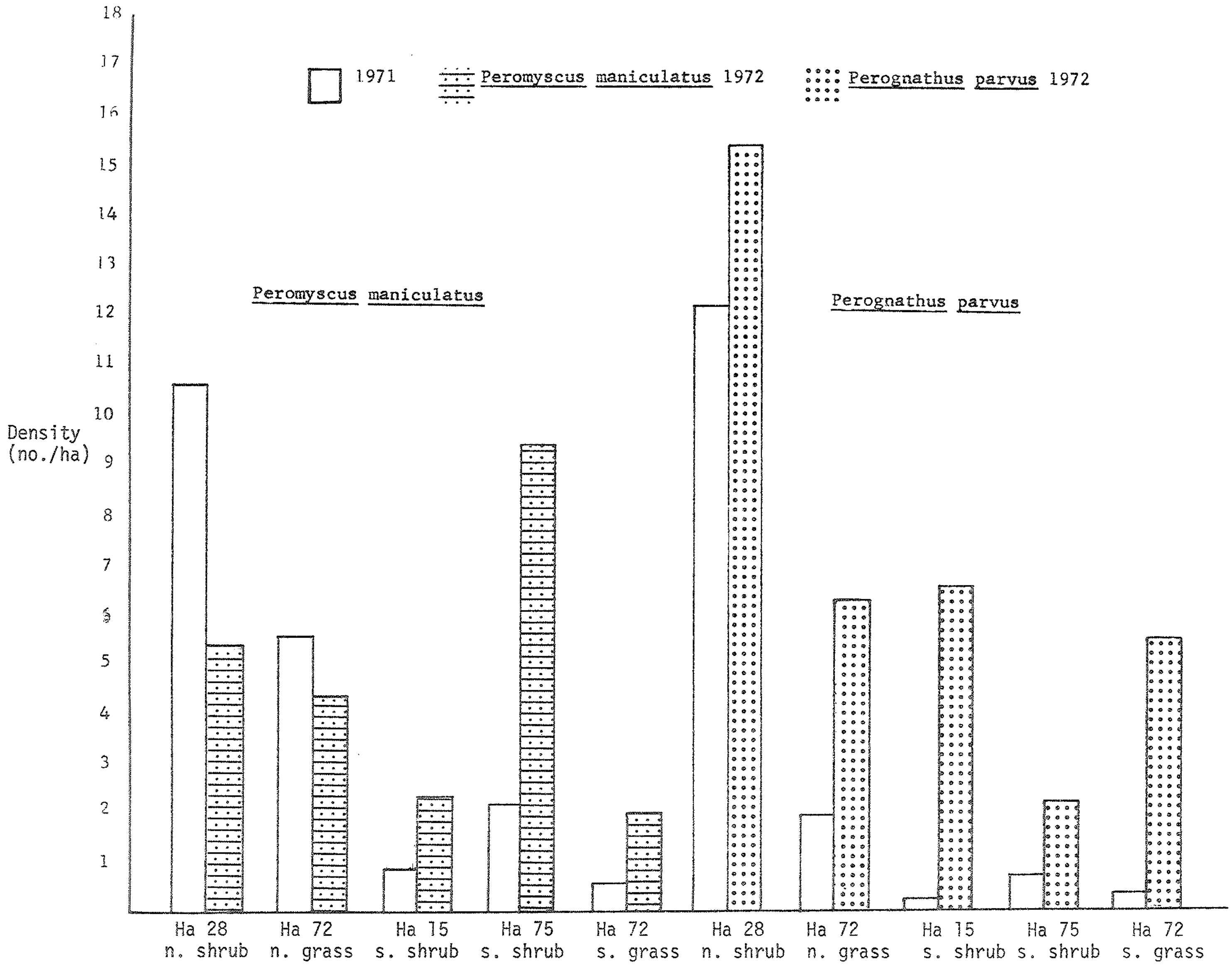


Figure 6. Changes in estimated density of two rodent species on Curlew Valley Validation Sites, 1971-1972.

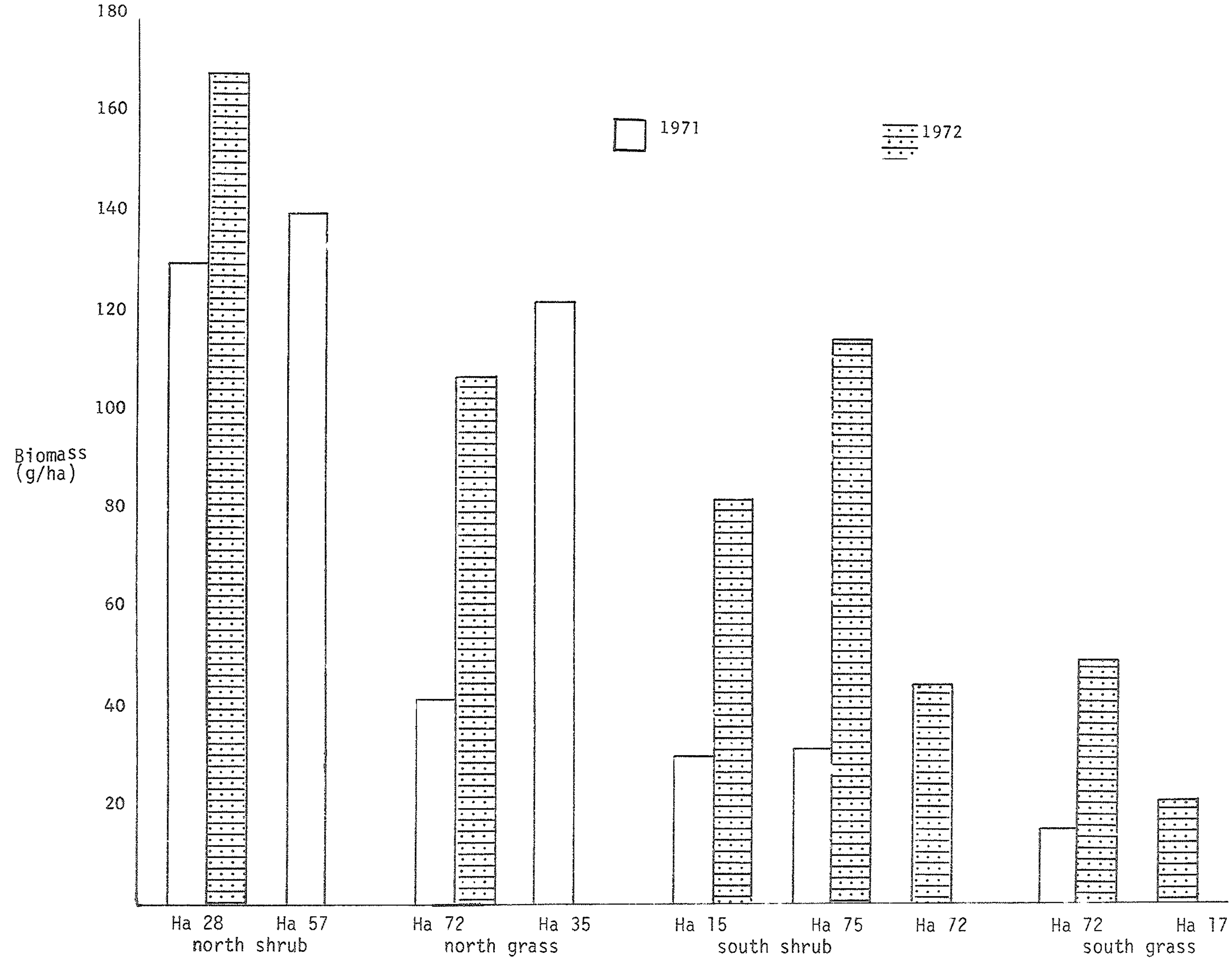


Figure 7. Changes in total estimated rodent biomass on Curlew Valley Validation Sites, 1971-1972.

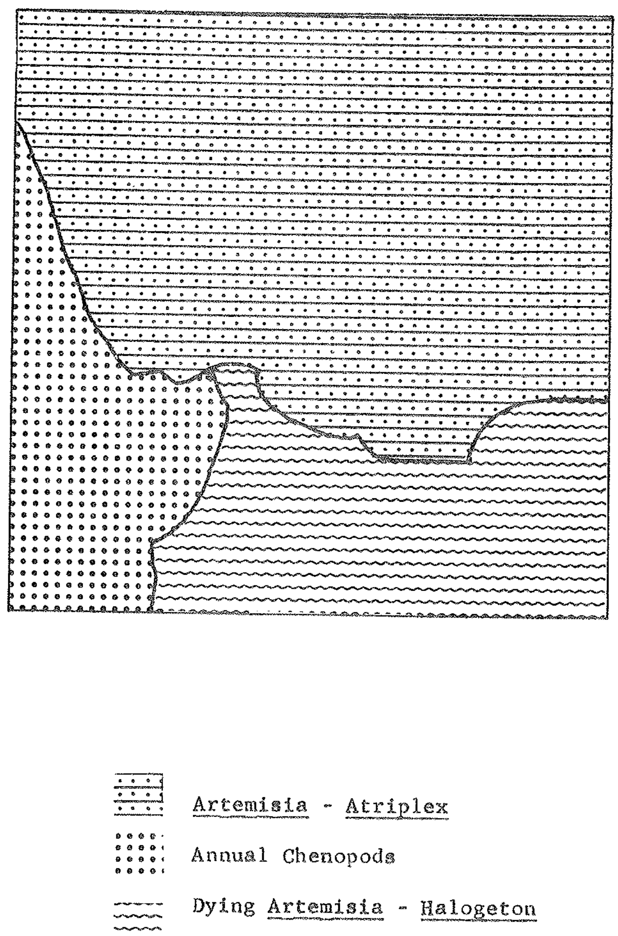


Figure 8. Vegetation map showing defined vegetation types on southern shrub site.

