

QUATERNARY STUDIES

CANYONLANDS NATIONAL PARK

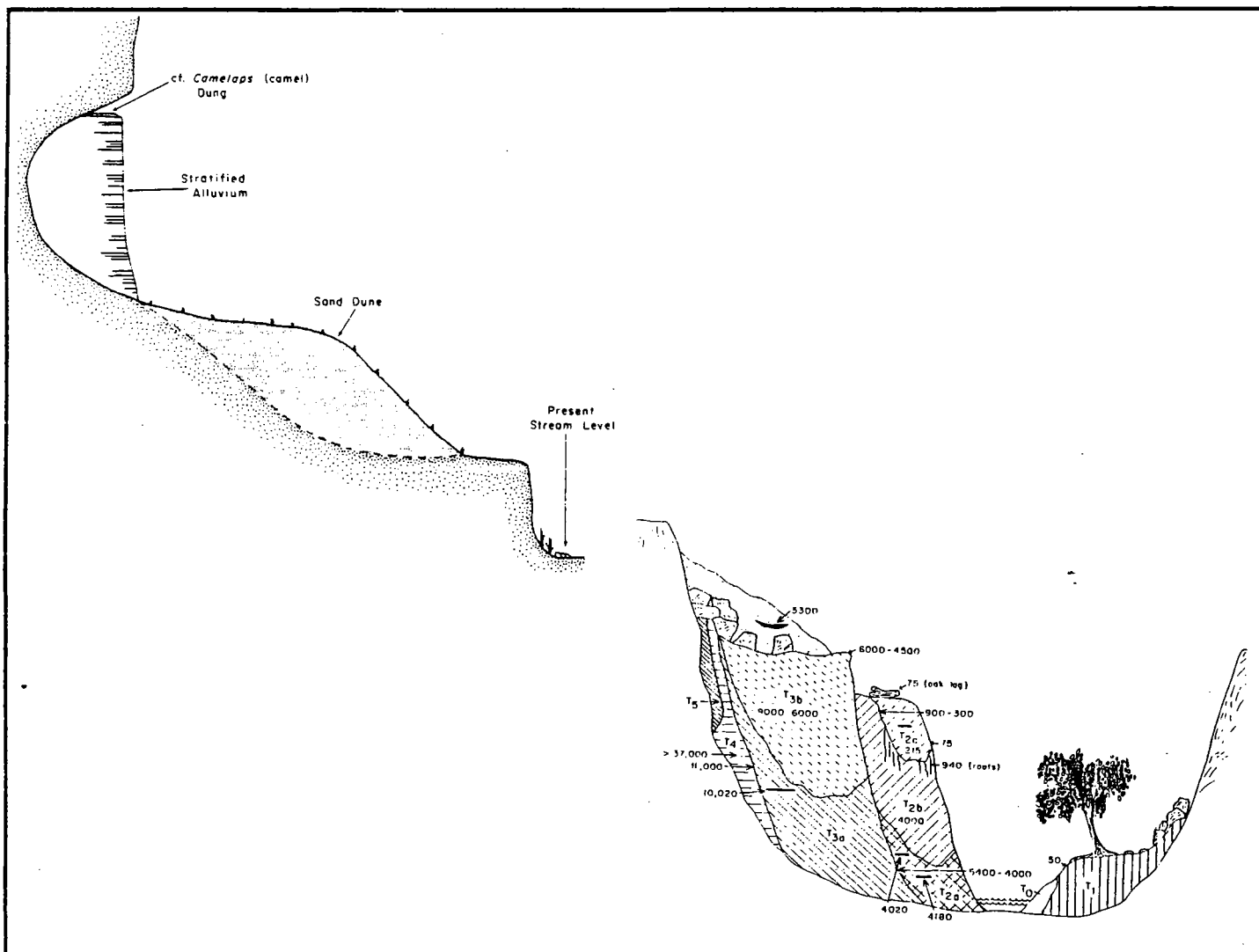
and

GLEN CANYON RECREATIONAL AREA

USDI-NPS' Contract CX-1200-4-AO62

by

L. Agenbroad, J. Mead, R. Hevly, S. Clay-Poole, G. Judges-Edwards



**Quaternary Studies of
Canyonlands National Park**

and

Glen Canyon National Recreation Area

by

Larry D. Agenbroad

with contributions by

J.I. Mead, R. Hevly, S. Clay-Poole, G. Judges-Edwards

Prepared under the direction of

**Larry D. Agenbroad
Principal Investigator**

Submitted in partial fulfillment of contract

CX-1200-4-A062

to

**National Park Service
12795 W. Alameda Parkway
P.O. Box 25287
Lakewood, Colorado 80225**

June 1990

Revised April, 1991

TABLE OF CONTENTS

	Page
ACKNOWLEDGEMENTS	i
ABSTRACT	ii
LIST OF FIGURES	iv
LIST OF TABLES	vi
Chapter 1: INTRODUCTION (L. Agenbroad)	1
Chapter 2: RESEARCH DESIGN (L. Agenbroad & J. Mead)	6
Chapter 3: ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE (R. Hevly, S. Clay-Poole, G. Judges-Edwards)	16
Chapter 4: LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES IN THE BECHAN CAVE AREA (G. Judges-Edwards and R. Hevly)	30
Chapter 5: LATE PLEISTOCENE ALLUVIUM AND ORGANIC DEPOSITS OF THE CENTRAL COLORADO PLATEAU: NEW DATA AND A REVIEW (L. Agenbroad & J. Mead)	42
Chapter 6: INVESTIGATIONS OF A NEWLY DISCOVERED PLEISTOCENE MEGA- FAUNAL DUNG BED AND ALLUVIAL SEQUENCE IN S.E. UTAH (L. Agenbroad & J. Mead)	58
Chapter 7: MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARKS (J. Mead and L. Agenbroad)	72
Chapter 8: SUMMARY AND CONCLUSIONS (L. Agenbroad)	86
REFERENCES CITED	
APPENDIX I: PALEONTOLOGICAL DATA SHEETS	I-1
APPENDIX II: PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA AND MUMMIES FROM GRAND GULCH, UTAH (R. Hevly)	II-1
APPENDIX III: RADIOCARBON DATA SHEETS	III-1
APPENDIX IV: MACROBOTANICAL DATA SHEETS	IV-1

ACKNOWLEDGEMENTS

A number of agencies and personnel have provided the funding and field and laboratory efforts that have resulted in this report. Funding was provided by the National Park Service contract CX-1200-4-A062; National Geographic Society grants 2711-83, 3016-85, and 3280-86; The National Science Foundation grant #EAR-8708287

National Park Service administrative staffs of Canyonlands National Park, Glen Canyon National Recreation Area, Natural Bridges National Monument, Cedar Breaks National Monument, and Arches National Park have been very cooperative and supportive of the research. Personnel in the Rocky Mountain Regional Office (NPS-RMR), especially D. Huff, R. Schiller, A. Anderson, A. Johnson, K. Warner, have been enthusiastic and supportive. Northern Arizona University has provided partial funding, requests for space, logistics, equipment, and storage.

Colleagues and graduate research assistants who have contributed to this report include: B. Cluer, K. Cluer, D. Elder, R. Hevly, G. Judges-Edwards, J. Mead, E. Mead. Typing and editing included M. Campbell and B. Kerns, final layout and editing was done by F. Agenbroad.

ABSTRACT

This preliminary report compiles the field and laboratory research efforts for Phase III (October 1986 - September 1987) of National Park Service Contract CX-1200-4-A062. The data presented here are the preliminary results from an interdisciplinary team which is evaluating and interpreting the Quaternary deposits in portions of Glen Canyon National Recreation Area and Canyonlands National Park. Much of our data are still in analysis stages in local and contract laboratories. Some of the data included in this report reflect the on-going nature of much of our research, in that material collected and submitted for analyses in Phases I and II have just become available for the chronology and interpretation of deposits collected and studied in Phase I & II.

The third season of research has extended the absolute chronology of +10,000 years to +37,000 years, in Bowns canyon. In addition, deposits have been discovered, whose surficial dates extend to +28,000 years on dung of extinct fauna. Underlying sediments suggest even greater antiquity, whose range will be probed in the Phase IV research efforts. Support from the National Geographic

Society has been provided, to analyze these deposits.

The results of Phase I, II, & III research are giving us a model of the Central Colorado Plateau prehistory (paleoenvironment, paleoclimate, paleohydrology, paleontology) that has never been recognized previously. Tied to the archaeological evidence, it can promote an understanding of man's entry into the region and his adaptation to, or modification of, that environment for at least the past 11,000 years.

FOREWORD

This report compiles the results of a third field season of research by an interdisciplinary team of researchers and graduate students. It conveys the information gained in that field season. It is not to be interpreted, or judged, as a compendium of the Quaternary of the Colorado Plateau. It is an additional step in that direction. The task of the research team was to provide a radiocarbon controlled geochronologic framework for the lands administered by the National Park Service in Canyonlands National Park (CANY) and Glen Canyon National Recreation Area (GLCA). Human occupation, adaptation

ABSTRACT

to, exploitation of, and movement within the natural environment could then be related to this framework, which would also provide causal relationships for human activities through time.

The alluvial record provides the repository in which the evidence of the environment and its temporal setting were preserved. Charcoal, and plant and animal materials which were preserved in the alluvial sediments provided the radiocarbon samples giving temporal control. Cycles of erosion and deposition were also recorded in the alluvial material preserved in the canyons. Temporal control of those events allows interpretation of the climatic change through time.

