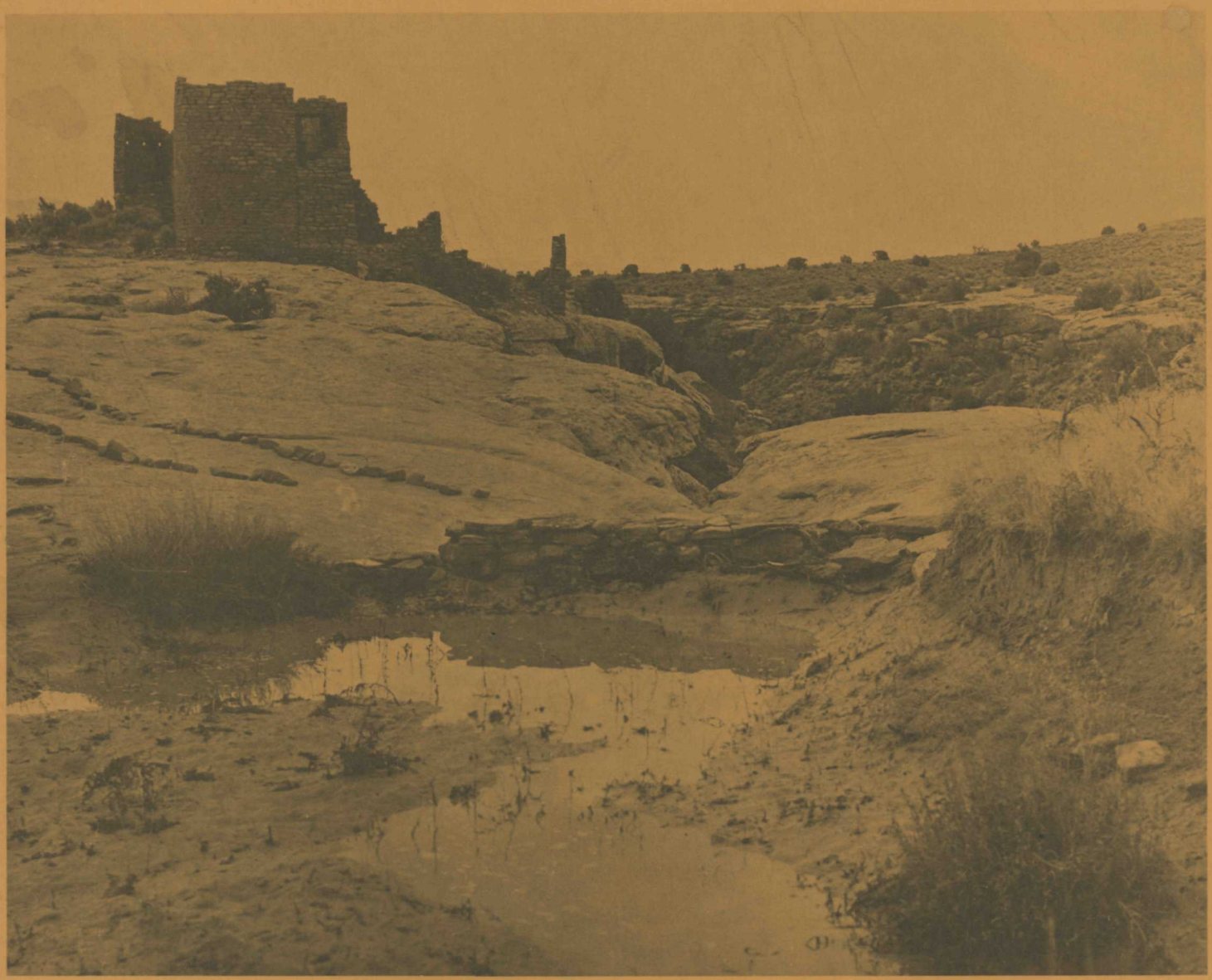
HOVENWEEP 1975

by Joseph C. Winter

Archeological Report No. 2



Anthropology Dept., San Jose State University, San Jose, Ca.

Reconstructed rim dam (Hov. 71) at head of Little Ruin Canyon above Square Tower. Hovenweep Castle (Hov. 4) in background

HOVENWEEP 1975

by
Joseph C. Winter

With sections by Dorothy K. Washburn,
Gayl Del Pero
Patricia Hicks
Colleen Culligan
Caroline Cockayne
Thomas White
Glendon Weir
William J. Litzinger
Brad Noisat
Eileen Camilli
Theodore Rado
Marilyn Swift, and
Barbara Greene

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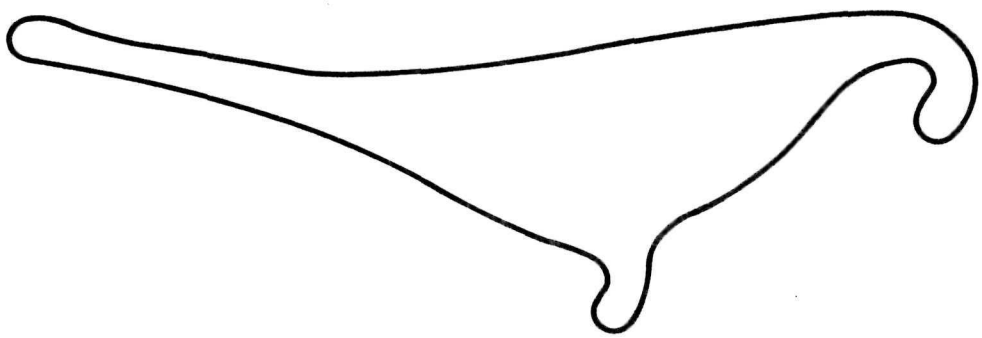

Anthropology Dept., San Jose State University, San Jose, Ca.
May 1976

ACKNOWLEDGMENTS

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The full-time field staff included Dorothy K. Washburn (assistant director); Eileen Camilli, Robert Neily and Bradley Noisat (crew chiefs); Nancy Davenport and Lynn Jacoby (cook and cook's helper); William Litzinger and Ted Rado (botanist and zoologist); John Taylor (photographer); and Alex Esparza and Patricia Hicks (laboratory supervisors). Roger Bailey, Chris Pierce, Arvis Talley, Jeff Seldomridge, Pete Bolima, Mike Pendleton, Jeff Vaughn, Barbara Greene, Marilyn Swift, Colleen Culligan, Rhoda Darden and Myrna Hoffman were full-time students. Part-time help in the field was supplied by Nelson Begay and Joe Merritt, who also provided valuable information about the history of the local Aneth Navajo. Glendon Weir of the Biology and Anthropology Departments at Texas A & M, Wayne Savage of the Biology Department at San Jose State University, Spense Havlick of the School of Environmental Design at the University of Colorado, and Robert Greene of the United States Geological Survey, Menlo Park, visited the Project during the summer and provided valuable advice about pollen, flora, environmental relations and geology. Artifacts were analyzed in the San Jose State University Archeology Laboratory under the direction of Dorothy K. Washburn, assisted by Anita Hornback, Colleen Culligan, Roger Bailey, Marilyn Swift, Caroline Cockayne, Dolores Schulman, Mike Pendleton, Patricia Hicks and Gayl Del Perro. The artifact sections on ceramics and unknown objects, seriation, projectile points, chipped stone and ground stone were authored by Dorothy K. Washburn, Gayl Del Perro, Patricia Hicks, Colleen Culligan and Caroline Cockayne, respectively. Mammal bone identifications were made by Thomas White; the contemporary flora of Hovenweep was analyzed by William Litzinger, who also ran the experimental gardens; contemporary faunal resources were studied

by Theodore Rado; and geological resources were examined by Barbara Greene and Marilyn Swift. Pollen was analyzed by Glendon Weir, while preliminary soil studies and water control experiments were made by Bradley Noisat. Dorothy K. Washburn, Gayl Del Perro and Eileen Camilli were responsible for the statistical analyses.

All photographs were shot by John Taylor, except for Fig. 42 which was made by William Litzinger and Fig. 27 and the cover of section III.1.A which were shot by the author. The high altitude photos in Figs. 28 and 35 were provided by the United States Soil Conservation Service. All illustrations were made by Kenneth Kroes, while final typing was by Marianne Tamberg.

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J.C.W.
April 1976

CONTENTS

		Page
	Acknowledgments	i
	Contents	iii
	List of Figures	vi
	List of Tables	x
I.	OBJECTIVES	1
II.	DATA COLLECTION AND ANALYSIS	9
	1. Ceramic Analysis by Dorothy K. Washburn	9
	2. Symmetry Analysis of Design on Black-on-White Pottery from Hovenweep National Monument by Dorothy K. Washburn	21
	3. Computer Seriation of Hovenweep Ceramics by Gayl Del Pero	36
	4. Projectile Points: Hovenweep Archeological Surveys 1974-1975 by Patricia A. Hicks	44
	5. Functional Typology of the Hovenweep Stone Tool Assemblage, 1975 by Colleen M. Culligan	51
	6. Ground Stone Tools by Caroline Cockayne	62
	7. Objects of Unknown Use and Ornaments by Dorothy K. Washburn	70
	8. Faunal Remains by Thomas D. White	76
III.	PRELIMINARY INTERPRETATIONS	81
	1. Farm Fields	81

Page

a. Farm Structures: Design and Use 81

b. Floral Indicators of Farm Fields by Joseph C. Winter and William J. Litzinger 123

c. Preliminary Pollen Analysis of Hovenweep Area Archeological Sediments by Glendon H. Weir . . 169

d. The Experimental Garden Project, 1975 by William J. Litzinger . . 177

e. Water Control Experimentation by Bradley Noisat 191

f. Environmental Constraint at Hovenweep, 1974 Sites by Eileen Camilli 197

2. Environment 215

a. Plant Zones of the Hovenweep Area Cajon Mesa, Colorado-Utah by William J. Litzinger 215

b. An Evaluation of Potential Prehistoric Faunal Resources on Cajon Mesa, Utah by Theodore Rado 239

c. Geology of Hovenweep in Relation to Possible Lithic Sources . . . 252

Background by Barbara Greene 252
Resources by Marilyn K. Swift 258

d. The Soils of Hovenweep by Bradley Noisat 270

3. Settlement Pattern 282

IV. PROJECTED 1976 RESEARCH 294

Page

REFERENCES 304

APPENDICES 327

Appendix I. Maps of Individual Survey Areas with Site Locations 327

Appendix II. Ethnobotanical Uses of Significant Plants at Hovenweep 370

Appendix III. Annotated Checklist of Vascular Plants of Cajon Mesa, Colorado-Utah by William J. Litzinger 387

Appendix IV. 1975 Hovenweep Survey Pottery Types 435

Appendix V. 1975 Hovenweep Survey Lithic Artifacts 448

Appendix VI. Cultural Designation of 1975 Sites According to Pottery and Projectile Point Types 461

LIST OF FIGURES

Figure		Page
1.	Locations of 1974-1975 Survey Areas of Cajon Mesa	3
2.	Mesa Verde Gray Ware	12
3.	Early Pueblo Pottery Types	12
4.	Pueblo II Pottery Types	17
5.	Pueblo III Pottery Types	17
6.	Thirteen Basic Element Shapes	23
7.	26 Motifs	24
8.	Symmetry Units	25
9.	Locations of 7 Drainage Areas on Cajon Mesa	26
10.	Representative Projectile Point Types at Hovenweep	45
11.	Examples of Chipped Stone Tool Types	45
12.	Examples of Chipped Stone Tool Types	53
13.	Examples of Chipped Stone Tool Types and Objects of Unknown Use	53
14.	Wear Pattern Correlated with Tool Function	56
15.	Ground Stone Tool Types	63
16.	Schematic Diagram of Four Types of Use Wear on Manos and Handstones	65
17.	Time Range Comparisons Manos and Handstones	65

Figure		Page
18.	Mid-Mesa Water Control and Habitation Sites at Hovenweep	90
19.	Square Tower Complex	93
20.	Akchin Terraces and Check Dams at Hov. 94/538.	95
21.	Hov. 49 Terraces/Check Dams	97
22.	Intact Check Dam at Hov. 644	98
23.	Hov. 64-68 Hackberry House	106
24.	Hov. 57 Horseshoe House	107
25.	Holly House Ruin Group	108
26.	Cajon Ruin Group	109
27.	Rock Tank in Boulder at Hov. 12 (Twin Towers).	98
28.	Aerial View of Intact Reservoir at Hov. 513 .	114
29.	Close-Up of Hov. 513 Reservoir	114
30.	Hov. 513 Reservoir	115
31.	Hov. 714 Big Ruin Reservoir	117
32.	Portion of Reservoir Wall at Hov. 714	118
33.	Possible Reservoir Wall at Hov. 600 (Painted Hand)	118
34.	Hov. 656 Prudden Unit Terrace Site	120
35.	Aerial View of Hov. 656 and Nearby Sites . . .	121
36.	Comparison of Actual with Expected Frequencies of Occurrence for Hovenweep Plants	139
37.	Comparisons of Actual with Expected Frequencies of Occurrence for Hovenweep Plants in Water Control Sites, Rubble Mounds and Small Sites	142

Figure		Page
38.	Close-Up of Sage (Artemisia tridentata) Growing on Hov. 656	147
39.	Greasewood (Sarcobatus vermiculatus) Re-Colonizing Abandoned Navajo Farm Fields in Montezuma Canyon	147
40.	Ground Cherry (Physalis hederaefolia) Growing at Edge of Slick Rock Near Hov. 513 Reservoir	157
41.	Close-Up of Wolfberry (Lycium pallidum) Growing on the Midden and Rubble at Hov. 47 . . .	157
42.	Aerial Infra-Red View of Large Site in the Sage Zone with Wolfberry (Lycium pallidum) Patch Growing On It	159
43.	Close-Up of Jimson Weed (Datura meteloides) at Edge of Navajo Farm Field in McElmo Canyon	159
44.	Seedling Height Correlated with Water Regime.	181
45.	Experimental Food Garden at Hovenweep Project Camp	181
46.	Water Control Data Graph	194
47.	Run I: Vector I	202
48.	Run II: Vector I	203
49.	Run I: Vector II	204
50.	Run II: Vector II	205
51.	Run I: Vectors I-II	207
52.	Run II: Vector I	208
53.	Run I: Vectors I-II	209
54.	Run III: Vectors I-II	212

Figure		Page
55.	Run III: Vectors I-II	213
56.	Run III: Vectors III-IV	214
57.	Vegetation Zones of Cajon Mesa	216
58.	Hovenweep Climatic Diagram	219
59.	Mammal Study Areas, Cajon Mesa, Utah	248
60.	Geologic Map of Cajon Mesa	253
61.	Aerial View of Navajo Corn and Squash Fields along McElmo Creek	291
62.	Abandoned Navajo Hogan at Hov. 568 in East Allen Canyon	291
63.	Functioning Navajo Sweathouse and Ramada at Hov. 609 in McElmo Canyon	293
64.	Abandoned Navajo Hogan in Montezuma Canyon .	293

LIST OF TABLES

Table		Page
1.	Distribution of 13 Element Shapes in 7 Drainage Areas	28
2.	Distribution of 26 Motifs in 7 Drainage Areas	29
3.	Distribution of 5 One-Dimensional Symmetry Classes in 7 Drainage Areas	31
4.	Regional Distribution of Decorated Sherds in the Two Major Temporal Periods	33
5.	Frequency of Symmetry Units in all 7 Drainage Areas at Hovenweep	35
6.	Meighan 3-Pole Plot of Mancos B/W, Wetherill B/W and McElmo-Mesa Verde B/W Pottery Types from 100 Sites	38
7.	Selected Segment of Entire Matrix	40
8.	Seriation Order of 100 Sites on Cajon Mesa	42
9.	Projectile Point Types and Suggested Time Range on Cajon Mesa	46
10.	Means and Ranges of Projectile Point Attributes	49
11.	Wear Characteristics on Hovenweep Tool Types	58
12.	Ground Stone Tool Measurements	64
13.	Objects of Unknown Use and Ornaments	71
14.	Faunal Remains	77
15.	Hopi Field Types and Locations	83

Table		Page
16.	Hopi and Zuni Water Control Devices Correlated with Field Types	85
17.	Probable Water Control Devices at Hovenweep .	86
18.	Cultigen and Weed Pollen from Hovenweep Water Control Devices	92
19.	Time Period Correlated with Site Numbers and Plant Zone	112
20.	Semi-Cultivated and Encouraged Pueblo Plants .	126
21.	Managed Plants of the Pueblos	127
22.	Plant Categories and Species Lists	132
23.	On-Site/Off-Site Plant Frequencies at Hovenweep	137
24.	On-Site Occurrences by Type of Site	140
25.	Site Distribution by Physiographic Zone and Time Period	145
26.	Comparison of Significant Species at Three Study Areas	149
27.	Pollen Associations of Wild Plants with Maize·	153
28.	On-Site Occurrences of Wolfberry Compared with Cultural Period	161
29.	Fossil Pollen Types and Frequencies	172
30.	Germination as of 1 July, 1975	180
31.	Mean Seedling Height in Cm.	180
32.	Seedling Survival	182
33.	Water Control Test Site Data	193

Table		Page
34.	47 Plant Variables Used in the Scaling of the 1974 Data	198
35.	Potential Semi-Cultigens Found on 1974 Sites .	198
36.	Vertebrate Species Present on Cajon Mesa . . .	240
37.	Checklist of Insects of Hovenweep National Monument	244
38.	Mammal Population Statistics for the Major Communities on Cajon Mesa	250
39.	Geological Strata of Cajon Mesa	254
40.	Geologic Components of Tool Materials	259
41.	Resource Materials of Hovenweep According to Geological Formation	262
42.	Lithic Distribution According to Site	267
43.	Major Soil Types at Hovenweep	272
44.	Soil Test Results	275
45.	Dendrochronological Dates for Hovenweep	288

OBJECTIVES

Detail of petroglyph panel near Ismay's below Cannonball Mesa

I. OBJECTIVES

Introduction

For thousands of years the Pueblo Indians and their Anasazi ancestors have lived by farming in the desert Southwest. Water is the master in their environment, so much so that an elaborate religious and technological system has been developed to produce abundant moisture and exploit the little which is actually available. This overriding concern with adequate water for crops permeates the Pueblo farming economy and forms the basis of a complex tradition of soil and water manipulation. The objectives of the Hovenweep Archeological Project are to determine which, if any, of the Pueblo agricultural techniques were utilized on Cajon Mesa, and how they developed. While certain facets of the Pueblo farming system would be exceedingly difficult to identify in the archeological context of Hovenweep, such as various rituals and beliefs of the snake-lightning cult, other aspects, particularly those associated with technology, should be visible when approached properly. One of the major assumptions of the Project, in fact, is that most parts of the local Anasazi economy can be reconstructed, along with the dynamics underlying its growth and abandonment in the Four Corners region. Field systems, water control devices, cultivated and weedy crops, and perhaps even the structure of the farming community can be identified, we believe, through a program combining archeology, ethnobotany, palynology, soil studies, gardening and water control experimentation.

Methods

During the summer of 1975 San Jose State University conducted the second season of a projected six-year archeological project at Hovenweep National Monument in southeastern Utah and southwestern Colorado. The 1975 season, supported financially by the National Science Foundation*

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*Grant #SOC-75-08760-A01

and with logistical support from the National Park Service, provided an opportunity to survey a wide range of environments and archeological sites on Cajon Mesa, the setting of Hovenweep. Specifically, it focused on a series of ecological questions whose answers will hopefully increase our knowledge of prehistoric Anasazi farming patterns and man's adaptations in a desert environment. The considerable amount of information that was obtained is summarized in this report.

The summer's research was the final season of a two-year survey phase that began in 1974. During the first summer the survey concentrated on five Monument and four Bureau of Land Management locations (Fig. 1, units 1-9), while in 1975 we focused on fifty forty-acre parcels of Bureau of Land Management, State of Utah, Navajo Reservation and private acreage (Fig. 1, units 10-59). Fig. 1 indicates the locations of all fifty-nine survey units, while Appendix I provides maps of site locations. The total project combines a concern for the general prehistory of the Hovenweep area with broader theoretical interests related to the dynamics of the development of the Anasazi agricultural economy. The 1975 season was oriented towards gathering data about site-environmental relations in all major plant communities and physiographic zones on the mesa, while the 1974 season concentrated on the major ruin clusters at canyonheads. The basic research problems, as outlined in the 1974 proposal to the National Science Foundation and in the 1974 Survey Report (Winter 1975), concerned the following:

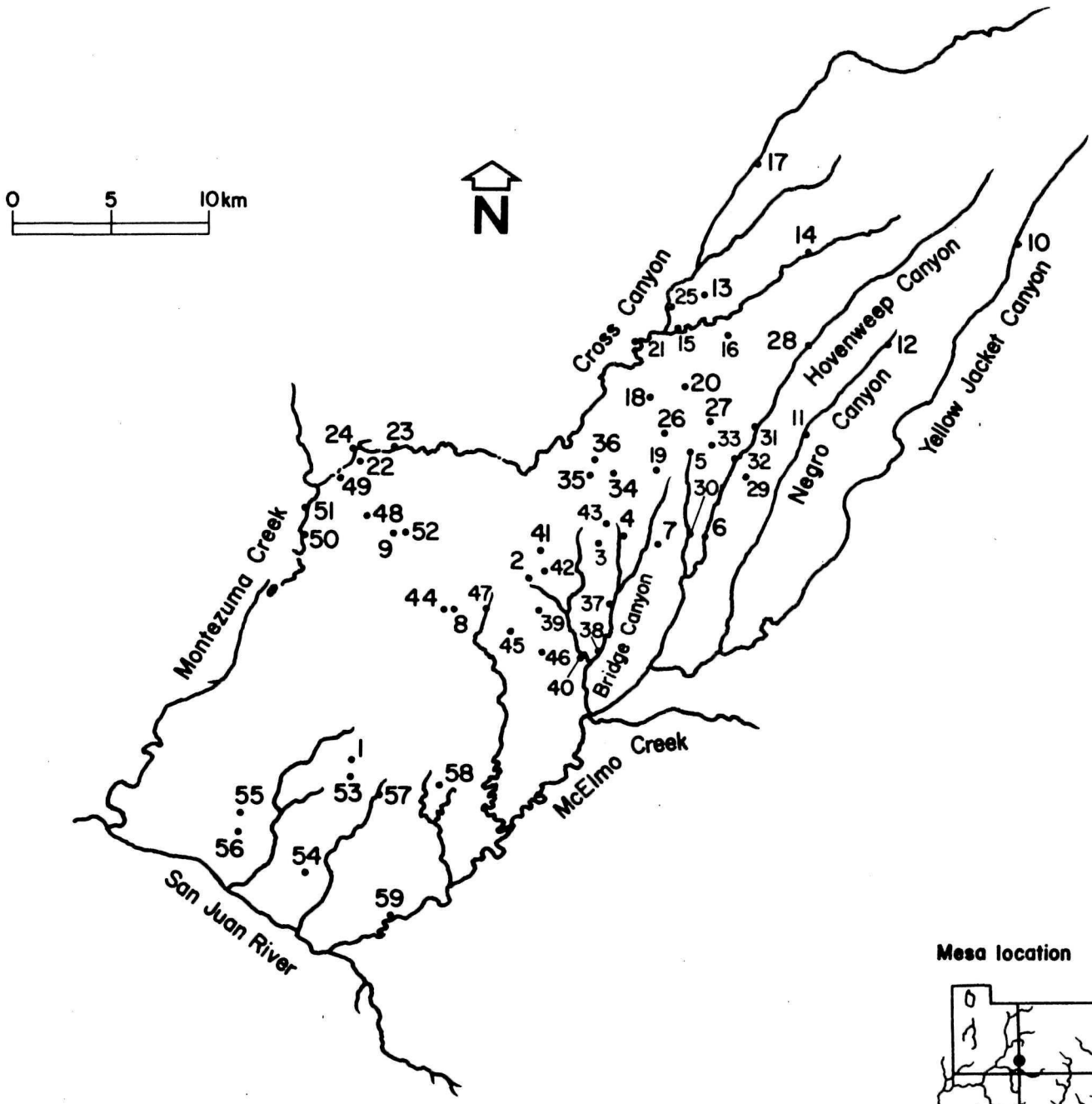
1) Determining the overall settlement pattern and chronological sequence at Hovenweep

2) Identifying the locations of past farming areas

3) Using floral and pollen indicators to determine prehistoric site function

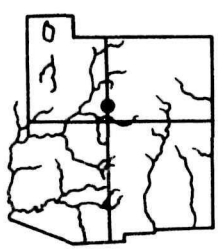
4) Analyzing the relations of population growth, changing resource base and technology

5) Evaluating the possibility of the Anasazi-Pueblo agricultural continuity



Location of 1974-75 survey areas of Cajon Mesa.
Fig 1.

Mesa location



6) Determining the reasons for the local initiation, growth and abandonment of farming (see hypotheses 1-19, 1975 NSF proposal; hypotheses 1-24, Winter 1975).

While the 1975 season's results will be discussed in much greater detail in a series of scientific reports to be published at the end of the Project, this preliminary report describes the work accomplished and summarizes the results in terms of certain of the problem areas listed above.

Four types of activity were necessary to accomplish the objectives of the research:

1) archeological survey

2) environmental research

3) identification and study of possible farming locations

4) laboratory analysis

Several subprojects of each type were undertaken during the 1975 field season, and these are described below.

1) Archeological Survey

The fifty forty-acre survey units scattered within the three major plant communities of the mesa (pinyon-juniper, sage, and shrubland) were located so as to cut across all major physiographic zones (e.g. canyonhead, canyon bottom, mesa top, sand dune, etc.). Most of the units were chosen randomly within each plant community so as to insure that all parts of the mesa were given an equal chance of being surveyed and thus provide unbiased data concerning the overall patterns of site/environmental relations on the mesa. A selected few units, however, were intentionally located within areas of known "water control" sites and ruin clusters. Two hundred and fourteen sites were located within forty of the survey units, and all were photographed and mapped and 25 percent surface artifact collections were made. Extensive environmental data were also collected, while subsurface pollen samples were taken from all sites

located outside of the Navajo Reservation. Vegetation maps of each site were drawn and notes were taken on plant species, fauna and geomorphology. Five additional sites in nonsurvey locations were also surfacially examined, since they represented rather unique samples of functional categories (e.g. possible reservoirs) or cultural periods (e.g. Archaic) which are critical to the research questions.

2) Environmental Studies

Botanical studies of on-site diversity and floral-faunal examinations of the mesa as a whole were run to determine the relations of site location with existing resource variation. On-site and off-site floral maps and species lists were produced as a regular part of the archeological survey so as to determine if certain plant species are indicators of various functional and cultural categories. Additional botanical studies were run to identify community boundaries, species composition, seasonal variations and the effects of grazing and other post-Anasazi disturbances on local vegetational patterns. Zoological analyses concentrated on an evaluation of the productivity of the various environmental zones so as to discover which parts of the mesa were more productive in terms of the availability of large and small game and how this productivity varied seasonally. Small mammal trapping quadrants were scattered across the mesa to identify species composition and density, augmented by large mammal estimations through the evaluation of tracks, scats, antlers and observations made during the archeological survey.

3) Identification and Study of Possible Farm Sites

One of the major goals of the project is to discover areas where farming may have occurred through the development and testing of a predictive model based on historic Pueblo farming patterns. Following observations made by Hack (1942), Forde (1931), Beaglehole (1937), Bradfield (1971) and others, a multi-discipline effort is underway to identify those areas which have the greatest potential for having been past farming locations. Six approaches are being used.

A. Structural Remains. The archeological survey identified thirty-two sites in 1975 whose structural features

were suggestive of past use as water control devices. All sites were mapped using compass and chain methods, topographic maps of certain categories were made, pollen samples were taken from each location, and extensive data on slope, exposure, soil type, plant cover, construction and associated sites were gathered.

B. Palynology. Since plant pollen is almost indestructible when preserved under certain conditions, palynology has great potential for serving as a means of discovering where plant cultivation once occurred. Studies by Martin and Schoenwetter (1960), Martin and Byers (1965) and Brooks (1974) recognized this potential, but the Hovenweep Project is the first archeological program which has attempted to identify agricultural sites on such a broad scale. Pollen samples were taken from all possible water control sites and other potential farming locations, such as wolfberry patches, alluvial fans and floodplains, as well as from existing gardens on Cajon Mesa. Samples were also taken from probable nonfarming areas for comparative purposes, and an in-depth study is currently underway at the Anthropological Research Lab at Texas A & M.

C. Floral Indicators. Careful attention was given to floral composition in on-site and off-site locations for three reasons: 1) to study resource variation across the mesa; 2) to identify economically important species whose presence on archeological sites might be indicative of past farming activities; and 3) to evaluate the critical environmental variables (e.g. soil type, water source, exposure, slope, physiographic condition, etc.) which may have determined farm site location and which are expressed by sensitive floral species. Over 200 plant species were noted as growing on the mesa or in surrounding canyons, and of these 170 were noted as growing on archeological sites or in off-site control quads. Twenty-six of these species are possible indicators of past Anasazi disturbances, and a much higher number have proven useful in determining the relation of farm site location and environmental constraint.

D. Water Control Experimentation. Of the ten types of probable water control sites discovered during the 1974 and 1975 surveys, four categories were examined through a program of experimental replication or reconstruction. This experimental phase of the project began with the rebuilding

of a rim dam in 1974 above the Square Tower site and the cleaning of a spring in a nearby canyon. It continued with the construction of a similar rim dam on private acreage in 1975, along with the construction of arroyo checkdams and diversion dams and ditches on Bureau of Land Management acreage. This phase of the project is aimed at a study of the mechanics of water control in relation to precipitation, run-off, soil buildup, water absorption and ground water flow. Data on soil buildup, sedimentation, moisture retention, water quality and vegetation patterns are being collected at the reconstructed sites, while the modified spring is serving as a control for the evaluation of the possible effects of the rebuilt rim dam on water percolation and aquifer formation.

E. Experimental Gardening. Five experimental garden plots were established during the spring of 1975 in order to obtain data on the potential of various locations for aboriginal farming. Four of the gardens were set up in the Square Tower Monument Unit in alluvial flat, arroyo checkdam, sage flat and ridge-side locations, while a fifth was established in the pinyon-juniper forest near Lowry Ruin. Conventional Hopi crops were grown at all locations, but several of the plots contained experimental maize varieties which were grown to provide data about germination, growth patterns, seed formation, differential moisture requirements and related critical factors. These and additional gardens will be grown throughout the life of the project, and it is expected that we will eventually be able to predict which field locations are best for particular types of crops. Weather and soil analyses are being carried out at each location to discern variations in frost, precipitation, humidity and evaporation, thereby permitting an estimation of the relation of different locations with regard to micro-weather patterns, crop productivity and weed growth.

F. Aerial Photography. A program of infra-red, black and white and color aerial photography was initiated in 1975 to determine if high altitude photography can be utilized to spot past farming locations. Infra-red and color photos of selected sites and floral areas were shot at various altitudes during the peak of the springtime vegetative period, while black and white photos were obtained from the United States Geological Survey and the Soil Service.

Numerous archeological phenomena and vegetation patterns were visible on different types of photos, and ground inspections were made of certain of the sites to evaluate the usefulness of the technique and to take pollen samples.

4) Laboratory Analyses

The careful analysis of artifacts under laboratory conditions is essential in an archeological project since it allows us to make interpretations about such diverse areas as temporal and cultural provenience, possible site function, raw material sources and diet. An intensive lab program is currently in progress under the direction of Dr. Dorothy K. Washburn and preliminary results have been obtained in the following areas: 1) pottery classification and the analysis of design patterns to aid in the determination of temporal/cultural periods and the establishment of site relations; 2) lithic classification and the study of tool function through wear pattern analysis; 3) identification of lithic sources; 4) projectile point classification. Related lab areas which are being run at San Jose and affiliated institutions include dendrochronological analyses at the University of Arizona Tree Ring Lab, soil sample studies at San Jose and pollen studies at Texas A & M. Computerized evaluations of a number of artifact variables (e.g. ceramic paint and corrugation design, tool morphological and wear pattern elements, on-site and off-site floral patterning, and site features and physiography) are also underway.

DATA COLLECTION AND ANALYSIS

II.1. CERAMIC ANALYSIS

By Dorothy K. Washburn

During the second field season at Hovenweep the program of quadrant surface survey which was initiated in 1974 was completed. Since the 1974 survey was conducted principally within the major Monument areas which have been accessible to the public for many years, the surface collections were quite small. In fact, the size of the artifact sample was usually inversely proportional to the size of the site.

The 1975 survey areas were located on private ranches, Bureau of Land Management, State of Utah and Navajo Reservation lands. The inaccessibility of these areas has protected the sites and thus enabled the recovery of a much larger and more representative surface artifact sample. In addition, the area surveyed during 1975 was more extensive. Fifty forty-acre survey units, representing a stratified random sample of slightly less than 1 percent of Cajon Mesa were studied in 1975. A total of 219 sites were located and collected.

Introduction

The 3980 identifiable decorated, 501 gray ware and 4102 corrugated sherds were classified following the type definitions for the Mesa Verde area established by Breternitz, Rohn and Morris (1974). No whole vessels were recovered. Appendix IV lists the numbers of sherds by type and site, while Appendix VIlists the approximate period of occurrence by site as deduced from comparison with dated collections in neighboring areas.

There are several changes in type entries from those presented in the 1974 report (Winter 1975: 49). These are largely additions to the most recent Mesa Verde area ceramic manual. In some cases the new types were previously established types which had been lumped as a variety under another type in the new manual. Since the Hovenweep area is not well known it was decided that it would be most useful to utilize some of these "retired" type names in order

to more completely describe the variability in the ceramic output. The reader should refer to Abel's Ceramic Series No. 3 for the full description of these types (1955).

Three varieties of Mancos Black-on-White have been adopted for descriptive purposes. In the 1974 report Mancos Black-on-White was subdivided into mineral and carbon painted components. In this report the carbon painted sherds are designated as Wetherill Black-on-White. It is apparent from examination of the combined 1974-1975 samples that there is a distinct group of sherds that, except for having carbon paint, are Mancos-like in design and technological features. Hayes (1964) labeled this carbon painted variety as Wetherill Black-on-White, while subsequent investigators of the Wetherill Project have considered it as a variety of Mancos Black-on-White (Swannack 1969; Rohn 1971). Since this form is distinct and comprises 10 percent of the 1975 surface sample from the Hovenweep area, it was decided to assign it separate type status.

The second variety of Mancos Black-on-White listed in this report for the first time is Morfield Black-on-Gray. This type was originally described by Abel (1955) but has not been widely utilized. Most frequently investigators mention the presence of some unslipped and/or unpolished sherds among those typed as Mancos, but do not isolate them as a separate type. The unslipped and slightly polished gray surfaced sherds with black mineral painted designs from the 1975 Hovenweep survey collections have been labeled as Morfield Black-on-Gray.

The third Mancos variant, Tin Cup Polychrome, is listed as a "deviant" in Breternitz et al. (1974), but has been given type status by Matheny in his investigations of the Montezuma Canyon area (Forsyth 1972). Its distinctive three color scheme argues for a separate typological status.

The two late types, McElmo Black-on-White and Mesa Verde Black-on-White, are still listed as one category. The McElmo-Mesa Verde Black-on-White type is subdivided into the two types of paint used for the decoration. The majority of the sherds of the combined type (72 percent) are decorated with a vegetal-based paint; 28 percent are decorated with a mineral-based paint. This deviation in paints used is noted as a western variant in the recent Mesa Verde area ceramic

manual. Hayes (1964:68) and Rohn (1971:190) mention that a very small number of their sherds were painted with mineral paint. Due to the fact that a much larger number of sherds from the Hovenweep area had mineral painted designs, this variation was deemed distinctive enough to warrant separate listing as a variation of the more common carbon painted type.

One new redware is listed--Abajo Polychrome. All plain gray ware body sherds have been classified this year as Mesa Verde Gray Ware. This includes body sherds from Chapin Gray, Moccasin Gray and Mancos Gray. However, these types have been separated from a much more coarsely tempered and finished plain gray ware labeled Hovenweep Gray (Abel 1955). The types Mancos Gray and Mocassin Gray can be and have been distinguished if rim sherds are present. The procedure of lumping of Mancos and Mesa Verde Corrugated and the separation of this composite type from Hovenweep Corrugated followed in the 1974 report has been continued here.

Mesa Verde Gray Ware Series

Mesa Verde Gray Ware: Body Sherds. This category includes all 368 body sherds of Chapin Gray, Mancos Gray and Moccasin Gray. The sherds vary from light tan to medium gray and are tempered with medium sized angular pieces of crushed rock. The surface is unslipped and unpolished and, although smoothed, it is uneven and bumpy due to the coarseness of the paste. Vessel walls range from 4-6 mm. in thickness.

Hovenweep Gray (Fig. 2). This is a group of 133 sherds distinguishable from the other plain ware types in the Mesa Verde Gray Ware series which has been labeled Hovenweep Gray. This type was described by Abel (1955) from material obtained during visits to the Hackberry House Ruin at Hovenweep. It is not given type status in the latest ceramic manual but subsumed as a variety of Kiet Siel Gray. These sherds do appear with fair frequency in the Hovenweep collections, although they may be nothing more than body sherds of Hovenweep Corrugated vessels that were only partially corrugated. The sherds are easily separable on the basis of the large amounts of angular rock temper which protrudes through the surface. The light to medium gray sherds are

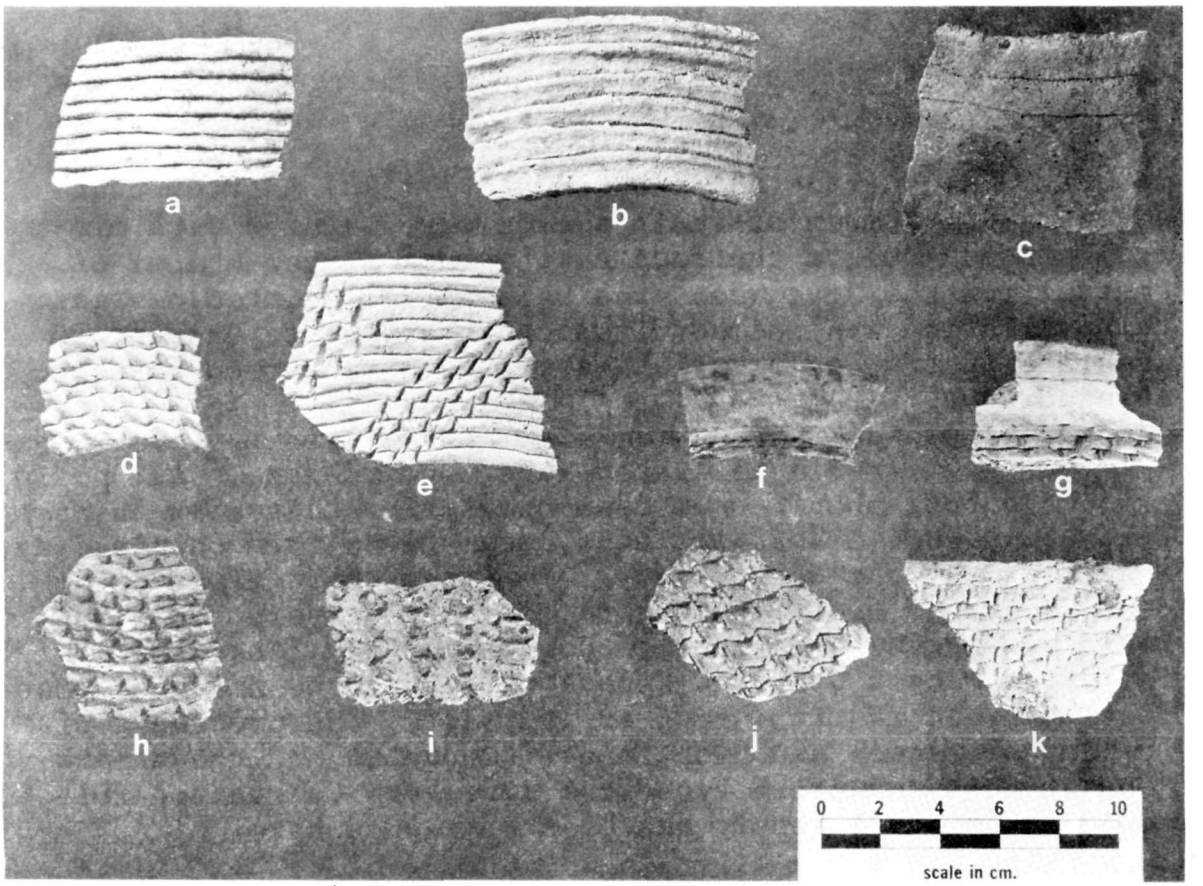


Figure 2. Mesa Verde Gray Ware - Mancos Gray: a-b; Moccasin Gray: c; McElmo/Mesa Verde Corrugated: d-g; Hovenweep Corrugated: h-k.

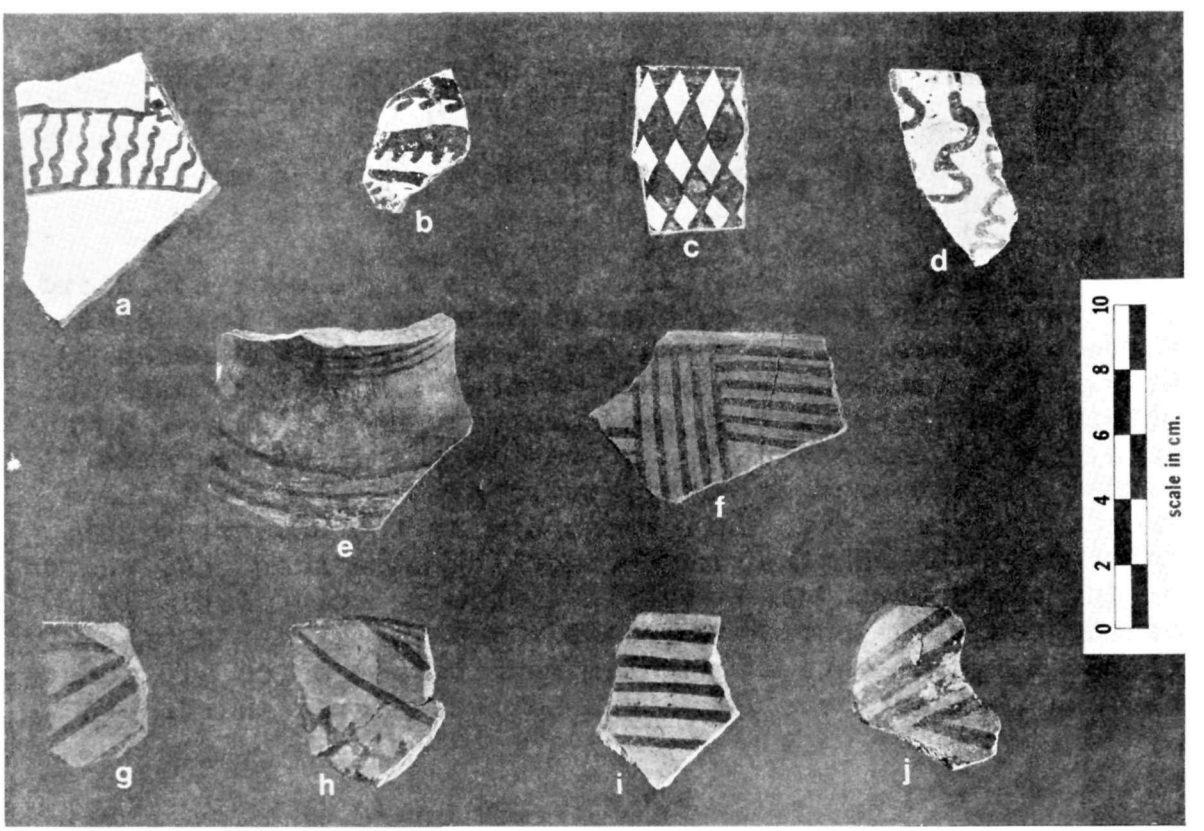


Figure 3. Early Pueblo Types - Cortez Black-on-white: a-d; Deadmans Black-on-red: e-f; Bluff Black-on-red: g-j.

unslipped and unpolished and range in thickness from 5 to 8 mm. Rim sherds are straight to slightly everted with round pinched edges. The heavily tempered coarse paste results in very bumpy, cracked, uneven surfaces.

Corrugated Ware

Four thousand one hundred and two corrugated sherds were recovered during the 1975 survey season. These were classified into four types. Moccasin Gray (29), Mancos Gray (133), Mancos-Mesa Verde Corrugated (2095) and Hovenweep Corrugated (1845). In the following section a brief description of each type will be given.

Moccasin Gray (Fig. 2). The small number of Moccasin Gray sherds in our collection are from Pueblo I sites scattered all over Cajon Mesa. The pottery is characterized by medium thick walled jars (6-7 mm.). The inner surface is smooth, but the outer neck area is covered with wide, unindented but flattened coils. The bands range from 8-14 mm. in width and extend down to the outcurving shoulder area. Below this shoulder, the body wall is smoothed but not polished. The paste is tempered with a large amount of light colored crushed rock. However, the surface has been smoothed sufficiently such that the temper does not protrude. The only rim sherd that was recovered indicates a straight sided neck area, and a fairly squared rim.

Mancos Gray (Fig. 2). Mancos Gray also is a neck banded plain bodied ware, however each neck band is distinctly thinner and unflattened. The coil widths range from 4 to 10 mm. and appear to be laid on top of one another giving the surface a clapboard effect. The paste is tempered with a moderate amount of crushed rock; the body walls range from 5-6 mm. in thickness. The sherds indicate a vessel shape similar to Moccasin Gray vessels--jars and pitchers with gently outcurving shoulder areas below which the body wall is smooth. The few sherds recovered that display both neck bands and plain body wall area do not display any polishing on the body wall as suggested by Breternitz (1974:6). In fact, the temper appears to protrude more than on Moccasin Gray sherds. On a few of the narrow banded sherds the coils were further demarcated by use of some tool to groove the underside of each coil.

Mancos-Mesa Verde Corrugated (Fig. 2). Although the 1975 survey sample of corrugated sherds is considerably larger than that recovered during 1974, it was decided to continue lumping these two types in one category. Other investigators have been able to clearly separate the types on the basis of differences in stratigraphic position, but we are unable to do this for the body sherds from the Hovenweep area until sites are excavated.

The sherds in this composite type are well made, 6-7 mm. thick, with indented corrugations usually covering the entire exterior surface. In some cases, the lower body wall is plain. A few of the sherds display patterns of indentations, grooving, and alternate plain and indented bands. However, these surface embellishments are not nearly as prevalent in the Hovenweep area as they are, for example, in the Montezuma Canyon area (Forsyth 1972). The paste is tempered with a moderate amount of crushed rock, but the surface has been so well smoothed that the temper does not protrude through the wall. The rims are generally highly everted and rounded. The corrugations stop just below the angle of eversion. When rim sherds are present, the two types are clearly distinguishable. Fig. 2 shows examples of the short, minimally everted rim area on Mancos Corrugated vessels. Rims on this type are a wide band that has been tapered and pressed slightly outward. Conversely, the two Mesa Verde Corrugated rims are markedly everted. The plain rim area on this type is composed of several coils that have been obliterated, smoothed and then everted. The rim edge is rounded to flat.

Hovenweep Corrugated (Fig. 2). The increase in sample size of the corrugated ware allowed us to confirm our prior separation of Hovenweep Corrugated from Mancos and Mesa Verde Corrugated, rather than giving it variety status as assigned by Breternitz et al. (1974:22). The vessel walls are considerably thicker (7-9 mm.) and are very heavily tempered with coarse angular gray crushed rock which protrudes from the wall surface. The indented corrugations are bold, frequently squarish (rather than diagonally oriented) and often fingernail incised. The rims are not as everted as are those on Mesa Verde Corrugated vessels, but the plain rim band is wider and more everted than on the Mancos Corrugated vessels. Because no stratigraphic tests have been conducted, the temporal position relative to the other two types is unknown. However, from the technological features alone, it would appear that a separate type designation would be useful.

Painted-Corrugated Sherds. A total of fifty-five sherds were recovered that were slipped and decorated on one side and corrugated on the other. Sometimes the corrugations were covered by a thin white slip. Fifty-two were bowl sherds; the exterior of which were corrugated and the interior decorated. On three jar sherds the exterior was corrugated and the decoration was restricted to the rim edge and everted rim area. This form of combined surface treatment was apparently used throughout the Puebloan occupation of the area. If the sherds are typed according to their decorated side, the sample from this season includes Cortez B/W, Wetherill B/W, Mancos B/W and McElmo-Mesa Verde B/W. The majority (45) were classified as Mancos B/W; only five were Wetherill B/W; one was Cortez B/W; and one was McElmo-Mesa Verde B/W. Three sherds were plain slipped on one side and two were of an unknown type.

Basket-Impressed Sherds. It is also notable that eight basket-impressed sherds were recovered. The reverse side (bowl interior) was slipped and decorated in all cases. Five Cortez B/W sherds were from one vessel from Hov. 593; one Cortez sherd was from Hov. 543; one Mancos B/W sherd was from Hov. 656; the other from Hov. 636.

Mesa Verde White Ware Series

Pueblo I Black-on-White Types

Chapin Black-on-White and Piedra Black-on-White. Despite the larger sample from the 1975 season, only twenty-four Pueblo I period Black-on-White sherds were recovered. The five Chapin Black-on-White sherds are unslipped, coarsely rock tempered with faint mineral painted designs. The nineteen Piedra Black-on-White sherds are separable from the Chapin sherds principally on the presence of a thin slip. These sherds are also rock tempered, coarsely finished and decorated with bold mineral painted motifs which hang from the rim line.

Cortez Black-on-White (Fig. 3). One hundred and nine sherds were classified as Cortez Black-on-White. Although this represents an increase over the small numbers recovered last year, the low frequencies of the early decorated wares would appear to suggest that the Cajon Mesa area supported a

sparse population during the Pueblo I period. Furthermore, since the main points of distinction between Cortez and Mancos Black-on-White lies in design elements used, many of which occur on both types, it is possible that some of the sherds classified as Cortez could fall into the Mancos category.

The Cortez Black-on-White sherds have a thick polished white slip which is decorated with a matte brown to black mineral paint. The paste is tempered with angular fragments of crushed rock and sherd. Although the surface is smoothed and sometimes polished, it is generally uneven and bumpy, particularly on bowl exteriors. The vessel walls range in thickness from 4 to 6 mm. Rims are straight, pinched and generally have a solid black line painted along the edge.

Pueblo II Black-on-White Types

Mancos Black-on-White (Fig. 4). As discussed in the introduction, Pueblo II period sherds from the immediate Hovenweep area fall into four categories: Mancos Black-on-White, Wetherill Black-on-White, Morfield Black-on-Gray, and Tin Cup Polychrome. The complete type description for Mancos Black-on-White is found in Breternitz et al. (1974); that for Morfield Black-on-Gray in Abel (1955); that for Wetherill Black-on-White in Hayes (1964); and that for Tin Cup Polychrome in Forsyth (1972). Since there is a substantial quantity of unslipped mineral painted Mancos and slipped carbon painted Mancos, the decision was made to recall type names previously assigned to these varieties in order to emphasize their presence in the Hovenweep area. They could just as easily be labeled Mancos Black-on-White--Morfield and Wetherill varieties, or alternatively, unslipped and carbon painted Mancos Black-on-White.

In general the 1446 Mancos sherds from Hovenweep are characterized by coil made vessels which have been well smoothed. However, the crushed rock and sherd temper gives the paste a coarse texture that causes the surface to be bumpy. A white to gray slip that has been thinly applied is polished only on the higher areas of the uneven vessel surface. The vessels are generally well fired; most sherds have a gray core without a carbon streak. A matte mineral pigment that fires reddish brown to black is used to compose the bold broad lined series of triangles, hatched and

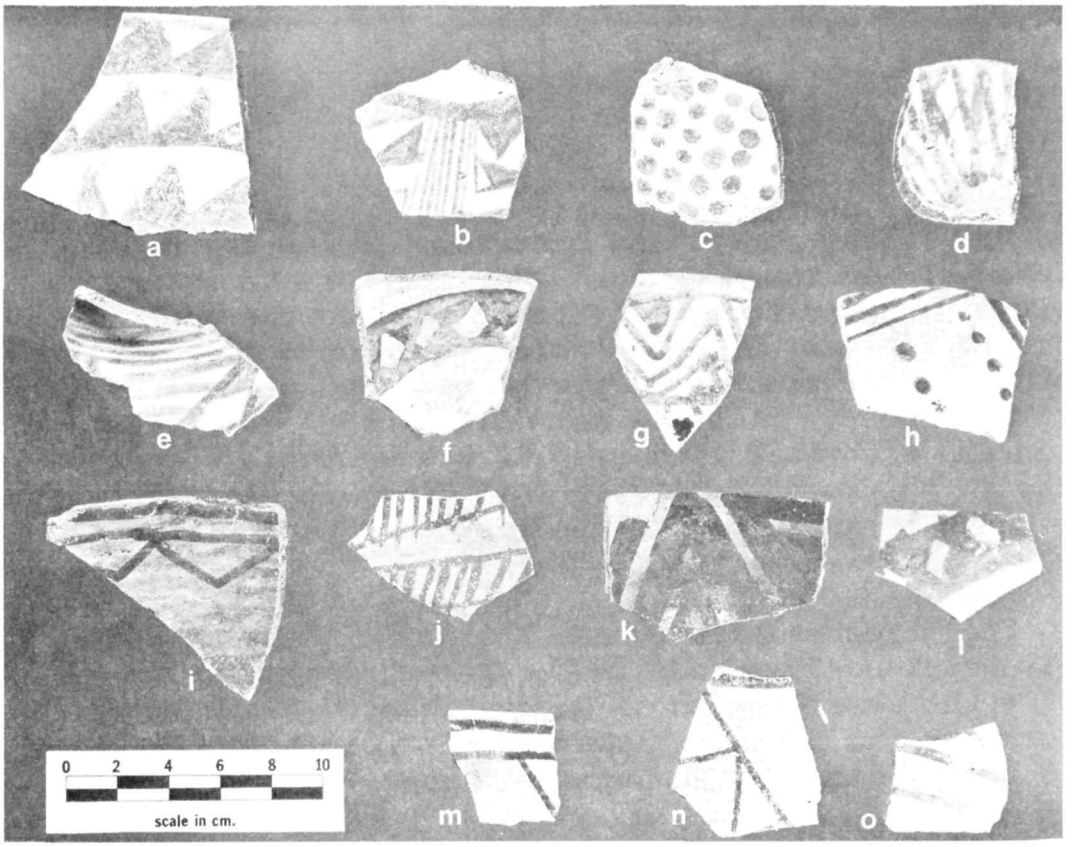


Figure 4. *Pueblo II Types - Mancos Black-on-white: a-d; Wetherill Black-on-white: e-h; Morfield Black-on-gray: i-l; Tin Cup Polychrome: m-o.*

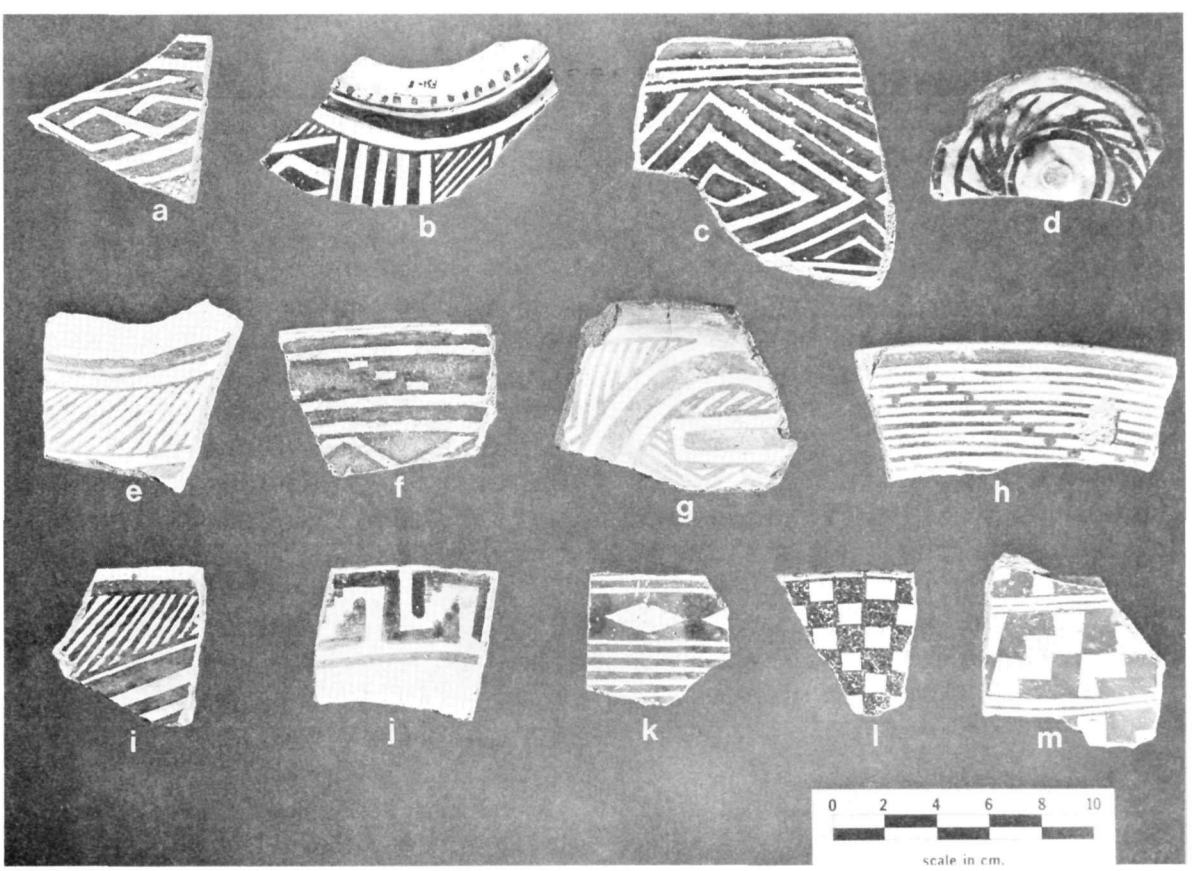


Figure 5. *Pueblo III Types - Mesa Verde Black-on-white (carbon paint): a-d; McElmo Black-on-white (carbon paint): e-h; Mesa Verde/ McElmo Black-on-white (Mineral paint): i-m.*

crosshatched patterns. Vessel forms range from bowls and jars to ladles, scoops and canteens. Bowls are usually slipped and polished on both the interior and exterior. Designs are most frequently found only on the bowl interiors, but occasionally are also found on bowl exteriors just below the rim. Jars are slipped and painted on the exteriors only. Rims are normally tapered and pinched, and often are decorated with a solid black line. Vessel walls range in thickness from 4 to 7 mm. and are distinctly thinner than the subsequent carbon painted Pueblo III wares from the same area.

The three related types (Wetherill Black-on-White, Morfield Black-on-Gray and Tin Cup Polychrome) display essentially the same attributes as does Mancos Black-on-White, except for the following characteristics which have been used to isolate them as separate types.

Wetherill Black-on-White (Fig. 4). The main unique characteristic of this type is the use of a vegetal based paint for the designs. Three hundred and ninety-seven sherds possess this difference in paint type. In addition, the slip is predominantly gray and rarely very poorly polished. The paste is tempered with a crushed rock as well as sherd, sand and sometimes caliche temper. The large amount of temper used makes the paste coarse and the fracture uneven. In comparison with the later carbon painted Pueblo III types Wetherill sherds display a greater variation in kind, amount and coarseness of tempering materials. This variation in paste is also paralleled in the surface treatment and designs used.

Morfield Black-on-Gray (Fig. 4). Seventy sherds have been classified as Morfield Black-on-Gray. Its distinctive character is the absence of a slip, or the polishing of a thin gray wash on the surface to make it appear as if a slip had been applied. The surface of the unslipped sherds is a matte, grainy dark gray while the surface of the washed sherds is a slightly polished gray. Mineral paint is used to decorate the vessels in bold broad-lined designs.

Tin Cup Polychrome (Fig. 4). This type occurs in very small frequencies (24 sherds) in the Hovenweep area. It is called a deviant in Breternitz et al. (1974:39), but Matheny has given it a type designation due to its abundance in the

Montezuma Canyon area of Cajon Mesa (Forsyth 1972). Brew refers to it as Pueblo II Polychrome (1946:280). In general the sherds resemble Mancos Black-on-White in having rock temper, thin walls, pinched, tapering rims and little to no polish on uneven bowl and jar surfaces. The distinguishing characteristic lies in the paint combinations used. The gray clay background is left unslipped and unpolished. On this unpainted surface are series of wide white bands which are bordered with thinner brown lines.

Pueblo III Black-on-White Types

McElmo-Mesa Verde Black-on-White (Fig. 5). Rohn's (1971) practice of combining the McElmo and Mesa Verde types has been followed for the preliminary sorting of the 1975 sherds.

The 1568 McElmo-Mesa Verde sherds from the Hovenweep collection are decorated with both mineral (426 sherds) and vegetal (1142 sherds) based paints and have been sorted and counted according to this basic difference. Both have a fine rock and sherd tempered paste, and have well-smoothed and highly polished slipped white vessel walls with square, often ticked rims. It is in the area of design composition that the Hovenweep area McElmo-Mesa Verde sherds can most easily be differentiated from those of the immediate Mesa Verde area. Local Hovenweep area patterns do not usually have the series of thick and thin parallel lines above and below the band of the design. Instead, only a single broad line, or several narrow lines, or no banding border lines are used. In the latter case the design is attached directly to the rim line. The same one-dimensional monocolor layout and the same series of elements (triangles, hatching, checkerboards, etc.) are used, however. In addition, on many sherds a slightly less polished surface, lack of design on the bowl exteriors, and a grayish white slip further isolates these sherds as local Hovenweep products. The few highly polished, precisely decorated, white slipped sherds with a dark carbon design are easily separable and probably represent imports from the Mesa Verde area.

The mineral painted sherds have all the same characteristics as do the more prevalent carbon painted ones. They are not variations of Mancos Black-on-White since the design elements and compositions as well as the technological aspects are identical to those on the carbon painted

McElmo-Mesa Verde sherds. According to the several Wetherill Mesa reports, very few mineral painted sherds or whole vessels are found in the immediate Mesa Verde area. However, this characteristic apparently increases in frequency on sites to the west of the Mesa Verde, as evidenced by the higher numbers of sherds on Hovenweep sites.

San Juan Redwares (Fig. 3). The sample of redware recovered during the 1975 season is slightly larger than that found during the 1974 season. However, it is considerably smaller than that recovered from Pueblo I sites to the north, such as Alkali Ridge (Brew 1946).

The two principal types of redware found are Deadmans Black-on-Red and Bluff Black-on-Red. A higher polish, thinner walls, and well-executed series of parallel lines characterize the twenty-eight Deadmans sherds. The thirty-eight Bluff sherds have thicker walls with broader lined designs. Both types have crushed rock temper, although the fragments in the Bluff sherds are larger which makes the paste slightly coarser. Vessel surfaces are well smoothed and polished; designs are painted with a matte mineral black paint.

A very small number of Abajo Red-on-Orange and Abajo Polychrome sherds were recovered. Bowl and jar vessel walls are thin, well smoothed, and slightly polished and painted with a matte red and black mineral paint. The paste is tempered with a moderate amount of crushed rock that renders the sherd fracture uneven.

A large number of sherds in Appendix IV are listed simply as San Juan Redware because they lacked painted designs or the designs are too worn for accurate type determination.

II.2 SYMMETRY ANALYSIS OF DESIGNS ON BLACK-ON-WHITE POTTERY FROM HOVENWEEP NATIONAL MONUMENT

By Dorothy K. Washburn

Theoretical Orientation

In addition to the typological study of the ceramics from Cajon Mesa, the Black-on-White sherds were subjected to a series of design element, motif and symmetry analyses. The purpose of this study was to determine whether there were differences in design composition among the ceramic output from the sites on Cajon Mesa. Furthermore, if differences were discernible, were they related temporally and/or spatially to certain other features on the mesa--such as major drainages, environmental zones, or other factors. In short, one way that it is possible to ascertain patterns of temporal and/or spatial interaction between major drainage systems, and thus to begin to illuminate the possible routes of exchange and community interactions, is to study some aspect of material culture that is sensitive to the system of information exchange.

This problem was tested in two ways using ceramic data. The first test was to select 100 sites, each of which had at least five decorated sherds that had been typed according to the established Southwestern typology, and subject them to a computerized seriation. Although many of the sites were multi-component units, it was hoped that some general temporal arrangement would be discernible, which would show spatial changes in site location through time. The results of this analysis are discussed by Del Pero in the following section. The second test involved a study of the distribution of the components of design--elements and motifs--as well as of the structure of design as this was expressed on the Black-on-White sherds.

Methodology

The designs were analyzed on three levels of compositional complexity: elements, motifs, and symmetry of structure. A series of basic element shapes were defined which were combined in various ways to form numerous motifs. (The numbers accompanying each element, motif, and symmetry units on the figures refer to the code used for the computer analysis.) However, since many of the elements and motifs observed occurred infrequently, similar design units were lumped together for this analysis. For example, all solid and empty stepped terraces were considered as element 43, and all forms of hatching on isosceles triangers were considered as motif 1. Thus, only thirteen basic element shapes (Figure 6) and twenty-six motifs (Figure 7) were studied.

However, neither the symmetry units nor the symmetry classes were combined into fewer categories. A symmetry unit is a section of a design that can be classified as either one- or two-dimensional. Analysis of this level of design (as opposed to the whole design observed on complete vessels) was necessary due to the incomplete nature of the designs due to their location on sherds rather than whole vessels. Frequency counts were made of the symmetry units and only those of high frequency were selected for distributional analysis (figure 8). Likewise, symmetry classes were not combined, except those of low frequency into an "other" category, since each symmetry class is a discrete structural entity. The methodology of symmetry analysis has been described elsewhere (Washburn, n.d.).

Finally, in order to be able to discern distributional differences in sites locations, the designs were analyzed as they occurred on sites in seven drainage areas. Seven such major areas were defined and are shown on Figure 9 as circled groups of survey quads, each of which contains a number of sites. All analyses were performed with the aid of a CDC 3300 computer and the SPSS program at the San Jose State University Computer Center.

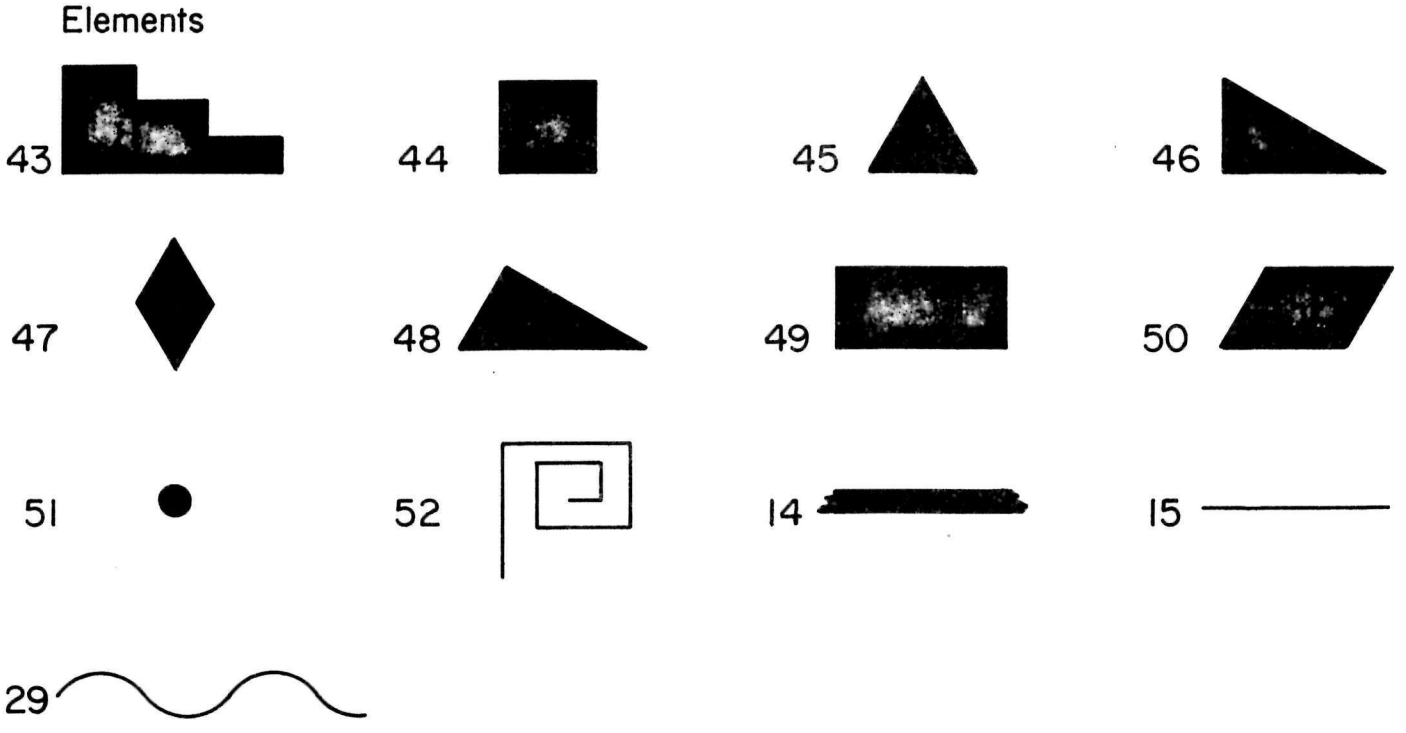


Fig. 6 Thirteen basic element shapes

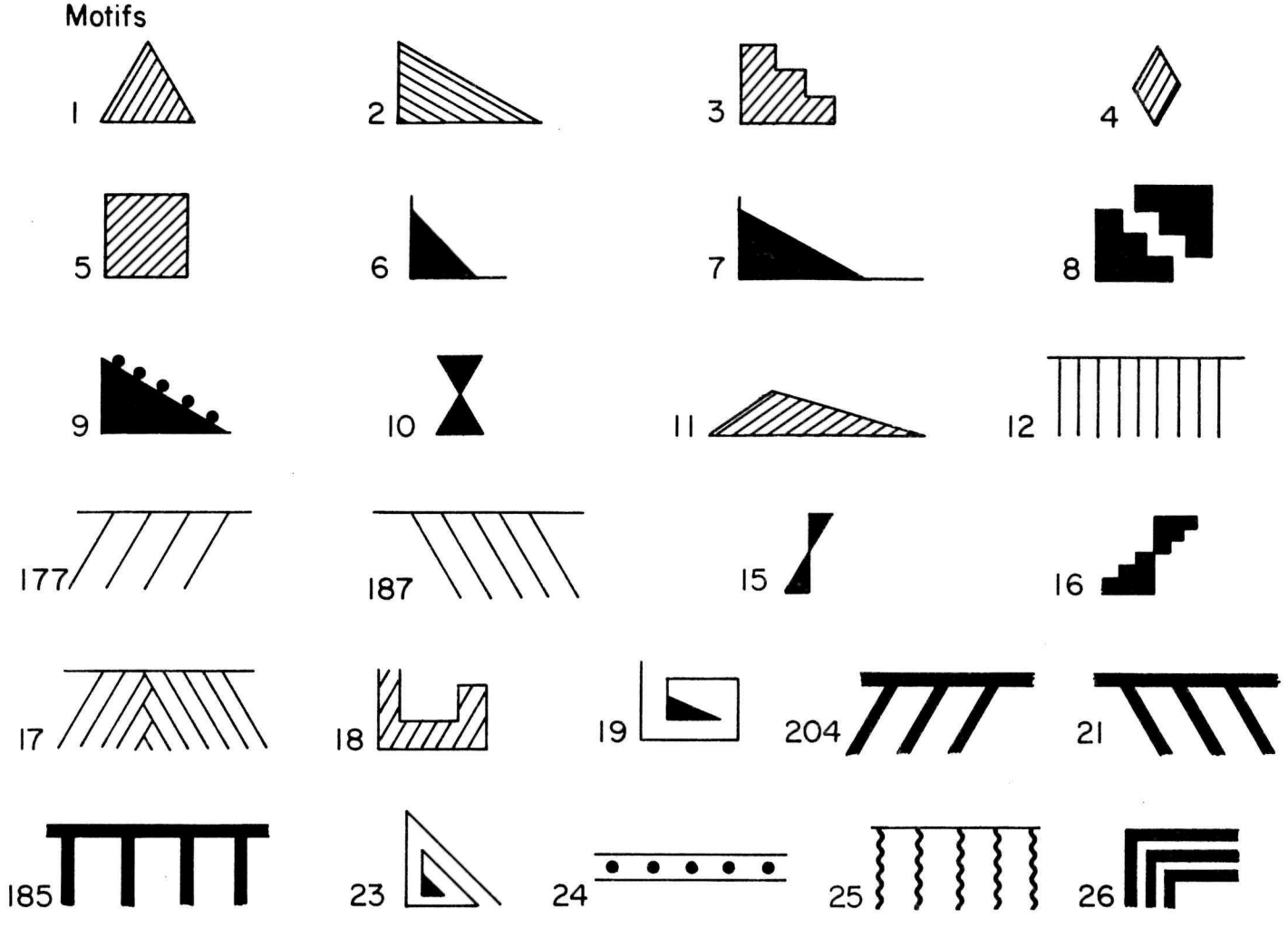
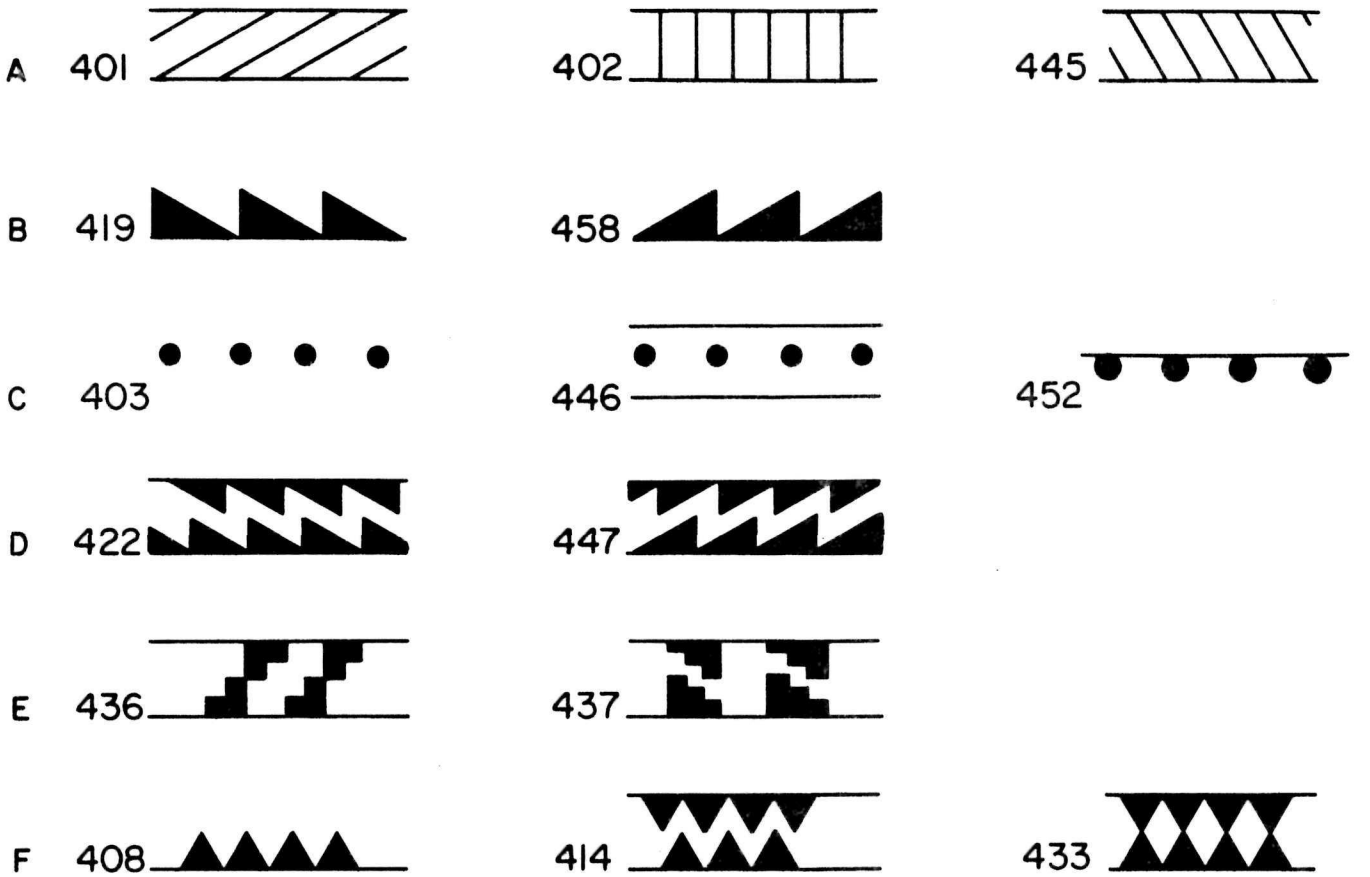


Fig. 7 26 Motifs

One-dimensional symmetry units



Two-dimensional symmetry units

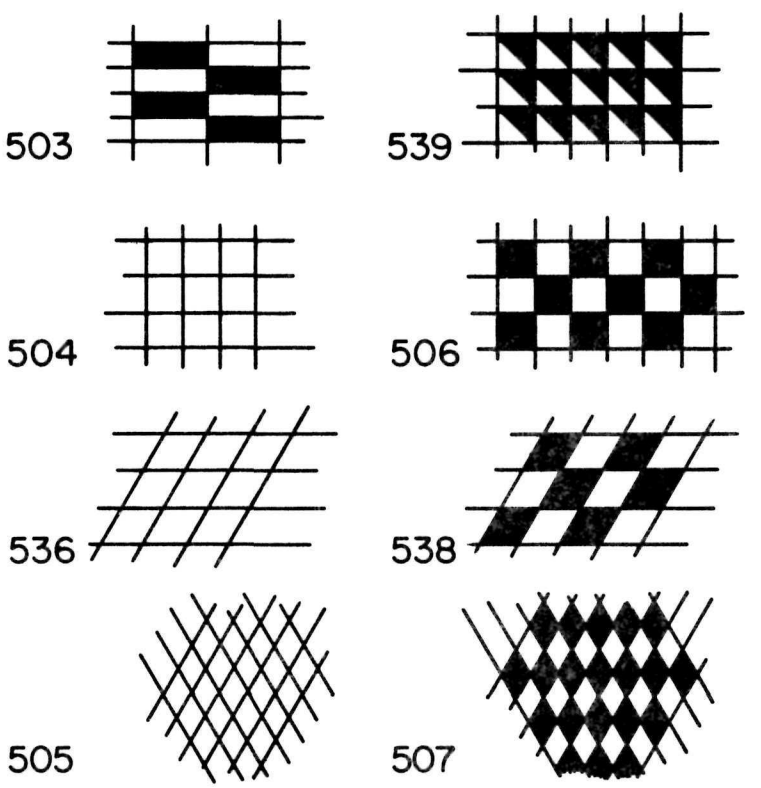
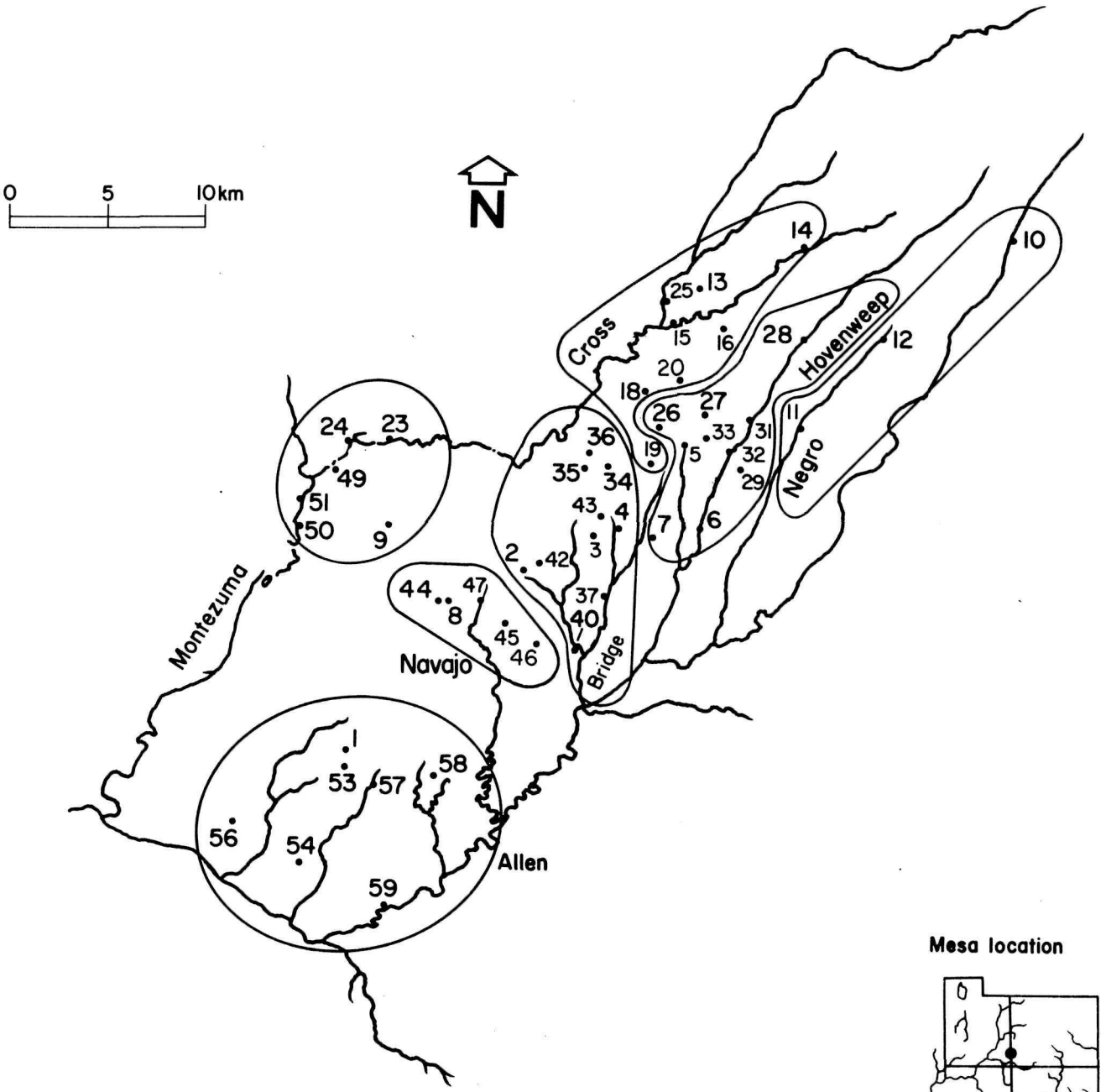
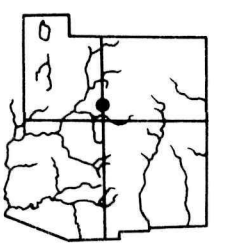


Fig. 8 Symmetry units



Mesa location



Location of 7 drainage areas on Cajon mesa.
Fig. 9

Analysis and Results

Because elements, motifs, and symmetry units represent quite distinct levels of design composition, it was of interest to test which level, if any, would reveal intra-mesa differences in design distribution. It was hypothesized that the population groups living within a drainage system could interact more frequently with each other than they would with groups living in adjacent drainage systems. Thus, the design output from sites within any one drainage system should be homogenous, but that between any two systems should display distinctive points of difference. If discernible, these patterns could be tested to determine whether they are also temporally related. Such patterns could be especially valuable in hypothesizing community boundaries.