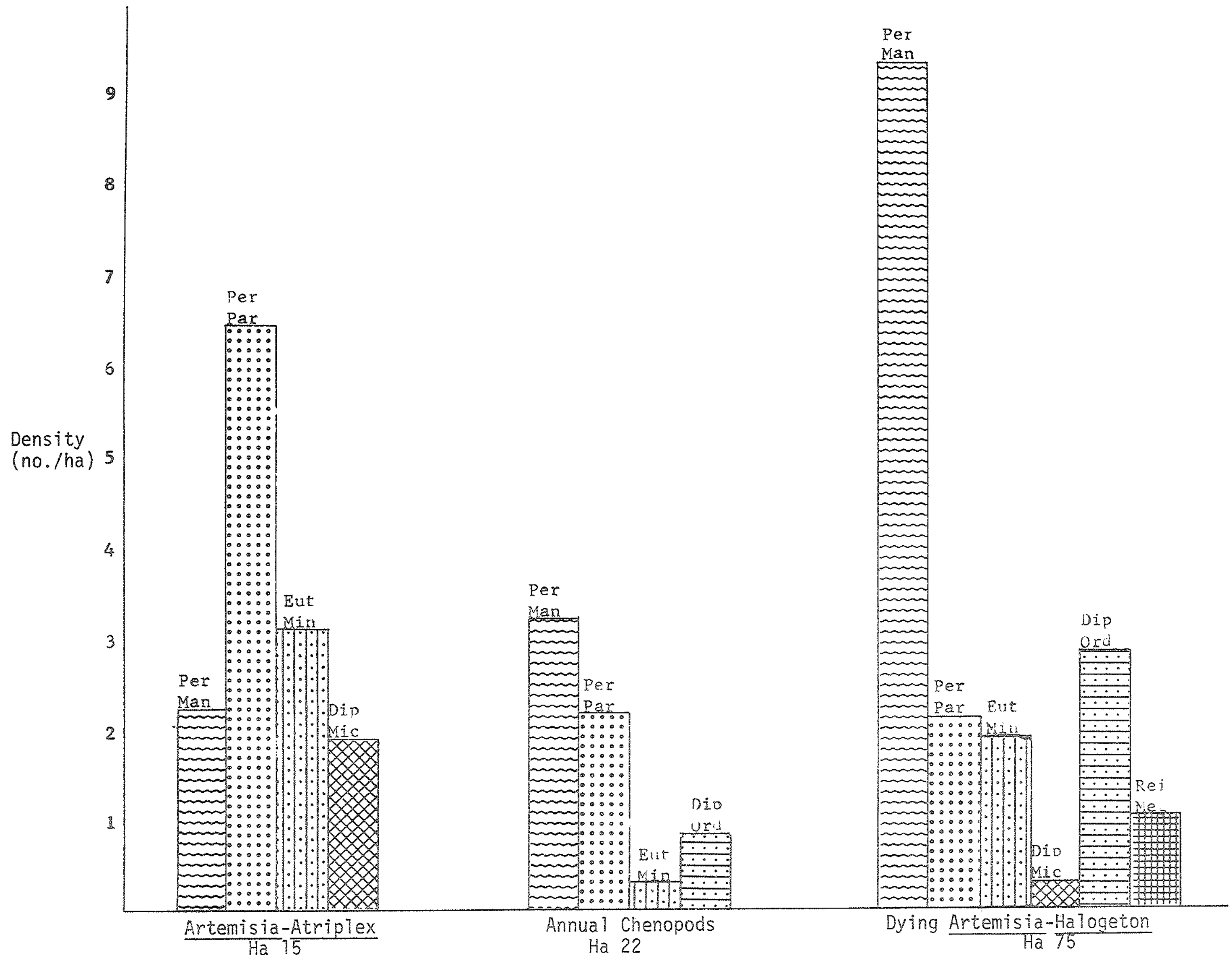


Figure 9. Estimated rodent density by species in three vegetation types, south shrub site, 1972.

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.

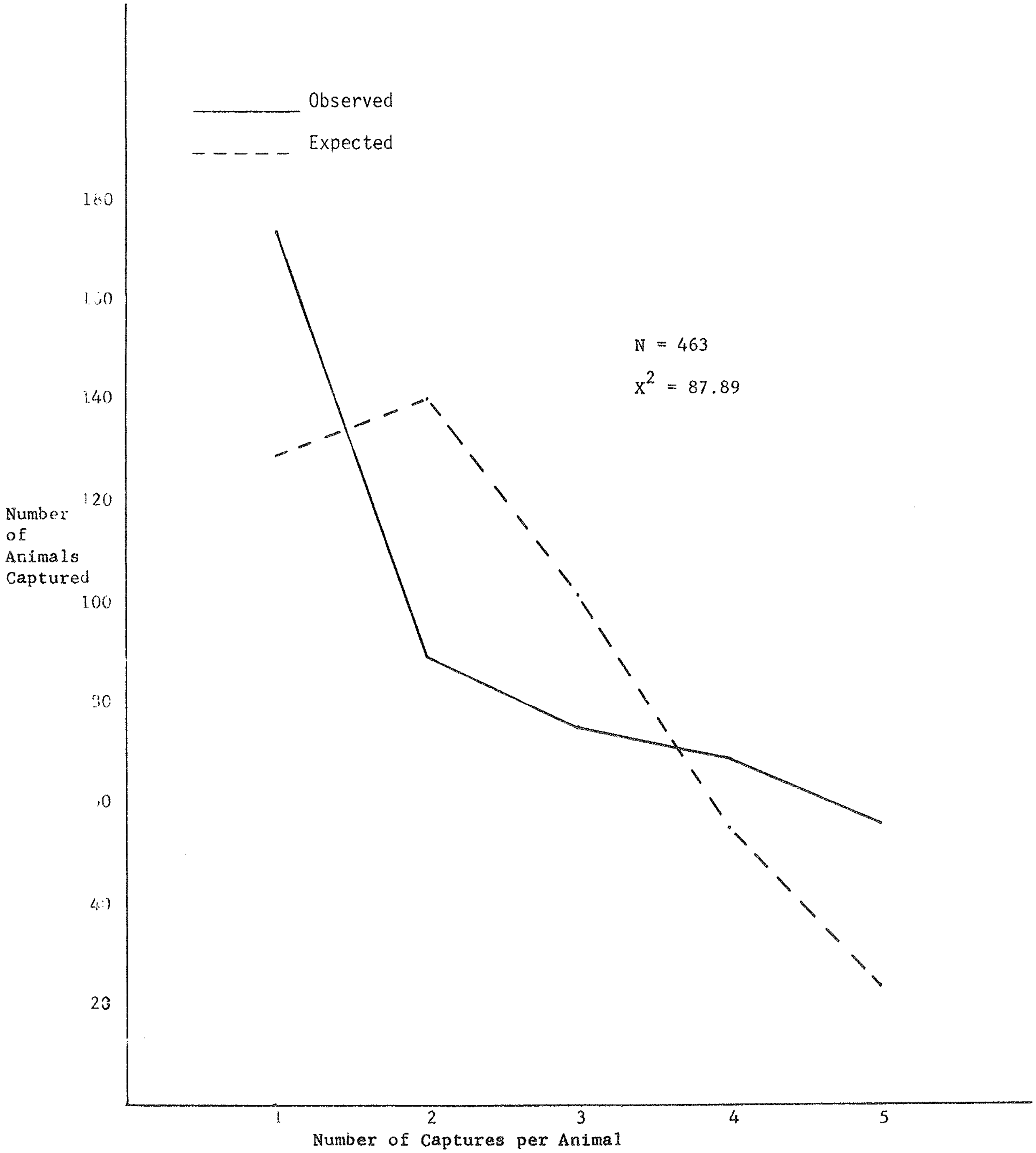


Figure 10. Comparison of *Peromyscus maniculatus* frequency of capture curve with Poisson distribution