Soil study documents and interprets the periods of stability of the canyon floor, which provided graze, gathering potential, horticultural-agricultural activity, or its potential. Buried soil horizons reflect a change in environmental conditions, indicating that alluvium was provided at a rate greater than that allowing mature soil development.

Paleohydrologic information is present in the alluvium as cut and fill sequences, water table fluctuations, marsh (ciénega) deposits and small impoundments (lakes or ponds). The fluctuation of the water table through time is intimately related to the climatic and geologic changes taking place.

Pollen studies provide evidence for the types of botanical communities present at a location, through time. With temporal control, we are able to document environmental change, as a result of climatic change, resulting in changing habitat. Environmental or habitat change requires different exploitation strategy by the fauna

(human, or non-human) who are utilizing the botanical base.

Packrat midden analysis serves as an independent check of the pollen (and to some extent the paleontological) record of the area. Packrats build a nest of botanical and faunal remains, which become cemented by their urine. These cemented nests (middens) become more erosion resistant than the adjacent rock and provide a sampling of botanical and fauna specimens at a specific locality through time.

Paleontological remains document fossil-like forms (plant and animal) at a study locality through time. Paleontological material is not abundant in alluvial deposits of the nature being investigated in Phase I, II. However, caves and alcoves do provide unique, highly significant deposits or remains. These data provide a cross-check on models built by the methods outlined above.

Buried archaeological remains, also preserved in the alluvium, provide evidence of human utilization of the natural resources of an area. The depth of burial, the temporal position, and the nature of deposition provide important insights as to geologic processes on-going during the human occupation of the study area.

In part, this Year III report elaborates on studies begun in Years I, II. Year III also provides data from new localities, which can be correlated to Year I & II localities, and future research.

Chapter 5 does not conform to American Antiquity style, having been peer reviewed and published (Agenbroad and Mead 1987) in the style dictated by the Arizona Bureau of Mines and Mineral Technology.

LIST OF FIGURES

Figure	Page
1. Location map of Glen Canyon National Recreation Area (GLCA)	3
2. Location map of Canyonlands National Park (CANY)	4
3. Map of SE Utah showing study localities	17
4. Alluvial map & pollen sample of Bowns-Bechan drainage	19
5. Alluvial stratigraphy of Bowns	20
6. Pollen diagram of Bowns-Bechan alluvial pine	23
7. Pollen comparisons	26
8. Map of macrofloral samples	32
9. Macroflora summary for Bowns/Bechan	38
10. Macroflora, microflora and geologic records of Bowns-Bechan	40
11. Index map of Colorado Plateau	45
12. Bechan Cave	45
13. Contours of dung bed, Bechan Cave	46
14. Histogram of alluvial ¹⁴ C Dates	48
15. Mammoth Dung Boluses	49
16. Size-fraction analysis of megafauna dung	49
17. Alluvial geology adjustment to Bechan Cave	51
18. Alluvial cross-section	52
19. Location map of Canyon with alcoves containing fossil localities . .	55
20. Schematic cross-section of BF alcove	56
21. Location map of Forty mile area	60
22. Documentation map of Fortymile area	61
23. Grobot Grotto	62

LIST OF FIGURES

Figure	Page
24. Mammoth Alcove	63
25. Schematic cross-section of Mammoth Alcove	63
26. Histogram of alluvial chronology	68
27. Histogram of dung & packrat chronology	68
28. Location Map of Snail Knob, Kane Springs, and Lake Canyon	73
29. Upper Salt Creek alluvial chronology	77
30. Mollusc and alluvial sequence at Lake Canyon	81
31. Molluscan sequence at Kane Springs	83-84
32. Distribution of Mammoth and Bison	87
33. Distribution of Covis, Folsom, and Plano artifacts	87
34. Regional correlation chart	91
35. Upper Salt Creek alluvial, chronologic, cultural schematic	92
II-1 Location map of sample sites	II-3
II-2 Modern pollen from soil surfaces	II-4
II-3 Comparison of modern and archeological pollen samples	II-6
II-4 Modern pollen samples from study area	II-7

List of Tables

Table		Page
1.	Paleoenvironmental features & data sources for construction of a geochronologic/Paleoecologic framework	9
2.	Progression of Quaternary paleoenvironmental research model	15
3.	Modern surface pollen composition in Bowns Canyon	22
4.	Plant taxa from Archaic, Preformative and Formative of GLCA . .	35-36
5.	¹⁴ C chronology of Colorado Plateau megafauna dung	47
6.	Fauna at Bechan Cave: Dung analysis	49
7.	Fauna at Bechan Cave: Hair Analysis	50
8.	¹⁴ C dates from alluvium	52
9.	Fauna from Canyon Alcoves	55
10.	¹⁴ C dates from Fortymile	64
11.	Alluvial sequences, Fortymile	65
12.	Fauna from Canyon alcoves	69
13.	Mollusc samples from S.E. Utah	75
14.	¹⁴ C dates with cultural affiliation	89
II-1	Pollen from Grand Gulch mummies	II-10&11
II-2	Pollen from external portion of mummies	II-12
II-3	Pollen from mummies: internal and external	II-13
III-1	Compilation of ¹⁴ C dates from CANY	III-2
III-2	Compilation of ¹⁴ C dates from GLCA	III-4
IV-1	Descriptions & measurements of float samples	IV-2
IV-2	Raw pollen counts from sites in Bechan Area	IV-8
IV-3	Results of charcoal analysis	IV-14

CHAPTER 1

INTRODUCTION

L. D. Agenbroad

This report is the result of Year III efforts for the NPS contract, National Science Foundation (NFS) and National Geographic Society (NGS), investigations in Canyonlands and Glen Canyon. The charge, given by the contract, was to assess and investigate late Pleistocene and Holocene deposits and investigate certain field localities, interpret the paleoenvironment/ paleoecology of those localities, and to tie these records to a radiocarbon chronology, to establish an environmental/chronologic framework with which the aboriginal occupation, exploitation, and utilization of the parks could be assigned to, and interpreted from.

Areas of field research within Glen Canyon National Recreation Area (GLCA) included:

- a) Bowns/Bechan Canyons
- b) Fortymile Canyon
- c) Willow Canyon

Areas of field research within Canyonlands National Park (CANY) included:

- a) Big Pocket
- b) Salt Creek

Some samples, collected in prior field work efforts from Years I & II were processed and analyzed during Year III, as our "feel" for the relative importance of samples grew. A good portion of the office and laboratory portion of Year III was spent in analyses and preliminary interpretations, models, and conclusions. These activities allowed us to see "gaps" or "weaknesses" in our data base, form preliminary working models, and present new data to the larger community of our peers via peer reviewed publications and presentations. Portions of this report are some of those presentations, included here as a part of this preliminary report. Some of the data are still in process and will be included in the Year IV report.

GLEN CANYON NATIONAL RECREATION AREA

Field and laboratory work in (GLCA) was concentrated in continued efforts in the Bowns/Bechan Canyons,

INTRODUCTION

Fortymile Canyon, and Willow Canyon (Figure 1). Work in the former two areas had been continued, or initiated, in previous contract, and pre-contract years. We have essentially completed preliminary work in the Bowns/Bechan area, and are concentrating efforts in the Fortymile/Willow area for part of Year III and IV efforts. Related to our (principal investigators) research, at least four theses have been produced, or are being produced by graduate students in the Quaternary Studies Program: Kirk Anderson (1989), Soil Development in the Bowns/Bechan Area; Gloria Judges-Edwards (1990), Pollen and Macrobotanical Remains for the Archaic Occupation of the Bowns/Bechan Area; Kim Withers (1989), Late Pleistocene and Holocene History of Oak in GLCA; Brian Cluer, Late Pleistocene and Holocene Sedimentation and Depositional Environments in the Fortymile region.

A manuscript on the archaeology of Bechan Cave, as encountered in the paleontological investigations of 1983 and 1984, and was published in the Kiva in 1989.

CANYONLANDS NATIONAL PARK

Our efforts in CANY during Year III were primarily in data analyses and interpretations of Year II field work. Results of the combined efforts of the archaeological contractors (P-III) and our field research provided a valid, post-field season, synthesis of the correlation of certain cultural periods (entities) and mappable Quaternary geologic units (Figure 2). In addition, our preliminary packrat record and resulting interpretations are still

being analyzed and enhanced, and additional field collections will be made in the next field period.

Pollen sampling in the Snail Knob section (near Kirk's Cabin) will provide a continuous pollen record from greater than 11,000 B.P. to 8,600 B.P. This will provide one of the few radiocarbon controlled pollen profiles that crosses the Pleistocene-Holocene boundary for the entire Colorado Plateau.

Analysis of the invertebrate fauna at this locale is presented in this report.

YEAR III INVESTIGATIONS

Experience gained in the previous years indicated the high potential for significant data in the Fortymile area of GLCA, as well as continued work in the Salt Creek drainage of CANY. Year III efforts were focused on the Fortymile region in GLCA. In the Bowns/Bechan area, micro- and macrobotanical efforts were concentrated on the Archaic cultural interval. These efforts by Gloria Judges-Edwards were conducted in Bechan Begay and in an alcove in Bechan Canyon which had been badly disturbed by pot hunting. The preliminary results are presented in chapter 4.