A cross tabulation was performed correlating the thirteen elements and the twenty-six motifs with the seven drainage areas. However, neither the elements nor the motifs showed any tendency to occur in a nonrandom pattern over the mesa (Table 1 and Table 2). Rather, it appears that although some elements and motifs were more popular than others, all were used in the same relative frequencies by groups living in all of the seven drainage areas. For example, wide lines (element 14) and thin lines (element 15) were used with the greatest frequency--occurring in over 30 to 40 percent of all the elements used in each drainage system. Next in preference was the dot (element 51) which occurred with a frequency of between 7 and 10 percent on designs in every drainage system. Likewise the twenty-six motifs also appeared to vary in the same degrees of popularity over the seven drainage systems. Most prevalent was angled hatching (motifs 177 and 187), and to a lesser degree hatched and solid isosceles and right triangles occurring on lines or in corners (motifs 1, 6, 7), interlocking stepped terraces (motif 8), and vertical hatching (motif 12).

Such information indicates the relative homogeneity of the individual units used for design composition in the Hovenweep area, but it does not indicate the existence of any subgroups within the mesa system. Merely because this land form has been designated as a separate geologic unit (mesa) by geologists does not mean that the people who

TABLE 1

Distribution of 13 Element Shapes in 7 Drainage Areas

Drainages	Montezuma		Navajo		Allen		Negro		Bridge		Cross		Hovenweep	
Elements	#	%	#	%	#	%	#	%	#	%	#	%	#	%
14	103	5	349	16.8	331	16	87	4.2	475	22.9	433	20.9	297	14.3
15	85	4.5	351	18.7	277	14.8	91	4.9	481	25.7	348	18.6	242	12.9
29	0		4	15.4	11	42.3	2	7.7	0		7	26.9	2	7.7
43	4	2.4	31	18.6	38	22.8	4	2.4	34	20.4	36	21.6	20	12.0
44	18	9.0	27	13.6	31	15.6	18	9.0	45	22.6	37	18.6	23	11.6
45	7	3.7	22	11.6	29	15.3	16	8.4	41	21.6	46	24.2	29	15.3
46	10	5.2	30	15.7	29	15.2	11	5.8	32	16.8	41	21.5	38	19.9
47	11	12.5	13	14.8	12	13.6	1	1.1	21	23.9	17	19.3	13	14.8
48	0		4	21.1	3	15.8	1	5.3	5	26.3	5	26.3	1	5.3
49	0		2	6.5	3	9.7	0		9	29.0	11	35.5	6	19.4
50	5	8.5	18	30.5	10	16.9	3	5.1	7	11.9	14	23.7	2	3.4
51	30	5.9	76	15.0	73	14.4	23	4.5	105	20.8	121	23.9	78	15.4
52	2	3.4	11	19.0	4	6.9	4	6.9	28	48.3	5	8.6	4	6.9

TABLE 2

Distribution of 26 Motifs in 7 Drainage Areas

Drainages	Montezuma		Navajo		Allen		Negro		Bridge		Cross		Hovenweep	
Motifs	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1	3	2.8	13	12.1	12	11.2	6	5.6	32	29.9	22	20.6	19	17.8
2	0		0		0		0		3	75.0	0		1	25.0
3	0		5	15.2	3	9.1	1	3.0	11	33.3	6	18.2	7	21.2
4	0		0		0		0		2	100.0	0		0	
6	5	4.0	13	10.4	19	15.2	15	12.0	29	23.2	23	18.4	21	16.8
7	5	5.3	15	15.8	12	12.6	7	7.4	15	15.8	21	22.1	20	21.1
8	1	1.1	17	18.1	23	24.5	3	3.2	29	30.9	12	12.8	9	9.6
9	3	8.6	6	17.1	10	28.6	1	2.9	6	17.1	7	20.0	2	5.7
10	2	5.7	4	11.4	2	5.7	1	2.9	3	8.6	16	45.7	7	20.0
12	8	6.3	23	18.0	16	12.5	10	7.8	29	22.7	24	18.7	18	14.1
15	1	8.3	2	16.7	2	16.7	1	8.3	2	16.7	1	8.3	3	25.0
17	0		3	18.7	1	6.3	2	12.5	4	25.0	3	18.7	3	18.7
18	2	7.4	6	22.2	3	11.1	1	3.7	10	37.0	1	3.7	4	14.8
19	0		2	22.2	1	11.1	0		0		3	33.3	3	33.3
21	2	4.9	8	19.5	6	14.6	1	2.4	5	12.5	10	24.4	9	22.0
23	3	13.6	2	9.1	2	9.1	1	4.5	2	9.1	10	45.5	2	9.1
24	8	9.5	9	10.7	14	16.7	2	2.4	10	11.9	16	19.0	25	29.8
25	0		3	18.7	7	43.7	1	6.3	0		4	25.0	1	6.3
26	1	1.2	9	11.1	10	12.3	9	11.1	11	13.6	21	25.9	20	24.7
27	2	2.9	14	20.0	10	14.3	5	7.1	16	22.9	18	25.7	5	7.1
154	1	5.6	6	33.3	3	16.7	0		1	5.6	6	33.3	1	5.6
177	19	4.9	76	19.7	48	12.5	25	6.5	103	26.8	69	17.9	45	11.7
185	5	9.6	6	11.5	13	25.0	3	5.8	7	13.5	13	25.0	5	9.6
187	9	3.5	51	20.0	35	13.7	14	5.5	67	26.3	52	20.4	27	10.6
204	2	3.7	12	22.2	11	20.4	2	3.7	4	7.4	13	24.1	10	18.5

inhabit its surface confine their activities to this same area. In fact, it is often more difficult to traverse the many drainages which crosscut the mesa than it is to move from one mesa to the next. Thus, the fact that the elements and motifs show a high degree of homogeneity over the whole of Cajon Mesa does not necessarily mean that these same elements and motifs were not used by people in adjacent mesa systems. In fact, these same design units are used by peoples over a broad geographical area in the Southwest.

The critical criteria which distinguishes one area from another is how these elements and motifs are structured into a decorative pattern. It has been demonstrated that separate population groups have distinctive rule systems for composing designs (Washburn 1976, in press). One would expect, therefore, that it would be possible to discern differences in design structure over an area as large as Cajon Mesa which has many separate, deep, and lengthy drainage systems bisecting its length, each of which may have been a focal point for a number of farming-based settlements. In short, one would expect, all other factors being equal, that there would be more interaction among groups within one drainage than between them. This would lead to differences in the design structures which are easily detectable by symmetry analysis.

This hypothesis is substantiated by a comparative study of the distribution of five principal symmetry classes of one-dimensional design (1-100, 1-200, 1-110, 1-211, and 1-201) in five drainage areas (Allen, Navajo, Hovenweep, Cross, and Bridge) (Table 3). Negro and Montezuma drainages had too few symmetry class occurrences and therefore the results are not statistically reliable. One and two-dimensional patterns were analyzed separately. Within the one-dimensional category, the two classes of very low frequency (1-101 and $1\text{-}100x^{1}$) were not considered.

A chi square test on the distribution of one-dimensional symmetry classes in the five drainages gave a X^2 value of 48.69 with twenty-four degrees of freedom and a p value of .002, thereby confirming a definite difference in design structure among the five drainages. Furthermore, it appears that the preferences for certain symmetry classes are most similar in two general groupings of drainage systems: Hovenweep and Cross Canyons have design structures more similar to

TABLE 3

Distribution of 5 One-Dimensional Symmetry Classes in 7 Drainage Areas

Drainages	Montezuma		Navajo		Allen		Negro		Bridge		Cross		Hovenweep	
Symmetry Classes	#	%	#	%	#	%	#	%	#	%	#	%	#	%
1-100	40	6.2	89	13.9	100	15.6	33	5.1	154	24.0	132	20.6	94	14.6
1-200	5	4.8	18	17.3	18	17.3	2	1.9	18	17.3	31	29.8	12	11.5
1-110	1	1.6	8	13.1	8	13.1	7	11.5	12	19.7	11	18.0	14	23.0
1-211	1	4.0	3	12.0	1	4.0	1	4.0	2	8.0	11	44.0	6	24.0
1-201	6	9.0	10	14.9	20	29.9	1	1.5	17	25.4	7	10.4	6	9.0

each other than they do to designs from Allen, Bridge, and Navajo drainages. A chi square test showed that there was no significant difference ($p = .2$) between the symmetry classes used to construct designs in Cross and Hovenweep canyons, and likewise that there was no significant difference ($p = .2$) between Navajo, Allen, and Bridge design structures.

It is notable (see Figure 9) that the Hovenweep and Cross drainages are at the northerly reaches of the mesa while Allen, Navajo, and Bridge are at the southern end of the mesa. That these same groupings are not confirmed statistically by a comparison of the distribution of Southwestern pottery types (Cortez Black-on-White, Mancos Black-on-White, Morfield Black-on-Gray, Wetherill Black-on-White, and McElmo/Mesa Verde Black-on-White) in the five drainages suggests that symmetry analysis may be a more sensitive tool of analysis than typology for demarcating interacting population groups. However, there was a definite difference to a $<.001$ confidence level between the distribution of decorated sherds with respect to location in the seven drainage areas when the types were lumped into the two general temporal categories (Pueblo II and Pueblo III) (Table 4).

It is also of interest to see if specific structural combinations of elements and motifs (here designated as symmetry units) were distributed differentially over Cajon Mesa. Six groups of one-dimensional symmetry units (Figure 8) and one group of eight two-dimensional patterns were studied. The units within each of the six groups of one-dimensional designs are not necessarily characterized by a single symmetry class. For example, groups A, B, and C are characterized by translation (Class 1-100) and groups D and E are characterized by bifold rotation (Class 1-200). However, the symmetry units in group F are characterized by three different symmetry classes. The single row of isosceles triangles has Class 1-101 symmetry; the series of interlocking isosceles triangles have Class 1-201 symmetry; and the series of opposing isosceles triangles have Class 1-211 symmetry. Thus, the six groups were not primarily composed on the basis of a common generating symmetry, but on the basis of the similar design elements which composed the unit. Furthermore, in the case of Groups A, B, and D, it was of interest to determine whether the direction of rotation of the elements was

TABLE 4

Regional Distribution of Decorated Sherds in the Two Major Temporal Periods

Drainage	Montezuma		Navajo		Allen		Negro		Bridge		Cross		Hovenweep	
Time	#	%	#	%	#	%	#	%	#	%	#	%	#	%
Pueblo II	30	35.2	82	40.0	44	21.9	54	75.0	129	38.0	108	39.5	93	48.0
Pueblo III	55	64.8	123	60.0	157	78.1	18	25.0	207	62.0	166	60.5	101	52.0

correlated with any spatial distributional differences. For example, would there be a difference in the spatial distribution of vertical hatching as opposed to hatching angled to the right or hatching angled to the left?

Separate cross tabulations were run on each of the six groups of symmetry units. However, none of the cells contained enough cases for a valid chi square test of significance of difference. Nevertheless, it does not appear from examination of the percentage frequency distribution (Table 5) that the members of any group showed differential distribution between the different arrangements of design elements. It may be, however, that a larger sample would show differential preferences for these different forms of similar symmetry units among drainage areas. Thus, for example, while both units are composed of the same elements, indicating area-wide use of common elements, differences in their structural arrangements may reveal more localized interaction patterns.

In conclusion it appears as if the use of a symmetry classification of patterned design can be a useful tool, even on fragmentary sherds from a surface survey, toward defining interaction patterns in a region. The general similarity in types of design structures used throughout the entire region suggests that the groups were probably interacting to a sufficient degree that the exchange of foodstuffs and other necessary products not locally available, and/or actual travel to other source zones occurred on a regular basis. Furthermore, study of the distribution of four symmetry classes in five drainage systems revealed that not only did the populations living in each drainage use specific constellations of design structures, but that, over the whole mesa area, two general interaction spheres appear to have existed which have a north to south spatial differentiation.

TABLE 5

Frequency of Occurrence of Symmetry Units in All 7 Drainage Areas at Hovenweep

Symmetry Unit	#	%
401	100	7.3
402	18	1.3
403	30	2.2
408	48	3.5
414	20	1.5
419	14	1.0
422	8	.6
433	15	1.1
436	16	1.2
437	13	.9
445	73	5.3
446	16	1.2
447	14	1.0
452	30	2.2
458	25	1.8
503	18	1.3
504	23	1.7
505	57	4.2
506	70	5.1
507	21	1.5
536	23	1.7
538	22	1.6
539	11	.8
other units	707	51.5
	1372	100.00

II.3 COMPUTER SERIATION OF HOVENWEEP CERAMICS

By Gayl Del Pero

Background

An area of special interest to the Hovenweep Project is the relation of site location with resource zone. Three major plant zones have been defined on the mesa. Although the boundaries and composition of these zones may have changed since the Anasazi use of the region, meaningful geographic patterns could still emerge by correlating site distributions at various points in time with zonal locations.

This section is therefore an attempt at using seriation to obtain a relative chronological ordering of the Hovenweep sites. While it does not discriminate between sites of different functional categories, it does outline the general site/environmental relations which occurred from Pueblo I through Pueblo III times.

Methods

Seriation is a method of ordering a body of dated cultural material into relative chronological position. The method is based on the premise that the units used in the seriation will sequentially increase then decrease in popularity through time. In the present analysis all of the 1974-1975 Hovenweep sites which had five or more surface sherds were considered. These 100 sites were arranged in relative chronological position by a seriation of the percentage frequencies of fourteen different ceramic types found at these sites. In order to achieve the most unbiased and accurate ordering of the large number of sites, the Hole and Shaw computerized Permutation Search Technique (1967) was

selected rather than the traditional manual strip arrangement method of Ford (1962).

Hole and Shaw's method is based on the Brainerd-Robinson correlation matrix which compares the percentage distribution of types in each possible pair of sites (1951). Hole and Shaw developed a program to perform the permutation search process which matches the most similar pairs of sites (i.e. those sites which have similar frequencies of the same ceramic types). The formula used for determining the agreement coefficient between site pairs is calculated as follows:

$$X_{I,J} = 200.00 - \sum_{K=1}^{T} /A_{K,I} - A_{K,J}/$$

$X_{I,J}$ = correlation of the two adjacent sites

T = number of types (which in this case is 14)

$/A_{K,I} - A_{K,J}/$ = absolute value (signs are disregarded) of the difference between the type frequencies of one site and its adjacent site

These absolute values are added together and subtracted from 200. This number will then become the agreement coefficient for both of the sites.

However, before the actual permutation search is run, it is advantageous to determine whether the material can be seriated. Meighan's three pole plot graph (1959) is a rapid method to not only test the potential of the material to be ordered, but also to arrange it in a preliminary order that can be used for the initial permutation search. The three most numerous ceramic types are selected and the percentage frequencies of each type in all the sites are calculated assuming they total 100 percent. In the present study Mancos B/W (34.57 percent), McElmo-Mesa Verde Carbon (31.03 percent) and Wetherill B/W (10.39 percent) were the types used. If the sites can be ordered, the plotted points will spread out along a line rather than clump with no obvious order. In this case, the sites were linearly arranged along the left side of the graph. Since we know that Mancos B/W was

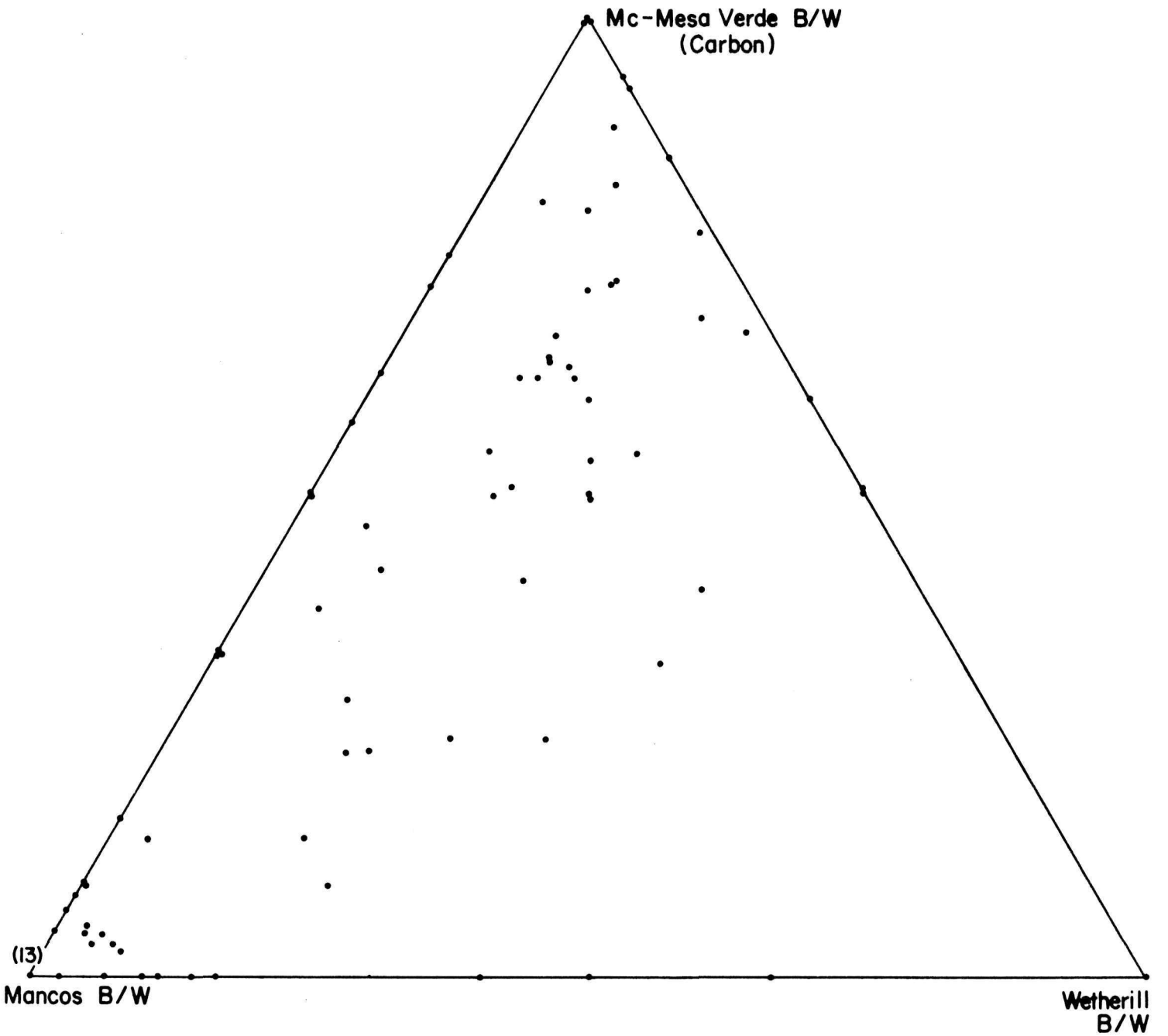


Table 6 Meighan 3-Pole plot
of Mancos B/W, Wetherill
B/W and McElmo/Mesa Verde
B/W Pottery types from 100 sites

produced before McElmo-Mesa Verde Carbon, the sites were arranged sequentially beginning with the Mancos corner of the graph. This initial ordering (Table 6) was used as the input for use in Hole and Shaw's permutation search method.

After calculating the agreement coefficient a symmetric matrix of similarity was constructed (Table 7). Since each site correlated perfectly with itself, the diagonal represents a perfect correlation of 200. The initial order of the sites is represented by the agreement coefficient adjacent to the diagonal.

At this point proximity analysis developed by Renefrew and Sterud (1967) was used to determine the presence of clustering. If strong clustering occurs, where the same unit is recorded as the most similar for many different units, good seriation is not possible because of the increasing difficulty of making valid judgments as to the proper ordering. The procedure is to take the complete similarity matrix and circle the two highest coefficients in each column excluding the diagonals and then examine the rows for more than two circled coefficients. If more than two coefficients are circled, clustering is occurring. The degree of clustering can be determined by the formula:

$$\frac{\sum_{j}^{N} \left| \text{Number of ringed coefficients in row } j \text{ beyond } 2 \right| - 2}{2N-3} \times 100$$

The cluster coefficient was found to be 13.36 with zero indicating absence of clustering and 100 maximal clustering.

With good seriation potential the next step is to compute the value of the norm which is done from the "errors" in a matrix. An error occurs when the difference between a matrix entry and the entry immediately adjacent to it moving from the diagonal along a row or column is negative instead of positive. Since the matrices are symmetric, it is sufficient to consider only differences within rows or columns. This insures that an error is only counted once. The

TABLE 7

SIMILARITY MEASURE MATRIX (selected segment)

200.00	160.00	160.00	160.00	160.00	157.50	125.88	160.00	160.00	162.86	150.63	156.36
160.00	200.00	**200.00**	**192.31**	171.43	162.50	155.88	180.00	173.33	171.43	152.25	**186.36**
160.00	**200.00**	200.00	**192.31**	171.43	162.50	155.88	180.00	173.33	171.43	152.25	**186.36**
160.00	**192.31**	**192.31**	200.00	179.12	170.19	152.04	187.69	181.03	179.12	156.76	**190.21**
160.00	171.43	171.43	179.12	200.00	**187.50**	134.45	188.57	**195.24**	185.71	156.76	174.03
157.50	162.50	162.50	170.19	187.50	200.00	130.88	182.50	187.50	181.55	169.26	170.45
125.88	155.88	155.88	152.04	134.45	130.88	200.00	145.88	139.22	143.98	137.25	160.43
160.00	180.00	180.00	187.69	**188.57**	182.50	145.88	200.00	**193.33**	**190.48**	156.76	185.45
160.00	173.33	173.33	181.03	**195.24**	**187.50**	139.22	**193.33**	200.00	**190.48**	156.76	178.70
162.86	171.43	171.43	179.12	185.71	181.55	143.98	**190.48**	190.48	200.00	161.52	178.79
150.63	152.25	152.25	156.76	156.76	169.26	137.25	156.76	156.76	161.52	200.00	156.76
156.36	186.36	186.36	190.21	174.03	170.45	**160.43**	185.45	178.79	178.79	156.76	200.00

formula used to compute the norm is:

$$\text{Norm} = \sum_{I=1}^{P} \sum_{J=1}^{P-1} /X_{I,J} - X_{I,J+1}/ \; X\Delta$$

P = number of site

$X_{I,J}$ = correlation of site I with site J

Δ = 0 if the entries in the correlation matrix go the right way (i.e. ascending toward the diagonal) or 1 if the entries go the opposite way.

The sum of errors was determined by comparing the agreement with the one above it and below it (i.e. columnwise). If the resulting figure of the comparison is less than zero indicating a step in the direction away from the diagonal it is counted as an error and added to an accumulating sum. If it is zero or greater it is not counted as an error and neither is it subtracted from the accumulating sum. When this process is completed the resulting total becomes the error for that column. When the process is complete the sum of the errors represents the norm for the odering of the data. The norm for the initial ordering was 75525.18.

Once the norm is calculated for the original ordering, the pairwise or interchange of sites permutation search with a resultant norm for each interchange can be checked against the original ordering norm. In the present analysis the interchange permutation search showed no improvement in the norm. The permutation search was terminated at this point with the original ordering of the sites (Table 8) being selected as the best order.

It should be noted that if an improvement had been noted, the next stage of the permutation search, successive rotation, would have been initiated. In this search the improved order would have been chosen as the initial ordering. Each site would have been put into every possible position calculating the norm at for each comparison and comparing it with the improved interchange norm.

TABLE 8

Seriation Order of 100 Sites on Cajon Mesa (arranged in order of earliest to latest)

Site	Drainage Area	Site	Drainage Area
559	Cross	561	Hovenweep
3	Bridge	405	Bridge
610	Allen	505	Hovenweep
604	Allen	567	Hovenweep
595	Negro	22	Bridge
678	Navajo	571	Cross
60	Bridge	495	Bridge
420	Bridge	716	Montezuma
477	Navajo	422	Bridge
447	Bridge	583	Negro
645	Cross	519	Hovenweep
695	Cross	605	Allen
521	Navajo	520	Navajo
592	Negro	496	Bridge
620	Negro	65	Bridge
703	Cross	654	Cross
705	Cross	359	Allen
706	Cross	404	Bridge
508	Hovenweep	381	Hovenweep
560	Hovenweep	455	Bridge
564	Hovenweep	70	Hovenweep
49	Bridge	11	Bridge
522	Hovenweep	423	Bridge
670	Montezuma	115	Bridge
511	Negro	13	Bridge
510	Negro	366	Bridge
572	Cross	600	Hovenweep
575	Cross	58	Bridge
593	Negro	597	Navajo
565	Hovenweep	547	Hovenweep
476	Navajo	61	Bridge
573	Cross	15	Bridge
574	Cross	12	Bridge
658	Cross	472	Bridge
602	Allen	617	Navajo
513	Bridge	608	Allen
694	Cross	669	Montezuma
47	Bridge	671	Cross
640	Cross	615	Cross
23	Bridge	676	Montezuma
709	Cross	606	Allen
504	Hovenweep	585	Negro
643	Cross	51	Allen
437	Bridge	43	Bridge
636	Cross	94	Bridge
657	Cross	714	Cross
656	Hovenweep	577	Bridge
473	Navajo	637	Cross
24	Bridge	398	Bridge
666	Montezuma	378	Bridge

Each time an improvement in the ordering norm was noted the corresponding order would be used as the initial ordering. This two-step process, pairwise and successive rotation would be repeated until no improvement was noted. This then would be accepted as the best ordering for purposes of seriating a given collection of material.

Results

The results of the computer seriation for the 1974-1975 Hovenweep sites indicate that the initial ordering of the collections as determined by Meighan's three pole plot method (1959) was the best, given the multi-component nature of many of the sites. Since there is a botanical gradient from pinyon-juniper forests in the northern part of the mesa through shrublands in the south, it was assumed that broad temporal differences in site location might become evident in a seriation process. However, the seriation results demonstrate that all areas of the mesa were occupied throughout Pueblo I through Pueblo III times (ca. 950 A.D.-1300 A.D.). Site numbers obviously increased through time, and changes in locations of functional categories of sites (e.g. water control sites) may have occurred, but the broad patterns of zonal utilization remained fairly constant.

Therefore, there does not appear to have been a preference for inhabiting any one part of the mesa at one time and a different part at another time. Rather, overall site location seems to be a result of localized availability of resources within major drainage areas (see preceding section). Settlement pattern shifts certainly occurred, as discussed in section III.3, but in general these shifts took place within zones, not between them. Seasonal movements between zones may also have taken place, since certain resources, such as deer, are more readily accessible at particular times of the year. In fact, the overall homogeneity of pottery types across the mesa could be explained by a pattern of seasonality. If the inhabitants wished to exploit resources on a different part of the mesa, they were probably mobile enough to temporarily move their sites while maintaining permanent villages in the prime farming areas.

II.4 PROJECTILE POINTS:

HOVENWEEP ARCHEOLOGICAL SURVEYS 1974 AND 1975

By Patricia A. Hicks

The two summers of archeological survey on Cajon Mesa have produced a collection of ninety-one projectile points exhibiting a wide range in style and artifactual association which appear to span the Paleo Indian, Archaic and Anasazi culture periods (Fig. 10). Following Irwin-Williams (1973) the most important criterion for typing the Hovenweep collection has been the formation and subsequent treatment of the projectile base. Other critical criteria we have employed are the general shape of whole points and the type of notching present, e.g. corner notching and side notching (cf. Miller 1974: 107; Hayes 1964: 129). Forty-three bifacially worked flakes which exhibited only distal portions or midsections were not typed. Table 9 lists the temporal assignment of the points, while Appendix V lists the site locations of the specimens.

Four projectile points of the Plano phase of the Paleo Indian tradition (ca. 8000 B.C. to 6000 B.C.) were classified. These points include a complete Gypsum Cave point, an incomplete basal fragment of a possible Scottsbluff I or Eden point, a basal fragment of a possible Plainview point, and a basal fragment of a possible Agate Basin or Angostura point (typology based on Hunt and Tanner 1960; Honea 1965; and personal communication with Irwin-Williams and Agogino). It should be emphasized that our Paleo Indian projectile point typology is tentative due to the fragmentary nature of three of the specimens and the fact that Paleo Indian projectile points are relatively rare in the general Hovenweep-Mesa Verde area (see Hunt and Tanner 1960, and Hayes 1964, however, for precedents).

In attempting to discern the presence and temporal extent of the Archaic occupation of Cajon Mesa, Mohr and Sample (1959), Hunt and Tanner (1960), and Irwin-Williams (1973 and personal communication) have provided valuable sources of reference. The Archaic occupation of the Hovenweep-Mesa Verde region is, as yet, not fully recognized or understood. Hence, in assigning type names, we have followed

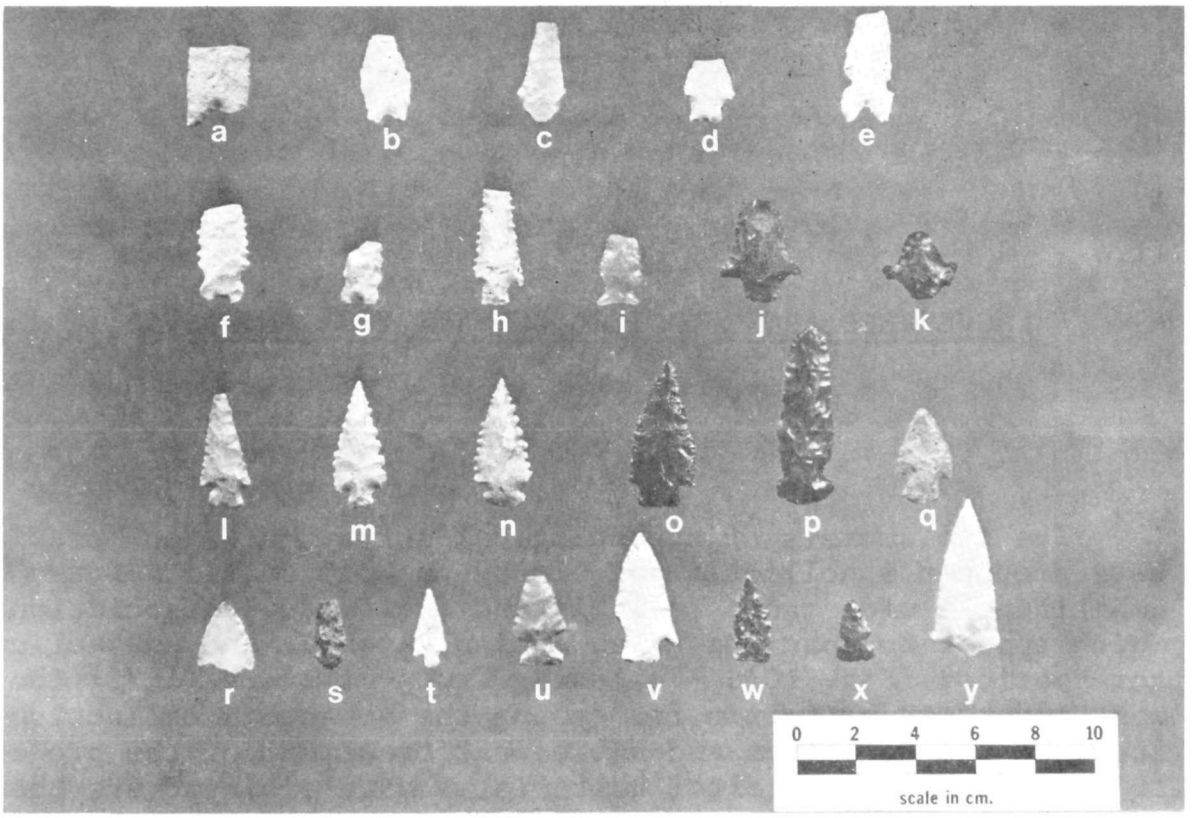


Figure 10. Representative Projectile Point Types at Hovenweep - Plainview (?): a; Gypsum Cave (?): y; San Jose Archaic: b,d; Chiricahua Cochise Archaic (?): e; Armijo Archaic: f,g,i; Armijo/En Medio Archaic: c,h,j,k; Early En Medio Archaic: l-n; Late En Medio (Basketmaker II): o-q; Trujillo (Basketmaker III): r; Basketmaker III: s-t; Basketmaker III - Pueblo III: u-v; Pueblo III: w-x.

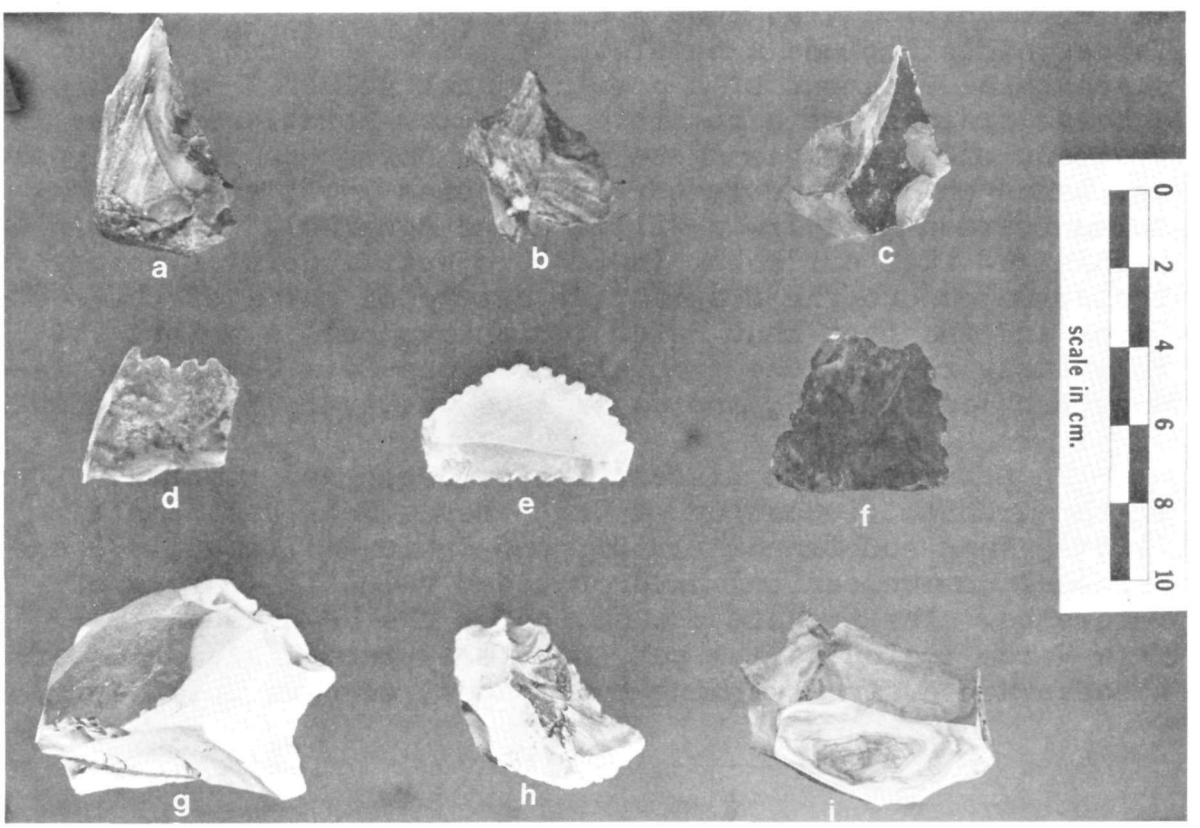


Figure 11. Examples of Chipped Stone Tool Types - Perforators: a-c; Saws: d-f; Scalloped edge tools: g-i.

TABLE 9 - Projectile Point Types And Suggested Time Ranges On Cajon Mesa

Culture Period	Temporal Range	Present (X) or Absent	Number of Points Present
Pueblo III	ca. AD 1300 - 1100	X	
Pueblo II	ca. AD 1100 - 900	X	19 side notched
Pueblo I	ca. AD 900 - 700	X	8 corner notched 1
Basketmaker III	ca. AD 700 - 400	X	5
Early Basketmaker III (Trujillo)	ca. AD 500 - 400	X	1
Basketmaker II (Late En Medio)	ca. AD 400 - 0	X	15 7
Early En Medio Archaic	ca. AD 0 - 800 BC	X	5
Armijo Archaic	ca. 800 BC - 1800 BC	X	12
Chiricahua Cochise	ca. 1500 BC - 2000 BC	X	2
San Jose Archaic	ca. 1800 BC - 3000 BC	X	6
Bajada Archaic	ca. 3000 BC - 4800 BC	absent	
Jay Archaic	ca. 4800 BC - 5500 BC	absent	
Plano Paleo Indian	ca. 6000 BC - 8000 BC	X	4
Folsom Paleo Indian	ca. 8000 BC - 9000 BC	absent	
Clovis Paleo Indian	ca. 9000 BC - 9500 BC	absent	

Irwin-Williams' (1973) designations for local phases within the larger Archaic culture period, since her research in adjacent areas of New Mexico has resulted in the most complete description of local Archaic points yet available. We have found six projectile points of the San Jose phase (ca. 3000 B.C. to 1800 B.C.), twelve projectile points of the Armijo phase (ca. 1800 B.C. to 800 B.C.), and five projectile points of a type common to the Early En Medio phase (ca. 800 B.C. to 0 A.D.) of Archaic culture. In addition, we have found seven points of a type that spans both the Armijo and En Medio phases (ca. 1800 B.C. to 400 A.D.). Two projectile points were found which did not fit into this typology, and on the basis of general morphology did not resemble projectile points of the later Pueblo periods of occupation. These points have tentatively been identified as Chiricahua-Cochise (ca. 2000 B.C. to 1500 B.C.). There is, as yet, no local evidence for materials from the early Archaic Jay and Bajada phases (ca. 5500 B.C. to 4800 B.C. and 4800 B.C. to 3000 B.C., respectively).

Thus, from the evidence of the projectile points alone, we appear to have a long temporal gap of some 3000 years in the occupation of Cajon Mesa, lasting from early to mid-Archaic. It must be emphasized that evidence for this hiatus is based on surface survey and the resulting projectile point collection alone, and therefore cannot be considered conclusive. Excavation of the sites where these projectile points were found and further surface survey may well reveal artifactual information to fill in this gap.

Irwin-Williams' (1973) En Medio phase (ca. 800 B.C. to 400 A.D.) encompasses, in the form of Late En Medio (ca. 0 A.D. to 400 A.D.) the Basketmaker II phase of the local Mesa Verde Anasazi culture. Because Irwin-Williams' typology applies to the north central New Mexico area, Morris and Burgh (1954) and Dalley (1973) were consulted for local Basketmaker II comparisons. Fifteen projectile points were found which could be assigned with confidence to the Late En Medio (Basketmaker II) phase. Irwin-Williams (1973) defines a Trujillo phase equivalent to Early Basketmaker III (ca. 400 A.D. to 600 A.D.). We have been able to classify one projectile point of this type.

Five small, corner notched points with convex bases were classified as belonging to the local Basketmaker III phase,

while one small, poorly made, corner notched point with a fragmentary base was classified as a type which spanned the local Basketmaker III and Pueblo I phases (ca. 400 A.D. to 900 A.D.). Eight corner notched and nineteen side notched points are similar to those found in the general Mesa Verde area, as described by Brew (1946), Dalley (1973), Hayes (1964), Lancaster et al. (1954), Lister and Lister (1964), Lister (1966), Martin (1936, 1938, 1939), Miller (1974), O'Bryan (1950), and Wylie (n.d.). Side notched points are especially frequent in Pueblo II and Pueblo III period (ca. 900 A.D. to 1300 A.D.) sites, but corner notched points appear to span the periods Basketmaker III (ca. 400 A.D. to 700 A.D.) to Pueblo III (ca. 1100 A.D. to 1300 A.D.). The latter have been illustrated for late Basketmaker III-early Pueblo I sites in the Ackmen-Lowry area of Cajon Mesa by Martin (1939:415) as well as by O'Bryan (1950) for a multicomponent Pueblo II-III site on Mesa Verde. Wylie (n.d.) discusses a corner notched point type which he calls "Abajo Tanged" which is frequently found in Pueblo I contexts on Elk Ridge, but also occurs on Pueblo II and Pueblo III sites in the general area. We decided, on the basis of this evidence, to assign all those corner notched points which remained to a large amorphous category spanning the periods Basketmaker III through Pueblo III, while assigning the side notched points to the Pueblo II and Pueblo III periods. It must be strongly emphasized that this general typology of corner notched and side notched projectile points for the Basketmaker III through Pueblo III periods is of a highly tentative order due to the unstratified nature of our sample, and for this reason these points have not been used in dating the sites.

Six projectile points which exhibited whole or partial bases could not be typed. Perhaps further survey of the literature, or excavation of sites on Cajon Mesa will shed light on their temporal placement.

Summarized in Table 10 are the means and ranges of the various attribute measurements recorded for the Hovenweep projectile point collection. All measurements have been rounded off to the nearest millimeter. The reader will note that means and ranges have not been included for the Plano phase Paleo Indian points, the two Chiricahua-Cochise points, the one Trujillo point, and the one Basketmaker III-Pueblo I point. The reason for this omission is the small sample size for each of these types. The reader will also note the number

TABLE 10 - Means And Ranges of Projectile Point Attributes

Point Type	#	Basal Width		Shoulder Width		Stem Width		Thickness		Length of Whole Points	
		Mean (#)	Range	Mean (#)	Range	Mean (#)	Range	Mean (#)	Range	Mean (#)	Range
Pueblo II - III Side Notched	19	16.45mm (11)	11-25 mm	13.67 (15)	7-25	10.19 (16)	6-17	3.74 (19)	2-6	23.25 (4)	20-29
Basketmaker III - Pueblo III Corner Notched	8	14.8mm (5)	13-17 mm	18.75 (4)	12-23	10 (6)	8-12	6 (6)	4-6	NA	NA
Basketmaker III	5	7.75mm (4)	5-10 mm	11 (5)	11	5.6 (5)	4-7	3.4 (5)	3-4	NA	NA
Late En Medio	15	14.34mm (15)	11-20 mm	19.8 (10)	11-25	12.2 (15)	9-16	5.14 (15)	3-7	42.17 (6)	30-61
Early En Medio	5	11-67mm (5)	9-14 mm	18 (5)	17-20	8.6 (5)	7-10	5.2 (5)	4-6	NA	NA
Armijo/En Medio	7	9.2mm (5)	9-10 mm	19.17 (6)	14-27	9.67 (6)	8-13	6 (6)	4-8	NA	NA
Armijo	12	13.73mm (11)	11-17 mm	15.86 (7)	10-19	11.4 (10)	9-14	5.08 (12)	4-6	NA	NA
San Jose	6	14.66mm (3)	11-21 mm	16.17 (6)	16-19	14 (4)	10-19	5.33 (6)	4-7	NA	NA

in parentheses in the mean column. This number refers to the number of projectile points of a specific type on which the measurement could be taken. Because of the fragmentary nature of much of the Hovenweep collection, all measurements could not be made on a great number of points. In order to maximize the amount of data at our disposal measurements of the various attributes were taken where the attributes were present. Because of the small sample sizes for the majority of the types, no attempt was made to perform any statistical analyses on the overall sample.

In the Pueblo II-III side notched sample a clustering of the basal and stem widths of the points into two distinct groups was noted. Four points having a mean basal width of 29.25 mm., with a range of 22 mm. to 35 mm., and six points having a mean stem width of 14.17 mm., with a range of 12 mm. to 17 mm. comprised one group. Seven points having a mean basal width of 12.43 mm. and a range of 11 mm. to 14 mm., and nine points having a mean stem width of 7.56 mm., with a range of 6 mm. to 10 mm. comprise the second group. These means and ranges have been combined in Table 10 for the sake of convenience, but they do suggest that we might be dealing with several types of Pueblo II-III side notched points.

II.5 FUNCTIONAL TYPOLOGY OF THE HOVENWEEP STONE TOOL ASSEMBLAGE, 1975

By Colleen M. Culligan

Introduction

The Hovenweep stone tools are being separated into both morphological types and functional types so as to establish a meaningful local typology. The sample includes all whole identifiable tools as well as a representative sample of utilized flakes recovered from the various sites. Classic studies by Semenov (1964) and Bordes (1969) have revealed a lack of adequate representation of utilized flake and waste flake categories, and a major emphasis on subjective tool categories such as scrapers, knives, etc. Although we are not performing our own experimental replication, we have begun a micro-wear analysis of the lithics recovered. In conjunction with the results of experimental tests already accomplished, these two analytical approaches can help avoid subjective type categories by shifting the emphasis from morphological to functional descriptions.

The tools, in association with the projectile points and decorated ceramics, range in date from sites of possible Paleo-Indian age through the Archaic, Basketmaker and Pueblo periods (see Appendices V and VI). Preliminary analysis of the lithic mineral composition has shown that most of the materials used for tools are chert (18 percent), quartzite (16 percent), sandstone (25 percent), quartz (3 percent), volcanic material (1.1 percent) and chalcedony (.8 percent). Wylie (1973) has noted that wear is less visible on the tougher and harder cherts and quartzites, since their rough crystalline surfaces resist use marks. This was found to be particularly true of the quartzite, which was of very rough surface texture. The finer cherts, including chalcedony, had the best visibility. The presence of opalization gave the tools a very polished surface in some cases. Since all of these materials have a high resistance to wear, the relationship of the type of stone to the production of micro-wear

should be taken into consideration.

The tools were initially typed according to the following categories: core/choppers, core/hammerstones, core/scrapers, hammerstones, scrapers, scraper/spokeshaves, spokeshaves, perforators, perforator/spokeshaves, knives, saws, axes, hoes and utilized flakes (Figs. 11-13). From preliminary examination of tool micro-wear evidence, it is evident that a variety of scraping, shaving, cutting, sawing and penetrating tasks were being accomplished at Hovenweep. Basic morphological characteristics also indicate that the activities of chopping, hammering and hoeing were being performed. In many cases the implements were used for multiple tasks, as determined by different micro-wear traces. Of the total cultural elements recovered from the sites, 70.0 percent were waste flakes (debitage). An additional 18.8 percent comprised the utilized flake category, while the utilized and nonutilized cores made up an additional 4.5 percent of the tools. Of the remaining 6.7 percent of the tools which implied specific, mutually exclusive functional activities, scraping was the dominant component (34.5 percent), followed by hammering (20.0 percent), cutting (8.8 percent), drilling (6.9 percent), chopping (6.5 percent), shaving (5.2 percent) and sawing (.9 percent). The remaining tools consisted of multiple-use implements (scraper/spokeshaves, perforator/spokeshaves), axes and hoes (3.9 percent) and other bifaces (13.8 percent).

Definition of Terms

Edge Wear Features

Tringham has noted (1974) that the mode or type of action a tool is used for can be determined by the distribution of the scars on the edge of the tools. The amount, regularity and direction of the scars varies with each type of action. Differences in the direction and angle of pressure result in the detachment of different types of microflakes. Several factors are significant in the distribution of the scars along the tool edge. They include reworking, whether the tool was worked on a hard or soft material, the shape of the edge, and the condition of the edge (i.e. whether it has undergone accidental attrition), as well as regular use-wear. The edge of the flake is much like a

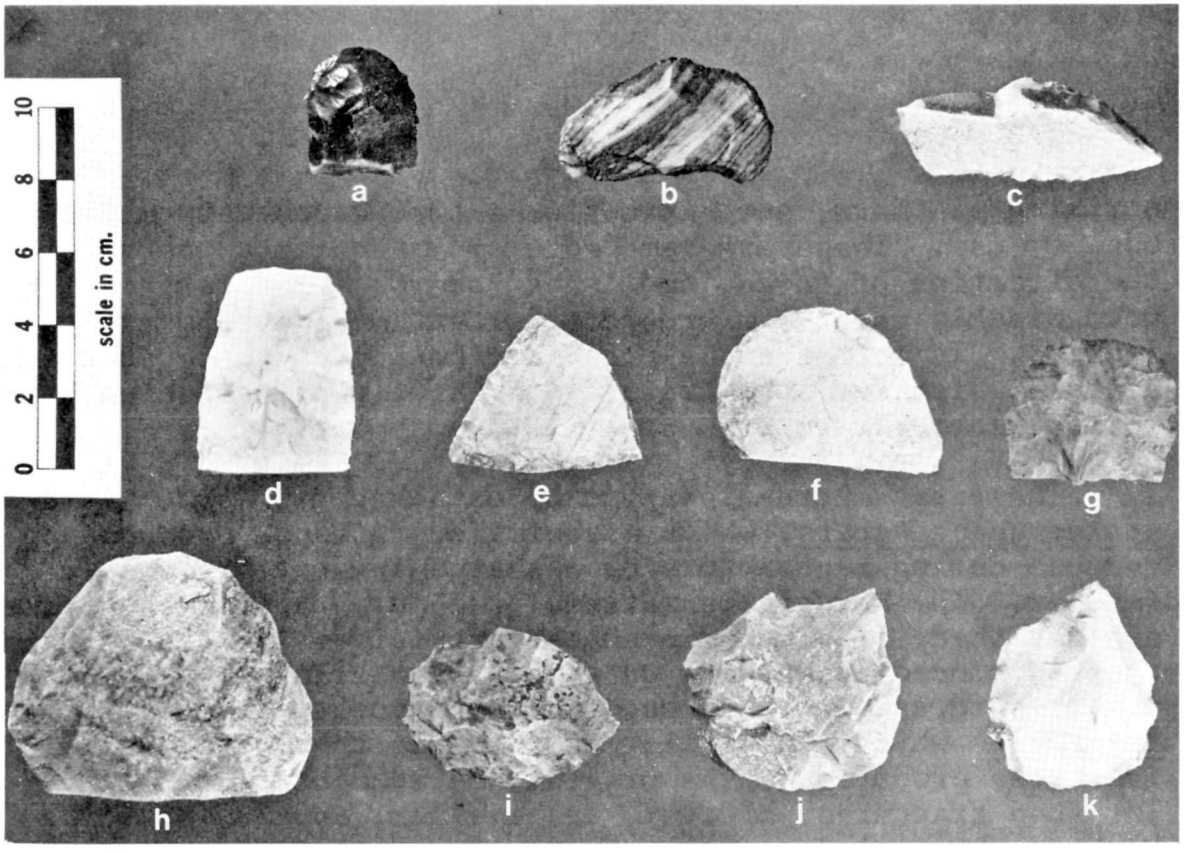


Figure 12. Examples of Chipped Stone Tool Types - Scrapers: a-c; Knives: d-g; Large bifaces: h-k.

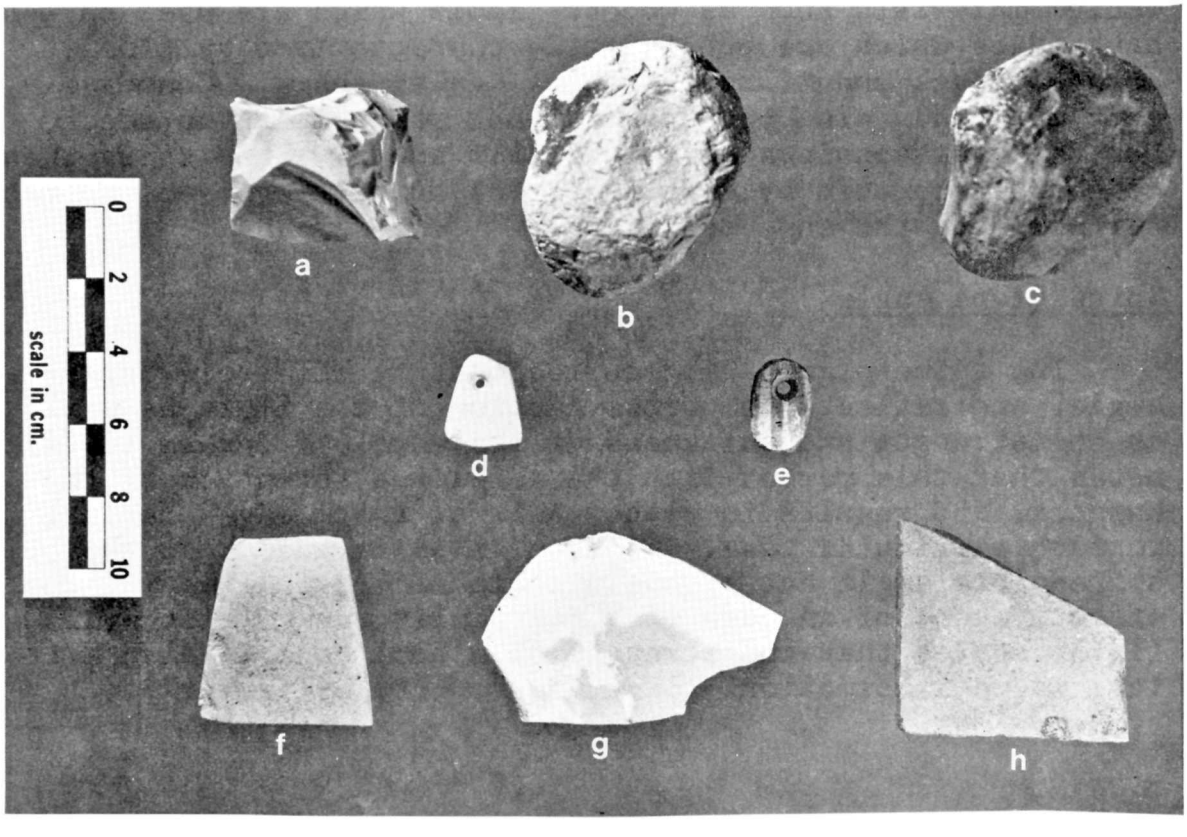


Figure 13. Examples of Chipped Stone Tool Types and Objects of Unknown Use - Core: a; Hammerstones: b-c; Pendants (?): d-e; Pieces with smooth faces (Tchamahias?): f-h.

striking platform, and micro-flakes are detached from the edge by use. These are removed from the surface opposite the direction of force, and leave "scars," which are easily recognizable under a microscope (oftentimes, even macroscopically). It is the shape and distribution of these scars on a flake which form the basic criteria of distinguishing different wear patterns.

The first micro-flakes to be detached from a tool are scalar-shaped scars, which are similar to those produced by retouch during manufacture or resharpening but are much smaller. The harder the material the more rapidly the flakes are detached. The scars produced are larger and deeper than those produced by working on a softer material. Hard materials, such as antler or bone, produce short, steep step fractures, which are similar in shape to the large hinge fractures produced by the original detachment of a flake. The step fractures, however, are smaller, appear within and between the scalar scars, and are a result of the rapid detachment of a flake worked on a hard material. Step fractures occur only on the edges used on hard materials and often completely obliterate the scalar scars. They are also primarily responsible for the blunting and dulling of the edges of the flakes. Tringham also distinguishes wear on medium materials such as woods. Tools which are used on wood have edges which are consistently characterized by finely abraded edges and "fuzzy" looking scalar scars. Conversely, soft materials also produce distinct wear along the edges, but the wear consists of only scalar scars. Step scars then, cannot be produced by scraping skins or cutting meat, no matter how long the edge is used.

Spine Plane Angle

The spine-plane angle corresponds to Wilmsen's "edge-angle" and reflects the cross section of the flake as well as the strength and thickness of its edge. Tringham (1974) notes that this varies with the skill and intention of the knapper, and results in either thin or thick edges for use in each particular task. Wilmsen (1968) argues that the spine-plane angle has a considerable effect in limiting the effectiveness of an edge in a particular task, while Wylie (1973) states that the strength of a tool edge is also critical in wear formation. Experiments (cf. Wylie, 1973;

Tringham, 1974) have shown that thin working edges undergo rapid and severe attrition whereas a stronger, thicker edge will resist use-wear. In this regard unmodified flakes or those which show no intentional retouch are more easily examined than those which have been secondarily modified. Those tools which have been modified have a less acute edge angle, and wear is less easy to detect.

Mode of Action

Use of a tool in a longitudinal direction produces tools with wear scars indicating both a unidirectional cutting edge and a bidirectional sawing edge (Fig. 14). Tools with a unidirectional cutting edge have a characteristic micro-flake wear pattern of scalar scarring on both the dorsal and ventral surfaces of the tool in an unequal proportion and an irregular distribution. Conversely, tools with a bidirectional sawing edge show regular and evenly distributed scalar scarring on both the dorsal and ventral surfaces.

Use of a tool in a transverse direction produces tools with regular scarring on one surface only. The tools were probably turned over and used in a transverse action when such scarring appears adjacent to or across from the original edge.

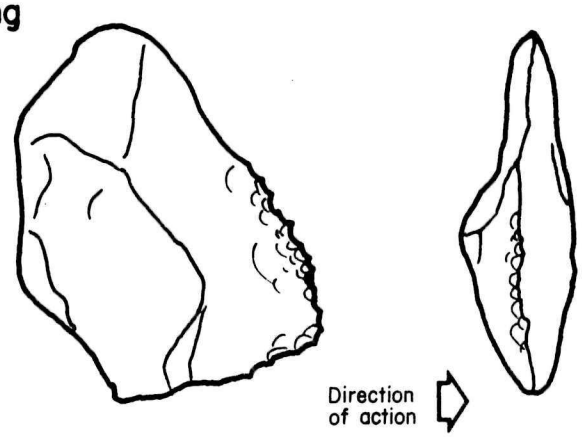
Secondary Retouch

1. Denticulation. Certain tools displayed small, closely spaced rounded saw teeth, produced by pressure flaking on one side of the thin edge of a flake.

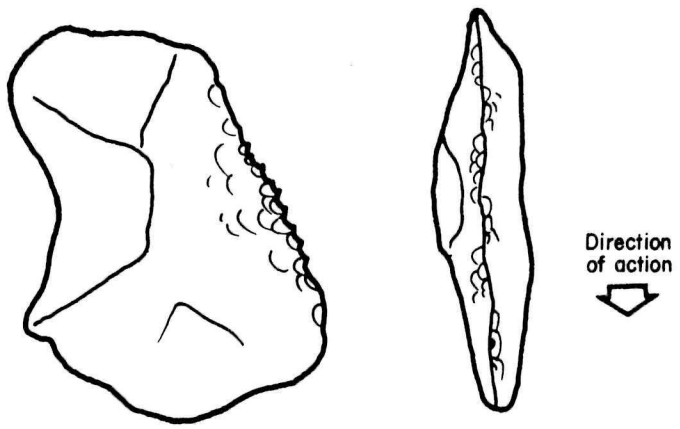
2. Scalloping. This type of retouch was characterized by broadly spaced crescent-shaped flakes removed by percussion on the vertical face of the domed scraper edge. No flakes have been removed on the flat plano surface. These scallops are larger and less regular than the small, closely spaced, pressure flaked indentations on the flat edge of denticulates.

3. Spoking. This edge is produced by removing a single flake from one side of the tool by a percussion blow. Alternatively, a natural indentation of the flake has often been used. During use of these tools, shafts were probably drawn through the indentation, causing hinge and step fractures in the base of the indentation.

A. Scraping



B. Cutting



C. Sawing

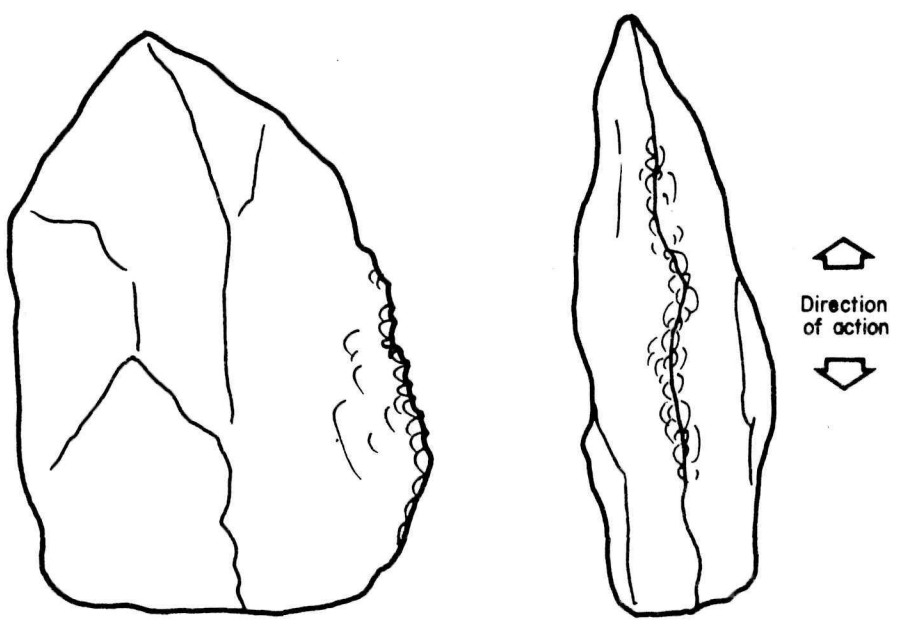


Fig. 14 Wear pattern correlated with tool function

Results of Analysis

Ten categories of tools were identified and analyzed for their micro-wear properties. Table 11 lists the occurrences of these types and their characteristic functional and morphological attributes. In the following paragraphs, each of these tool categories are discussed.

One hundred and eighty-four scrapers were recovered (Figs. 11-13). Of these, forty-three had some special modification: thirty had scalloped edges, nine had scraper edges on both sides, and four were cores which had been used as scrapers. Most of the scrapers are unifacially worked and are predominantly plano-convex in cross section. The flakes removed from the scraper edge are predominantly scalar; step fractures are less common. Polish is infrequent on the working edges.

These tools were probably used for planing or shaving of hard and soft materials. The implements appear to have been hand-held on a vertical plane with the flake surface facing the direction of work in a transverse, undirectional mode of action. Many of the scrapers were very well worn, suggesting that continued resharpening and dulling of the tool edge had resulted in a light polish or a very dulled edge on which characteristic micro-wear was difficult to distinguish. Most of the scrapers had several edges which exhibited scraping micro-wear features.

Forty-seven knives were recovered. Most of the knives have been modified bifacially and are generally symmetrical in form. They are bi-convex in cross section and are triangular, lanceolate or elliptic to oblong in shape. The flaking is predominantly fine percussion with some fine pressure retouching of the edges. Blunted and dulled edges occur on the thicker cross sectioned tools. The cutting action is indicated by irregular scarring and step fractures on both the dorsal and ventral surfaces of the thin and thick tools, although it is more easily distinguishable on the thinner tools. Battered edges, hafting striae and polish are rare.

These tools were mostly hand-held, although a very few may have been hafted. Wylie (1973) has noted what he calls

TABLE 11

Wear Characteristics on Hovenweep Tool Types

Wear Pattern / Tool Type	#	Bifacial	Unifacial	Denticulation	Scalloping	Spoking	Longitudinal Bi-Directional	Longitudinal Uni-Directional	Transverse	Boring	Chopping	Hammering	Hafted
Scrapers	184	x	x		x				x				
Knives	47	x						x					x
Saws	5	x	x	x			x						
Perforators	37	x	x							x			
Bifacials	74	x					?	?	?		?		
Spokeshaves	37		x						x	x			
Core/ Hammerstones	94											x	
Core/ Choppers	35										x		
Axes	5	x									x		x
Hoes	3	x											x

"tool backing" on his flake saw/knives from Hogup Cave. Most of the Hovenweep knives display this feature, which is interpreted as a place for the operators index finger to be positioned in order to increase the downward cutting pressure during use. Most of the tools appear to have been used on hard materials such as wood or bone with a longitudinal, unidirectional mode of action. The thicker tools had less distinguishable use-wear, probably due to their more obtuse edge angle.

Five saws were recovered. In contrast to the knives which were used in a unidirectional motion, saws were apparently used for cutting in a back-and-forth motion. Both bifacial and unifacial saws are present and are concave/convex in cross section. The edge denticulation is by secondary retouch (fine pressure flaking) on one side. Regular scalar scarring as well as light polish is present on both the ventral and dorsal surfaces of the saw.

These saws were probably hand-held implements used for cutting in a back and forth motion. All of the saws were made of chert which is less resistant to heavy wear than other stone material. However, heavy use wear is indicated, suggesting that these tools were probably used on very hard materials. Although the edges are very thin, the denticulation seems to have added strength as well as sharpness to the sawing surface, and probably added to the effectiveness of the cutting edge.

Thirty-seven perforators were recovered. Because these tools are often a part of another tool, their shape varies widely. The perforator itself, however, is a sharp point at one end which is attached to a broad blunt base. The pointed top is triangular in cross section and very thin. The base is thick, and convex in cross section, and has been modified bifacially by percussion flaking. The perforator tip is covered with polish, abrasion, and parallel striations giving it a rounded, dulled appearance. Scalar scarring and step fractures appear on the sides of the tip as a result of the shaping process.

These implements were also probably hand-held and most likely used for drilling in a twisting motion to penetrate various types of surfaces. The high polish exhibited at the

tip of the drills and extending down from the edges, as well as the heavy scalar scarring and step fracturing on the edges indicates heavy usage, particularly on hard materials. Most of these tools were utilized flakes which had a convenient drilling edge. These latter perforators had less significant use wear, perhaps because they lacked a substantial base which would have allowed them to be hand-held and used more easily.

Seventy-four bifacials were recovered. This is a general category, the members of which were undoubtedly made and used for a number of different functions. Most of the bifacials were modified with irregular percussion flaking into ovoid, triangular, crescentic forms. They are thick, and bi-convex in cross section; rarely they are thin and bi-convex in cross section. There is little or no pressure flaking on the edges and most appear not to have been used, since the edges are sharp rather than dull and scarred from use.

Complete micro-wear analysis has not yet been performed on these tools. However, from preliminary study, several show very little use wear, or dulled edges, and others show some use scarring. Further analysis may reveal more regularity in wear patterns, although it may be that this category represents a conglomerate in tool functions and therefore a uniformity in wear patterns would not be expected. It may be that some of these tools are "preforms" or blanks in the process of manufacture into another tool, such as a knife or projectile point. This explanation would account for the lack of wear on the edges.

A total of thirty-seven spokeshaves were recovered, of which nine were combination tools (six are scraper/spokeshaves and three are perforator/spokeshaves). Commonly, spokeshaves are unmodified flakes with one or two spoked edges. A spoked edge is one which has been removed to create a groove for a shaft to pass, presumably for shaft straightening. In addition, these tools often possess a scraping edge adjacent to the spoked edge. Scalar scarring and heavy, deep step fracturing appear within the grooved (spoked) area. In general, the wear characteristics are similar to those on scrapers and perforators. Some of the use scars were produced by intentional flaking of the edge to produce a crescent-shaped working platform. Other spoked edges were simply a natural indentation on the flake.

Many of the cores were used for chopping and hammering tasks. Ninety-four have been used as hammerstones (Core/hammerstones) while thirty-five were also used as choppers (Core/choppers). The form of these tools is highly varied, depending on the size and amount of flakes removed from the core. The edges of core/choppers are characterized by severe bit-edge battering and dulling, as well as by step fracturing on the chopping edge. The edges of core/hammerstones are characterized by severe edge crushing.

Core/hammerstones probably served a variety of pounding and battering purposes on hard surfaces. Alternatively, core/choppers may have been used for heavy percussion of heavy duty cutting and chopping tasks. These tools were probably used on a variety of different surfaces, including wood and bone. They may have functioned in the preparation of food.

Five bifacially chipped axes were recovered (two ground stone axes are discussed in the following section). These tools are large, ovoid in form, and are generally symmetrical and bi-convex. Some are notched on the sides, while others are fully grooved on all sides. All axes are thinner in cross section at the bit end and are thicker and rounder at the poll end. They range in length from 11.5 cm. to 19.5 cm. The edges of these tools are heavily battered, crushed and dulled, and show heavy step fracturing. The wear patterns suggest that the tools were used for striking against hard surfaces, or in a chipping motion for pulping wood and/or bone.

Three chipped hoes (and one ground hoe) were recovered. They differ from axes in that they are plano-convex and concave-convex in cross section and are much thinner. The chipped hoes are notched on both sides, rather than fully grooved. They are very thin at the bit end. Fine percussion flaking on this edge has reduced the spine plane angle. Scalar scarring and step fracturing characterized the bit end, while striae is found in the hafting area. Presumably, these tools were used for some agricultural purpose.

II.6 GROUND STONE TOOLS

By Caroline B. Cockayne

This analysis involves the 267 ground stone tools from eighty-seven sites collected during 1974 and 1975. By combining the material from both surveys we hoped to have a large enough sample to detect areal and/or temporal change in the tool types. Only the manos and handstones, however, were present in sufficient quantity to detect such changes. Appendix V lists the occurrences of each tool type by site, while Table 12 lists the size ranges of each type and Fig. 15 shows representative samples of each type. The type categories are those generally used by other investigators in the Mesa Verde area, except where noted. The materials used for the tools are discussed in Section III. 2.C.

Attention was focused on the surface treatment and shape characteristics of the tools. Surface treatments ranged from ground, rubbed and polished, to pecked, battered, grooved and notched. The treatment given to each face of the tool was also distinguished, since a tool could be ground and pecked on one side but merely ground on another. It was also noted whether the metates were trough, basin or flat slab forms, and whether the axes and hammers were full or partially grooved. A particularly interesting shape characteristic of the manos and handstones was the form of beveling due to use/wear. Four categories were distinguished: a) beveled on one side, no angle; b) beveled on one side, one angle; c) beveled on two sides, two angles; and d) beveled on two sides, four angles (see Fig. 16).

Handstones and Manos

Handstones are round to oval single-handed grinding stones while manos are two-handed, generally flat faced rectangular grinding stones. The term handstone has been used by Rohn (1971) and Swannack (1969), while Hayes and Lancaster (1975) refer to them as "biscuit" manos. Of the forty handstones, the majority (72.5 percent or 29) were made of fine-grained sandstone (individual grains less than

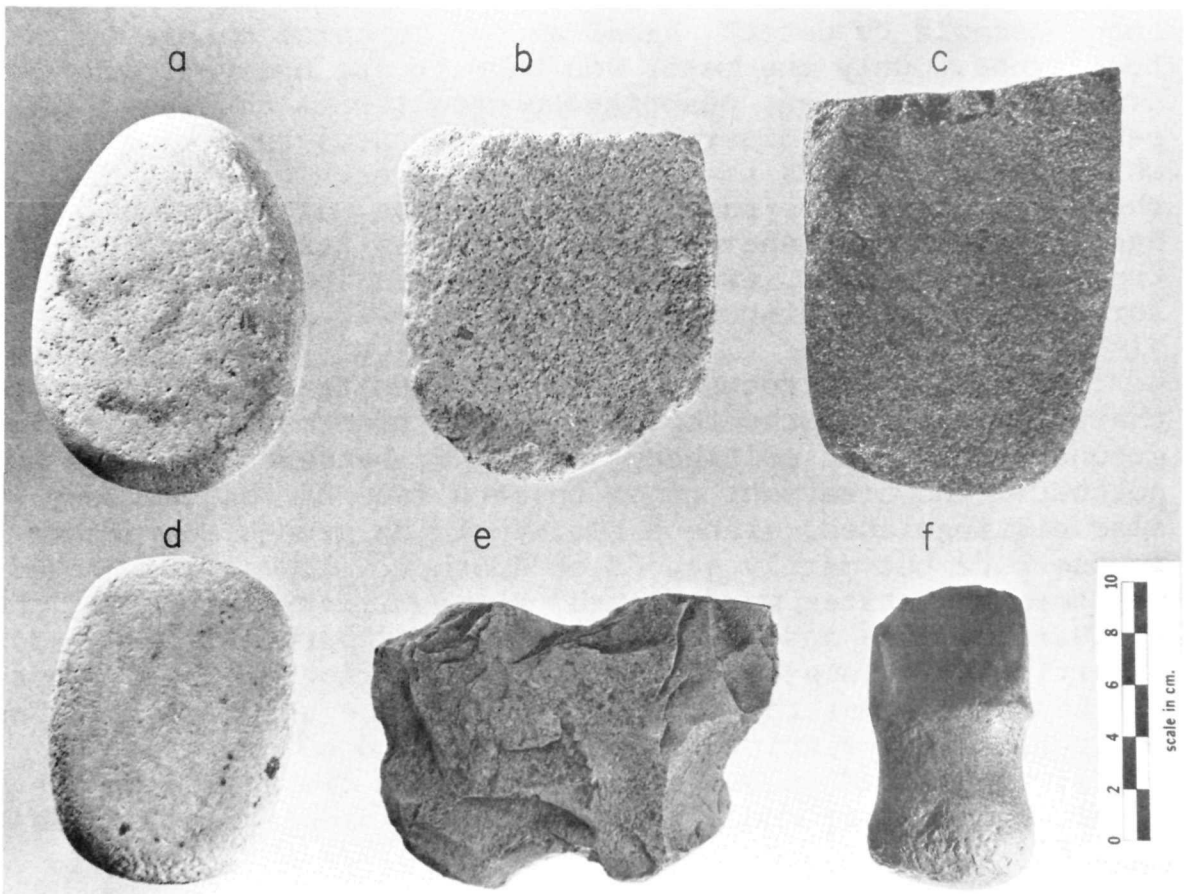


Figure 15. Ground Stone Tool Types - Handstones: a,d; Manos: b,c; Hoe (?): e; Axe: f.