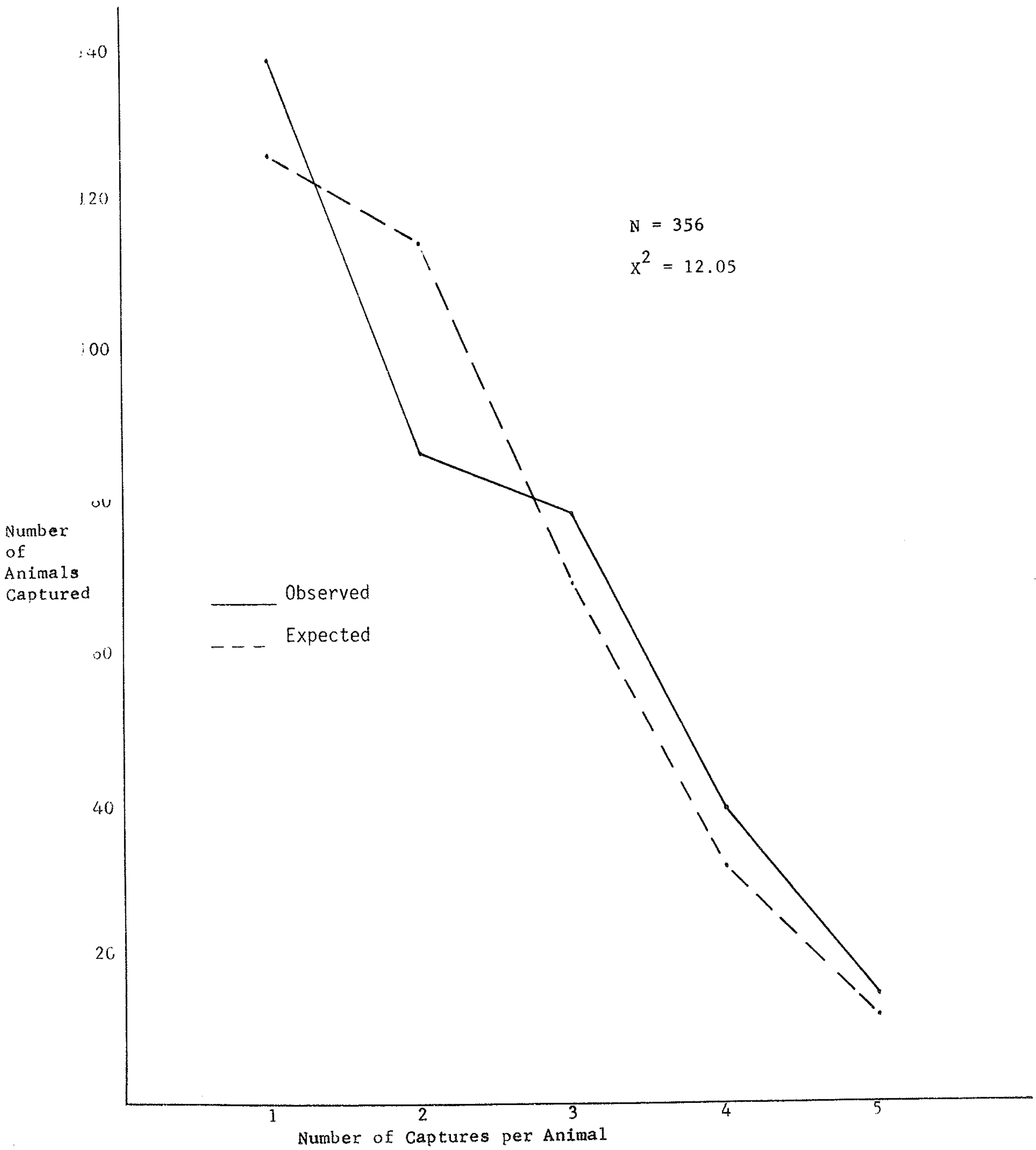


Figure 11. Comparison of *Perognathus parvus* frequency of capture curve with Poisson distribution.

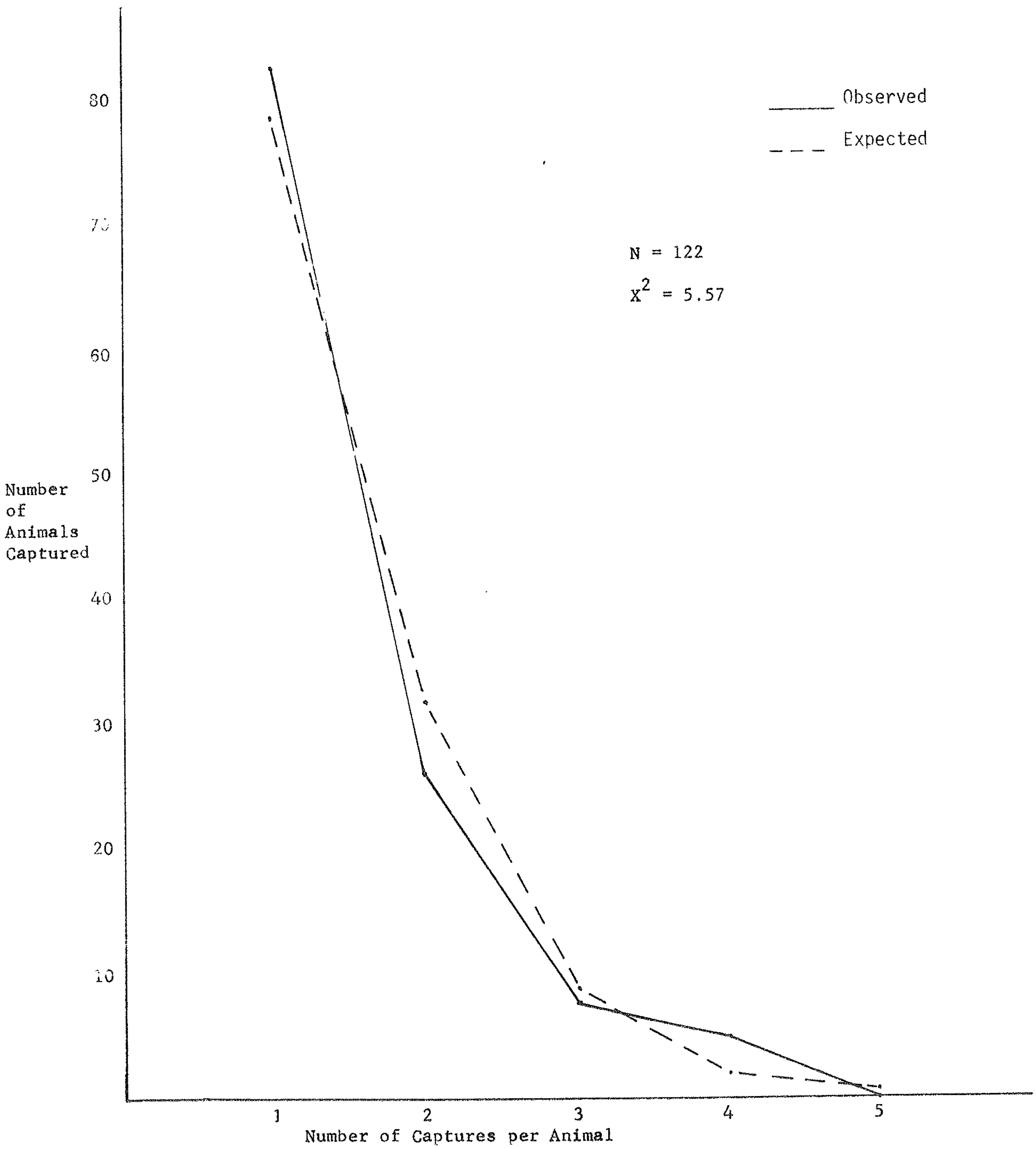


Figure 12. Comparison of *Eutamias minimus* frequency of capture curve with Poisson distribution.

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	--

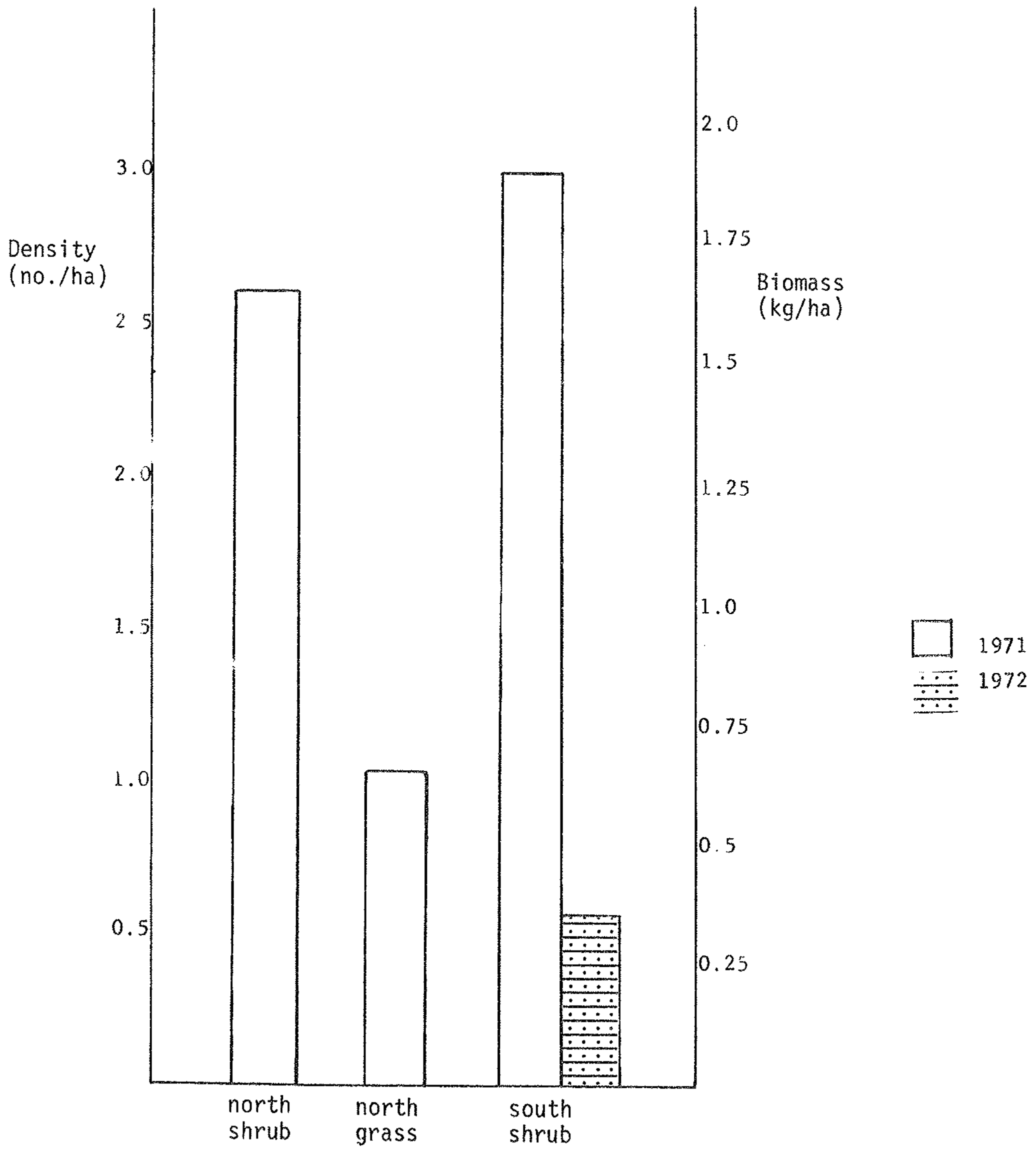


Figure 13. Estimated jackrabbit density and biomass on Curlew Valley Validation Sites, 1971 and 1972.