In addition to the field efforts, laboratory analyses of materials collected in prior seasons were conducted, yielding syntheses not previously derived, and enhancing earlier conclusions. Publication and/or presentation of research results in professional journals and at national meetings was an important part of Year III activities - the dissemination of new information (see Appendix IV). A joint field trip for

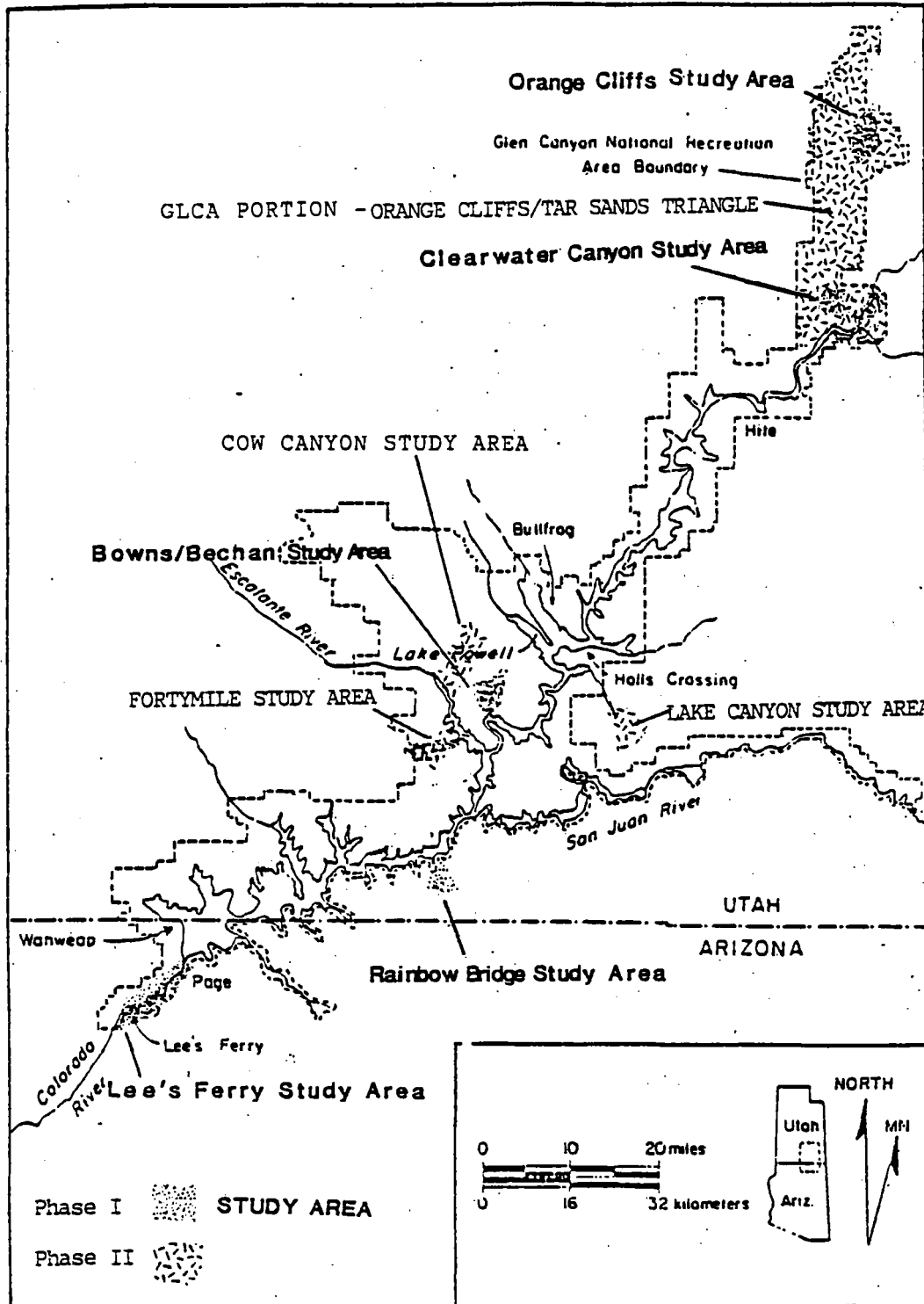


Figure 1. Location map of Glen Canyon National Recreation area.

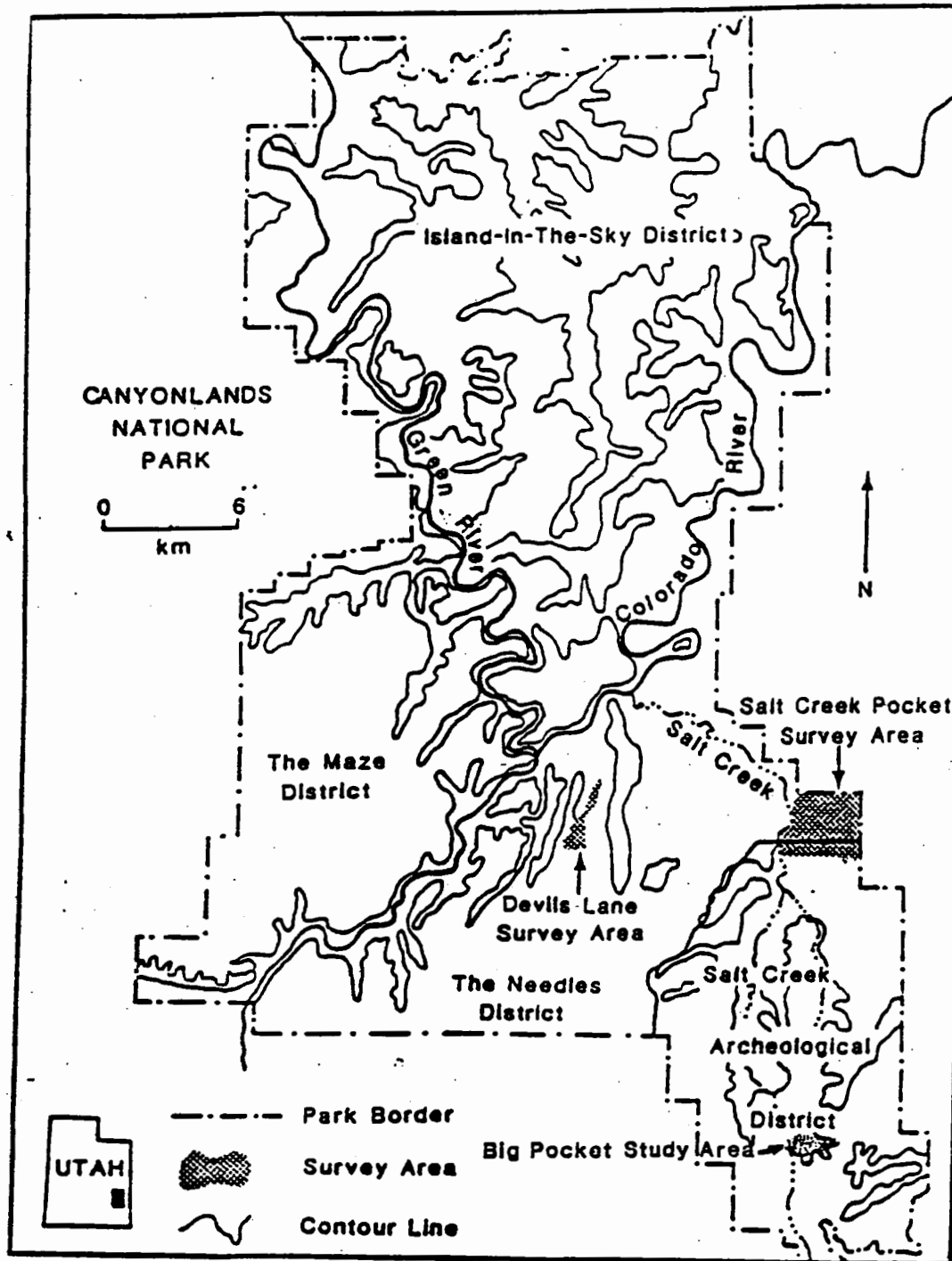


Figure 2. Location Map for Canyonlands National Park.

INTRODUCTION

NPS personnel from GLCA and CANY was held in GLCA in the fall.

YEAR IV FIELD INVESTIGATIONS (RESEARCH DESIGN)

Year IV field efforts will be directed to CANY with the Salt Creek Drainage/Big Pocket areas as a major focus. The Grabens, Red Lake Graben, in particular, will be the focus of reconnaissance efforts. Work in GLCA will continue in the Fortymile region as well as additional exploration in the Escalante and upper Colorado mainstream tributaries.

CHAPTER 2

RESEARCH DESIGN

L. Agenbroad and J. Mead

INTRODUCTION

This project is part of a multiyear program to study the aboriginal occupation and use of Canyonlands National Park and Glen Canyon National Recreation area. The purpose of the Quaternary Studies contract is to develop a geochronological framework for understanding area prehistory through study of the late Quaternary alluvium, soils, paleontology, palynology, paleobotany, paleohydrology and sedimentation, and other data sources relevant to interpreting the paleoclimate and paleoenvironment. Because of its relationship to study of regional prehistory, this project, of necessity, focuses heavily upon those areas where archaeological survey is underway and addresses those problems specific to the interpretation of regional prehistory. There are two ultimate goals of the study:

1. Establishing a regional paleoenvironmental history and sequence of events tied to absolute chronology; and

2. Correlating the archaeological record with the paleoenvironmental conditions and tying it to an absolute chronological framework.