TABLE 12 - Ground Stone Tool Measurements

Tool Type	#	Length (cm)		Thickness (cm)		Width (cm)		Weight (oz)	
		Mean	Range	Mean	Range	Mean	Range	Mean	Range
Handstone	40	10.9	8.7-15.1	4.2	1.7-6.9	8.6	6.2-10.6	20	9-40
Mano	121	17.8	14.1-27	3.3	1.1-8.2	11.3	1.0-14.1	63	27-93
Metate	32	34.9	11-4-58.1	5.2	1.9-8.4	23.8	9.1-35.5	NA	NA
Rubbing Stone	7	14.9	9.3-16.4	4.0	1.3-4.7	8.8	6.7-9.9	33	10-58
Hammer	4	12.2	5.5-16.7	3.5	3.1-3.8	6.9	4.3-9.1	34	16-70
Hammer-stone	3	8.1	6.7-9.5	4.0	3.4-4.9	5.8	4.5-8.0	11	5-21
Axe	4	13.3	11.5-15.6	4.6	3.8-5.7	6.9	6.1-8.0	24	21-27
Handstone/ Hammerstone	6	8.1	7.1-10.1	3.8	2.8-4.5	7.5	6.1-8.6	NA	NA
Crusher	3	NA	NA	6.3	6.0-7.0	13.7	13.2-14.2	NA	NA
Rubbing stone/ Hammerstone	6	12.4	9.9-17.3	5.6	5.4-7.1	8.2	6.3-9.6	34	24-48
Hoe	1	14.6	NA	2.8	NA	11.2	NA	19	NA
Unknown	39	NA	NA	NA	NA	NA	NA	NA	NA

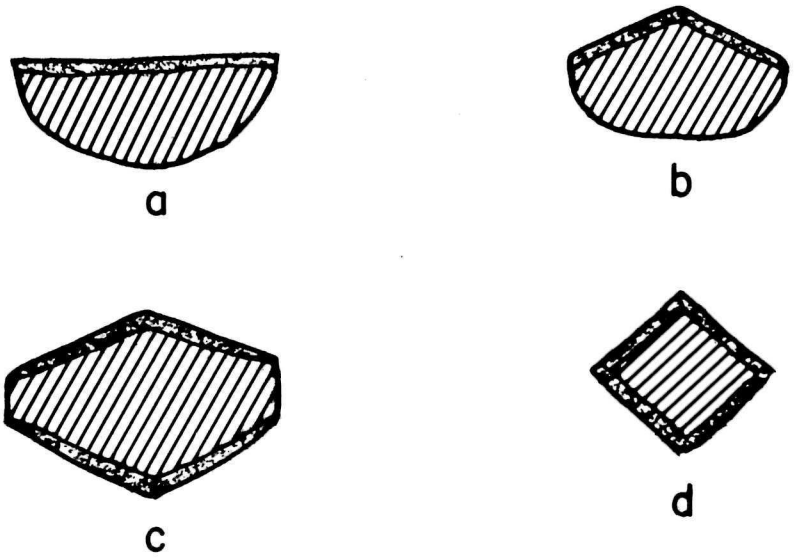
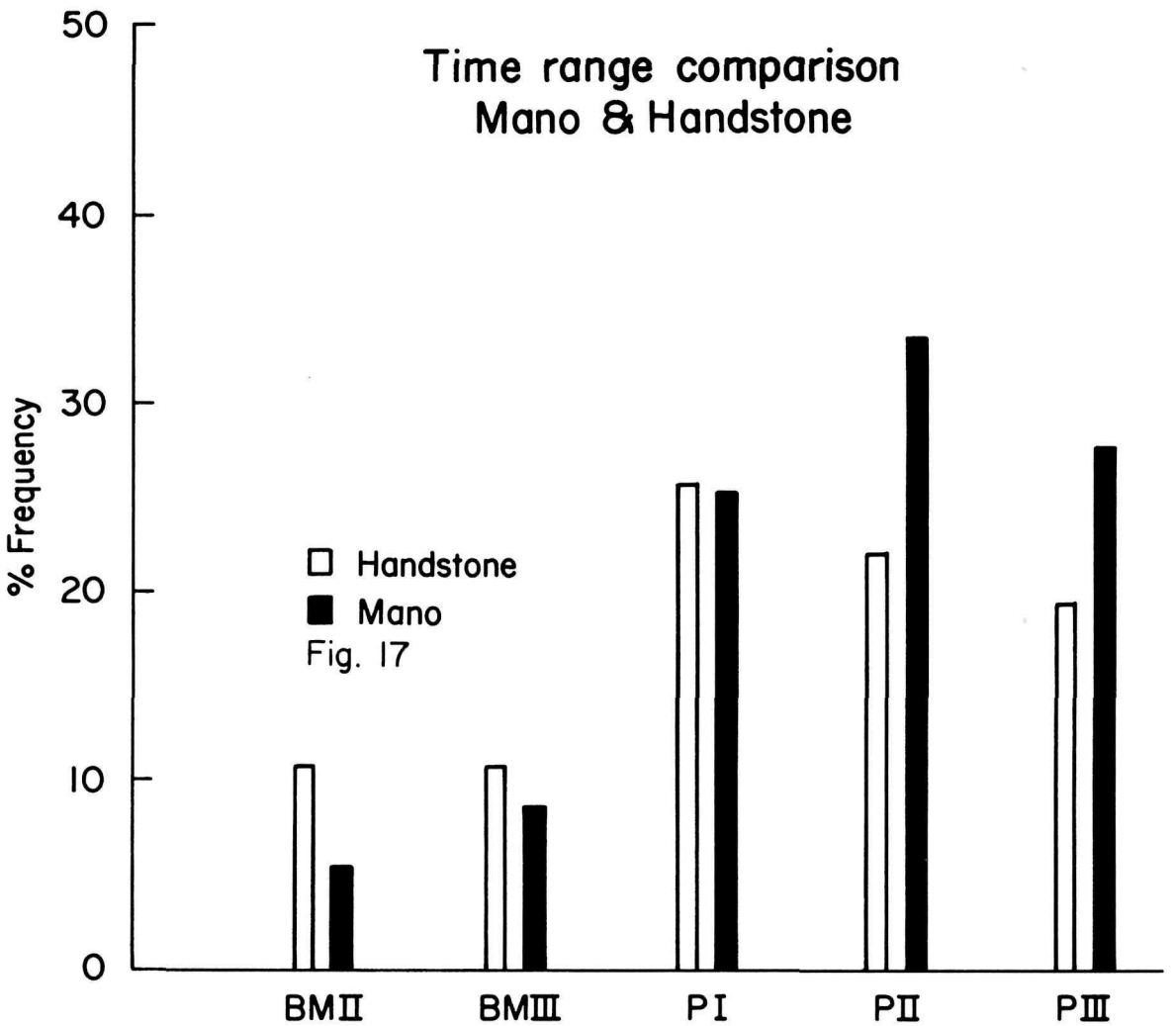


Figure 16. Schematic diagram of four types of use wear on manos and handstones: a) beveled one side, no angle; b) beveled one side, one angle; c) beveled two sides, two angles; d) beveled two sides, four angles. Stipled areas represent beveled faces.



1.6 mm. in diameter). Other materials used included medium- and coarse-grained sandstone (grains over 1.6 mm. in diameter), highly lithified sandstone, quartzite, and a volcanic material. In contrast, the stone material used for the 121 manos was more evenly divided between coarse-grained sandstone (35.5 percent) and fine-grained sandstone (41.3 percent). Medium-grained and lithified sandstone and volcanic material, as well as conglomerate, were also used for the manos. No handstones were made of conglomerate. There thus appears to be a definite difference between the type of stone used for handstones and manos. While most of the handstones were of fine-grained sandstone, preference for this material decreased, relative to the increased use of coarse sandstone and the introduction of the use of conglomerate, among the manos.

As is clear from Fig. 17, this difference is also correlated with a temporal change in use of manos and handstones. While handstones appeared to have been used more frequently during Basketmaker times, by Pueblo I times the use frequency was about equal, and by Pueblo II and Pueblo III times, manos had replaced the handstones in frequency of use.

This trend correlates with the known shift in other areas from basin metates to trough and flat slab forms. Fragments of both types of metates were recovered during the Hovenweep survey but the sample was too small to document this trend for Hovenweep. This shift from fine-grained to coarse-grained material associated with the shift from handstone to mano may well have occurred with a shift in the type of plant product being processed. The most obvious shift occurred during Pueblo II and Pueblo III times, perhaps in association with an increasing dependence on agriculture.

The two types of grind stones are also differentiated on the basis of shape. Whereas most of the handstones are either round (30 percent) or oval (50 percent) most of the manos are rectangular (30.6 percent). Unfortunately many of the manos were broken (52.9 percent) so that the whole shape was indeterminate. However, it is clear that very few of either the handstones or manos were unshaped fragments of stone. The sides of the handstones had been smoothed into an oval shape, while the sides of the manos had at least been chipped and/or pecked into a rectangular shape. Forty-three

percent of the manos and 30 percent of the handstones were ground on only one side. Twenty-four point eight percent of the manos and 32.5 percent of the handstones were ground on two sides. A smaller percentage of the surfaces were pecked, although more of the handstones (35 percent) were pecked than the manos (16.5 percent).

It is also informative to compare the type of wear which appears on these two forms of grinding stones. Although 30 percent of the handstones displayed no apparent wear, 25 percent were flattened on one side (Fig. 16a); 12.5 percent were beveled on one side with one angle (Fig. 16b); 17.5 percent were beveled on both sides at one angle on each side (Fig. 16c); and 12.5 percent were beveled on both sides at two angles on each side (Fig. 16d). This beveling of the handstone faces would more likely have been produced from use on a flat slab metate, rather than on a trough form.

On the manos, in contrast, there is a clear preference for a grinding material that produces beveling on one side at one angle only. Thirty-four point seven percent of them display this type of wear, while 46.3 percent display no particular angling and were probably used with a flat back and forth motion. Very few manos are beveled on two sides (3.3 percent). The difference in beveling may also be due to the type of stone material used for the different forms of grinding stones. Since most of the handstones were of fine-grained sandstone, the user would not have to prepare and preshape the tool before use. However, since many of the manos were made of coarse-grained sandstone that required more surface preparation, fewer surfaces were prepared and used. The length of time the grinding stones were used is certainly another factor in the degree of wear and possibly the number of use-wear bevels on the faces. It may be that after a certain amount of wear to the surface of the tool, the user turned the stone over and used it on the other side.

Metates

Handstones and manos were the only tool types which had sufficient numbers of whole tools for the above types of analysis. Although there were thirty-two metates recovered, twenty-two were broken fragments, so it was not possible to weigh or measure them or determine the shape characteristics. It was possible, however, to tabulate the type of stone

material used. Of the thirty-two fragments, 68.7 percent (22) were of coarse sandstone; 15.6 percent (5) were of fine-grained sandstone; 6.3 percent (2) were of medium-grained sandstone; and 9.4 percent (3) were of conglomerate. The range in the surface texture of these rocks suggests that the users needed a variety of grinding surfaces, presumably either for the processing of different kinds of plants or the continual refinement of the flour from seeds from one species of plant. Seventy-one point one percent (23) of the metates were ground on one side only, and an additional 18.7 percent (6) were pecked as well as ground on one side. Although it was possible to determine that four metates were basin and seven were trough, the remainder were too fragmentary for a shape determination.

Other Ground Stone Tool Types

Very few of the other tool types were recovered. The seven rubbing stones were made of large quartzite river pebbles, a dark volcanic material or a fine-grained sandstone. All but one is oval and none had received secondary shaping or showed signs of extensive wear that would have led to beveled faces, such as was observed on the manos and handstones. Kidder has termed these "floor polishers" (1932:63). However, although it is possible to suggest from surface indications that these tools were probably used for some rubbing activity, it is not possible at this time to make a statement for the Hovenweep area on their specific function.

The four hammers were made of hard materials (quartz, quartzite, and a volcanic material) and were not further shaped. Conversely, all four axes were of lithified sandstone and were heavily smoothed and polished on both faces. Two of the axes and two of the hammers were partially grooved (notched), while the other two axes and two hammers were fully grooved for hafting. Six other specimens were classified as combination handstones/hammerstones, and six were classified as rubbing stones/hammerstones.

The three crushers were all of conglomerate and were ground on one side, possibly for the processing of very coarse material. Thirty-nine of the 267 ground stone tools were too fragmentary to be classified within any of the above tool types. The hoe was a thin, flat tool made of a medium-grained sandstone. The faces were ground while the

edges and haft area were originally chipped, but had been dulled by use, presumably as an agricultural tool.

Comparisons

In general, the range of the types of ground stone tools is very similar to the tool kits found at the sites adjacent to Cajon Mesa. In the ground stone assemblage from the modified Basketmaker sites in the Ackmen-Lowry area (Martin 1939), for example, both one and two surfaced manos were present. Instead of detailing the number and location of the worn faces, as we have indicated in this report by the types of beveling, Martin described the faces of the tools as flat, concave, or convex.

A comparison of the Hovenweep material to that from Mug House (Rohn 1971), Big Juniper House (Swannack 1969), and Badger House (Hayes and Lancaster 1975) on the Mesa Verde reveals that a comparable tool kit was shared in both areas. The manos and handstones were either ground on one or two sides; the metates were both troughed and flat slab; the axes were both fully and partially grooved. The fact that no mortars, small polishing stones, paint palettes, or abraders were recovered at Hovenweep but were at the Mesa Verde sites is probably due to the small size of the surface sample collected rather than an actual absence of these tool types and their associated activities in the Hovenweep area.

II.7. OBJECTS OF UNKNOWN USE AND ORNAMENTS

By Dorothy K. Washburn

Twenty ground stone objects were recovered which are of uncertain function (Table 13). Most are fashioned from slate, kaolin, or sandstone into thin slabs whose edges are highly smoothed and subsequently beveled and/or rounded. All have clearly visible striations although they are not consistently aligned in any one direction. The high degree of smoothness of both surface and sides, as well as the random direction of the striations suggests that these pieces may have been used as polishing stones for a lengthy period of time, and for a variety of purposes. In the following paragraphs the pieces will be described in detail and compared to similar objects found by investigators in areas adjacent to Hovenweep. (See Fig. 13.)

Since almost all of the pieces exhibit more than one broken edge (a fact interesting for its own implications), only width measurements could be taken. Only one piece was whole; i.e., all edges were rounded by smoothing.

I Pieces with Two Smooth Faces and Rounded Edges

Over half of the pieces are characterized by bifacial smoothing. In addition the edges are smoothed and slightly rounded. Five pieces have both faces smoothed as well as at least one smoothed and rounded edge remaining. Six other pieces are bifacially smoothed and probably also had the smoothed edge treatment, although it is missing. The type of raw material varies from sandstone to kaolin and shale, but material does not seem to affect the degree of smoothness attained. However, a high degree of gloss was attained on five of the pieces made of kaolin.

All of the pieces display quantities of striations, most probably from use as a smoothing tool on objects with a fine-grained abrasive surface. The striations are visible without magnification and vary from unidirectional to randomly aligned and from a few deep scratches to shallow striations which have been partially obliterated by subsequent

TABLE 13 - Objects Of Unknown Use And Ornaments

Type	Site	Stone	Thickness (mm)
I. Pieces With Two Smooth Faces And Rounded Edges	573	sandstone	8
	605	sandstone	7
	571	sandstone	8
	632	sandstone	12
	49	sandstone	-
	636	kaolin	-
	636	kaolin	6
	600	kaolin	7
	636	kaolin	-
	565	kaolin	4
	565	kaolin	7
	565	kaolin	-
	671	sandstone	6
II. Pieces With Two Smooth Faces And Beveled Edges	565	shale	-
	670	shale	13
III. Pieces With Two Smooth Faces And Chipped Edges	571	kaolin	4
	564	kaolin	6
IV. Pieces With Smooth Faces And Hafting Grooves	574	sandstone	20
	636	sandstone	-
V. Possible Gaming Piece Blank	636	kaolin	5
VI. Paint Stone	520	hematite	-

VII. Pendants	Site	Material	Length (mm)	Width (mm)	Diameter (mm)	weight (gms)
	47	ceramic	2.5	1.5	-	3.1
	577	ceramic	8.2	6.8	-	-
	617	ceramic	-	3.4	-	-
	617	ceramic	-	-	6	-
	504	kaolin	2.5	2	-	3.
	683	kaolin	5.7	1.9	-	-
	Cow Canyon (Offsite)	kaolin	2.3	2	-	2.3

smoothing. One piece has a slight depression on the smoothed surface, in which the striations are at right angles to those on the remainder of the object.

The mean thickness of these pieces is 8 mm. No length or width measurements were taken since all the pieces were broken. It may be that the users always carefully guarded whole polishers and thus they would not be as easily recovered, particularly on the surface, as would broken, discarded fragments. Alternatively, since many of the "broken" edges display some smoothing and striations, it may be that these fragments are actually the whole tool. The user may have merely used any suitable stone, regardless of shape. The two flat faces were used to smooth broad surfaces, while the edges became rounded by use on narrower areas. Morris and Burgh (1954:59) illustrate two similar pieces from the Durango Basketmaker sites and suggest that they were used to smooth hides during the tanning process.

Two pieces were considered to be whole since all the edges were smoothed. One was made of sandstone, the other of kaolin. The sandstone piece did not have pronounced straight sides which had been rounded by smoothing as was characteristic of the kaolin piece. Instead, it was smoothed into a one angle bevel on one of the flat faces. This object is most similar to a disk illustrated by Lancaster from site 40 at Mesa Verde which he calls a polishing tool (1954:64).

II Pieces with Two Smooth Faces and Beveled Edges

Two pieces have highly smoothed surfaces on both faces as well as the two lateral sides. Both pieces are broken in half. In addition, the piece from Hovenweep 565 is missing one face. The sides of both pieces are not straight with rounded corners as on type I, but have been flattened in the center and beveled between the edge center and the flat face. All smoothed edges have scratched surfaces, but the striations are not aligned in any one direction. However, the striations on any one face are all generally aligned in one direction. This suggests that these objects may have been used as polishers. The broad flat face was used on a broad surface, while the narrower edge on another type of surface. When the user moved from one surface to another he may have shifted position of the polisher in his hand or the surface to be polished so that the striations were now aligned in another

direction. This suggestion is strengthened by the observation that the amount, angle, and number of bevels on the two narrow edges are not identical. If these objects were made as ritual items, it is more likely that every effort would have been made to achieve a symmetrical shape. However, if they were polishing tools, the particular shape of the edges would not have been a major concern, unless of course they needed to maintain a particular shape in order for the tool to effectively perform the task. It is true that both remaining halves of both objects are the same general shape. Slanted sides indicate that the missing end would have been wider than the end remaining.

One possible identity for these objects--a tchamahia--has been suggested by Rohn (1971), Miller (1974), Wheeler (n.d.) and others. O'Bryan (1950:84) and Morris (1939) refer to them as "skinning knives." Parsons (1939) claims tchamahias are stone hoes used as alter fetishes. Many other researchers refer to these as hoes (Judd 1954; Woodbury 1954; Morris 1939). The mug house tchamahias of Rohn (1971:247) were first chipped into shape, then smoothed on all faces. Some have chipped hafting areas; others have chips at the narrow ends, presumably from use as hoes. Neither of the two specimens from Hovenweep appear to have been chipped into shape, hafted, or chipped from use.

III Pieces with Two Smooth Faces and Chipped Edges

Two broken fragments from the Hovenweep collection have chipped edges and highly smoothed and striated faces. Both pieces are made from thin slabs of kaolin. On the Hovenweep 564 piece the narrower end appears smoothed and dulled by wear. Striations run both longitudinally and perpendicularly to the edge. These attributes are similar to those on other tchamahias. On the other hand, the objects are rectangular to oval in shape, as opposed to the characteristic wedge shape of most tchamahias illustrated in Morris (1939) and Rohn (1971). In addition, the two Hovenweep specimens are much thinner than most tchamahias. The piece from Hovenweep 571 is 4 mm. thick, while that from Hovenweep 564 is 6 mm. thick. In contrast, the average thickness of the "skinning knives" which Morris examined from Site 41 was 16 mm. at the thin end (1939:140). It is notable that after both were made and used for some time they broke, but continued to be used, as evidenced by smoothed and rounded edges along the lines of fracture.

IV Pieces with Smooth Faces and Hafting "grooves"

Morris (1939) and Rohn (1971) note that a few of their tchamahias showed chipped indentations, possibly for hafting. Two specimens from Hovenweep do not have chipped haft areas, but there definitely is a worn area for this purpose. The example from Hovenweep 636 has beveled face and a flat face and striations on the thin end, as if it was used as a miniature hoe. It is only 7 cm. long. The other example is broken at both ends, much wider (20+ cm.), but has two more distinct worn grooves on either side of the piece. Neither piece is chipped; the latter has shallow striations on the smooth surface.

V Possible Gaming Piece Blank

A small oval disk of kaolin might possibly be a blank for a gaming piece. Both faces are flat, smoothed, and heavily striated. The edges appear to have been chipped, then smoothed. The striations on the edges may be from the smoothing process. The faces do not carry the characteristic deep grooves arranged in a regular pattern as do those illustrated by Morris and Burgh (1954, Fig. 95). However, the disk is so much smaller than the other polishers that assignment as a gaming piece blank is more reasonable.

VI Pendants (See Fig. 13.)

Seven pendants and one possible pendant blank were found on the Hovenweep survey. Four were worked sherds, three were kaolin. The possible pendant blank is of a green shale. Three of the ceramic pendants are oval, and one is circular. One of the oval ceramic pendants is perforated at both ends, and should probably more properly be called a gorget. Each of the ceramic pendants has been ground and smoothed into shape. The one plain red pendant has also been smoothed on its two flat faces.

Of the three kaolin pendants, one is oval, one is triangular, and one is rectangular. Pendants from both types of material are perforated in two ways. Some have the single hole drilled all the way through from one side; others are drilled from both sides.

The Hovenweep pendants are very similar in type to those found by other investigators (Morris 1939:141; Lancaster et al. 1954:66; Martin 1939:418; O'Bryan 1950; Swannack 1969; Miller 1974; Hayes and Lancaster 1975). The pendants were manufactured from a wide variety of materials: lignite, shell, hematite, gypsum, coal, shale, turquoise, and soapstone. No pendants were mentioned as being made from kaolin, which is the prevalent material used at Hovenweep.

VII Paint Stones

Swannack (1969:139) mentions finding paint stones at Big Juniper House. These are mineral fragments which have been scraped and chipped to obtain pigment for decorating pottery or other artifacts. One such piece of hematite (4.5 x 3.0 x 1.5 cm.) was found at Hovenweep 520. It has been chipped and scraped on all surfaces, and thus would appear to have been used for this purpose.

II.8

FAUNAL REMAINS

By Thomas D. White

Twelve sites at Hovenweep yielded fifty-six bone elements, not including many small unidentifiable fragments representing both avian and mammalian remains. Of this total, thirty-eight (67.9 percent) were identifiable to genus, yielding six taxa (see Table 14). All were collected from the surface. Both prehistoric and recent origins were indicated by the presence of tools and modern domesticated species.

These elements were identified with the use of the reference collection at the Museum of Birds and Mammals at San Jose State University. References used were Hall and Kelson (1959) and Schmid (1972).

Tools

Four elements were identified as tools or worked bone. (See Table 14). Descriptions are as follows:

Bone Awl. This tool from Hov. 714 was made from the distal end of a right tibiotarsus of a turkey. The shaft was broken to produce a point. Both condyles have been worn down, possibly with rock. The entire medial edge above the condyle exhibits microwear patterns. It measured 7.2 cm. in its longest dimension.

Bone Awl. This tool from Hov. 572 was recovered in six pieces and is extremely weathered. It was fashioned from the right metatarsals of a deer. Again, the shaft appears to have been broken to produce a point. Microwear patterns may be observed on both sides of the functional point. Reconstructed, it measured 11.6 cm. in its longest dimension.

Bone Scraper (?). This fragment from Hov. 561 of the left innominate, including the acetabulum, of a deer is covered with a myriad of parallel and overlapping microwear

TABLE 14

Faunal Remains

Provenience	Scientific Name	Remarks
HOV 94	a. ?	Mam., frag.
	b. ?	" " , carbonized
	c. ?	" " "
HOV 528	a. Ovis sp.	Lumbar vert. frag. w/clean cut
	b. " "	Lumbar vert. frag.
HOV 532	Ovis sp.	Left radius, frag. w/clean cut
HOV 561	Odocoileus hemionus	Left innominate w/many microwear pat.
HOV 571	a. Odocoileus hemionus	Right tibia, frag.
	b. Homo sapiens	Right ulna
	c. Artiodactyla	Left humerus, frag. carbonized
	d. Meleagris gallopavo	Left humerus
	e. " "	Right tibiotarsus, frag.
	f. " "	Right humerus, frag.
	g. " "	Cerv. vert., frag.
	H. ?	Left tibiotarsus, carb., not M. gallopavo
	i. ?	Mam., frag.
	j. Homo sapiens	Right cuboid
	k. " "	Atlas w/drilled hole
	l. Meleagris gallopavo	Right humerus, frag.
	m. Homo sapiens	Right humerus, frag.
HOV 572	Odocoileus hemionus	Right metatarsals, awl w/microwear patterns
HOV 600	a. ?	Mam., frag.
	b. ?	" " , carbonized
	c. Odocoileus hemionus	Cerv. vert., frag.
	d. Sus scrofa	Right astragulus

TABLE 14 (cont.)

Provenience	Scientific Name	Remarks
HOV 605	a. *Ovis* sp.	Right metacarpals
	b. ?	Mam., frags.
HOV 617	a. *Sylvilagus* sp.	Left max., w/teeth
	b. " "	Right tibia, frag.
HOV 656	a. *Meleagris gallopavo*	Left coracoid, frag.
	b. *Sylvilagus* sp.	Left dentary w/teeth
	c. " "	Left humerus, frag.
	d. " "	Left innominate
	e. ?	Mam., left rib
	f. ?	Frags., mem. and avian
	g. *Odocoileus hemionus*	Right scapula
	h. *Meleagris gallopavo*	Left femur
	i. ?	Mam., frag.
	j. ?	" "
	k. *Odocoileus hemionus*	Right metatarsals, frag.
	1. *Meleagris gallopavo*	Fused thoracic verts.
	m. Artiodactyla	Right rib, frag.
	n. *Odocoileus hemionus*	Right femur, frag.
	o. " "	Left innominate
	p. *Meleagris gallopavo*	Right humerus
	q. ?	Mam., frag.
	r. *Homo sapiens*	Right calcaneus
HOV 707	a. ?	Mam., frag.
	b. ?	" "
	c. ?	Avian, ulna, frag.
	d. *Sylvilagus* sp.	Right tibia
HOV 714	a. *Meleagris gallopavo*	Right humerus
	b. " "	Right innominate
	c. " "	Fused lumbar-sacral verts., frag.
	d. " "	Right tibiotarsus, frag.
	e. " "	Right tibiotarsus, awl

patterns. It appears that every available edge was heavily used. The function of this tool is unknown. It measured 16.6 cm. from the broken ends of the ilium and ischium.

Drilled Bone. The last bone element to be described in this section is an intact human atlas from Hov. 571. A hole has been drilled through the right lateral process. On the dorsal surface, the hole's greatest diameter is 3.4 mm. The hole's greatest diameter on the ventral side is only 1.6 mm. It appears unlikely that this hole is an artifact created by insects or rodents.

Meleagris gallopavo (Turkey)

Fourteen elements from three sites representing 25.0 percent of the total made this the most common taxon. This was a significant increase over the previous summer's results. An awl, modified from a tibiotarsus, was recovered from a midden from Hov. 714 (Pueblo II and Pueblo III). None of the other turkey bones showed working. Turkey remains have long been associated with the Anasazi culture (Hargrave 1965).

Sylvilagus sp. (Rabbit)

Two species are known to occur about Mesa Verde, S. audubonii and S. nuttallii. Of the six elements (10.7 percent), none were identifiable to species. No evidence of charring or wear patterns were observed. Most were fragmented.

Homo sapiens (Man)

Four features from two sites yielded five elements. All were intact except for a humerus of a juvenile. An atlas was especially interesting as the lateral process had a hole drilled through it. The remaining elements include an ulna, a calcaneus, and a cuboid.

Sus scrofa (Domestic Pig)

A single element, a right astragulus, was recovered. This certainly represents a recent deposition.

Odocoileus hemionus (Mule Deer)

Eight elements (14.3 percent) were identified making this the second most common taxon. An awl and a curiously worked innominate were included among these remains. None of the elements were obviously of recent age. Deer are presently rare on Cajon Mesa.

Ovis sp. (Sheep)

Only four elements (7.2 percent) from three sites were identified. Two elements from two of the sites possessed clean cuts, probably from a steel knife or saw. It appears probable that these remains all represent very recent depositions.

Summary

Three taxa, *Lepus*, *Neotoma*, and *Canis*, which were recovered the previous summer (see Holst 1975) were absent from this year's faunal remains. New taxa for this year were *Homo* and *Sus*. In addition, a significant increase of turkey bones over last year was observed.

Last summer's results, together with the present data, including the presence of worked bones and tools, indicate that the prehistoric inhabitants of Cajon Mesa utilized the turkey, deer, and rabbit for food. Some of the remains of these species and all of the pig and sheep are probably of modern origin.

PRELIMINARY INTERPRETATIONS

1. Farm fields

Hill of Hopi maize in experimental garden

III.1.A FARM STRUCTURES: DESIGN AND USE

Introduction

The manipulation of water is the key to successful Pueblo agriculture, and to properly understand the prehistoric Hovenweep farming system it is necessary to identify the locations of the ancient fields and the types of water control devices which may have been used. To do so, we have examined the contemporary Pueblo field systems and developed test implications based on expected structures, locations, floral indicators and pollen associations. This section describes the design and probable use of the Hovenweep fields, while following sections discuss floral and pollen associations.

Two general types of field systems are present in the Southwest: dry fields, which are watered directly by rainfall, and water control fields, which are moistened indirectly by irrigation or by run-off from higher elevations. Dry farming is presently impossible at most of the Pueblo villages, so various techniques of water manipulation have been developed, ranging from temporary brush and earth dams built across shallow washes, to sophisticated river fed canal networks. Water control is a necessary insurance against drought, even in marginal dry farming areas such as the Zuni region. The Hopi farming system best typifies the use of different water control devices as insurance. They scatter numerous dams, ditches, terraces and other structures across a variety of field locations and stagger the dates of planting so that some crops are almost always available, whether the year is cold and wet or hot and dry.

Previous surveys at Hovenweep have suggested that certain of the Pueblo water control devices were utilized by the prehistoric Anasazi. Prudden (1903, 1916) and Fewkes (1925) discovered large earth and rock banks which they decided were "reservoirs," while more recent investigations by Schroeder (1967-1968), Martin et al. (1971) and others recorded a number of "check dams" and "terraces." Sixty-eight sites which are

reminiscent of Pueblo water control structures were examined during the two survey sessions, and we are attempting to determine if the sites were in fact used as farms and how they worked. Unlike Chaco Canyon and other areas to the south, none of the Hovenweep sites appear to have been large-scale canal networks; instead, all are remarkably similar to small-scale Hopi-Zuni devices, rather than eastern Pueblo hydraulic systems. References to Hopi-Zuni water control features have therefore been consulted, so as to construct a baseline with which to compare the Hovenweep structures. This in no way implies a direct continuity between the Hovenweep Anasazi and the western Pueblo, but it does demonstrate that similar environments were manipulated in the same fashion by farmers of a common cultural tradition. The floral and pollen studies have provided independent evidence that most of these sites were in fact used as farm fields. A study is now underway to determine how they were built and maintained, as well as how they functioned. In the following pages each of the Hopi-Zuni devices is first described, then compared with the Hovenweep analogues. Palynological evidence is noted when appropriate. An immense amount of data on slope, exposure, dimensions, soils, etc. have yet to be analyzed, so comparisons with other Southwestern water control studies (e.g. Woodbury 1961; Rohn 1963; Lindsay 1961; Plog and Garrett 1972) will be presented in future Hovenweep reports.

Background

A major determinant in the location of most Hopi-Zuni farm fields is the availability of water and soil. Permanent habitation sites are commonly located in centralized areas near domestic water sources, while farms are scattered over a variety of locations so as to utilize all suitable agricultural areas. Because the Pueblo farming system is dependent upon every favorable spot of soil, the distribution of the different field types which are in use at any one time depends upon minute differences in drainage pattern and soil quality. Field location is especially dependent on surface run-off pattern and ground water flow. Eleven field types are listed in Table 15, classified first on the basis of water supply and drainage pattern, and second by soil type (after Hack 1942). Most types are associated with specific

TABLE 15 - Hopi Field Type And Location
(after Hack 1942)

Field Type	Location
1. Floodwater Fields	locations receiving run-off from summertime storms
a. akchin fields	arroyo mouth alluvial fan locations, often with nearby dunes or low sandy ridges
b. main wash floodplains	wide canyons with shallow washes which seasonally inundate the alluvial flats
c. low terraces	incipient floodplains in the bottoms of the larger washes which receive overflow from large floods or seepage from small floods
d. arroyo bottom fields	small arroyos or gullies on steep hillsides with limited drainages
e. slope wash fields	locations on slopes and below scarps where soil is porous enough to absorb runoff from higher elevations
2. Sand dune fields	fields on thin dunes above colluvial soils or bedrock, on climbing or falling dunes, or on stabilized dunes cleared of vegetation
3. Seepage fields	in colluvial soils below seeps, or in wet dunes or dune hollows with seeps
4. Springside fields	in clayey alluvial soils beside or below springs, often on hillsides
5. Stream-side fields	in Moencopi Canyon

functions and environmental characteristics. Certain locations are useful for rare crops, others are especially reliable in times of drought or frost, while still others are not affected by cycles of erosion or deposition.

Superimposed over the above field system is a pattern of intensive water manipulation. The minimal environmental requirements for a successful corn harvest without water control are 120 days of frost-free growing season, 26 - 30 cm. of yearly precipitation, 11 - 15 cm. of rain in the summer, and sufficient wintertime moisture or at least five cm. of springtime precipitation to permit germination (cf. Hack 1942; Carter 1945; Winter 1974: 134-138). These conditions are rarely met, however, so the Hopi use a number of moisture and soil manipulating techniques in different field locations to insure a successful harvest, no matter what the weather. The Zuni depend on a similar system of water control, although they live in a region of slightly higher precipitation and have a greater dependence on dry farming (cf. Cushing 1920; Bohrer 1960). In both regions, the diverse structures are scattered along a drainage course, and each control technique can be correlated with a set of field types. Table 16 outlines these correlations, following the typology developed by Hack (1942).

Possible Pueblo Fields and Water Control Devices at Hovenweep

Relatively intact Pueblo-like water control "communities" have been discovered at a number of Anasazi sites, including the Far View system on Mesa Verde (Stewart 1940a; Rohn 1963), Beaver Creek (Lindsay 1961), Chaco Canyon (Vivian 1970), and Point of Pines (Woodbury 1961). In terms of diversity of probable devices, however, Hovenweep represents a remarkable array of Hopi-like structures which appear to have been centered around the mid-mesa tower complexes of Square Tower, Holly House, Horseshoe House and Hackberry House (Table 17). Scores of others have been noted on the mesa, and all evidence points towards the existence of dozens of well-organized farming communities at Hovenweep. During Pueblo II times they were probably organized around clusters of mesa top Prudden Units, while the late Pueblo III devices were built near the

TABLE 16 - HOPI AND ZUNI WATER CONTROL DEVICES, CORRELATED WITH FIELD TYPES
(see text for references)

Field Type	Hopi Devices	Zuni Devices
1. Floodwater fields		
a. akchin fields	earth banks, ditches and channels	earth and brush dams and barriers, windbreaks
b. main wash flood-plains	earth spreaders, ditches, diversion dams	earth and brush dams and barriers, windbreaks
c. low terraces	none mentioned	none mentioned
d. arroyo bottoms	stone, earth and brush check dams with trinchera terraces	stone, earth and brush check dams and trinchera terraces, windbreaks
e. slope wash fields	boulder block walls and terraces	none mentioned
2. Sand dune fields	rock and brush windbreaks	none mentioned
3. Seepage fields	none mentioned	none mentioned
4. Springside fields	ditches, reservoirs, dams, banks, boulder terraces, pot irrigation, waffle gardens	pot irrigation, waffle gardens, jacal walls, ditches, banks, dams
5. Stream-side fields	canals, dams, banks, ditches	dams, log aqueducts, waffle plots, ditches, banks, pot irrigation
6. Dry fields	none mentioned	none mentioned
	Miscellaneous	
	Rock and earth reservoirs and rock tanks for domestic water	walk-in wells

TABLE 17 - Probable Water Control Devices At Hovenweep

Site	Akchin terrace	Arroyo check dam	Slope wash terrace	Talus bottom terrace	Run-off dam	Modified spring	Springside terrace	Rim dam terrace	Rock tank	Reservoir	Mesa top terrace	Navajo ditch	Navajo field	Navajo reservoir
Square Tower Cluster														
Hov. 3						x								
4							x		x					
8			x											
9									x					
11		x	x											
12		x	x					x	x					
13			x					x						
18		x	x											
21								x						
71	x							x						
72								x						
115			x											
343		x												
344		x												
345		x							x					
360			x											
366			x											
376								x						
379		x												
Holly House Cluster														
53							x	x						
421		x												
424		x												
426		x												
430			x											
439		x												
446		x												
450	x													

Site	Akchin terrace	Arroyo check dam	Slope wash terrace	Talus bottom terrace	Run-off dam	Modified spring	Springside terrace	Rim dam terrace	Rock tank	Reservoir	Mesa top terrace	Navajo ditch	Navajo field	Navajo reservoir
Cutthroat Castle Cluster														
70		x	x											
384	x													
Cajon Cluster														
51						x	x							
456										x				
457		x												
Hackberry House Cluster														
64		x				x	x	x						
423			x											
437		x												
Horseshoe House Cluster														
57		x				x	x	x						
60			x											
61			x	x										
Other sites														
49		x	x	x	x									
94	x	x	x											
477		x												
483			x											
493		x												
509			x											
513										x				
535										x				
538		x												
539		x												
540		x												
541		x												
554										x				
555		x												
589			x											
599									x	x				

Site	Akchin terrace	Arroyo check dam	Slope wash terrace	Talus bottom terrace	Run-off dam	Modified spring	Springside terrace	Rim dam terrace	Rock tank	Reservoir	Mesa top terrace	Navajo ditch	Navajo field	Navajo reservoir
600										x				
605			x											
608			x											
616		x												
617									x	x				
636			x											
642		x												
643											x			
644		x												
652		x	x											
656											x			
665										x				
666												x		
667													x	x
714										x				
Cajon Lake										x				
Total	4	30	22	2	1	4	5	9	6	10	2	1	1	1

canyonhead tower complexes organized around permanent springs. Mainwash floodwater farming was also probably practiced, although structural remains are generally nonexistent due to the nature of the techniques utilized. Fig. 18 shows the water control sites associated with the Square Tower, Holly, Horseshoe and Hackberry groups, and the following pages describe many of the individual site characteristics, working from a western Pueblo baseline. Maps and photos of individual sites or site complexes accompany many of the descriptions. We feel fairly certain that most of these devices are old farm fields, since we have structural evidence, pollen and modern floral indicators. Investigations of the proposed "community organization" of the past farms will occur in the excavation seasons, as we explore the methods of construction and maintenance, the crop complexes, and the styles of ceramic and lithic debris.

1. Floodwater Fields

In terms of total acreage the bulk of the Hopi-Zuni fields are located along the alluvial flats of the major washes, on tributary arroyo mouths, on hillsides and slopes below scarps, and in steep arroyo bottoms. These are the floodwater fields or temporales which receive moisture not so much from direct rainfall as from run-off in the form of floods from higher elevations. The Hopi are especially dependent on this form of farming; Hack (1942) has estimated that 73 percent of the total Hopi fields are floodwater moistened, while Bradfield (1971) has stated that 920 acres around 3rd Mesa are in floodwater positions. Fields are situated in a variety of locations, but all are dependent on the run-off of storms which drop .75 cm. or more of late summer rain. The fields are fed by considerable drainages on Black Mesa, with an approximate ratio of 20:1 (drainage acreage to field acreage; Hack 1942; Bradfield 1971). Specific field types and associated structural remains include the following:

a) Akchins. Farming on the fans of tributary arroyos has become very popular among the Hopi in the last century (Hack 1942). Akchins are formed wherever arroyo channels end as the grades flatten, thereby spreading the seasonal floods over the fan and depositing their loads of silt. This yearly buildup renews soil fertility, acts as a mulch over underlying clayey soils, increases the moisture of the soil,

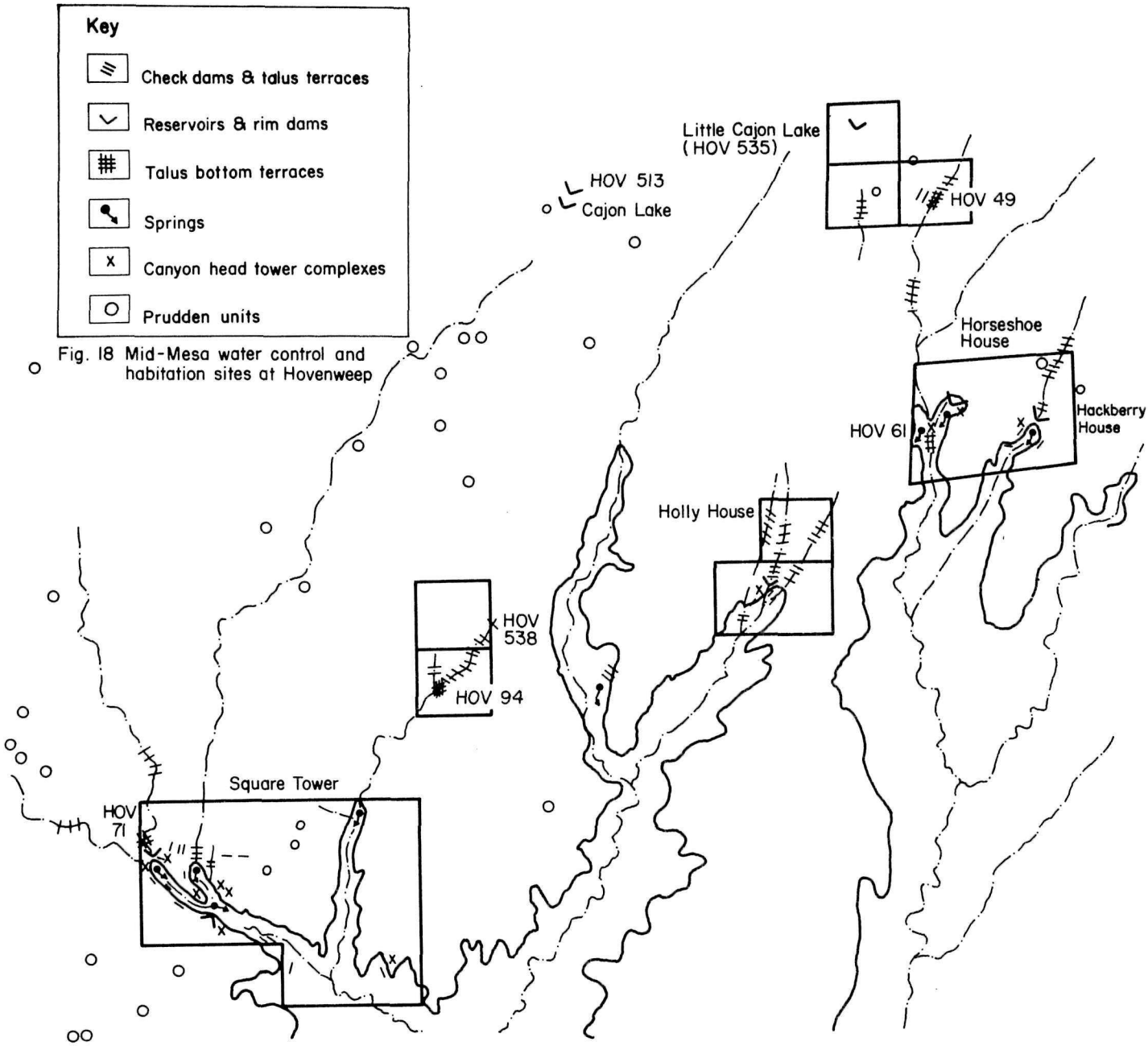


Fig. 18 Mid-Mesa water control and habitation sites at Hovenweep

and insures seed germination and early growth during the critical springtime dry period. Upwards of 90 percent of the 3rd Mesa floodwater fields are in akchin positions (Bradfield 1971), as were most of the traditional Zuni farms (cf. Stewart 1940b; Bryan 1929).

The akchin position can change drastically through alterations in the volume of flow, so fields often have to be abandoned after a few years. Structures are thus often built to stabilize the fan's position, control the water spread and conserve the sandy soil. These include earth, rock and brush dams which are often built across the top of the akchin to prevent channeling or severe flooding, and ditches which are used to spread the waters evenly across the fields. Ridges of sand are also common on akchins, as wind and water action piles sand up against the brush at the edge of the plot and stabilizes the fan's position. Shallow basins are sometimes built around the individual corn hills to conserve moisture, while windbreaks are commonly built (or planted) around the edges of the fields or between the rows of exposed corn (Forde 1934; Stewart 1940b; Cushing 1920; Hack 1942). Many of these structures remain intact after the fields have finally been abandoned, and at times extensive gridworks of abandoned Hopi akchins are visible from the air (Hack 1942).

Four akchin-like fields with intact dams have been found at Hovenweep (Table 17). Numerous arroyo fans may also have been used, but akchins are often farmed without artificial water spreading or soil conservation, so the features may have been washed away. We at least know that akchin-type farming occurred at Hovenweep, however, as indicated by cultigen pollen from a one meter high terrace at Hov. 71 above Square Tower (Table 18). The site consists of several terraces on a tributary fan of Little Ruin arroyo, near the remains of a large rim dam between Hovenweep Castle (Hov. 4) and Hovenweep House (Hov. 1) immediately above the head of the canyon (Fig. 19; Volume Cover). Pollen test pits in the terrace demonstrated that corn had probably been raised. Beeweed (Cleome sp.) and "cheno-ams" (unidentified species of Chenopodiaceae and Amaranthaceae) were also present, perhaps as tolerated or encouraged weeds. The corn and weed pollen could have been washed in from nearby fields, of course, but the consistent occurrence of cultigen and weed pollen with water control structures at Hovenweep increases the probability that the devices were actual farms.

TABLE 18

Cultigen And Weed Pollen From Hovenweep
Water Control Devices *

Site Type	Number of Sites	Sites With Pollen	Cleome sp.	Asclepias sp.	CHENO-AMS	CYPERACEAE	Rumex sp.	SOLANACEAE	Lycium sp.	Physalis sp.	Typha sp.	Corn	Beans
Akchins	4	1	x		x							x	
Floodplain Fields	1	1	x		x		x	x	x			x	
Trincheras	30	7	x	x	x	x	x	x	x	x	x	x	x
Slope Wash/ Bottom Terraces	22	6	x	x	x	x		x	x		x	x	
Springside Fields	5	1		x	x	x	x	x	x	x	x	x	
Rim Dam Terraces	9	1	x		x			x	x			x	x
Reservoirs	10	4	x		x	x		x	x	x	x	x	
Mesa Top Terraces	1	2		x	x			x				x	x

* See Tables 27 and 29 for specific sites and full pollen profiles

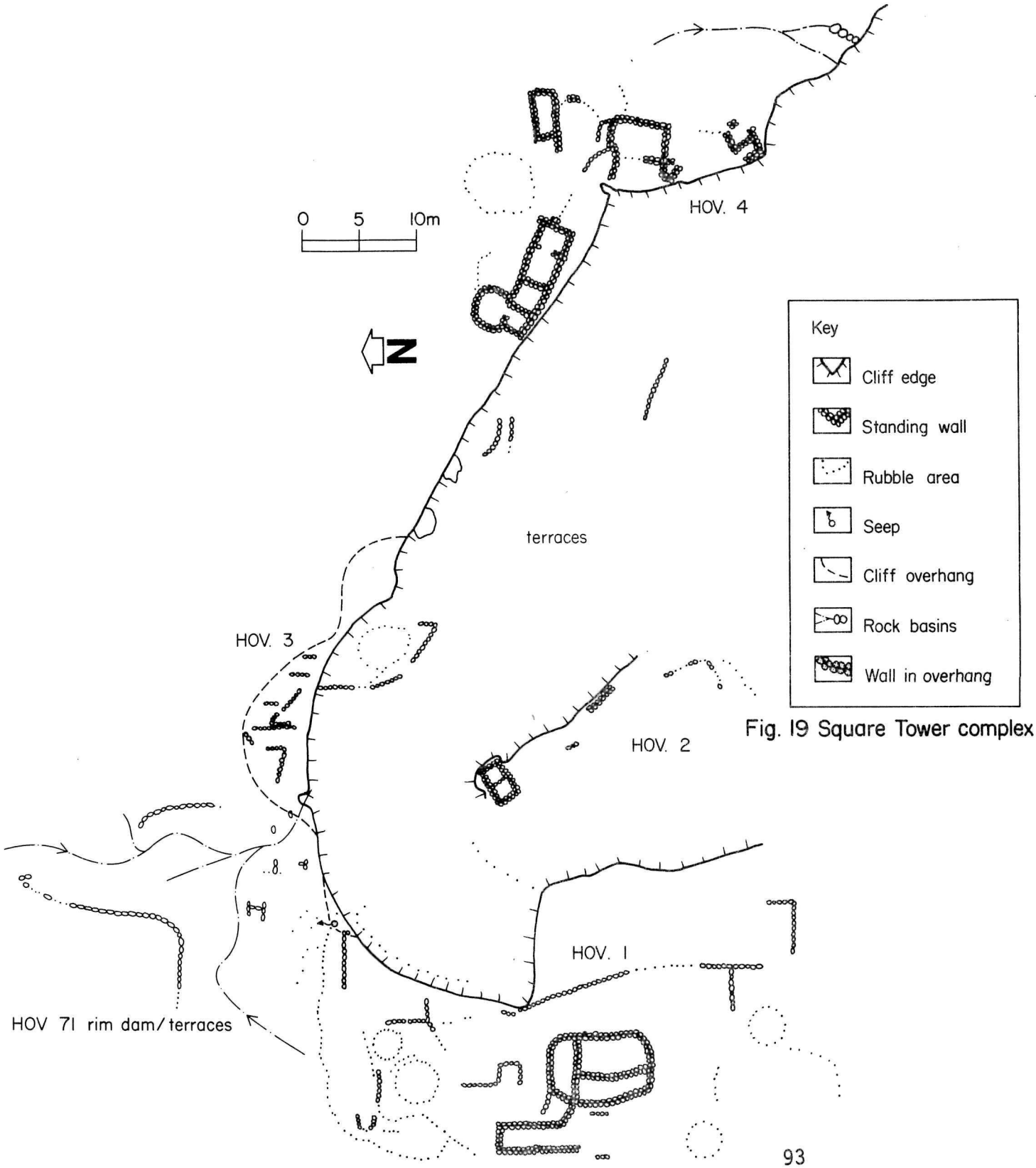


Fig. 19 Square Tower complex

The most intact akchin-like system at Hovenweep is site 94 (Fig. 20), which involves ten terraces on a fan on the eastern tributary of Little Ruin Canyon. The site also has Pueblo I - III midden, storage or habitation rooms, and a possible talus terrace system, while three check dams occur nearby in the main arroyo. The terraces are generally one course wide and several courses high, and vary in length from three m. to seven m. Pollen samples have not yet been analyzed. The other two sites include a short series of possible terraces (Hov. 384) on a small fan above Cutthroat Castle, and a similar dam arrangement (Hov. 450) of a fan below Holly House.

b) Main Wash Floodplains. Prior to A.D. 1900 the bulk of the Hopi fields were along the main Tusayan Washes, where summertime floods innundated the alluvial flats. These were the best corn fields, but the onset of deep arroyo cutting in the late 1800's destroyed most of the farms, since floods could no longer breach the banks and the water table was lowered. Over 800 acres of prime cropland was lost in the Oraibi Valley alone (Bradfield 1971), resulting in a shift to akchin and sand dune farming (Bradfield 1971; Hack 1942) as well as the breakup of Old Oraibi (Hack 1942; Titiev 1944; Bradfield 1971).

Several areas of main wash flood water farm fields still remain intact around the Hopi washes, however, and it is probable that main wash fields have always been important to the Pueblos and Anasazi. Corn fields are also sometimes planted within the large washes as well as alongside them, as the low terraces which are forming incipient floodplains are excellent sources of moisture. Most of the large floods spread over these terraces, and even the smaller flows are of value through underground seepage.

Water manipulation often accompanies main wash floodwater farming. Dams are sometimes constructed to prevent channeling, while ditches and earth banks divert the water from shallow washes. Diversion structures are generally impermanent, however, and none of the sources have recorded structural remains of abandoned fields, in contrast to akchin positions. No obvious water control devices were found along the main washes at Hovenweep, but it is likely that many of the broad canyon bottoms were farmed, as indicated by

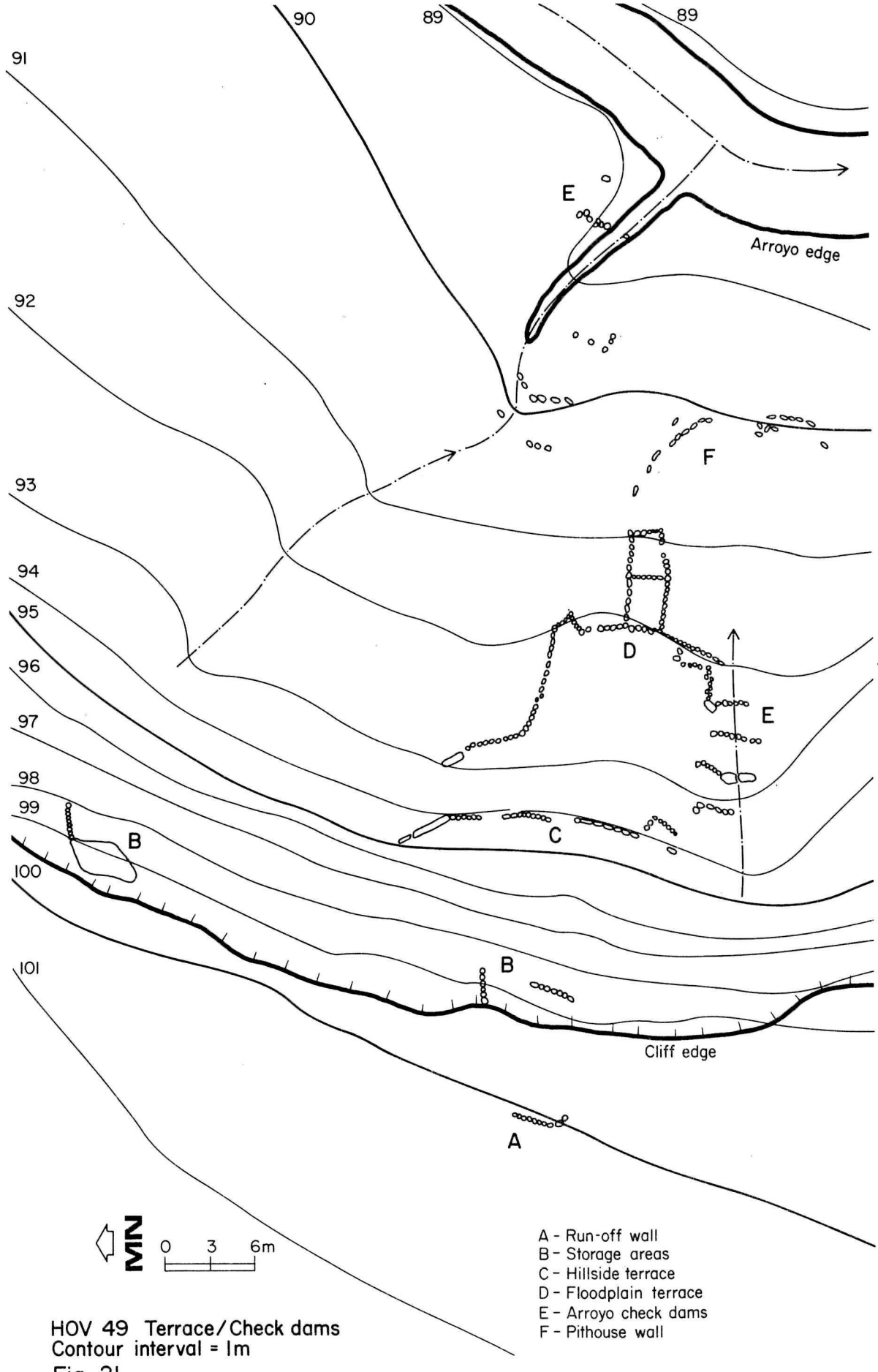
Fig. 20 Akchin Terraces and check dams at HOV. 94/538
Contour interval = 1m

Key
A. - Talus terraces
B. - Akchin terraces
C. - Check dams

granaries scattered along the talus slopes. In fact, pollen from a test pit in the alluvium below Hov. 423 in the Hackberry Group indicates that crops of corn, beeweed, dock (Rumex sp.), wolfberry (Lycium sp.), cheno-ams, and an unidentifiable solanaceous species may have been grown on the floodplain (Table 18). Again, this material may have washed in, but considering its location below granaries it is probable that it represents an old field.

c) Arroyo Bottom Fields. Another favored floodwater field location for both the Zuni and Hopi is the bottom of small tributary washes, particularly steep-walled gullies on hillsides (Cushing 1920; Beaglehole 1937; Forde 1931, 1934; Stewart 1940b; Hack 1942; Bohrer 1960). Since the nocturnal radiation from the arroyo banks prevents frost damage to the crops, arroyo fields are especially desirable locations for early Hopi corn which is planted in April and harvested for the Niman Katchina Dance in July. Squash and pumpkins are also planted in arroyo bottoms at Zuni; the plants rarely wash out and they are productive even during a drought (Bohrer 1960). Arroyo bottoms are subject to violent floods, however, so both the Hopi and Zuni minimize flood damage by building check dams which slow the water's flow. The dams also hold back soil and moisture, thereby creating level terraces (trincheras) which are excellent corn fields. Forde (1931, Fig. 2) describes three check dam variations in a system at Hano, with the individual dams ranging from .3 m. to 1 m. high and up to 10 m. long. Hack (1942, Fig. 16) describes a system of six trincheras at the same village, while Cushing (1920) discusses a similar arrangement at the Zuni farming village of Nutrias. Dams are never built singly, except to prevent channeling, and they are generally constructed so that each terrace is banked up against the next dam. Akchin dams and lateral diversion dams are also sometimes linked up with the trinchera fields.

Probable check dams are the most common water control feature at Hovenweep (Table 17), and thousands have been found at other locations in the Southwest (over 900 at Mesa Verde alone). From two to sixteen dams were strung along the mesa top arroyos and in steep canyon side or canyon bottom gullies, often in association with other water control structures. Typical sites include Hov. 538 and Hov. 49 (Figs. 20-22), located in the drainages above the Horseshoe House and Square Tower complexes. Sixteen probable dams are scattered



HOV 49 Terrace/Check dams
Contour interval = 1m
Fig. 21

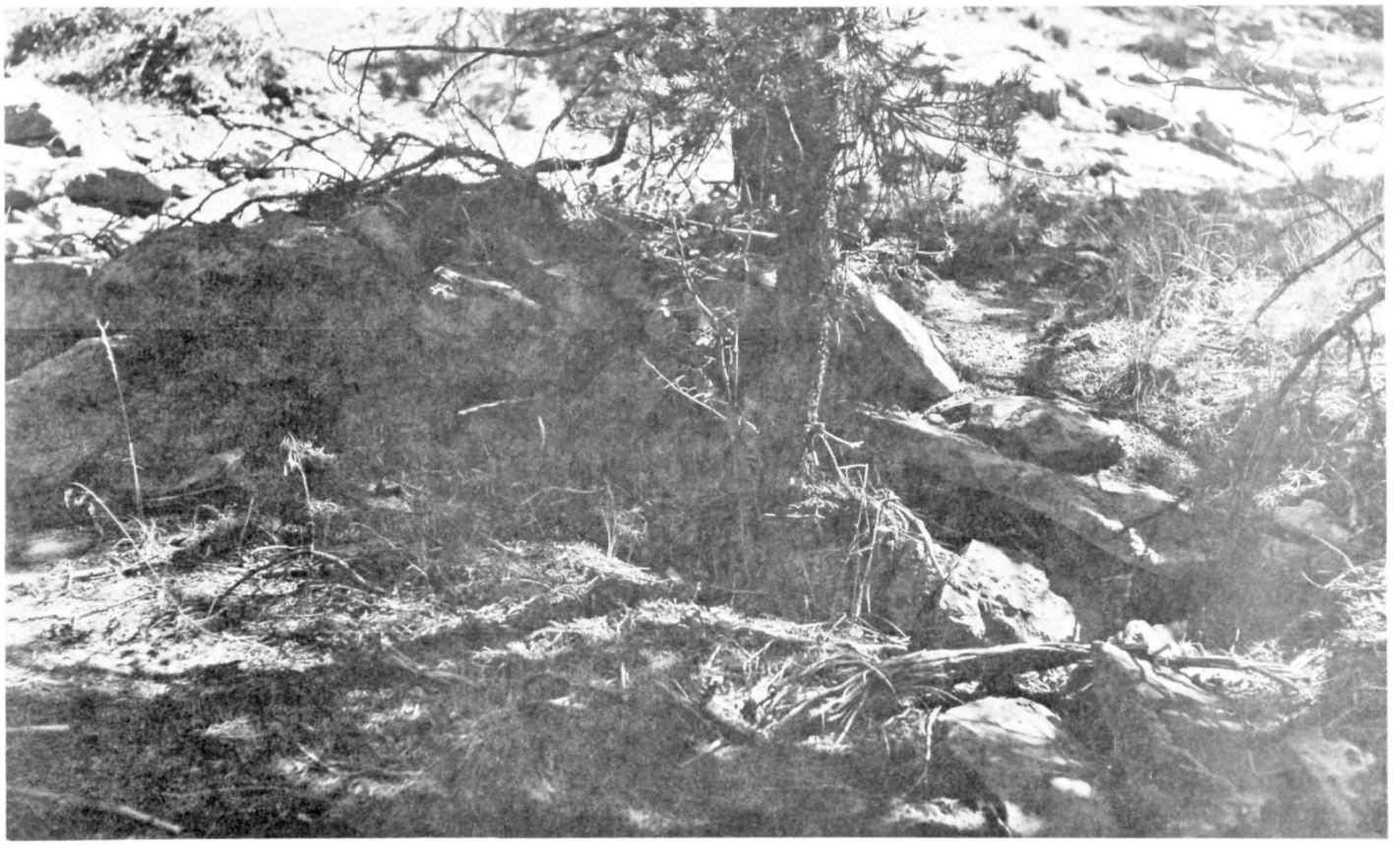


Figure 22. Intact check dam at Hov. 644 above Big Ruin Canyon.

Figure 27. Rock tank in boulder at Hov. 12 (Twin Towers).

along 670 meters of arroyo at Hov. 538, on a grade of 2°. The dams link up with the Hov. 94 akchin system, so a considerable amount of arroyo bottom farm land was made available, and probably utilized by the Square Tower inhabitants. The Hov. 49 system is equally complex. It involved eight dams on tributary washes, several talus terraces, a talus bottom terrace system, and storerooms. Pollen samples from both sites have yielded crop evidence. At Hov. 538, cattails (Typha sp.) and cheno-ams grew along with maize (Table 18; also see Tables 27 and 29), while beeweed, cheno-ams, cattails and an unidentifiable solanaceous species grew with corn at Hov. 49. Six other check dam sites at Hovenweep yielded corn pollen, and at one of these bean pollen was retrieved as well. Milkweed (Asclepias sp.) Cyperaceae (rushes or sedges), dock, wolfberry and ground cherry (Physalis sp.) also grew in association with maize at certain of these sites. The presence of cattails suggests that the dams may have served as small reservoirs as well as gardens for domesticated and semi-cultivated species.

d) Slope Wash Sites. The final Hopi floodwater control technique is the slope wash field which is located below scarps or hills. Such sites are very rare in the Tusayan country, and apparently nonexistent among the Zuni. When present they are usually perched on the steep mesa edges or benches (Hack 1942) where the soils are loose mixtures of sand, talus debris, pottery sherds, trash and weathered shale. Bryan (1929) refers indirectly to Hopi slope wash fields, while Stewart (1940a: 215) shows a boulder terrace field on a slope below 1st Mesa. Bradfield (1971) is the most informative of the Hopi scholars when he notes that the drought of the last quarter century forced the abandonment of many of the marginal fields on side valley slopes which lacked a sandy mulch to retain moisture.

Fields on slopes seem to have been relatively popular at Hovenweep, at least as indicated by structural remains, pollen data and floral patterns. Twenty-two sites, including most of the large tower complexes, yielded evidence of talus walls and terraces. Many of these may actually have been garden terraces irrigated by springs or room retaining walls, but others were most likely slope wash farms. Talus bottom terrace systems are also present at several of the sites, where it appears that the overflow from the talus terraces

was sometimes channeled to rock gridworks on the flats below. Hov. 49, which was first described by Schroeder (1967-1968), is an excellent example of this type of system, as shown in Fig. 21. Two talus walls measuring up to 42 m. long follow the contours of a 14° slope, thereby creating a series of step-like terraces. Run-off from higher up the slope would have moistened the terraces and permitted the growth of crops, and it is even possible that a dam may have channeled additional water onto the slopes from several shallow mesa top arroyos. Check dams were also built at several places in steep arroyos on the talus and in the main wash in the canyon, while a gridwork of three terraces immediately below the slope received overflow. Schroeder (1967-1968) also recorded the remains of a possible irrigation canal in association with the grid terrace, but it is more likely that this double row of upright slabs represents an earlier Pueblo I pithouse. Pueblo I ceramic trash is abundant immediately to the southeast, and a pollen pit demonstrated that the area between the slabs is rich in charcoal, fill and rubble, rather than alluvial sediments. Corn, beeweed, cheno-ams, wolfberry, milkweed, cattail and unidentifiable solanaceous pollen from this and the nearby Hov. 61 slope bottom terrace indicate that gardening and weed gathering took place on the terraces. The Hov. 61 site is remarkably similar to Hov. 49. It includes both talus and talus bottom terraces built over an earlier pithouse.

Possible slope wash systems occur at many other Southwestern sites, including Mesa Verde (Rohn 1963; Hayes 1964) and Point of Pines (Woodbury 1961).

2. Sand Dune Farming

The second major Hopi field is the sand dune farm, which accounts for approximately 27 percent of their total acreage (Hack 1942). Dune farming is especially popular at Hotevilla on 3rd Mesa, where it accounts for 60 percent of the fields and where acres of orchards, melons, corn and beans cover the mesa top dunes beyond the village and dot the talus slopes (Hack 1942; Titiev 1944, Plate 1). Dunes are excellent moisture reservoirs, since run-off is nonexistent. Dunes, therefore, cannot be used for irrigated gardens, which must have channels and ditches running with water, but they are excellent dry or seepage locations for beans, fruit and other

long-rooted crops. Many dunes also have northeastern exposures, which results in lower temperatures and less evaporation (Hoover 1930).

While several types of sandy areas on the barren mesa tops and talus slopes are used, the most common field is in an area where .3 - 1 m. of sand overlays a less pervious colluvial soil or rock and acts as a mulch, thereby trapping moisture which is absorbed during storms. The deeper falling dunes are also utilized for beans and fruit, due to a layer of moisture which forms several centimeters below the dune surface by condensation from much deeper water during diurnal temperature changes (Hack 1942). Young beans, fruit trees and some corn plants can get a start by absorbing moisture from this zone, and by the time they reach maturity their long roots can tap the deeper moisture at the base of the dune.

Dunes are thus very dependable sources of moisture, but because of the constant danger of drifting sand considerable labor must be spent in building and maintaining windbreaks. Vegetation which competes with the crops for moisture has to be cleared before planting, yet to do so means that sand can now blow away or damage the young plants. Rock and brush windbreaks are therefore built around the edges of the fields and between the exposed rows (Hack 1942), while miniature twig and reed windbreaks, large rocks, circular piles of stones and tin cans often protect individual hills of corn, beans, melons and cotton plants (Forde 1931; Beaglehole 1937). Where exposure is an especially serious problem, as on sandy slopes, great efforts are expended as lines of brush are placed in rows 2 - 5 meters apart and held down by stones. The rocks slowly become buried in drifting sand, and eventually only the tops of the brush protrude above the surface of the field. These partially buried windbreaks are still functional, however, and the plots are used year after year as new brush is brought in to replace gaps in the fence. Eventually all of the sand blows away, the field is abandoned and the brush rots away, leaving long rows of stone on the bedrock.

Because of the extensive windbreaks associated with dune agriculture, sand dune farms leave their traces in the form of long lines of rocks. "Linear borders" and "grid borders" are fairly common archeological structures which could be the

remains of dune windbreaks. Hack (1942), for example, noted fifty-one old dune fields to the south of Awatobi on Antelope Mesa, at least one of which was associated with a Pueblo III ruin. Woodbury (1961) suggested that many of the Pueblo II and Pueblo III linear and grid borders at Point of Pines are probably remnants of dune windbreaks.

Dunes are common at Hovenweep, but unlike the Hopi region they rarely occur close to the better known ruins. Instead, they are frequent on the southern benches of the mesa in and near the McElmo, San Juan and Montezuma Creek valleys, in the form of active as well as stabilized hanging and valley dunes (see cover photo, section III.2). Dunes almost always have sites on them, which invariably take the form of scatters of rough stones and lithic debris eroding out of the dunes, usually near a seep line. No clear linear or grid borders have been recognized, but it is possible that the stone scatters are the remains of old windbreaks which have been partially eroded away, then covered over, moved by the dune, and recently uncovered. They may also represent early hunting camps, since lithic debris is generally present, so one of the objectives of the 1976 research is to map and core all of the dunes on the mesa. No pollen samples from the dunes have been analyzed.

3. Seepage Fields

Another Hopi field type is the seepage farm, which is generally rare except in dune locations. Forde (1934) suggested that the seepage from springs is a very important source of moisture for farm fields, and Stewart (1940b) and Whiting (1939) added that seeps commonly feed fields along slopes, cliffs and wash bottoms. Hack (1942), in contrast, argued that true seepage fields are very rare, while Bradfield (1971) found no evidence of seepage fields at 3rd Mesa. Hack's nondune seepage fields were limited to a few places on the talus slopes between springs where seeps formed in colluvial soils. Seepage dune fields, however, are fairly common, especially on dunes at the mesa edge and in dune hollows. Seepage fields do not have windbreaks or other water control devices, and none have been found at Hovenweep.

4. Springside Irrigated Gardens

Gardens irrigated by permanent springs are of immense value to the western Pueblos, notwithstanding the fact that only eleven out of approximately 6000 Hopi acres are irrigated. Favorite delicacies and ceremonial plants, including green and sweet corn, onions, squash, chile, gourds, sunflowers, melons, cotton, tobacco, and some fruit trees and beans are grown, along with dye plants such as coriander and coxcomb (Forde 1931, 1934; Beaglehole 1937; Whiting 1939; Stewart 1940b; Hack 1942; Bohrer 1960). Weedy plants, for example, ground cherry and amaranths, are often tolerated or semi-cultivated, while trees may be encouraged to grow around the plots to impede evaporation (Stevenson 1915; Forde 1931, 1934; Whiting 1939; Bohrer 1960).

At least sixty good springs issue from the Hopi mesas, and several occur at the Zuni farming villages of Ojo Caliente, Nutrias and Pescado. Many of these are used for garden irrigation as well as for domestic water. Numerous terraced gardens with "waffle" plots, basins and furrows are laboriously constructed around the edges of the springs or on the slopes below, but the effort is worth it since the gardens are the only source of most of the vegetable delicacies and ceremonial plants. Some gardens are fairly large, with twenty or more families each farming three to four tiny plots (Forde 1931, 1934). At the Tallahogan gardens below Awatobi, for example, brooklets and pipes feed the water to an abandoned rock holding tank, and from there the water seeps to a peach orchard or is channeled to a crude earth and stone reservoir where it is temporarily stored (see Hack 1942, Figs. 20-21). A ditch and pipe system then carries the water to the carefully terraced fields, where smaller ditches, banks and dams of mud and stone channel the water into the plots. Each of the twenty-five owners carefully guides the moisture to individual plants in basins and furrows by means of tiny runnels and earth dams. Similar irrigated gardens can be found at Wepo Spring on 1st Mesa, Sityatki Spring on 2nd Mesa and Hotevilla Spring on 3rd Mesa, among others. The Hotevilla gardens are especially spectacular, with their acres of terraced plots clinging to the steep slopes below the village (see Titiev 1944, Plate 1).

Other Hopi springs are in low hollows which have been artificially deepened, in which case the water is carried up

from the "well" and pot fed to the plants, which either encircle the tank or slope away from its rim (Forde 1931). Most of the irrigated gardens are watered several times a week directly by dams and ditches from the reservoirs, but at times the spring's water level will be lowered by domestic use and hand irrigation is necessary (Beaglehole 1937).

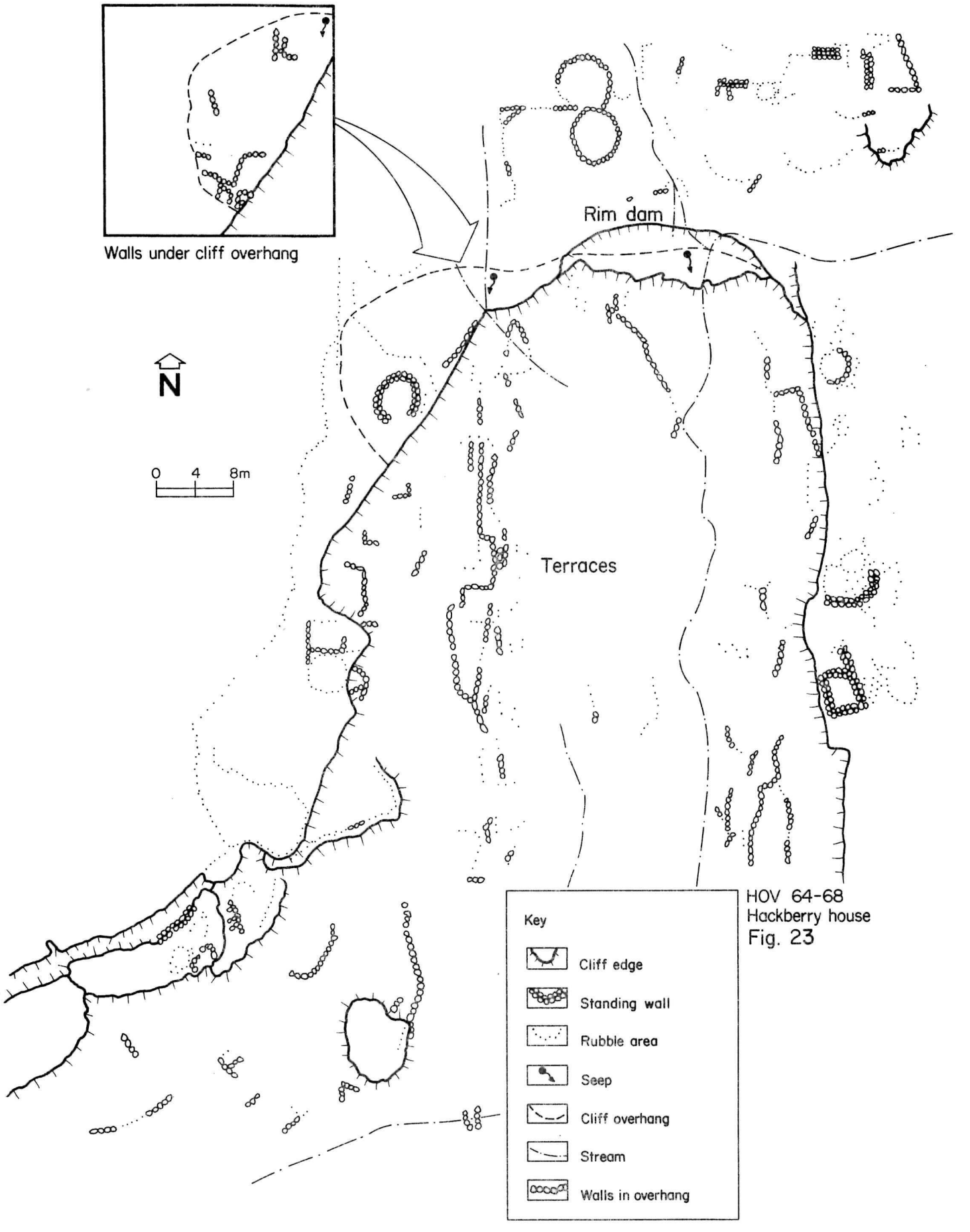
The same types of irrigated gardens are also present at the Zuni farming villages: one type has low deflecting walls, channels and terraces, while the other is pot fed from walk-in wells. The latter is the famous "waffle garden" of Cushing (1920), which is enclosed by a jacal wall. The garden consists of numerous tiny waffle-like plots built up ten centimeters or so and enclosed by earth banks approximately twenty centimeters high (Bohrer 1960). Each waffle measures about thirty centimeters wide, and is irrigated by water brought up from a well in the Zuni riverbed. Most crops are irrigated immediately before flowering and more frequently if possible, while gourds have to be watered every three days. Many of the Hotevilla gardens are also waffle-shaped, but fed directly from springs high up on the mesa wall (Cushing et al. 1922).

Springs are also the major source of drinking water for the Hopi, and in this regard the mesa side springs are particularly important. The porous Mesa Verde sandstone with its underlying impervious shales and clays is an excellent aquifer, so water stored in it issues out along the mesa side as springs and seeps where plants concentrate the flow (Hack 1942). Several other types of springs, such as dune contact springs, landslide springs, dune hollows and shallow wells are also used for gardens and domestic purposes, but most of the drinking water springs and all of the larger irrigated garden springs are on mesa sides. Dune covered intake areas on the mesas immediately above the springs are the major sources of water (Hack 1942). The barren, rocky spurs at the end of the mesa serve as excellent collecting areas during storms, and the frequent dune cover greatly impedes run-off and enhances percolation to the spring through the porous sandstone. Free dunes above the springs are thus very important, since they lack vegetation which would otherwise use water through transpiration, and all of the large irrigated gardens have active dune fields above them on the mesas.

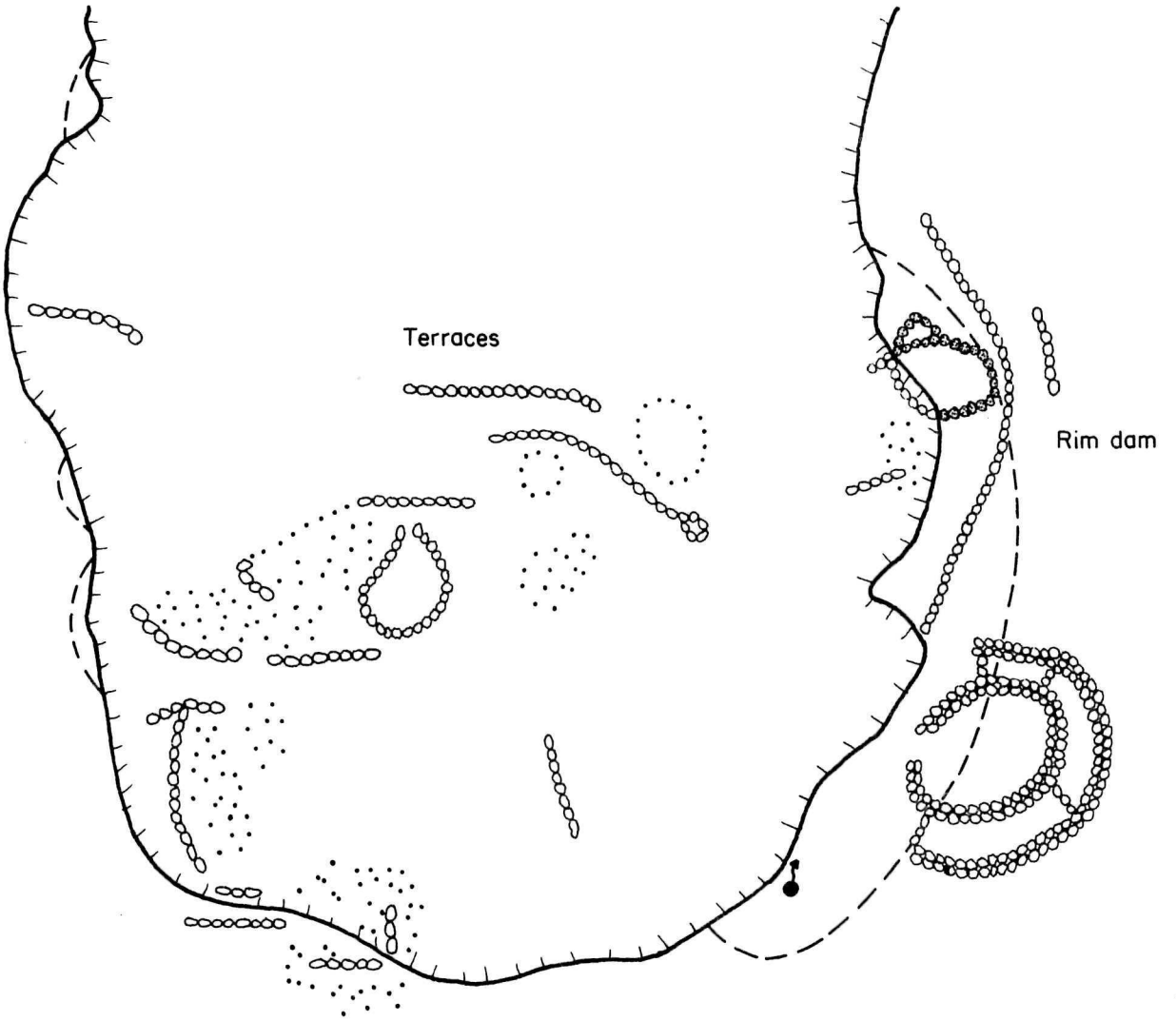
Irrigated gardens, like sand dune fields, demand considerable maintenance. Walls, terraced plots, dikes, ditches, and other structures are constructed and repaired; the springs are often artificially enlarged and walled in; and large stone and earth reservoirs are sometimes built as holding tanks. Periodic cleaning of the springs and terraces is also necessary, after which ritual paraphernalia, such as pottery bowls and prayer sticks, are ceremonially placed in the spring (Beaglehole 1937). Abandoned spring-side irrigated gardens should therefore be relatively visible, since all of this activity results in material remains. In rare cases ritual items might even be found, as at Lowry Ruin where Martin (1939) found "prayer sticks" in the bottom of a modified spring.