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

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

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

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

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

	Grass Site		Shrub Site	
Date	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.

LITERATURE CITED

Anderson, R.D., and D.F. Balph. 1972. An evaluation of trap stimulus in relation to probability of rodent capture. U.S./IBP Desert Biome Res. Memo. RM 72-9.

Balph, D.F 1968. Behavioral responses of unconfined Uinta ground squirrels to trapping. J. Wildl. Mgmt. 32(4):778-794.

Balph, D.F. 1971. Sampling small mammal populations in Curlew Valley. U.S./IBP Desert Biome Research Memo. RM 71-8.

Blaxter, K.L. 1962. Energy metabolism of ruminants. Charles Thomas Co., Springfield, Ill. 332 p.

Brant, D.H. 1962. Measures of the movements and population densities of small rodents. Univ. Calif. Publ. Zool. 62:105-184.

Brody, S. 1945. Bioenergetics and Growth. Reinhold Pub. Co, New York.

Chapman, D.G. 1948. A mathematical study of confidence limits of salmon populations calculated from sample tag ratios. Int. Pacific Salmon Fish. Comm. Bull. No. 2: 67-85.

Cohen, C.A., Jr. 1960. Estimating the parameter in a conditional Poisson distribution. Biometrics 16:203-211.

Cook, C.W. 1970. Energy budget of the range and range livestock. Colo. State Univ. Exp. Sta. Bul. TB 109. 28 p.

Crowcroft, P., and J.N.R. Jeffers. 1961. Variability in the behavior of wild house mice (*Mus musculus* L.) toward live traps. Proc. Zool. Soc. London. 137(4): 573-582.

Emlen, J.T. 1971. Population densities of birds derived from transect counts. Auk 88:323-342.

Garret, W.N., J.H. Meyer, and G.P. Lofgreen. 1959. The comparative energy requirements of sheep and cattle for maintenance and gain. J Animal Sci. 18:528-546.

Geis, A.D. 1955. Trap response of the cottontail rabbit and its effect on censusing. J. Wildl. Mgmt. 19(4):466-472.

Graham, N. McC. 1965. Energy costs of feeding activities and energy expenditure of grazing sheep Austral. J. Agr. Res. 15:969-973.

Hanson, W.R. 1967. Estimating the density of an animal population. J. of Research on the Lepidoptera 6(3):203-247.

Holte, K.E. 1972. U.S./IBP Desert Biome Research Memo. RM 72-1, pp 30-47.

Huber, J.J. 1962. Trap response of confined cottontail populations. J. Wildl. Mgmt. 26(2):177-185.

Jennrich, R.I., and F.B. Turner. 1969. Measurement of non-circular home range. J. Theoret. Biol. 22:227-237.

Johnson, D.R. 1961. The food habits of rodents on rangelands of southern Idaho. Ecology 42(2):407-410.

Jolly, G.M. 1965. Explicit estimates from capture-recapture data with both death and immigration - stochastic model. Biometrika 52(142):225-247.

Mitchell, G.W. 1969. Nutritive values of Russian wildrye, crested wheatgrass, and intermediate wheatgrass grazed by cattle on Utah Foothill ranges. M.S. Thesis, Utah State University, Logan. 47 p.

N.A.S. 1970. Nutrient requirements of beef cattle (4th ed.). National Academy of Sciences Publication No. 4. Washington, D.C. 55 p.

Overton, W.S. 1965. A modification of the Schnabel estimator to account for removal of animals from the population. J. Wildl. Mgmt. 29(2):392-395.

Rosenzweig, M.L. 1973. Population interactions and ecological surprises. U.S./IBP Desert Biome Second Annual Conference, Arizona State University, Tempe, Arizona, March 14-16. (Unpublished)

Schnabel, Z.E. 1938. Estimation of the total fish population of a lake. Amer. Math. Monthly 45:348-352.

Stoddart, L.C. 1972. Population biology of the black-tailed jackrabbit (*Lepus californicus*) in northern Utah. Ph.D. Dissertation, Utah State University, Logan.

Stumpt, W.A., and C.O. Mohr. 1962. Linearity of home ranges of California mice and other animals. J. Wildl. Mgmt. 26(2):149-154.

Turner, F.B., R.D. Anderson, and D.F. Balph. 1971. Correspondence on home range determination for small mammals. U.S./IBP Desert Biome Research Memo. RM 72-27.

Williamson, K. 1964. Bird census work in woodland. Bird Study 11:1-22.

Young, B.A. 1971. A practical means for estimating cold stress in cattle. Proceedings of the 7th Ranch Field Day. University of Alberta, Edmonton. p. 12-14.

Young, H., J. Neess, and J.T. Emlen, Jr. 1952. Heterogeneity of trap response in a population of house mice. J. Wildl. Mgmt. 16(2):169-180.

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

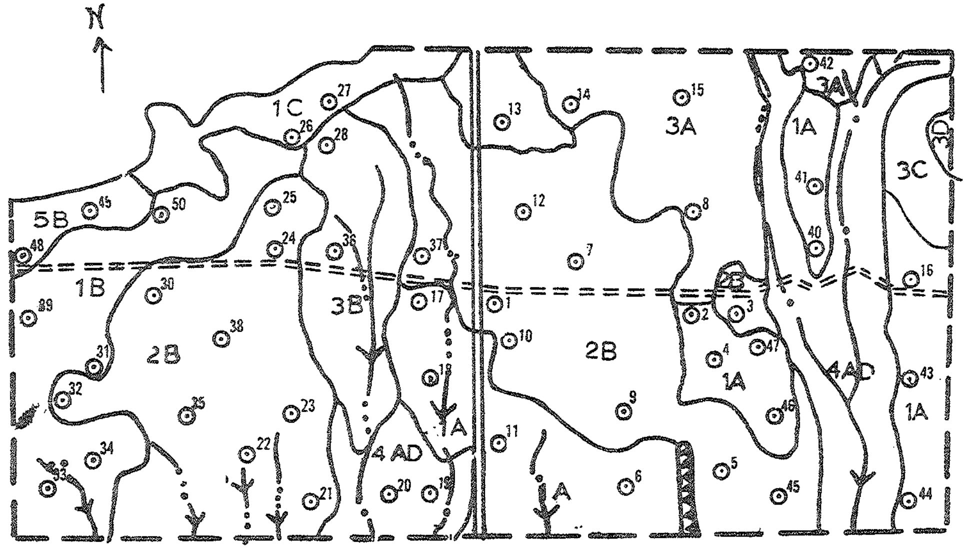
The northern sites are characterized by rolling topography with deep dissection and severe sheet and gully erosion. The upper levels of Lake Bonneville lie within the sites and at least two distinctly different geologic materials are encountered. The lower-lying rocks are of the Salt Lake Formation; 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.



NORTHERN SHRUB SITE NORTHERN GRASS 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

SOIL SYMBOL	SOIL MAPPING UNIT
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 simılar 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 $\frac{mmho}{cm}$	OC (%)	N (%)	$CaCO_3$ (%)	CEK $\frac{me}{100g}$	EK $\frac{me}{100g}$	ES $\frac{me}{100g}$	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 $1 m^2$ 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 x 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 x 10^{-3})	Chlorophyll *a* / Biomass (mg) X 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 $8.6\text{x } 10^{-6}$ 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. The 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	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-AI		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