This, then, allows interpretation of the human utilization, exploration, habitation, and demography, as tied to the environment and to environmental change, from the advent of the Paleoindian megafauna hunters through Archaic, agriculturalist, historic, and modern human groups.

BACKGROUND

The natural deposits (alluvium, cave fill, packrat middens) compromise the preserving medium and the physical repository for the prehistory of the area, of which the archaeology is but one aspect. Without the analysis of the paleoenvironmental evidence, the archaeological report does little more than record the artifactual materials left at a given locality at an approximate time (often derived only by relative typology of the artifacts recovered). The Quaternary deposits are the mechanism of preservation and

RESEARCH DESIGN

the temporal-physical framework to which the archaeology must be related for optimum understanding of human presence, exploitation and adaptation/modification of the area resources. The inundation of the main stream Colorado River canyon by the backwaters from Glen Canyon Dam effectively destroyed the potential of study of the major alluvial system of the area. Paleoenvironmental reconstruction and the chronology of events to which the archaeology is related must be built from smaller (second and third order) drainage systems, which the waters of Lake Powell have made more accessible.

The Quaternary history of the areas is little known. Recent work on the Escalante river (Boison and Patton 1985), a very preliminary paper of Lake Canyon (Lipe et al. 1975) and a preliminary analysis of Bechan Cave (Davis et al. 1984; Agenbroad et al. 1984; Mead et al. 1986) are the only studies available, other than those in the now drowned Colorado River Canyon (Cooley 1960, 1961, 1962, 1975), or the studies more regional, or more removed from the designated areas of concern, such as Agenbroad (1975), Biggar, Harden and Gillam (1982).

Recent multidisciplinary studies such as those at Chaco Canyon, New Mexico; Black Mesa, Arizona; or Cedar Mesa, Utah indicate that there is a cause-response relationship to human occupation-adaptation-migration patterns that is discernible from the geologic-botanical-paleontological records preserved in the Quaternary deposits. This data base and its effect on prehistoric human populations and the evidence of climatic change is crucial to understanding the prehistory of the area, as well as modern phenomena, and can serve as a predictive tool for the future. Many key deposits have been

relatively undisturbed, due to their remoteness, in the past. The access provided by Lake Powell and new and or improved roads and means of transport threaten the existence and preservation of such deposits. An example is the attempted protection of Rampart cave in the western portion of Grand Canyon, with the result of forced entry, a fire (vandalism or accident makes no difference) that destroyed a "one of a kind" deposit of extinct sloth dung (*Northrotheriops shastense*). The threat of a similar occurrence for the mammoth dung blanket at Bechan Cave is just as real and would be just as damaging. This example is a paleontologic cave deposit, but similar cases can easily be cited for archaeological or geological resources. All have paleoenvironmental significance and should be evaluated scientifically before they are modified extensively, or destroyed.

THEORETICAL FRAMEWORK/ PARADIGM / MODEL

It has been amply demonstrated that there is a cause-response relationship between man and the environment that is discernible in the Quaternary record, evidenced mainly as geological, botanical, palynological, and cultural data. Therefore we assume that (1) understanding this record is crucial to understanding area prehistory, and (2) extracting this record from the Quaternary deposits is possible. Recent work on the Colorado Plateau (including Year I and Year II of this study in Canyonlands National Park and Glen Canyon National Recreation Area) has shown that key drainages contain alluvial fill sequences that document

vegetational, faunal, climatic, and cultural change for the past 15,000 to 20,000 years. Analyses of these data permit:

- 1.Reconstruction of the paleoclimate;
- 2.Reconstruction of the paleoenvironment;
- 3.Creation of an absolute chronology of events;
- 4.Documentation of geologic, climatic, faunal, floral, and cultural change in the area;
- 5.Interpretation of area cultural history and environmental utilization;
- 6.Correlation of the Bechan Cave depositional sequence to the canyons' alluvial sequence.

Work in Bechan Cave, Glen Canyon National Recreational Area, has documented a 15,000 year history of change in flora, fauna, climate, and culture for the cave fill. The Quaternary record is contained in the canyons adjacent to the cave. It consists of up to 15 m of alluvium evidencing cut and fill sequences, fluctuating water tables, paleosols, standing bodies of water, paleontological remains, and archeological materials. It is hypothesized that analysis of this record will enable (1) tying the record to an absolute chronology, (2) correlating the record with widespread climatic, botanical, and cultural events, and (3) tying the events in the canyons to the events recorded in Bechan Cave fill. The results of this study would be the creation of a "Master Key" for correlation with other canyons, adjacent or distant, on that portion of the Colorado Plateau occupied by Glen Canyon National Recreational Area and Canyonlands National Park and would help achieve the goals of the study.

ASSUMPTIONS

Table 1 presents the research model in a tabular format; specific hypotheses and methods of testing these hypotheses follow, later. The relationship between independent variables and dependant variables presented in Table 1 revolve around four physical factors: (1) time, (2) change in climatic character with time (cyclicality); (3) moisture availability; (4) temperature. A given locality will produce a biological community (floral and faunal) that reflect the above independent variables. For example, the same locality can be demonstrated to have had environmental change - as reflected by the record of its floral, faunal (and geological-hydrological) entities, through time. The modern environment may be semi-arid high plateau with its characteristic pinyon-juniper scrub forest modified by riparian habitat and biologic community near water sources, or by black brush-steppe in more elevated, less watered environmental locations. By analysis of pollen, fauna, flora, and geohydrologic materials, the same locality can be demonstrated to have been a spruce-birch forest with a different riparian habitat and biological community, and a sage brush-grass steppe as recently as 11,6000 B.P.: 9650 B.C. (Davis et al. 1984; Agenbroad et al. 1984; Mead et al. 1986). Human presence is also recorded intermittently within the last 8000 years of the record at this locality. The presence or absence of prehistoric people is intimately tied to the environment and its resources as a function of the hydrogeologic processes in action at a given time interval.

The interpretation and understanding of the paleoenvironment

TABLE 1 : PALEOENVIRONMENTAL FEATURES AND DATA SOURCES USED TO CONSTRUCT A GEOCHRONOLOGIC AND PALEOECOLOGICAL FRAMEWORK

<u>TEMPORAL INTERVAL</u>	<u>PALEONTOLOGIC</u>	<u>ARCHEOLOGIC</u>	<u>GEOLOGIC</u>	<u>HYDROLOGIC</u>
pre- 11,000 B.P. (9,000 B.C.)	extinct fauna: mammoth, horse, camel, shrub oxen, sloths, mountain goat	Paleoindians: Clovis projectile point  Folsom projectile point 	cut and fill (erosion) color and texture of sediment guide fossils (vertebrate and invertebrate) soils sand dunes	cut and fill (erosion/deposition) oxidizing/reducing environment water table position lacustrine/paludal deposits invertebrates and amphibians
11,000 B.P. (9,000 B.C.) to 7,000 B.P. (5,000 B.C.)	absence of extinct fauna (modern fauna present)	Paleoindians: Plano cultures  Early Archaic cultures 	cut and fill (erosion) color and texture of sediment guide fossils (vertebrate and invertebrate) soils sand dunes	cut and fill (erosion/deposition) oxidizing/reducing environment water table position lacustrine/paludal deposits invertebrates and amphibians
7,000 B.P. (5,000 B.C.) to 2,000 B.P. (0 B.C.)	absence of extinct fauna (modern fauna present) domestic ? forms	absence of Plano middle and late Archaic cultures	cut and fill (erosion) color and texture of sediment guide fossils (vertebrate and invertebrate) soils sand dunes	cut and fill (erosion/deposition) oxidizing/reducing environment water table position lacustrine/paludal deposits invertebrates and amphibians
2,000 B.P. (0 B.C.) to 0 B.P. (1950 A.D.)	absence of extinct fauna (modern fauna present) domestic ? forms	ceramics, Basketmaker and Pueblo artifacts 	cut and fill (erosions) color and texture of sediments guide fossils (vertebrate and invertebrate) soils sand dunes	cut and fill (erosion/deposition) oxidizing/reducing environment water table position lacustrine/paludal deposits invertebrates and amphibians

CHRONOLOGIC

buried organic remains
charcoal as sediment
buried cultural features (hearths)
fossils
packrat midden chronology

PALYNOLOGIC

chronologically controlled
pollen profiles

MACROBOTANICAL

plant remains
dung
packrat middens

MALACOFUNA

Boreal-mesic species

ENVIRONMENTAL AND PALEOCLIMATIC INTERPRETATIONS

interpret fossil vs. modern
communities of plants and animals
Infer temperature and moisture condition
Describe geologic processes at work in the
temporal interval

buried organic remains
charcoal as sediment
buried cultural features (hearths)
fossils
packrat midden chronology

chronologically controlled
pollen profiles

plant remains
dung
packrat middens

Fewer number of boreal species;
ponding phases

interpret fossil vs. modern
communities of plants and animals
Infer temperature and moisture condition
Describe geologic processes at work in the
temporal interval
plus new cultural adaptations

buried organic remains
charcoal as sediment
buried cultural features (hearths)
fossils
packrat midden chronology
ceramics for relative dates

chronologically controlled
pollen profiles

plant remains
dung
packrat middens

Spotty records of mesic species
indicating local ponding phases

interpret fossil vs. modern
communities of plants and animals
Infer temperature and moisture condition
Describe geologic processes at work in the
temporal interval
plus new cultural adaptations
presence or abandonment of areas
previously occupied

buried organic remains
charcoal as sediment
buried cultural features (hearths)
fossils
packrat midden chronology
ceramics for relative dating

chronologically controlled
pollen profiles
evidence of cultigens

plant remains
dung
packrat middens
evidence of cultigens

Spotty records of mesic species
indicating local ponding phases

interpret fossil vs. modern
communities of plants and animals
Infer temperature and moisture condition
Describe geologic processes at work in the
temporal interval
plus new cultural adaptations
presence or abandonment of areas
previously occupied

RESEARCH DESIGN

RESEARCH DESIGN

as derived from the evidence preserved in remnant geologic deposits provide the key to the understanding the presence or absence of human groups at the study locality.