At least five possible irrigated spring systems have been found at Hovenweep, always in association with major canyon-head tower clusters. Large, often obviously modified mesa side springs are present in canyonhead shelters at Square Tower, Horseshoe House, Hackberry House and Cajon Ruin, while the vegetation at Holly House is indicative of a buried spring. The extensive talus terracing below the roomblocks and springs are especially reminiscent of the gardens at Hotevilla, Tallahogan and other Hopi springs, as shown in Figs. 19 and 23-26. The terracing below Hackberry House is so complex that it extends for 100 meters on both sides of the canyon (Fig. 23), and although many of the walls may have supported rooms or served as slope wash terraces, others were probably irrigated garden plots. Domesticated plants and garden weeds obviously grew near the Square Tower Spring, as demonstrated by corn, beeweed, milkweed, dock, cheno-am, ground cherry, wolfberry, cattail and unidentifiable solanaceous pollen.

Several other types of probable farming structures are also associated with the Hovenweep springs. A possible holding tank is present at Hov. 600, while large rim dams occur on the mesa tops immediately above the springs at many tower sites. Grid terraces or check dams are usually attached to the rim dams. Both gardening and soil/water conservation were undoubtedly the objectives of the rim dam terracing, as indicated by the pollen of corn, beans, beeweed, wolfberry, and cattails from the rim dam/terrace system at Holly House.



HOV 64-68
Hackberry house
Fig. 23



0 4 8m

Key

Cliff edge

Standing wall

Rubble area

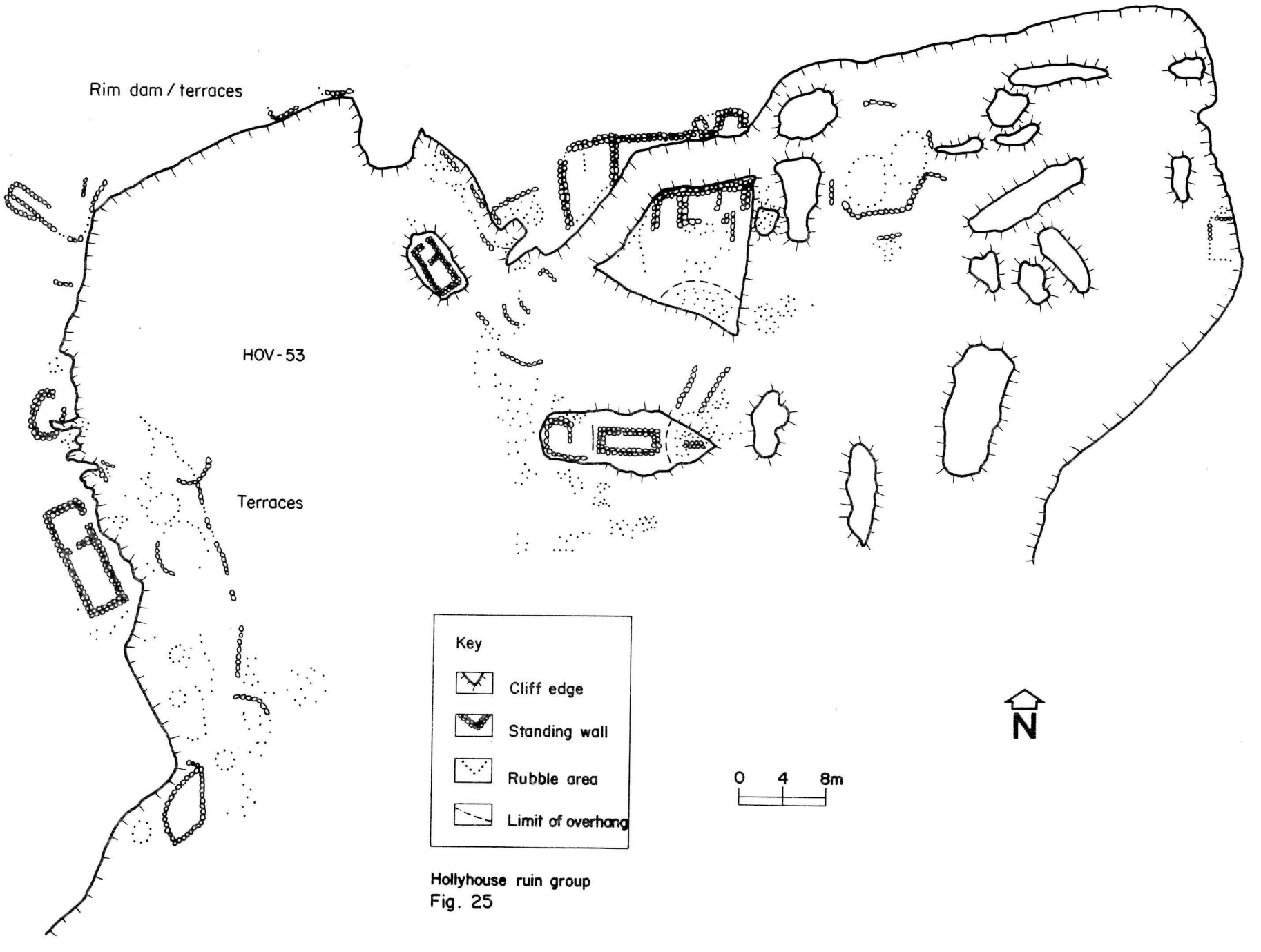
Cliff overhang

Wall in overhang

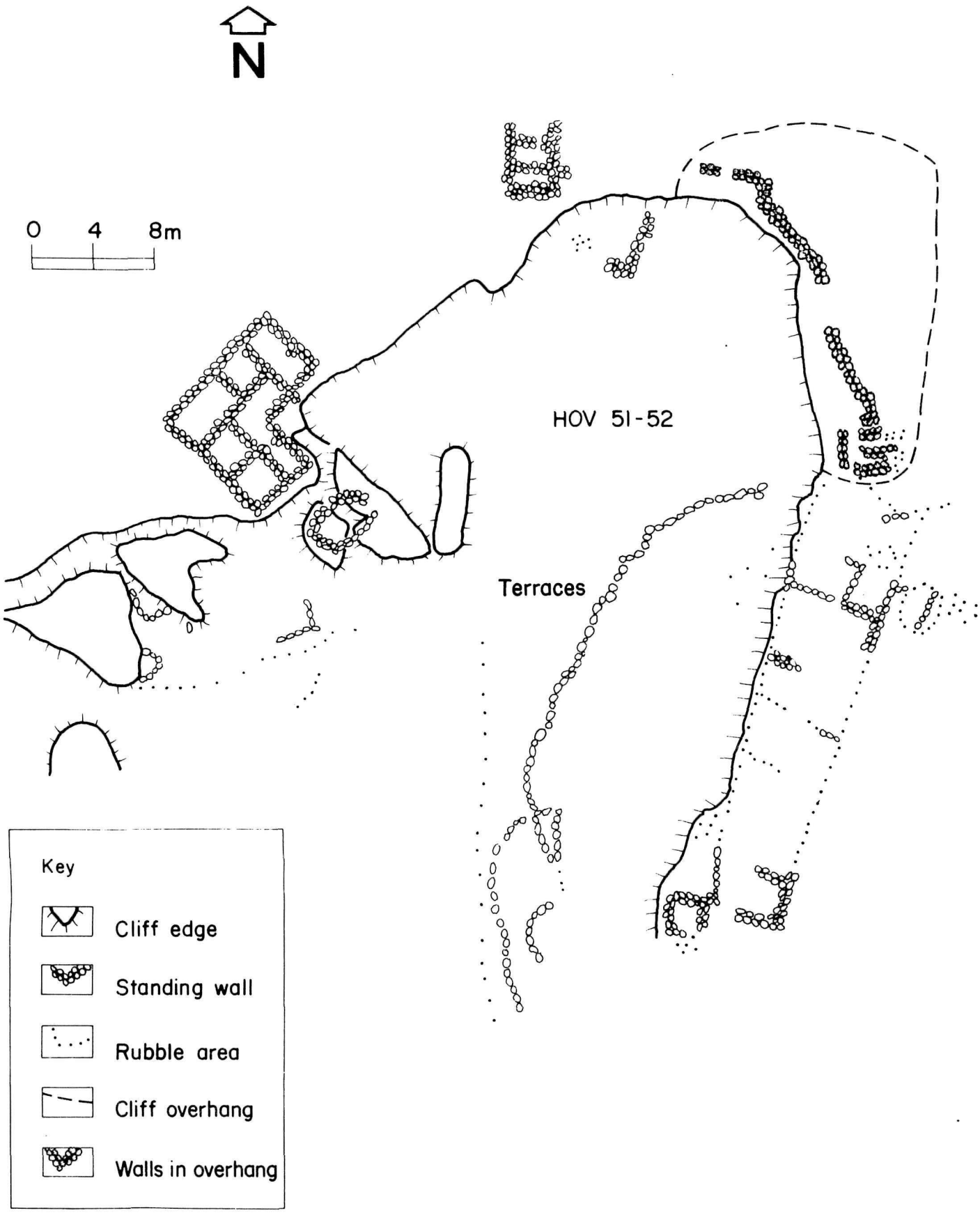
Seep

HOV-57 Horseshoe house
Fig. 24

N



Hollyhouse ruin group
Fig. 25



Cajon ruin group
Fig. 26

The rim dams and terraces could also have served to enhance the percolation of water to the springs below, in lieu of dunes, as large plots of sandy soil built up behind the dams. Rohn (1963, 1972) first noticed their relationship, and tests are now underway at four of the Hovenweep springs to see if the dams enhance percolation by impeding run-off and increasing hydrostatic pressure (see section I.E, this chapter).

5. River Irrigation

Both the Zuni and Hopi practice a limited form of the river irrigation which is so extensive among the eastern Pueblos along the Rio Grande and its tributaries. Wittfogel (1957; Wittfogel and Goldfrank 1943), in fact, described the western Pueblos as a "limited water supply" society, while their relatives to the east were a hydraulically compact "miniature water control society." River irrigation was especially common at Zuni, even before the damming of the river in 1908 (Cushing 1920; Stevenson 1904; and Stewart 1940b). Irrigation was also practiced at Nutrias, where a mountain stream was dammed, fed through a three kilometer long log aquaduct and channeled into numerous waffle wheat gardens. Over forty families farmed the six kilometer square scatter of walled pens, basins and ditches. Smaller waffle gardens were also located along the bank of the Zuni River at the main village, but by 1956 only two areas of waffle gardens appear to have remained, both near the river (Bohrer 1960). Since the river became a trickle after the construction of the dam, the waffle gardens are now pot irrigated from walk-in wells (see preceding section).

In the Tusayan country river irrigation is restricted to the outlying village of Moencopi ("cotton fields"). Originally a summertime farming settlement, it became a permanent town after the split-up of Old Oraibi in 1908. Large springs and a permanent stream with a discharge of ten second feet insure a well-watered canyon bottom for the Moencopi farmers who now return to Oraibi only for the major rituals. Over 1000 acres were available for irrigation by the 1920's (Hoover 1930), while the nearby springs at Tuba City became the focal point for a large Navajo settlement. Corn is the major crop in the irrigated Hopi fields; water reaches the fields through long supply ditches running along the sides of the valley bottom.

River irrigation could have been practiced along the San Juan River at Hovenweep, but it is unlikely that it occurred in the other valleys, since they lack permanent streams. The sources of the Yellowjacket, McElmo and Montezuma have been pirated by the north flowing Dolores, and even the San Juan is subject to great seasonal variations in flow. A large irrigation ditch runs for several hundred meters along Montezuma Creek near the confluence with the Nancy Patterson; its antiquity is suspect, however, and other old canals are unknown in the region.

6. Dry Fields

True dry farming is nonexistent at the Hopi mesas, yet common near the village of Zuni. Limited dry farming also occurs on Black Mesa (Hack 1942), but these are probably Navajo rather than Hopi fields. Bohrer (1960) suggests that the large number of Zuni dry fields is a relatively recent innovation; most of the areas now dry farmed were originally flood water farmed with diversion dams.

Dry farming may once have been practiced at Hovenweep, at least as suggested by the preponderance of Basketmaker II--Pueblo II habitation sites on the broad mesa top in the pine forest and sage zones where the soils are deepest (see Fig. 18; Table 19). Water control sites are rarely associated with these ruins, so it is possible that the farmers subsisted primarily by dry farming. No dry field locations have yet been identified, but it is anticipated that extensive coring of the flats around the Pueblo II Prudden Units will yield the pollen of corn and other cultigens.

7. Reservoirs and Rock Tanks

Besides building reservoirs as holding tanks for the irrigated gardens, the Hopi construct domestic water impoundments on the slickrock near the villages (Forde 1931; Beaglehole 1937; Hack 1942). Natural holes, seepage tanks, cisterns and artificial reservoirs provide water for drinking, laundry, stock and adobe mud. Summertime run-off and snow-melt often fills the smaller natural or artificially enlarged tanks, while large earth walls and rock arcs impound great quantities of moisture. Runnels are also carved in the rock to channel the run-off, and mesa top seeps are sometimes enlarged with masonry walls (see Plate XLV, Forde 1931).

TABLE 19 - Time Period Correlated With Site Number And Plant Zone

Plant Zone	Paleo Indian	Archaic	Basketmaker II	Basketmaker III	Pueblo I	Pueblo II	Pueblo III	Navajo	Unknown
Pinyon-Juniper	0	6	7	10	24	47	47	1	20
Sage	2	16	9	9	26	102	86	9	85
Shrubland	2	6	2	3	13	25	23	22	26
Total	4	28	18	22	63	174	156	32	131

Rock tanks and probable reservoirs are fairly common at Hovenweep and other ruin groups in the Four Corners region. Six sites have natural or artificially enlarged rock tanks, while intact masonry and earthen reservoirs were found at eleven locations in the survey area. Bedrock tanks are especially common around the Square Tower complex (Fig. 27). Ten of the canyon bottom tanks (Hov. 9), for example, holds water for most of the year.

The early stockmen recognized the value of the old reservoirs, and many of the modern tanks are supposedly built over earlier Indian reservoirs. Prudden (1903, 1916) described several of the intact embankments, which were usually associated with large ruin clusters and smaller check dams. Reservoirs were noted at Goodman Point, Pierson (or Squaw) Lake, Bug Lake and an unnamed site in the Yellowjacket. All were built of low earth and rock dams around natural basins. The dam at Bug Lake measured over fifty meters across and up to two meters high, and created a seasonal lake over four acres in size (see Plate IIIa, Prudden 1916). Pierson Lake was almost as large, with a one point five to two meter high earthen bank built on the slickrock and a nearby check dam and rim dam constructed near the ruin. Fewkes (1925) also described several reservoirs in the area, but by 1920 the stockmen had already begun to enlarge them. From his photographs and descriptions, it appears that both Cajon Lake and Little Cajon Lake (Hov. 535) are built over earlier reservoirs. Pollen tests at both stock tanks have confirmed this conclusion. Corn, cheno-am, Cyperaceae, wolfberry, cattail and unidentifiable solanaceous pollen were found in association in sediments at Cajon Lake, while corn, beeweed, cheno-am, cattail, ground cherry and unidentifiable solanaceous pollen were similarly associated in the bank at Little Cajon Lake. Both reservoirs have been modified, but a completely intact impoundment device (Hov. 513) was found several hundred meters to the north of Cajon Lake (Figs. 28-30), while the probable butt of another dam was located between the lake and reservoir. The immediate area is rich in archeological sites, with Pueblo I and Pueblo III habitation units clustered along many of the nearby ridges, and the reservoirs probably provided moisture for gardens and domestic needs. Hov. 513 is built on a slickrock area of twenty or more acres, which makes an excellent collecting basin with a slope of 2^{o}. The intact reservoir consists of an earthen bank constructed around a core of boulders and upright slabs,

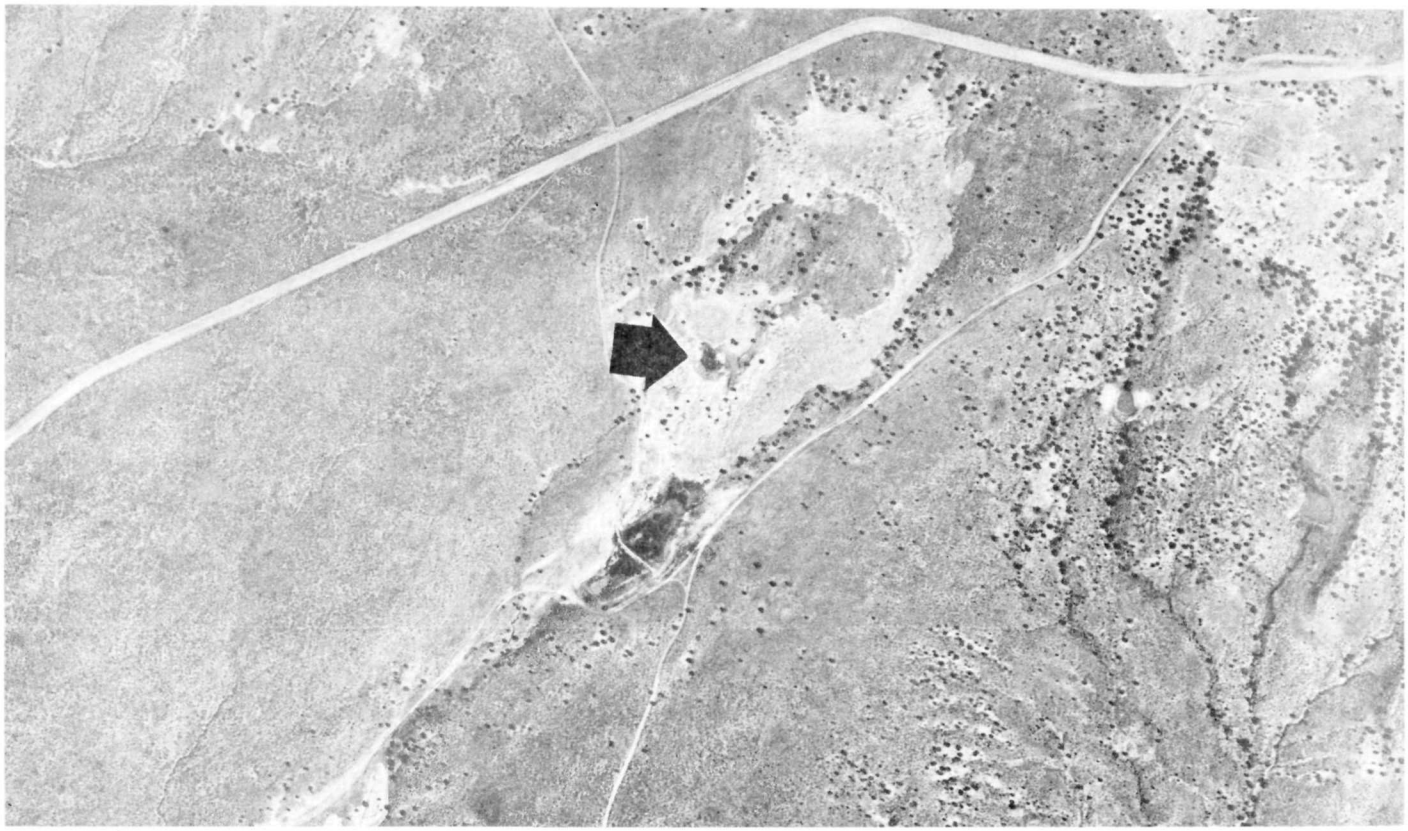


Figure 28. Aerial view of intact reservoir at Hov. 513 (see arrow). Note vegetation behind reservoir and surrounding slick rock areas. Nearby reservoirs are modern stock tanks.

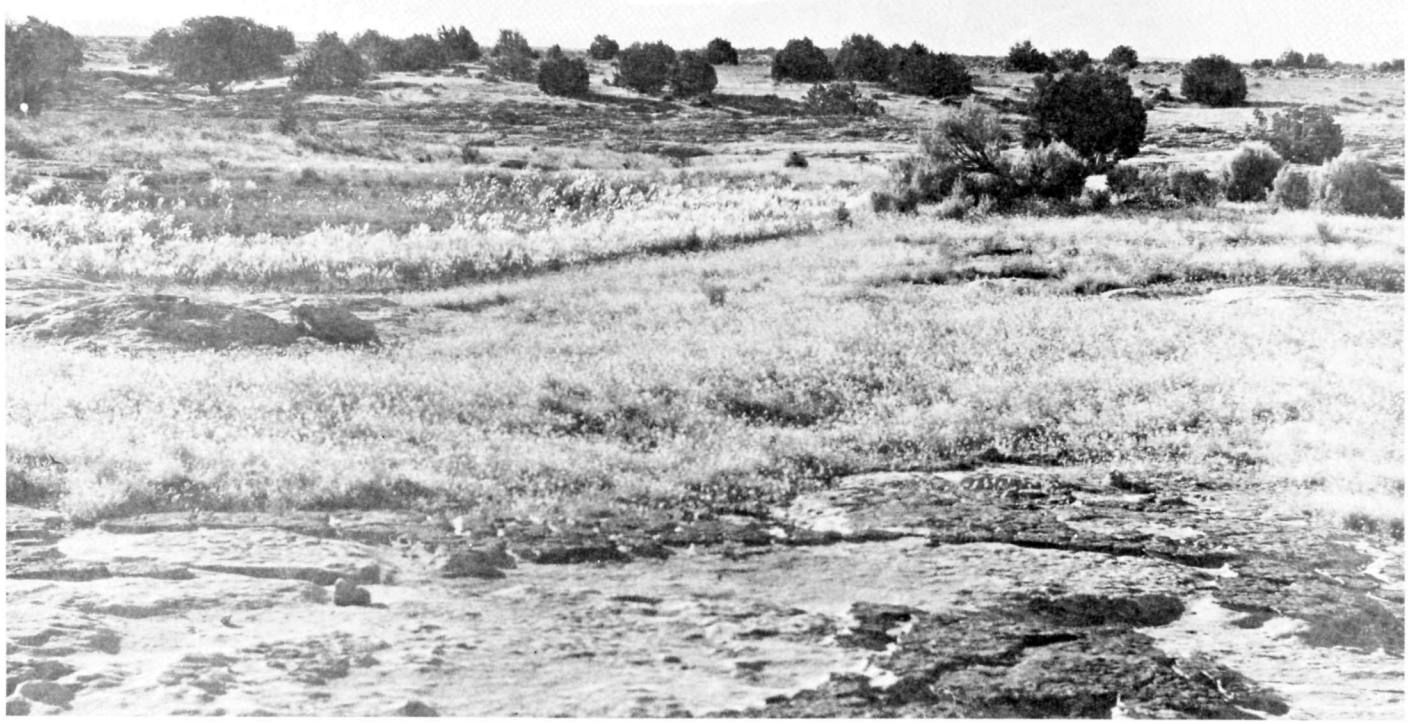


Figure 29. Close-up of Hov. 513 reservoir. Note depression filled with rabbitfoot grass (Polypogon monspeliensis) and rush (Juncus longistlyis) and surrounding slick rock. Compare with Figs. 28 and 30.

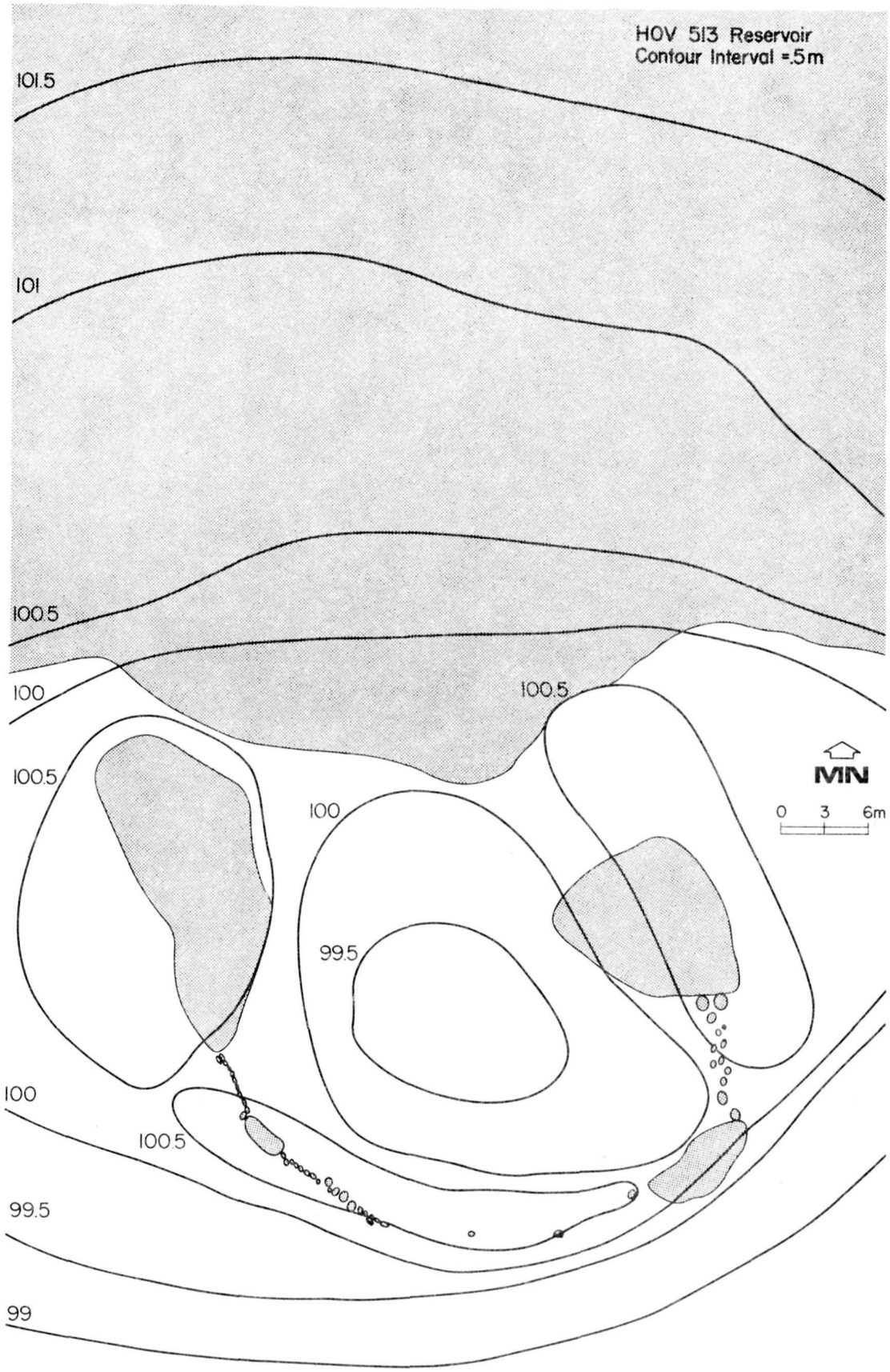

HOV 513 Reservoir
Contour Interval =.5m
101.5
101
100.5
100
100.5
100.5
100
99.5
100
100.5
99.5
99
MN
0 3 6m
Slick rock and rocks
Clear area is soil

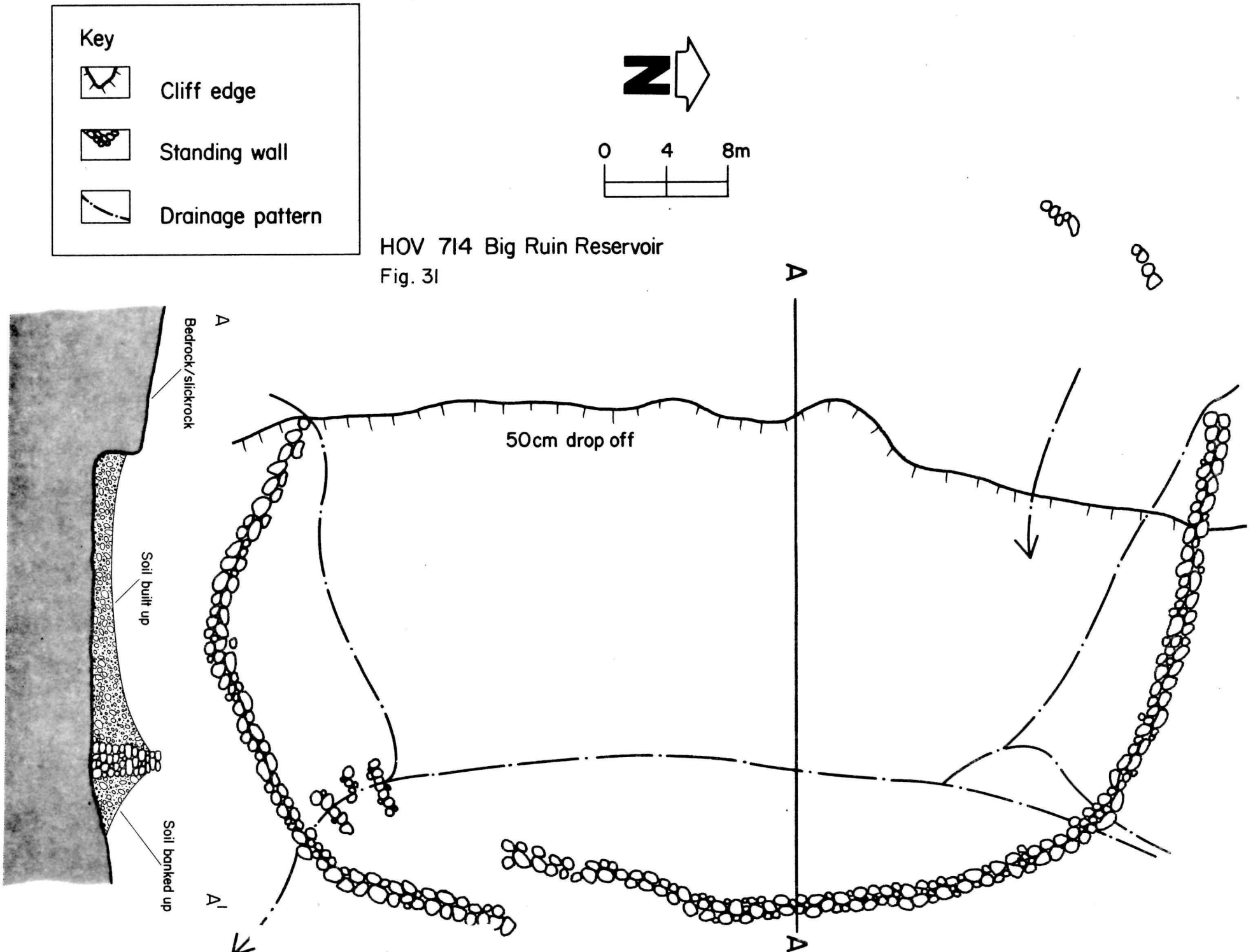
Fig. 30

with at least one meter of silt banked up in front of the ninety meter long, curving dam. It still functions to hold back water and soil, so for weeks after a large storm rushes and other mesophytes thrive in the moist sediments. Corn pollen was found in the bank, along with cheno-am, Cyperaceae, ground cherry, wolfberry, cattail and unidentifiable solanaceous pollen.

An even larger earth and rock dam was discovered at the eroded Hov. 714 tower complex, on an isolated spur above Cow Canyon. The impoundment device is completely intact (Figs. 31-32). It consists of a 120 meter long arc of rough masonry, several check dams or gates, and a double wall outlet. A similar large reservoir (Hov. 554) was found on a slickrock area several kilometers south of Square Tower, while much smaller earth and rock dams occur at the remaining sites. One is a two meter high and broad bank stretching across a wash several kilometers to the west of Hov. 554, in association with the Hov. 617 site tested by Matheny (1964). Hov. 617 is a complex of towers, roomblocks and catch basins perched on a rocky outcrop by a spring in the sage zone, and it is the only mesa top Pueblo III tower complex known on the mesa. Immense piles of rough sandstone blocks occur on either side of the reservoir, laid out in possible roomblock patterns. The piles do not appear to have been actual living sites, however, since no walls were ever built and artifacts are nonexistent, but they could represent stockpiles of building rocks prepared for the construction of several large roomblocks. Prudden (1903, 1916) noted that canyonhead sites often consist of large roomblocks on either side of a wash with a reservoir running between them, and the canyonhead clusters at Square Tower, Holly and Hackberry House include roomblocks separated by large rim dams.

The remaining reservoirs are two small earth and rock impoundments (Hov. 456 and Hov. 599) to the northeast and southeast of Cajon Ruin, a talus impoundment below a cliff in Cross Canyon (Hov. 665), and a possible reservoir below the cliff at Painted Hand (Hov. 600). The latter structure (Fig. 33) could also be the remains of a Great Kiva or a springside impoundment tank.

Many of the Anasazi reservoirs at Hovenweep probably served dual purposes. They obviously held water throughout


Key
Cliff edge
Standing wall
Drainage pattern
N
0 4 8m
HOV 714 Big Ruin Reservoir
Fig. 31
A
A'
Bedrock/slickrock
Soil built up
Soil banked up
50cm drop off

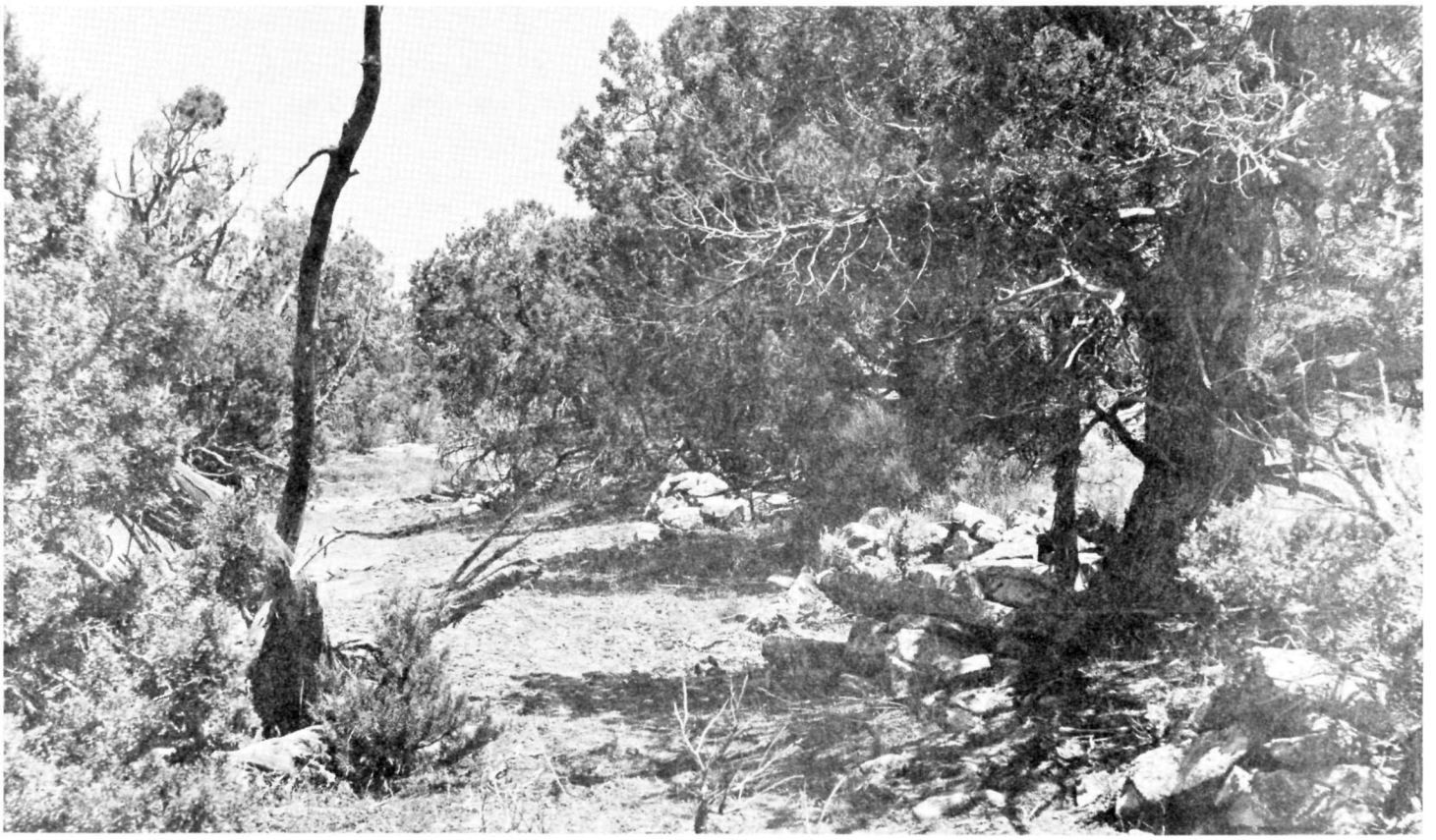


Figure 32. Portion of reservoir wall at Hov. 714. Compare with Fig. 31.

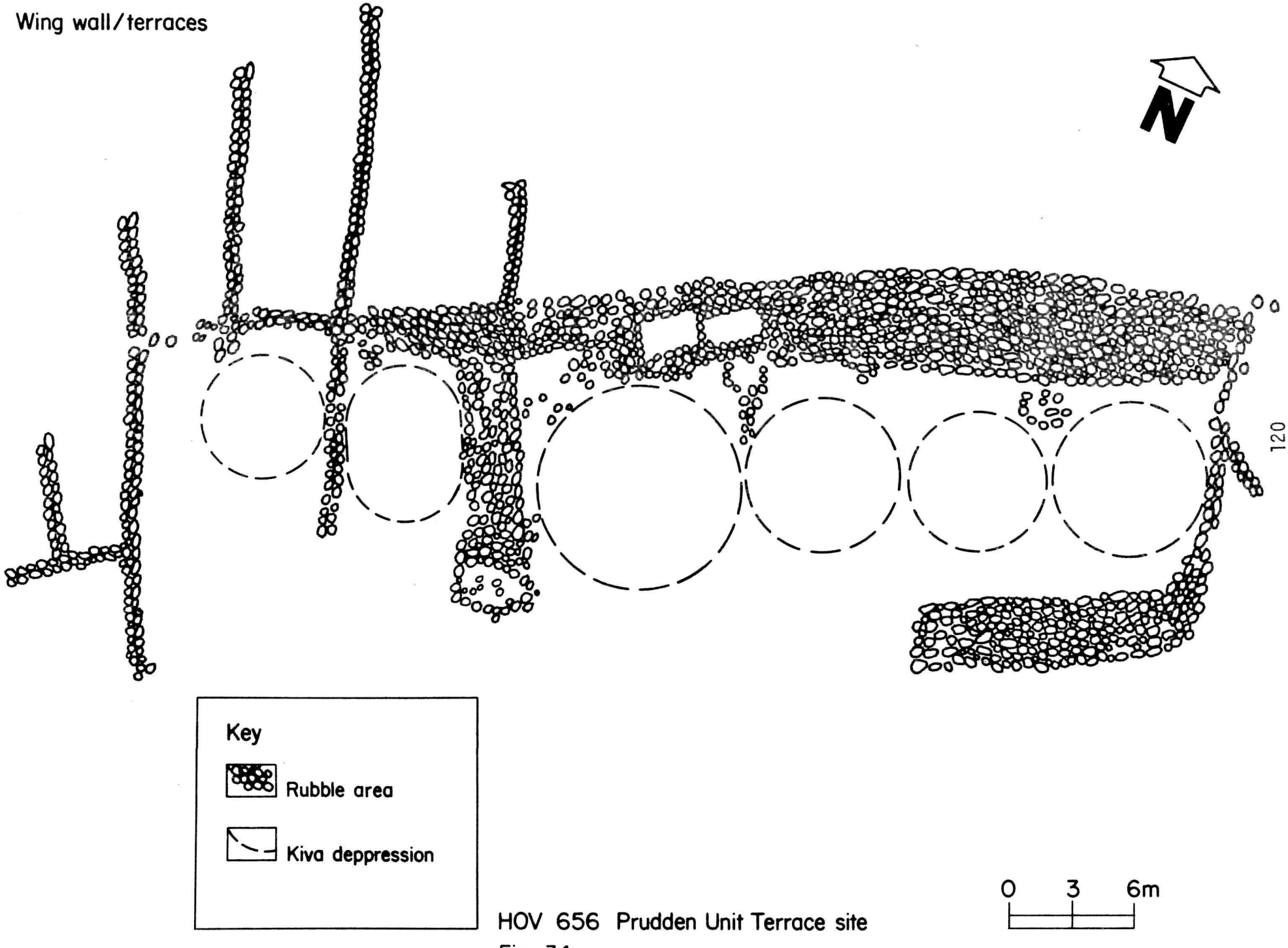
Figure 33. Possible reservoir at Hov. 600 (Painted Hand). Note arc of rocks attached to massive boulders.

much of the year, and probably served domestic needs, such as water for drinking, adobe mud and laundry. The pollen of corn and potential semi-cultigens were found at four of the tanks (Hov. 456, Hov. 513, Hov. 535 and Cajon Lake), so agricultural uses may have been involved as well. Water for pot irrigation may have been taken from them, and as the pots became contaminated in nearby irrigated fields the pollen would have been brought back to the lakes. It is also possible, however, that fields grew along the edges of the reservoirs and received seepage and overflow during floods, much the same as do the Hopi gardens which are planted around reservoirs served by springs. Certain of the reservoirs are also located above springs, so they may additionally have functioned to increase percolation in the underlying aquifer, as earlier suggested for rim dams.

8. Mesa Top Terraces

The final probable water control device at Hovenweep is the mesa top terrace, which is not used by the Hopi or Zuni. Two large multiple unit pueblos were mapped with this feature (Fig. 34). One site (Hov. 656) is situated in an extremely dense area of pueblos which include several of the "Unit Pueblo" type sites excavated by Prudden (1914, 1916). They were relocated through the use of high altitude black and white photos provided by the United States Soil Conservation Service, in which the pueblos stand out clearly as large open glades of sage in the midst of pinyon forests (Fig. 35). In the next section we discuss the probable relationship between the thick sage stands around these sites and post-abandonment successional patterns.

Hov. 656 consists of five possible kiva depressions, at least one tower, a massive roomblock and several middens, along with the terrace system. One smaller pueblo stands in the same glen, while six units are clustered in a much larger glade located approximately one kilometer to the southeast. The area has not been surveyed, but the presence of so many large pueblos in such a limited area, with permanent water located less than .5 kilometers to the northeast (Risley's Spring), suggests that several large farming communities may have existed in the area in Pueblo II and Pueblo III times. At least two of the eight sites also have terraces, consisting of extensive masonry grids abutting



HOV 656 Prudden Unit Terrace site

Fig. 34

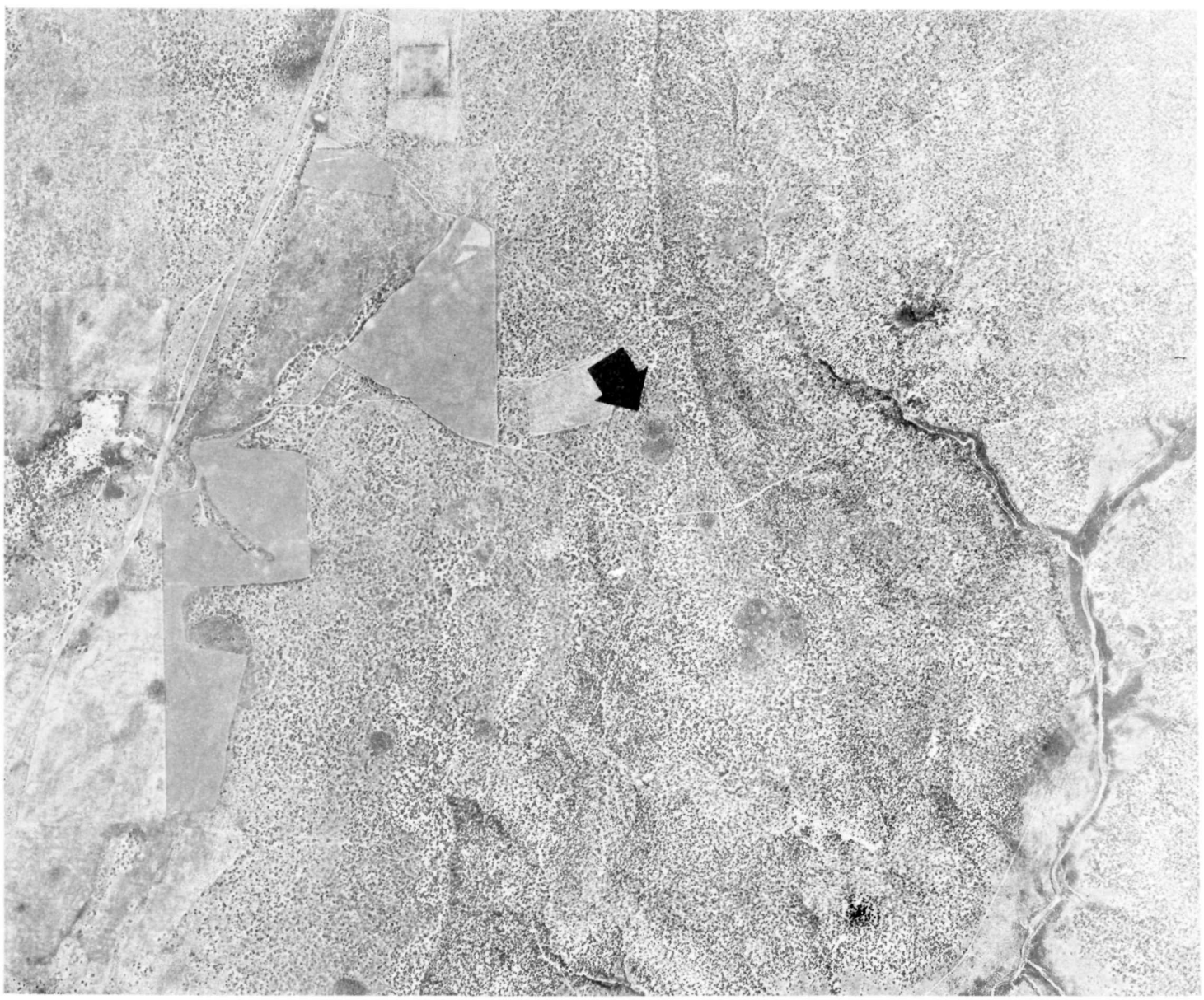


Figure 35. Aerial view of Hov. 656 (see arrow) and nearby sites. Note the sage (Artemisia tridentata) parks around the sites and the surrounding pinyon-juniper forests. Compare with Figs. 34, 38 and 42.

onto the roomblocks. Each grid is composed of several connected rows of masonry piled several courses high. They do not appear to have been habitation, storage or other wing-wall rooms, however, since jacal, rubble and artifacts are absent. A similar terrace was mapped at Hov. 643, which is a large unit pueblo located approximately six kilometers to the north on the rim of Big Ruin Canyon. This type of terrace has not been described elsewhere in the Southwest, but on the basis of pollen evidence it appears that it may have been a pot irrigated garden for growing early corn and vegetables, and perhaps even dye plants and tobacco. Corn, bean , chenoam, milkweed and unidentifiable solanaceous pollen were found in two terraces at Hov. 656. The devices could thus have been similar to the Hopi springside terraces, except that in this case the spring was located a kilometer away and water had to be hauled in, rather than diverted by ditches. Gardening experiments run this past summer (section III.1.d) demonstrated that isolated plots are especially vulnerable to the local berbivores, so the farmers may have decided that the laborious task of carrying water from distant springs was worth it in terms of protecting the plants from certain destruction by pests. The gardening experiments also yielded similar unidentifiable solanceous pollen, which we suspect came from wild tobacco (Nicotiana attenuata) and/or wild tomato (Solanum triflorum).

Both have extremely restricted distributions on the mesa, since they only grow as weeds on the Lowry Ruin experimental garden, which is also a location where the unidentifiable solanaceous pollen was found, along with Physalis pollen. Both could also have been grown at Hov. 656 and the seven other sites where the unidentifiable pollen was found, in much the same way that they are manipulated in Hopi or Zuni gardens, along with ground cherry, beeweed and other desirable weeds.

III.1.B FLORAL INDICATORS OF FARM FIELDS

By Joseph C. Winter and William J. Litzinger

The economy of the Pueblos is based as much on the manipulation of plants as it is on soil and water exploitation. The domesticated species, particularly maize, are obviously the most important manipulated plants, but many of the weedy and wild species are also very useful. They provide food, construction materials, medicine and ritual items, and also serve as sensitive indicators of soil and water conditions which are carefully interpreted by the Indian farmer. Since wild and weedy plants were also probably important to the Anasazi, we are utilizing the contemporary vegetation of Cajon Mesa in our reconstruction of the prehistoric Hovenweep economy. Three approaches are being used.

1. The overall network of potential resources is being identified by mesa-wide floral studies. The resources may have changed since the end of the 13th century, of course, but a modern analysis can still reveal important environmental relationships. Both off-site and on-site flora are relevant. Many Anasazi farming activities may have taken place some distance from the actual fields, or been dependent on floral patterns in distant locations. Live brush, for example, is often collected to plant as windbreaks around Zuni corn fields (cf. Cushing 1920; Bohrer 1960), while flood water fields are dependent on plant cover and run-off rates in drainage areas several kilometers from the fields. A mesa-wide study of existing as well as past resources is therefore underway. Existing community boundaries and species composition have already been determined; analyses of the productivity of different zones, variations in seasonal availability, and the effects of grazing and other post-abandonment disturbances are currently underway. The identification of past resources cannot be completed until floor pollen, flotation samples, and faunal remains are collected this summer, but the flora and pollen of the water control sites has already yielded important information. Existing floral resources are discussed in section 2A of this chapter, while section 2B examines the faunal resources and Appendix III is an annotated plant list.

2. The second justification for studying modern environmental relations is that vegetation can be used as a convenient yardstick of the determinants of farm site location. Soil types, water sources and physiographic variables are especially critical site determinants which are reflected by floral composition. Camilli discusses this in section 1F, where she points out that plant cover allows us to understand certain of the environmental constraints placed on the location of archeological sites, including water control devices.

3. The final reason for studying the modern flora is that certain vegetation patterns may have developed as a result of past farming activities and related anthropogenic disturbances. On-site floral distribution can therefore serve as a guide in understanding the prehistoric behavior responsible for the presence of particular species. This approach is discussed in detail below.

Background

The fact that vegetation is often distinctive on Indian ruins has been recognized for nearly a century (cf. Dall 1877; Jepson 1909). On-site floral patterns in a variety of environments have been studied, leading many ethnobotanists and archeologists to conclude that the presence of exceptional soil conditions, the creation of open habitats, or perhaps even past use of the plants are responsible for the modern distribution (Bank 1953; Brown 1936; Chikishev 1965; Clark 1968; Dall 1877; Dimbelby 1967; Gilmore 1931; Helbaek 1966, 1969; Hrdlicka 1937; Jepson 1909; Kearney and Peebles 1942; Lundell 1939; Meigs 1938; Mosley 1931; Prudden 1916; Struever 1962; Welsh and Moore 1968; Yarnell 1964, 1965; Zeiner 1946).

The relationship between plant growth and aboriginal man has been especially noticeable in the Southwest, where it appears that the distributions of certain species almost certainly resulted from past Indian activities. Archeologists who have been interested in this relationship include Prudden (1916), who noted that large rubble mounds in the pine forests on Cajon Mesa usually occur in sage-filled glades, and Rohn (1963) who observed vegetation patterns on

the Far View Ditch system at Mesa Verde. Botanists interested in the problem include Whiting (1939), who commented on the weedy species which grow around Hopi villages, and Kearney and Peebles (1942) who concluded that beeweed (Cleome serrulata) was introduced into the Southwest in prehistoric times. Ethnologists have also taken note of plant patterns in the Southwest (cf. Forde 1931; Beaglehole 1937). Bradfield (1968, 1969, 1971), for example, found that plants around the Hopi villages are excellent indicators of the agricultural potential of soils. He did not examine the question of past manipulation, but he nevertheless recognized, as do the Hopi, that "the plant cover presents a palimpsest of its past agricultural use, to be read as best we are able" (1971: 16).

The most complete study to date of on-site plant distribution in the Southwest is Yarnell's (1965) examination of vegetation patterns at Bandelier National Monument in New Mexico. Twenty-one species had "significant" distributions, so he concluded that the presence of at least eight had resulted from past use and perhaps even prehistoric introduction. Clark (1968) went on to test Yarnell's conclusions at Walnut Canyon in Arizona. While he agreed that certain species are unique to archeological sites, he disagreed about the reasons for their presence. Yarnell had suggested that the on-site growth of wolfberry (Lycium pallidum) is due to past use; Clark, in contrast, argued that favorable soil conditions and open habitats are the primary distributional factors.

Based on Yarnell's (1965) theory that certain species reflect prehistoric use, the on-site and off-site floral patterns at Hovenweep have been analyzed to determine if functionally and temporally different sites have unique vegetation distributions. If Yarnell is correct, a dense cover of ground cherry (Physalis hederaefolia) or wild tomato (Solanum triflorum), for example, could indicate that a site was used as a farm or similar location where plant manipulation occurred. These and other species are often semi-cultivated by the Hopi and Zuni (cf. Whiting 1939; Stevenson 1915); they also have abnormal distributions on sites in Yarnell's study area. The Pueblos, in fact, actively manipulate sixteen species of wild plants through semi-cultivation and encouragement (Table 20). They may also have indirectly altered over fifty species through selective management (Table 21). The

TABLE 20

Semi-Cultivated And Encouraged Pueblo Plants *

	Tewa	N. Tiwa	S. Tiwa	Towa	E. Keres	W. Keres	Zuni	Hopi
Nicotiana attenuata (Wild tobacco)	S		S				S?	S
Nicotiana trigonophylla (Wild tobacco)								S
Solanum jamesii (Wild potato)								SE
Solanum triflorum (Wild tomato)						S		S
Physalis longifolia (Ground cherry)							SE	
Chamaesaracha coronopus					E?			
Rumex hymenosepalus (Dock)								S
Eriogonum jamesii (Wild buckwheat)								S?
Cleome serrulata (Beeweed)						S	SE	S?E
Monarda menthaefolia (Beebalm)								S
Martynia louisiana (Devils claw)								E
Typha angustifolia (Cat-tail)								S
Populus sp. (Cottonwood)								S
Salix sp. (Willow)								S
Clematis pseudoalpina (Virgin's bower)			S					
Rosa fendleri (Wild rose)			S					
Asclepias subverticillata (Milkweed)							S?	

Key: S - Semi-cultivated (planted)
E - Encouraged (not planted, but protected through weeding, irrigation, c
SE - Both semi-cultivated and encouraged

* Data and sources summarized in Appendix II and Winter 1974

TABLE 21

Managed Plants Of The Pueblos *

Abronia elliptica (Sand verbena) H **
Acanthociton wrightii H
Adenostegia wrightii H
Allionia coccinea (Umbrella wort) H
Allioniella oxybaphoides H
Amaranthus graecizans (Pigweed) H,Z,T
A. palmeri H
A. paniculatus H,Z
A. powellii Z
A. retroflexus T
A. torreyi H
Amelanchier pallida (Shadblow) H
Asclepias fasicularis (Milkweed) H
A. involucrata H
A. speciosa H
A. subverticillata H,Z
A. sp. H
Aster hesperius (Aster) Z
Atriplex canescens (Four-wing saltbush) H,Z,I,J,C
A. powellii (Orache) Z
Berberis fremontii (Holly grape) Z
Boerhaavia erecta H
Bouteloua eriopoda (Black grama) H
B. gracilis (Blue grama) H
Calamovila gigantea (Sand grass) H
Calochortus aureus (Mariposa lily) H
Celtis occidentalis (Hackberry) T
Chamaesaracha coronopus H
Chenopodium album (Lambsquarters) H
C. fremontii H
C. graveolens H,Z
C. incanum H
C. leptophyllum H,Z
Chrysothamnus howardii (Rabbitbrush) H
C. nauseosus H,Z,T
C. stenophylla H
Cirsium pulchellum (Thistle) H
Croton texensis H,Z
Cryptantha crassisepala H
C. jamesii setosa H
Cycloloma atriplicifolium H,Z
Datura meteloides (Jimson weed) H,Z,WK
Descurainia pinnata (Tansy mustard) H,Z,T,WK
Dicoria brandegii H
Echinocereus fendleri H
Ericoma cuspidata Z
Gaertneria acanthicarpa (Ragweed) Z
Helianthus annuus (Sunflower) H,Z,T
H. petiolaris H
Hilaria jamesii (Galleta grass) H
Hymenopappus filifolius Z
Juniperus monosperma (Juniper) H,Z,T
Linum puberulum (Yellow flax) Z
Lycium pallidum (Wolfberry) H,Z,WK,I,J
Mentzelia multiflora (Blazing star) H
M.pumila H,Z
Mirabilis multiflora (Four-o'clock) H,Z,T,WK
Muhlenbergia pungens (Purple hair grass) H
Opuntia arborescens (Prickly pear cactus) Z
O. comanchia T
O. hystricina H
O. lindheimeri EK
O. polycantha H
O. whipplei H,Z,T
Oryzopsis hymenoides (Rice grass) H
Padus melanocarpa (Chokecherry) T
Panicum barbipulvinatum (Panic grass) T
Phoradendron juniporinum (Juniper mistletoe) H
P. sp. H
Phragmites communis (Reed cane) H
Pinus edulis (Pinyon pine) H,Z,T
P. monophylla H
Portulaca oleracea (Purslane) H
Quercus utahensis (Utah oak) T
Reverchonia arenaria H
Rhus trilobata (Squawbush) H,Z
Ribes inebrians (Wild currant) H
Rosa arizonica (Wild rose) H

TABLE 21 cont'd

Rumex mexicanum (Dock) Z
Sarcobatus vermiculatus (Greasewood) H
Schmaltzia bakerii T
Solanum elaegnifolium (Trompillo) H,Z,WK,EK,I
Sphaeralcea angustifolia (Globe mallow) H
S. incana H
S. lobata T,Z
Sporobolus airoides (Alkali sacaton) H
S. contractus (Dropseed) H
S. giganteus (Giant dropseed) H
Stanleya albescens (Prince's plume) H
S. pinnata H,Z
Thelypodium wrightii Z
Tripterocalyx wootoni H,Z
Vagnera amplexicaulis (False solomon's seal) T
Verbesina encelicides exauriculata (Crown beard) H
Yucca angustissima (Broadleaf yucca) H,Z,T
Y. baccata (Datil yucca) H,Z,T,EK
Xanthium commune (Cocklebur) Z,T
X. saccharatum H

* Species which are consistently gathered in such a manner so that their genetic structures have probably been altered. Many other weeds, grasses and other plants were also probably effected by the foraging activities of the Pueblos

** Key and sources:
H Hopi (Whiting 1939)
Z Zuni (Stevenson 1915)
T Tewa (Robbins et al 1916)
WK Western Keres (Swank 1932)
EK Eastern Keres (White 1945,1962)
I Isleta (Jones 1930)
J Jemez (Cook 1930)
C Cochiti (Lang 1951)

genotypes of many of these species were undoubtedly changed by thousands of years of constant manipulation, thereby producing a complex of weeds which frequent gardens, middens, abandoned villages and old farm fields. Beeweed, wild potato (Solanum jamesii), wild tomato, ground cherry, wolfberry, jimson weed (Datura meteloides), wild tobacco (Nicotiana attenuata and N. trigonophylla), cattails (Typha angustifolia) and numerous grasses and other forbs are especially weedy species, and there is a good chance that many were introduced aboriginally from Mexico as manipulated plants along with the true domesticates.

The Pueblo horticultural strategy thus has an established relationship with wild plant manipulation. It is likely that this association began in the past, since many of the manipulated plants are adapted to culturally disturbed habitats. If this relationship in fact existed at Hovenweep the consistent occurrence of certain species on particular types of sites, such as water control devices, could be a very useful tool in inferring past site function. Farm sites, for example, would be expected to support stands of gardenside weeds, while nonplant manipulating sites, such as hunting stations and storerooms, should have normal plant distributions.

Methods

Five techniques were used to identify abnormal plant distributions:

1) Line transects and quadrants were initially set up to obtain an overall idea of species composition and community boundaries.

2) Extensive on-site and off-site plant counts were then run by the archeological crews as a regular part of the survey. The flora of 398 sites in fifty-nine survey areas (approximately 3000 acres) were examined, with the sites representing all culture periods from possible Paleo Indian and Archaic through Anasazi and Navajo.

3) Plant cover in forty-nine off-site control quadrants was also examined by the archeological crews so as to provide

a base-line of "natural" plant frequencies with which to compare the on-site cover. Each 50 x 50 meter off-site control quadrant was located as far away as possible from the nearest archeological site to minimize the effects of aboriginal disturbance.

4) Subsurface pollen samples were then taken from the 398 sites and from most of the control quadrants. These samples have served as independent tests, and have confirmed that our conclusions about past use and modern plant distribution are correct. The floral patterns have suggested, for example, that sites with large patches of wolfberry were once used as farms or farm-side villages where the plant grew as a weed. If this conclusion is valid, the pollen of wolfberry should occur in direct association with cultigen pollen at the site. As discussed in sections 1A and 1C of this chapter, such associations are present at many water control sites, along with heavy growths of wolfberry. Unique floral distributions and corn pollen associations are present for many other weeds as well.

5) Finally, experimental gardens have been established in five probable Anasazi field locations. Traditional Hopi crops and gardening techniques are being used, and in one area wild plants have intentionally been sown. The growth of garden weeds is an especially critical part of the study, since it enables us to observe how weeds behave on abandoned farms. If Yarnell's (1965) hypotheses are correct, certain weeds should continue to grow on the fallow fields in spite of successional patterns and thus serve as indicators of past use. Detailed discussion of the garden results are discussed in section 1D.

Data

Over 170 species were found growing on the 398 sites or in the control quadrants. Nearly one hundred additional species grow in neither location, so they have not been considered in the present study. Six off-site, off-quad species are considered, however, since their isolated occurrence on experimental gardens, Navajo fields and other special niches makes them relevant.

For analytical purposes, the 170 species have been grouped into fifteen categories. Each category is composed of species which commonly occur together or which are used very similarly by the Pueblos. While this lumping may mask patterns formed by the individual species, it summarizes an enormous amount of data and permits necessary organization. Important patterns still emerge, however, and when necessary the groups have been broken down to see how individual species are behaving. Only two on-site species, snakeweed (Gutierrezia sarothrae) and cheatgrass (Bromus tectorum), have been ignored, since they grow on almost every site and off-site quadrant, regardless of site type and environmental location. Table 22 lists the fifteen plant groupings, while Table 23 and Fig. 36 compare on-site with off-site distributions. Table 24 and Fig. 37 compare occurrences on particular types of sites.

The on-site/off-site comparisons on Table 23 are organized in four areas: 1) the number of control quadrants a category appears on; 2) the natural frequency on the control quadrants (total number of control quadrants divided into number of quadrants a category occurs on); 3) the number of archeological sites a particular category is found on; and 4) the expected natural frequency on sites. This last figure is obtained by multiplying the natural frequency times the total number of sites, thereby obtaining an estimation of the effect of the site on each plant category. Pinyon pine (#1 category), for example, grows on seventeen of the forty-nine control quadrants, which is a natural frequency of 34 percent. It also grows on 103 of the 398 sites, but is actually expected to grow on 135 sites (34 percent of 398). Fig. 36 presents the same data in bar graph form, where it can easily be seen that pinyon pine is under-represented on archeological sites, in comparison with what is expected on the basis of its natural occurrence on the control quadrants. This suggests that a site-related factor is at work, such as special soil conditions provided by the rubble, the dominance of another species, or the creation of open habitats. The table and graph similarly demonstrate that practically every category is under-represented or over-represented on archeological sites; possible explanations are presented in the following pages.

Table 24 and Fig. 37 compare the on-site data in terms of types of sites: water control sites, large rubble

TABLE 22 - Plant Categories And Species Lists

1. PINYON PINE

Pinus edulis Engelm. in Wisliz.

2. UTAH JUNIPER

Juniperus osteosperma (Torr.) Little

3. SAGE

Artemisia tridentata Nutt. (Big sage)
A. dracunculus L. (Tarragon)
A. ludoviciana Nutt.
A. frigida Willd. (Fringed sage)
A. bigelovii A.Gray

4. RABBITBRUSH

Chrysothamnus nauseosus (Pall.) Britt. (Big rabbitbrush)
C. pulchellus (A.Gray) Greene
C. depressus Nutt. (Little rabbitbrush)
C. viscidiflorus (Hook.) Nutt.

5. LOWLAND SHRUBS

Atriplex canescens (Pursh)Nutt. (Four-wing saltbush)
A. obvata Moq.
Grayia spinosa (Hook.) Moq. in DC (Hopsage)
Coleogyne ramosissima Torr. (Blackbrush)
A. confertifolia (Torr.& Frem.) S.Wats. (Shadscale)
A. truncata (Torr.) Gray
Sarcobatus vermiculatus (Hook.) Torr. (Greasewood)

6. TALUS SLOPE/CANYON RIM SHRUBS

Rhus trilobata Nutt. (Squawbush)
Quercus gambellii Nutt. (Gambel oak)
Fraxinus anomala Torr. ex S.Wats. (Single leaf ash)
Amelanchier utahensis Koehne. (Utah serviceberry)
Peraphyllum ramosissum Nutt. (Squawapple)
Purshia tridentata (Pursh) DC (Bitterbrush)
Ephedra Torreyana Wats. (Mormon tea)
Q. turbinella Greene
Cercocarpus montanus Raf. (Mountain mahogany)
Cowania mexicana Don. (Cliffrose)
Prunus virginia L. (Chokecherry)
Stanleya pinnata (Pursh) Britt. (Prince's plume)

7. ECONOMIC MESOPHYTES AND PHREATOPHYTES

* a. Populus balsamifera L. (Cottonwood)
P. fremontii S.Wats.
b. Salix exigua Nutt. (Willow)
c. Typha latifolia L. (Cat-tail)

8. OTHER MESOPHYTES AND PHREATOPHYTES

Phragmites communis (Trin) (Reedcane)
Ribes aureum Pursh (Golden currant)
Celtis occidentalis L. (Hackberry)
Scirpus americanus Pers. (Bulrush)
Polypogon monspeliensis (L.) Desf. (Rabbitfoot grass)
Tamarix pentandra Pall. (Tamarix)
Eleocharis acicularis (L.) R.& S. (Spikesedge)
Juncus tenuis Willd. (Rush)
J. longistylis Torr. (Rush)

9. RICE GRASS

Oryzopsis hymenoides (R.& S.)Ricker

10. OTHER GRASSES - see Appendix III; over forty species of grasses grow on the mesa

11. ECONOMICALLY USEFUL WEEDS WHICH ARE OFTEN MANIPULATED

a. Chenopodium album L.(Lambsquarters; introduced)
C. glaucum L.(introduced)
C. leptophyllum Nutt.

* a,b,c,etc. refers to species or genera identified individually on Tables 23-24 and Figs. 36-37

b. Amaranthus californicus (Moq.) S.Wats. (Pigweed)
A. graecizans L.
A. retroflexus L.
A. torreyi (A.Gray) Benth.

c. Rumex hymenosepalus Torr. (Dock)

d. Asclepias capricornu Woodson (Milkweed)
A. subverticillata (A.Gray) Vail

e. Helianthus annuus L. (Sunflower)
H. petiolaris Nutt.

f. Descurainia pinnata (Walt.) Britt. (Tansy mustard)

g. Sphaeralcea coccinea (Pursh.) Rydb. (Globe mallow)

h. Mirabilis multiflora (Torr.) Gray (Four-o'clock)

i. Cirsium neomexicanum A.Gray (Thistle)

j. Clematis ligusticifolia Nutt. ex T.& G. (Virgin's bower)

k. miscellaneous weeds not identified individually on Tables 23-24 and Figs. 36-37:
Mentzelia pumila (Nutt.) T.& G. (Blazing star)
Lepidium campestre (L.)R.Rb.
L. perfoliatum L.

12. GROUND CHERRY

Physalis hederaefolia (Gray) Waterfall

13. WOLFBERRY

Lycium pallidum Miers.

14. CACTI/YUCCA

Echinocactus whipplei Engelm.& Bigel. (Fishhook cactus)
Echinocereus coccineus Engelm. & Bigel. (Hedgehog cactus)
Opuntia hystricina Engelm.& Bigel. (Prickly pear cactus)
O. davisii Engelm. & Bigel. (Ragtail cactus)

O. polycantha Haw.
Yucca angustissima Engelm. ex Trel. (Narrow leaf yucca)
Mamillaria vivipara (Nutt.) Haw.
Y. baccata Torr.(Datil yucca)

15. MISCELLANEOUS PLANTS (all other plants found on archeological sites and off-site control quads)

Berberis repens Lindl.(Holly grape)
Cryptantha bakeri (Greene) Payson
C. fendleri (A.Gray) Greene
Balsamorhiza sagittata (Pursh) Nutt. (Balsamroot)
Chrysopsis viscida (A.Gray) Greene (Golden aster)
Haplopappus armerioides (Nutt.) A.Gray (Goldenweed)
Senecio longilobus Benth (Groundsel)
Tetradymia canescens DC.
Townsendia incana Nutt. (Daisy)
Wyethia scabra Hook. var. canescens W.A.Weber (Mules-ears)
Euphorbia fendleri T.& G. (Spurge)
Physaria australis (Payson) Rollins (Double bladderpod)
Erodium cicutarium (L.) L'Her (Filaree)
Astragalus biculcatus (Hook.) Gray var. haydenianus (A.Gray) Jones
A. utahensis (Torr.) Torr. & Gray
A. scopulorum T.C.Porter

Zygadenus paniculatus (Nutt.) Wats. (Death camas)
Abronia fragrans Nutt. ex Hook. (Prarie snowball)
Lupinus ammophilus Greene (Lupine)

Ipomopsis aggregata (Pursh) V.Grant (Scarlet gilia)
Plantago purshii Roem.& Schult. (Wooly plantain)
Erigonum densum Greene
E. lonchophyllum T.& G.
E. ovalifolium Nutt. var.purpeum (Nutt.) Nels.

Achillea millefolium L.(Yarrow)
C. gracilis Osterh.
Aster arenosus Blake (Dwarf aster)
Brickellia californica (T.& G.) A.Gray (Bricklebush)
Erigeron divergens T.& G. (Fleabane)
Stephanomaria tenuifolia (Torr.) (Wirelettuce)
Senecio multilobatus T.& G.ex Gray

T. spinosa Hook.& Arn.
Xanthium spinosum L. (Cocklebur)
Erysimum asperum (Nutt.)DC. (Wallflower)
E. robusta (Engelm.) Small
Corydalis aurea Willd.(Goldensmoke

Linum lewsii Pursh (Blue flax)

A. coltoni Jones
A. flexuosus (Hook.)Dougl.ex Hook.
A. nuttallianus DC.
Calochortus nuttallii Torr. (Sego lily)
Sphaeralcea angustifolia (Cav.) Don. (Mallow)
Oxybaphus linearis (Pursh) Rob.

Orobanche fasciculata Nutt. (Broomrape)
Leptodactylon pungens (Torr.) Rydb. (Granite gilia)
Delphinium nelsoni Greene (Larkspur)
E. inflatum Torr.& Frem.
E. microthecum Nutt.
E. umbellatum Torr.

Comandra umbellata (L.) Nutt.
(Bastard toadflax)
Penstemon angustifolius Nutt. ex Pursh
ssp. caudatus (Heller) Keck.
P. linariodies A.Gray ssp. coloradoensis
(A.Nels.) Keck.
Castilleja linariaefolia Benth.
Lomatium dissectum (Nutt.) Math.& Const.

Cordylanthus wrightii Gray
(Birdbeak)
P. barbatus (Cav.) Roth.
P. strictus Benth.
Castilleja chromosa A.Nels.
(Indian paintbrush)
Cymopterus bulbosus A.Nels.
L. grayi Coult.& Rose

NOTE : Six additional species were absent from both the sites and control quads, yet their occurrence on experimental gardens, Navajo fields and other isolated niches justifies their consideration

Datura meteloides Dunal. in DC.
(Jimson weed)
Nicotiana attenuata Torr. ex S.Wats.
(Wild tobacco)
Allionia choiysi Standl. (Umbrella wort)

Solanum triflorum Nutt.
(Wild tomato)
Cleome serrulata Pursh (Beeweed)
Solanum carolinense L. (Wild potat

TABLE 23

On-Site/Off-Site Plant Frequencies At Hovenweep

Category	Control Quad Frequency T = 49		On-Site Frequency T = 398	
	#	%	#	# expected
1. Pinyon	17	34	103	135
2. Juniper	35	72	307	287
3. Sage	32	65	281	259
4. Rabbitbrush	29	59	207	235
5. Lowland Shrubs	33	67	197	267
6. Talus/Canyon Edge Shrubs	27	55	265	219
7. Economic Phreatophytes/ Mesophytes	4	8	15	31
a. Cottonwood	4	8	7	31
b. Willow	1	2	12	7
c. Cat-tail	1	2	1	7
8. Other Phreatophytes/ Mesophytes	6	12	26	47
9. Rice Grass	30	61	200	243
10. Other Grasses	42	85	189	339
11. Weeds	33	67	167	267
a. Lambsquarters	3	6	10	23
b. Pigweed	0	0	2	0
c. Dock	1	2	11	7
d. Milkweed	5	10	21	39
e. Sunflower	6	12	10	35
f. Tansy Mustard	9	18	31	71
g. Globe Mallow	14	28	52	111
h. Four-o'clock	8	16	34	63
i. Thistle	5	10	21	40
j. Virgin's Bower	1	2	5	7

TABLE 23 cont'd

Category	Control Quad Frequency		On-Site Frequency	
	#	%	#	# expected
12. Ground Cherry	1	2	5	7
13. Wolfberry	9	18	80	73
14. Cacti/Yucca	38	77	241	307
15. All Other Plants	40	81	271	323

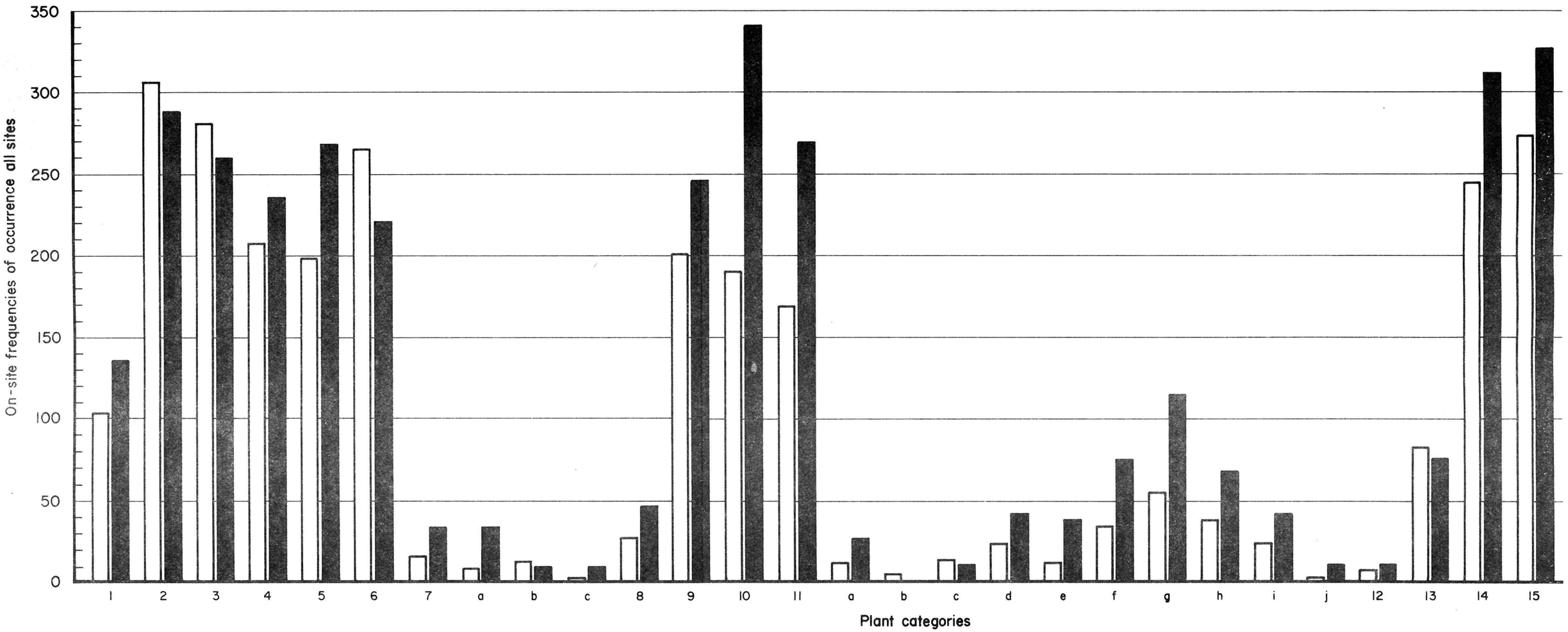

On-site frequencies of occurrence all sites
350
300
250
200
150
100
50
0
1
2
3
4
5
6
7
a
b
c
8
9
10
11
a
b
c
d
e
f
g
h
i
j
12
13
14
15
Plant categories
Actual occurrence
Expected occurrence

Fig. 36

TABLE 24

On-Site Occurrences By Type Of Site

Plant Category	Water Control Sites T = 68 (17%)		Rubble Mounds T = 43 (11%)		Small Sites T = 287 (72%)	
	#	# expected	#	# expected	#	# expected
1. Pinyon	15	17	10	11	78	74
2. Juniper	53	52	34	33	220	221
3. Sage	56	48	36	31	189	202
4. Rabbitbrush	44	35	24	33	139	149
5. Lowland Shrubs	43	33	22	22	132	141
6. Talus/Canyon Edge Shrubs	51	45	25	29	189	190
7. Economic Phreatophyte/ Mesophyte	10	2.5	2	2	3	11
a. Cottonwood	5	1.3	1	1	1	5
b. Willow	9	2	1	1.4	2	8.6
c. Cat-tail	1	0	0	0	0	1
8. Other Phreatophyte/ Mesophyte	15	4.5	4	3	7	19
9. Rice Grass	41	34	23	22	13	14
10. Other Grasses	32	32	28	21	12	13
11. Weeds	38	28	25	18	104	120
a. Lambsquarters	3	2	1	1	6	7
b. Pigweed	2	.5	0	0	0	1.5
c. Dock	3	2	0	1	8	8
d. Milkweed	8	6.5	2	2	11	15
e. Sunflower	5	1.75	0	1	5	7.25
f. Tansy Mustard	4	5	5	3.5	22	22
g. Globe Mallow	6	8.8	8	5.7	38	37
h. Four-o'clock	6	6	6	4	22	22

TABLE 24 cont'd

Category	Water Control Sites		Rubble Mounds		Small Sites	
	#	# expected	#	# expected	#	# expected
i. Thistle	10	4	0	2	11	15
j. Virgin's Bower	1	0	0	0	0	1
12.Ground Cherry	1	1	0	0	4	4
13.Wolfberry	30	13	19	9	31	57
14.Cacti/Yucca	47	41	22	27	167	173
15.All Other Plants	54	46	32	30	185	195

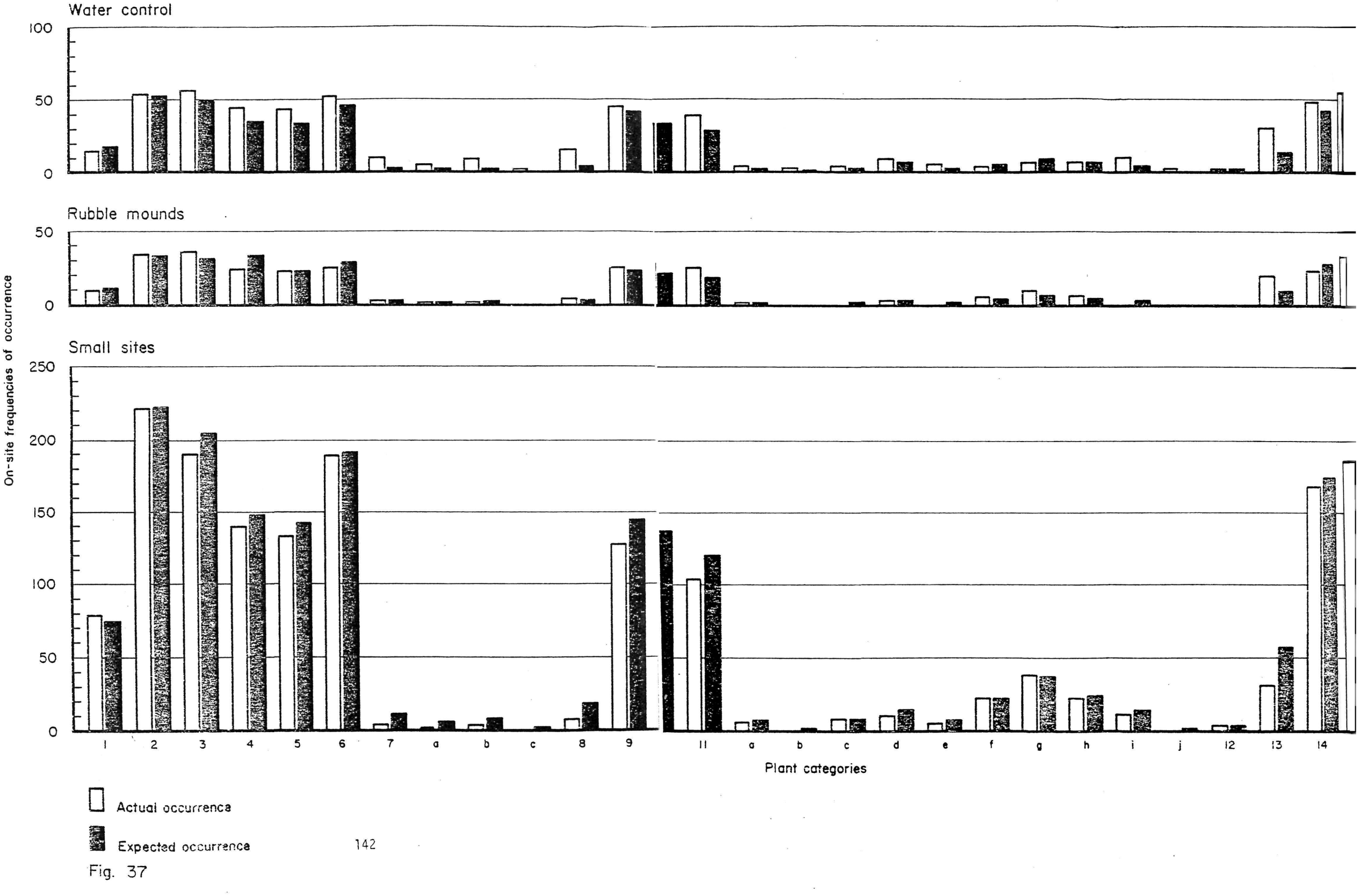

Water control
100
50
0
Rubble mounds
50
0
Small sites
250
200
150
100
50
0
On-site frequencies of occurrence
1
2
3
4
5
6
7
a
b
c
8
9
11
a
b
c
d
e
f
g
h
i
j
12
13
14
Plant categories
Actual occurrence
Expected occurrence

Fig. 37

mounds, and small sites. Water control sites include all sites with any structural evidence for water control, ranging from strings of small arroyo check dams and isolated reservoirs to massive multiple unit pueblos with rim dams, talus walls, and modified springs. Rubble mounds are any large ruin, such as mesa top Prudden Units and canyonhead tower complexes, which lack evidence of water control devices. Many rubble mounds have water control features (and are therefore listed under the water control group) so the two categories behave together in many respects. There are, however, certain important differences which emerge when the two are examined separately. Small sites include all other sites, such as lithic ceramic scatters, shelters, granaries, small roomblocks and Navajo ruins. Two hundred and eighty-seven sites (72 percent) are small sites; forty-three (11 percent) are rubble mounds; and sixty-eight (17 percent) are water control sites.