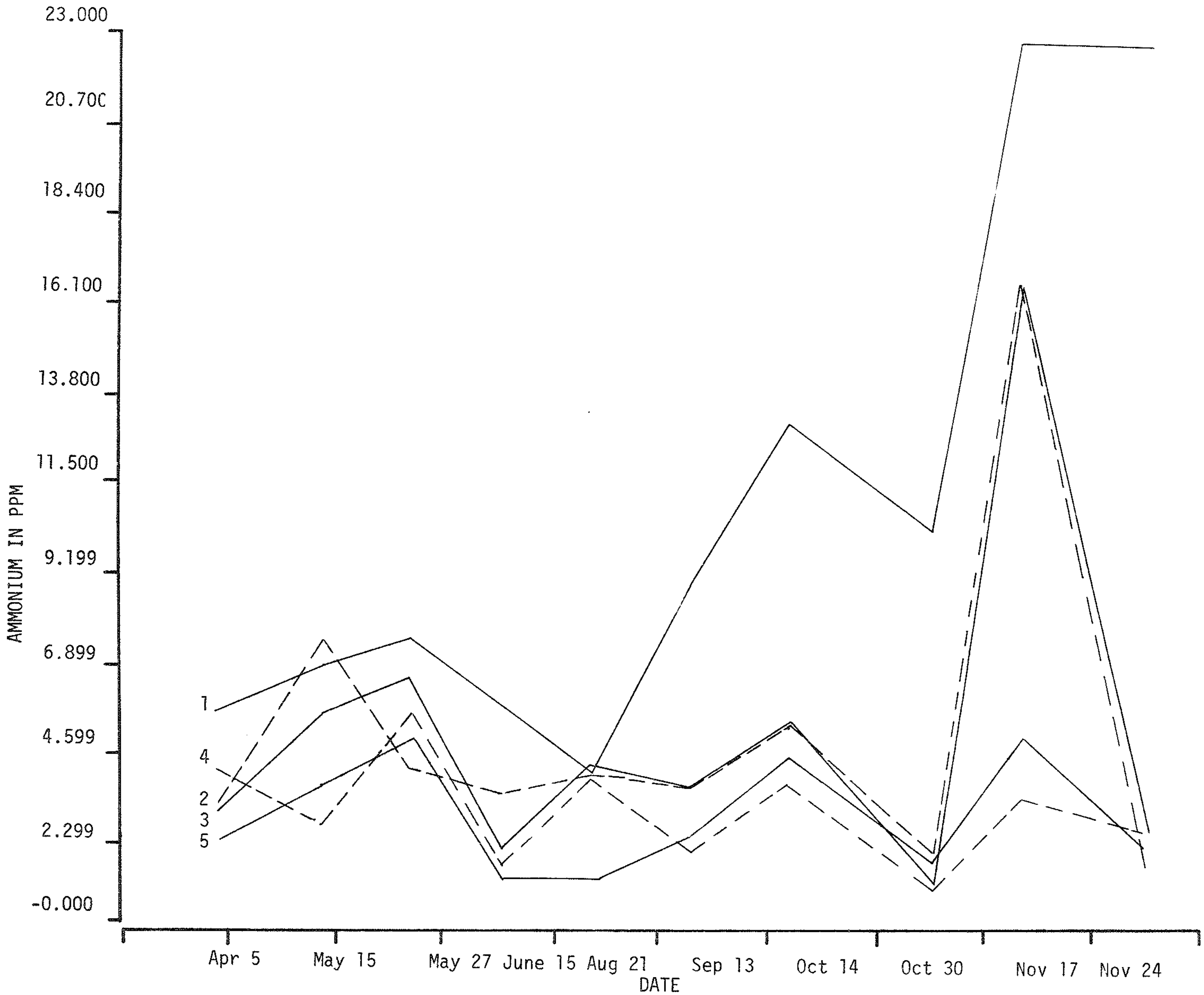


Figure 2. Seasonal changes in mean ammonium at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

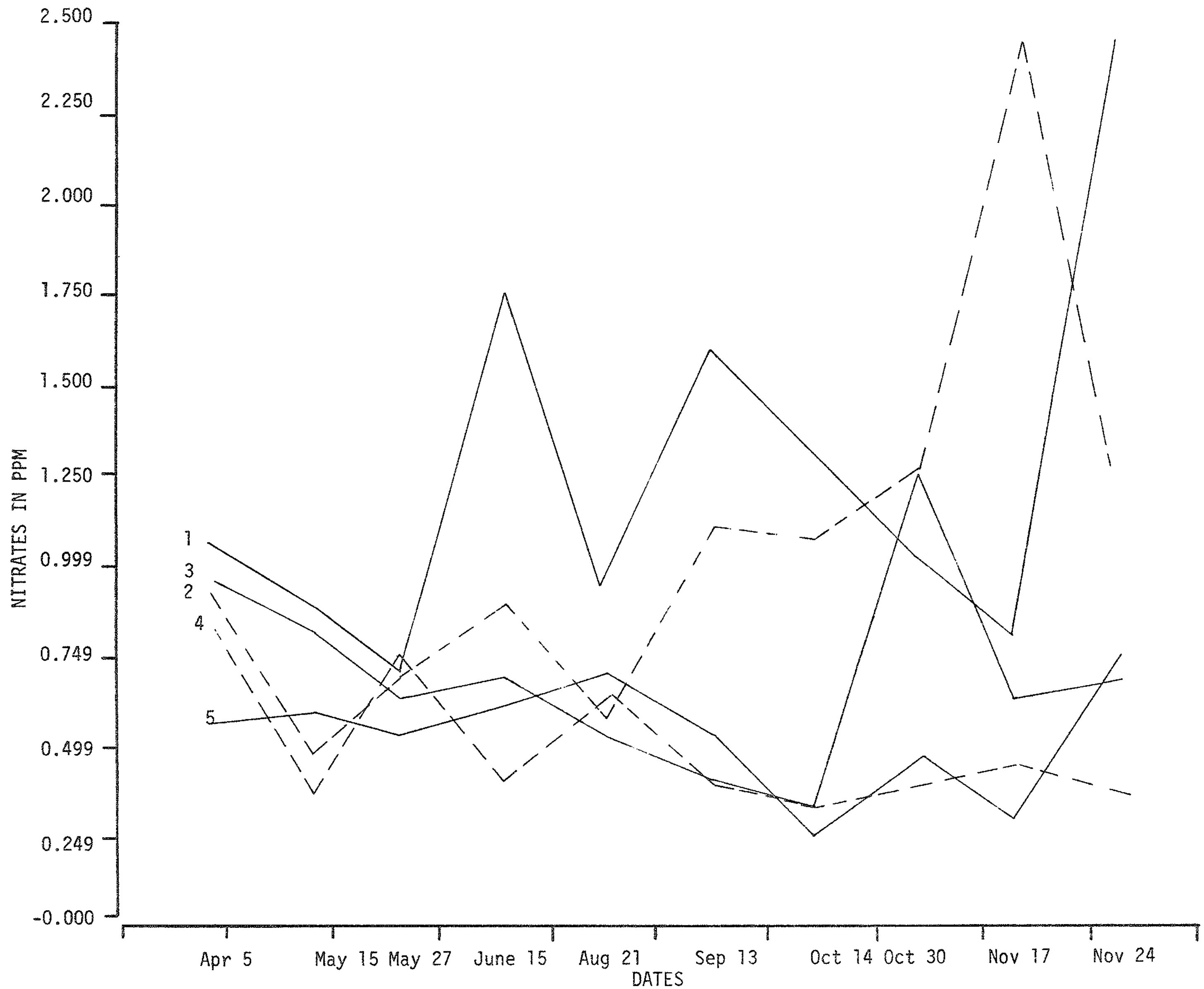


Figure 3. Seasonal changes in mean nitrates at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

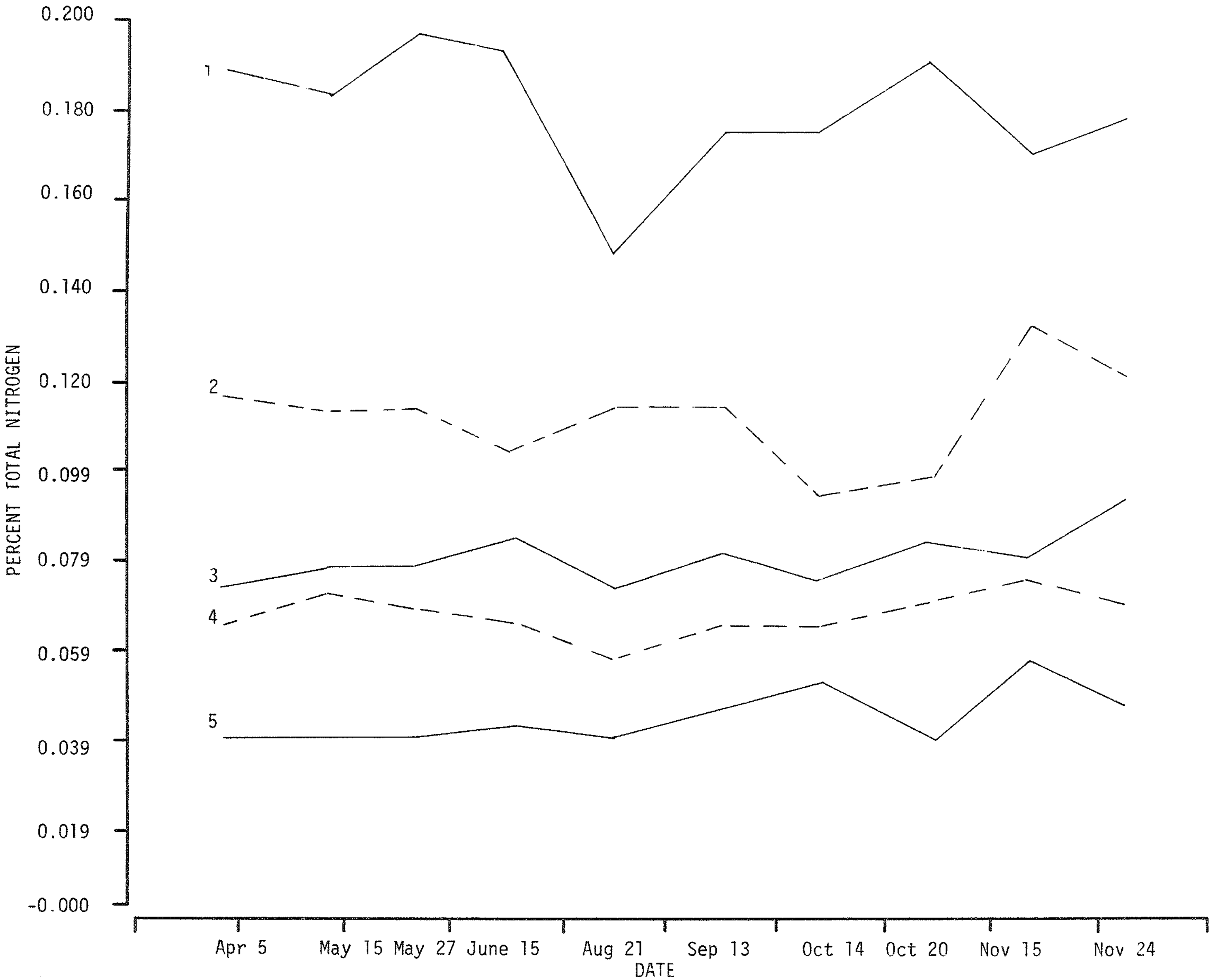


Figure 4. Seasonal changes in mean nitrogen at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