HYPOTHESES GUIDING FIELD RESEARCH

The specific hypotheses guiding field research has been developed to provide the information necessary for (1) creating the "Master Key" discussed above and, (2) addressing the goals of the project. These hypotheses will be tested by the field data and revised as necessary. New hypotheses may be developed as new data are acquired.

Hypothesis I :

There is alluvium in canyons of GCNRA and CNP (Canyonland National Park) that records paleoenvironmental data, chronological material, paleontologic, cultural evidence of late Pleistocene-Holocene conditions on the Colorado Plateau.

Testing of Hypothesis :

1. Select key canyons containing alluvial fill and:

a. map the alluvium;

b. establish a chronology by radiometric dating of material within the alluvial units to record episodes of cut and fill, paleoenvironmental data including floral and faunal information;

c. study pollen profiles keyed to the dated alluvial units; and

d. study pedologic evidence for soil formation, tied to the chronologic framework.

2. Extend the model from "key" localities to other areas, both proximal and distance to verify local or regional trends.

Hypothesis II :

Faunal and floral resources were available on the Colorado Plateau in late Pleistocene times that allowed exploitation of such resources by early human groups.

Testing of Hypothesis :

1. Collect, identify, and correlate to the radiometric chronology any paleontological materials incorporated in the alluvium, cave fill, etc.

2. Analyze the palynological evidence from radiometrically dated alluvial sequences and cave fill to document botanical materials.

2. Identify resources or potential resources (both faunal and botanical) for various temporal intervals, for human exploitation.

4. Plot reported distributions of potential game animals, i.e. bison, mammoth, and the cultural entities that exploited this game base, i.e. Plano, Folsom, Clovis, etc.

Hypothesis III :

Cave deposits within the study area contain records not often found in alluvial/cultural sites. The investigation, and correlation to the alluvial and surface sites, will provide additional refinement for the reconstruction of the paleoenvironment, its change, and its exploitation by the human inhabitants of the area.

Testing of the Hypothesis :

1. Correlate the alluvial history/chronology with cave chronologies such as at Bechan Cave (Davis et al. 1984), Cowboy Cave (Jennings 1980), Allan Cave (Betancourt 1984), etc.

2. Conduct paleobotanical investigation (macrobotany and pollen) of the units of selected cave fills and correlate to reported data references in (1) above.

3. Document and date cultural horizons within cave fills.

4. Test selected caves for Pleistocene megafaunal remains such as at Bechan Cave, Cowboy Cave, Bare Ladder (Mead et al. 1989)

Hypothesis V :

A cause and effect relationship exists between climatologic, biologic, and geologic changes on the Colorado Plateau.

Testing of Hypothesis:

1. Adverse climatic conditions caused local portions of the study area to be abandoned by flora, fauna, and cultural entities.

2. Beneficial climatic conditions allowed local portions of the study area to be abandoned by flora, fauna, and cultural entities.

3. Evidence of such conditions are recorded in the alluvial and cave fill; it can be documented and tied to an absolute chronology, allowing interpretation of the cultural chronology of the area.

Hypothesis VI :

A synthesis of paleoenvironmental conditions can be constructed based on an absolute chronology from alluvial fill, cave fill, and packrat middens. The synthesis will allow estimates as to biological and geological resources, arable land, and migrational impetus for given temporal intervals for prehistoric cultural entities.

Testing of Hypothesis :

1. Construction of a local (a given canyon or drainage) synthesis.

2. Correlation of local syntheses to form a regional synthesis.

3. Interpret paleoenvironmental conditions / factors available to human groups at temporal intervals provided by the absolute chronologic framework.

4. Test the paleoenvironmental data and interpretations with reported archaeological evidence.

DATA COLLECTION PRIORITIES

Those localities which have potential for the preservation of long (temporal) alluvial records are of first priority. The Bechan Cave-Bowns Canyon area provide not only an alluvial record, but a stratified cave fill as well. Key sections within a canyon or study area contain thick stratified alluvial sequences, with datable (absolute dating such as C-14) material, pollen preservation potential, macroflora and fauna, and cultural remains (hopefully in stratified context). Surficial archaeological remains, while interesting, rarely have great antiquity, or if they are old, often reflect erosional lag deposits lacking the environmental data outlined above. Canyons with great drainage areas will often be denuded of ancient alluvial deposits due to episodic events (Webb 1985; Boison and Patton 1985). Key areas, then, will be canyons containing thick alluvial deposits, with some evidence of great antiquity in the older units. Such areas are sought out by the Quaternary geology contractor and his colleagues, whether or not they coincide with the areas of interest of the archeological contractor, or the current needs of park management. It will prove, more often than not, that the evidence of human presence will also be documented in such localities and will provide clues to the cultural adaptation to the region not provided by the younger, ceramic cultures.

Years I and II areas of investigation prescribed by the NPS proposal (or the archaeological contractors) were investigated, but most often were not optimum localities for paleoenvironmental information predating 4000 B.P.: 2050 B.C. because they omitted much of the Archaic and

RESEARCH DESIGN

potentially all of the Paleoindian periods of human prehistory on the Plateau.

Areas with High Research Potential

Any area within GLCA and CANY having the above criteria has excellent research potential. As noted Bechan-Bowns is outstanding as a key data point. We have chosen alcove Fortymile Canyon (GLCA) for its thick, ancient alluvial deposits. The Big Pocket area of CANY

has similar (though probably younger) potential. Fortymile Canyon has an extremely exciting potential predating most prehistoric cultural potential, so the geologic contractors are seeking outside funding to pursue research, which will provide a necessary record for the paleoenvironment just prior to the advent of human populations in the area, and just prior to extinction of major species of Pleistocene megafauna, providing a critical test of the overkill hypothesis.

Year I Field Investigations

Field work for the Glen Canyon National Recreation Area was concentrated in the Lee's Ferry, Rainbow Bridge, Orange Cliffs, and Bechan Cave localities. Of particular significance are the studies in the alluvial fill of canyons adjacent to Bechan Cave.

Radiocarbon dates from selected sites and levels in the alluvial fill have produced a sequence of dates ranging from 75 B.P.: A.D. 1875 to 10,020 B.P.: 8070 B.C., with other dating samples still in progress. The dates currently available allow correlation with the post-dung deposits in Bechan Cave; they also put alluvial dates to within less than 1700 years of the youngest portions of the dung deposit of the cave. Older alluvial units are waiting laboratory

results, which should extend the alluvial chronology 1000-10,000 years for these canyons. Alluvial units lacking material suitable, or in insufficient quantity, for standard C-14 dates are being dated by TAMS (Tandem Linear Accelerator Mass Spectrometer) methods, and / or by thermoluminescent dating techniques.

Palynological and pedological studies of the alluvial units are in progress, with preliminary interpretations being written.

The ultimate goal of the study is twofold:

1. To establish the paleoenvironmental history and sequence of events tied to an absolute chronology;

2. To tie the archaeological record to the paleoenvironmental and absolute chronologic framework in (1) above. This will allow an interpretation of the human utilization, exploitation, habitation, and demography, as tied to the environment change in the area, from the advent of Paleoindian megafauna hunters, to Archaic, agriculturist, historic, and modern human groups.

Year II Field Investigations (Project Design)

Using the above data base and experience, it was proposed that key canyons be investigated for their alluvial sequence possibilities. It was proposed that canyons adjacent to the 1984-1985 study area and canyons more removed, geographically, be studied as a further test and an expansion of the data base generated and initially tested in the Bechan Cave area.

Study areas for 1985-1986:

1. Glen Canyon National Recreation Area

- a. Long Canyon

- b. Cow Canyon

PHILOSOPHY AND APPROACH TO FIELD STUDIES FOR CONTRACT CX 1200-4-AO62

c. Lake Canyon
d. Fortymile Canyon
2. Canyonlands National Park
a. Big Pocket
b. Salt Wash Drainage
3. Areas specified by the National Park Service and the archaeological contractors.

Years III and IV Investigations

Using the experience and data base generated in Years I and II, the model has been expanded to include other areas of alluvium, cave fill, and packrat midden research. Areas were selected based on the results of Year II studies and the areas specified by the National Park Service and the archaeological contractors.

Areas of study for Phase III:

1. included additional work in Bowns / Bechan Canyons (GLCA);
2. alluvial and dung analysis of deposits in the Fortymile Canyon area (GLCA);
3. Big Pocket-Kirk's Cabin research of Salt Creek (CANY).