Fig. 37 and Table 24 match actual distribution of a particular category of plant on each site type, with expected frequency. The expected frequency is obtained by multiplying the total number of occurrences of a category on sites by the percentage of a particular site type. Pinyon pine, for example, grows on a total of 103 sites; since water control sites make up 17 percent of the total number of sites, while small sites make up 72 percent, it is expected that pinyon pine would grow on seventeen water control sites (.17 x 103) and seventy-four small sites (.72 x 103) if site type has no effect on plant growth. In fact, the actual frequency of pinyon pine follows quite closely the expected frequency, which suggests that type and size of site have little effect on the growth of this particular species. The low number of pinyon pine on sites in general therefore does not appear to be directly related to past functional activities. Rather, we have concluded that the dominance of species such as sage and rocky conditions are the prohibitive factor. Other plant categories behave quite differently, however, such as wolfberry (#13) which grows on a far higher number of water control and rubble mounds than expected, and on a lower number of small sites.

Interpretations

As demonstrated by the tables and figures, there is considerable variation in the frequency in which different plant categories grow on ruins. Many species are under-represented on sites, and some, while thriving on recently disturbed roadsides and in waste areas, rarely grow on ruins. The most prevalent pattern, in fact, is one of under-representation of the majority and over-representation by a few (sage, juniper and wolfberry). Inter-site patterning is also apparent, and while many species are under-represented on sites as a whole, they occur in much higher frequencies than expected on the water control and/or rubble sites. The smaller sites generally account for the over-all low representation.

The data are now discussed in terms of the significance of plant growth in relation to possible functional activities. Range, palynological and ethnobotanical information are presented when they are relevant, and when established relationships are present between certain plants and Indian usages. Appendix II is a detailed synopsis of ethnobotanical uses of the significant plants, while section 2A of this chapter is an in-depth discussion of the botanical trends.

I. Plants of No Apparent Significance

The growth of most plants on Cajon Mesa is not related to past uses of the ruins. The floral distributions are still informative, however, since they suggest certain post-Anasazi successional trends.

a. No significance, but over-represented on sites. Plants falling within this category include juniper, the talus/canyon edge species, and sage. The high on-site frequencies of juniper and the talus/canyon edge plants can be explained by the clustering of many sites in locations where these species grow naturally, rather than by past functional activities. Both of these categories are azonal on the mesa, in that they follow cliffs and canyons from one plant community to another. Many sites also occur on or near canyon edges (Table 25) so it is logical to expect a far higher number of these plants on-site than plants such as pinyon

TABLE 25 - Site Distribution By Physiographic Zone And Time Period

Zone	Paleo Indian	Archaic	Basketmaker II	Basketmaker III	Pueblo I	Pueblo II	Pueblo III	Navajo	Unknown
Canyon	1	10	6	7	23	82	85	20	63
Mesa	4	24	15	17	41	109	75	20	73
Total	5	34	21	24	64	191	160	40	136

Note: Less sites of each cultural period actually occur, but many are located at canyon/mesa edges and have been counted twice

pine which are restricted to a particular physiographic zone. The talus/canyon edge physiographic zone is also one of the most productive areas of the mesa in terms of small game and wild plant products, which may indicate that the plants in this instance were the determining factor for the location of the sites, rather than vice versa.

The other over-represented category is sage, which is especially common on sites of all types in the pine forests and rocky sites in all zones (Fig. 38). This pattern apparently represents a post-Anasazi successional trend, as first suggested by Prudden (1916) for this very region. He concluded that one of two factors could explain the predominance of sage on ruins in the otherwise dense pinyon forests: 1) sage invaded the large open glens in the forests which had been cleared of pine for the villages and fields; or 2) both pinyon and sage invaded the abandoned fields, but pinyon was unable to establish itself on the villages as a result of the past disturbances. We agree with Prudden that a post-abandonment successional pattern is probably involved, but we disagree about the sequence. As discussed in section III.2.A, it appears that the fields and ruins were recolonized first by sage, then more recently by juniper and pinyon. The conifers eventually succeeded in replacing sage on most of the old fields in the north, and today the only areas in the pinyon-juniper forests where sage predominates are the former habitation sites. (Erdman et al. (1969) and Martin and Byers (1965) outlined a similar successional sequence for Mesa Verde.) It is remotely possible that past use of sage on farms may also have been a factor, since the Zuni sometimes plant rows of sage and other shrubs as windbreaks around corn fields (Cushing 1920; Bohrer 1960). Sage is prevalent on all types of sites at Hovenweep, however, so past use is probably not a major factor. Rather, it appears that the rockiness of the rubble mounds and large water control sites is the main factor in the dominance of sage and the exclusion of other species, as suggested by Clark (1968). Soil moisture, temperature and textural conditions were probably changed by the rubble, thereby giving species which could not succeed well in open competition an adaptive advantage.

False tarragon sage (Artemisia dracunculus) is one of the plants unique to sites in Walnut Canyon, while Artemisia frigida and A. filifolia have a "doubtful significance" in

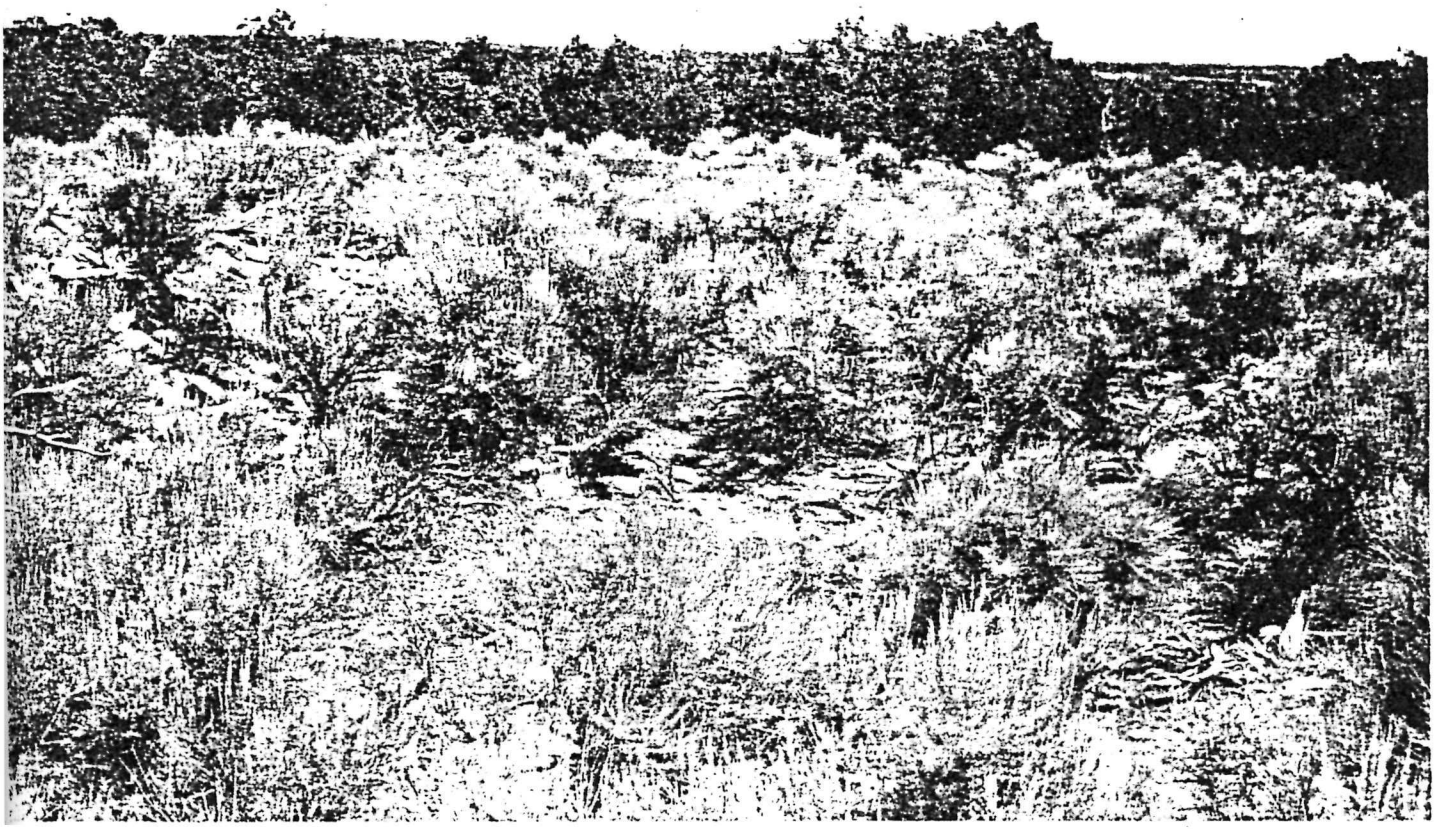


Figure 38. Close-up of sage (Artemisia tridentata) growing on rubble at Hov. 656. Note pinyon-juniper in background, and compare with Figs. 34, 37 and 41.

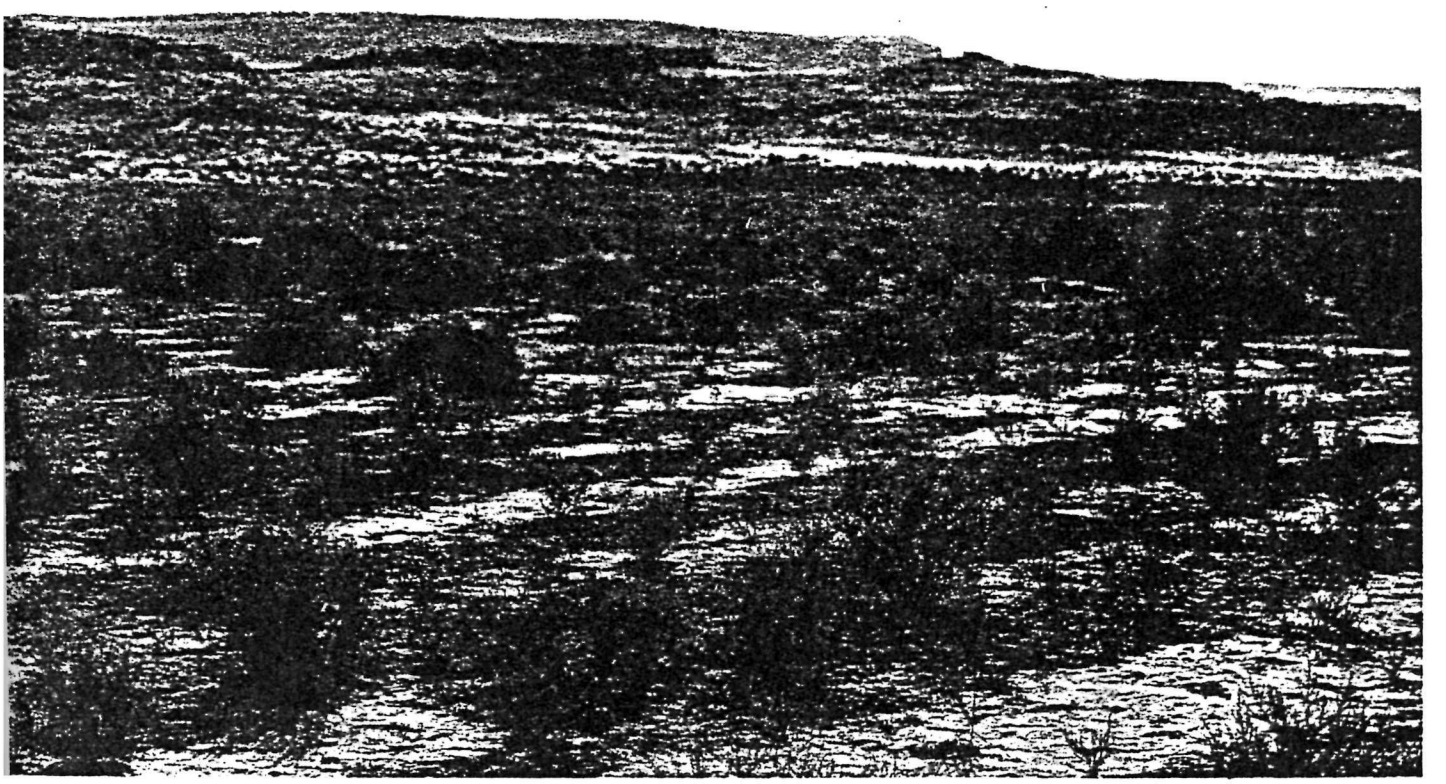


Figure 39. Greasewood (Sarcobatus vermiculatus) re-colonizing abandoned Navajo farmfields in Montezuma Canyon. Note how the greasewood grows along the old rows.

relation to on-site occurrence in Yarnell's (1965) New Mexican study area. Table 26 compares the on-site significance of these and other plants for all three study areas.

b. Under-represented species of no apparent significance. Plants occurring in this category include pinyon, the grasses, cacti/yucca and most of the miscellaneous species of category #15. Their low frequency in over-all terms is probably due to the dominance of sage, juniper, the talus/canyon edge species and wolfberry. In inter-site terms many of these species are somewhat more common on the water control sites and rubble mounds, which is probably the result of rockiness and unique moisture conditions.

II. Plants of Possible Significance Due to Past Use

a. Indicators of excellent farming soils and possible indicators of past fields. Plants in this category are rabbitbrush, greasewood and four-wing saltbush. All are under-represented on sites as a whole, yet occur in higher frequencies than expected on water control sites. All three are excellent indicators of agricultural soils, and the Hopi often gauge an area's potential on the basis of their height (Bradfield 1971). In the Oraibi Valley they grow well on alluvial sandy loams or clay loams which have two to four times the moisture retaining capacity of sand. Rabbitbrush and four-wing are also rapid recolonizers of abandoned farm fields in Oraibi Valley, while greasewood recolonized possible farms in Chaco Canyon (Beaglehole 1937; Bradfield 1971, 1969). Greasewood similarly recolonized abandoned Navajo fields in Montezuma Canyon at Hovenweep, as indicated by Fig. 39 which shows neat rows of greasewood now growing where maize was once raised. Greasewood, four-wing and rabbitbrush are therefore species which can be used in determining the locations of possible Anasazi fields, and their high frequency on water control sites is undoubtedly significant. Yarnell (1965), in fact, found that four-wing was one of the twenty-one species of "apparent significance" at Bandelier (Table 26).

b. Possible indicators of past farming activities and other disturbances. A diverse group of weedy annuals and perennials, phreatophytes and mesophytes makes up this category which could indicate the location of past fields,

TABLE 26 - Comparison of Significant Species At Three Study Areas

	Hovenweep		Bandelier			Walnut Canyon		
	no significance	possible significance	no significance	doubtful significance	apparent significance	off-site only	on-site only	both on- and off-site
SAGE								
Artemisia tridentata	x		x					
A. ludoviciana	x		x					
A. dracunculus	x		x				x	
A. frigida	x			x				
A. filifolia				x				
RABBITBRUSH								
Chrysothamnus nauseosus		x						
C. depressus		x						
C. viscidiflorus	x							x
C. parreyi				x				
SHRUBS								
Atriplex canescens		x			x			
Sarcobatus vermiculatus		x						
WEEDS								
Chenopodium album (introduced)		x?						
C. glaucum (introduced)		x?						
C. leptophyllum		x		x				
C. watsonii				x				
C. albescens				x				
Amaranthus californicus		x						
A. graecizans		x						
A. retroflexus		x						
A. torreyi		x		x				
Rumex hymenosepalus		x						
Asclepias subverticillata		x						
A. capricornu		x						
Cirsium neomexicanum		x						
Helianthus annuus		x		x				
H. petiolaris		x						

	Hovenweep		Bandelier			Walnut Canyon		
	no significance	possible significance	no significance	doubtful significance	apparent significance	off-site only	on-site only	both on- and off-site
MEDICINAL PLANTS								
Sphaeralcea coccinea		x		x				
S. fendleri				x			x	
S. parviflora				x				
S. digitata				x				
Mirabilis multiflora		x						
M. linearis				x				
TANSY MUSTARD								
Descurainia pinnata		x						
D. obtusa							x	
VIRGIN'S BOWER								
Clematis ligusticifolia		x		x				
COTTONWOOD/WILLOW/CAT-TAIL								
Populus balsamifera		x						
P. fremontii		x						
Salix exigua		x						
Typha latifolia		x						
GROUND CHERRY								
Physalis hederaefolia		x			x			
P. foetens var. foetens					x			
WOLFBERRY								
Lycium pallidum		x			x		x	
JIMSON WEED								
Datura meteloides		x			x			
WILD TOMATO								
Solanum triflorum		x			x			
WILD TOBACCO								
Nicotiana attenuata		x						

	Hovenweep		Bandelier			Walnut Canyon		
	no significance	possible significance	no significance	doubtful significance	apparent significance	off-site only	on-site only	both on- and off-site
UMBRELLA WORT Allionia choisyi		x						
BEEWEED Cleome serrulata					x			
WILD POTATO Solanum jamesii					x			
S. elaegnifolium					x			

middens and other disturbed areas. Only three (willow, pigweed and dock) occur with greater frequency than expected on sites as a whole, but all grow with greater frequency than expected on water control sites or rubble mounds. It should be noted that the actual occurrences both on-site and off-site are generally low, so sampling error may be a problem. Seven subgroups can be distinguished:

1) Economic weeds. All of the weeds in this group (lambsquarters, pigweed, dock, milkweed, thistle and sunflower) grow more frequently than expected on water control sites and generally less on small sites. Rockiness does not appear to be a factor, however, since none grow frequently on rubble mounds. These plants thrive in naturally disturbed moist areas, where many water control sites are also located, but past economic activities could also explain their presence, as indicated by pollen samples. Table 27 lists the water control and related sites where the pollen of various species occurred in direct association with cultigen pollen. The pollen of dock (Rumex sp.), milkweed (Asclepias sp.) and "chenoams" (Chenopdium sp., Amaranthus sp., Atriplex sp., and Sarcobatus sp.) were found in close association with corn, bean, squash and cotton pollen at a number of water control and granary sites. This evidence suggests that the weeds may have been growing around or on the old gardens, and perhaps were even manipulated. Dock (Rumex hymenosepalus) is semi-cultivated in small unirrigated plots by the Hopi, while milkweed (Asclepias subverticillata) may once have been manipulated by the Zuni (Appendix II). A. fasicularis also grows near reservoirs on the Hopi mesas, and several species of amaranths appear to have been manipulated by both the Hopi and Zuni. Several of the local water control sites still function in holding back moisture and soil, so it could be that these weeds have been thriving in the locations since the plants were Anasazi farms. (Fig. 29 shows milkweed, sedges, and other weeds growing on the Hov. 513 reservoir site.)

2) Medicinal plants. Although both four o'clock (Mirabilis multiflora) and globe mallow (Sphaeralcea coccinea) thrive in nonsite locations, they also prefer to grow on large rubble mounds over other types of sites. Rockiness may be a factor in their distribution, particularly with mallow, but it could also be that past use as medicinal herbs resulted in the deposition of seeds and their

TABLE 27

Pollen Associations Of Wild Plants With Maize

	Cleome sp.	*Asclepias* sp.	CHENO-AMS	CYPERACEAE	*Rumex* sp.	SOLANACEAE	*Lycium* sp.	*Physalis* sp.	*Typha* sp.
Water Control Sites With Corn Pollen									
Hov. 3		x	x	x	x	x	x	x	x
11			x	x					
49	x		x			x			x
* 53	x		x				x		x
61	x	x	x			x	x		x
70			x						
71			x						
345	x		x	x					x
366			x						
421	x	x	x						x
423	x		x		x	x	x	x	
424	x							x	x
426	x		x				x		x
437	x		x	x					
456	x		x	x			x		x
483			x	x					x
513			x	x		x	x	x	x
535	x		x			x		x	x
538			x						x
539									x
* 656		x	x			x			
Cajon Lake			x	x					x
Granaries With Corn Pollen									
Hov. 10			x	x					
* 367			x						
* 400	x		x	x			x		
* 455			x						
472	x		x						x

TABLE 27 cont'd

Middens With Corn Pollen	*Cleome* sp.	*Asclepias* sp.	CHENO-AMS	CYPERACEAE	*Rumex* sp.	SOLANACEAE	*Lycium* sp.	*Physalis* sp.	*Typha* sp.
Hov. 47	x		x	x		x	x		x

* Note: Bean pollen occurs with maize at sites 53, 367 and 656, while cotton pollen occurs with corn at site 400. Squash pollen occurs without maize at site 455.

subsequent growth around midden and town sites. Mallow is a common weed in disturbed areas around Hopi towns, where it is used as gum and a remedy for broken bones and bowel troubles (Fewkes 1896; Whiting 1939). It has also been found in an archeological context at Glen Canyon (Clark 1966; Martin and Sharrock 1964), and a closely related species (S. fendleri) grows only on-site in Walnut Canyon. Four o'clock has an even wider archeological and ethnobotanical distribution. Bohrer (1975) first noted its occurrence archeologically in New Mexico, where it appears to have been used as a food, and possibly as a medicine, by Archaic groups from approximately 1700 B.C. to 100 A.D. At Hovenweep, bundles of Mirabilis sp. roots were recently found in a burial salvaged by the Navajo Tribal Museum from a Pueblo III village at Aneth. The Pueblos use four o'clock as food, an appetite suppressant, medicine and an hallucinogen (Appendix II).

3) Tansy mustard. Descurainia pinnata has a slightly higher frequency on rubble mounds than expected. This distribution may be the result of the rocky, open habitats created by the sites, along with deposition in the middens after past use as food and paint. The species has been recovered from sites in Glen Canyon (Clark 1966), and the related D. obtusa grows only on-site at Walnut Canyon. Both the Hopi and Tewa use tansy mustard for food greens and pottery paint.

4) Virgin's bower. Clematis ligusticifolia has an extremely restricted occurrence on Cajon Mesa--one on-site and one off-site location. It may merely be a relict population, but the distribution could also have resulted from prehistoric use. The Southern Tiwa at Isleta grow a closely related species (C. pseudoalpina) as an ornamental while, C. ligusticifolia has "doubtful significance" at Bandelier.

5. Willow, Cattail and Cottonwood. All of these plants occur from 70 percent to 77 percent more frequently than expected on water control sites. Part of this distribution is undoubtedly due to the fact that many water control devices occur near seeps and springs where these plants naturally grow, but functional reasons may be involved as well. Many of the intact check dams, retaining walls and reservoirs still hold back moisture, thereby enhancing the growth of phreatophytes and mesophytes, as well as the weeds mentioned earlier. The pollen analysis is significant in this regard--

cattail, Cyperaceae (rushes and sedges) and maize occurred in association in a number of water control sites, granaries and middens. Their pollen also occurred in several granary/ midden contexts which lacked maize pollen. Cattail and Cyperaceae pollen are often waterborne, so their appearance in granaries and middens is suggestive of use as food. Cottonwood and willow pollen were also found in numerous water control sites, but they are windborne and can travel considerable distances. They are still considered important, however, since willow and cottonwood, as well as cattails, are Hopi semi-cultigens. All three are transplanted into washes near the villages for construction or food, while unspecified trees (probably cottonwood) are encouraged to grow around springside irrigated gardens to impede evaporation (Forde 1931).

6) Ground Cherry. One of the most important plants at Hovenweep is Physalis hederaefolia, which was found on five sites and one off-site location. It grows equally well on both water control and small sites, primarily in isolated patches along slickrock areas (Fig. 40).

Taxonomically the genus Physalis is puzzling, due to the integradations of the species. There has been considerable ethnobotanical confusion, and several of the close species have yet to be adequately differentiated. Certain authors separate Physalis fendleri from P. hederaefolia (Harrington 1964; Kearney and Peebles 1951; MacDougall 1962), while others recognize only P. hederaefolia (Waterfall 1958; Yarnell 1965). Waterfall's study is the most complete taxonomic analysis of the genus, so we have followed his practice of listing P. fendleri as a synonym of P. hederaefolia.

At Bandelier, both P. hederaefolia var. cordifolia and the close P. foetens var. neomexicana are "significant" plants. P. foetens grows infrequently off-site while growing on fifteen sites, as well as on the nearby Guisewa and Pa'ako ruins. P. hederaefolia similarly grows rarely off-site, and can be found on at least nine sites. Yarnell (1965) therefore concluded that the distribution of P. foetens is especially important, and he suggested that it may have been introduced aboriginally from Mexico where it is commonly grown as a condiment. Since Waterfall (1958) identified P. foetens var. foetens as "of Mexico," Yarnell concluded that

Figure 40. Ground cherry (Physalis hederaefolia) growing at edges of slick rock near Hov. 513 reservoir.

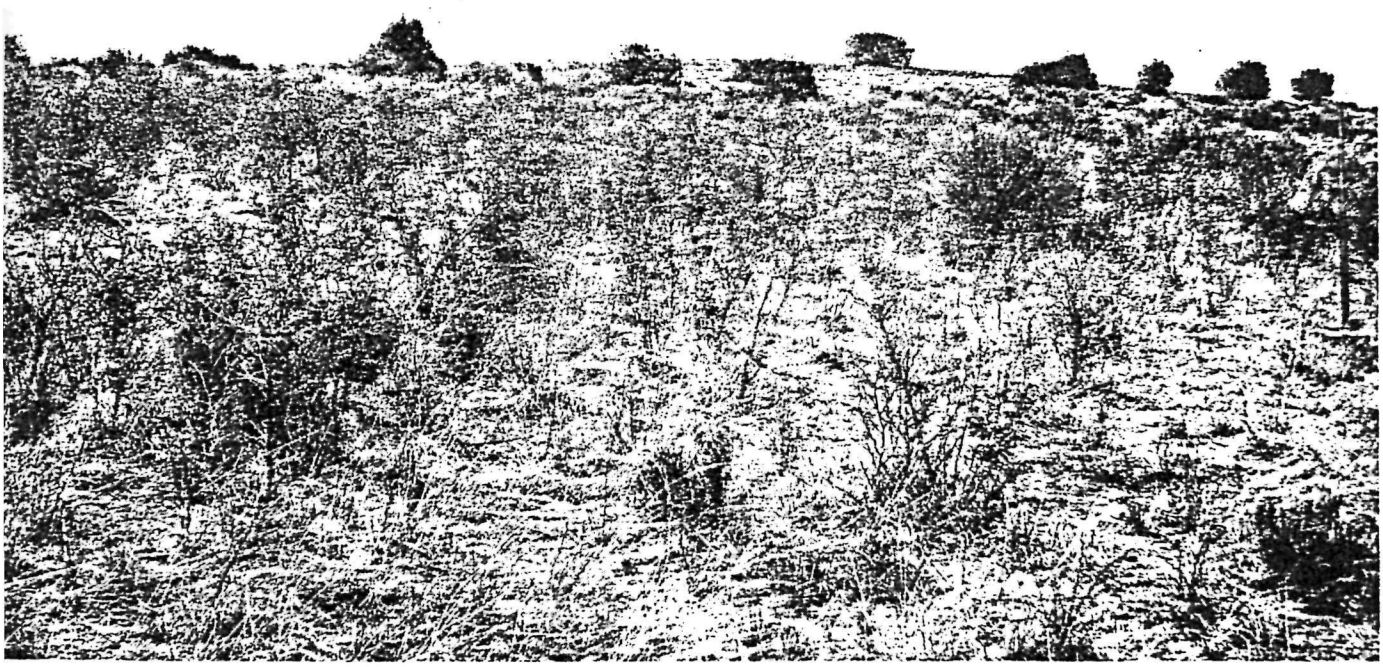


Figure 41. Close-up of wolfberry (Lycium pallidum) growing on the midden and rubble at Hov. 47. Compare with Figs. 35, 38 and 42.

the New Mexican form probably evolved as a result of the introduction of the species from the south. He added that its growth on off-site locations at Bandelier indicates that it has become relatively well adapted for competition.

The Zuni give both P. longifolia and P. hederaefolia the same name, and use both as condiments. P. longifolia is semi-cultivated in the irrigated waffle gardens, while other Pueblo groups gather one or another of the species in the wild. The Hopi, for example, used to eat the fruit of P. hederaefolia in famine times (Hough 1898; Whiting 1939), while P. foetens var. neomexicana is eaten by the Western Keres and Tewa (Swank 1932; Robbins et al. 1916). The seeds of P. foetens var. neomexicana have been found in Jemez Cave, while Physalis seeds of an unidentified species were noted at Mug House (Rohn 1971).

The distribution of P. hederaefolia on Cajon Mesa is very similar to that of P. hederaefolia and P. foetens at Bandelier, so both species may have evolved as a result of gardening activities. This conclusion is certainly supported by the pollen data. Physalis sp. and corn pollen occurred together at two check dam sites, one springside garden and two reservoirs. The plant is still growing around the two reservoirs, in fact, and it is possible that patches have been growing continuously on the sites since the 13th century.

7) Wolfberry. Lycium pallidum, which is sometimes called boxthorn, moquibush, desert thorn, squawberry, squaw-thorn, chico or tomatillo, is the plant with the best potential for serving as an indicator of Anasazi farms and middens at Hovenweep (Fig. 41 and Fig. 42). It grows far more frequently than expected on both water control sites and rubble mounds, but is relatively rare on small special use sites. The few patches which do grow away from sites are generally restricted to sheepcamps or talus slopes. Since the latter location could be areas where talus farming once took place, pollen samples were taken to see if crops had actually been grown on the slopes. No cultigen pollen, however, was found in off-site wolfberry patches.

Throughout the Southwest a pattern of on-site preference prevails. Wolfberry is very rare off-site at Bandelier, yet common on over twenty-five ruins. At Walnut Canyon it is restricted to on-site locations, and at Natural Bridges it

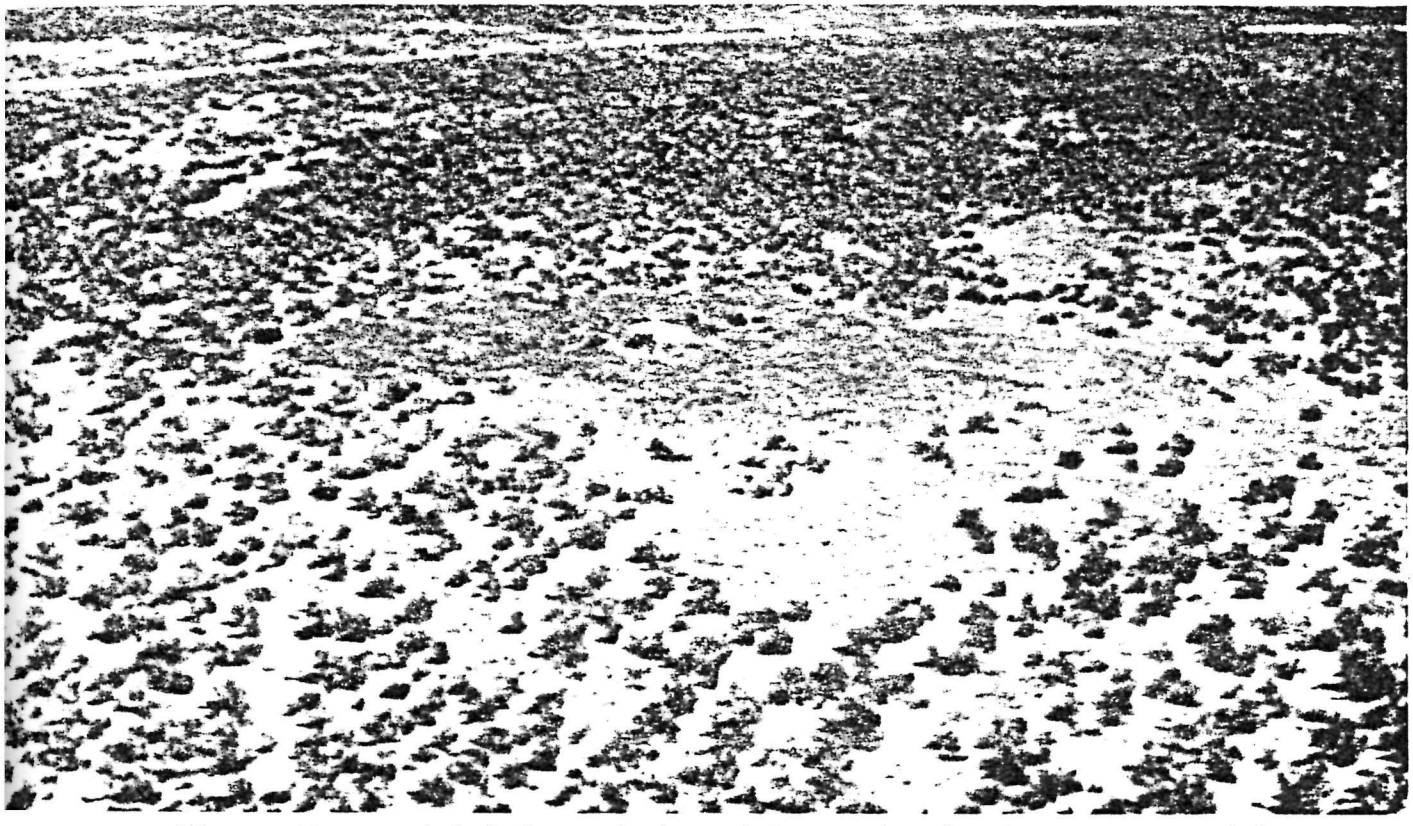


Figure 42. Aerial infra-red view of large site in the sage zone with wolfberry (Lycium pallidum) patch growing on it. Compare with Fig. 35 which shows a similar patch of sage around a site in the pinyon-juniper zone.

Figure 43. Close-up of jimson weed (Datura meteloides) at edge of Navajo farm field in McElmo Canyon. See Fig. 61 for aerial view of the field.

grows only in the vicinity of ruins (Welsh and Moore 1968). The plant is also common in Chaco Canyon, at Far View House on Mesa Verde and Puye (but not on the surrounding mesas), at Tsin Kletzin, at Puoje, and at ruins in the Rio Grande and Little Colorado valleys (Yarnell 1965).

Ethnobotanically the species has a widespread distribution, yet always in association with man (cf. Hitchcock 1932 and Bailey 1949 for the worldwide distribution of the genus). It grows commonly around the Hopi villages, particularly on talus slopes (Whiting 1939; Bradfield 1968, 1971). Both the Hopi and Zuni use it for food and a sacred object, and it is a food of the Western Keres, Isleta, and Jemez pueblos (Appendix II). The Aneth Navajo gather the fruit from the dense ruin patches as food and fodder. (A stand measuring 1200 meters square yields over 100,000 berries.)

Because of its on-site preference and ethnobotanical uses, Yarnell again (1965) concluded that Lycium pallidum was introduced into the Southwest from Mexico. Clark (1968) agreed that its Walnut Canyon distribution was significant, but rather than suggesting that past use was an agent in its dispersal, he argued that the rockiness of the sites provided a favorable locality for colonization. He did not, however, mention where the species could have come from, or what biotic factors may have led to its establishment.

The wolfberry on Cajon Mesa supports Yarnell's suggestions, since the botanical, historic and palynological data shows that the plant has probably been growing on the Hovenweep sites for over 700 years. Grazing certainly has not been responsible for its on-site growth; as early as 1892 Eastwood (1893) noted dense stands of Lycium pallidum scattered throughout the sagebrush on the mesa. The plant once grew on or near Anasazi gardens, as indicated by the occurrence of Lycium pollen in direct association with maize pollen at seven water control devices, one granary and one midden. Wolfberry thus has an extremely close palynological association with water control sites, and in fact the plant is still growing on six of the seven water control sites and the one midden in which its pollen occurred. It also grows primarily on Pueblo II and Pueblo III sites (Table 28) and rarely on earlier ruins, so it may have been introduced into the region relatively late, perhaps during a period of

TABLE 28 - On-Site Occurrence Of Wolfberry Compared With Cultural Period

Site Type	Paleo Indian	Archaic	Basketmaker II	Basketmaker III	Pueblo I	Pueblo II	Pueblo III	Navajo	Unknown
Single Component	0 *	1	0	0	2	9	7	5	
Multiple Component	1	5	1	10	25	41	39	3	
Total	1	6	1	10	27	50	46	8	10

* Number of sites of a particular cultural period and site type that wolfberry occurs on

resource stress when supplemental sources of food were necessary.

At present no explanation can be offered as to why L. pallidum could have maintained itself for so long in dense, island-like, on-site populations. The shrub is not greatly effected by heavy grazing, since its thorniness makes its leaves relatively impalatable, and by the time the plant is in fruit most of the local sheep have been moved to higher pasture. Even on the Navajo reservation, where year-round grazing takes place, the plants do not appear to suffer from grazing, and in fact dense patches of Lycium thrive around sheep corrals where the seeds are defecated. No other biotic factors seem to be involved in dispersing the plants off of archeological sites. Preliminary germination studies have shown that its seeds have a very low viability, so the islands of L. pallidum on archeological sites and in a few talus patches are probably its true niche on the mesa. Once the plant became established on the old fields and middens by gardening, it somehow was able to maintain itself over the competing native plants. One possibility that could account for this dominance is that Lycium produces bioactive chemicals which retard the germination of other plants in the densely populated stands.

III. Off-site plants of Possible Significance

Four species are completely absent on archeological sites and the off-site control quads. However, their growth in isolated niches, such as experimental Hopi-style gardens near ruins and Navajo fields makes them of special interest to the Project.

a. Jimson weed. Datura meteloides DC. has a definite nonrandom occurrence on Cajon Mesa: it can only be found on or near Navajo farms. The Navajo sometimes use it as an hallucinogen, so certain fields at the south end of the mesa have Datura plants scattered around their edges (Fig. 43). It also grows around recently abandoned hogans and corrals, but has never been noted on Anasazi sites or in undisturbed areas. This distribution contrasts with its range in other parts of the Southwest, where isolated patches of jimson weed often frequent Anasazi ruins. Yarnell (1965), in fact, stated that more than any other plant at Bandelier it

fulfilled the criteria of significance. It rarely grows off-site in his study area while occurring on ten sites, and has been found in archeological contexts in at least six areas (Yarnell 1959). In most regions it is not well-established in off-site locations, except along cliff bases and river terraces where the seed pods are borne by water. Yarnell therefore concluded that it was introduced aboriginally into the Southwest during the early Pueblo III period.

Datura is also used extensively by the Pueblos. It is a common weed around the Hopi towns, where it is used as a powerful hallucinogenic drug for curing and diagnostic visions (Appendix II). The Zuni also use it for medicine and visions, as do the Western Keres and certain eastern groups.

Several reasons could account for the absence of Datura on Anasazi sites at Cajon Mesa. First, it may have never been used by the inhabitants, and only recently been introduced by the Navajo. This is unlikely, however, since it was obviously used by other Anasazi in the Southwest and grows on sites in nearby regions, such as Comb Wash approximately sixty miles to the west. Seeds have yet to be excavated in controlled contexts at Hovenweep, but Eastwood (1893: 360) noted that "The seed pods are often found in the ruins of the ancient peoples who once filled the land and guarded every spring with towers of stone." It is more likely, therefore, that jimson weed was once used in the past, and that it could not survive locally on its own.

b. Wild Tomato. Solanum triflorum has a very restricted distribution on Cajon Mesa, since it grows only on the experimental Hopi-style garden at Lowry Ruin (Section III.1.D). It also occurs only in experimental gardens on Cedar Mesa. Elsewhere in the west it is an annual of waste areas from Canada to Arizona; it once grew as a weed on the gardens of the Mandan and Minitaries of the northern prairies (Yarnell 1965). It has a significant distribution at Bandelier, and has an established relationship with the Pueblos, so Yarnell (1965) again concluded that it was introduced from Mexico and tolerated or manipulated as a weed. The Hopi semi-cultivate it with melons as sympathetic magic, while the Zuni make it into a condiment (Appendix II). The Tewa of Robbins' time apparently did not use it, but it is a Western Keres famine

time food and is semi-cultivated with melons to aid their growth.

If Yarnell's conclusions are correct, the very restricted distribution of wild tomato on experimental gardens in the Four Corners region might indicate that the plant is limited to areas of prehistoric farm fields which have recently been disturbed. Its seeds are probably viable for decades, and can succeed in germinating and producing mature plants only when very special conditions are met. The winter of 1974-1975 was exceptionally moist, and the gardens were burned over, so it is possible that the seeds will germinate only when sufficient moisture and freshly disturbed soils are present. If it was manipulated as a weed around the prehistoric Lowry gardens it would have been restricted historically to very precarious niches around the old fields or middens, where it succeeded in producing a new generation only a few times each century. The appearance of the experimental garden and moist soils, however, provided exactly the type of disturbed, wet and perhaps burned over environment that it formerly thrived in as a manipulated weed. Its pollen has not been identified at any of the Hovenweep sites, but unidentifiable solanaceous pollen was found at eight sites. This may well be wild tomato or wild tobacco pollen, since unidentifiable solanaceous pollen also occurred in the Lowry garden samples, where both of these plants grow.

c. Wild Tobacco. Nicotiana attenuata's distribution on Cajon Mesa is identical to that of wild tomato: it grows only on the Lowry Ruin experimental garden. Elsewhere in the Southwest it generally occurs only in heavily disturbed areas, but neither Yarnell (1965) nor Clark (1968) found it in their study areas. N. attenuata and related species have commonly been manipulated by Indians throughout North America. The Hopi, Tewa, Southern Tiwa, and perhaps the Zuni, for example, semi-cultivate N. attenuata or the related N. trigonophylla (Appendix II). The domesticated N. rustica is grown by the Western Keres, Eastern Keres, Towa and Northern Tiwa, but this species was most likely introduced into the Southwest in historic times. Many other Southwestern and Basin peoples encourage wild tobacco through burning, irrigating, or even pruning (cf. Winter 1974: 113-117). Wild tobacco has been found in at least five southwestern archeological sites, including a Basketmaker III site in northern Arizona (Switzer

1969). Kroeber (1941) suggested that the use of tobacco was introducted from Mexico via the Gila River Valley, while Switzer (1969) argued for an introduction from Southern California.

Wild tobacco thus has a strong relationship with manipulation. Considering its use, history and Cajon Mesa distribution, the conclusions drawn about wild tomato can also be applied to it.

d. Umbrella wort. Allionia choisyi was found growing only in and around a Navajo garden at the south end of the mesa where it is manipulated as a medicinal weed. The Aneth Navajo use it for spider bites, while the Hopi use the related A. coccinea (Oxybaphus coccineus of Harrington 1964). The related Oxybaphus linearis grows on Cajon Mesa with no apparent significance.

IV. Significant Plants Which are Absent from the Mesa

Several species are practically unknown at Hovenweep. The presence of their pollen in association with corn pollen or the occurrence of very closely related species warrants consideration, however.

a. Beeweed. Although Kearney and Peebles (1951) and Yarnell (1965) suggested that Cleome serrulata was introduced aboriginally into the Southwest and perhaps manipulated, the species does not grow on archeological sites at Cajon Mesa. Instead, it is restricted to several isolated locations in the bottoms of the larger, well-watered canyons, and is absent even along roadsides in the pinyon-juniper forests.

Ethnobotanically, beeweed is one of the most widely used of the southwestern semi-cultigens. Both the Hopi and Laguna Pueblos manipulate it as a weed in corn fields, while the Zuni semi-cultivate it for pottery paint and food. The Eastern and Western Keres, Tewa and Southern Tiwa merely gather it wild for food, paint or medicine (Appendix II).

The absence of Cleome on archeological sites at Hovenweep is puzzling, especially since it commonly grows around the peripheries of ruins at Bandelier. It rarely grows on Mesa Verde, yet it is frequent in canyons and along roadsides

in the pinyon-juniper forests to the west on Cedar Mesa. Seeds or pollen have been found at Pueblo Bonito (Judd 1954), Mug House and Long House (Martin and Byers 1965; Rohn 1971), Glen Canyon (Martin and Sharrock 1964), Horse Flats (Brooks 1974), and several water control sites on Wetherill Mesa (Martin and Byers 1965). Yarnell (1965) therefore concluded that it was introduced from Mexico, but hasn't been in the Southwest long enough to become well adapted for competition in the open.

Although Cleome is presently rare on the mesa, the pollen data adds important details. Beeweed pollen was identified in eleven water control sites at Hovenweep, always in direct association with maize pollen. It was also found in samples from three granaries (twice with corn and once with cattails), and at one midden with corn, so it probably grew as a garden weed and was used for food. Similar conclusions about past manipulation were reached by Martin and Byers (1965) for Wetherill Mesa, where beeweed and corn pollen were found in two check dams, Mug House and Long House. Its pollen also disappeared along with maize pollen in the post-abandonment sediments, which suggests a symbiotic relationship with gardening activities. Schoenwetter (in Martin and Byers 1965: 131) noted that Cleome pollen predominated in the Long House samples just prior to abandonment, so he concluded that there was "an increase in use, perhaps as a starvation plant during the final phase of occupation." Beeweed pollen was also found with corn pollen in a probable gardening context at check dams at Horse Flats above Cedar Mesa (Brooks 1974).

b. Wild Potato. Solanum jamesii is an important economic plant which is semi-cultivated in Hopi farm fields and sometimes eaten with clay. The Zuni gather the related S. fendleri, while Tewa and other Pueblo groups collect S. jamesii or the related S. elaegnifolium and S. rostratum for food and medicine.

None of these species have significant distributions on Cajon Mesa. S. rostratum and S. elaegnifolium grow occasionally in disturbed locations, while the introduced S. carolinense grows at times on sites. S. jamesii grows elsewhere in Southern Colorado, however, and its absence at Hovenweep is probably the result of grazing.

Both S. jamesii and S. elaegnifolium are significant species at Bandelier; S. jamesii grows on the Towa ruins of Unshagi and Nonashagi, on Zuni ruin, in Chaco Canyon, and on Guisewa ruin. It is also abundant in the Kayenta Anasazi area (Yarnell 1965), and has been found at Betatakin (Judd 1930, 1954) and Pueblo Bonito (Yarnell 1965). Again, it seems to be another one of the solanaceous plants which was introduced from Mexico.

Conclusions

The most critical part of any program which is aimed at a study of prehistoric farming is the identification of the actual locations where horticulture took place. Once the gardens have been found the researcher can move to broader questions, such as the relations of the farms with habitation centers and hamlets, the growth and abandonment of the system, and the causes of variation in farm site position. The locating of farm fields is not that simple, however, since structural features are often absent, and even when present they do not constitute proof that a particular structure was actually a farm rather than a retaining wall for a room, a domestic water source, or a soil conservation device. One of the major goals of the Hovenweep Project has therefore been to independently verify the past use of particular sites as farms through palynology and analyses of the modern flora. The botanical studies have demonstrated that certain types of plants which are common around modern Pueblo farm fields or which are intentionally semi-cultivated are consistently associated with the Hovenweep water control structures, thereby increasing the probability that they were used as farms. The pollen data has added additional proof by demonstrating that certain of these plants once grew on or around the sites in association with maize and other domesticates. In fact, two plants (Lycium and Physalis) are still growing on the very sites in which their pollen was associated with maize pollen. The data therefore supports and amplifies the conclusions made by Yarnell (1965) concerning the past relations of these plants with the Anasazi, and demonstrates that floral composition can be extremely useful in determining the past function of an archeological site. Twenty-nine species have possible significance in terms of past Indian uses at Hovenweep (Table 26). Twenty-five of these grow on archeological sites and are suggestive of

prehistoric activities, such as farming, clearing of ground, conserving moisture and soil, making paint, collecting wild plant foods, and preparing medicine. The remaining four species occur only on modern Navajo fields or experimental gardens near Anasazi ruins. Two additional species do not grow at all on the mesa, but the presence of their pollen or their growth in nearby regions indicates that they may once have been locally important.

Three general types of prehistoric activity can be discerned on the basis of floral indicators and pollen: farming activities which occurred at water control sites; habitation-related activities which took place at rubble mounds; and all other actions which occurred at many different types of small, special use sites. Most of the garden-side weeds and potential semi-cultigens grow in greater frequencies than expected on water control sites, which suggests that they were once grown or tolerated as important weeds on the very sites where they now grow in abundance. Rubble mounds also support high frequencies of these and other plants, indicating that they were probably brought home from the fields and forests, processed, consumed and deposited to grow. Rockiness of the rubble sites also probably encouraged the growth of many of these plants, along with sage. Small sites, in contrast, have low to normal frequencies of most species, which is to be expected if the activitires which went on at the sites (e.g. hunting, storing and tool manufacturing) had very little effect on local plants.

III.I.C PRELIMINARY POLLEN ANALYSIS OF HOVENWEEP AREA ARCHEOLOGICAL SEDIMENTS

By Glendon H. Weir, Biology Department,
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Introduction

The archeological sediments examined in this preliminary report were collected from sites on Cajon Mesa during the summers of 1974 and 1975. Pollen sampling during 1974 and 1975 included collection of archeological sediments and modern pollen rain transect samples for comparative studies of the modern and fossil pollen rain. Pollen sampling planned for 1976 will include collection of controlled stratigraphic samples, atmospheric sampling of the modern pollen rain, and intensive sampling of pueblo floor surfaces. Other sampling will include basketry washings and pottery matrix scrapings for pollen associations as such material becomes available. Additionally, if available, human coprolites will be subjected to pollen and macrofossil analysis for possible clues to paleodiets and seasonality.

The pollen data thus collected will be analyzed for evidence bearing on 1) plant taxa (especially potential cultigens) which may have been utilized by prehistoric aboriginal groups of the region; 2) changes (if any) in specific plant taxa utilized through time; 3) vegetational changes in the area as reflected by the fossil pollen record; and 4) relationships of the modern pollen rain to the present flora and vegetation of the region.

Sampling Techniques

Collection of the eighty approximately 100 gram archeological sediment samples from a variety of site surfaces and test pits was accomplished using clean trowels which were rinsed

with distilled water and wiped after each use. Samples were collected in wind-free environments with no ambient dust contaminants and immediately placed in sterile polyethylene containers and sealed. Modern pollen rain transect surface samples were collected using a modified pinch technique (based on Hevly, Mehringer and Yocum 1965) and included: 1) selecting a sample area of about 100 feet in diameter; 2) collecting of about one gram pinch samples of surface sediments no deeper than one cm. while traversing the collection area in a random manner; and 3) sampling a total of no less than twenty-five subsamples from the area and mixing them in a sealed, sterile container to prevent contamination. All samples were then recorded in a field log and on attached tags, and included such data as site designation and location, plant associations and other essential information. Tags were then placed in an outer polyethylene bag and sealed with the sample. Photographs were taken of the sample area. During sampling care was exercised to avoid sample contamination from ambient pollen environments.

Extraction Techniques

The eighty archeological sediment samples examined for their pollen content were processed according to Horowitz's technique for extraction of pollen from arid land sediments (Horowitz 1975, personal communication to Dr. V.M. Bryant, Jr., Texas A & M University Palynology Laboratory). The Horowitz extraction technique minimizes the impact of low pollen concentration factors and permits the concentration of the available pollen with greatest efficiency. No colloids or insoluble precipitates were formed during processing in any of the eighty sediment samples. Extraction techniques consisted of two basic steps: first the removal of extraneous materials and then the concentration of the pollen in each sample. Samples were first premoistened and then passed through a series of screens with jets of distilled water and ethanol to remove particles of mineral or organic origin. The liquid fraction recovered beneath the screen series was processed according to a six-step procedure: 1) removal of carbonates with hydrochloric acid; 2) concentration of pollen through a swirl technique; 3) removal of silicates by hydrous hydrofluoric acid; 4) removal of nonpolliniferous

fine-grained material using a two-step zinc chloride heavy density separation method (1.96 and 1.65 specific gravity solutions); 5) removal of extraneous organic materials through acetolysis (Erdtman 1969); and 6) removal of charcoal where present with 10 percent potassium hydroxide treatment and additional screenings (using a 150 um. screen). Solutions were maintained at high acidic levels during steps 1) through 5) to avoid formation of colloids and insoluble precipitates. During the extraction procedure, great care was exercised to prevent pollen contamination of the samples.

Pollen Identification and Analysis

Identification of pollen grain types in this report are based on morphological comparisons with samples from the Texas A & M Pollen Reference Collections and with pollen reference material collected on Cajon Mesa during 1975. For this preliminary report pollen type frequencies only were recorded for the eighty archeological sediment samples. This consisted of recording each identifiable pollen grain type for each sample on tabular sheets and then estimating frequency of occurrence of each type for each sample, as summarized in Table 29. Pollen analyses of these and future samples also include standard 200-grain pollen counts for each sample (Barkley 1934; Faegri & Iversen 1975). Grains so badly crushed or deteriorated as to be unidentifiable, and fungal or cryptogramic spores were excluded from the pollen counts. Some few well-preserved pollen types not identified were included as unknowns.

Pollen recovered was sparse in less than 20 percent of the samples (i.e. not susceptible of 200-grain counts on a single sample slide). Sample H437 FS9 contained no pollen and of the sparse samples pollen counts varied from about 50 to 150 individual pollen grains. There are a number of reasons as to why some specimens contained abundant pollen while others contained lesser amounts or none. The pollen samples analyzed represented usually calcareous fine-grain alluvial sediments consisting mainly of sand, silt and clay size particles, from which small amounts of pollen had to be separated. Generally, the arid Southwest is characterized by low pollen concentrations in the soil. This is due to a relatively low density of plant coverage in arid environments;

TABLE 29

FOSSIL POLLEN TYPES AND FREQUENCIES

Key cf = compares favorably
1 = Present-sparse frequency
2 = Present-moderate frequency
3 = Present-high frequency

SITES: / POLLEN:	H3 FS7	H3 FS8	H3 FS9	H3 FS10	H10FS3	H11FS10	H11FS11	H12FS2	H47LC2	H47LC3	H49LC4	H49LC5	H49LC6	H53FS15	H53FS16	H53FS17	H57FS1	H57FS2	H61FS22	H70FS21	H70FS23	H71FS2	H71FS3	H71FS4	H71FS5	H71RS1	H71RS2	H345FS2	H366FS6	H367FS4	H379FS6
Cleome									1	1	1		1	1					1					1			1	1			
Cucurbita																															
Zea	1		1		2	1	1			1	1			1	1	1			1	2	1		1		1	1	1	1	1	2	
cfPhaseolus																															
Gossypium																														1	
cfAtriplex	2	1	2		1	2	1	1		1		1		2	1	2			2			2	1						1	1	
Sarcobatus		1	1			1			2	2		1	1									1									
COMPOSIT.(HS)					1				1	1	1		1										1	1		1	1			1	
COMPOSIT.(LS)	2	2	2		2		2		2	2	1	1	1	2	1	2			2	2	2	2	2	2	2	1	1	2		2	2
Artemisia	2	2	3	1	2		1		2	2	2	1	2				1	2	1			2		1	1	2	2	1	2	1	2
Liguliflorae					1				1																						
Quercus		1	1		1				1	1	1		1			1								1					1		
Juniperus	1	1	1		1			1	2	2	2	1	2	1		1		1	2					1		1	1	1	1	1	
Pinus	2			2	2	2	2	1	3	3	3	2	3	3	2				3	1	2	3	2	3	3	2	1	2	2	1	2
ROSACEAE	1	2	1		1	1		1	2	1	1	1	1						1			1			1	1	1				
cfRhus	1		1		1			1	2	1			1						1			1				1		1			
cfAsclepias		1	1																1												
Opuntia(Plat)											1	1	1													1					
CHENO-AM	2	3	3	2	2	2	2	1	1	3	3	1	2	3	2	2	1		2	1	2	3	2		1	2	1	2	2	2	2
CRUCIFERAE			1																			1									
CYPERACEAE			1		1	1			1	1																		1			
Ephedra(nev)		2	2	2	2	1		1	1	2	1	2	2	2	2	2			1	1	1	2	2	1	1	2	1	1	1	1	2
(torreyana)				1	1	1			1	1				1					1							1	1				1
GRAMINEAE	1	1	1	1	1	1	1	1	1	1	1		2	1		2	1	1	2	1	1	1	1		1	1	1	1	1	1	
LILIACEAE		1	1								1		1			1			1												
Yucca	1	1											1			1					1										
Eriogonum																															
cfRumex			1																												
RANUNCULACEAE						1															1			1							
Populus	1		1			1			1	1		1	1			1		1	1				1	1		1		1			1
Salix			1		1	1		1						1		1			1		1	1	1	1	1						
cfPenstemon			1		1																										
SOLONACEAE			1						1	1	1								1												
Physalis			1																												
cfLycium	1	1							1	1						1			1												
Typha(lat)		1	1						1	1			1	1					1										1		
Celtis	1	1							1				1			1			1	1											
Spores	1	1	1	1	1	1	1	1	2	2	3	2	2	1	1	2	1	1	2	1	1	3	1	1	1	1	3	3	2	2	1
Unknown									1	1												1	1		1		1	1	1		

TABLE 29 (contd. 2)

SITES:	H383FS4	H400FS1	H421FS2	H421FS3	H423FS5	H423FS6	H424FS7	H424FS8	H424FS9	H424FS10	H424FS11	H426FS1	H437FS8	H437FS9	H437FS10	H455FS3	H456FS4	H460FS2	H472FS3	H473FS10	H476FS3	H483FS1	H513CL1	H513CL2	H513CL3	H535LC1	H538WC1	H538WC2	H538WC3	H538WC4	H538WC5
POLLEN:																															
Cleome		1		1	1	1	1			1		1	1				1	1	1			1			1						
Cucurbita																1															
Zea		1	1	1		1	1			1	1	1	1				1		2			1	1		1	1	1			1	
cfPhaseolus		1										1																			
Gossypium																															
cfAtriplex		3		1		1		1				2	3		1	2		2		1		1	2	1	1						
Sarcobatus																			1				2	2	1	2	1	1	2		1
COMPOSIT.(HS)		1				1						1				1		1					1	1	1	1	1	1	1	1	
COMPOSIT.(LS)		1				2	1				1	2	2		1	2	2	2	1	2	1	2	1	1	1	1	1	2	1	1	1
Artemisia		3		1		2	1	1			1	2	1			2	2	2	3	2		2	1	1	1	2	1	2	1	1	1
Liguliflorae							1																1	1	1		1				
Quercus		1																1	1			1	1	1		1	1	1	1		1
Juniperus		1	1		1		2			1	1						1	1	2			1	2	1	2	2	2	2	2	2	2
Pinus	2		2	3	1	2	2			1	1	2	3		1	2	2		3		1		2	2	2	3	3	3	3	3	3
ROSACEAE										1									1				1	1	1	1	1	2	2	1	1
cfRhus																			1				1	1	1	1	1	1			
cfAsclepias				1																											
Opuntia (Plat)																	1							1	1						
CHENO-AM	2	2		3	1	2	2	2				2	3		1	2	2	3	2		1	3	2	2	2	3	1	1	2	2	2
CRUCIFERAE		1					1					1	1				1													
CYPERACEAE		1											1				1	1				1	1	1	1						
Ephedra (nev)	1	2		1		2	1					1	2			2	1	2	1	1	1	2	2	2	2	2	1	2	2	2	1
(torreyana)		1											1											1	1	1	1		1		1
GRAMINEAE	1	1	2	2		1	1	1		1	1	1	1			1	1	1	1	1	1	1	1	1	2	2	1	1	1	1	1
LILIACEAE							1										1		1				1			1					
Yucca		1															1						1	1		1					
Eriogonum						1	1																								
cfRumex						1	1																								
RANUNCULACEAE							1																								
Populus		1	1		1	1	1				1	1				1	1	1	1	1			1	1	1	1	1	1	1	1	1
Salix		2			1	1	1				1	1	1				1	1			1	1	1		1	1					
cfPenstemon										1																					
SOLONACEAE						1	1																1	1		1					
Physalis						1	1																1			1					
cfLycium		1				1						1					1						1								
Typha (lat)			1				1			1	1	1					1	1	1	1	1	1	1	1	1	1		1		1	
Celtis					1												1								1						
Spores	1	1	1	1	1	1	1	3	1	1	1	1	1		1	1	1	1	1	1	1	1	2	2	3	3	3	2	2	2	2
Unknown								1								1			1				1	1	1	1	1	1		1	

TABLE 29 (contd. 3)

SITES:	H538WC6	H539WC7	H539WC8	H539WC9	H539WC10	H539WC11	H539WC12	H539WC13	H539WC14	H539WC15	H656PS1	H656PS2	HCSpCH1	HWfPCC1	HWfPCC7	HLTGFS2	HLTGFS3	HLTGFS4
POLLEN:																		
Cleome																		
Cucurbita																		
Zea	1						1				1	1				1	2	2
cfPhaseolus											1							
Gossypium																		
cf Atriplex													1					
Sarcobatus	1		1	1	1	1	1	1					1					
COMPOSIT.(HS)	1	1		1	1	1	1	1					1	1	1	1	1	
COMPOSIT.(LS)	1	1	1	1	1	1	1	1	1	1	1	1	2	2	1	1	1	1
Artemisia	1	1	1	1	1	1	1	1	2	1		2	2	1		1	2	2
Liguliflorae		1	1				1		1							1	1	1
Quercus			1	1					1			1		1		1	1	1
Juniperus	2	2	2	2	2	2	2	2	2	1	2	2	2	2	1	2	2	2
Pinus	3	2	3	3	3	2	2	3	2	1	2	3	3	3	1	3	3	3
ROSACEAE	1	1	1	1	1	1	1	1		1	1	1	1	1				1
cfRhus											1	1	1					
cfAsclepias											1							
Opuntia (Plat)																		
CHENO-AM	2	1	1	1	2	1	1	1	2	1	1	2	2	3	1	1	1	1
CRUCIFERAE													1					1
CYPERACEAE																		
Ephedra (nev)	1	1	2	2	1	1	2	1	2	1	2	2	2	1	1	1	1	2
(torreyana)															1			
GRAMINEAE	1		1	1	1	1	1	1	1	1	1	1	1	1		1	1	2
LILIACEAE	1												1					
Yucca													1					
Eriogonum																		
cfRumex																		1
RANUNCULACEAE																		
Populus	1	1	1	1	1			1	1		1	1	1	1				
Salix													1					
cfPenstemon																		1
SOLONACEAE											1	1	1	1	1	1	1	1
Physalis																1	1	1
cfLycium													1		1			
Typha (lat)	1	1	1	1	1	1		1	1	1			1		1			
Celtis													1					
Spores	2	2	2	2	2	1	2	1	3	3	1	1	2	1	2	2	2	2
Unknown	1	1	1	1	1	1	1		1	1	1			1	1	1	1	1

prolonged exposure of the pollen rain on the surface to agents of chemical and mechanical weathering combined with increased bacterial and fungal activity; high summer soil temperatures leading to further oxidation and pollen degradation; and generally poor preservation of pollen in alkaline soils of the Southwest due to a high calcium carbonate content.

Preliminary Findings

The examination and analysis of the eighty archeological sediment samples from Hovenweep are preliminary and subject to further refinement from extended and continuing sampling.

Anemophilous (wind-pollinated) plants contribute most of the pollen found in modern and fossil deposits. Anemophilous plants produce great quantities of pollen and disperse it in the pollen rain. Some of the high frequency pollen types represented in Table 29, such as Pinus (pine) and Ephedra (jointfir) are representative of anemophilous plants, and appear to be an ubiquitous part of the pollen rain in this area in the past. Similarly, the relatively high frequencies of the Chenopodiaceae (CHENO-AM of Table 29), including Atriplex (saltbush, shadscale, hopsage) and Sarcobatus (greasewood) species; and the Compositae, represented by such species as Chrysothamnus (rabbitbrush), Ambrosia (ragweed) and Artemisia (sagebrush) may not have primarily cultural significance due to local overrepresentation in the pollen spectra.

The widespread presence of Populus (cottonwood) and Juniperus (juniper), pollen types not always well preserved in fossil states, as well as Salix (willow) pollen, may be indicative of aboriginal use in the specific areas from which these samples were taken. However, these pollen types (Populus and Juniperus) are easily airborne, and like Pinus and Ephedra may be carried some distance from their source. Nevertheless, the high degree of correlation between the occurrence of Populus, Juniperus and Salix may prove to have ethnobotanical significance apart from the ubiquitous pollen rain. The close association of Quercus (oak) pollen grains with Zea (corn) pollen in sixteen samples may provide, in certain cases, indication of seasonality in storage or consumption of the corn.

Other pollen types are likely to have been indicators of possible ethnobotanical usage. The eighty Hovenweep area sediment samples included forty-four samples consistent with Zea size range and morphology (as determined by phase contrast microscopy), and five samples containing cf. Phaseolus (bean), Gossypium (cotton) or Cucurbita (squash) pollen, and may be indicative of possible cultigens. Also represented were twenty-two samples containing Cleome (beeweed) and thirteen samples containing cf. Lycium (wolfberry) pollen which could indicate possible manipulated plant species. The presence of such plant species pollen in a sample of eighty specimens is considered to be significant in such limited data The preliminary pollen evidence thus suggests association of possible cultigens and manipulated species with archeological sites and water control devices such as check dams. Continuing analysis of a broader range of pollen data will refine and amplify this preliminary interpretation.

III.1.D THE EXPERIMENTAL GARDEN PROJECT, 1975

By William J. Litzinger

Five experimental garden plots were established during the 1975 field season. Each plot was in some way unique, and each was selected with a different purpose in mind. Two of the plots were chosen to replicate Hopi gardening practices; one was grown as a weed experiment; one was maintained as a watering experiment; and on one plot a variety of cultigens were grown for food and to assess their potential in the contemporary Hovenweep climate. Seeds used in these experiments came from several sources. Most of the corn (Zea mays) was of several traditional Hopi varieties obtained through the courtesy of William Lipe of the Museum of Northern Arizona. Gourds (Lagenaria vulgaris), squash (Cucurbita sp.) and other varieties of maize seeds were obtained by the author from traditional sources in Mexico, as were most of the bean seeds (Phaseolus vulgaris). All other vegetable seeds were from commercial sources.

1. The Checkdam and Canyonbottom Terrace Plots

Two probable Anasazi water control devices are checkdam (trinchera) and floodplain terrace gardens. Garden plots were placed in representative locations of each device at Hovenweep in an effort to establish their potential as agricultural sites. The results from these plots were generally poor in terms of the short range objectives, but valuable long range data was nonetheless obtained.

The trinchera plot was located immediately behind a checkdam on the arroyo just above the Square Tower canyonhead complex (see Cover shot of this report). The dam itself was reconstructed on the site of a former Anasazi rim dam (Hov. 71) by one of the field school students during the summer of 1974 (see Noisat, in Winter 1975), and was further modified during the spring of 1975 as a result of heavy winter and spring storm damage. By June of 1975 only several inches of soil had accumulated behind the structure, but it

was decided to test the location for its garden potential anyway in the hope that some data could be obtained. Corn, beans and squash were planted behind the dam on May 27, and by June 15 excellent corn germination was recorded. No water was added by artificial means, and none occurred naturally as rainfall or run-off. By June 25 all of the young corn seedlings had succumbed to drought stress or were eaten by small herbivores. Squash did not germinate until after a heavy flood in early July, and it was rapidly consumed by small mammals.

The floodplain plot was located on a rebuilt talus bottom terrace located below Unit Pueblo (Hov. 13). Corn, beans and squash seeds were also planted here on May 27, and by June 15 excellent germination was recorded. Again, by June 24 nearly all of the seedlings of corn had been destroyed by drought stress and small herbivores. The few corn seedlings that did manage to survive had succumbed to drought stress by June 30.

Although the gardens were not successful in terms of raising a harvestable crop, certain information was obtained. It is obvious that Hopi corn and most other crops need several feet of soil for root growth and moisture requirements, and it was concluded that inadequate soil and moisture, combined with animal predation, caused the failure of the plots. Four points can be drawn: 1) Natural silting in of trinchera terraces is a long process, and gardens cannot be grown behind water control devices until adequate soil depth and moisture reserves are present. 2) At least 50 cm. of soil are probably required for corn growth. 3) Constant protection from herbivoresis an absolute necessity for successful gardening in this environment. 4) Squash is dependent upon flooding or other sources of heavy moisture for germination.

2. The Mesa Top Water Experiment

A third plot was selected on a level spot in a deep soil location in the mesa top sage zone. At the onset of the experiment the plot was dominated by Hilaria jamesii and Bromus tectorum. A single young sage (Artemisia tridentata) was removed during the course of the experiment. Seeds from

different ears of Hopi corn were planted in a rectangular plot with ten rows and ten holes in each row. The rows and holes were about 1.25 m. apart.

The object of this experiment was to determine the effect of varying amounts of supplemental watering on corn growth and vigor. Originally this experiment was designed to chart the growth of the corn from germination to maturity. Time limitations, however, made it impossible to grow mature plants. Instead the development of the plants was recorded in different water regimes during the time available. The experiment was conducted for eight weeks, but differential watering was only done for the last six weeks.

Seeds were planted on June 16 and each hill was given three liters of water. Row 1 served as the dry control and was watered only on the first day of planting. In the other rows, each hill was given three liters of water every two days, until good germination was obtained, after which measured and graded amounts of water were used. On July 1 the watering experiment was begun. Table 30 summarizes the germination data as observed on that date. The following water regimes were used in the experiment: Row 1, none; Row 2, 100 ml.; Row 3, 200 ml.; Row 4, 400 ml.; Row 5, 600 ml; Row 6, 1000 ml.; Row 7, 1200 ml.; Row 8, 1500 ml.; Row 9, 2000 ml.; Row 10, 2500 ml.

Between 1 July and 15 August the garden was watered every two days. On four occasions the heights of the seedlings were measured. This data is presented in Table 31. Herbivor damage accounts for the lessening of the mean seedling heights between 7 July and 14 July. On 14 July the garden was fenced to prevent further damage from small mammals.

Perhaps the most significant result of the experiment was the low survival of seedlings in the dry control row. Table 32 summarizes the survival rate, or the number of holes in each row with live seedlings at the end of the experiment. Comparing Tables 30 and 32, it will be noted that poor seedling survival accompanied the lower water regimes. Besides being small, the plants in the lower water regimes appeared spindly and constantly exhibited curled leaves associated with drought stress. Figure 44 plots the data for the first and last recording dates. For the 7 July

TABLE 30

Germination as of 1 July 1975

Row Number	Hole Number 1	2	3	4	5	6	7	8	9	10
1)	x	x	x	x	0	x	x	x	x	0
2)	0	x	x	x	x	x	x	x	x	0
3)	x	x	x	x	x	x	x	x	x	0
4)	x	x	x	x	x	x	x	x	x	0
5)	0	x	x	x	x	x	x	x	x	0
6)	0	x	x	x	x	x	x	x	x	x
7)	0	x	x	x	x	x	x	x	x	x
8)	x	x	x	x	x	x	x	x	x	x
9)	x	x	x	x	x	x	x	x	x	x
10)	x	x	x	x	x	x	x	x	x	x

x = good germination

0 = no germination

TABLE 31

Mean Seedling Height in Cm.

Row	1	2	3	4	5	6	7	8	9	10
Date 7/7	8	12	13	13	18	19	19	20	21	22
7/14	11	10	10	9	9	9	9	9	11	13
8/1	13	15	18	20	21	21	29	30	38	46
8/15	16	18	21	28	32	33	33	52	96	104

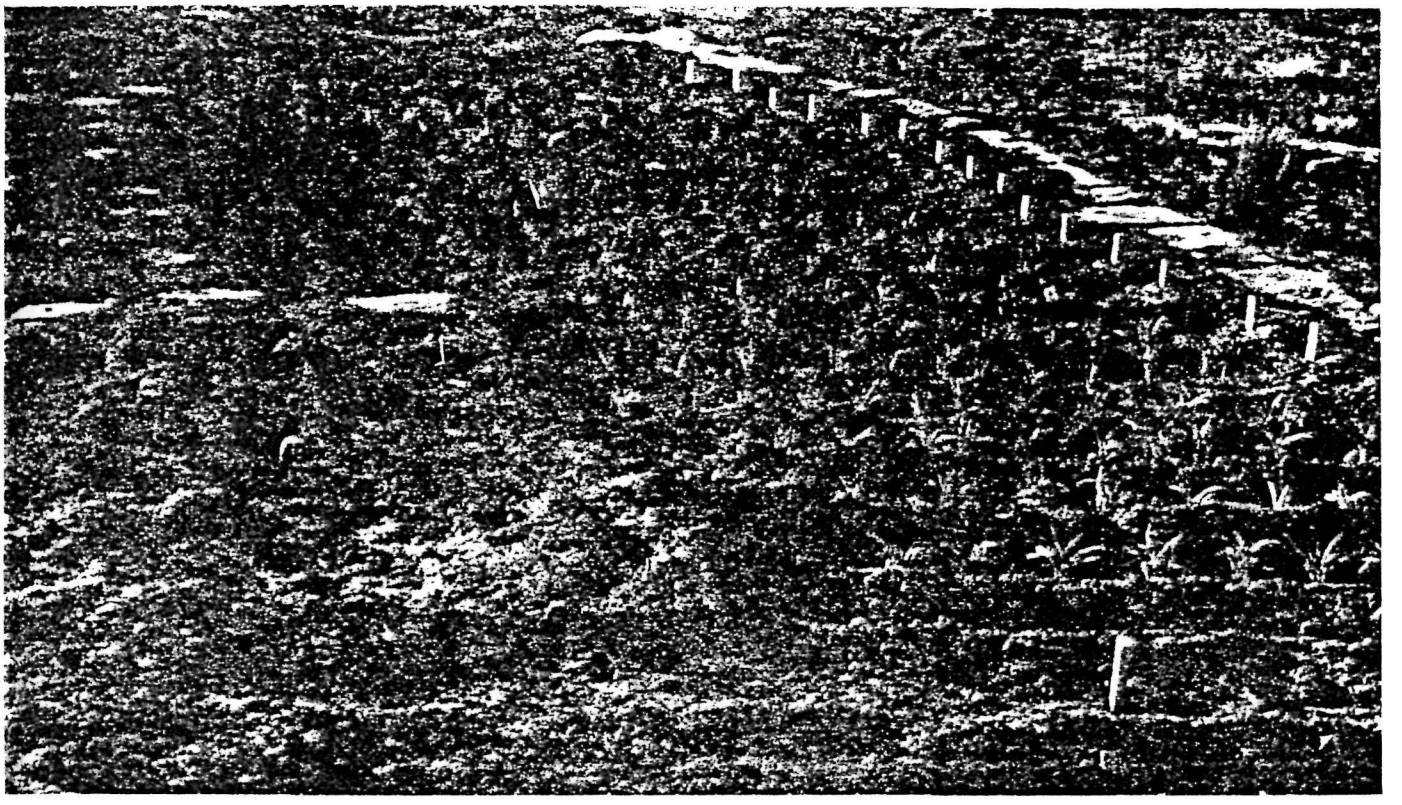


Figure 45. Experimental food garden at Hovenweep Project camp. Note retaining wall and terraced plot.