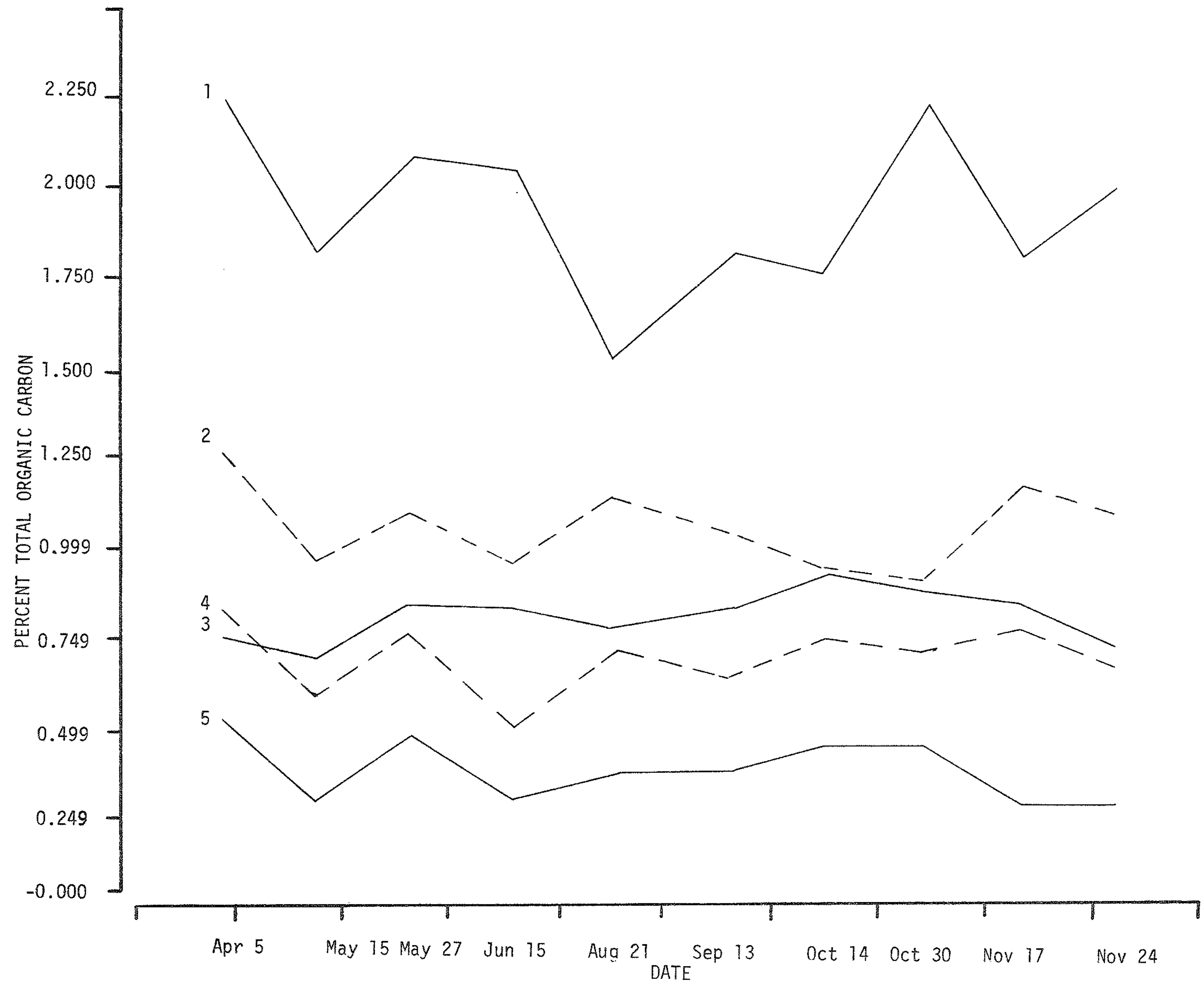


Figure 5. Seasonal changes in mean organic carbon at different soil depths on southern sites. 1 = 2 cm, 2 = 15 cm, 3 = 45 cm, 4 = 75 cm, 5 = 120 cm.

The Carbon-Nitrogen ratio values indicate the carbon availability for nitrogen immobilization (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 extracellular 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).

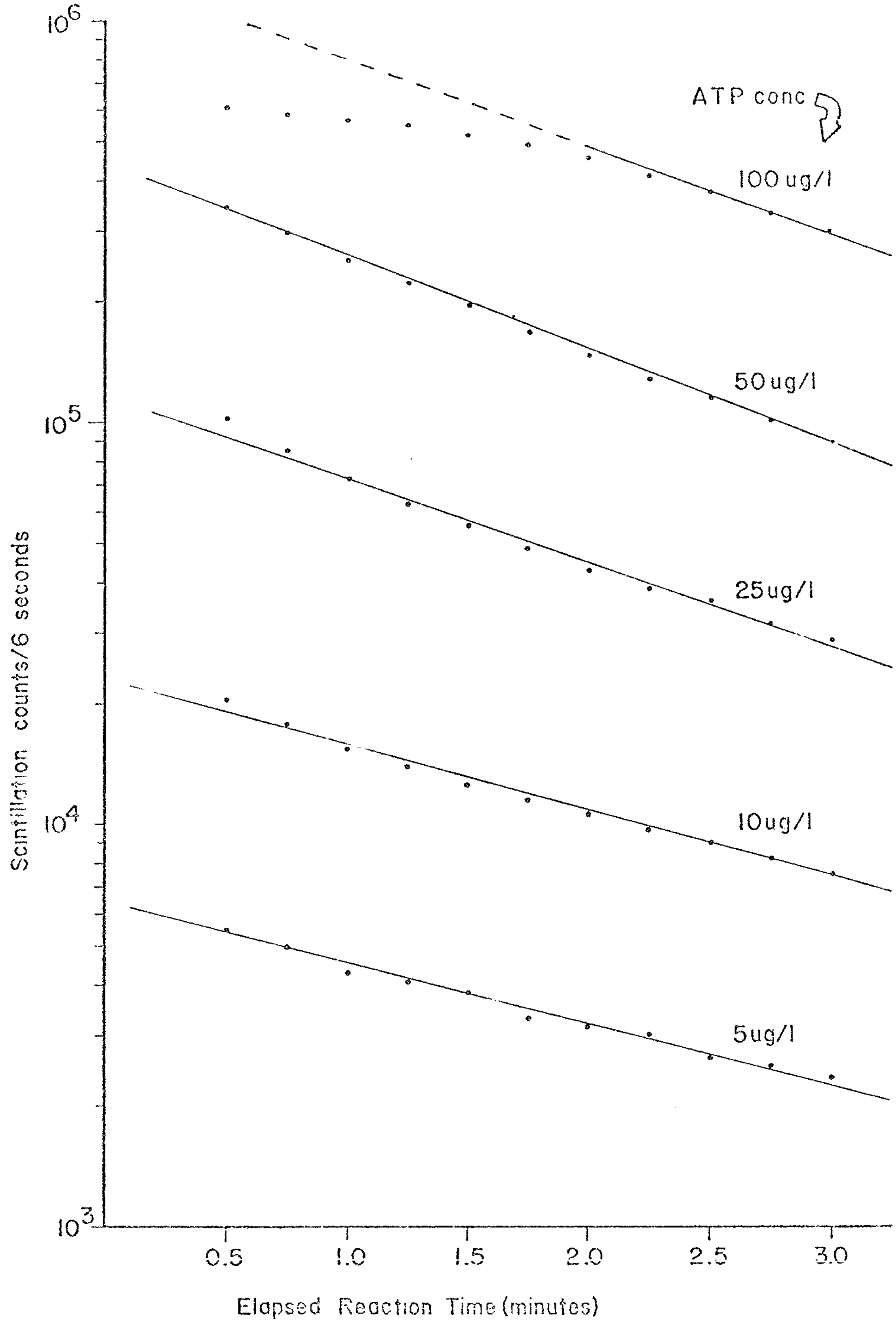


Figure 6. Luminescence decay curves of ATP standard concentrations with reaction time.