To understand the human adaptation to and exploitation of the prehistoric resource potential of the Colorado Plateau requires an understanding of the pre-human conditions. Only by understanding the pre-human environment can we correctly address the human resource exploitation and be in a position to document change after human impact on those resources. Was the extinction of the Pleistocene fauna due to climatic change which affected the faunal and botanical resource base, or was it human induced extinction? Was the human cultural development on the Plateau unique to a climatic driven environmental change?

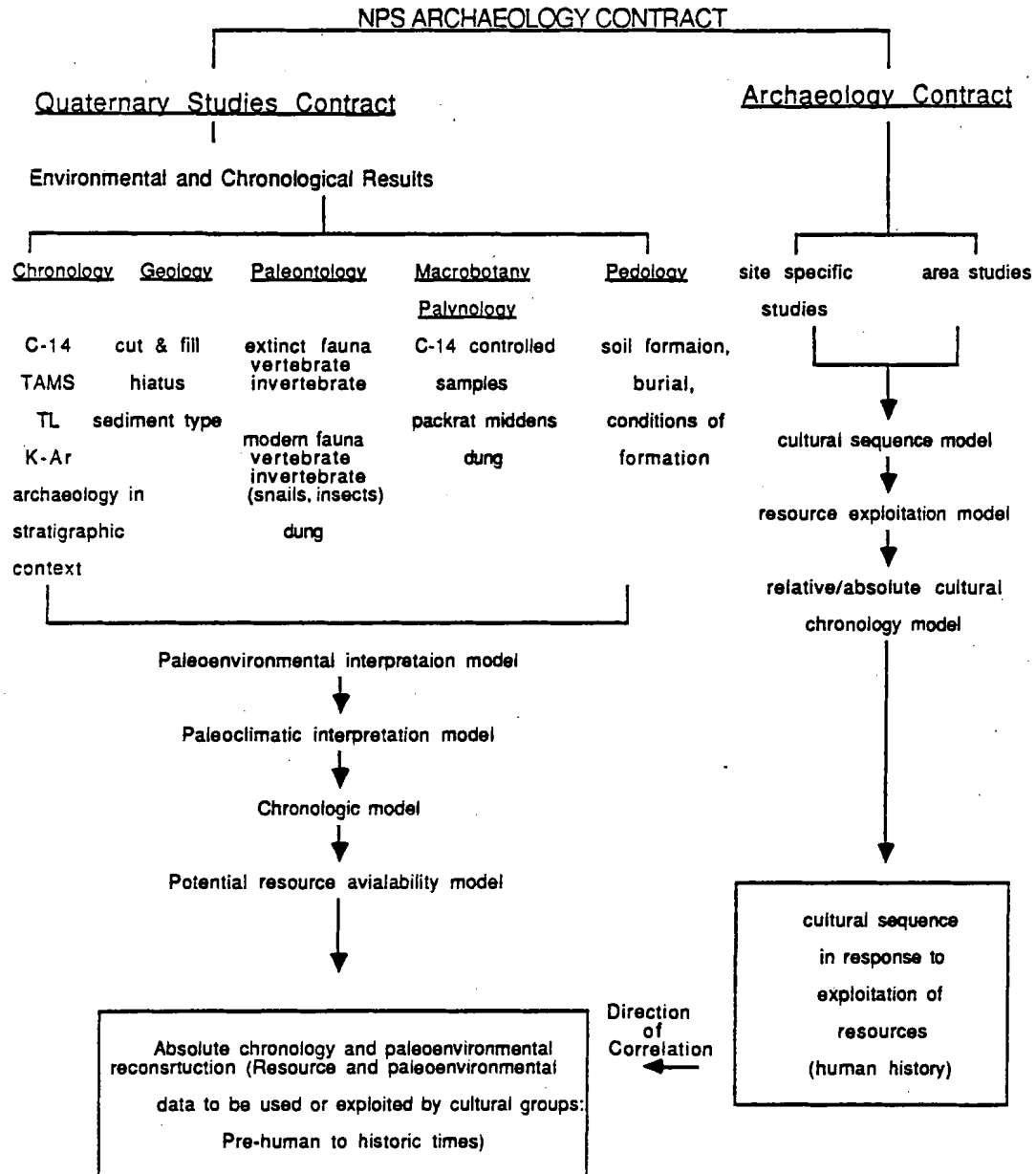
To address these questions and to formulate a model, and test that model has been a progression based on the data gained from each phase of the contract. That progression is currently on-going, but to present the data base in a tabular format refer to Table 2 and model 1.

Table 2: Progression of Quaternary Geochronological and Paleoenvironmental Model to which the Archaeology can be related.

<u>Year I</u>	<u>Year II</u>	<u>Year III</u>
Bowns/Bechan (GLCA)	Salt Creek Pocket (CANY)	Fortymile Area (GLCA)
Canyon alluvium,	Devils Lane (Grabens) (CANY)	Big Pocket/Upper Salt (CANY)
pollen chronology	Fortymile Area (GLCA)	Cross-correlation of
packrat midden,	Bowns/Bechan (GLCA)	contract data and previous
soils analysis	Cow Canyon (GLCA)	works in the region
archaeological studies	construct tentative model	Test and expand our model
		from Year II

RESEARCH DESIGN

MODEL 1: PALEOENVIRONMENTAL INVESTIGATIONS OF CANY AND GLCA: PRODUCTION OF A CHONOLOGIC/PALEOENVIRONMENTAL FRAMEWORK TO WHICH CULTURAL ACTIVITY CAN BE RELATED



Model 1.

CHAPTER 3

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE AND ON THE SOUTHERN COLORADO PLATEAU

Richard H. Hevly, Scott Clay-Poole and Gloria Judges-Edwards

The deeply eroded bedrock canyonlands of southern Utah and northern Arizona have generally yielded only a relatively sparse and sporadic record of environmental conditions existing prior to the last millennium (Agenbroad 1975; Briscoe 1974; Hack 1945; Hansen 1978; Hevly 1968, 1979; Laudermilk and Munz 1938; Lipe et al. 1975; Martin et al. 1961; Phillips 1977; Salkin 1975; West 1978). Recent archaeological and geological investigations in southeastern Utah and adjoining Arizona have revealed the existence of deeply eroded but fossiliferous remnants of intermittently deposited late Quaternary alluvial, lacustrine and aeolian sediments. (Aasen 1984; Agenbroad 1986, 1987, 1988; Betancourt 1984; Clay-Poole 1989; Davis et al. 1984; Dean 1988; Hevly 1988; Karlstrom 1988). These sediments contain sporadic archaeological and biological remains which have yielded both datable materials and also evidence of

the changing nature of the prehistoric environments in a region from which previous Quaternary data > 1000 years old were relatively scarce.

One locality which has proven to be particularly productive of biological remains is the Bowns/Bechan Canyon System, a minor tributary of the Colorado River in southern Utah (Figure 3). The floor of the Bowns/Bechan drainage is situated at an elevation of approximately 1300 m below towering cliffs of Navajo Sandstone. Permanent water flows through the system and is bordered by riparian vegetation including *Salix* (willow) and *Populus* (cottonwood) as well as *Typha* (cattail), *Juncus* (rush) and *Carex* (sedge). This canyon system contains numerous erosional remnants (terraces) of sequential alluvial deposits (Figure 4) on which occur *Atriplex* (salt-brush), *Chrysothamnus* (rabbitbush), *Celtis* (hackberry), *Quercus* (oak) and occasional *Juniperus* (red cedar).