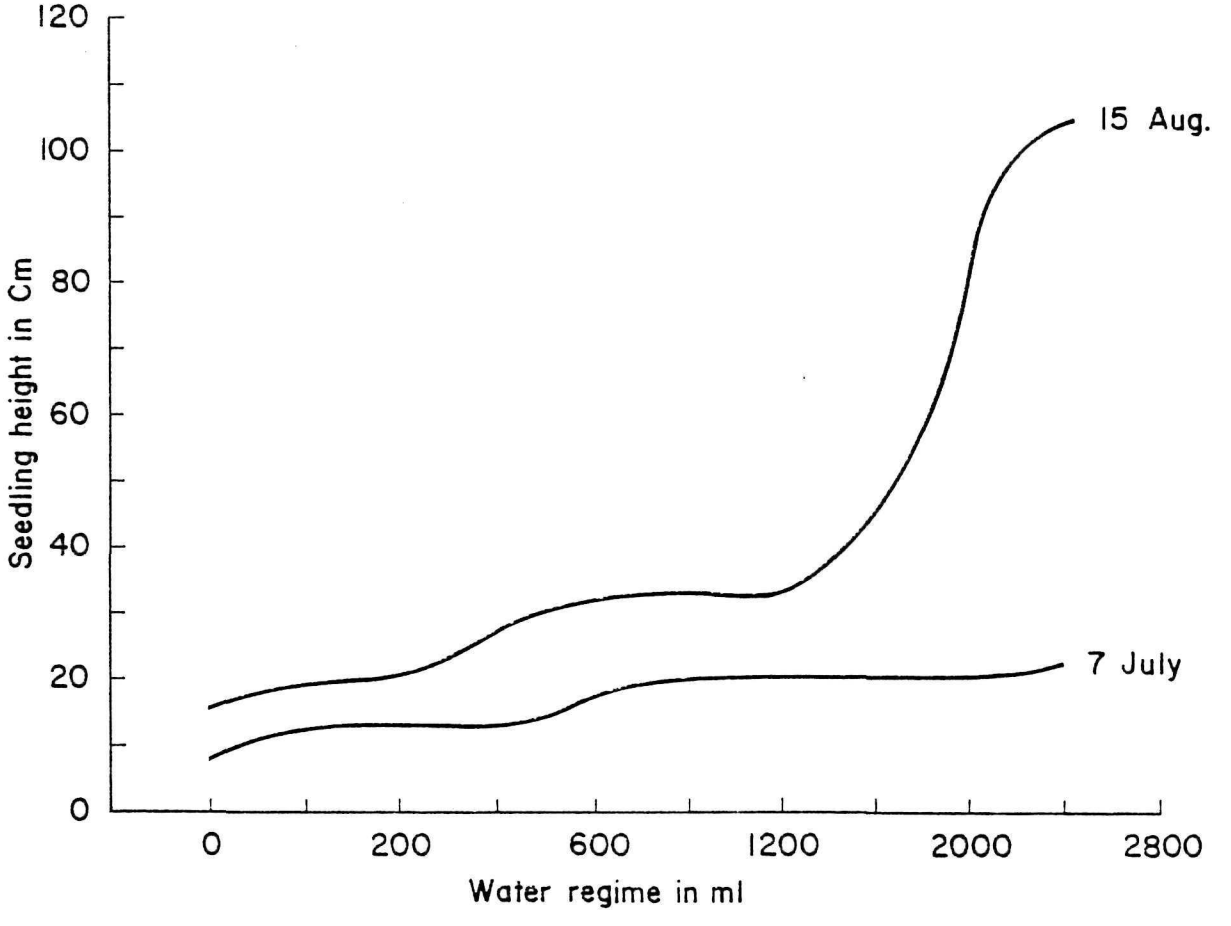


Figure 44. Graph of seedling height correlated with watering regime.

TABLE 32

Seedling Survival (as recorded 15 August 1975)

		Hole Number										
		1	2	3	4	5	6	7	8	9	10	
	1)	0	0	0	0	0	x	0	x	x	0	
	2)	0	x	x	0	x	x	0	x	0	0	
	3)	x	0	x	0	x	x	0	x	x	0	
	4)	0	x	x	x	0	x	0	x	x	0	
Water	5)	0	0	x	x	0	x	0	x	x	0	x = live
Row	6)	0	x	x	x	x	x	x	x	x	x	0 = dead
Number	7)	0	x	x	x	x	x	x	x	x	x	
	8)	x	x	x	x	x	x	x	x	x	x	
	9)	x	x	x	x	x	x	x	x	x	x	
	10)	x	x	x	x	x	x	x	x	x	x	

date there seems to be only two levels of growth response associated with the varying water regimes, with a break between 400 and 600 ml. At the end of the experiment the response of the seedlings to the water regimes is more dramatic. However, there still appears to be several plateaus of response: one between 200 and 400 ml.; one between 1200 and 1500 ml.; and one between 1500 and 2000 ml.

This data indicates that there were wide moisture regimes within which the response of the seedlings is much the same. Looking at these results in terms of the size of the seedlings and the amount of water they are transpiring, it seems that while the seedlings are small, only a small amount of water (500 ml. each watering) would suffice to keep

them going. Then as the seedlings increase in size, they will require higher optimum levels of moisture to develop properly. The dramatic difference between 1.2 L. and 2.0 L. (15 August data) nicely illustrates this. Obviously as the plants continue to grow larger they will need greater amounts of moisture. At some point an optimum will be reached which will be sufficient to allow the corn to flower and mature its fruits.

There were a total of twenty waterings during the experiment. Rainfall, measured from a rain gauge in the garden plot, would only have amounted to a single watering of all the hills with 500 ml. of water, with approximately 450 ml. from one storm and 50 ml. from a second. Thus the moisture from natural rainfall can be considered as having little effect on the experiment, and in terms of the present climate is insufficient to raise Hopi corn.

3. The Camp Food Garden

For several years Ranger Jim Court had a small vegetable garden located in a severely disturbed area near the park pumphouse and well. It is in this same general area that San Jose State University sets up its field camp, hence this plot became known as the camp food garden.

Ranger Court's original garden was set on a slope, and the soil was found to be very shallow and full of construction debris. To solve this problem a low stone retaining wall was built across the lower end of the garden and approximately twelve cubic yards of good mesa top-soil was hauled in to level and deepen the garden. To this about one cubic yard of well composted manure was cultivated into the soil before seeds were planted.

Before the original garden was disturbed the following weedy species were collected from the surface:

Cryptantha gracilis

Descurainia pinnata

Descurainia sophia

Helianthus petiolaris

Erodium cicutarium

Helianthus annuus

Lappula redowskii

Sisymbrium altissimum

Solanum carolinense

Lepidium perfoliatum

The garden was planted with a variety of commercial cultigens, along with a number of varieties of Mexican and Hopi corn and Mexican beans (see Fig. 45). The following is a list of the species and varieties planted in the camp garden:

Beans (Phaseolus vulgaris), twenty varieties

Bock Choy (Rumex aceosta)

Corn (Zea mays), twenty varieties

Cucumbers (Cucumis sativus)

Lettuce (Lactuca sativa), four varieties

Melons (Cucumis melo)

Onions (Allium cepa), three varieties

Peppers (Capsicum frutescens)

Radishes (Raphanus sativus)

Spinach (Spinacia oleraceae)

Squash (Cucurbita pepo)

Sweet peas (Latharyus odoratus)

Tomatoes (Lycopersicum esculentum)

Most of these vegetables did well when kept adequately moist. However, lettuce, spinach and radishes usually wilted during the heat of the day. Of course when kept well watered, corn, beans, tomatoes, squash and melons did well. The most drought tolerant plants were Bock Choy, onions, and peppers. The camp garden was planted at a relatively late date, 16-18 June, hence most of the corn varieties did not mature before the end of the season. By the end of the field season (18 August 1975) first fruits had been harvested from many of the garden vegetables. The gravest mishap with the camp garden

occurred after the San Jose State University Field School left Hovenweep on 18 August. Jackrabbits (Lepus californicus), cottontails (Sylvilagus auduboni) and rock squirrels (Citellus variegatus), kept away all summer by the presence of people, descended upon the succulent greenery of the garden and devoured most of it.

Altogether, several interesting facts were learned from this experience. It was found that several varieties of beans, onions, and tomatoes were fairly resistant against the herbivores, or at least the little creatures saved these plants for last. Bock Choy was not eaten, even after all other plants had been removed from the plot. Corn, beans, and squash (the traditional Hopi crops) did very well as long as they were watered frequently and protected from predation.

During the growing season weeds were numerous on the garden plot, although they were limited to the following species:

Amaranthus californicus

A. retroflexus

A. torreyi

A. graecizans

Lactuca sariola

Salsola pestifera

Avena sativa

Only a single plant of Avena sativa occurred on the garden. L. sariola was the most numerous single species; it and S. pestifera were continually removed from the plot. Of the amaranths A. retroflexus was the most numerous single species. The amaranths were tolerated as weeds on the garden plot, but were thinned out several times. Cheno-am pollen is common in prehistoric gardens on the mesa, and it appears that gardens and their disturbed soil represent a considerable source of weedy food.

4. The Lowry Ruin Garden

The most significant data to come from the 1975 gardening project were the results from the Lowry Ruin Garden.

This garden had been the location of experiments run by Bill Lipe and Vic Fisher of the Museum of Northern Arizona and Towson College. They began the experimental plot in 1972 by clearing the brush off of the approximately 20 m. x 30 m. area by a combination of burning and digging. Three successive corn crops were grown on the garden from seed originally obtained from the Hopi. Fisher (personal communication) indicated that during the growing seasons the garden was periodically weeded and that good crops were produced through dry farming. Early in April, 1975, Fisher enlarged the plot by about one quarter and burned off the plants he had removed, as well as some of the dry vegetation of the plot.

On 9 June 1975 corn was planted in the garden. Six rows of 12-15 hills per row were planted. The seed used had been obtained from John Pock, a local farmer who had obtained Hopi seeds from Fisher in 1972. Mr. Pock propagated the corn in a field adjacent to the Lowry ruins for three years by the dry farming method. He was interested in the corn as a curiosity and he strove to maintain its unique genetic character. The closest neighbor to the Pock's who has grown corn during the last four years is approximately four miles air distance away, hence it has been assumed that the seed obtained for the 1975 experiment was of a comparable nature to the original corn used by Lipe and Fisher, except that it had three generations of local history.

The seeds were soaked in water for twelve hours before planting. At the time of planting each hill was given approximately two liters of water. No additional watering was done at the Lowry Garden. Besides the corn, two rows of squash (Cucurbita sp. and zucchini, C. pepo) and one row of gourd (Lagenaria vulgaris) were planted.

On 19 June the garden was inspected. About 80 percent germination of the corn was observed. On 22 June Fisher planted about fifty new corn seedlings along the north and east edge of the first seed plantings. These plants generally did not survive and only a few were able to establish themselves. By 3 July, no germination of the squash, gourd or zucchini were recorded, even though tests had shown these to be 99 percent viable.

At this point it was decided not to weed or in any way disrupt the competitive forces between the cultigens and the aggressive weedy invaders on the garden plot. This was a critical part of the experiment for three reasons: 1) to identify the nature of the aggressive species; 2) to see if any possible past semi-cultigens would appear on the plot; and 3) to study the effect of weeds on corn growth and vigor.

The following is an inventory of the weedy species found on the garden plot (introduced species are indicated by *):

Agropyron smithii

Aristida fendleriana

Artemisia tridentata

Astragalus haydenianus

Astragalus flexuosus

Cordylanthus wrightii

Cryptantha gracilis

Cryptantha bakerii

Descurainia pinnata

*Descurainia sophia

Draba reptans

Gayophytum ramosissimum

Helianthus annuus

Helianthus petiolaris

*Lactuca scariola

Lappula redowskii

Lupinus ammophilus

Nicotiana attenuata (wild tobacco)

Oryzopsis hymenoides

*Sisymbrium altissimum

Solanum triflorum (wild tomato)

Sphaeralcea coccinea

Zygadenus paniculatus

An inventory was also made of the surrounding ground cover of the undisturbed pinyon-juniper understory. The following is the list of the species found there (introduced species are indicated by *):

Agropyron smithii

Aristida fendleriana

Opuntia hystricina

Oryzopsis hymenoides

Astragalus haydenianus	Penstemon angustifolius ssp. caudatus
Cordylanthus wrightii	Theleopodium rhombiodeum
Cryptantha bakerii	*Tragopogon dubius
Echinocereus coccineus	Zygadenus paniculatus
Lupinus ammophilus	

It should be noted that all of the perennials found on the garden plot were first year seedlings except for C. Bakerii and Z. paniculatus. These two perennials probably survived the clearing and subsequent weeding of the plot. The small number of introduced species is surprizing and such notable weedy species as Bromus tectorum and Amaranthus sp. are missing. Of the native invaders on the plot the bunch grasses greatly outnumber all other seedlings, with O. hymenoides being the most vigorous and aggressive. The second most vigorous invader was A. tridentata. Among the introduced weeds the seedlings of L. scariola were most numerous. In fact L. scariola was the most numerous invading species on the garden. It also was the most competitive weed with corn (see below). The presence of N. attenuata and S. triflorum is probably due to the use of fire as a clearing agent, and their possible use as past semi-cultigens by the prehistoric Lowry inhabitants. This possibility is discussed in greater detail in Chapter III, section 1 B. These species also exhibit a strong correlation as after burn species, as do species of Astragalus, Penstemon, Lupinus and Sisymbrium.

The list of species from the pinyon-juniper understory helps to differentiate the invading species from the natural ground cover. Of course this does not diminish the aggressiveness of the native perennial grasses as noted above.

The effect of weed competition on the growth and vigor of the corn was dramatic. No corn plants developed to over one meter high, while in previous years two-meter corn was grown on the same plot. This cannot be attributed to diminished soil productivity, as most of the local corn farmers agree that corn can be grown on the same plot year after year without greatly reducing the yield. The longest that any local farmer had cropped corn on the same plot was

seven years, a fact which attests to the great natural fecundity of the soils of the area.

All of the corn seeds used in this garden were from the middle section of a single cob. Careful measurements were made of this cob so that comparison could be made with the cobs from the resulting harvest. The following summarizes the data from the parent cob:

Number of rows: 16

Cob length: 19.5 cm.

Cob diameter at base: 3.2 cm.

Cob diameter at mid-length: 2.6 cm.

Cupule width: 0.75 cm.

Rachis diameter; base: 2.1 cm.

Rachis diameter; mid-length: 1.2 cm.

The cob was even rowed, broad at the base and gradually tapered to a point. A total of twenty-three cobs were harvested from the garden plot. Of these only a single cob had mature kernels. Some of the same measurements were taken from these cobs, and the means of these measurements follow:

Number of rows: 8 rows, 22 percent; 10 rows, 44 percent; 12 rows, 22 percent; 14 rows, 12 percent; 16 rows, 0 percent

Cob length: 7.4 cm.

Diameter at base: 1.2 cm.

Diameter at mid-length: 1.6 cm.

Cupule width: 0.72 cm.

By examining these cobs it is apparent that there is a great variety of shapes and row numbers represented. Cupule width, however, hardly varied at all. Also, when the cobs are examined in cross-section it was found that there is a great deal

of crowding of rows and many exhibited erratic cross-sections. This suggests that of all of the characteristics utilized by paleobotanists in studying prehistoric maize, only cupule width is not affected by environmental conditions. Many of the conclusions reached by ethnobotanists such as Cutler (1966), Winter (1973) and Galinat (1969) concerning the types of corn grown by the Anasazi and their geographic relations have been based on row number as well as on cupule width. Cupule width, it seems, is the only dependable genetically based factor not affected by environmental conditions. The results also demonstrate that active weeding is an absolute necessity in obtaining a successful harvest. Although weeds are an important source of food, they are also aggressive competitors which must be controlled. Weeds were therefore probably tolerated or semi-cultivated along the edges of gardens or on fallow fields, but not in the gardens themselves.

III.1.E WATER CONTROL EXPERIMENTATION

By Bradley Noisat

In 1974 we began a series of tests designed to verify Rohn's (1972) hypothesis concerning water conservation techniques at Hovenweep. Referring to the Hackberry House Monument group, Rohn contended that the use of canyon-rim check dams formed an important water management unit during Pueblo III period times since it increased spring water output. The preliminary evidence presented at the end of the 1974 season (Noisat 1975 in Winter 1975) indicated that the relation of spring output, aquifer discharge and dam location is exceedingly complex, necessitating more sophisticated tests. Because of this we have re-evaluated our concepts and intensified our methods in order to consider the role of water management in Pueblo prehistory. The data and programs presented here summarize our expanded efforts to consider this problem.

Experiments

In 1974 we reconstructed a check dam (Hov. 71) above a modified spring (Hov. 3) in the Square Tower group. A washed-out rim dam (Hov. 345) above a spring at Hov. 109 was left in its eroded state so that 109 could serve as a control in testing the effect of the rebuilt dam above Hov. 3. The moisture output of each spring/seep was measured weekly while storm data and soil/water retention data were taken. While these methods were informative, in that they suggested that Rohn's hypothesis appeared partially correct, we concluded that a more flexible and comprehensive program was needed for two reasons. First, we wanted to expand our techniques to avoid sample bias and/or inadequate test procedures. Second, we wanted our data to summarize many other aspects of the water conservation system, beyond the rim dam/spring question, including soil buildup rates, engineering technology, the effects of terracing on vegetation, the relation of slope and different techniques, etc.

For these reasons, six new sites were added to the experiments, with two of them relevant to the Rohn hypothesis. In addition to the 1974 test sites, the Cline's spring site and the modified spring at Hackberry House (Hov. 64) were studied. A large rim dam measuring nine meters in length and one meter high was constructed above the cistern at Cline's spring. The nearby spring at Hackberry House was used as a control, thereby providing two test sites and two control sites in different canyon systems. Measurements of spring depth at the Hov. 3 and Cline's spring sites and seepage drops per hour at the Hackberry House and Hov. 109 sites were taken, along with storm data.

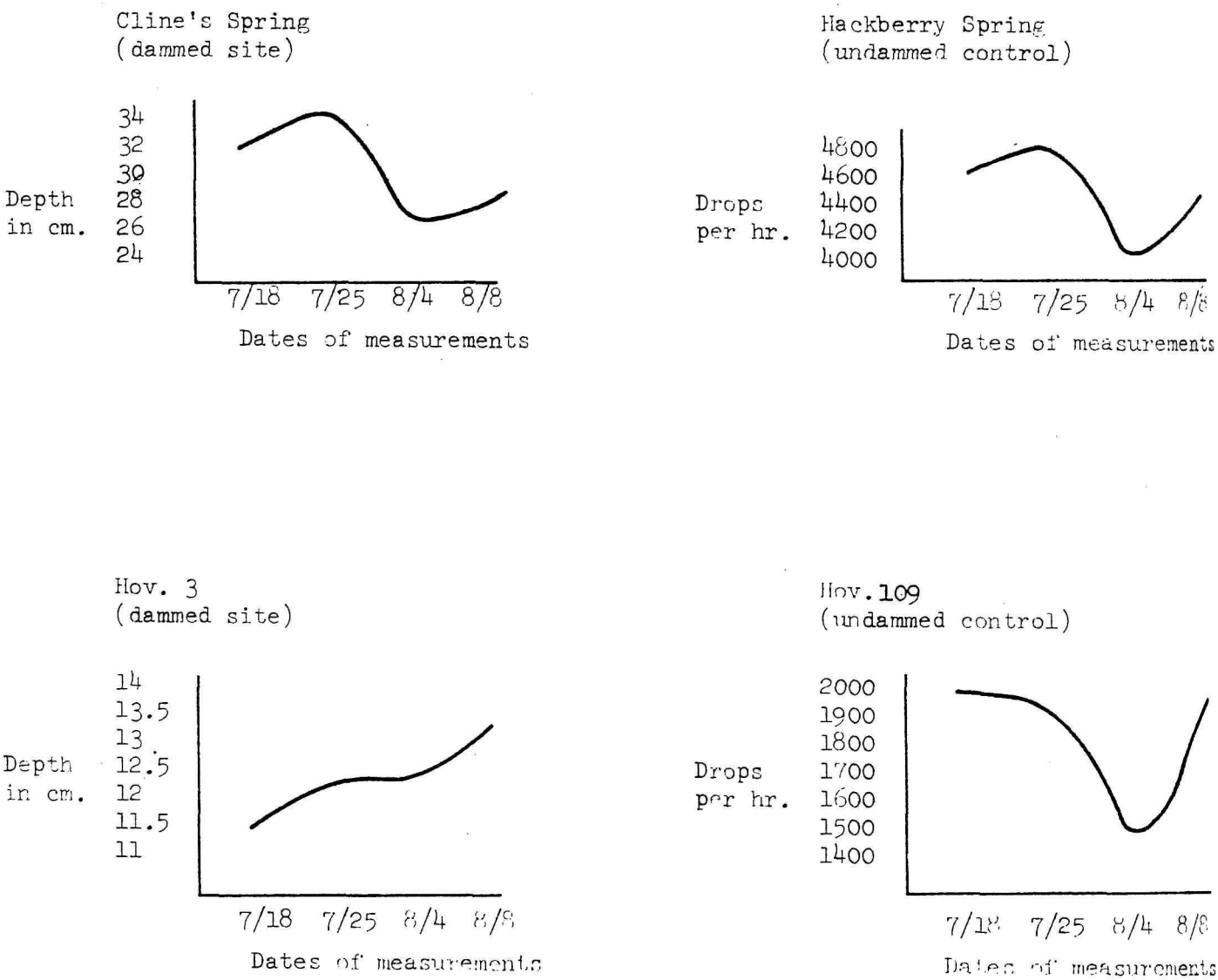
Interpretations

Table 33 presents the weather and measurement data, while Fig. 46 graphs out the measurement relations. As indicated in the charts, there is a measurable difference between the spring output at the dammed and undammed sites. The flow at both dammed springs increased somewhat after the rainy days of July 9-July 18, while the undammed springs increased only at Hov. 64 and not at all at Hov. 109. The outputs then decreased drastically at three of the four sites, with the exception being the dammed Hov. 3 spring, which evened out rather than dropped. After a low point at August 4, all of the springs increased their flow, presumably as a consequence of the inclement weather during the last week in July. Two tentative conclusions can thus be drawn: 1) Rim dams do appear to increase spring output, perhaps by enhancing percolation through the impoundment of water above the spring and increased hydrostatic pressure. Output increased in all four springs after a rain, reflecting general percolation throughout the aquifer system, but the increase was greater in the dammed sites. 2) The rate of percolation is relatively fast, since the increase in flow occurred less than a week after the rainfall in both dammed and undammed springs. Decrease in flow similarly occurred approximately a week after dry spells, again indicating a relatively rapid rate of percolation. Since the dams in both instances were built about 100 meters above and to the north of the canyonhead springs, the rate is approximately fifteen meters per day. This is an extremely crude calculation, since

TABLE 33 - Water Control Test Site Data

Test Date	Measurements				Weather Pattern
	Cline's Spring (dammed site)	Hackberry (Hov.64) (undammed control)	Hov. 3 (dammed site)	Hov. 109 (undammed control)	
7/18/75	32 cm. deep	4608 drops/hr.	11.8 cm deep	1940 drops/hr.	7/9-7/18 - rainy and cool, with major storm on 7/9
7/25/75	34.5	4716	12.5	1908	7/19-7/28 - hot and dry
8/4/75	26	4068	12.5	1488	7/29-7/31 - cool with slight rain 8/1-8/8 - hot and dry
8/8/75	28	4464	13.5	1944	

FIGURE 46 - Water Control Data Graph



permeability/percolation rates are better measured through field pumping tests, but this data does give an indication of one of the uses of rim dams, i.e., the enhancement of spring discharge. The extra water thereby gained would have been especially important for a major habitation center, since Beaglehole's (1937) research among the Hopi demonstrated that daily use of a spring for irrigation and domestic purposes often lowers the level of the spring to a dangerous point. The data thus tentatively supports our conclusion in Chapter III, section 1.A that rim dams serve the same purpose as do dune fields above springs at the Hopi mesas. In both cases spring discharge is enhanced through 1) the capture of water in the dunes or in reservoirs behind the dams, and 2) the increase of aquifer percolation by hydrostatic pressure.

Other Experiments

In addition to the work mentioned above, several other water control studies are underway. These include:

Examination of checkdam function and soil buildup rates. A series of arroyo checkdams above the Square Tower Monument group was reconstructed, and a detailed study of the original sediments is underway to determine the patterns of construction and soil buildup. The dams will be maintained throughout the life of the project, and soil samples are being collected periodically so as to understand the buildup patterns while they are in operation. Preliminary results of the soil tests are discussion in section II. D of this chapter.

Diversion dams. In addition to constructing arroyo check dams to facilitate soil buildup and moisture retention in terraced garden plots, the Hopi and Zuni also manipulate floodwaters by constructing dikes, banks and other diversion devices in association with the check dams and in tributary fan and alluvial floodplain locations. Three series of diversion dams were built in 1975 in an attempt to understand the long term effects of the dams on soil moisture, mineral content, buildup rates and plant growth on adjacent plots. Similar studies by Hubbell and Gardner (1944) suggested that diversion dams have definite effects on the soil and

vegetation of rangeland test areas in New Mexico, and it is anticipated that the present study will shed light on the ecological effects of Pueblo water diversion.

III.1.F ENVIRONMENTAL CONSTRAINT AT HOVENWEEP, 1974 SITES

By Eileen Camilli

This report summarizes and evaluates the environmental diversity displayed by archeological sites surveyed at Hovenweep during the 1974 field season. The report also begins to identify the environmental constraint placed on these sites (see Camilli and Winter 1975). This evaluation of environmental diversity centers around the use of botanical data collected from two sets of sampled sites in conjunction with the use of two complementary multivariate analysis techniques and a multidimensional scaling routine.

The first group of sites used in the analysis includes habitation and nonhabitation sites of all prehistoric periods. The second group is composed of sites containing water control structures. Each group of sites was scaled twice. The first scaling used all forty-seven plant categories (Table 34) which were found growing on the sites, with the exception of cheatgrass and snakeweed. The second scaling used the fifteen plants growing on the sites considered to be potential and semi-cultivated species (Table 35).

Each group of sites was compared botanically using the one-complement of Jaccard's coefficient as a measure of distance between the sites. Since this coefficient ignores negative matches when calculating similarity between units, only the mutual presence of particular species at two sites is taken into consideration. The species, in turn, provide information about the environment which can be compared between locations. The computer program BICOEF (Wood 1973) was used to calculate the matrix of distance coefficients. All computer programs were run on the Zerox Sigma 6 computer at Northern Arizona University.

TABLE 34

47 Plant Variables Used In The Scaling Of The 1974 Data *

Ash
Aster
Beardtongue
Blazing Star
Blue Grass
Bulrush
Chokecherry
Cliffrose
Cottonwood
Dock
Fishhook Cactus
Globe Mallow
Golden Currant
Greasewood
Hackberry
Hedgehog Cactus
Horehound
Juniper
Lambsquarters
Milkweed
Mint
Mormon Tea
Mountain Mahogany
Oak
Peppergrass
Pinyon Pine
Prickly Pear Cactus
Prince's Plume
Rabbitfoot Grass
Reedcane
Ricegrass
Rabbitbrush
Sage
Saltbush
Serviceberry
Shadscale
Squawbush
Tamarax
Tansy Mustard
Thistle
Townsendia
Wheatgrass
Wild Four-O'clock
Willow
Wolfberry
Yucca

* cheatgrass and snakeweed ignored, since they grow on nearly all sites

TABLE 35

Potential Semi-Cultigens Found On 1974 Sites

Blazing star
Bulrush
Cat-tail
Cottonwood
Dock
Lambsquarters
Mint
Milkweed
Ricegrass
Saltbush
Shadscale
Tansy Mustard
Wheatgrass
Willow
Wolfberry

Methods

The model for the multidimensional scaling analysis comes from the concept of environmental niche space where the niche space is composed of n dimensions (Hutchinson 1957; Matson 1974). The environmental variables represented by the dimensions grade from favorable to restrictive conditions for the organism occupying the niche space. Each dimension can be seen as representing a gradient of environmental constraint on the niche or in this case the settlement pattern. In this way, the dimensions can serve as a descriptive mechanism to define the environmental parameters of the location of farm sites.

Dimensions in this analysis were obtained using Torgerson's metric multidimensional scaling routine (Torgerson 1960) with the use of the matrix of distance coefficients based on the plant variables. This technique arranges the sites along dimensions or vectors in space while preserving the relationship between them as represented in the matrix of coefficients.

Botanical variation among sites is used as an indicator of environmental difference between the locations. The plants are thus being used as a descriptive device to determine the nature of environmental diversity between the archeological site locations. The description of variation in site location began with an inspection of the scaled vectors for continuums of variation represented by key plants. These continuums were then inspected for topographic variation. Temporal and functional differences between sites could then be correlated with physiographic variation.

Data

The two groups of sites were scaled using forty-seven plant variables (Table 34). Run I consists of a scaling of fifty-eight sites selected at random from sites surveyed in 1974. Six vectors accounting for most of the variance received interpretations from the resultant scaling.

Inspection for the presence of certain plants distributed over Vector I reveals that serviceberry, squawbush and wolfberry occur on sites at the upper end of this vector. These plants occur on canyon rims, talus slopes and canyon bottom locations. Plants present on sites at the opposite end of this vector occur over a broader range of topographic variation including the mesa top. Accordingly, this vector has been interpreted as representing a canyon-mesa top continuum. Vector II has been interpreted as a topographic gradient at one end of which is located a moist canyon bottom and/or canyon head habitat around seeps and springs. The presence of seeps and springs is indicated by such plants as cottonwood, willow and bullrush. Sites containing cliffrose, serviceberry and mountain mahogany occur on the upper end of Vector III. These site locations represent talus or exposed bedrock locations in areas of shallow soil. Sites containing pinyon pine occur on the left side of Vector IV. This vector might represent a gradient between the pinyon-juniper and sage plant communities. Physiographic variation here would take elevation, temperature and amount of precipitation into account. Weedy species such as aster, beardtongue and the grasses occur on sites on the lower portion of Vector V. Sites containing these plants are possibly located in areas of disturbed soils. A tentative interpretation of Vector VI concerns direction of exposure on the site. Southerly exposed sites are present on the left side of the vector.

Thirty-five water control sites selected from the 1974 survey were also scaled using forty-seven plant variables, Run II. Six vectors accounting for much of the variance received interpretations. Like the scaling in Run I, Vector I of Run II represents a canyon-mesa top continuum with sites containing serviceberry and/or squawbush at the upper end of this vector. Vector II is unlike that of the first run, however. The major difference in plants present on sites distributed along this vector has to do with shadscale and saltbush. Sites containing shadscale and rice grass occur on the left while sites containing saltbush are on the right side of the vector. This vector may represent a gradient in elevation and soil type. Saltbush occurs up to 7100 feet in elevation in subalkaline soils while shadscale occurs lower, between 2200 and 5500 feet, in alkaline soils (Vines 1960). Vector III contains sites along its lower portion which contain wolfberry. This plant often grows in rocky areas and

frequently inhabits Pueblo rubble mounds. Wolfberry may also indicate areas of fine silty sand with good drainage receiving seasonal runoff (Dr. Richard Hevly, personal communication). Sites containing willow, tamarisk, reedcane and cottonwood occur on the right side of Vector IV. These are located in canyon bottoms or at canyon heads near seeps and springs. Sites containing pinyon pine are present on the lower end of Vector V. Vector IV contains sites along its right portion on which beardtongue, aster and prince's plume grow possibly indicating areas of disturbed soils.

Interpretations

Comparison of scaled sites in Run I and Run II reveals differences in the variables responsible for imposing constraint on the distribution of sites. It is reasonable to expect differences between variables constraining the distributions of these two groups of functionally distinct sites. The first vector from each run accounts for the greatest amount of variance in the distributions. Thus, in Run I the greatest degree of difference in site locations has to do with a distribution from canyon to mesa top environments (Fig. 47). With Run II, the water control scaling, the greatest degree of difference between site locations also has to do with a canyon-mesa top distribution (Fig. 48). The constraining factor on Vector II of Run I has to do with the presence of seeps and springs and the moisture provided by them (Fig. 49). On Vector II of Run II, however, the constraining factor has to do with soil type and elevation (Fig. 50). It might be reasonable to conclude, then, that elevational factors such as temperature and amount of precipitation combined with type of soil are key constraints on the placement of water control structures and impose stronger restrictions on site location than the presence of seeps or springs. In contrast, the availability of water provided by seeps and springs is a constraining factor of more importance on the locations of nonwater control sites (including habitation sites). Vector III in the scaling of water control sites may indicate the availability of seasonal runoff, another important factor to consider in the placement of water control structures. Vector III in Run I represents a gradient of exposed bedrock. Degree of soil disturbance, presence of pinyon pine and direction of exposure as

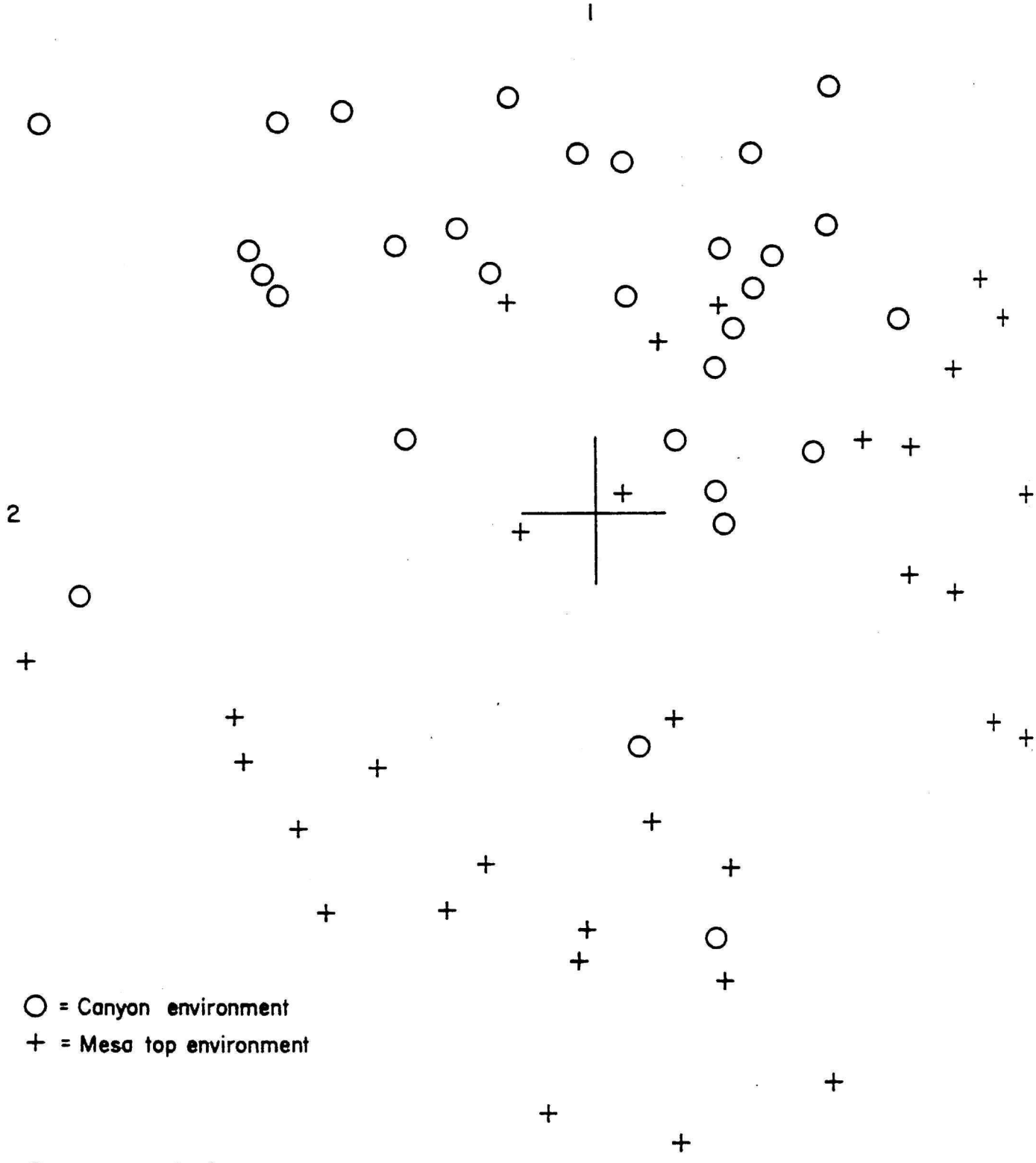


Fig. 47

Run I: Vector I

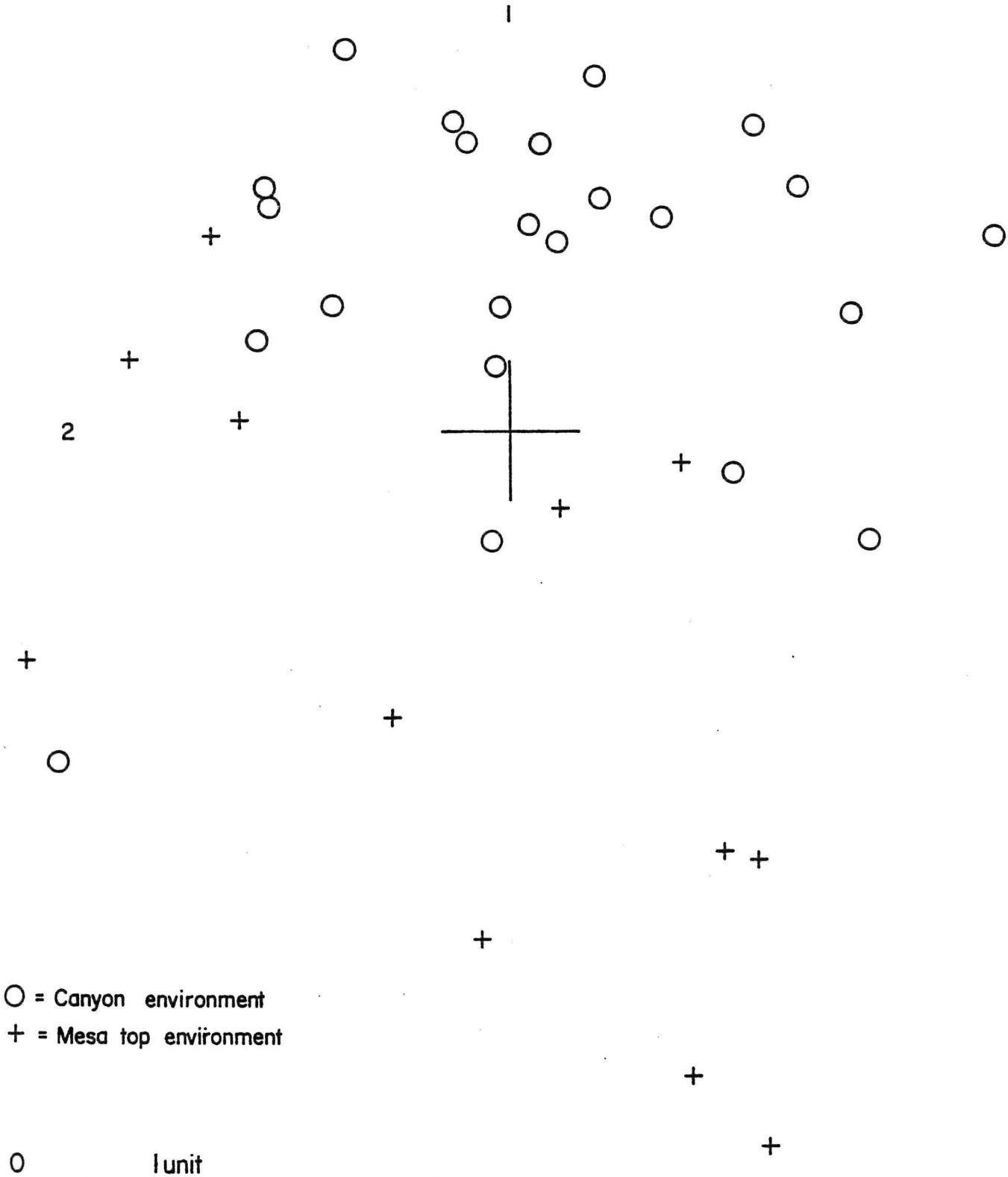
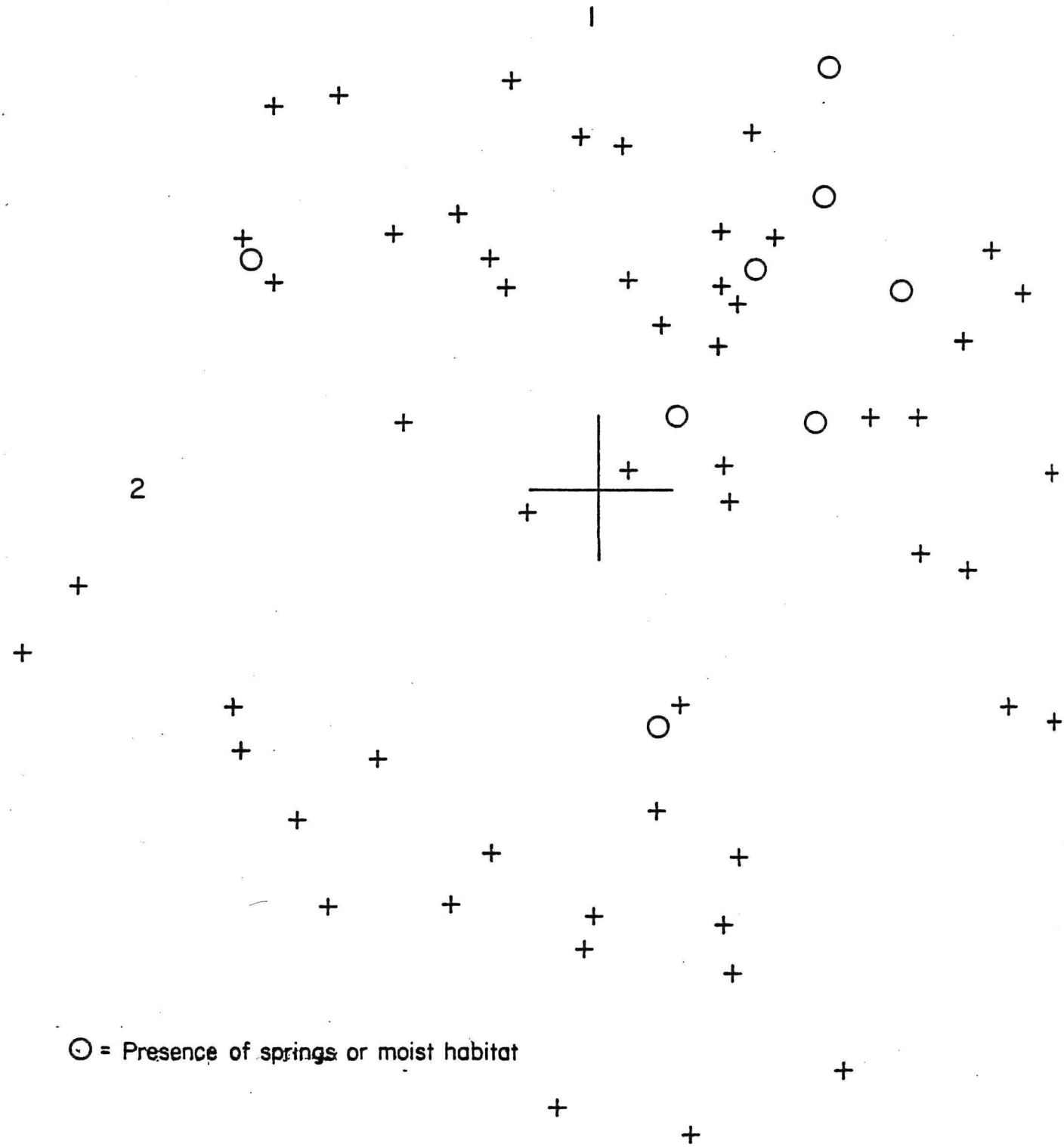


Fig. 48

Run II: Vector I

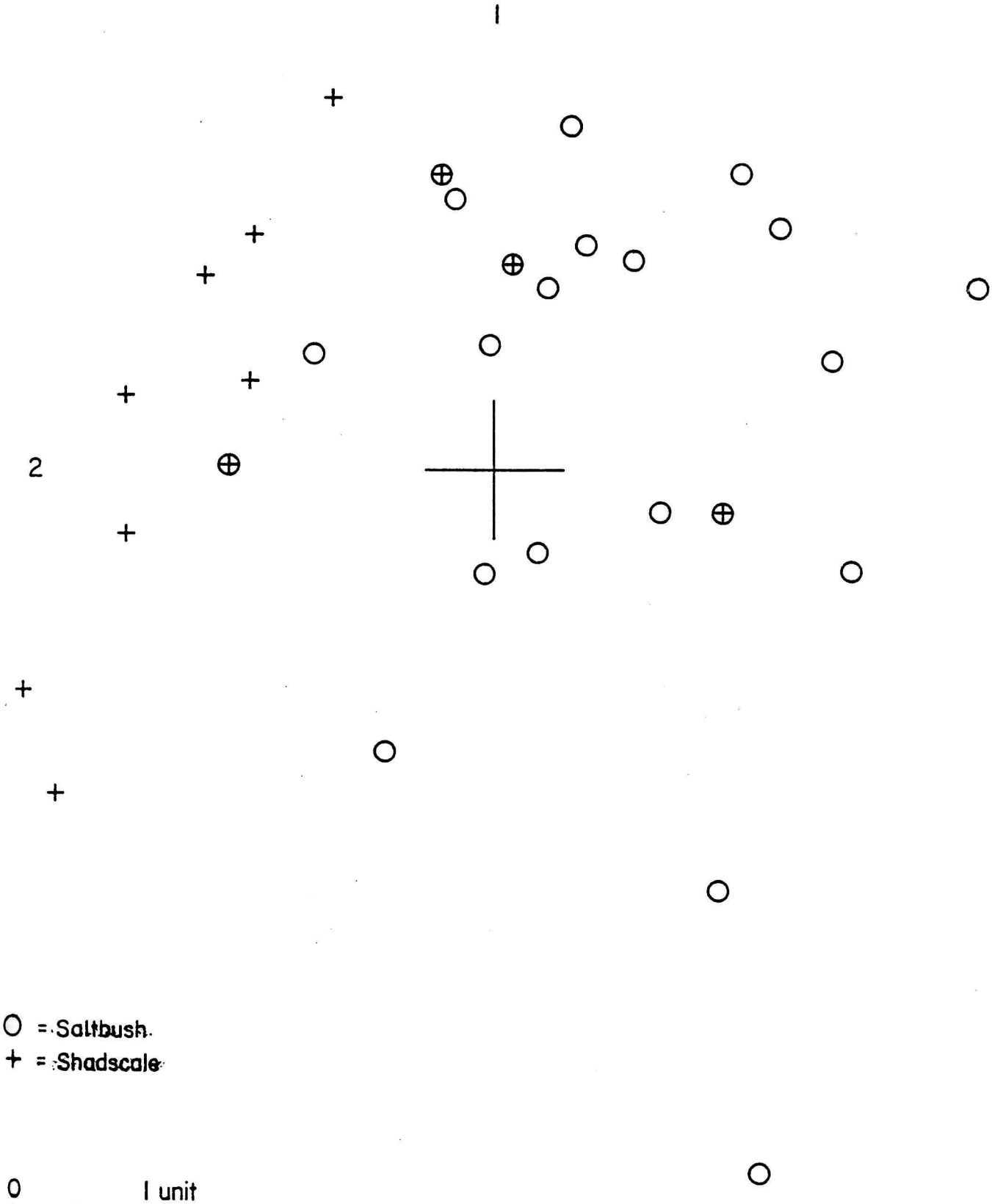


⊙ = Presence of springs or moist habitat

0 1 unit

Fig. 49

Run I : Vector II



O = Saltbush
+ = Shadscale

0 1 unit

Fig. 50

Run II : Vector II

interpreted from other vectors represent factors imposing lesser amounts of constraint on the sites in these runs.

Variables interpreted from the scaling represent gradients of environmental constraint on each group of sites. To understand more fully the nature of this constraint, both temporal and functional differences between sites are now introduced into the description of the scaled vectors.

Environmental constraint differs on sites thought time along Vector I, the canyon-mesa top gradient, in both Runs I and II. Temporal differences along Vector I include the presence of Pueblo II sites in the middle portion of the vector while Pueblo II-III and III sites are located at the vector's upper end (Fig. 51 and Fig. 52). Many undated sites occur on the lower end of the vectors. These are perhaps early Basketmaker or Archaic occupations or special use Pueblo sites on which no ceramic materials were present. The distribution of sites through time along the canyon-mesa top gradient may indicate more restrictive conditions for later sites on the mesa top. A similar distribution of sites through time is seen along Vector II in Run I with all Pueblo sites tending to be located on the "spring" (right) end of the vector while undated sites are on the opposite end (Fig. 51). If the undated sites represent earlier occupations, then the niche occupied by later Pueblo sites may have become more restrictive in terms of water supplied by springs.

Constraint may also differ between sites of distinct functional natures. Temporal variation has been noted in the distribution of sites along the canyon-mesa top continuum. There is an even greater difference in the distribution of sites when only habitation sites are plotted along this vector, Pueblo habitation sites occurring farther along the canyon end of the vector (Fig. 53). Pueblo II and III limited use sites occur over the same space on this vector.

Most water control sites also occur on the upper portion of the canyon-mesa top vector in Run I. A gradient of water control site type along the vector shows arroyo check dams occurring with Pueblo II and Pueblo II-III sites and talus and rim dams with Pueblo III and Pueblo II-III sites.

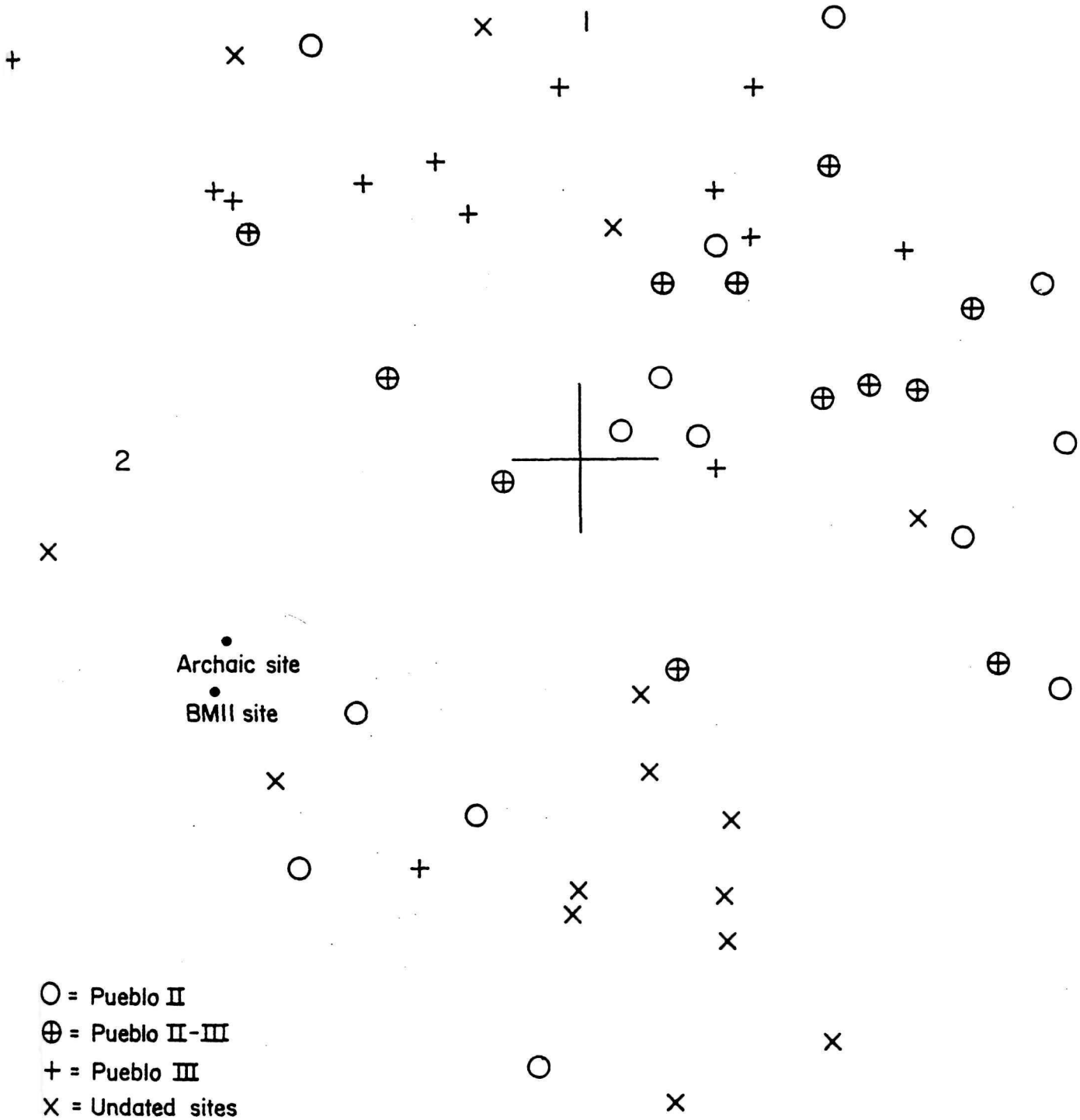
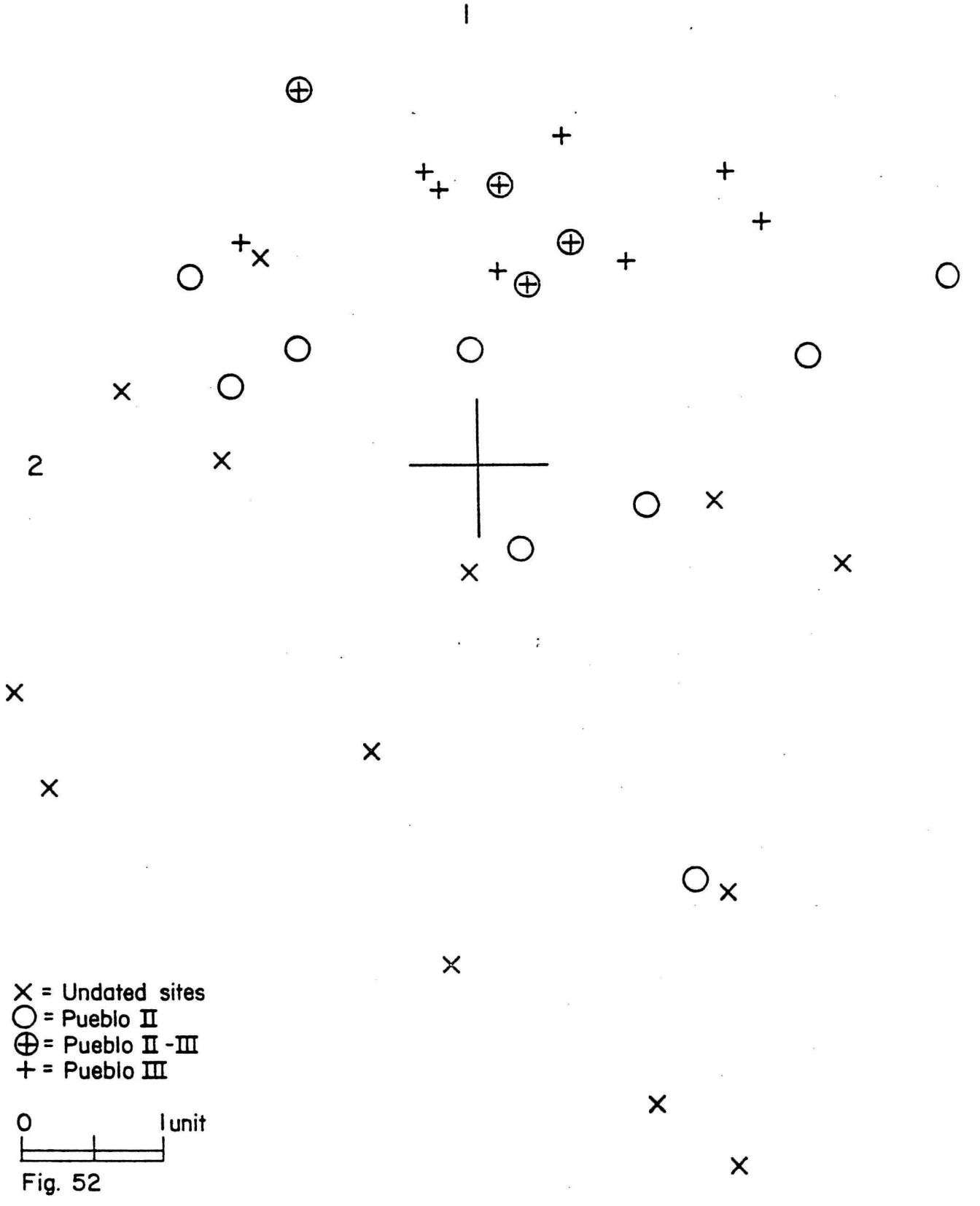


Fig. 51

Run I: Vector I and Vector II



× = Undated sites
○ = Pueblo II
⊕ = Pueblo II-III
\+ = Pueblo III

0 1 unit

Fig. 52

Run II: Vector I

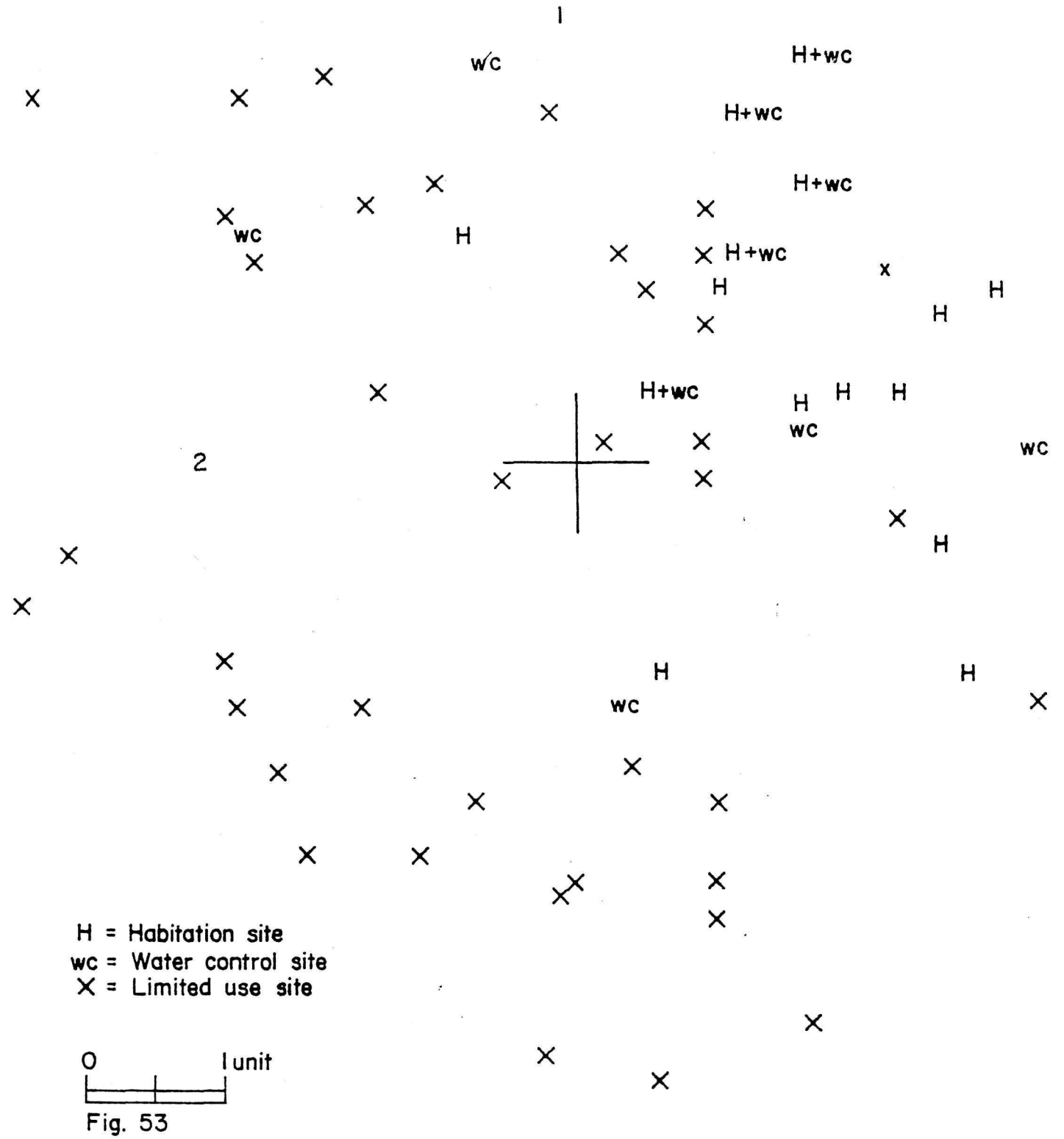


Fig. 53

Run I: Vectors I and II

The gradient of different types of water control sites along Vector I in Run II illustrates a continuum of arroyo check dams to rim and talus dams, with talus and modified spring dams occurring along a similar temporal continuum.

The presence of seeps and springs is another major constraint on Pueblo habitation sites. The "spring" (right) side of Vector II on Run I is dominated by both Pueblo II and Pueblo III habitations (Fig. 53). All types of water control sites occur here also. Special use Pueblo sites and undated sites occur on the opposite end of the continuum.

Vector IV on Run I also exhibits functional variation along its continuum. Both Pueblo II and Pueblo III habitation sites and water control sites tend to occur nearer the pinyon end of this vector. Plant community may be the constraining factor here.

The fifty-eight selected sites and thirty-five water control sites were also scaled using fifteen potential encouraged and semi-cultivated plant types. Four vectors received interpretations in each scaling. Except for their order the vector interpretations are the same for both groups of sites.

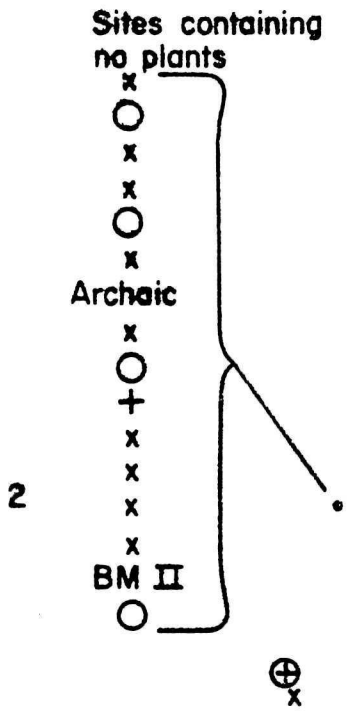
Vector I of the selected sites (Run III) is a continuum on which the presence of shadscale grades into the presence of saltbush on the sites. Vector II is characterized by the absence of all plant variables of the right side of the vector and the presence of many of the plants on the sites at the opposite end. The presence of these plants, furthermore, correlates with canyon bottom, rim and talus topography; the absence with mesa top ridge and arroyo locations. A possible explanation for this is that potential semi-cultigens by their nature are weedy species tending to inhabit areas of disturbed soils. The ecotone between canyon bottom and mesa top would contain conditions favorable to these species. Vector III is dominated on one end by sites containing wolfberry. The last vector, IV, indicates the presence of springs on one end.

The scaling of water control sites, Run IV, received the same interpretations, the shadscale-saltbush gradient emerging as the first and therefore, most important vector. Vector II represents a canyon-mesa top gradient one end of

which is dominated by sites on which many of the plants are present. The opposite end of this vector contains sites on which none of the plant variables are present. Vector III indicates the presence of springs on one end and Vector IV contains sites on which wolfberry is present on one end. The order of these last two vectors is reversed from Run III.

Vector II of Run III reveals differential environmental constraint through time on the canyon-mesa continuum (Fig. 54). A majority of the sites located on the mesa top (left) end of the vector are undated sites and include an Archaic and a Basketmaker II site. These sites do not contain any of the plant variables. Sites on which the variables do occur are located on the right side of the vector (the canyon end). The majority of these date from the Pueblo time periods. No major temporal variation was seen over vectors from Run IV, although Pueblo II sites tend to show a wider range over Vector IV, the wolfberry vector, than do Pueblo III sites.

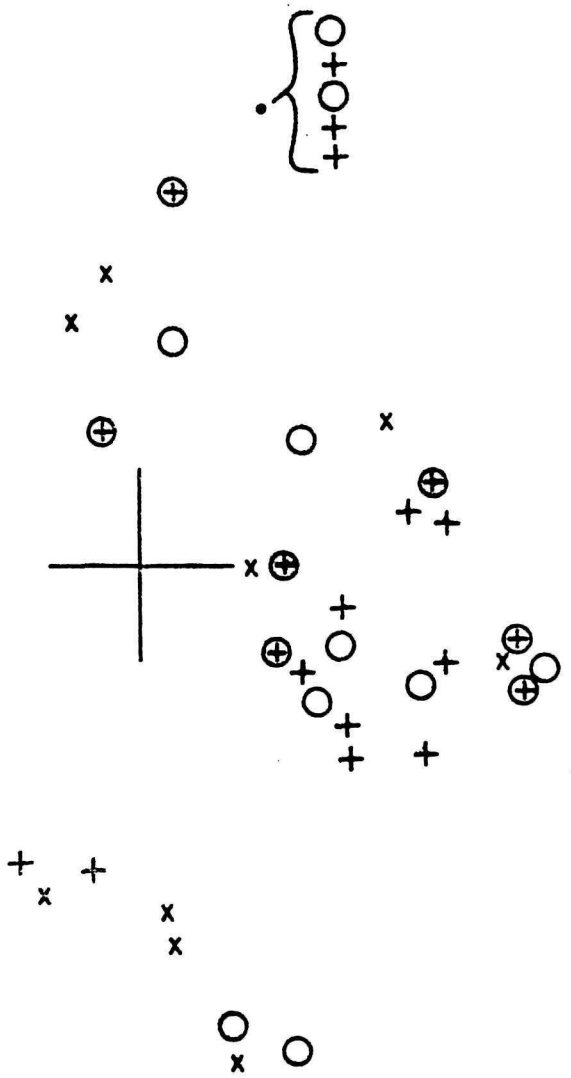
Functional differences between sites distributed along the vectors of Run III have to do with distinctions between habitation and water control and nonhabitation sites. More habitation and water control sites tend to be located on the saltbush end of Vector I (Fig. 55). The lower end of this vector (saltbush) may represent higher elevation and less alkaline soil conditions acting as constraining factors on the location of these sites. All habitation sites as well as most of the water control structures occur on the right side of Vector II (Fig. 55). This is the portion of the vector representing the presence of many of the plant variables and the presence of a canyon related environment. Environmental constraint on these sites seems to be related to canyon physiography. Vector III (Fig. 56) contains water control sites in the wolfberry portion (lower end) of the vector. Constraint on these sites may have to do with amount of seasonal precipitation and type of drainage. Vector IV illustrates the presences of habitation sites and water control sites near areas containing springs on the right side of the vector (Fig. 56).



Pueblo II
Pueblo II and III
Pueblo III
Undated sites

0 1 unit

Fig. 54



Run III: Vectors I and II

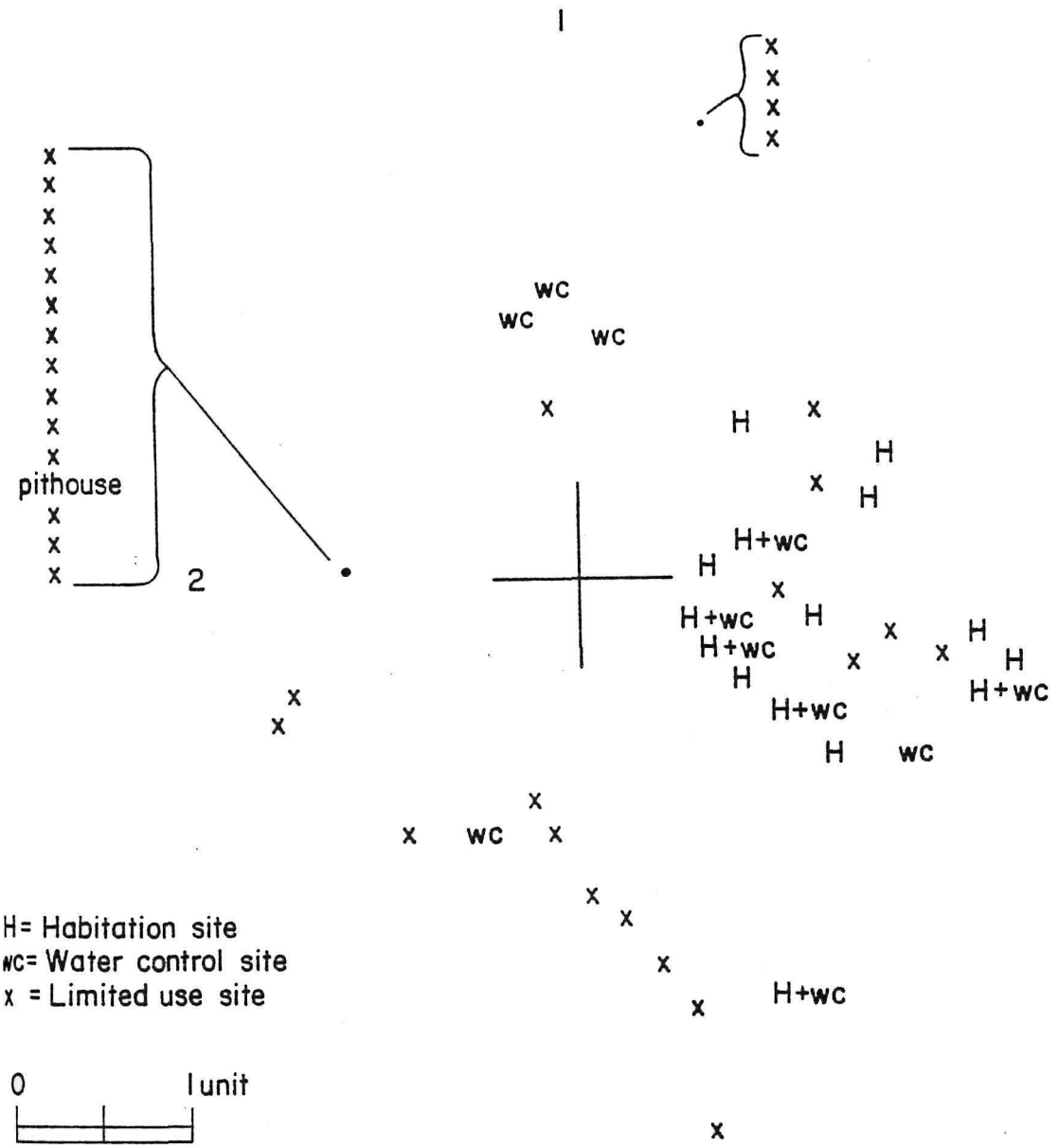
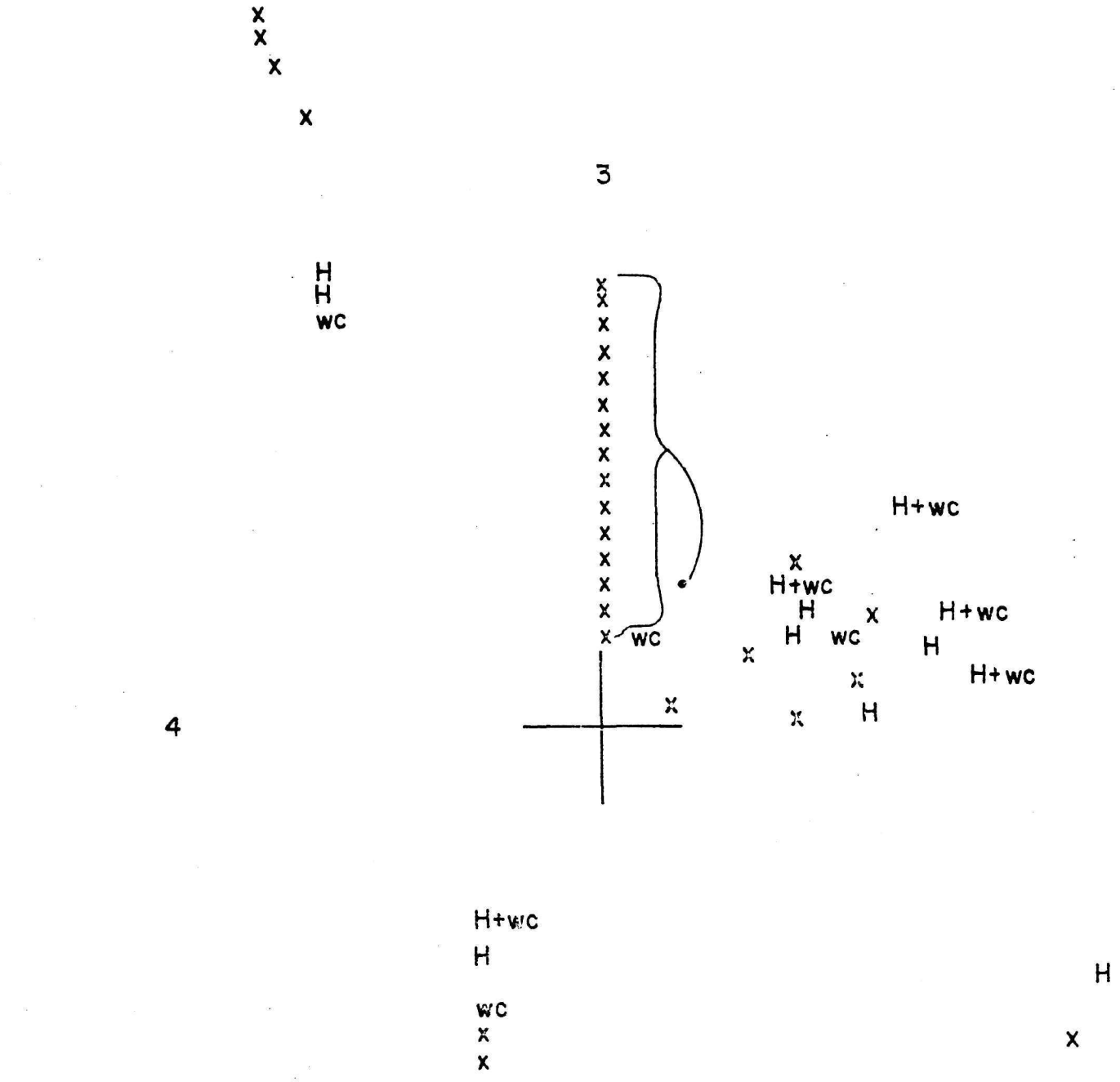


Fig. 55

Run III: Vectors I and II



Run III : Vectors III and IV

Fig. 56

PRELIMINARY INTERPRETATIONS

2. Environment

Active dune in McElmo Canyon

III.2.A PLANT ZONES OF THE HOVENWEEP AREA

CAJON MESA, COLORADO-UTAH

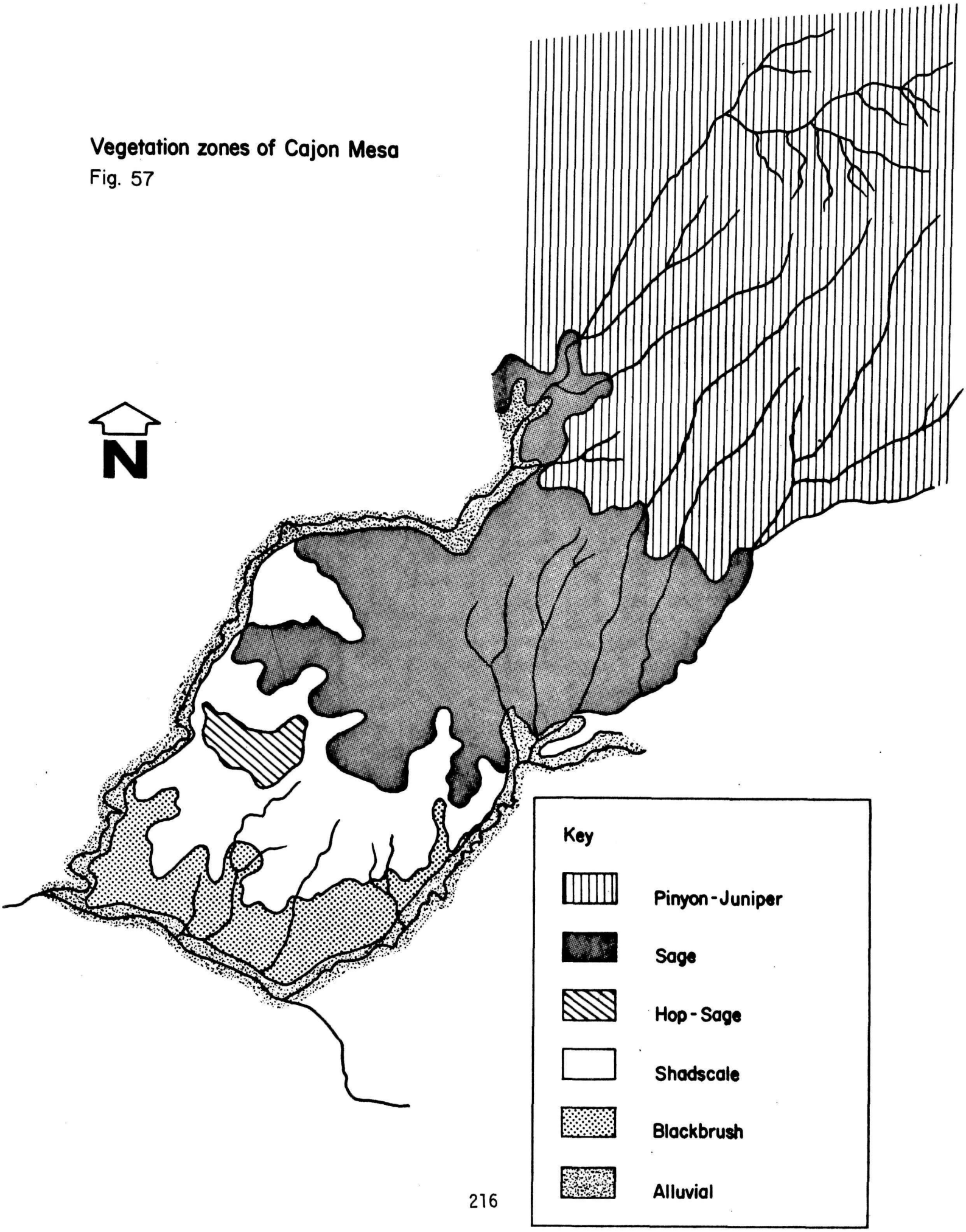
By William J. Litzinger

Hovenweep National Monument is located on Cajon Mesa, which covers approximately 300 mi^2 (800 km^2) of canyons, ridges and relatively flat uplands on a great plain that slopes from the base of the Southern Rockies to the San Juan River. Located in southwestern Colorado and southeastern Utah, the natural boundaries of the mesa are formed by the San Juan River on the south, the large canyon systems of Montezuma and Cross Canyon to the west, Yellowjacket-Sandstone Canyon to the east, and McElmo Canyon to the southeast (see Fig. 1). The northern boundary is essentially cultural, brought about by the destruction of the natural vegetation by extensive bean and wheat fields. The overall gradient is relatively gentle, since the elevation gradually slopes from approximately 2040 meters in the northern forests to 1200 meters in the San Juan Valley. All of the canyons have seasonally running streams which eventually flow into the San Juan River, while permanent springs and seeps are common at canyonheads and along arroyos where the stream bed contacts aquifer strata.