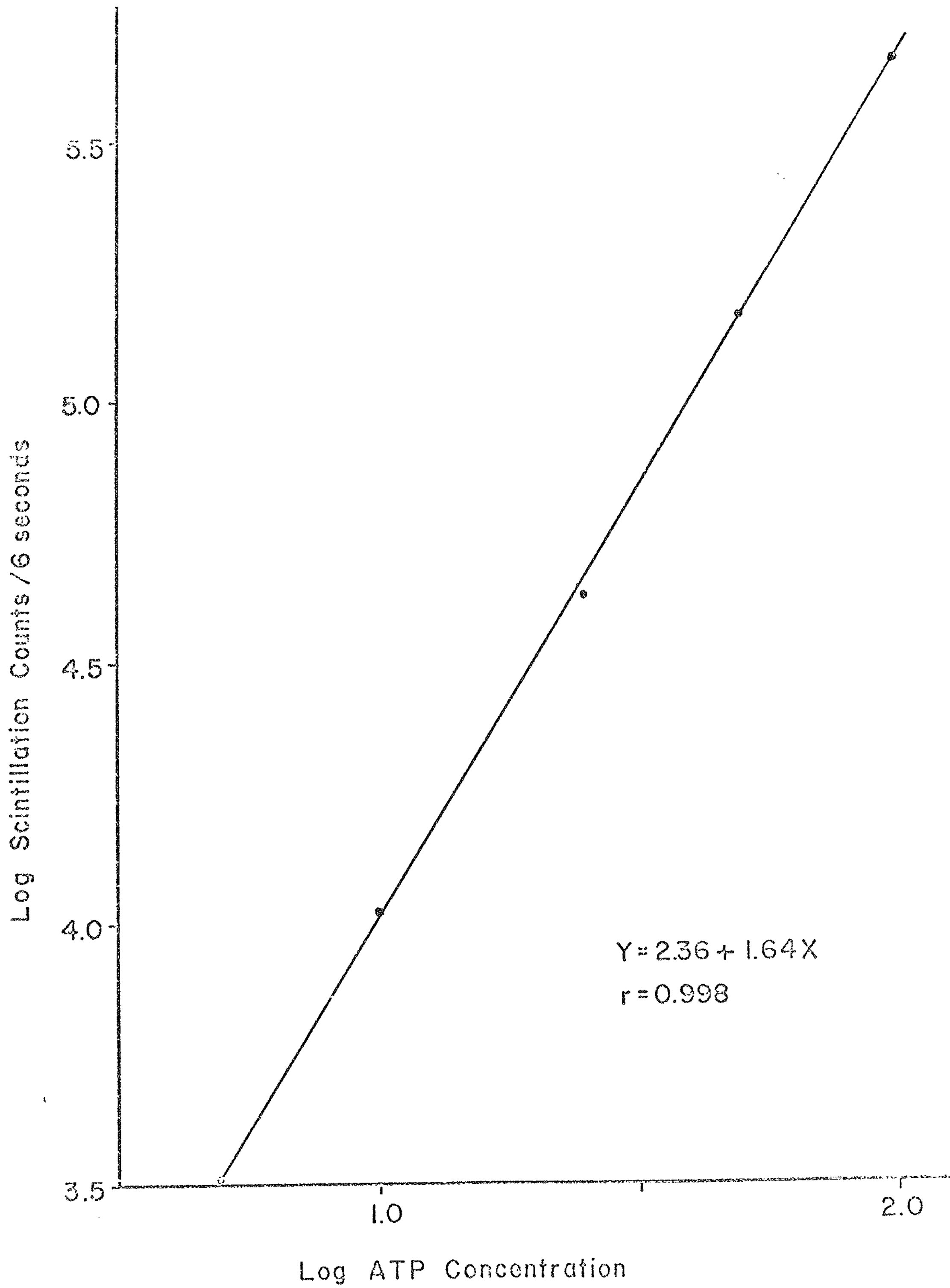


Figure 7. Standard curve for light emission versus ATP concentration at an elapsed reaction of 3.0 minutes.

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.

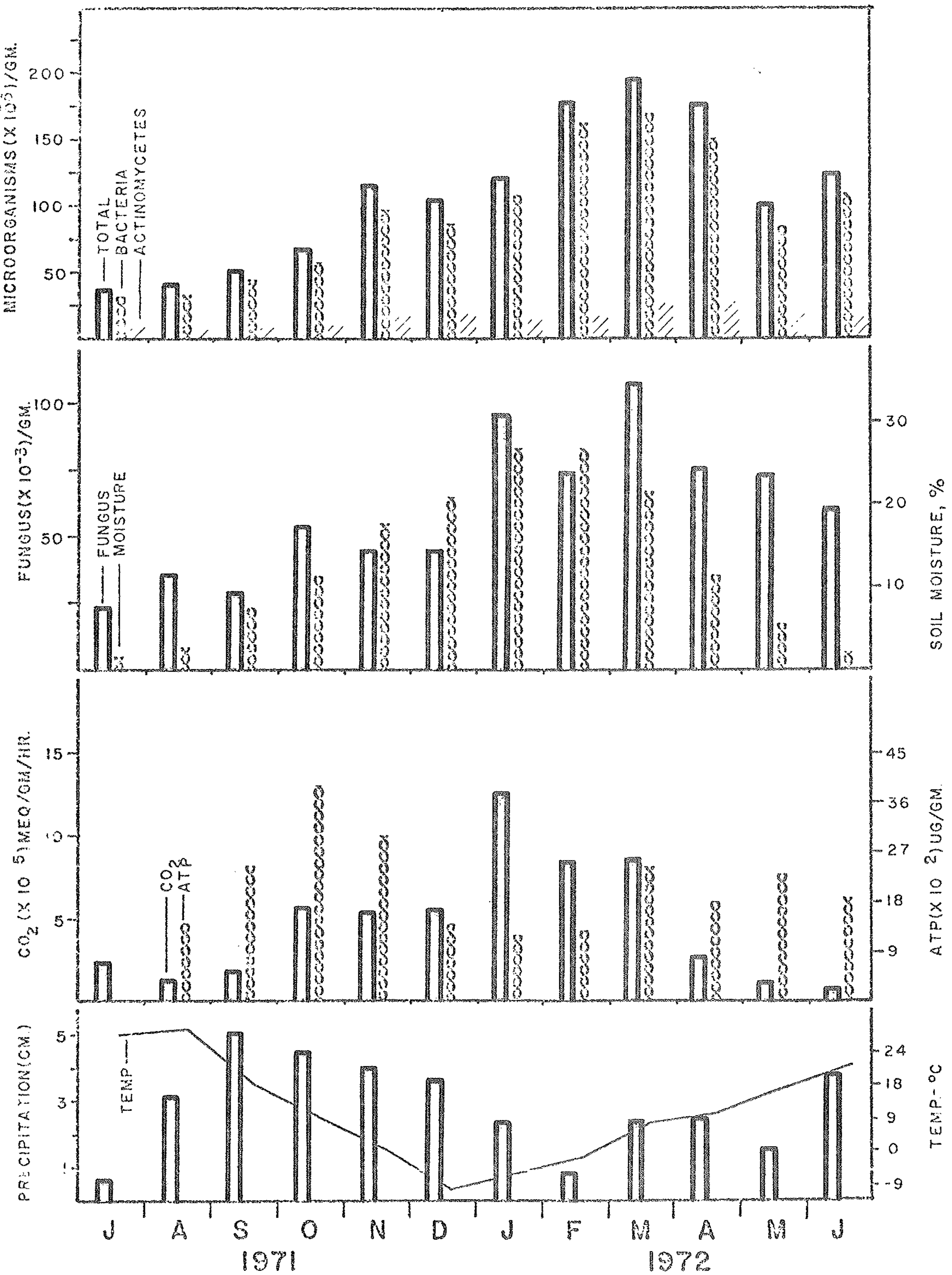


Figure 8. Biological and physical parameters monitered during a 12-month period in the grass-shrub sampling group (location no. 6-8). Soil values expressed per dry gram soil.