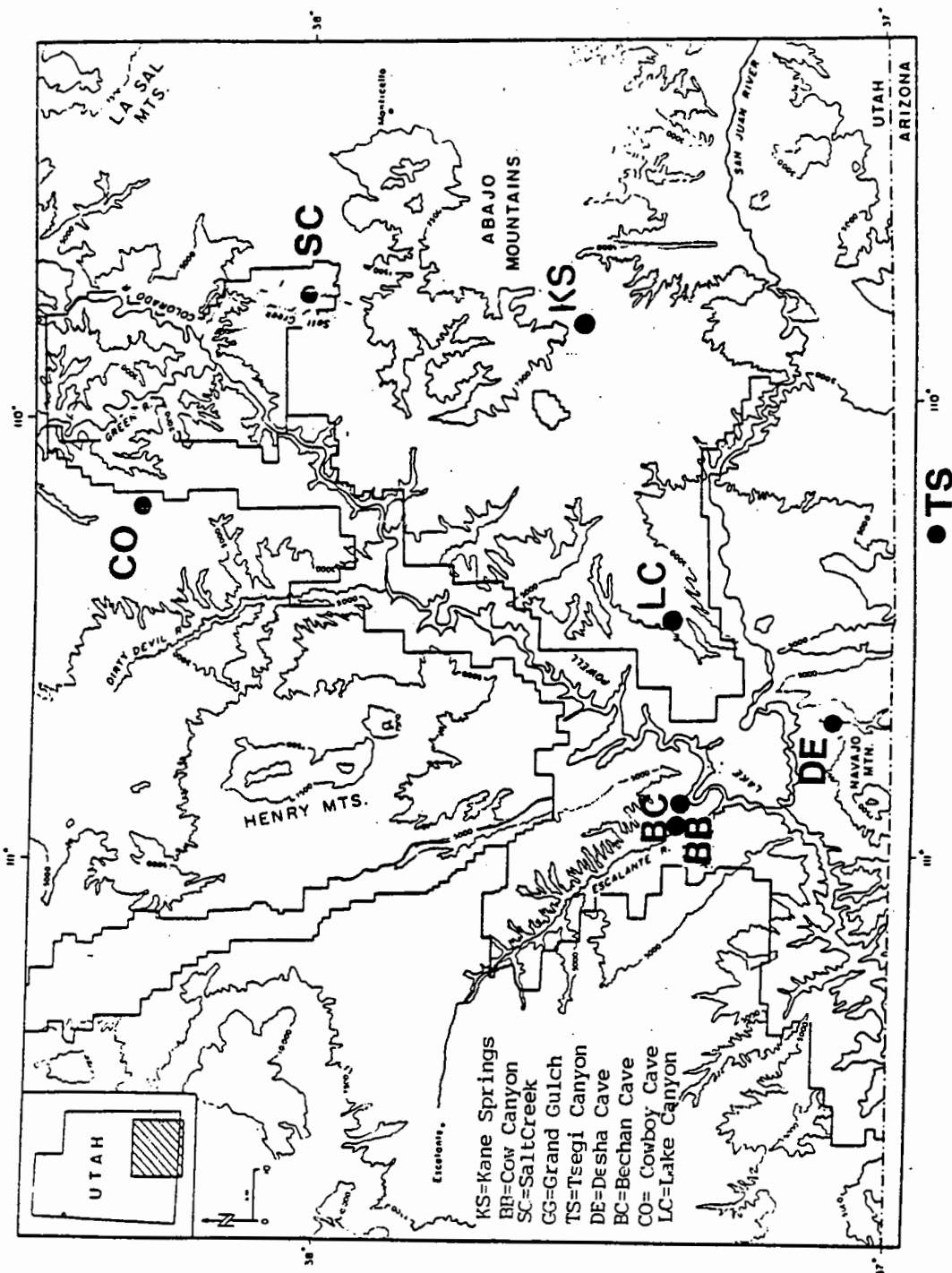


Figure 3. Map of southeastern Utah showing the locations of localities discussed in text: Bowns-Bechan Canyon and adjoining Cow Canyon (BB), Kane (KS), Lake Pagahrit in Lake Canyon (LC) on or adjoining Cedar Mesa, Sand Dune Cave on the flank of Navajo Mountain and Tsegi, a comparative alluvial pollen locality in Arizona.

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

Dated archaeological and biological remains in the alluvium of the terraces have been used to establish the following scenario of alluvial history (Agenbroad et al. 1989). The oldest depositional unit (Terrace 4) dates 32,800 B.P. (30,850 B.C.) and contains the remains of freshwater clam *Pisidium*. It is this alluvial deposit which has partially filled many water-cut alcoves in the canyon system and which may also have provided the surface upon which a number of now extinct mammals roamed while utilizing Bechan Cave as a refugium from inclement weather between 11,670 and 13,505 B.P. (9720 and 11,555 B.C.) (Davis et al. 1984).

Erosion removed almost all of this alluvial unit within approximately 1650 years (Figure 5). Deposition was well underway again by 10,020 B.P. (8070 B.C.) and alluvium continued to be deposited until almost 6000 B.P. (4050 B.C.), filling the canyon system to almost the same height as Terrace 4. This stable surface was occupied by prehistoric nomadic hunter and gathers who lived in Bechan Cave at 7795, 7525 and 5500 B.P. (5845, 5575 and 3550 B.C.) as well as among the aeolian sand dunes forming in the area by 5300 B.P. (3350 B.C.) (Agenbroad 1986). Macroscopic biotic remains dating to this period of deposition have been recovered only from the alcoves and frequently in archaeological association.

A major episode of erosion followed which removed nearly all of preceding 4000 years of deposition except for those remnants identified as Terrace 3. Alluvial deposition was initiated again by 4965 B.P. (301 B.C.) and continued until sometime after 940 B.P. (1010 A.D.). During this interval of deposition the drainage of Bowns canyon was temporarily blocked at least once by falling sand dunes to create a local impoundment of water

about 1970 B.P. (20 B.C.) within which fresh water snails (*Gyraulus*) occurred (Agenbroad, this volume). Occupation of Bechan Cave and other rock alcoves by prehistoric agriculturalists occurred intermittently from 2640 to 950 B.P. (690 B.C. to 1000 A.D.). The prehistoric people appear to have farmed the accumulating alluvium of Terrace 2 in Bowns and Bechan Canyons as several hearths were buried by the accumulating sediments. (Judges-Edwards 1990).

This interval of deposition in Bowns Canyon was terminated about 1000 A.D. and human occupation of the canyon appears thereafter to have been minimal. However, in other nearby areas (e.g. Cow Canyon) occupation of the surface of this alluvial unit continued into the late 12th or early 13th centuries', prior to dissection, creating Terrace 2. Human occupation of the area by prehistoric agriculturalists appears to have terminated by the 13th century. However, another unit of deposition did occur thereafter. In Bowns Canyon the oldest tree thus far found to be buried by this alluvium dates 215 B.P. (1745 A.D.) but at nearby areas in northern Arizona this deposition interval buried trees dating to the 14th and 15th centuries as well. This interval of deposition was terminated by erosion creating Terrace 1 about 75 B.P. (1885 A.D.) based on the ages of wood recovered from the terrace surface (Agenbroad 1989).

This scenario of events is closely paralleled by alluvial history in nearby areas of southern Utah and northern Arizona (Agenbroad 1975; Hack 1945; Karlstrom and Karlstrom 1986; Karlstrom 1988). Soil description, and inferred alluvial and environmental history have been previously presented (Anderson 1987).

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

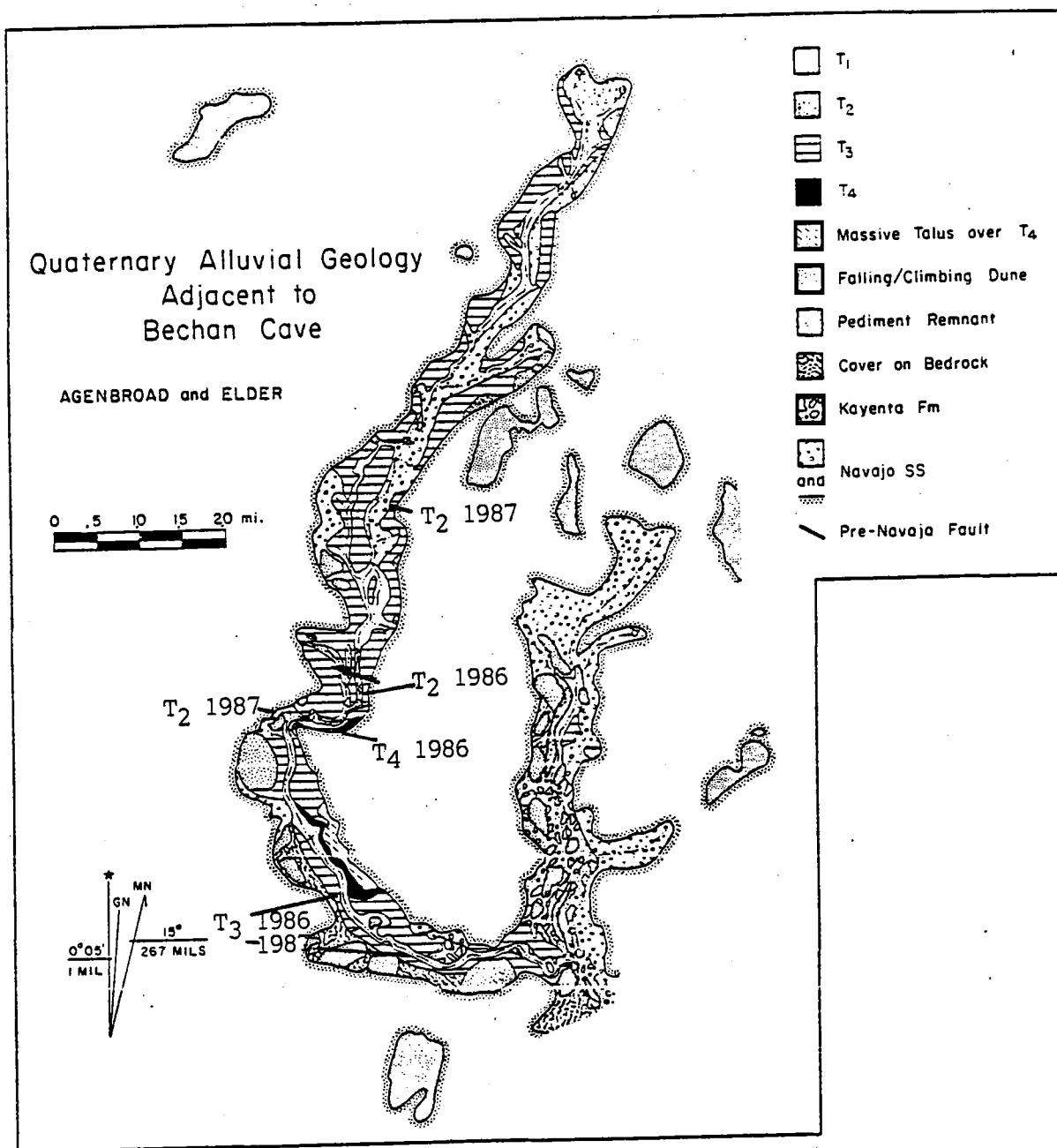
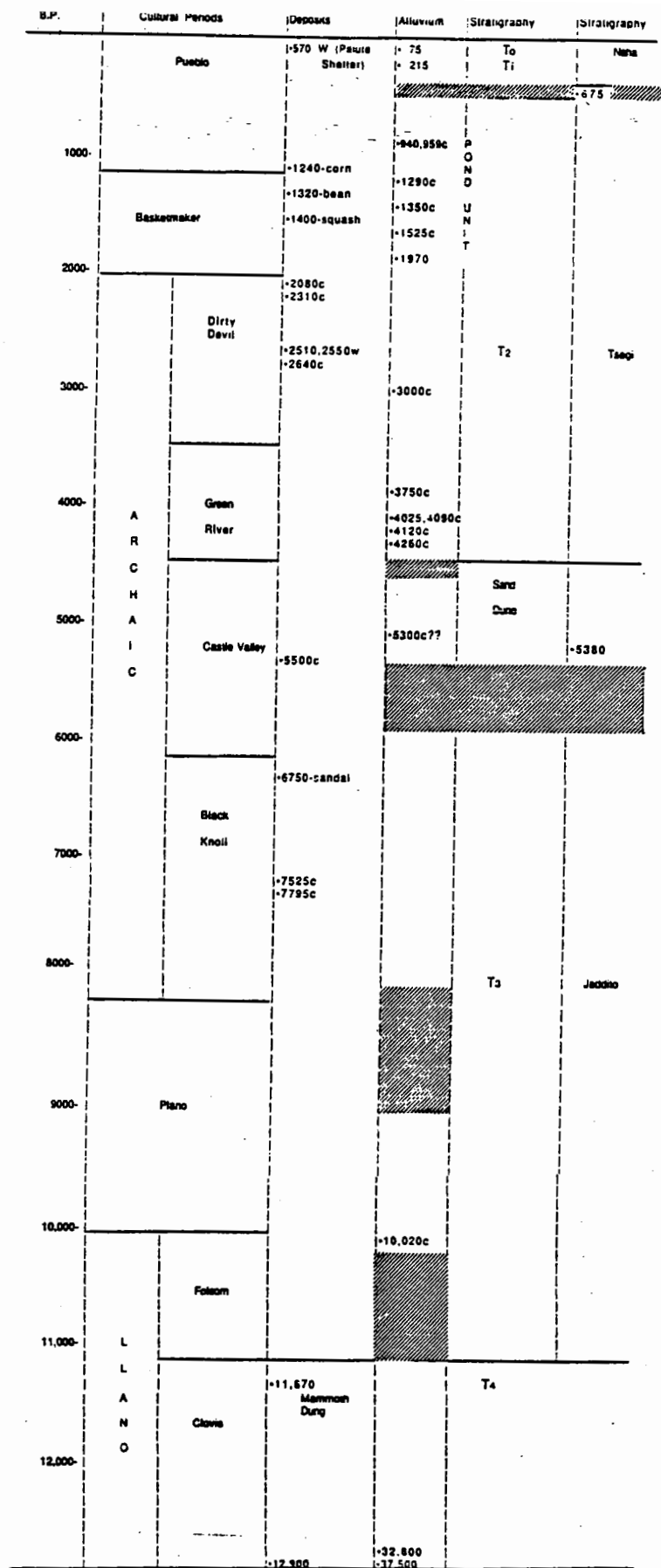