Many factors, such as slope, elevation, moisture, and soils greatly influence the flora of the area. Five distinct vegetation zones occur, ranging from pinyon-juniper woodland in the north, through sage and shadscale shrublands, to the blackbrush zone which borders the river bottom alluvial zone of the San Juan Valley (see Fig. 57). The situation is further complicated by the following physiographic divisions which dissect the major plant zones of the mesa, thereby producing many microhabitats, each with its own particular plant communities: ridges, canyonhead springs, canyon rims, canyon bottoms, slickrock areas, cliffs, talus slopes, seeps and arroyos.

One of the salient features of the Hovenweep environment is the long history of biotic change attributable to human influence. The first people to intensely occupy the mesa

Vegetation zones of Cajon Mesa
Fig. 57



were Anasazi farmers, whose presence and influence on the environment comprise one of the central themes of this volume. It is fairly certain that earlier peoples than the Anasazi made use of the Hovenweep environment, and even after their abandonment at ca A.D. 1300 scattered bands of Ute and Navajo undoubtedly made seasonal use of the area's resources. Grazing was introduced in the late 1880's and by the early 1900's a few white settlers were living on the mesa. The southern half of the mesa was included within an extension of the Navajo Reservation in the 1930's, so numerous Navajo families now occupy the area. In the northern part of the mesa, where available moisture permits, modern white farmers are able to cultivate large acreages of pinto beans and winter wheat without irrigation.

Nonhuman biotic factors may also have had their effect on the Hovenweep environment. A great many small herbivores, for example, are constantly at work altering the plants around them (Fautin 1946), and many small subterrestrial animals, such as mice (Peromyscus ssp.), kangaroo rats (Dipodomys ordii), and chipmunks (Eutamis quadrivittatus), may be important in soil aeration and enrichment. They also break up the caliche layer with their burrows, a factor probably important to Artemisia tridentata. Reptiles and insects are also important in many of the above respects. Large browsing animals such as deer (Odocoileus hemionus) are very rare in the area today, but they may have been important in the past, as were other large animals such as bison (Bodivea sp.) and mt. sheep (Ovis canadensis) (Anderson 1961; Hayes and Lancaster 1975).

Climate

The climate of the Hovenweep area is a cool semi-arid type marked by two seasons of precipitation, winter-spring and summer. Hovenweep occupies a unique position in relation to southwestern winter weather types, being on the fringes of two major Pacific storm patterns. Moisture comes in part from the Pacific Northwest pattern, which is characteristic of the Great Basin in general, and from the east and northeast moving fronts which originate along Lower California. This latter pattern is characteristic of Arizona and Southern California. The Pacific Northwest storms are responsible for

most of the cold weather and snow of fall and mid-winter, while the Lower California pattern is responsible for the spring moisture.

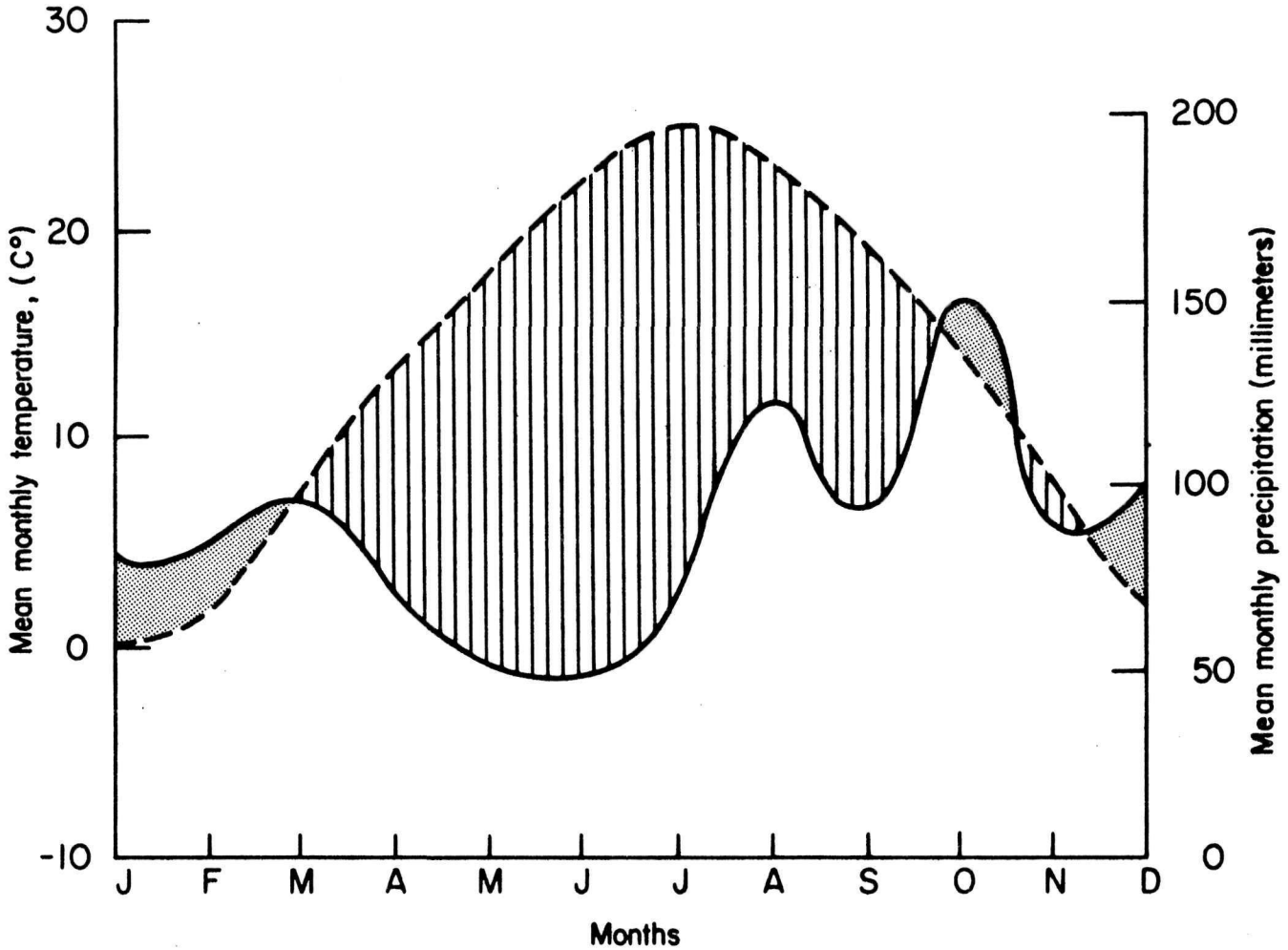
Almost without exception, the month of June is characterized by extreme drought. Summer moisture comes mostly from the Sonoran Summer Monsoons (Bryson 1957), which arrive from the south and southeast. The effect of climate on vegetation is discussed when appropriate in the text that follows.

The weather information presented in Fig. 58 was compiled from records kept by the National Park Service over a fifteen-year period. Although these records apply only to the mid-portions of the mesa, where the station is located, there seems to be a gradient in temperature and precipitation coincident with the south to north rise in elevation. At the lower end of the mesa, along the San Juan River, moisture may only amount to 100 mm. annually, while the annual average for the upper mesa is 400-450 mm. There is a corresponding gradient in temperature which may vary as much as 8-10 degrees C. from the lower end of the mesa to the upper elevations, on any given day.

A graph of the temperature and precipitation, as in Fig. 58, reveals several important relationships. First, during the period of relative drought the evaporation potential usually exceeds the available moisture. Conversely, during periods of relative humidity, the evaporation potential is generally less than the available moisture. The greatest period of relative humidity occurs during the mid-winter when temperatures are low. During these months the ground can be expected to have snow cover on 50 percent to 80 percent of the days. On many of these days temperatures will be well above freezing, however, so most of the resulting snow melt is evaporated directly into the atmosphere. The net result in terms of effective moisture is very little, if any, run-off, except from slickrock areas.

When evaporation is low, however, winter and early spring moisture is very effective in penetrating the soil. Moisture is thus stored and made available to plants during the high drought stress period of late spring and early summer. The short period of relative humidity indicated in the fall is quite variable and in many years may not occur at all.

Hovenweep climatic diagram



Period of relative drought

Period of relative humidity

— Precipitation

– – Temperature

Fig. 58

The summer monsoons bring considerable moisture, but it is much less effective than the winter-early spring moisture. The evaporation potential is extremely high at this time, and the precipitation, usually in the form of thundershowers, falls on dry soil where the volume of rainfall greatly exceeds the soil's absorbing capacity. This results in the typical flash floods common in arid areas throughout the Southwest. In June of 1975, for example, an overnight thunderstorm left more than 25 cm. of precipitation at Hovenweep. The following morning soil cores demonstrated that moisture penetrated only 17 cm. in mesa top aeolian soils and 21 - 23 cm. in the coarser talus and canyon bottom alluvium soils. Penetration in residual mesa top soils was slightly greater than 6 cm. During the peak of the storm, the runoff water in the arroyo above the canyonhead at the Square Tower Monument Group measured 83 cm. deep, and was 37 cm. deep at the time the soil cores were taken. All of these factors have a direct bearing on the vegetation pattern of the mesa.

The Vegetation Zones of Hovenweep

The basic concept utilized in discussing the flora of Cajon Mesa is the vegetation zone. The necessity of defining this term is inherent in the problem that there has been little consistency in its use, even within a distinct geographic region such as the Southwest. Graham (1937) illustrates the problem with a discussion of the varied use of the term by many Great Basin and Southwestern plant geographers. Perhaps the most currently accepted use of the term is the statement by Billings (1951) which defines a vegetation zone as "a large climax unit whose boundaries are caused primarily by the effects of climate and soil on the distribution of the dominant species of the zone."

The field investigator is thus faced with deciphering the recognizable units of vegetation that occur on the mesa. Billings (1951) gives some good practical advice to the field worker: "in mapping the extent of vegetation zones of a given region, an ecologist must be guided by discontinuities in both physiognomy and quantitative floristics and draw the boundary lines on a map more or less arbitrarily according to his judgment." For the present discussion a vegetation zone is therefore regarded as an association of species

defined by consistency of physiognomy and dominant species. Each plant zone contains numerous microzones (or microhabitats) created as a result of numerous physiographic variables. The units of plant species associated with the various microhabitats will be considered plant communities. A plant community is thus defined as a group of plants having mutual relationships among themselves and their environment. In terms of the vegetation of Cajon Mesa this definition allows the description of such distinct floristic units as Rimrock Communities, Talus Slope Communities, Ravine and Canyon Bottom Communities, Seep Communities, etc. The term community is also applicable to such anthropogenic microhabitats as roadsides, farm fields, and stock tanks. There is even a distinct wolfberry community associated with certain pueblo ruins of the mid-mesa sage zone.

Many communities are azonal on the mesa, and certain species extend their range over a variety of physiographic and elevational gradients. Thus shadscale (Atriplex confertifolia) is not uncommon along the moist upper reaches of canyons, well within the pinyon-juniper zone, while juniper (Juniperus osteosperma) is found on the dry lower benches of the mesa. This leads to the conclusion that some communities, such as the Talus Slope Community, are in reality diverse continuums that run from one end of the mesa to the other.

Taxonomic investigations of the plants of Cajon Mesa have been carried on for two field seasons. A list of the plants identified, along with such notes as their ecology, distribution and seasonality is presented in Appendix III. Brief descriptions of each zone follow.

The Alluvial Zone

This plant association is considered a zone because of its extent and the limited number of species which occupy it. The zone is confined to the flood water terraces and stream beds of Montezuma Canyon and McElmo Canyon, and the flood water terraces and banks of the San Juan River.

Today the dominant species of the zone is Tamarix pentandra, which is a naturalized Mediterranean plant that has been invading the Southwest at the expense of native species

since ca A.D. 1880 (Christenson and Johnson 1964; Harris 1966). It is estimated that the plant was not common in the Hovenweep area until relatively recently. In 1892 Alice Eastwood, for example, passed along the San Juan River near Aneth, yet she made no mention of the plant (Eastwood 1893). Instead, she described thick stands of Beeweed (Cleome surrulata) and Jimson weed (Datura meteloides) along the flood water terraces, as well as extensive areas dominated by Sarcobatus vermiculatus. Today, C. serrulata and D. meteloides have all but been eliminated in the Hovenweep area. C. serrulata occurs in a few isolated locales along the flood water terraces of Montezuma Creek. D. meteloides seems to occur as a weed along the edges of Navajo farm fields, and is also known from a few disturbed mesa top locales. There is a strong possibility that D. meteloides is intentionally planted, or at least tolerated as a weed by the Navajo, who use the plant in a variety of ways (see Winter and Noisat 1975, and section III.1.B of this volume). Gregory (1938) similarly made no mention of T. pentandra along the San Juan in this area, and local residents have confirmed that T. pentandra has only been locally common during the last thirty to forty years. This fact supports the hypothesis of Harris (1966) that T. pentandra dominates and forces out native phreatophytes most aggressively in areas where the construction of dams has cut down on seasonal flooding and the accumulation of alluvium. This is the situation along McElmo Creek and the San Juan River, and it is only along Montezuma Creek, where no extensive flood water control has been undertaken, that there are still remnant stands of the native phreatophytes. These include Salix sp., Chrysothamnus sp., Sarcobatus vermiculatus, and Suaeda sp.. Groves of Cottonwood (Populus balsamifera) occur occasionally along the bottoms of the broader canyons, and while they grow only rarely along the San Juan, they probably grew extensively along it in former times.

The Blackbrush Zone

Most authors class this plant association as a more or less transitional buffer zone between the Shadscale Zone and the Creosote Zone (Cronquist 1972). Cronquist does note, however, that in its eastern extensions, the blackbrush association appears as a broader belt of zonal character.

This is the case found on the lower benches of Cajon Mesa.

The Blackbrush Zone consists of an open to dense stand of low, broadleaf, evergreen shrubs. The dominant species is Coleogyne ramosissima. Other shrubs are:

Artemisia frigida	Ephedra torreyana
Artemisia bigelovii	Tetradymia spinosa
Atriplex confertifolia	Wyethia scabra

Several perennial grasses, such as Hilaria jamesii, Aristida longiseta, and Sporobolus airoides occur within the zone. Important annuals are:

Bromus tectorum	Salsola pestifera
Cryptantha gracilis	Erodium cicutarium
Halogeton glomeratus	

The Blackbrush Zone on Cajon Mesa lies entirely within the limits of the Navajo Reservation and is subjected to heavy grazing. The response of this zone to grazing has not been investigated, and no information is available at the present time. It seems likely, however, from the presence of the perennial bunch grasses, that grazing has reduced the grass cover and allowed less palatable shrubby species to dominate. This topic will be covered in the discussion of the sage zone.

One important aspect of the ecology of Coleogyne ramosissima is its dominance on colonized sand dunes. Along the lower benches of the mesa, there occur numerous active and stabilized dunes which may coincide in age and origin with similar dunes in northern Arizona (Hack 1942). Dunes support no vegetation until a portion becomes colonized by perennial grasses such as Aristida longiseta or Hilaria jamesii. This initial grass invasion is followed by C. ramosissima and, depending on alkalinity, by Sarcobatus vermiculatus. No rate of local dune stabilization has been established, but it should be noted that many stabilized dunes are rich in archeological sites (see section III.1.A).

The Shadscale Zone

Shadscale is widely distributed throughout the Great Basin, but is most prevalent in the more xeric regions.

Shadscale zone plants are generally well adapted to xeric conditions, both morphologically and physiologically. These plants occur in areas in which the precipitation is considerably less than those areas in which sagebrush is found, and in which the mineral content of the soil is beyond the tolerance of sagebrush (Fautin 1946). Küchler (1962) considers shadscale as a Atriplex-sarcobatus association, with Sarcobatus vermiculatus a codominant. West and Ibrahim (1968) give the most complete analysis of the shadscale zone by dividing it into four soil-vegetation units. Their Atriplex confertifolia/Hilaria jamesii unit best agrees with the shadscale zone found on Cajon Mesa; their other three units do not occur in the area.

The shadscale zone appears as an open, relatively widely spaced stand of low, spinose, small leaved shrubs, dominated by Atriplex confertifolia. Other shrub species associated with A. confertifolia are:

Artemisia frigida	Grayia spinosa
Artemisia bigelovii	Gutierrezia sarothrae
Atriplex canescens	Lycium pallidum
Chrysothamnus viscidiflorus	
Ephedra torreyana	Tetradymia spinosa
Eurotia lanata	Sarcobatus vermiculatus

Perennial bunch grasses, usually occurring in scattered stands, are comprised of Aristida longiseta, Hilaria jamesii, Oryzopsis hymenoides, Sitanion hystrix, Sporobolus airoides, and Stipa comata. Important herbaceous perennials are:

Abronia fragrans	Opuntia ssp.
Calcochortus nutallii	Rumex hymenosepalus
Cymopterus bulbosa	Senecio longilobatus
Echinocereus coccineus	Sphaeralcea coccinea
Eriogonum ssp.	Sphaeralcea parvifolia
Delphinium nelsonii	Suaeda ssp.
Lomatium grayi	Yucca angustissima
Oxybaphus linearis	Zygadenus paniculatus

The associated spring and summer annuals are:

Bromus tectorum	Erodium cicutarium
Chaenactis douglasii	Halogeton glomeratus
Cryptantha gracilis	Phacelia corrugata
Draba reptans	Salsola pestifera
Eriogonum sp.	

In addition to the above species Utah Juniper (Juniperus osteosperma) and Single-leaf Ash (Fraxinus anomala) are occasionally found in the zone, especially in rimrock and talus slope communities.

Much investigation has been done on the shadscale vegetation zone, although most of this work has been devoted to the relationships and distribution of various shadscale associations and their accompanying soil types (cf. Billings 1949; West and Ibrahim 1968). Most authors concur that shadscale does best on shallow pan soils of low acidity and relatively high salt content. Bolen (1964) points out that A. confertifolia is much less salt tolerant than many of its associates. His description applies to vegetation zones around spring-fed salt marshes in Utah, however, so more than one factor may be at work at Hovenweep. Walter (1973) reports that A. confertifolia is extremely tolerant to excessive moisture. Fautin (1946), however, reports that A. confertifolia does best when the soil salt concentration does not exceed 0.09 percent. Walter (1973) classes A. confertifolia as a halyophyte, i.e. a plant which can store large quantities of salts in its organs without undergoing any damage. The root system of A. confertifolia is well adapted to making use of all available soil moisture, since it has an extensive root system near the ground surface which is capable of effectively utilizing the temporary water supplies resulting from summer thundershowers. It also has a tap root that extends 40 - 60 cm. into the soil allowing the plant to make use of stored winter moisture. The caliche layer is usually found 60 - 80 cm. below the ground surface in the shadscale zone, and thus below the roots of A. confertifolia (West and Ibrahim 1968). The above ground morphology also makes the plant well-adapted to xeric conditions. The plants are low and spinulose, with small deciduous leaves covered by a dense farinose substance. Apparently it also has the ability to reduce photosynthesis to a near standstill during drought, and can greatly reduce its transpiring surface by losing its leaves.

Sarcobatus vermiculatus usually forms a community in the shadscale zone on ground too saline for A. confertifolia (Cronquist 1972). This usually occurs in low areas and along drainage patterns where runoff water tends to concentrate alkaline salts. S. vermiculatus normally requires considerable amounts of water, despite its succulent,

heavily cutinized leaves, and high cell sap concentration which classify it as a halophyte (Fautin 1946; Billings 1949). It is also a phreatophyte, since it has an extremely deep tap root of 6 - 20 meters, and it apparently has the ability to penetrate the soil to a depth where ground water is sufficiently available. Suaeda sp., Rumex hymenosepalus, and Aristida longiseta are usually associated with S. vermiculatus in the shadscale community.

Heavy grazing has almost eliminated Sarcobatus vermiculatus from most of the upland valleys in the shadscale zone. Today the community survives in some of the side canyons of Montezuma Canyon, where it imperceptibly merges with the alluvial zone. There are also remnants of this community in some of the upland valleys of the sage zone where it has been subjected to less grazing pressure. S. vermiculatus also seems to favor sand dunes and disturbed areas, and it is common around the pueblo ruins at the Cajon Monument Group. It also has been observed as an invading species on abandoned farmland in Montezuma and McElmo Canyons, where irrigation probably increased the soil salinity beyond the tolerance of most other local species, thus allowing S. vermiculatus to become established. This observation confirms Bradfield's (1968) account of S. vermiculatus occurring on abandoned Hopi farm fields.

Another important community in the shadscale zone is composed of the "blackbrush island." These islands are actually ancient stabilized sand dunes, similar to those of the blackbrush zone, which are generally small oval or eliptically-shaped sand mounds 30 - 60 meters long, and 1 - 2 meters deep.

None of the past studies on the shadscale zone have investigated successional trends as a result of grazing. West and Ibrahim (1968) state that there seems to have been no change in the vegetative cover of their study area in the last one hundred years, even though the area was once heavily grazed. Most of the shadscale zone found on Cajon Mesa occurs on the Navajo Reservation, and, consequently, has been subjected to heavy grazing, especially during the last forty years. In most areas where the shadscale zone has been severely grazed, cheat grass (Bromus tectorum) is exclusively the dominant species. Other areas have been observed in which Senecio longilobatus has replaced the shrubs,

accompanied by cheat grass. In less severely grazed areas where Atriplex confertifolia has survived, its dominance is greatly reduced by the presence of Gutierrezia sarothrae and Bromus tectorum.

The ecotone between the shadscale zone and the sage zone is narrow and dramatic. Walter (1973) suggests that this sharp ecotone is due to the differences in salt between the species, with Artemisis tridentata being extremely salt intolerant. A. tridentata never invades below its zonal boundary, yet Atriplex confertifolia occurs well into the pinyon-juniper zone, where it probably does best on more xeric sites, and in areas in which soil salinity lessens or eliminates competition from other species.

The Sagebrush Zone

The sagebrush zone has been considered by many authors to be the most important zone in the entire Great Basin. Certainly it has been the most exploited by humans. On Cajon Mesa, sagebrush occupies a uniform zone on the deep soiled, upland flats of the mid-mesa, and covers about one-third of the entire study area.

The sagebrush zone appears as a fairly dense to open stand of low to medium height shrubs, dominated by Artemisia tridentata. Other components of the shrub layer are:

Amelanchier utahensis	Gutierrezia sarothrae
Atriplex canescens	Lycium pallidum
Chrysothamnus nauseosus	Prunus virginiana
Chrysothamnus depressus	Rhus trilobata
Cowania mexicana	Ribes aureum
Ephedra torreyana	Sarcobatus vermiculatus
Eurotia lanata	Tamarix pentandra
Grayia spinosa	Yucca angustissima

The trees encountered in this zone are Juniperus osteosperma, Celtis occidentalis, and Populus fremontii.

Common perennial grasses of the zone are:

Agropyron spicatum	Oryzopsis hymenoides
Aristida fendleriana	Phragmites communis

Aristida longiseta	Sitanion hystrix
Bouteloua gracilis	Sporobolus airoides
Hilaria jamesii	Stipa comata

Other important perennials of the zone include:

Apocynum cannabinum	Hymenoxys acaulis
Arabis pulchra	Juncus
Asclepias capricornu	Leptodactylon pungens
Asclepias subverticillata	
Astragalus utahensis	Lomatium grayi
Brickellia californica	Marrubium vulgare
Calochortus nutallii	Mirabilis multiflora
Carex sp.	Opuntia sp.
Castilleja chromosa	Penstemon angustifolius
Chrysopsis villosa	caudatus
Cryptantha bakerii	Rumex hymenosepalus
Cymopterus bulbosus	Senecio longilobatus
Delphinium nelsonii	Senecio multilobatus
Echinocereus coccineus	Stanleya pinnata
Eriogonum sp.	Townsendia incana
Haplopappus armerioides	Tragopogon dubius
	Typha latifolia

Important annuals of the zone include:

Amaranthus ssp.	Erodium cicutarium
Aster arenosus	Euphorbia fendleri
Bromus tectorum	Halogeton glomeratus
Chaenactis douglasii	Helianthus annuus
Chenopodium glaucum	Lactuca scariola
Cirsium neomexicanum	Lappula redowskii
Comandra umbellata	Lepidium sp.
Descurainia pinnata	Melilotus sp.
Draba reptans	Plantago purshii
Eriogonum sp.	Sisymbrium altissimum

Artemisia tridentata is considered sclerophyllous in its adaptive response to the semi-arid conditions in which it grows. The ecological significance of sclerophylly is the ability of the species to conduct active gaseous exchange in the presence of adequate moisture, but to cut down rapidly by shutting the stomata during drought. This enables sclerophyllous species to survive months of drought without losing their leaves. Sclerophylly seems to be equally important

among perennial bunch grasses of such genera as Agropyron, Hilaria, Oryzopsis, and Stipa (Walter 1973).

The underground morphology of Artemisia tridentata is well suited to the deep soils in which it is found primarily. The below ground portion of the plant consists of an underground stem, below which a tap root extends to a depth of up to three meters beneath the surface. From the tap root extend numerous lateral branch roots, which facilitate the utilization of soil moisture at a considerable depth, as well as near the surface (Dittert 1938; Walter 1973). The underground stem is of considerable adaptive value as well. The stem, both above and below the ground surface is covered by a thick mat of fiber. During times of moisture, this fiber acts as a wick drawing water into itself and down into the plant's root system. When dry, it acts as a protective covering guarding against loss of moisture by evaporation.

A. tridentata's small leaves, as well as their tomentose covering, also help decrease water loss. The vigor and size of an individual plant may often be attributable to the depth of the caliche layer, which acts as an effective barrier to penetration by the roots of A. tridentata. Intolerance of A. tridentata to excessive soil moisture has been noted by Stewart (1941) and Fautin (1946). When the soils of a sagebrush area suddenly become wet, e.g. by the creation of a dam or irrigation, the plants die very quickly. This situation has been observed at several locales on Cajon Mesa. A. tridentata also has a low tolerance for saline soils.

The earliest records of whites in parts of the Great Basin generally agree that areas now occupied by sagebrush may have been occupied in contact times by a dense cover of perennial grasses among which were scattered moderate sized shrubs. Two factors seem to have been primary in this historic change to the present condition: the introduction of domestic grazing animals and the control of fire, both brought on by the white settlers (Blaisdell 1953).

The effect of grazing by animals has been well documented (Pickford 1932; Cottam and Stewart 1940; Stewart et al. 1940; Costello and Turner 1941; Blaisdell 1953; Christenson and Johnson 1964; Pearson 1965). Generally these studies show that the perennial grasses were favored greatly for forage, and since grazing was primarily winter-spring, these

grasses were stressed during their prime growth season (Pearson 1965). Besides being weakened, their reproductive potential was also severely reduced since animals ate their seed producing stems. Soil dessication then occurred as the grasslands were reduced, resulting in great amounts of erosion and runoff after storms. Since Artemisia tridentata is an aggressive colonizing perennial species, these conditions made possible an explosive sagebrush invasion into degenerating grasslands (Cottam and Stewart 1940).

In contrast to the above interpretation, Woodbury (1947) argues that the sagebrush type appears to have been well-established in the Great Basin in pre-white times. His work suggests that early white impact on the vegetation may have been limited to certain areas, even though the influence within these areas may have been extensive. Furguson (1964) tested Woodbury's hypothesis by making a study of sagebrush age over a wide area of the Southwest. In those regions most similar to Hovenweep, he found that most of the plants were in the twenty to sixty year old age class, and that one hundred year old sage was not uncommon. Since one hundred year old sage anti-dates grazing in many regions, it is possible that Furguson's technique will allow a detailed description of the age of sage and its relations with grasses in the Hovenweep area.

There is also reason to believe that the historic grasslands themselves were the result of anthropogenic change (Sauer 1950). Stewart (1941) recounts the records left by the Spanish explorer Escalante as he passed through central Utah in A.D. 1776: "We found the grasses of the plains where we came recently burned over and others being burned (by the Indians)." Nearly sixty years later Captain Bonneville, whose early explorations date back to A.D. 1832, noted that the sky was darkened for days at a time by fires set by the Indians (Fautin 1946). Although lightning-caused fires undoubtedly had some effect on the vegetation, the use of fire as a game driving technique and as a growth stimulant for certain desirable plants, such as Oryzopsis, Nicotiana, Calochortus and Lomatium, was widespread in North America.

Pickford (1932) has given the most detailed account of the effects of both grazing and fire on this zone. His results include the following:

1. By comparing grazed areas with protected, relict grassland areas, he found that palatable perennial grasses represent 41 to 81 percent of the ground cover in the protected area, while sagebrush was unimportant if present at all. In grazed areas, sagebrush was the dominant species while the perennial grasses represented less than 10 percent of the total ground cover.

2. Observations on burned, ungrazed plots indicate that sagebrush has practically been eliminated by fire, while the other perennial shrubs showed little effect from burning. He also found that the perennial grass cover was lessened, but this can partially be explained by the increase in the annual cheat grass (Bromus tectorum). This species is a late European introduction which forced out the other grasses which probably would have been present in prehistoric, burned situations.

3. On both burned and grazed plots both the native bunch grasses and Artemisia tridentata were nearly eliminated. Bromus tectorum and other perennial and annual weeds formed the dominant ground cover.

Good historic information for the pre-contact vegetation on Cajon Mesa is presently lacking. However, with the above sequence in mind it is possible to hypothesize that within the present-day sagebrush zone, Artemisia tridentata could have been considerably less extensive and the perennial bunch grasses more extensive than they are today. The presence of sagebrush parks within the pinyon-juniper zone may be an exception to this generalization, as will be discussed later in this report.

Whatever the pre-contact pattern, grazing was introduced into the Hovenweep area in the 1880's, and by the early 1900's Cajon Mesa was a heavily grazed winter and spring range. The southern half of the mesa was added to the Navajo Reservation by 1935, and grazing then became even more disruptive as the pattern in the south shifted to year-round use. The effect upon the modern dominant species of the sagebrush zone can dramatically be seen in Reservation areas in which Artemisia tridentata was eliminated and Bromus tectorum became the dominant ground cover, within a period of forty years. In areas outside of the Reservation continued heavy grazing during the winter-spring season has resulted in

widespread establishment of B. tectorum. Snakeweed (Gutierrezia sarothrae) has also been able to take advantage of the weakening sagebrush dominance, and has become dominant in some areas and codominant in others with B. tectorum. In areas of intensive grazing, such as around repeatedly used sheepcamps, the native vegetation has been eliminated and B. tectorum alone exists.

Once established, B. tectorum appears to form a "closed stand," i.e. it effectively maintains its dominance through time. Daubenmire (1942) found that after thirty years of grazing protection Agropyron spicatum seedlings had not invaded dense stands of B. tectorum, and he suggests that B. tectorum can maintain its hold on an area indefinitely. Harris (1966), in contrast, summarizes the work of other investigators who indicate that reinvasion may occur more rapidly. Some of these authors do not make clear, however, whether the perennials return as seedlings or as regenerating remnants of old established plants.

This introduced annual brome is a good example of the effects which result from the replacement of native perennial species by a vigorous exotic weedy species in a disturbed environment. B. tectorum was first recorded in the eastern states around 1860, but by the 1890's it was well established over wide areas of the West. Disturbance is probably the key factor in the spread of B. tectorum. According to Harris (1966) the basic factors controlling competitive relationships between perennial and annual species include the control of fire, grazing and farming, i.e. disturbances of an anthropogenic nature (cf. Hulbert 1955).

The ecotone between the sagebrush and pinyon-juniper zones is very broad and difficult to define. In many places the disjunction occurs along community boundaries such as talus slopes or canyon rims, where no clear dividing line is present. To make matters more confusing juniper extends well into the lower zones, while Artemisia tridentata extends well into the pinyon-juniper where it often grows as an understory shrub. Sagebrush, in fact, is known to tolerate a wider range of climatic and elevational conditions than pinyon-juniper (Woodbury 1947). Thus climate and elevation alone do not explain differences in distribution, which increases the possibility that anthropogenic disturbance was

an important factor in the respective distributions of sage, pinyon and juniper.

The Hop-Sage Zone

The island occupied by hop-sage (Grayia spinosa) in the shadscale zone has sufficient attributes to make it a separate vegetational zone but with a relatively small area. It could also technically be a part of the sagebrush zone, save for a narrow neck of shadscale vegetation separating it from the sagebrush region. This disjunction between the sagebruch and hop-sage zones may, in fact, be artificial, since this is one of the heaviest grazed regions of the Reservation. The hop-sage zone is essentially a pure stand of Grayia spinosa, a medium height shrub with small deciduous leaves. The only other species of note within the zone are Bromus tectorum and Gutierrezia sarothrae.

The Pinyon-Juniper Zone

The pinyon-juniper zone occurs on the higher, moister uplands of the mesa where increased precipitation and lower temperatures make it the most mesic of all of the local environments. The zone is composed of open groves of low, needle-leaved evergreen trees, which rarely exceed six meters in height. The trees are usually spaced such that their branches do not touch, and the understory consists of a mixture of medium and small sized shrubs, grasses, and herbaceous plants. The zone changes composition conspicuously along altitudinal lines, and as noted earlier, junipers actually occur throughout the mesa, extending into the lower zones along canyon rims, talus slopes and draws. At present, the pinyon extends down the mesa to a line approximating the 350 - 400 mm. level of precipitation. In Fig. 57, the line representing the lower limits of the pinyon-juniper zone is actually equivalent to the lower extension of the pinyon, while juniper occurs as far south as the San Juan Valley.

The pinyon-juniper zone is dominated by two species of gymnosperms: Pinus edulis and Juniperus osteosperma. The only other trees in the zone are Celtis occidentalis and Populus fremontii, which occur in very restricted locales.

Shrubs in the pinyon-juniper zone are:

Amelanchier utahensis
Artemisia tridentata
Atriplex canescens
Atriplex confertifolia
Cercocarpus montanus
Chrysothamnus nauseosus
Quercus gambellii
Quercus turbinella
Ribes aureum
Chrysothamnus depressus
Cowania mexicana
Ephedra torreyana
Gutierrezia sarothrae
Peraphyllum ramosissimum
Purshia tridentata
Rhus trilobata
Tetradymia canescens

Perennial grasses associated with this zone include:

Agropyron spicatum
Aristida longiseta
Bouteloua gracilis
Oryzopsis hymenoides
Poa fendleriana
Sitanion hystrix
Sporobolus airoides
Stipa comata

Some herbaceous perennials of the pinyon-juniper zone include:

Achillea millefolium
Astragalus sp.
Balsamorhiza sagittata
Castilleja sp.
Chrysopsis villosa
Eriogonum sp.
Ipomopsis aggregata
Hymenoxys acaulis
Opuntia sp.
Penstemon sp.

Some annuals associated with the zone include:

Amaranthus sp.
Bromus tectorum
Chaenactis douglasii
Chenopodium album
Convolvulus arvensis
Cordylanthus wrightii
Descurainia sp.
Draba reptans
Eriogonum sp.
Erodium cicutarium
Helianthus annuus
Lactuca scariola
Lepidium sp.
Plantago purshii
Polygonum sp.
Verbascum thapsus

The root systems of both pinyon and juniper are well adapted to the soil and climate found in the zone they occupy on Cajon Mesa. The root system of pinyon is diffuse near the soil surface, but also occurs abundantly at greater depths, so pinyon appears to be adapted to both summer and winter

moisture (Fritts et al. 1965). Emerson (1932) describes the juniper root system as having both widely branching roots near the surface and a tap root capable of spreading out on rock surfaces when it contacts bedrock. This also is an adaptation for both winter and summer moisture, but the ability of juniper roots to spread out on rock surfaces may give it the adaptive advantage of extending its range through the more xeric parts of the mesa. There is also more available water on the rock surface than in the surrounding soil, while cracks and depressions in the bedrock gather and hold moisture for long periods of time. The areas south of the pinyon where juniper is able to extend are thus usually rimrock or talus areas.

Successional trends in the pinyon-juniper zone have been discussed by many authors, most of whom seem to agree that there is both a tendency for pinyon to replace juniper in the more mature stands and for it to follow juniper in as the latter invades. At Mountain Meadows, for example, Cottam and Stewart (1940) found that after the wet meadow grasslands had given way to sagebrush, juniper was beginning to invade from the surrounding ridges. Woodbury (1947) noted a similar invasion of juniper, followed by pinyon, in the Ceder and Rush valleys of Utah. He stated that the pinyon-juniper tend to stay on ridges, canyons, and talus slopes where the soils are coarser, rockier and more porous, while sagebrush usually occurs on fine textured, deep soils. He also noted that there is a great deal of competition between pinyon-juniper and sagebrush on intermediate soils. He cited additional data from Black Mesa in northeastern Arizona, where it was found that there are a great many more young pinyons than old junipers. The young pinyon on Black Mesa seemed to be in competition with old juniper, since several young pinyons were noted replacing dead juniper, whereas juniper replacing pinyon did not occur. Christenson and Johnson (1964) found that juniper invasion of former grasslands has only occurred since the introduction of grazing and the control of fire, and Harris (1966) believed that cessation of recurrent fires which formerly effected grasslands adjacent to the pinyon-juniper zone was probably responsible for initiating juniper invasion.

Erdman (1970) suggested that the situation on the nearby Mesa Verde in southwestern Colorado may have been slightly different. The oldest junipers on the mesa are several hundred years older than the pinyon, and while there is a dearth

of dead and fallen pinyon, there is an abundance of old and dead juniper. He concluded that biotic factors which normally cause early death in pinyon, such as porcupines, fungus and bark beetles, cannot explain the young stands of pine on Mesa Verde. He contended, instead, that the situation supports Smiley's (1958) and Malde's (1964) suggestion that a widespread drought may have caused many less resistant species, such as pinyon, to die out at ca A.D. 1600. The recent dendroclimatic study by Fritts et al. (1965) supports this argument as well, since it indicates that a drought occurred from A.D. 1571 - 1595. Juniper is the more xeric of the two species, and it could have withstood drought while pinyon was killed back, only to return in more recent mesic conditions.

The age relations in the pinyon-juniper zone on Cajon Mesa have not been thoroughly investigated, hence no statement, even of a tentative nature, can be made at present.

The occurrence of sagebrush parklands within the pinyon-juniper zone on Cajon Mesa presents an extremely important ecological problem, especially since they are the locations of many large archeological ruins. A similar situation occurs on Mesa Verde, where Erdman (1970) stated that "the ecological status of the brush has been a puzzle." There is a certain amount of historic evidence, however, which indicates that post-Anasazi successional patterns may be at work. Brandagee (1876), for example, made one of the earliest records of sage parklands in the pinyon-juniper as he crossed Mesa Verde by horseback: "Sagebrush (Artemisia tridentata) covers these parks so thickly that they are almost impassable excepting by narrow trail, so narrow that as we ride along the encroaching Artemisia is continually brushing against us."

From the history of the settlement of this area we can conclude that sagebrush thickets in the pinyon forests existed prior to the introduction of large herds of domesticated animals (Freeman 1958). It is therefore doubtful that these areas could have been grasslands before white contact, which is the normal case in most areas of natural sagebrush succession, as discussed previously. These sagebrush parks are frequently filled with Anasazi pueblo ruins, so much so that many settlers found them easier to clear and cultivate than the surrounding pinyon, and it is possible

that prehistoric human disturbances figured in their creation. Martin and Byers (1965) and Erdman et al. (1969), in fact, have suggested that sage became established around the ruins during the Anasazi occupation, and that the incursion of the conifers is a post-abandonment phenomenon. In the pollen studied by Martin and Byers (1965), for example, it was found that cheno-ams, grasses and A. tridentata dominated the sites during their occupation, probably as weeds in the disturbed areas around the villages and on the nearby farm fields. Immediately after abandonment, however, conifer pollen became dominant, which has led Martin and Byers to conclude that a successional change occurred, as pinyon and juniper moved back into the disturbed areas. The faunal remains from the Badger House site on Wetherill Mesa add supporting evidence (Hayes and Lancaster 1975), since jackrabbit bones (Lepus californicus texianus) occurred in higher numbers than cottontail bones (Sylvilagus audubonii warreni). Because jackrabbits, whose natural environment is the open plains and valleys, are not found on the heavily forested mesa today, while the brush loving cottontail is, the faunal data indicates that the habitat around the pueblos was much more open than it is now.

A similar pattern may have occurred on Cajon Mesa, as first suggested by Prudden (1916) and discussed in section III.1.B in relation to the significance of sage on the ruins. For whatever reason the Anasazi abandoned the area seven hundred years ago, it appears that a natural succession occurred on the old farm fields and villages. The Anasazi undoubtedly cleared vast areas for farms, thereby thinning considerably the existing conifers, and it is probable that large sagebrush parklands developed immediately after abandonment. We can only speculate about the exact nature of the ensuing successional pattern, but it could be that juniper, then pinyon, succeeded in re-establishing themselves in the northern areas, except on the rocky ruins proper where sage was at an adaptive advantage. Hopefully, a thorough study of their ecology will shed further light on the sagebrush-juniper-pinyon succession problem.

Climatic Change and Vegetation Shifts

With the exception of the above speculation, little can be said about vegetational changes at Hovenweep over the past 1000 years. Since our project is concentrating on prehistoric agricultural activities, a knowledge of the past climate and vegetation would be extremely useful. For this reason the pollen analysis is concentrating on paleo environmental reconstruction, along with the identification of farm fields. For the present, the findings at Mesa Verde will shed some light on the subject.

Most authors have suggested that the climate of the immediate area, and Mesa Verde in particular, has not changed appreciably during the last 1000 years (Martin and Byers 1965; Anderson 1961; Erdman 1970; Erdman et al. 1969; Hayes and Lancaster 1975). As Erdman (1970) points out, regional climatic variation and post-abandonment succession may have produced minor vegetational alterations, but the overall floral patterns on Mesa Verde do not seem to have changed. Fritts et al. (1965) add that while there have been at least ten major droughts during the last eight hundred years, none appear to have had any great effect on the total vegetation cover of the mesa. Because of its proximity to Mesa Verde, it seems likely that the plant zones of Hovenweep would also have remained relatively stable during the last 800 - 1000 years, notwithstanding droughts and post-abandonment successional trends.

III.2.B AN EVALUATION OF POTENTIAL PREHISTORIC FAUNAL RESOURCES ON CAJON MESA, UTAH

By Theodore Rado

Introduction

The prehistoric inhabitants of Cajon Mesa, as evidenced by artifacts such as knives, scrapers, a variety of projectile point types and processed animal bone (see Chapter II, section 8) must have depended heavily upon the local faunal resources. Since site location was probably determined in part by the location of resources necessary to sustain the community, we are analyzing the faunal resource patterning on Cajon Mesa. This report summarizes an attempt at determining the faunal resources in each of the major plant communities on the mesa, and the potential merit of the community as a hunting area.

The Animals of Hovenweep

Data collected over the summer months of 1974 and the spring and summer months of 1975 are the basis of this report. Table 36 is a phylogenetic listing of the vertebrates found on Cajon Mesa, their occurrence in the various Monument groups, and their status in the major plant communities. Table 37 is a listing, down to family, of the insects found in the Hovenweep area.

Animal observations were obtained by a variety of means. Night driving on the roads in the vicinity of the monument yielded abundant data concerning the nocturnal fauna. Stops were made on several such excursions at the area's more permanent water sources, so as to obtain information on the local amphibian populations. Setting live traps in the major plant communities added invaluable data concerning the small mammal species found here and their relative densities in the communities, as well as their overall status in the monument.

TABLE 36 - Vertebrate Species Present On Cajon Mesa

Species	Plant Zones Occupied And Status *					
	Sage ridge	Sage canyon-rim	Sage talus slope	Sage canyon bottom	Pinyon-juniper	Shrubland
Amphibians						
Ambystoma tigrinum (Tiger Salamander)	c*			c		
Scaphiopus hammondi (Western Spadefoot Toad)	c	u				
Bufo woodhousei (Rocky Mountain Toad)	u					
B. punctatus (Red-spotted Toad)	c	c		c	c	
Reptiles						
Crotaphytus collaris (Collared Lizard)	u	c	c	c	r	u
C. wislizenii (Leopard Lizard)	u	r				
Sceloporus magister (Desert Spiny Lizard)		r	r	s		
S. undulatus (Eastern Fence Lizard)	r	c	c	c	c	r
S. graciosus (Sagebrush Lizard)	c					
Uta stansburiana (Side-blotched Lizard)		c	c	c		
Urosaurus ornatus (Tree Lizard)		u	c	u		
Phrynosoma douglassi (Short-horned Lizard)	r				r	
Cnemidophorus tigris (Western Whiptail Lizard)	c	c	c	c	c	c
Opheodrys vernalis (Smooth Green Snake)			r			
Masticophis taeniatus (Striped Whipsnake)	c	u	u	r		
Arizona elegans (Glossy Snake)	u					
Pituophis melanoleucus (Gopher Snake)	c	c		c		
Lampropeltis getulus (Common King Snake)		r				
L. triangulum (Milk Snake)		r				
Crotalus viridis (Western Rattlesnake)	c	c	u	u		u
Birds						
Anas platyrhynchos (Mallard Duck)	u			u		
Cathartes aura (Turkey Vulture)	u	c				c
Accipter cooperii (Cooper's Hawk)	u					
Circus cyaneus (Marsh Hawk)	c					
Buteo jamaicensis (Red-tailed Hawk)	c	c			c	
Aquila chrysaetos (Golden Eagle)	r					
Haliaeetus leucocephalus (Bald Eagle)		r		r		
Falco sparverius (Sparrow Hawk)	c					
Lophortyx gambelii (Gambel's quail)	r					
Alectoris graeca (Chukar)	r					
Fulica americana (American Coot)	u					
Charadrius vociferus (Killdeer)	c					
Zenaidura macroura (Mourning Dove)	c	c	c	c	c	c
Bubo virginianus (Great Horned Owl)	u	u				
Asio otus (Long-eared Owl)	u	c		c		

	Sage ridge	Sage canyon rim	Sage talus slope	Sage canyon bottom	Pinyon-juniper	Shrubland
Phalaenoptilus nuttallii (Poor-will)	c	c		c		
Chordeiles minor (Common Nighthawk)	c	c			c	
Selasphorus platycercus (Broad-tailed Hummingbird)	u	u		u	u	
Archilochus alexandri (Black-chinned Hummingbird)	u					
Colaptes cafer (Red-shafted Flicker)		c				
Dendrocopos villosus (Hairy Woodpecker)		r				
Tyrannus sp. (Kingbird)		r				
Myiarchus cinerascens (Ash-throated Flycatcher)		c	u	c	c	
Empidonax difficilis (Western Flycatcher)		u				
Eromophila alpertris (Horned Lark)	c					
Hirundo rustica (Barn Swallow)	u	r				
Tachycineta thalassina (Violet-green Swallow)	r	r				
Cyanocitta stelleri (Steller's Jay)		r				
Aphelocoma coerulescens (Scrub Jay)	u	r				
Gymnorhinus cyanocephalus (Pinyon Jay)		c			c	
Pica pica (Black-billed Magpie)		u		u		
Nucifraga columbiana (Clark's Nutcracker)		r				
Corvus corax (Common Raven)	c	c	u	c	c	
Parus gambeli (Rocky Mountain Chickidee)	c	c		u	u	c
P. inornatus (Plain Titmouse)		c				
Psaltriparus minimus (Common Bushtit)		r				
Thryomanes bewickii (Bewick's Wren)		r				
Salpinctes obsoletus (Rock Wren)		c	c	c		
Catherpes mexicanus (Canyon Wren)		c	r			
Mimus polyglottos (Mockingbird)	r					
Oreoscoptes montanus (Sage Thrasher)	r					
Turdus migratorius(Robin)	u					
Myadestes townsendi (Townsend's Solitaire)	r					
Hylocichla guttata (Hermit Thrush)		u			u	
Sialia currucoides (Mountain Bluebird)	c	u		u		
Polioptila caerulea (Blue-gray Gnatcatcher)		r				
Lanius ludovicianus (Loggerhead Shrike)	c					
Sturnus vulgaris (Starling)	u	u				
Vireo vicinior (Gray Vireo)		u				
Dendroica audoboni (Audobon's Warbler)		u				
D. nigrescens (Black-throated Gray Warbler)	r					
D. petechia (Yellow Warbler)		c	u			
Oporonis tolmei (Macgillivray's Warbler)		u		u		
Wilsonia pusilla (Wilson's Warbler)		u				
Passer domesticus (House Sparrow)	u					
Agelaius phoeniceus (Red-winged Blackbird)	u					
Euphagus cyanocephalus (Brewer's Blackbird)	c					

	Sage ridge	Sage canyon rim	Sage talus slope	Sage canyon bottom	Pinyon-juniper	Shrubland
Sturnella neglecta (Western Meadowlark)	c	u				
Icterus bullockii (Bullock's Oriole)		u			u	
Pheucticus melanocephalus (Black-headed Grosbeak)	u					
Passerina amoena (Lazuli Bunting)		r				
Carpodacus mexicanus (House Finch)	c	c		c		
Spinus tristis (American Goldfinch)	u	u				
Chlorura chlorura (Green-tailed Towhee)		u			u	
Piplo erythropthalmus (Rufous-sided Towhee)		c			u	
Amphispiza bileata (Black-throated Sparrow)	c					
Aimophila ruficeps (Rufous-crowned Sparrow)		u	u	c		
Junco oreganus (Oregon Junco)		c		c		
J. caniceps (Gray-headed Junco)		c				
Spizella breweri (Brewer's Sparrow)	r					
Zonotrichia leucophrys (White-crowned Sparrow)	c			c		
Mammals						
Sorex merriami (Merriam Shrew)	r					
Myotis subulatus (Small-footed Myotis)	c	c				
M. californicus (California Myotis)	c					
Taxidea taxus (Badger)	u			u		u
Spilogale putorius (Spotted Skunk)		u		u		
Mephitis mephitis (Striped Skunk)	r					
Canis latrans (Coyote)	u	u				u
Urocyon cinereoargenteus (Gray Fox)				u		
Lynx rufus (Bobcat)		c	c	c		
Ammospermophilus leucurus (Whitetail Antelope Squirrel)	c					c
Eutamias quadrivittatus (Colorado Chipmunk)		c	c	c	r	
Perognathus flavus (Silky Pocket Mouse)	c	u		u		c
Dipodomys ordi (Ord Kangaroo Rat)	c	c		c		
Reithrodpntomys megalotis (Western Harvest Mouse)	u	u	u	u		u
Peromyscus crinitus (Canyon Mouse)		r				
P. maniculatus (Deer Mouse)	c	c	c	c	c	c
P. boylei (Brush Mouse)		r		r		
P. truei (Pinon Mouse)		c	c	c	c	c
Onychomys leucogaster (Northern Grasshopper Mouse)	r					
Neotoma albigula (Whitethroat Woodrat)		u	c	c		

	Sage ridge	Sage canyon rim	Sage talus slope	Sage canyon bottom	Pinyon-juniper	Shrubland
Neotoma mexicana (Mexican Woodrat)		u	u			
Ondatra zibethica (Muskrat)				r		
Erethizon dorsatum (Porcupine)		r			r	
Lepus californicus (Black-tailed Jackrabbit)	c					c
Sylvilagus audoboni (Desert Cottontail)	u	c	c	c	u	c
Odocoileus hemionus (Mule Deer)	r	r		r	u	

* The status of a particular species refers to its abundance of sightings. A definition of the terminology used in this list is as follows:

c - common; several sightings each week during the part of the year in which the animal in question is in the area and active

u - uncommon; at least one sighting per month during favorable times of the year

r - rare; sighted usually less than once per year

TABLE 37

Checklist Of The Insects Of Hovenweep
National Monument

Class Insecta
- Order Thysanura (Bristletails)
  - Family Lepismatidae (Silverfish)
- Order Collembola (Springtails)
  - Family Poduridae
- Order Orthoptera (Grasshoppers)
  - Family Acrididae (Short-horned Grasshoppers)
  - Family Tettigoniidae (Long-horned Grasshoppers)
  - Family Gryllacrididae (Wingless Long-horned Grasshoppers)
  - Family Phasmatidae (Walking Sticks)
  - Family Mantidae (Praying Mantis)
  - Family Blattidae (Cockroaches)
- Order Isoptera (Termites)
  - Family Kalotermitidae (Dry-wood Termites)
  - Family Rhinotermitidae (Subterranean Termites)
- Order Hemiptera (True Bugs)
  - Family Corixidae (Water Boatmen)
  - Family Notonectidae (Backswimmers)
  - Family Gerridae (Water Striders)
  - Family Miridae (Plant Bugs)
  - Family Nabidae (Damsel Bugs)
  - Family Reduviidae (Assassin Bugs)
  - Family Phymatidae (Ambush Bugs)
  - Family Lygaeidae (Seed Bugs)
  - Family Coreidae (Leaf-footed Bugs)
  - Family Cydnidae (Negro Bugs)
- Order Homoptera (Hoppers)
  - Family Cicadidae (Cicadas)
  - Family Membracidae (Treehoppers)
  - Family Cicadellidae (Spittlebugs)
  - Family Cercopidae (Leafhoppers)
  - Family Fulgoridae (Planthoppers)
  - Family Aphididae (Aphids)
- Order Ephemeroptera (Mayflies)
  - Family Baetidae
- Order Odonata (Dragonflies and Damselflies)
  - Family Libellulidae (Common Skimmers)
  - Family Calopterygidae (Broad-winged Skimmers)
  - Family Coenagrionidae (Narrow-winged Skimmers)
- Order Neuroptera
  - Family Raphidiidae (Raphidiid Snakeflies)
  - Family Hemerobiidae (Brown Lacewings)
  - Family Chrysopidae (Green Lacewings)
  - Family Myrmeleontidae (Antlions)

Order Trichoptera (Caddisflies)
    Family Limnephilidae (Northern Caddisflies)
Order Lepidoptera (Butterflies and Moths)
    Family Papilionidae (Swallowtails)
    Family Pieridae (Whites)
    Family Danaidae (Monarchs)
    Family Nymphalidae (Mourning Cloak)
    Family Lycaenidae (Gossamer-winged Butterflies)
    Family Hesperiidae (Skippers)
    Family Sphingidae (Sphinx Moths)
    Family Arctiidae(Tiger Moths)
    Family Noctuidae (Noctuid Moths)
    Family Lasiocampidae (Tent Caterpillars)
    Family Geometridae (Geometrid Moths)
    Family Pyralidae (Pyralid Moths)
Order Coleoptera (Beetles)
    Family Cicindelidae (Tiger Beetles)
    Family Carabidae (Ground Bettles)
    Family Dytiscidae (Predaceous Diving Beetles)
    Family Histeridae (Hister Beetles)
    Family Hydrophilidae (Water Scavenger Beetles)
    Family Leptodiridae (Small Carrion Beetles)
    Family Silphidae (Carrion Beetles)
    Family Staphylinidae (Rove Beetles)
    Family Dermestidae (Dermestid Beetles)
    Family Dasytidae (Soft-winged Flower Beetles)
    Family Cleridae (Checkered Beetles)
    Family Elateridae (Click Beetles)
    Family Buprestidae (Metallic Wood-boring Beetles)
    Family Dascillidae (Soft-bodied Plant Beetles)
    Family Coccinellidae (Ladybird Beetles)
    Family Meloidae (Blister Beetles)
    Family Mordellidae (Tumbling Flower Beetles)
    Family Tenebrionidae (Darkling Beetles)
    Family Bostrichidae (Branch and Twig Boring Beetles)
    Family Scarabaeidae (Scarab Beetles)
    Family Cerambycidae (Long-horned Wood-boring Beetles)
    Family Chrysomelidae (Leaf Beetles)
    Superfamily Curculionoidea (Weevils)
Order Siphonaptera (Fleas)
    Family Hystrichopsyllidae (Mammal Fleas)
Order Hymenoptera (Bees and Wasps)
    Family Braconidae (Braconoid Wasps)
    Family Ichneumonidae (Ichneumond Wasps)
    Family Cynipidae (Gall Wasps)
    Family Chrysididae (Cuckoo Wasps)

Family Mutillidae (Velvet Ants)
Family Formicidae (Ants)
Family Vespidae (Vespoid Wasps)
Family Pompilidae (Spier Wasps)
Family Sphecidae (Sphecid Wasps)
Superfamily Apoidea (Bees)

Order Diptera (Flies)

Family Tipulidae (Crane Flies)
Family Ceratopogonidae (Biting Midges)
Family Culcidae (Mosquitoes)
Family Tabanidae (Horse Flies, Deer Flies)
Family Asilidae (Robber Flies)
Family Bombyliidae (Bee Flies)
Family Empididae (Dance Flies)
Family Syrphidae (Syrphid Flies)
Family Muscidae (House Fly)
Family Calliphoridae (Blow Flies)
Family Tachinidae (Tachinid Flies)

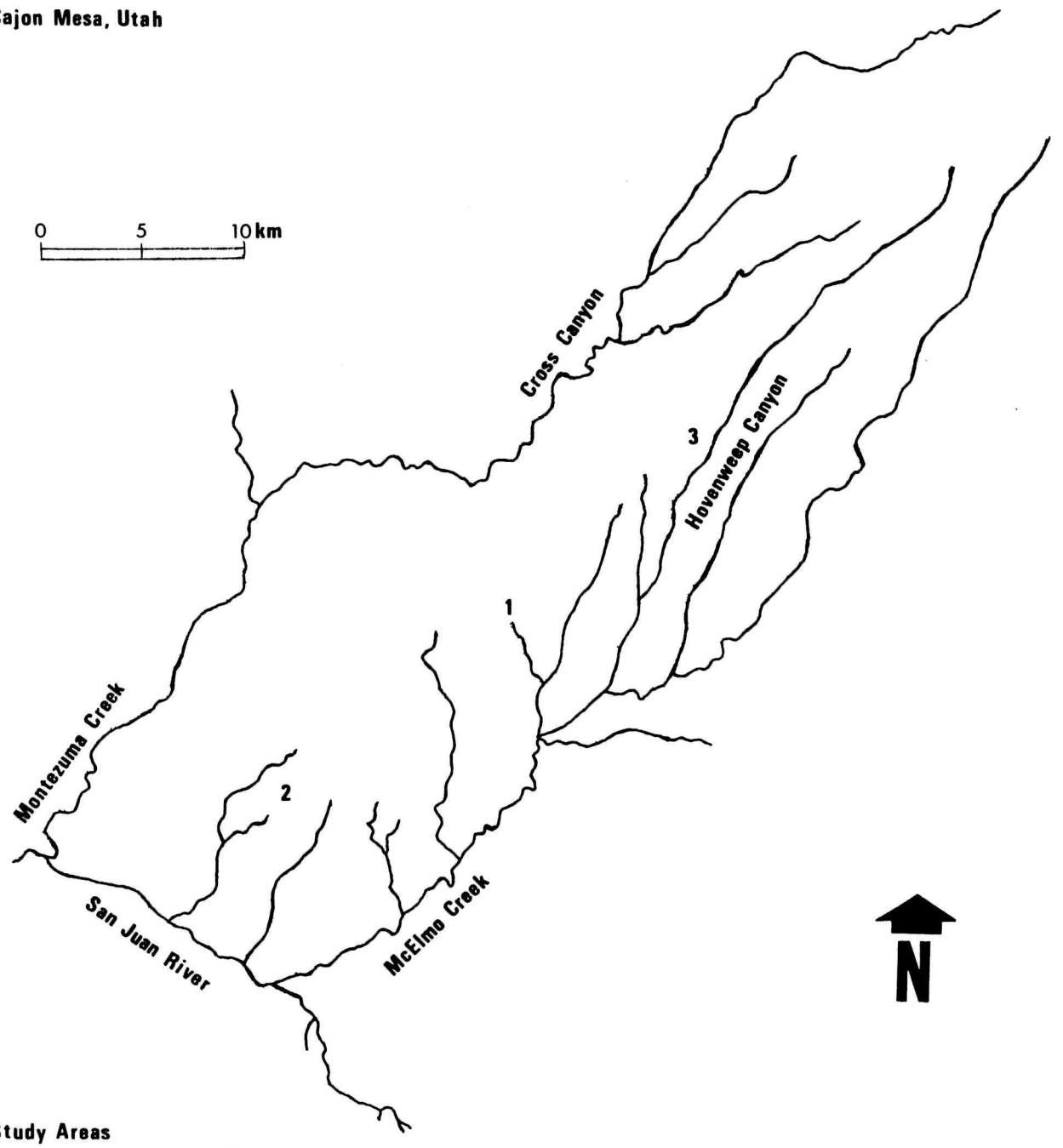
Extensive insect collecting throughout the area, and bird watching (particularly during the months of May and June) added still more information. Lastly, a thorough search through the park files filled in gaps on the extremely rare animal inhabitants such as the milk snake.

Mammal Variation on the Mesa

Materials and Methods. Since Cajon Mesa is divided into three basic plant communities (pinyon-juniper woodlands, sage flats and shrublands) cross-cut by a number of mesa top and canyon bottom physiographic zones, the mammal variation study was constructed so as to assess the relative productivity of each zone. Hectare quadrants measuring 100 by 100 meters were set up in each major plant community and in a number of the more important sage zone microhabitats (Fig. 59). Each quadrant was divided into one hundred 100 m^2 grids, and fifty live traps were periodically set up in the quads between April and August, 1975. In order to insure uniform trapping coverage, alternate grid rows were used in each trapping trial. Canyon bottom, canyon rim and mesa top quads in the sage zone were trapped a total of ten times; the quads of the shrublands to the south and the pinyon-juniper forests to the north underwent five trapping trials. The animals trapped in each quadrant were examined as to their sex, relative age and weight, and were tagged in the ear and released. The location of the animal when trapped was also determined. After each trapping trial, the Lincoln Index formula for determining small mammal population size was utilized to evaluate the abundance of a particular species at that time. The formula used in determining population density was $N = \frac{MT}{P}$, or the population of a particular species equals the total number of tagged individuals multiplied by the number captured in that trial and divided by the number in that sample that have been recaptured.

Data concerning the rabbit populations of the area was largely obtained during the summer months by the archeology crews. The crews picked representative forty-acre quads in each plant community and surveyed them by sweeping each systematically. During each survey a count of the rabbits was taken. Since the size of the study area was known, an estimation of the rabbit population density within each plant

Figure 59
Cajon Mesa, Utah



Study Areas

1. Canyon Rim, Canyon Bottom, Sage Communities
2. Shrubland Community
3. Pinyon-Juniper Community

community could then be determined.

Information concerning the larger mammals, such as the mule deer, was based largely upon field observations and talks with some of the local ranchers in the study area.

After all trapping had been completed and the data compiled, an average population density of each mammal species trapped in the various communities was determined. The mean weights for the species were likewise obtained (Table 38).

In order to better study plant-animal community relationships, a plant count, consisting of all perennial plant species present, was also taken in each quadrant. The total ground cover of a community was based on the sums of those values of all species present. Mean ground cover values, based on at least thirty basal measurements for each plant species, were also obtained.

Observation. Faunal data indicates that the prehistoric inhabitants of Cajon Mesa may have depended heavily upon small game for their meat supply. The study results show that the mule deer, the largest animal in the area, is too rare to have been hunted intensively. Excavations at Alkali Ridge (Brew 1946), Lowry Ruin (Martin 1936) and Mug House (Rohn 1971) show animals ranging in size from deer mice to mule deer in association with these sites. Such evidence suggests a very broad utilization of the local prehistoric faunal resources by their human populations. Identification of the bones found in shelter by the present project demonstrate that most of the species available in the region today were utilized in the past (Holst 1975; section II.8 this report).

The accompanying table shows the various kinds of mammals for which population estimates were obtained during this study, and their mean weights and densities in the major communities represented on the mesa (Table 38). It is evident that the sage zone has the most potential of all of the plant communities as a hunting area. Within the sage zone, the canyon rim and bottom are more productive than the mesa top. These areas contain the most diverse faunal populations and the most potential food resources. Although evidence does suggest a wide usage of the local fauna, the

Table 38

Mammal Population Statistics for the Major Communities On Cajon Mesa

Species	Mean Weight	Average Population Density*				
		Sage			Pinyon-Juniper	Shrub-land
		hill side	canyon rim	canyon bottom		
Rock Squirrel	490	0	2.5	2.0	0	0
Whitetail Antelope Squirrel	85	2	0	0	0	ND
Colorado Chipmunk	44	0	4.8	5.3	0	0
Silky Pocket Mouse	9.1	21	1.7	1	0	8.3
Ord Kangaroo Rat	59	5.4	5.9	2.3	0	0
Western Harvest Mouse	17	ND	ND	3.4	0	ND
Canyon Mouse	23	0	2	0	0	0
Deer Mouse	22	24	8.9	9.7	20	20
Brush Mouse	23	0	ND	ND	0	0
Piñon Mouse	22	0	8.5	14	3.0	2.0
Northern Grasshopper Mouse	26	ND	0	0	0	0
Whitethroat Woodrat	120	0	ND	4.3	0	0
Mexican Woodrat	140	0	ND	ND	0	0
Blacktail Jackrabbit	no data	.0088	.0056	0	0	.031
Desert Cottontail	570	.044	.21	.041	.18	.14

* Density expressed as number per hectare

Weight expressed in grams

"ND" - Mammal present, density unknown

larger game was probably preferred when available. Animals such as the mule deer, desert cottontail, black-tailed jackrabbit, white-throated woodrat and rock squirrel were most likely the prime targets for the aboriginal hunter. With the exception of the jackrabbit, all are found in both the canyon rims and canyon bottoms.

Conversely, the pinyon-juniper community on the mesa seems to have the least amount of faunal resources. Species diversity here is the lowest of any community and the species density of the mammals present is not high enough to compensate for this (Table 38). However, the mule deer population on the mesa seems to be highest in this community. During the winter months the deer move down to the mesa from higher elevations such as the Ute Mountains, and in the spring they leave for the hills. This suggests the possibility of seasonal hunting taking place in this community with winter influx of the deer population.

The shrubland community on the mesa was probably hunted to a lesser extent than the sage zone but to a greater degree than the pinyon-juniper woodlands. The shrubland community has sufficiently high faunal populations to have warranted hunting forays.

Although this report is mainly concerned with zoology, plant-animal relationships should not be overlooked. The most productive hunting area, the canyon bottom zone in the sage community, was found to have the greatest diversity of perennial plants. Since the aboriginal inhabitants of Cajon Mesa were heavily dependent upon such plants for a variety of needs, it is probably that one area, the canyon bottom, was utilized above all others.

III.2.C

GEOLOGY OF HOVENWEEP IN RELATION TO POSSIBLE LITHIC SOURCE AREAS

BACKGROUND

By Barbara Greene

Cajon Mesa is a broad expanse of eolian soil deposited along the top of the resistant Dakota Sandstone Formation. The underlying stratigraphy consists of a sequence of flat, virtually horizontal beds of sedimentary rock which are exposed along the walls of the major canyons and which probably served as source areas for much of the raw material used by the Hovenweep inhabitants (Fig. 60). Stratigraphic units of the Jurassic Period make up the majority of the rock layers that outcrop in the Hovenweep area (Table 39). These Jurassic strata consist of alternating marine and nonmarine types.

The oldest stratum currently exposed is the Navajo Sandstone of Triassic (?)/Jurassic age, which is probably the remains of solidified desert sand dunes, since the fine-grained, light-colored layers exhibit eolian cross-bedding. The red, sandy siltstone of the Carmel (?) Formation rests unconformably on top of the Navajo Sandstone and was probably deposited in shallow marine waters. The next stratigraphic unit up from the Carmel (?) is the massive, light-colored Entrada Sandstone which is composed of a lower unit showing subaqueous cross-bedding, a middle unit of eolian cross-bedding, and an upper unit with both subaqueous and eolian cross-bedding layers present. This combination of marine and nonmarine origins suggests that the Entrada was formed along the margins of the fluctuating Carmel and Entrada sea. Lying directly atop the Entrada Sandstone are the even-bedded, red sandstone layers interbedded with reddish siltstone which make up the Summerville Formation. The peculiarly red color of the sandstone is due to a very thin coating of iron oxide on the quartz grains which mixes with the cement that binds the grains together. Consequently, the rock is

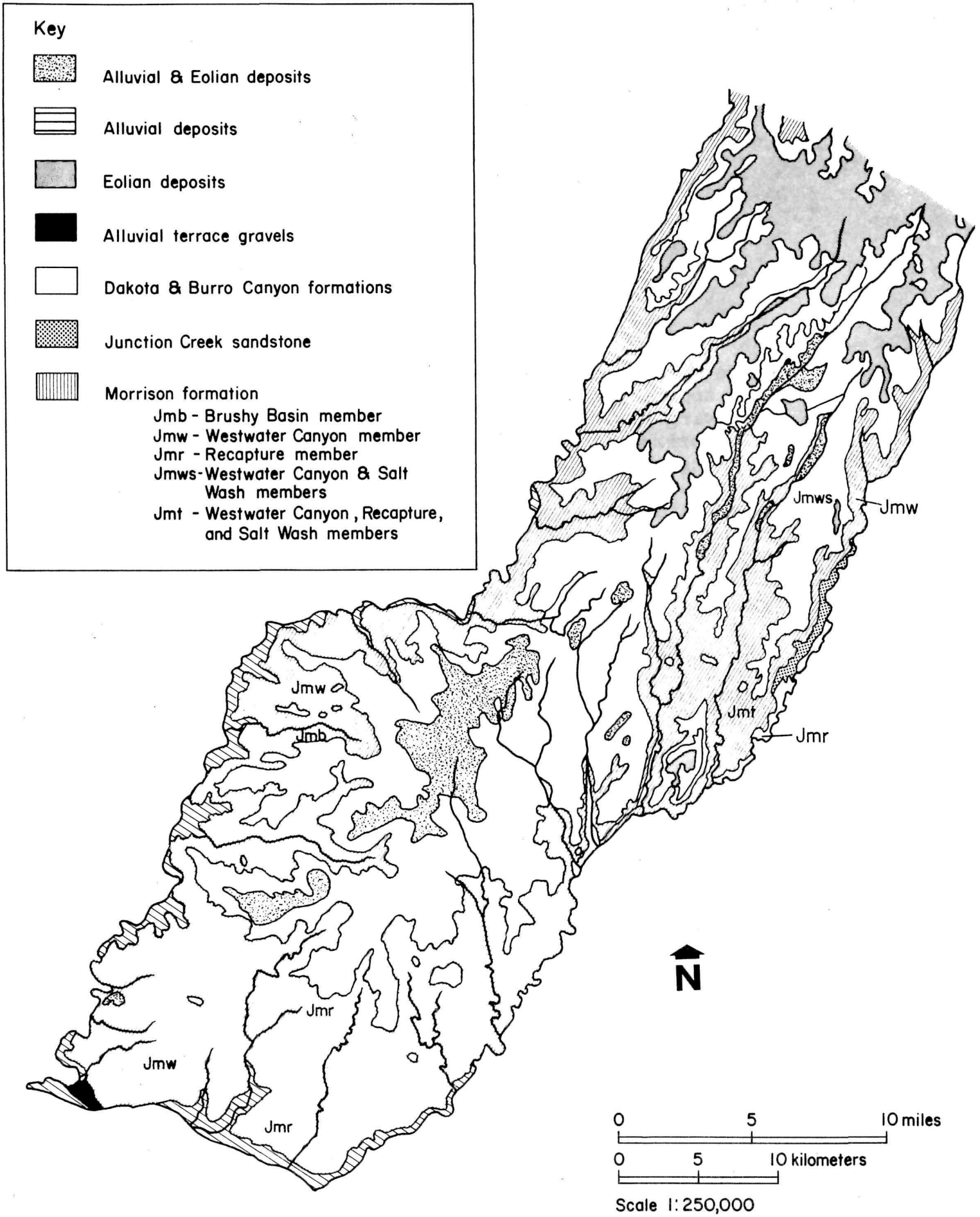


Fig. 60 Geologic map of Cajon Mesa

TABLE 39

Geological Strata of Cajon Mesa

Dakota Sandstone

Burro Canyon Formation

Morrison Formation

- Brushy Basin Member
- Westwater Canyon Member
- Recapture Member (not present on the Mesa)
- Salt Wash Member

Bluff Sandstone (not present on the Mesa)

Summerville Formation

Entrada Sandstone

Carmel Formation

Navajo Sandstone

very intensely colored, though the coloring material makes up less than 1 percent of the rock. The even bedding, lack of cross-bedding, and the presence of ripple marks, mud cracks, and salt crystal impressions indicate deposition under shallow marine conditions. An unconformity separates the Summerville from the overlying Morrison Formation. The latter was formed by overlapping layers of fluvial sediments and is divided into three distinct members: the Salt Wash Member, the Westwater Canyon Member, and the Brushy Basin Member. The Morrison Formation contains most of the known Jurassic dinosaur remains and it is in the thick sandstone lenses of its Salt Wash Member that the local deposits of uranium/vanadium ores are found, with the high-grade ore generally in association with conglomeratic zones. The Salt Wash Member's beds of light-colored sandstone alternating with thin mudstone units suggests "a braided stream system that deposited thick sand lenses in stream channels, and mud, silt and very fine-grained sand on broad floodplains" (Huff et al. 1965:24). Where exposed, the Salt Wash Member forms a series of step-like sandstone cliffs. Atop the Salt Wash Member is the Westwater Canyon Member, which is composed of yellow and greenish-gray lenticular sandstone and interbedded mudstone. The Westwater Canyon lenses are less resistant than the sandstone outcrops of the underlying Salt Wash and hence form a minor cliff set back from the beds below. Streams carrying source material from the southeast deposited what became the Westwater Canyon Member on a broad fan-shaped alluvial plain which was formed by the intersection with a second stream bringing in material from the southwest. The southwestern drainage brought in the deposits which formed the upper part of the Salt Wash and the lower section of the Brushy Basin. Thus the Morrison was formed by overlapping layers deposited by streams bringing material from two different source areas. The uppermost member of the Morrison, the Brushy Basin, is made up of unconsolidated mudstone and claystone beds and a few lenticular sandstone beds. Near the top of this stratigraphic unit are often found conglomerate lenses measuring a few to twenty feet thick which contain well-rounded pebbles of light-colored chert. The mudstones and claystones of the Brushy Basin represent either deposits in lakes or on extensive alluvial plains, while the sandstone and conglomeratic beds represent stream deposits formed by rivers meandering over this plain.

An unconformity marks the boundary between the Jurassic and the Cretateous, probably dating to approximately 135

million years ago. The lowest stratigraphic unit of the Cretateous is the Burro Canyon Formation which forms the face of the rimrock cliff dividing upland from canyon. Laid down as river, and possibly lake, deposits, it is composed primarily of white conglomeratic and sandstone layers which grade into each other with most of the conglomerate near the base. These beds commonly weather by solution of their cement which reduces the rock to a mass of friable sand and pebbles. The pebbles and cobbles contained in the conglomerate are rounded fragments of chert, silicified limestone, and quartzite. Quartzite is metamorphosed and partly recrystallized sandstone. Chert is a form of quartz made of silica originally dissolved in water and precipitated out along cracks in other rocks or as beds on the sea floor. Chert, chalcedony, jasper and agate are different names for rocks that are all essentially quartz. The name chalcedony is given to rocks which are cryptocrystalline and multi-colored, with delicate banded precipitation layers. Quartz with a crypocrystalline texture which is somewhat transparent along the edges is called agate. The upper layers of the formation are generally silicified, with hardened sandstones and hard silty chert. An unconformity separates the Burro Canyon from the Dakota Sandstone. The latter consists chiefly of yellow sandstone interbedded with gray mudstone and a few thin beds of coal. Due to differences in the concentration of the cementing material and increased weathering along joints and cross-bedding plains erosion of Burro Canyon and Dakota Sandstone often produces overhangs and small cavities in some of which the Anasazi built small shelter/granaries. The Dakota commonly forms a series of rocky ledges or steep cliffs capping the mesa. The lower sandstone layer was formed on the beaches of a sea which invaded the southwest in late Cretaceous times. The sand built up in ridges behind which plant fragments, silt, and clay were deposited in swamps eventually becoming the mudstones and coals of the middle Dakota beds. The upper sandstone beds of the Dakota were deposited offshore as the sea advanced. Above the Dakota Sandstone the marine deposits of the Mancos Shale were laid down. This thin-bedded gray shale unit has mostly been eroded away and only remnants forming a few gentle hills on the upland surface now remain in the four corners area.

At the close of the Mesozoic Era approximately seventy million years ago, the sea retreated from the Southwest for the last time. On top of the Mancos Shale it left layers of

younger Cretateous and Tertiary formations a thousand feet thick, all of which have since been eroded away.

In Miocene times, approximately 10 - 25 million years ago, masses of molten trachyte worked their way up from underground and intruded into the weak layer of Mancos Shale. Since the magma intrusions never reached the surface and cooled underground, the rocks that formed are crystalline in nature. The nearby Abajo and Sleeping Ute Mountains are examples of such laccolithic intrusions.

During the next epoch, the Pliocene, the upper Cretaceous and Tertiary beds were eroded away, exposing the Ute and Abajo Ranges. By the Pleistocene erosion had developed Cajon Mesa into a prominent landform with mountains of resistant igneous rock rising above it. Streams flowing on the plain at this time had become graded and started to meander, and when a major cycle of erosion occurred, downcutting rapidly developed, resulting in entrenched meanders which are present in many of the broader canyons. The canyon-cutting cycle continued until the late Pleistocene/Early Recent when a reduction in the flow of water occurred, producing the deposition of valley fill. In Recent times a blanket of loess was deposited on the mesa. It is generally thickest in the central part of the upland areas, and thins out toward the cliffs of Dakota and Burro Canyon sandstones which rim the upland. The loess is composed mostly of rounded grains of quartz with a reddish coating of iron oxide and is virtually homogeneous throughout its depth. At about .5 m. to 1 m. under the surface, it has been slightly cemented by carbonate to form a light-colored caliche layer. The loess is of eolian origin, probably blowing up from the extensive desert areas to the south and southwest where reddish-brown, very fine-grained sandstones and mudstones of Permian, Jurassic and Triassic age are exposed in broad outcrops.

Cajon Mesa and neighboring mountain ranges are rich in source areas which could have provided valuable raw materials for the Anasazi inhabitants. Sandstone, mudstone, siltstone, chert, chalcedony, and quartzite abound in the canyons, while the nearby Abajos and Sleeping Ute are rich in volcanic materials. The following section considers each stone by type, and the areas which could have been sources for the Hovenweep tools.

RESOURCES

By Marilyn K. Swift

Introduction

The intent of this categorization of lithic material according to geological composition is to facilitate source area identification. Mineral composition can be used to "fingerprint" exact locations of the source of igneous materials. Once location has been established, activity and trade routes may be hypothesized. Source areas are provided for the archeologist through various geologic surveys.