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

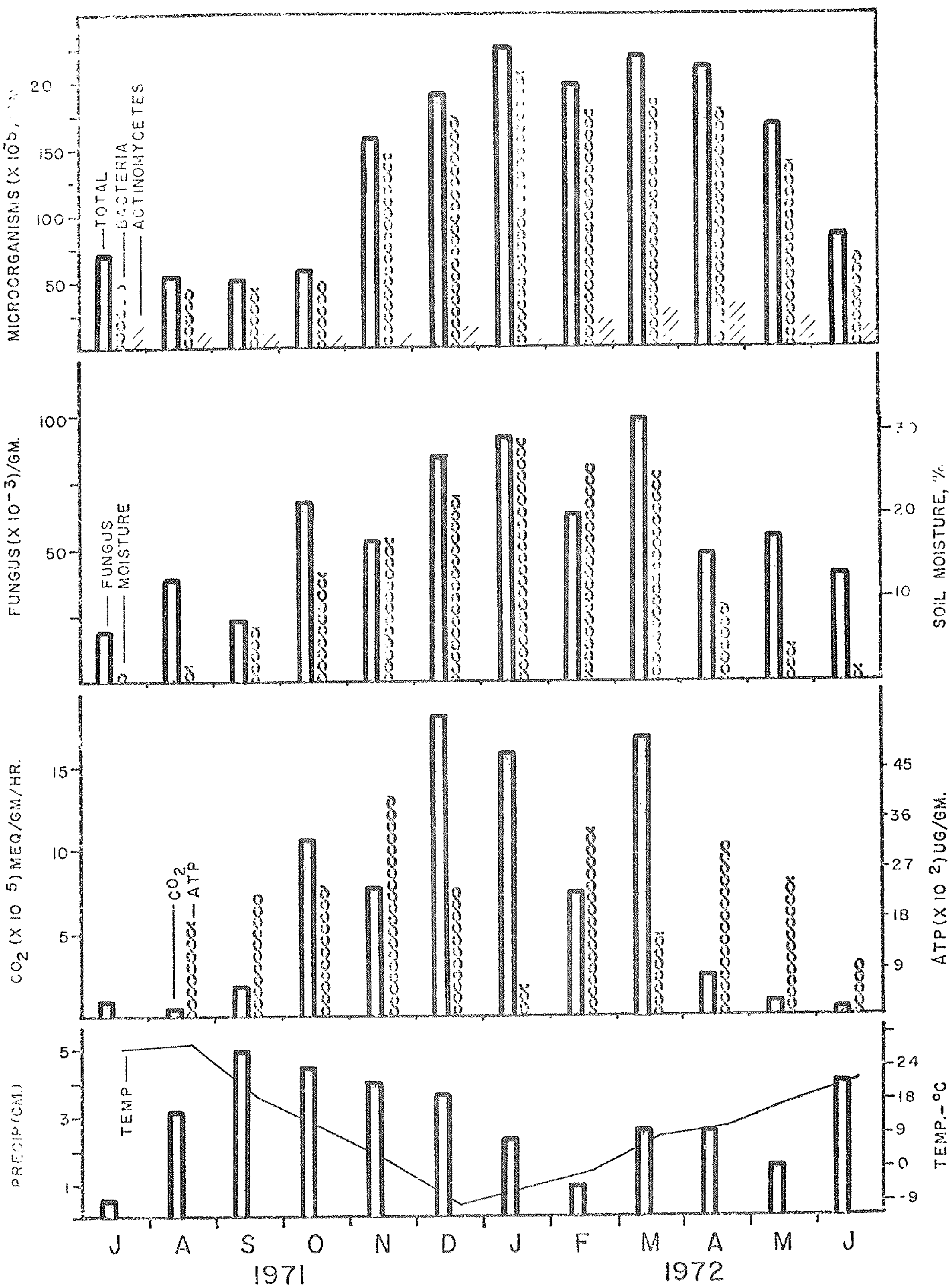


Figure 9. Biological and physical parameters monitered during a 12-month period in grass (location no. 5). Soil values expressed per dry gram soil.

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

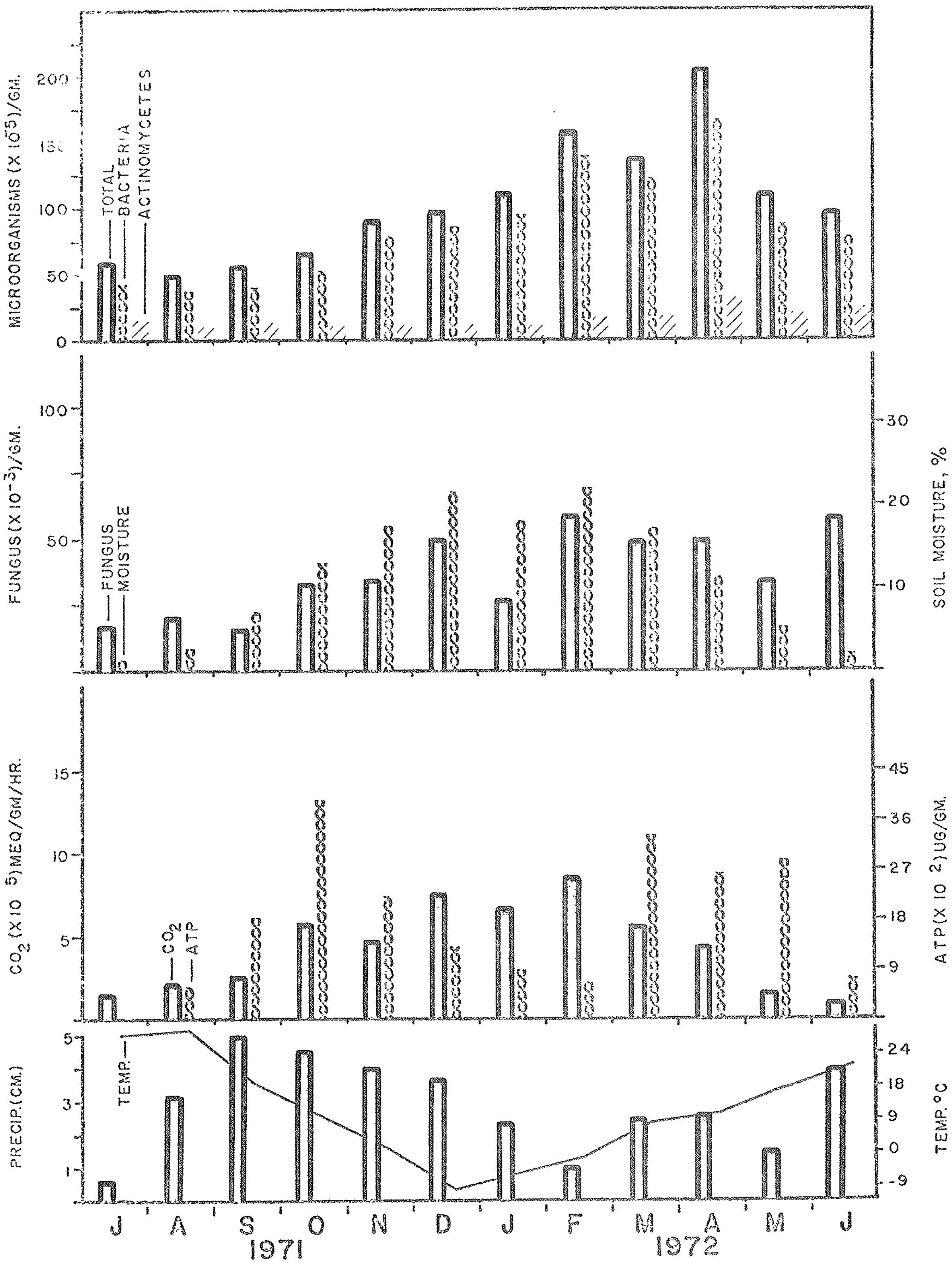


Figure 10. Biological and physical parameters monitered during a 12-month period on the sage brush site (location no. 1-4). Soil values expressed per dry gram soil.

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

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.

LITERATURE CITED

Alexander, M. 1961. Introduction to soil microbiology. John Wiley & Sons, Inc., New York & London. 472 pp.

Black, C. A. 1965. Methods of soil analysis, Part 2. Chemical and microbial properties. American Society Agronomy, Madison, Wisconsin. p. 771-1572.

Bond, G., and G. D. Scott. 1955. An examination of some symbiotic systems for fixation of nitrogen. Ann. Botany N. S. 19:67.

Booth, W. E. 1941. Algae as pioneers in plant succession and their importance in erosion control. Ecology 22:38-46.

Brock, T. D. 1966. Principles of microbial ecology. Prentice-Hall, Inc., Englewood Cliffs, New Jersey. 306 pp.

Cameron, R. E., and C. B. Blank. 1966. Soil studies -- desert microflora. XI. Desert soil algae survival at extremely low temperatures. Space Programs Summary No. 37. Vol. IV Jet Propulsion Laboratory, Pasadena, California.

Cameron, R. E., and W. H. Fuller. 1960. Nitrogen fixation by algae in Arizona soils. Proc. Soil Sci. Soc. Amer. 24:352-356.

Collins, F. M., and C. M. Sims. 1956. A compact soil perfusion apparatus. Nature. 178:1073-74.

Elkan, G. H. and W. E. C. Moore. 1962. A rapid method for measurement of CO_2 evolution by soil microorganisms. Ecology 43:775-776.

Fletcher, J. E., and W. P. Martin. 1948. Some effects of algae and molds in the rain crusts of desert soils. Ecology 29:95-100.

Henriksson, Elisabet. 1951. Nitrogen fixation by a bacteria-free, symbiotic *Nostoc* strain isolated from *Collema*. Phys. Plant. 4:542.

Henriksson, Elisabet. 1957. Studies in the physiology of the lichen *Collema*. I. The production of extracellular nitrogenous substances by the algal partner under various conditions. Phys. Plant. 10:943-948.

Henriksson, Elisabet. 1961. Blagröna algers betydelse för fixering av luftens fria kväve. Sv. Naturv. 1961:246-249.

Lund, J. W. G. 1962. Soil algae, In Physiology and Biochemistry of Algae, R. Lewin (ed.), Academic Press, N.Y. pp. 759-770.

Lynn, R. I. and T. D. Brock. 1969. The ecology of a species of *Zygogonium* (Kutz.) in Yellowstone National Park. Jour. Phycology 5:181-185.

Martin, J. P. 1950. Use of acid, rose bengal, and streptomycin in plate method for estimating soil fungi. Soil Sci. 69:215-232.

Mayland, H. F., J. H. McIntosh and W. H. Fuller. 1966. Fixation of isotopic nitrogen on semiarid soil by algal crust organisms. Soil Sci. Soc. Amer. Proc. 30:56-60.

Pearson, L. C. 1969. Influence of temperature and humidity on distribution of lichens in a Minnesota bog. Ecology 50:740-746.

Pearson, L. C. 1970. Varying environmental factors in order to grow intact lichens under laboratory conditions. Amer. J. Bot. 57:659-664.

Peltier, G. L., C. E. Georgi, and L. F. Lindgren. 1965. Laboratory manual for general bacteriology. John Wiley & Sons, Inc., New York, London, Sydney.

Scott, G. D. 1956. Further investigations of some lichens for fixation of nitrogen. New Phytologist 55:111.

Shields, L. M., and L. W. Durrell. 1964. Algae in relation to soil fertility. Bot. Rev. 30:93-128.

Skujins, J. 1964. Spectrophotometric determination of nitrate with 4-methylumbelliferone. Analyt. Chem. 36:240-242.

Skujins, J. 1967. Enzymes in soil. In: Soil Biochemistry, Vol. I (A. D. McLaren and G. H. Peterson, editors) Marcel Dekker, N. Y., pp. 371-414.

Skujins, J. 1972. Unpublished data. Utah State University, Logan, Utah.

Wiebe, H. H., R. W. Brown, G. S. Campbell, et al. 1971. Measurement of Plant and Soil Water Status. USU Bulletin 484. Utah Agricultural Experiment Station. pp. 68-70.