Materials Used as Tools

The tools discovered during the 1975 surface survey consist of the following categories: quartz, chalcedony, chert, opalized chert, silty chert, porcellanite, jasper, agate, siltstone, sandstone, quartzite, varicolored siliceously cemented sandstone and petrified wood (Table 40). Quartz is distinguishable by its vitreous luster, hardness of seven, and crystalline aggregate or six-sided crystal nature, along with its colorless or white appearance. Chert is identified by its microscopically fine-grained texture (aphanitic), its smooth surfaces and hardness of seven, and its tendency to fracture concoidally. Chalcedony is the principal rock forming mineral and if opal is present it will contribute a greasy nature to the texture of the rock. Porcellanite is a very fine-textured cryptocrystalline chert-type material, and its extremely fine, smooth, unglazed porcelain-like surface distinguishes it from other chert materials. Silty chert is a less-fine grade of chert and results in a less-smooth surface. Highly siliceous shale is similar to silty chert and for our purposes is distinguished from silty chert by an even less-fine-textured surface. Due to its siliceous nature, the shale still exhibits a somewhat concoidal fracture, although it is not as well

TABLE 40 - Geologic Components of Tool Materials

Tool Type	Siltstone	Chert	Silty Chert	Porcellanite	Chalcedony	Jasper	Agate	Petrified Wood	Quartz
Utilized Flake	4(2)*	56(30)	34(18)	17(9)	2(1)	1(.5)			1(.5)
Core	3(2)	38(25)	30(20)	5(3)	1(.5)				7(5)
Biface	1(2)	9(16)	7(13)	1(2)					2(4)
Point		18(21)				3(3)	5(6)		8(9)
Knife		10(22)		5(11)		1(2)		1(2)	3(7)
Saw		2(50)	1(25)						
Perforator	1(3)		9(26)	9(26)	2(6)				
Spokeshave	2(7)	12(41)	7(24)	3(10)	1(3.5)				
Scraper	1(1.5)	14(20)	16(23)	3(4)					1(1.5)
Core/Scraper		2(66)	1(33)						
Scraper/Spoke-shave		5(83)		1(17)					
2-Sided Scraper		1(20)	1(20)	1(20)					
Perforator/ Scraper		1(50)	1(50)						
Scalloped Edge	4(14)	5(17)	8(28)	4(14)					
Hammerstone	2(18)		1(9)						
Core/Hammerstone	3(4)	17(23)	15(20)	1(1)	2(3)				5(7)
Core/Chopper		1(3)	13(36)	3(9)		1(3)			3(9)
Chopper									1(50)
Hoe	2(66)		1(33)						
Axe	1(20)		2(40)						
Hammer									
Rubbing Stone									
Handstone									
Mano									
Metate									
TOTAL	24	191	146	53	8	6	5	1	31
% of sample	2	19	15	5.3	.8	.6	.5	.1	3

* Number in parentheses ( ) refers to percent of total for that tool type

Quartzite	Lithified Sandstone	Lithified Sandstone With Igneous Clasts	Vari-Colored Siliceous Shale	Siliceous Shale	Coarse-Grained Sandstone	Fine-Grained Sandstone	Conglomerate	Light-Colored Volcanic Rock	Dark-Colored Volcanic Rock	Unidentified Rock
19(10)	7(4)	8(4)	38(20)							
19(13)	4(2)	17(11)	26(17)							
20(36)		2(4)	13(24)							
41(47)										12(14)
18(40)		5(11)	2(5)							
			1(25)							
	1(3)	4(12)	8(24)							
1(3.5)	1(3.5)	1(3.5)	1(3.5)							
8(11)	5(7)	4(6)	10(14)	8(11)						
2(40)										
2(7)	1(3)	3(10)	2(7)							
5(45)		3(27)								
15(20)	9(12)	2(3)	5(7)	1(1)						
8(23)	4(12)		2(6)							
1(50)										
	1(20)	1(20)								
1(33)								1(33)	1(33)	
						2(40)		1(20)	2(40)	
	1(3)				3(9)	29(85)		1(3)		
	1(1)				43(39)	50(45)	12(11)	5(5)		
	1(4)				22(70)	5(16)	3(10)			
160	36	50	108	9	68	86	15	8	3	12
16	3.6	5	11	1	7	8	1.5	.8	.3	1.2

defined as when the silica content is much higher as in a true chert material. Some of the materials recovered seem to represent a highly weathered chert with clay-type kaolinite materials eroding out. This probably indicates that volcanic, fine-grained clasts were present when this sedimentary rock was formed. Jasper, Agate, and Petrified Wood are other variations of the local silica material. Jasper is identified by its blood red color, agate stones are somewhat transparent around the edges, and petrified wood has a cellular composition. A highly lithified, siliceously-cemented Sandstone constitutes another part of the sample. It is identified by its hardness of seven, dull luster, individually visible sand grains and clastic nature, which distinguish it from shale. Petrographic analysis has shown this material to consist of extremely fine-grained volcanic debris which was probably derived from a sedimentary formation. Its fine-grained nature prohibits a definitive analysis by mineralogical content, but a gross categorization as "sandstone material consisting of igneous matter" is sufficient. Another grade of sandstone with a hardness of five was found and is recognizable by its clastic nature. A very small percentage has reacted positively to an acid test, thus demonstrating that calcium carbonate forms its cement. A Mudstone or Siltstone, hardness of six, constitutes another portion of the sample. This material is comprised of extremely compacted, highly lithified, minute clay and mud particles. Quartzite is another material which was used. It is recognizable by a hardness of seven, vitreous luster and visible quartz grains. A final specimen has been identified as an apparent tuffaceous, cherty type of rock.

Source Areas

The geological formations discussed in the previous part of this section (Fig. 60) probably provided a rich source of tool material for the Hovenweep Anasazi. Each formation is now discussed in relation to potential materials (Table 41).

The Navajo Sandstone contains buff-colored, cherty limestone beds and, at the point of contact with the Carmel Formation, rich chert concentrations (Wright-Dickey 1958). Two components, a medium-to-coarse grained quartz sandstone and an earthy red siltstone, comprise the Entrada Sandstone

TABLE 41

Resource Materials Of Hovenweep According To Geological Formation

FORMATION	RESOURCE
Dakota Formation	White-gray and brown quartzites; black and white cherts; dense siliceous limestones; sandstones; mudstones
Burro Canyon Formation	Conglomerates; sandstones; varicolored shales; petrified wood; fossilized materials; silty cherts; quartzites
Morrison Formation	
Brushy Basin Member	Orthoquartzites; sandstones with quartz; feldspar; white, green-gray and red tuffs and cherts; cherty conglomerates; silty cherts
Westwater Canyon Member	Altered white tuffs; sandstones; mudstones
Recapture Member	Quartz- and feldspar-grained sandstones; red siltstones
Saltwash Mmeber	Red-brown, green-gray siltstones; tuffs; cherts; sandstones; mudstones
Bluff Sandstone	Chert nodules
Summerville Formation	Red siltstones; white sandstones
Entrada Sandstone	Medium- to coarse-grained quartz; sandstones; earthy red siltstones
Carmel Formation	Rich in various colored cherts; red siltstones

TABLE 41 cont'd

Navajo Sandstone	Buff colored cherty limestones; sandstones
Sleeping Ute Mountain	Black volcanic rocks (micro-gabbro porphyries); medium to light colored volcanic rocks (diorite porphyries; quartz monzonite)

unit. The Summerville Formation also contains the red siltstone units which are interbedded with a fine-grained white sandstone. The most notable chert nodules or concentrations are found in the Bluff sandstone at the bottom of the Morrison Formation. Although this formation does not occur on the mesa, it is located fifty miles to the west near Bluff, Utah, below the Morrison Formation. The Saltwash Member of the Morrison is the lowest member with a siltstone material, and its colors range from a red-brown, grayish red-brown, and grayish red to light green-gray (Craig and Cadigan 1958). There are also light gray to brown grains of quartz and feldspar, and white, green and gray grains of tuff and chert. The dark grains are magnetite, tourmaline and ilmenite. Within the nearby Recapture Member of the Morrison which is intertongued with the Saltwash Member, the siltstone again is a pale red, grayish red and dusky red color and there are coarse grains of quartz and feldspar. The Westwater Canyon Member contains altered white tuff, altered magnetite, and ilmenite and tourmaline. Orthoquartzite is found near the Four Corners area, as well as the clay minerals (kaolinite, hydromica, montmorillinite). Light green-gray and pink are colors typical of southeast Utah's Brushy Basin Member (Ibid.). The sandstone contains colorless to white grains of quartz, feldspar, white, gray-green and red tuff and chert fragments, with dark minerals of magnetite, magnetite ilmenite and tourmaline (Ibid.). Craig and Cadigan contend that the material in the Four Corners area is highly tuffaceous (40 to 50 percent is a fine volcanic ash) and that north and northwest of the Four Corners, the components are made up of highly siliceous volcanic materials, including sedimentary and metamorphic rocks.

Within the Burro Canyon Formation are found conglomerates, sandstone, shale, varicolored shale, petrified wood and fossilized materials (Katich 1958).

Gregory (1938) describes the Dakota Formation as consisting of a basal layer of stone one-to-three inches in diamter comprised of white gray and brown quartzite, small stones of black and white chert and dense limestone solidified by a siliceous cement. Another layer within the Dakota Formation contains black shale coal, while other layers are rich in sandstone.

The final layer apparent in the uppermost portion of the survey area is the Mancos Formation which consists of steel-gray sandy shale (Ibid.).

The igneous rocks of Sleeping Ute Mountain are porphyries which range from a microgabbro to quartz monzonite. The microgabbro porphyries are black rocks which closely resemble basalts and contain plagioclase, pyroxene and amphibole. Diorite porphyries range from near-gabbro to near-granodiorite and are medium-to-light in color. They contain plagioclase and conspicuous hornblende and biotite phenocrysts. The quartz monzonite is particularly rich in potash feldspar (Ekren and Houser 1958).

All of the Hovenweep tools can thus be traced to specific source areas on or near the mesa (Table 41). Color, as well as hardness, luster and grain size has been used in their analysis, based on the Munsell system (Goddard et al. 1970). Each material is now discussed in relation to color and source area.

1. Quartz material is primarily milky white, although a few specimens are rose colored; due to its occurrence as a vein-forming mineral it could occur anywhere in the survey area.
2. Chert materials are primarily tan, brown, green and light-to-dark gray. Sources are believed to exist within the conglomerates and nodules of the Carmel Formation, Bluff Sandstone, Saltwash Member of the Morrison, Burro Canyon Formation and Dakota Formation.

3. Porcellanite is light-to-medium gray; the probable source areas are as yet undetermined.

4. Quartzite is generally gray and red-brown or pale orange; source areas could be the Entrada Sandstone, the Recapture Member of the Morrison, the Brushy Basin Member of the Morrison and the Dakota Formation.

5. Sandstone which is consistently a pinkish-gray may originate within the Entrada Sandstone.

6. Siltstone varies from dark green to green-gray; some specimens are pink and yellow-gray. The Saltwash

Member of the Morrison is the probable source of the former; the latter source area is undetermined.

7. Chalcedony is recognized as a cryptocrystalline, multi-colored, banded, silica-dioxide material; its occurrence is assumed to be similarly scattered across the area as is the quartz material.

8. Highly lithified sandstone is moderate red, red-orange, pale brown, olive, pink and dark gray. Dark red layers occur beginning with the Navajo Sandstone and continue through the Saltwash Member of the Morrison. The Brushy Basin Member of the Morrison, Burro Canyon and Dakota Formations are likely the source areas for the remaining sandstones.

9. Varicolored siliceous shales are primarily combinations of the following colors: black, gray, brown, blue, green, red and orange. The source area is undoubtedly the Burro Canyon Formation.

Results

The specimens analyzed on Table 40 represent a percentage frequency comparison of material used for specific tool types. All of the sites were lumped together. The materials with high amounts of silica dioxide constituted the largest percentage of the same (39 percent). These materials included chert, 18 percent; silty chert, 15 percent; and porcellanite, 6 percent. Quartzite represented the next largest percent (16 percent). Next was the varicolored siliceous sandstone (10 percent), while fine- and coarse-grained sandstone used for ground stone tools totaled 15 percent. Of lesser consequence, perhaps due to nonpracticality or nonavailability, were siltstone, jasper, agate, petrified wood, chalcedony, highly lithified sandstone, conglomerate and volcanic material. The materials chosen for cutting purposes represented a contrast in choice between those materials used for grinding purposes (Table 40).

The information presented in Table 42 reflects a small sample of sites; the materials compared do not include ground

Site	Siltstone	Chert	Silty Chert	Porcellanite	Chalcedony	Jasper	Quartz	Quartzite	Siliceous Sandstone	Highly lithified Sand-Stone with igneous clasts	Siliceous Shale	Vari-colored Shale
Hov. 495		6(86%)										1(14%)
504		3(60%)	1(20%)									1(20%)
520		14(18)	17(21)		1(1)			4(5)		2(3)	1(1)	41(50)
528		5(45)		3(27)				2(18)				1(9)
572		19(61)	3(10)			1(3)	1(3)	3(10)	2(6)	1(3)		1(3)
608	2(3)	7(10)	19(27)	15(21)				10(14)	4(6)	6(8)		8(11)
630		1(17)	2(33)						1(17)			2(33)
651	1(5)	5(22)	1(5)	3(14)			4(18)	7(32)	1(5)			
660		2(100)										
668		3(33)	2(22)				1(11)		1(11)		1(11)	1(11)

TABLE 42 - Lithic Distribution According To Site

stones and waste flakes. Among the sites with a large number of specimens, there appears to be a wide range of geologic material used. At Hovenweep 520, for example, varicolored siliceous shale represented 51 percent of the sample. At Hov. 572, chert represented 32 percent, while at Hov. 608, silty chert comprised 29 percent, and at Hov. 651, quartzite represented 33 percent of the sample.

Several possible explanations for these differences are under investigation. First, the sites may have been located adjacent to a source area. Hovenweep 520, for example, is situated within the area in which the Burro Canyon Formation outcrops. This formation is, in fact, the source area for varicolored shale, which represents the largest percentage of stone tools recovered at Hov. 520. At site 572, in contrast, chert materials were found. This site is located near Brushy Basin exposures which are believed to be source areas for chert tools. Sites 608 and 651 are situated near the Westwater Canyon and Saltwash Members, whose resources are primarily siltstone material. Site 608 yielded high numbers of silty chert tools, while at site 651 quartzite material constituted the majority of the sample. The evidence thus suggests that source areas were located near many of the sites. At other sites, however, source areas were more distant. At site 528, for example, chert tools were in abundance, yet the nearby Recapture Member is not believed to be a source of cherty materials. Thus, at certain sites the specific type of stone tool being manufactured, rather than access, may have dictated choice of material.

In summary, the material recovered often correlates well with specific local geographic areas, as summarized in Table 41. In other cases, however, accessibility does not appear to have been a factor, as tool materials were brought in from off-mesa source areas. It is even possible that large quantities of chert and other materials could have been derived from such distant areas as the Goosenecks along the San Juan River where Pennsylvanian strata with known chert concretions are exposed.

It is unlikely that source areas for volcanic materials were much further removed than the Sleeping Ute Mountains. It thus appears that the Anasazi were, for the

most part, gathering the raw material for most tools from the exposed formations in the survey area. Further analysis of possible areas of origin should aid in determining activity routes and dispersal patterns.

III.2.D

THE SOILS OF HOVENWEEP

By Bradley Noisat

Introduction

The soil study at Hovenweep has two broad aims: a) to provide a descriptive summary of soils in the Hovenweep region; and b) to determine the potential of various soils for producing viable crops under dry farming and water control situations. The processes of soil formation and distribution on Cajon Mesa are topics that are discussed in Part 1. The relationship of soil fertility to water control devices of different slopes and vegetation zones are subjects taken up in Part 2. The 1975 season marks the first year of a long-term study of soils on Cajon Mesa, and the results presented here, while very tentative, are intended to stimulate hypotheses for future research. The study of soil at Hovenweep has broad applications, since soils can tell us much about the life that once existed in a site, based on the chemical residues that remain. Moreover, reflected in the sediments are changes in the environment that supported this life. The relationship of Man to soils is a fundamental one, especially since the past inhabitants were farmers and thus dependent on good soils as a habitat for their crops.

At Hovenweep, we therefore approach the study of soil as a living, functional part of the ecosystem in which we observe the flow of energy, air, and water from the soil to plants and Man. This viewpoint allows us to consider soil in terms of the processes of genesis and evolution that affect, and are affected by, the living and nonliving forces of the environment. Wind and water erosion are principle factors in the development of soils at Hovenweep. Blown by warm winds from the south, abrasive sands carve up the sandstone formations of the San Juan Valley and deposit fine sands and silts at Hovenweep. Then modified by undulating hills, arroyo runoff fills the deep canyons with alluvium. Local factors of soil genesis such as vegetation, temperature, climate, and relief further modify the cycling of soils at Hovenweep. The

mechanisms of this development and the gradation of one soil type to another are described in the following section.

Soil Forming Processes

Table 43 lists the four major soil types found at Hovenweep classified on the basis of slope and erosional processes. Although not included in this table, vegetational differences cut across these soil types and contribute even more to soil micro-differences. Drainage, climate, and seasonal temperature variation are additional factors that add to the complexity of the soil classification system.

All the soils at Hovenweep have a number of characteristics which help us to understand the nature of soil-forming processes in the region. Most of the representative types can be studied first-hand at canyonhead locales, where variation in physiography have produced a variety of soil types. Large villages also once occupied many of these areas, so the canyonheads are especially interesting as natural laboratories for the study of both natural and cultural soil-forming processes.

At the canyonheads the soils overlying the steep slopes and rim areas are rather young in comparison to soils that have developed in water control sites (see Part 2). Evidence of horizon differentiation, even in the deep soils of the upper mesa, seems to be lacking. Many of these soils have an aeolian origin and are very susceptible to constant denudation from winds swirling up the face of the canyons. Significant concentrations of organic matter are therefore lacking in the local soils (Olsen 1962). Although most are formed from shales and sandstone beds which are good developers of humus and organic constituents (Volobuev 1964), erosion strips the soil of these important edaphic components.

The principle influence of parent rocks on soil formation is evident in the chemical and physical properties of the soil particles (Volobuev 1964: 17). The fine texture of these soils is derived from transported wastes shaken loose from shale and sandstone formations. These parent materials also impart the reddish cast to the soils, since arid,

TABLE 43

Major Soil Types At Hovenweep *

I. Soils of Gentle Slopes (less than 5^{o})	Soils generally found on mesa tops and represented by continuous soil cover
A.	Mesa top soils
B.	Soils on terraces and benches on mesa spurs
C.	Canyon bottom soils (generally have poor drainage)
II. Soils of Slight to Moderate Slopes (5^{o} to 20^{o})	Well-drained soils on ridges and gentle talus slopes
A. Slight slopes (5^{o}-10^{o})	Low ridges
B. Moderate slopes (11^{o}-15^{o})	Hillsides with rocky outcrops
C. Moderately steep slopes (16^{o}-20^{o})	Eroded hillsides with discontinuous soil cover and the development of deluvial processes
III. Soils of Steep Slopes (21^{o}-45^{o})	True talus slopes where cover is deformed by gravity; barren rocks common; colluvial processes at work
A. Steep slopes (21^{o}-30^{o})	Small patches of soil may be present in areas
B. Very steep slopes (31^{o}-45^{o})	Colluvial processes dominating
IV. Cliffs (greater than 45^{o})	Soils almost completely removed; boulders may form very limited areas for soil catchment where plants can anchor their roots

* adapted from Olsen (1962) and Volobuev (1964)

alkaline environments tend to favor the separation of low-hydrate ferric oxides from the carbonate compounds locked in these rocks (Volobuev 1964: 20). Physically, this is important because lighter-colored soils tend to conduct more heat (even though they have a lower heat capacity), limiting the type of life at Hovenweep. Combined with the erosive effects of winds, only low shrubs, scrub vegetation, and grasses can therefore survive the hot, dry alkaline soils that dominate much of the lower mesa.

The pinyon-juniper forests in the northern portion of the mesa receive more rainfall and thus have greater soil diversity. The soils of this region have greater concentrations of organic matter, since arboreal vegetation imparts the residues of lignins, while grassy soils are high in cellulose. Both substances aid in the formation of humus and nitrogen exchange systems that are so vital for agricultural soils. The difference in precipitation (from 40 cm. in the north to 10 cm. in the south) is also very significant for the genesis of agricultural soils. The extensive rooting action of plants in the north encourages the mechanical process of soil formation, along with greater bio-chemical activity and water flow.

Some plants are also excellent indicators of major soil types. Greasewood (Sarcobatus sp.) and saltbush (Atriplex sp.), for example, dominate the poorly drained soils in canyon bottoms. Here, high concentrations of carbonate and sodium compounds produce toxic conditions which are lethal for most plants. Greasewood and saltbush, on the other hand, find these conditions suitable because of their physiological needs (e.g. reduction of plasmolysis) and/or their ability to concentrate roots deep in the solum of halomorphic soils. In most cases, the exclusive dominance of several species in an area probably reflects the high tolerance of such species for particular soil conditions.

In general, the more extreme the slope, climatic, or vegetational variable, the more distinctive the representative soil type seems to be. Therefore, each area should first be carefully evaluated on the basis of plant diversity, micro-climate, and relief, and then compared with the soil classifications in Table 43. During the 1976 season, a more detailed classification will be completed which will reflect

the concept of dominant soil-forming processes mentioned above. In this way, such efforts will focus on the complex natural history of the region and how it relates to the soil environments of the present.

Soils of Farm Fields

The productivity of soils behind water control devices is dependent to a large degree on their fertility, i.e., the ability of soils to transfer nutrients to higher plants. The availability of these nutrients in agricultural plots is determined by a number of complex factors including soil texture, pH, and the air and water of the soil. In 1975 a series of tests were initiated to determine the fertility of sediments from pollen test pits at the prehistoric water control devices. Using a LaMotte Combination Soil Testing Outfit (Model STH-14), soil pH and five macronutrient elements were tested: nitrate nitrogen, phosphorus, potassium, calcium, and sulphur. Each element was measured in terms of its "immediate" availability since, at various times, they may be cycling through the ecosystem as inert gases and/or inorganic compounds. Soil fertility is thus interpreted as a dynamic cycle in which various elements become available in an optimal set of conditions, thereby enhancing productivity.

In testing the fertility of soils we are interested in two factors: a) how conditions of soil fertility differ among diverse water control systems; and b) which differences in fertility can be attributed to slope and vegetation zone. Ten water control sites and one possible dry farm field ranging from simple check dams to hillside and talus-bottom terraces were selected for the study. Although these sites were not randomly chosen, they illustrate the diversity at Hovenweep and aid in the generation of hypotheses for the 1976 season. They have shown, for example, that we need to explore the relationship between increasing slope and the availability of phosphorus (see Table 44).

Soil samples were taken from the pollen pits at every discernible layer in the sediments of the water control structures. Prior tests from various mesa-top locations demonstrated that unstratified deposits should be tested at

TABLE 44 Soil Test Tesults

Site	Site Type	Vegetation Zone	Slope
Hov. 555	Check Dam	Sage	2°
Hov. 424	Check Dam	Sage	2.5°
Wolfberry Patch	Dry Field?	Sage	3°
Replicated Test Sites	Check Dam	Sage	3°
Hov. 539	Check Dam	Sage	4°
Hov. 72	Rim Dam	Sage	6°
Hov. 644	Talus Terrace	Pinyon-Juniper	7°
Hov. 49 (F1)	Talus Bottom Terrace	Sage	8°
Hov. 49	Talus Terrace	Sage	14°
Hov. 70	Talus Terrace	Pinyon-Juniper	19°

Soil Texture	ph	NO_4	Phos.	K
0-20cm. - sandy loam 21-100cm.- silt loam	8 - 8.2 7.4	10 lbs./ acre	175 lbs./ acre	100 lbs./ acre
0-20cm. - sandy loam 21-100cm.- silt loam	8.3 6.9-7.0	0 lbs./ acre	175 lbs./ acre	120 lbs./ acre
0-20cm. - silt 21-100cm.- silt	8.4 8.4	0 lbs./ acre	150-175 lbs./ acre	320 lbs./ acre
0-20cm. - silt loam 21-100cm.- silty clay loam	8.3-8.4 8.4	10 lbs./ acre	175 lbs./ acre	125 lbs./ acre
0-20cm. - silt loam 21-100cm. -loam/gravel	8.3 7.8-8.4	15 lbs./ acre	175 lbs./ acre	200 lbs./ acre
0-20cm. - sandy silt 21-100cm. -silt/gravel	8.2-8.3 8.0-8.4	0 lbs./ acre	200 lbs./ acre	175 lbs./ acre
0-20cm. - silt loam 21-100cm. -silt/gravel	7.9-8.0 8.4	15 lbs./ acre	200 lbs./ acre	145 lbs./ acre
0-20cm. - silty clay loam 21-100cm. -clay/gravel	8.0-8.2 8.3	0 lbs./ acre	200 lbs./ acre	340 lbs./ acre
0-20cm. - silt/rock 21-100cm. -clay/rock	8.6 8.6	0 lbs./ acre	175 lbs./ acre	300 lbs./ acre
0-20cm. - sandy loam 21-100cm. -silt loam	7.8-8.0 8.0	60-100 lbs./ acre	200 lbs./ acre	190 lbs./ acre

depths of 0-20 cm. (surface), 20-100 cm. (subsurface), and 100-200 cm. (deep). In such cases, each sample depth represents a possible locus of bio-chemical activity similar to the well-stratified deposits of dams and terrace structures at Hovenweep. Man's agricultural habits effect soils at various depths in different ways, and the testing schemes described above attempt to understand the nature of this activity.

Results

1. Slope (Table 44). The unmodified soils of Hovenweep undergo drastic changes as the gradient of a hillside becomes steeper. The effect of increasing slope, as shown in Table 44 is indicated by eroded soils and poor agricultural acreage. However, the introduction of water control systems counteracts these natural tendencies by: a) inhibiting head and channel erosion; and b) modifying the contour of a slope, thus permitting greater expanses of arable soil to be available for cropping. The relationship of water control devices to this type of soil development is especially critical, since the results of the 1975 soil tests indicate that soil fertility responds differently from system to system. Therefore, the control of erosion on slopes at Hovenweep represents a sophisticated agricultural technology and an important turning point in the food production system in Pueblo II and Pueblo III times, when it appears that many of these devices were developed.

2. Sedimentation. The study of sedimentation at Hovenweep provides information on how water control methods improved the productive quality of the land. Natural alluviation in a reconstructed dam (Noisat 1975: 151), indicates that soils are deposited relatively slow, perhaps as slow as 5-10 cm. per year. Modern Hopi fields require up to 50 cm. of soil for corn growth (see section III.1.D), thus suggesting that five to ten years of buildup are required until the first plantings. The alternating deposition of silt and sand behind dams is far more rapid, however, than natural soil development in nonwater control areas. By checking erosion, dams increase the speed of horizon development along with true organic and mineral fractions. This

is especially true in deep sites such as hillside terrace systems and rim dam areas where the soil buildup is constantly fed by heavy loads of alluvium all year-round. Horizons in these soils are especially important for agriculture because every new deposit of alluvium contains a complex of materials necessary for the growth of plants. Moreover, the circulation of water, obtained from successive floods, is crucial for the proper growth of plants, since nutrient exchange from different loci in the profile is accomplished in the medium of the soil solution.

The fine-earth sediments of dams also permit a high degree of permeability and moisture-holding (Brady 1974: 311). The sands in the dam topsoils accumulate many mobile substances in solution, such as lime, ferric oxides, organic colloids, and salts. The cohesion, and subsequent impermeability, of these substances can be detrimental in arid environments. When worked, though, these soils are most favorable for agriculture because of their high degree of biological activity, mobility of solutions, and greater moisture-holding capacity. In addition, permeable sands and silts in the topsoil can also serve as mulches by capturing needed moisture that otherwise would be lost to evaporation.

Agricultural soil development via sedimentation is thus greatly enhanced by the construction of water control devices. Investigators at Mesa Verde (Rohn 1963), Chaco Canyon (Vivian and Matthews 1964) and Cedar Mesa (Brooks 1974) reached similar conclusions, which suggests that the pattern of soil management practices in prehistoric water control devices was similar throughout much of the northern Southwest.

3. Soil Texture and Structure. Both characteristics are essential determinants for proper plant growth. Table 44 indicates that water control devices tend to promote uniformity from system to system. This implies that the natural effects of slope and vegetation zone are minimized when soils are managed for a single purpose, such as farming. In most cases, water control systems possess soils that are predominantly sandy to sandy-loams. Moreover, the overall texural composition of soils in water control systems compares closely with possible dry-farm locations, indicating that aboriginal farmers were attempting to duplicate and expand on former practices of dry-farming in the transition to

water control. In addition, results from soil consistence tests show that the friable conditions of soils in water control sites could easily support simple horticultural manipulation. In fact, these soils are most easily worked when moist, such as after a summer rain or flood.

5. pH. The pH of these soils is moderately alkaline, owing to the predominance of salts which are ultimately derived from parent material. While local xeric shrubbery is well-adapted to high concentrations of the hydroxyl ion, the vigor of agricultural plants may be effected adversely. High pH is not necessarily lethal, however, and proper management of the soil can alleviate the problem. In fact, several important elements (e.g. potassium, calcium, and magnesium) become more available in moderately alkaline soils (Brady 1974: 35).

6. Nitrogen. The nitrogen component of unmodified soils at Hovenweep is subject to depletion from a number of causes. Most of the nitrate nitrogen available to plants is slowly released from the organic fraction, and outside of the root zone of grasses, the development of true organic horizons is markedly absent. In most water control sites the pattern of deficient nitrogen is also prevalent. In only a single site (Hov. 70), was nitrogen available in sufficient amounts, and this may be explained by the fact that this site is still fully operational. Nitrogen depletion is normally caused by crop removal, drainage, erosion, and gaseous loss, which have all occurred since the abandonment of the water control sites. However, the maintenance and use of water control systems over extended periods of time, as shown by Hov. 70, may actually enhance the availability of nitrogen by counteracting the detrimental affects of erosion.

7. Phosphorus. The results of Table 44 clearly indicate that as soils become deeper and slope increases, there is a corresponding increase in the availability of phosphorus. The slope variable may thus be a regulating factor in the uptake of phosphorus by plants. A number of other factors including increased water flow or different on-site plant species may also improve the availability of this important nutrient. We are, therefore, approaching this data very carefully in order to determine if a one-to-one

correspondence exists between slope and phosphorus uptake. If so, then slope-side terrace systems could have been used for special crops which demand high amounts of phorphorus.

8. Calcium and Sulphur. The results of the calcium tests show that this element dominates in the soils at Hovenweep, while the evidence for the presence of sulphur is scanty. High concentrations of calcium are not unusual, especially in soils of semi-arid environments. Sulphur, on the other hand, is a common component in this environment and its absence is puzzling. Sulphur is normally bound and then released from the organic portions of the soil, so that sites devoid of plants, and thus organic constituents, might reflect a lack of sulphurous compounds in their sediments (Brady 1974: 449). The sulphur component at the Hovenweep water control sites may thus be temporarily immobilized until new gardens can stimulate its production. In any case, the absence of this crucial element is important and future soil tests will shift to areas of plentiful flora to determine if sulphur is present in nonwater control soils.

Summary

Although the conclusions presented are tentative, they show that the relationship of water control devices in producing arable soils is a critical one. If modern weather patterns represent those of the past, then dry-farming methods would be severely limited by natural processes of soil formation (e.g. erosion and subsequent nutrient depletion). Water control systems would have been a feasible alternative, permitting the reclamation of fine-textured, friable soils rich in necessary elements and organic matter for plant consumption. We are, therefore, continuing to test the association between soils and prehistoric farming practices, especially as they apply to the following hypotheses:

1. The natural processes of erosion are halted, while sediment deposition and horizon development are encouraged, by the construction of water control systems.

2. Regardless of slope and vegetation zone, the texture, pH, and soil consistence of water control sites are generally uniform.

3. The nitrogen cycle at Hovenweep seems to be initially unaffected by the construction of water control devices, since the absence of N in most sites is characteristic of nonwater control areas (Olsen 1962).

4. An increase in slope, in any vegetation zone, may increase the concentration of soluble phosphorus in water control sites.

5. Calcium is extremely abundant in both water control sites and mesa-top dry fields, while sulfates are relatively absent in the sediments at Hovenweep.

PRELIMINARY INTERPRETATIONS

3. Settlement pattern

Tower at Painted Hand (Hov. 600)

III.3 SETTLEMENT PATTERN

The two summers of survey at Hovenweep resulted in an examination of 3000 acres, slightly under 1 percent of the total mesa area. All major environmental zones and site clusters, and most micro-environments were sampled, thereby permitting a general overview of the local culture history. Personal communication with other archeologists involved in research on the mesa (Wheat, Rohn, Schroeder and Matheny) and the examination of previous published reports have augmented the present study. While a considerable amount of data from 398 sites remains to be analyzed, and subsurface tests have yet to be run, the general sequence appears as follows.

A. Paleo Indian. Sometime between ca. 6000 B.C. and 8000 B.C. small groups of hunters apparently visited Hovenweep, probably in the pursuit of Big Game (see Table 25). This period remains the most tentative and poorly understood of all of the occupations on Cajon Mesa, but we feel fairly certain that it occurred. Several types of early points (Gypsum Cave, Plainview, Scottsbluff or Eden, and Agate Basin or Angostura) were found, usually in association with large scatters of lithic debris. Ridges above springs and canyon/mesa edges which may have been overlook hunting sites were preferred camping spots. An especially popular site was the slopes above Cajon Spring at the south edge of the mesa, where projectile points and lithic trash were scattered over twenty acres of ridges, blowouts and arroyos. This would have been an ideal location for hunters, since it overlooks the broad San Juan Valley and seeps can be found on the mesa benches immediately below. Cajon Spring, in fact, is one of the largest springs on the mesa.

The variety of point types found across the mesa suggests that the region was visited sporadically for several thousand years. Early man sites are not common in the Four Corners area, but Folsom and Gypsum Cave points have been collected to the north near Moab (Hunt and Tanner 1960), while a Milnesand point was found on Wetherill Mesa (Hayes 1964). It is unlikely, however, that Big Game hunters frequented the mesa in large numbers or settled in permanent camps.

B. Archaic. After a hiatus of approximately 3000 years Cajon Mesa was again visited by foraging groups. These so-called "Archaic" hunters and gatherers frequented the area from ca. 3000 B.C. until the time of Christ, when a mixed foraging/farming economy appeared in the region. Twenty-eight locations yielded Archaic points, with two-thirds of them strikingly similar to the San Jose and Armijo points of the Oshara tradition (cf. Irwin-Williams 1973). San Jose and Armijo materials are fairly common in southeastern Utah, and numerous specimens have been recovered from the San Juan Valley north to the La Sals (Mohr and Sample 1959; Hunt and Tanner 1960). Like the earlier Big Game hunters, the Archaic foragers frequented ridges above springs and canyon/mesa edges, rarely venturing into the valleys (Table 25). A wider range of environments was utilized, however, with an especially heavy concentration of sites located above the springs at Square Tower where most of the San Jose points were recovered. Other types were found as well at this cluster of sites, so the ridges around the canyonhead appear to have been a popular exploitation area from Late Archaic through Pueblo times. Rado (section III.2.B) studied this area in his faunal analysis, and found that it is one of the most productive zones on the mesa. The ridges around Hackberry Spring were also utilized by foragers throughout the Archaic and Anasazi occupations, as were the canyon edges near Montezuma Canyon. The heaviest utilized area, however, remained Cajon Spring. As in earlier times it probably served as a waterhole and lookout site, where small groups of hunters and gatherers camped in an area which undoubtedly drew animals from miles around. A much larger population was probably present on the mesa than during the Paleo Indian times, as indicated by the twenty-eight sites, and it may well be that the Square Tower and Cajon locations supported relatively permanent groups of seasonal wanderers. The four San Jose sites above Square Tower might even represent repeated visits by the same group of foragers. No clear inter-site patterning is present, and structural features are absent.

C. Basketmaker II. Small scale farming occurred in parts of the Southwest almost 2000 years before the time of Christ, but a mixed farming/foraging economy did not appear in the Four Corners region until approximately 0 A.D., when the "Basketmaker II" culture developed. Relatively dense local Basketmaker II site concentrations have been found to the east of Hovenweep in the Durango area (Morris and Burgh

1954) and to the west on Cedar Mesa (Lipe and Matson 1971). Hovenweep, however, seems to have been a marginal region, since only eighteen possible Basketmaker II sites were found during the two seasons of survey and none have been noted by other researchers. Most of the surveyed sites were classified on the basis of Late En Medio style points, which have been dated at approximately 0 A.D. to 400 A.D. by Irwin-Williams (1973). Many of the points in the local sequence indicate a clear developmental trend, so the Archaic-Anasazi transition in the region probably occurred without any perceptible artifact break. Pithouses were added to the Archaic base, however, as indicated by two noncermaic sites with the remains of shallow, slab-lined semi-subterranean structures. The majority of the sites occur in the deeper, well-watered soils of the pinyon-juniper and sage environments (Tables 19 and 25). The site clusters above Square Tower and Cajon Springs were temporarily abandoned, as more of an emphasis was placed on site locations in the deeper soils of the upland ridges and broader canyon bottoms. This may represent the beginning of dry farming and rudimentary floodwater agriculture. Hunting and gathering was undoubtedly still important, however, as indicated by the large number of sites with projectile points (sixteen out of eighteen) and the location of most sites near canyon edges where access to a number of resource zones would have been maximized. The population was still probably relatively small, no villages are visible, and the economy was most likely oriented around seasonal wandering with farming fairly sporadic. The addition of horticulture was nonetheless extremely important, since it would have provided a relatively reliable and concentrated food supply at certain times of the year, thereby allowing temporary aggregations. This small seasonal surplus of cultigens and garden weeds could also have favored semi-sedentism, perhaps in pithouse hamlets in the dry farming zones.

D. Basketmaker III. The Basketmaker III use of Cajon Mesa is defined by Lino Gray and Chapin Black-on-White pottery, Trujillo Complex points, and large semi-subterranean pithouses. None of the multi-pithouse villages found by Matheny (personal communication) in Montezuma Canyon or by Martin (1939), Wheat (1955) and Rohn (1975) at the north end of the mesa and by Brew (1946) on the nearby Alkali Ridge were located during the survey. All three of the probable hamlets which were noted consisted of isolated pithouses and

associated surface rooms on upland ridges and shallow canyon bottoms. The twenty-one other Basketmaker III sites included point scatters and isolated sherds on ridges and in canyons, along with ceramic debris in the middens of later village sites.

The survey data thus indicates a continuation of the Basketmaker II settlement pattern, with a few pithouse hamlets located in areas of deeper soil and the remainder of the sites representing foraging camps. This pattern of site dispersion is markedly different from the large settlements observed by Martin, Brew, Matheny, Wheat and Rohn, and it may well indicate a developmental sequence. All of the large pithouse villages are late Basketmaker III-early Pueblo I sites, while the smaller sites appear to be earlier, so it appears that population aggregations did not develop locally until ca. 700 - 800 A.D. Two settlement strategies could therefore be represented. The sites found during the survey could be the earlier farming camps and foraging locations which were still seasonally utilized, while the larger villages represent the transition to an economy oriented around nearly complete sedentism. The earlier sites were scattered through a variety of environments so as to exploit all seasonally available resources, with agricultural products representing only one of the many local foods which were utilized. The larger villages, in contrast, were clustered in the locations best suited for dry farming and rudimentary floodwater control. This transition from small seasonal hamlets scattered across the mesa to large villages located in farming zones probably occurred as a result of a change in the seasonal exploitation pattern, with farming becoming more important at the expense of foraging. The severe period of dessication and erosion which has been documented to the south (Irwin-Williams 1973) could have been a factor, as the farmers were forced to congregate in the deep soils of the northern forests and broader canyons where agriculture was still possible. It is also likely that continuing population growth also favored the shift from a seasonal foraging/farming pattern to sedentism. Site numbers merely increased from twenty-one to twenty-four between Basketmaker II and early Basketmaker III times, but by the beginning of the Pueblo I period the number had tripled to sixty-four. Competition over strategic resources may have been associated with this dramatic increase in site numbers, and it may be no coincidence that certain of the late Basketmaker III-early

Pueblo villages are in defensive locations on hilltop positions in the broader canyons. Others are perched at the ends of mesas, such as the multiple pithouse village which is separated from the rest of Cannonball Mesa by a massive masonry wall, and still others appear to have stockades (Rohn 1974). All of these features are indicative of a period of stress, with the increasing emphasis on farming, larger villages and defensive measures representing adaptive responses brought about by environmental deterioration and/or population pressure.

E. Pueblo I. On the basis of his work at Ackmen-Lowry, Paul Martin (1936, 1939) suggested that the local late Basketmaker III-early Pueblo I villages were abandoned in late Pueblo I times as a pattern of dispersed settlement developed. This conclusion was also reached after the 1974 survey (Winter 1975), and while the 1975 data partially supports this reconstruction, we now realize that the situation was far more complicated. Many of the villages on the mesa remained fairly large with signs of continuous habitation from Basketmaker III through Pueblo III times, and relatively dense clusters of villages developed along certain ridge tops and in the broader canyons. In the McElmo I canyon bottom survey quad, for example, five of the twelve sites yielded neck banded, Cortez Black-on-White and other early Pueblo ceramic types. Several of these sites were small special use areas, but others were sizable habitation centers which lasted from Pueblo I through terminal Pueblo III times. A similar pattern occurred in Montezuma Canyon, and it is likely that most of the broad, well-watered canyons supported dense population concentrations from ca. 800 A.D. until the region was abandoned shortly before 1300 A.D. The situation was similarly complicated on the mesa tops, where many of the canyonhead tower ruins and ridge top Prudden Units show evidence of Pueblo I period use. Numerous small Pueblo I sites also occurred on the mesa and in the canyons, so the period seems to have been one of both aggregation in large villages and dispersion in special use sites.

F. Pueblo II. By approximately A.D. 1000 the number of local sites had tripled to over 190, which undoubtedly reflects an enormous increase in population. Sites ranged in size from small lithic and ceramic scatters located in all environments to dense clusters of multi-unit pueblos on the ridges around canyons in the pinyon-juniper and sage zones.

Many of the ruins were occupied both before and after the Pueblo II period, but the evidence indicates that the Pueblo II farmers concentrated their villages and special use sites on the mesa ridges and surrounding flats more so than any other group. Mesa top dry farming was probably the basis of the economy, perhaps along with small scale arroyo check dam farming and limited foraging. Considerable pressure must have been placed on local resources, to judge from the large number of sites in all environmental zones and the arroyo check dams, reservoirs and other probable water control devices which often occur near the mesa top Prudden units. The period seems to have been one of relatively successful adaptation, however, since most ruins are clustered in dry farming zones and obvious defensive features are lacking.

G. Pueblo III. The Pueblo III period use of Cajon Mesa lasted from approximately A.D. 1150 to A.D. 1300, as determined by McElmo-Mesa Verde Black-on-White ceramic types and dendrochronological dates. It was characterized by a slight drop in the overall number of sites, and a clear decrease in sites in the sage zone.

Many of the mesa top special use locations and ridge top Prudden units were abandoned by late Pueblo III times, as major population clusters developed around the canyonhead towers. Massive complexes of roomblocks, modified springs, rim dams and terraces, and talus slope and irrigated gardens were built in association with these graceful structures. Ruin beams (Table 45) provide a series of tower construction dates ranging from A.D. 1163 to A.D. 1277. The majority of the towers were probably built after A.D. 1230, however, since only one of the sixteen beams was cut before A.D. 1200 and most were cut after A.D. 1230. A D-shaped tower at Hovenweep Castle (Hov. 4) in the Square Tower complex has the early Pueblo III period cutting date, but the larger rectangular tower built around it was probably not added on until A.D. 1277, over 100 years later. Several other dated towers in the Square Tower group were also late, with Twin Towers (Hov. 12) built no earlier than A.D. 1232 and Square Tower (Hov. 2) built after A.D. 1234.

Most of the other canyonhead tower complexes at Hovenweep have similar late Pueblo III period construction dates. Two beams from separate roomblocks at Cutthroat Castle (Hov. 70) were cut after A.D. 1258, while two separate towers at

TABLE 45

Dendrochronological Dates For Hovenweep

Site	Date
Square Tower Complex	
Hovenweep Castle (Hov. 4)	
Fea. 1 (D - shaped tower)	AD 1166 +B *
Fea. 1 (rectangular tower around the D - shaped tower)	AD 1277 B AD 1208 ++v
Square Tower (Hov. 2)	AD 1239 B
Twin Towers (Hov. 12)	
Fea. 7 (west tower)	AD 1232 +v
Stronghold House (Hov. 13)	
Fea. 11 (midden)	AD 1204 vv
Fea. 15 (midden)	AD 1173 vv
Cutthroat Castle Complex	
Cutthroat Castle (Hov. 70)	
Fea. 9 (canyon bottom tower)	AD 1261 ++vv
Fea. 9 (canyon bottom tower)	AD 1265 +v
Fea. 14 (room under cliff)	AD 1258 +vv
Holly House Cluster	
Holly House (Hov. 53)	
Fea. 6 (Boulder House)	AD 1201 +vv
Fea. 10 (square tower with two rooms on west side of canyon)	
-north room	AD 1236 +B
-south room	AD 1246 +L AD 1267 +B
Hov. 430	AD 1254 +vv
Cajon Ruin Cluster	
Cajon Ruin (Hov. 51)	
Fea. 3 (multiple room tower on west side of canyon)	AD 1168 +vv

cont'd

* Key:

B - bark present

v - a subjective judgement that, although there is no direct evidence of the true outside on the specimen, the date is within a very few years of being a cutting date

vv - there is no way of estimating how far the last ring is from the true outside

\+ - one or more rings may be missing near the end of the ring series whose presence or absence cannot be determined because the specimen does not extend far enough to provide an adequate check

++ - the ring count is necessary due to the fact that beyond a certain point the specimen could not be dated

Holly House (Hov. 53) were built no earlier than A.D. 1236. A canyon point site (Hov. 430) located several hundred meters down canyon from Holly House was also built or remodeled fairly late, and a beam from Cajon Ruin (Hov. 51) at the far southern end of the mesa was cut no earlier than A.D. 1168. The majority of the canyonhead towers thus have relatively late Pueblo III period construction dates, which suggests that the move to the canyonheads occurred near the end of the terminal Anasazi use of the mesa. These multi-story, aesthetically pleasing O -, D - and square-shaped towers represent the culmination of a local tradition of tower building which began on the mesa top and ended at the canyons. The sequence began with the raising of small round towers which were attached to L - and U - shaped Pueblo II unit pueblos on ridge tops. Many of these ruins were occupied well into the Pueblo III period, at least as suggested by the presence of both McElmo and Mesa Verde ceramic types, and the tower beams demonstrate that the shift to the canyonheads was a late phenomenon. Pueblo II and early Pueblo III groups also lived around the canyonhead springs, but the major construction activities did not begin in most cases until after A.D. 1230. The nearby floodwater control and irrigated gardens were also probably late, and perhaps the shift from mesa top to canyonhead habitation sites occurred as a consequence of the loss of mesa top dry farming fields. This shift could have been effected by environmental modification, such as drought, which necessitated a movement to the only areas left on the mesa where permanent water was available and farming still possible. Organizational changes most likely accompanied the settlement pattern changes, and it is probable that each of the tower complexes was the center of a farming community based on a variety of water control techniques. Whether each cluster of towers, kivas, roomblocks and associated garden areas was made up of a localized kin group, such as a group of extended families, is unknown, but it is possible that a descent system of some sort was an organizational factor.

This attempt at manipulating the permanent springs in the canyons and the flood waters rushing over the rims and down the talus slopes apparently succeeded for fifty to a hundred years. The arroyo check dam terraces and slick rock reservoirs in the drainages above the towers may have been especially important during this period, particularly if dry farming was impossible. Canyon bottom floodwater farming

was also probably practiced, as indicated by the floodplain corn pollen, granaries, storage shelters and hamlets located down canyon from the towers. It may also be significant that the canyonheads and talus slopes support the greatest diversity and quantity of small mammal and plant life of all of the mesa environments. These resources would have been extremely appealing to a group undergoing environmental stress, and they could have been determining factors, along with the permanent waters of the springs and the summertime floods, in the locations of the large sites. It is also probable that wild plant manipulation was intensified in late Pueblo III times, as indicated by the clusters of wolfberry and other famine time plants on water control sites and rubble mounds and the presence of their pollen in farm field sediments. All of these exploitative activities eventually failed, however, as the Anasazi farmers were forced to abandon the Hovenweep area shortly before A.D. 1300.

H. Navajo. The Navajo use of Cajon Mesa began sometime before A.D. 1864. The economy is oriented around pastoralism, wage labor and limited agriculture, with most of the outfits concentrated along the drainages of the McElmo, San Juan and Montezuma (Fig. 61). Other outfits live near wells in the highlands, and while many families farm and graze in one area only, certain have seasonal camps in both the lowlands along the watercourses and the higher mesa. Except for woodcutting in the northern forests the Navajo use of Cajon Mesa is currently restricted to the sage and shrubland zones which fall within or immediately adjacent to the Reservation boundaries. At one time, however, Navajo use of the region extended as far north as the pinyon-juniper forests. Sweathouses, cabins, and corrals, along with possible shelters and trapping stations were found during the survey well to the north of the present Reservation borders, and it appears that hunting, farming, gathering and perhaps herding activities once took place to a limited extent across much of Cajon Mesa, although primarily in the canyons.

Gregory (1938:30-31) suggested that the Navajo did not move north of the San Juan until the 1870's, but information gathered this past summer suggests otherwise. Certain of the families appear to have had a long history on the mesa, and one elderly informant stated that several groups were in the area prior to the Fort Sumner incarceration. The Aneth/Cajon area, in fact, was a refugee region during the Carson

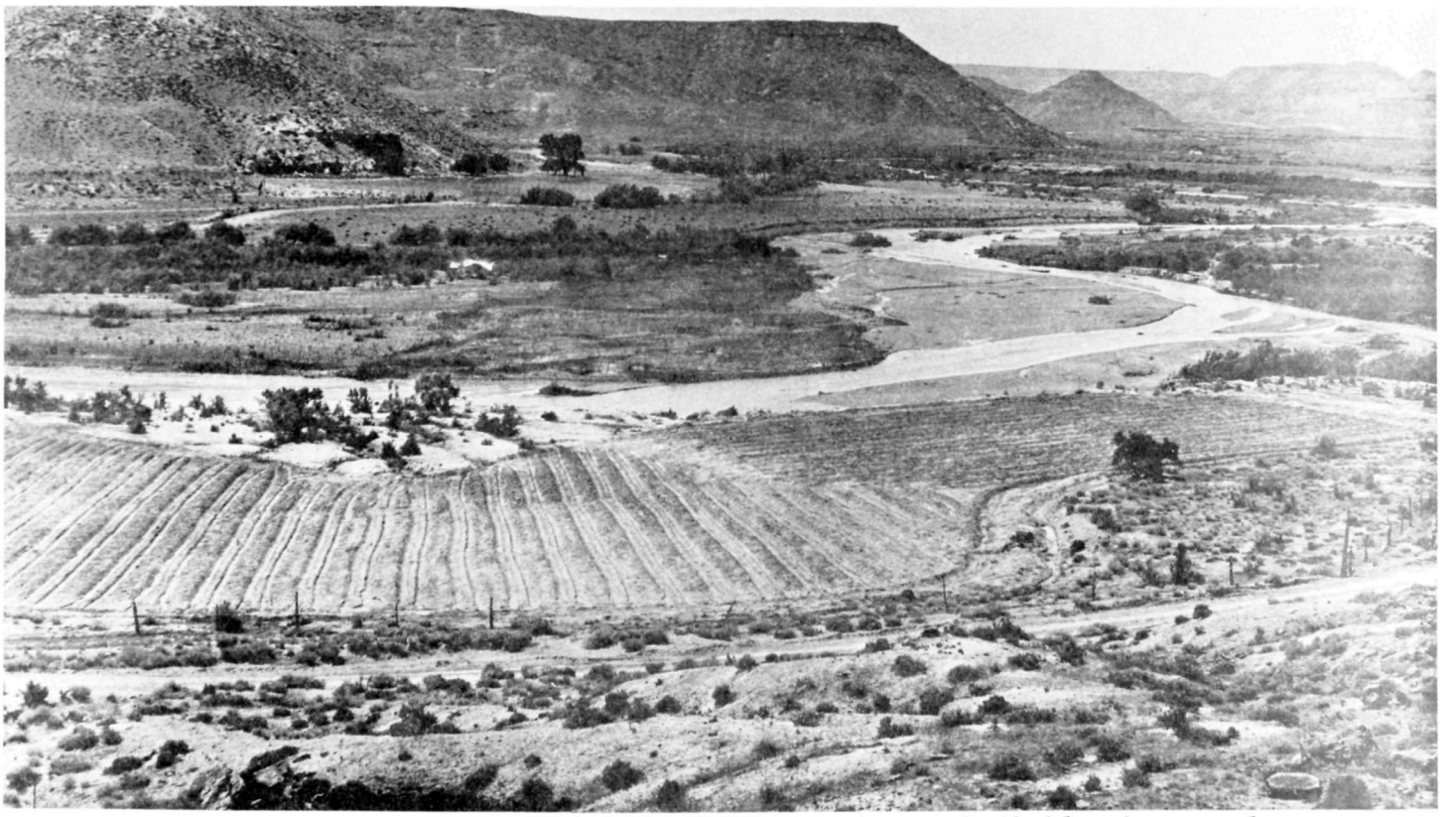


Figure 61. Aerial view of Navajo corn and squash fields along McElmo Creek. Datura plants in Fig. 43 are in the dunes between the fields and the creek.

Figure 62. Abandoned Navajo hogan at Hov. 568 in East Allen Canyon.

wars. Most of the Navajo moved north of the San Juan after the Reservation expansion in 1905, while others moved in when the present Reservation boundaries were established in the 1930's. Settlement pattern shifts in response to local white pressure occurred as recently as the 1940's and 1950's, but at present a number of families own private acreage in Montezuma Canyon, on McCracken Mesa and in other nearby localities.

Navajo archeological site distribution generally follows the present day land use patterns, with the exception of the northern locations. Twenty-two of the thirty-two Navajo sites surveyed during the past two summers occur on or immediately adjacent to the Reservation, and most of these are probably associated with the activities of local outfits. A cluster of twelve sites in an eighty-acre area around Cajon Spring, for example, evidently represents the sheep herding activities of an outfit which has utilized the neighborhood for a hundred or more years. Sites near Cajon Spring include hogans, sheep camps, stock tanks, corrals, middens, rock circles (winbreak foundations?), upright slabs and scatters of cut logs (Fig. 62). A similar cluster of six sites in McElmo Canyon is also associated with a nearby outfit, and several of the sites, such as a hide tanning station and a sweathouse, are still being used (Fig. 63 and Fig. 64).

Ten sites located north of the Reservation in the pinyon-juniper (one site) and sage (nine sites) zones probably reflect a variety of economic activities. Parties of Navajo regularly travel to the uplands to gather firewood in chained areas and to collect wolfberries on the large Anasazi rubble mounds, and certain of the sweathouses and brush fronted shelters may represent temporary camps. Others could reflect sites associated with herding or earlier foraging activities, while still others were probably built by Navajo stabilization crews working for the Park Service and Bureau of Land Management.

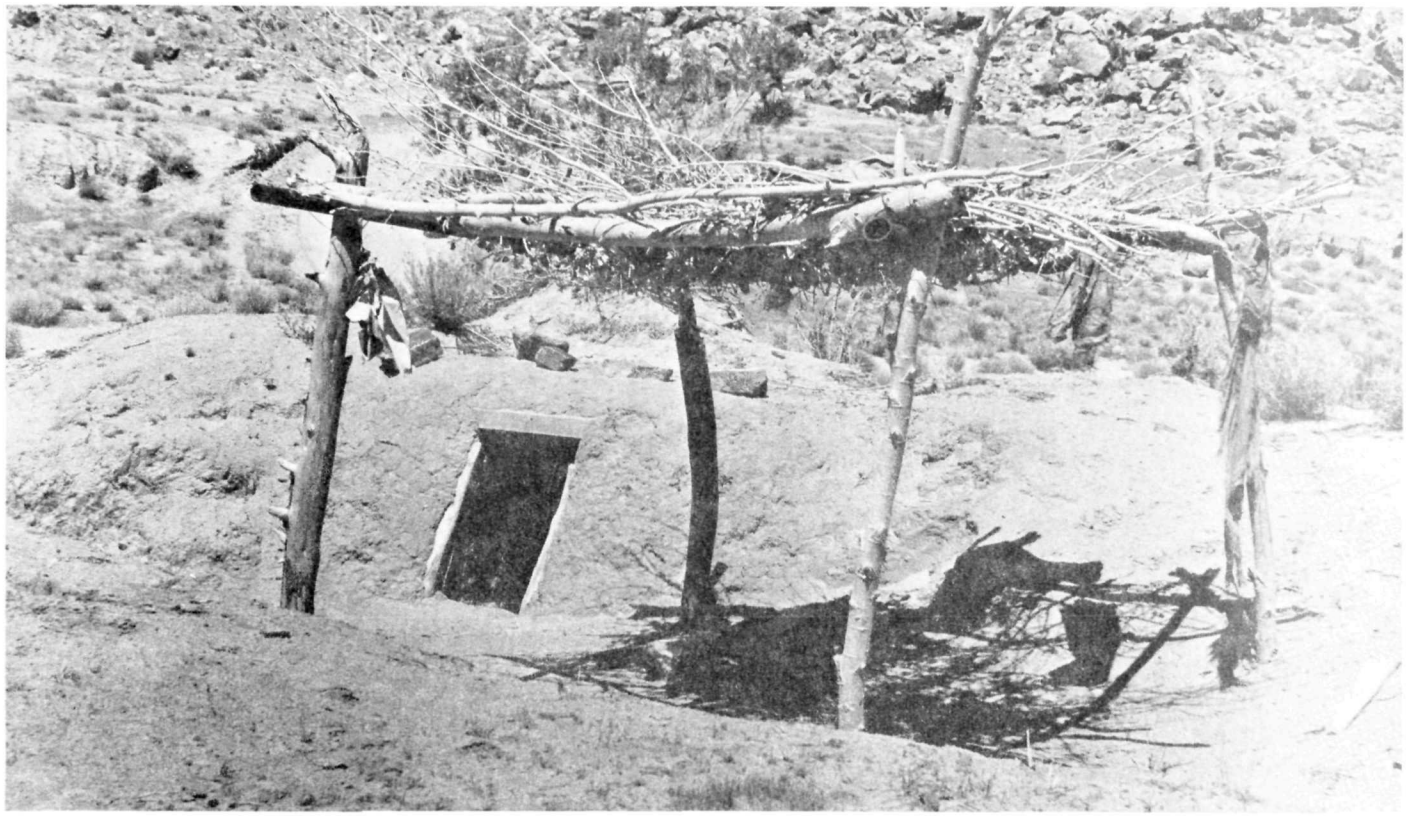


Figure 63. Functioning Navajo sweathouse and ramada at Hov. 609 in McElmo Canyon.

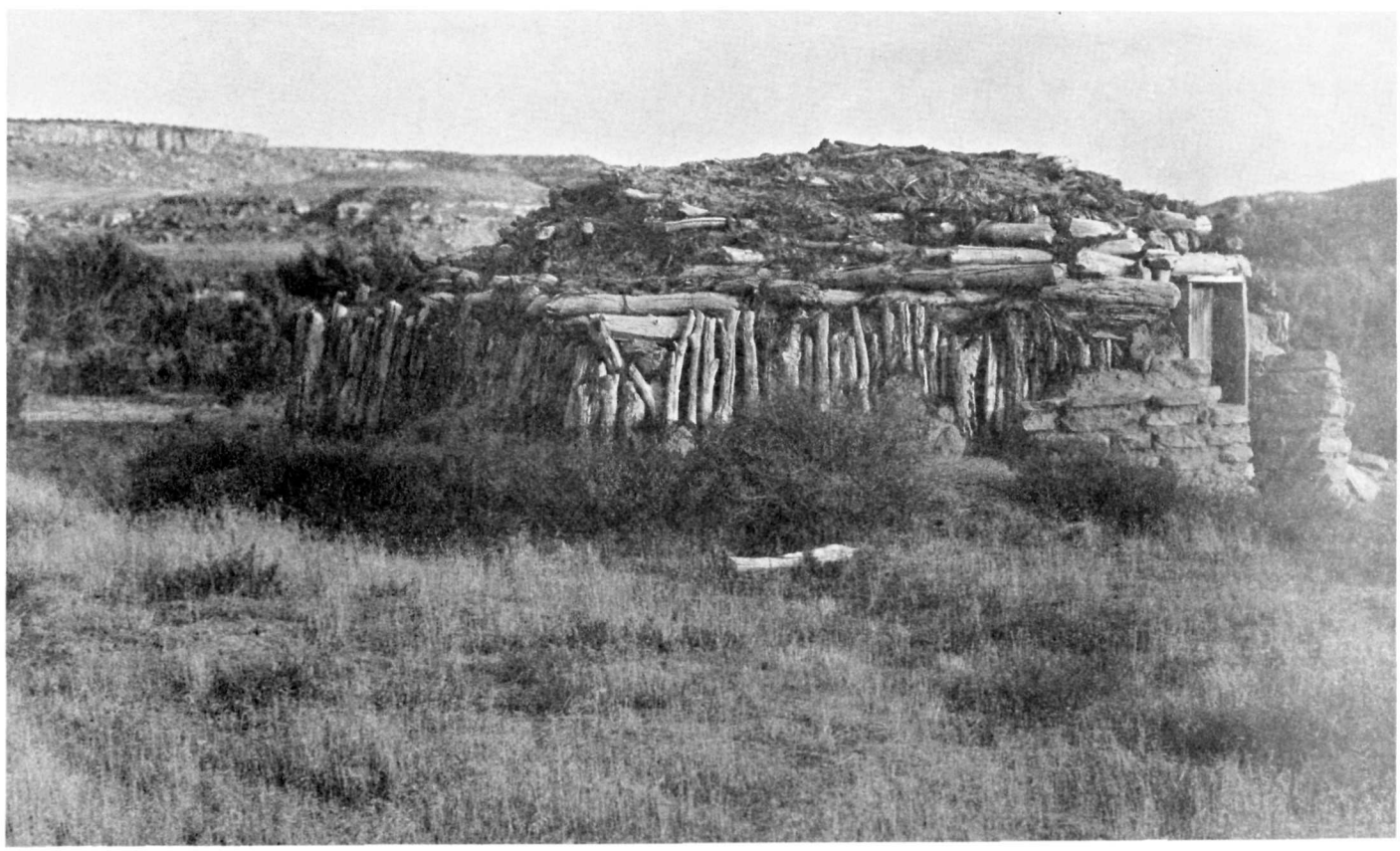


Figure 64. Abandoned Navajo hogan in Montezuma Canyon.

PROJECTED RESEARCH

IV. PROJECTED 1976 RESEARCH

The two years of survey have determined what kinds of potential farm sites exist on Cajon Mesa, and their spatial distribution. Much remains to be accomplished at Hovenweep before the goals of the Project are realized, however, since we still need to know how the sites worked, why they were built in their respective locations, when they were constructed and abandoned, and how they were integrated into a functioning agricultural system built around the mesa top and canyonhead habitation centers. The 1974-1975 surveys recorded an enormous amount of information about general environmental relations and resource distributions, but the more basic temporal/explanatory questions cannot be answered until we obtain crucial subsurface economic, environmental and chronological data. Problems dealing with the processes of economic change and growth, or with the relations of environmental disturbance and regional abandonment, or with the effects of altered resource base on population dynamics, for example, can only be answered by excavating well-controlled subsurface materials from middens, shelters and farm sites. For this reason the 1976 season will be oriented around the subsurface testing of thirty sites on Cajon Mesa, along with the continuation of the environmental/experimental research. Three stages which cross-cut archeology and environmental studies will be involved. Phase I will be a continuation of the floral/faunal analyses which were initiated in 1974 and which are concentrating on the local plant and animal resources to determine the full range of resource variation on the mesa. Phase II will involve limited testing of selected sites to collect economic, ceramic, and paleoenvironmental data, and to obtain essential dendrochronological and C14 specimens. Phase III will involve a continuation of the experimental gardening and water control programs which were initiated in 1974-1975, using traditional Hopi crops and water control devices.

The overview of Hovenweep prehistory presented earlier summarizes the cultural/historical framework which has been developed from the survey data. In order to understand much of the behavior responsible for this sequence, certain research questions have been developed to guide the

subsurface testing and environmental studies. Several of these are stated below, and followed by comments.

1. Why did the local transition from the nonhorticultural Archaic to a mixed foraging/farming Basketmaker II economy occur?

Projectile point evidence indicates a link from Archaic to Basketmaker without any perceptible break, thereby suggesting an adoption of farming by indigenous hunters and gatherers rather than the replacement of one group by the other. If farming did indeed "diffuse" into the Hovenweep area during the late Archaic times, why was it accepted? Did population growth and/or environmental change result in a reduced resource base, thereby favoring the adoption of plant manipulation (cf. Irwin-Williams and Haynes 1970; Winter 1976)? Or was there an hiatus between the Archaic and Basketmaker occupation, with the early farming culture representing an entirely new liftstyle? Pre-farming Archaic, as well as early farming Basketmaker sites will be tested so as to obtain the necessary economic and environmental data to evaluate these questions.

2. What caused the development of the large late Basketmaker III-early Pueblo I period villages with their apparent defensive features?

As a working hypothesis, we suggested that the transition from small dispersed seasonal hamlets in early Basketmaker III times (ca A.D. 450-600) to large, sometimes stockaded multi-room villages by A.D. 800 was associated with a change from a mixed farming/foraging economy in which agriculture played only a small part to an economy emphasizing farming. Coincident with this economic change the population apparently shifted from many small dispersed seasonal sites in a variety of resource zones to much larger, more permanent villages located in the prime farming areas. Was this transition in fact associated with population growth and/or resource stress, as suggested by Irwin-Williams (1973)? Or were other factors involved, such as the movement of new groups into the region? Did a transition in fact occur, or did the original group retain a mixed foraging/farming pattern while the new migrants settled in larger farming villages? Subsurface tests at both types of sites are necessary,

with an emphasis on retrieving dietary information relating to the question of seasonality.

3. Why was there an expansion into all environments of the mesa during Pueblo I and Pueblo II period times?

Most large Pueblo I sites remained in the broader valleys, but smaller sites began to appear in many other areas. By Pueblo II times sites were abundant on all parts of the mesa. This may indicate an expansion into new resource zones, brought on by a continuation of the population growth which began several centuries earlier. It also suggests that an increasingly successful adaptation to farming developed, perhaps as a result of new techniques of dry farming and water control which permitted the utilization of the less productive southern sage and upland shrublands. The identification of dry farming fields and the retrieval of economic data from Pueblo I and Pueblo II sites will be key factors in determining the actual course of events in this expansion.

4. What caused the massive population increase in Pueblo II times?

Between the Basketmaker III and Pueblo I periods site numbers almost tripled on the mesa, followed by another tripling of site numbers in Pueblo II times. This near geometric rather than arithmetic increase may have important implications for a Neo-Malthusian model and it could reflect the continued development of increasingly sophisticated farming techniques combined with optimal climatic conditions. All arable parts of the mesa were now being utilized, and large unit pueblos were built on ridge tops, at canyon edges and in canyon bottoms across the mesa. Clusters of two-eight pueblos sometimes occurred in favorable spots in the pinyon-juniper and sage zones. Water control had undoubtedly been developed by this time, since several of the unit pueblo clusters have reservoirs associated with them. It still appears, however, that dry farming and natural flood water farming continued to provide the bulk of the produce, as suggested by site locations.

5. Why and when did wild plant manipulation begin?

The exploitation of garden weeds probably developed shortly after the arrival of farming in the region, but the

active semi-cultivation and encouragement of beeweed, wild tomato, and similar species may have been a relatively late phenomenon. Certain of these species, such as wild potato and wolfberry, are considered famine time foods by the Hopi, and it is possible that their manipulation may not have become important until the onset of a period of resource stress.

6. Did the growth of the late Pueblo III tower complexes near the canyonhead springs occur in response to a loss of mesa top crop lands?

Most of the Pueblo III period tower complexes are situated near springs and water control devices, which suggests that the mesa top farmlands were abandoned in favor of more dependable but less productive crop lands. Since wolfberry patches are commonly associated with water control sites, towers and Pueblo II and Pueblo III rubble mounds, the terminal Anasazi occupation of the mesa may have been a period of resource stress brought on by deteriorating environmental conditions. Tower construction dates indicate that the move to the towers was relatively late. Did this move, in fact, coincide with the abandonment of the mesa top dry farming areas? Or did it represent a continuation of the Pueblo II pattern, with habitation and farming now occurring in both the canyonhead and mesa top localities?

7. When and why did water control develop on the mesa?

Simple canyon bottom floodwater farming may have been a basic part of the local agricultural technology from Basketmaker II through Pueblo III times, with the more sophisticated forms of water control devices added on in late Pueblo times. It is also possible, however, that dry farming was the basic agricultural technique throughout much of the Anasazi occupation, and that floodwater control was developed only during a period of resource stress and/or population pressure. When were the check dams, reservoirs, talus terraces and other devices constructed? Which villages were they actually associated with? Were they built by farmers from the Pueblo II habitation units situated on nearby ridgetops? Or were they constructed by the Pueblo III villagers who lived around the canyonheads? Many of these structures lack surface ceramic material, and even

when present sherds could have been washed in from surrounding sites. Trenching is an absolute necessity to determine if datable sherds were used as chinking or to find if sherds are present below the pollen bearing levels.

8. Was the Pueblo III farming community similar in form and function to the historic Western Pueblo community?

Many of the canyonhead ruins are similar to Hopi villages in layout, in that the sites form the centers of an apparent farming "community" composed of a centralized village with outlying fields and storehouses. The large tower complexes, like Hopi villages, are almost always located near permanent springs, with nearby hamlets, granaries, terraced gardens, check dams, reservoirs, and other possible satellite sites clustered within a radius of several kilometers. If they are in fact analogous to the Hopi communities, each may have been an independent, integrated economic unit. As shown in Fig. 18, there may have been at least four such late Pueblo III period farming centers in the mid-mesa sage zone, organized around the canyonhead springs at Square Tower, Holly House, Horseshoe House and Hackberry House (also see Figs. 23-26). The Square Tower group was by far the largest, since it is composed of sixteen standing towers in eight sites, with assorted roomblocks, possible kiva depressions, shelters, granaries, check dams, modified springs, talus gardens, and other associated sites. The possibility that the Square Tower and other clusters were the focal points of separate agricultural-based communities leads to a series of important questions concerning their structures and boundaries.

a) Was each community an independent, well-integrated and centralized unit composed of cooperating economic groups? Although divisiveness among clans has sometimes contributed to the breakup of Hopi villages, as at Old Oraibi, the typical Western Pueblo village is actually a tightly integrated community of nonlocalized lineages or clan segments tied together by complex, cross-cutting socio-religious organizations (cf. Dozier 1965). Each lineage and extended family seems fairly independent economically, but none can actually survive in isolation and intra-village economic integration is fairly strong. Immense amounts of food are exchanged between families at marriage, for example (Nequatewa and Colton 1933), while the exchange of food at feasts, Katchina dances and in return for services is an

integral part of Hopi economic life. Beyond the basic household or lineage the village is thus an essential economic unit. Clans and individuals hold title to much of the farming lands, but village-owned land is also present and its boundaries are carefully maintained (cf. Forde 1931, 1934; Beaglehole 1937). Similar integrated communities may have once existed at Hovenweep during late Pueblo III times, as well as at other places in the Southwest, such as Mug House (Rohn 1965, 1971) and Betatakin and Kiet Siel (Dean 1969, 1970).

b) How was each community structured? Were nonlocalized lineages and extended families the basic economic units? Or was the basic food-producing unit a localized descent group, perhaps organized around a single room-block with an associated kiva or tower? How did this structure change through time? Were the earlier mesa top Pueblo II habitation units the locations of localized descent groups, as suggested by many researchers (cf. Mindeleff 1900; Fewkes 1919; Eggan 1950; Steward 1955; Vivian 1970; Dean 1969, 1970; Rohn 1971)? How were the late Basketmaker III and early Pueblo communities organized? Was the tendency towards inter-village friction (suggested by defensive features) countered by Great Kivas which linked the villages together in a loose society? Much later, when tower aggregations developed around the canyonheads in the 13th century, did nonlocalized descent groups evolve? Were village-wide cooperation and organization necessary to construct and maintain the larger water control devices, such as the reservoirs and talus terrace systems, as suggested by Rohn (1963, 1965, 1971, 1972)? Or did each separate family or household maintain its own farm fields and diversion dams, with relatively little village-wide cooperation, as suggested by Woodbury (1961)?

c) What were the boundaries of each community, and how were they organized in a mesa-wide society? Was each completely independent, or, like the historic Pueblo villages, were they loosely tied together ceremonially and economically? Could Great Kivas, or the larger tower sites such as Horseshoe House, have served as inter-village integrative devices, perhaps with redistributive functions (cf. Plog 1974)? Among the Hopi, certain of the villages, such as Walpi on First Mesa, Shongopivi on Second Mesa and Oraibi on Third Mesa, are main villages which extend ceremonial supervision over a number of

subordinate villages. While the bonds between villages are normally limited to religious matters, economic ties are also involved. During times of famine inter-village sharing is especially important, and even under normal circumstances inter-village gift giving among trade partners, at Katchina dances and other feasts, and between families related by marriage or descent is a significant distributional mechanism. It may be no coincidence that most of the large tower clusters are located in the mid-portion of the mesa, where they may have functioned as the focal point of a mesa-wide, inter-community organization. Horseshoe House, like many other tri-walled structures, could even have been the central ceremonial site, and thus have been similar to Long House, Fire Temple and Sun Temple on Mesa Verde (cf. Plog 1974, Vivian 1959; Fewkes 1916).

It should be obvious that none of the above questions can be answered on the basis of two years of survey and the upcoming season of testing. It will probably take at least one additional year of testing, followed by several seasons of extensive excavation in one of the large canyonhead tower clusters, before we can even begin to find the proper answers. Several of the questions, especially those dealing with intra-village structure, merit research programs of their own. We at least know, however, what the questions are and how we can go about obtaining some of the answers. Many of these are actually beyond the scope of the Hovenweep Project, so the key issues in our research are limited to the description of the crops, field systems, and approximate boundaries of the Anasazi community at various points in time, and the identification of the dynamics underlying its local development and abandonment. Certain of these areas, such as late Pueblo field systems, have already been examined in great detail, but we still know next to nothing about the Basketmaker and early Pueblo field systems or the extent of dry farming and canyon bottom floodwater fields. Other topics, such as community structure and boundaries, we can only guess at. For these reasons much of the extensive testing during the next two seasons and intensive excavation in following years will be organized around the community concept. Detailed data on crops, the function of the water control systems, and environmental relations will be obtained, along with ceramic and economic data concerning community structure and boundaries. The latter part of the research will entail three approaches:

1) architectural and geographic contexts; 2) design element and symmetry studies; and 3) maize attribute comparisons. The first two of these approaches have been used successfully in identifying the approximate boundaries of Pueblo communities at Mug House and Betatakin-Kiet Siel. At Mug House, for example, Rohn (1965, 1971) used geographic and situational data to determine that the Pueblo III community may have been composed of three small cliff-dwellings which could have served as seasonal farm houses, a reservoir, a burial cave, mesa top fields, check dam terraces, and talus terraces, along with Mug House itself. Inter-community ties were also apparently present on Wetherill Mesa, again identified on the basis of architectural and geographic contexts. The nearby Jug House community probably shared farm fields and water sources with Mug House, while both may have pariticipated in the larger mesa-wide society which had as its focal point the Great Kiva-like ceremonial structure at Long House (Rohn 1971).

Similarly, at Kiet Siel and Betatakin, Dean (1969, 1970) used architectural features and dendrochronology to identify a loose community of several sites which may have been linked together by "informal ties based on trade, interpersonal relations, intermarriage and contiguity" (1970: 169). Dean suggests that strong multi-village units were probably not present at Tsegi, and proposes instead that some of the smaller sites may have been informally linked to Betatakin and Kiet Siel in the same manner in which the Moencopi farming settlement was a colony of Oraibi before 1900. At the village level the room clusters, courtyard complexes and kiva arrangements indicated that both v i l l a ges were separate, functioning communities which possessed intra-village organizations capable of directing the cooperation of the members of the nonlocalized lineages in economic matters.

The ceramic approach is best typified by Longacre's (1964) original work at Carter Ranch, where he demonstrated that nonrandom distributions of design elements could be used to distinguish intra- and inter-village community structure. Nonrandom clusters were present at three levels: 1) within the village, which may have represented residence units, perhaps organized around localized lineages; 2) among the separate villages of the valley, with the design elements clustering into a southeastern group of villages and a

northwestern group; and 3) among the villages of different local valleys, with the villages of each valley tending to cluster together. Although our research is also concerned with intra-village structure, since much of the farming may have been organized at the household or lineage level, it is Longacre's second level that concerns us the most. By correlating the two design element clusters within the valley with geographic site clusters and the locations of Great Kivas, he concluded that a "multi-community" structure was present, perhaps with economic overtones. Such a structure could be analogous to the historic Pueblo farming community, with a centralized town associated with outlying suburbs and farming settlements. For this reason Washburn (section II.2) is studying both the individual design elements and the symmetry of layout of the local ceramics to determine if nonrandom distributions are present at Hovenweep. As with Longacre's analysis, she hopes to find three levels of organization: 1) intra-site patterning which might reflect household units; 2) inter-site relations which might reflect community boundaries; and 3) intra-regional relations which could reflect the mesa-wide, inter-community network. Although we have not yet obtained the necessary subsurface data for the intra- and inter-site analysis, the survey material has already indicated that a regional pattern of relationships was apparently present at Hovenweep, as discussed in section II.2.

Finally, maize attribute distributions might also reflect inter- and intra-site patterning. Pueblo farmers go to great lengths to maintain pure lines of corn for ritual purposes, so much so that seeds are inherited within the matrilocal household (Whiting 1939). Different varieties are planted in separate fields, and care is taken that no viable seeds normally leave the house except for planting and blessing. Exchange of corn among families nonetheless occurs, however, through matrilocal marriage customs, gift giving and famine-time sharing. A newly married farmer sometimes combines both his mother's and his wife's varieties of maize in a common pool (Whiting 1937), while a village chief may distribute seed corn to the workers who have planted his field (Beaglehole 1937). Both of these customs insure the distribution of corn varieties throughout a village, as does the planting and cultivation of a sick man's fields by his clan members and the sharing of corn during famines (Beaglehole 1937; Whiting 1939; Bohrer 1960). Thus, while maize

types are kept fairly distinct within each household, social and economic obligations necessitate the sharing of types during marriage, periods of community cooperation and famine. A careful examination of morphological variation within a village, among nearby villages and among the villages of a region should reflect the arrangements of households (through a tight clustering of certain varieties), the economic and social relations of households within a community (through the consistent sharing of particular varieties), and the relations among villages within a region and between regions (through the general sharing of maize varieties). Only seventy cobs were found during the two summers of survey, so this type of analysis must await the retrieval of large numbers of dried and burned cobs from the subsurface tests. The small surface collection has still yielded important information, however, since it has suggested that inter-regional relations were present with Mesa Verde to the east and the Kayenta region to the west and southwest (Winter 1975; 76-79). Preliminary research by Miksicek (1974) at Chevlon and Koschik (1974) at Arroyo Hondo has also demonstrated the potential of this technique in determining inter- and intra-site patterning.

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