Figure 4. Map of the Bowns-Bechan drainage showing the distribution of alluvial units and the location of profiles sampled for pollen. Note that the alluvial units of which Terrace II is composed were sampled at 3 localities.



Episodes of erosion are indicated by hatched blocks. Chronology of Bona Canyon alluvium and Sechan cave deposits adapted from Agard et al (1989).

Figure 5. Diagram showing the alluvial stratigraphy of Terraces 1-4 including the associated C-14 dates (extrapolated from the various sampling localities). Additional temporal control is provided to Terrace II sediments by C-14 dates of charcoal recovered from buried hearths found in this alluvial unit.

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

The purpose of this study was to reconstruct from studies of fossil pollen the prehistoric vegetation and inferred climate under which this alluvial history evolved.

MATERIALS AND METHODS

Most of the pollen entering the alluvial systems of the southwest was initially transported by wind but becomes secondarily transported and redeposited by water. The dearth of pollen in sandy alluvium is related to water velocity where deposition of sediment occurred (pollen may not necessarily be deposited with sand), mechanical abrasion by the sediment while in transport, and chemical corrosion following deposition (Fall 1982, 1987; Hall 1988, Solomon et al. 1982). For these reasons care was exercised to select alluvial profiles for analysis which contained evidence of at least some silt and clay as well as organic material which might be radiometrically dated (Agenbroad 1986, 1987 and this report).

One or more samples for pollen analysis were selected from each alluvial unit which could be characterized as different in color or sediment texture within a profile. Sediment samples, each consisting of a volume of at least 150 ml, were removed with a clean trowel from a cleaned alluvial face and placed in a previously labeled whirl-pack bag. Modern surface samples, collected for comparative purposes, were obtained from three slightly different microhabitats: (1) a bedrock plunge pool at the base of a west facing cliff below the intersection of Bowns and Bechan Canyons, (2) the eroded but vegetated alluvial surfaces of Terrace 2 and (3) the currently accumulating

alluvium of Terraces 0 and 1 in the bottom of Bechan Canyon.

Upon return to the laboratory, the samples were extracted by standard techniques including a swirl technique to concentrate organic rich fines which are expected to include whatever pollen may be present and eliminate from further chemical treatment the major inorganic component of the samples (Gray 1965). To each sample a spike of exotic spores was also added to ascertain should pollen be sparse and poorly preserved whether the extraction procedure was responsible. Following extraction five microscope slides of each sample were prepared by placing a drop of presumably pollen-rich residue on each slide, staining with basic fuchsin, and covering with a 20 X 40 mm cover slip. Slides were examined at 450 X and pollen identified and counted until 200 pollen grains had been tabulated or all five slides of a sample has been completely counted.

RESULTS

All modern samples yielded counts of 200 or more grains from 1 slide. The pollen was well preserved and 20 different pollen types were recognized (Table 3). The pollen data from 5 samples obtained from the recent alluvium of Terraces 0-1 were pooled yielding a total pollen sum of 1042 grains. Entomophilous pollen accounted for only 3.7% of all pollen and was derived from locally growing plants. Anemophilous pollen accounted for 96.3% of all pollen and was usually derived from locally occurring plants but with some notable exceptions: *Abies* (2.3%), *Betula* (0.4%), and *Pinus* (26.8%). *Betula* (birch) occurs in a number of nearby canyons with permanent water at

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

Table 3. Pollen Composition (%) of Modern Surfaces in Bowns Canyon. Data from Hevly and Clay-Poole 1986, 1987: Judges Edwards 1990.

Local Pollen Types	Mesa Top Soil n=238	Mesa Top Pool n=241	Plunge Pool Cliff Base n=200	Soil Surface Terrace 2 n=200	Canyon Bottom #1-5 n=1004	Packrat Midden n=200
AP:PAP	4.0	0.4	-	-	2.3	-
<i>Pinus</i>	5.9	4.6	51.5	51.0	26.8	16.5
<i>Juniperus</i>	4.6	3.3	2.2	4.0	16.1	8.5
<i>Quercus</i>	1.3	2.5	-	-	1.2	2.5
<i>Acer</i>	0.4	0.4	(<i>Alnus</i>)	0.4	-	-
<i>Celtis</i>	-	0.4	-	-	-	1.5
<i>Salix/Populus</i>	-	-	-	-	0.4 (<i>Betula</i>)	.5 + .5
<i>NAP Ephedra</i>	7.6	3.3	6.0	1.3	4.0	1.0
Poaceae	12.6	10.4	11.8	0.4	18.3	12.0
Cheno-Am	12.6	16.6	3.6	35.0	5.9	15.0
Asteraceae:						
<i>Artemisia</i>	25.2	27.0	15.0	2.4	13.3	3.5
Low Spine	25.2	27.8	3.0	2.4	5.1	17.5
High Spine	2.1	3.3	6.6	2.6	2.0	5.0
Liguliflorae	0.4	0.4	-	-	-	6.0
Entomophilous varia	1.2	2.5	-	0.8	1.7	2.5
Anemophilous Aquatic	-	-	-	-	2.4	3.5
Anemophilous Terr.	98.8	97.5	100.0	97.0	93.9	94.0

slightly higher elevations. *Pinus* (pine) and *Abies* (fir) occur today on the tops of nearby mountains such as Navajo Mountain to the south and Henry Mountains to the north. The proportions of pollen types in these modern samples are similar to modern samples examined by West (1978) from similar plant communities at slightly higher elevations. The reason for this is that the existence of surface water in Bowns/Bechan drainage permits many species typical of slightly higher elevations to extend their distribution down stream.

Excluding the extra-local pollen, the pollen composition generally reflects local vegetation. In the

canyon-bottom where grass (Poaceae), sunflowers (Asteraceae) and junipers are common, the predominant pollen types were Asteraceae (20.4%), Poaceae (18.3%), *Juniperus* (16.1%) Cheno-Ams (5.9%) and *Ephedra* (4.0%). The mesa-top soil-surface and pool samples are derived from a plant community characterized by widespread sagebrush and other taxa in the Asteraceae, Cheno-Ams such as *Atriplex* and depauperate *Juniperus*. The most abundant pollen types were those of the Asteraceae (52.9%), particularly those of the sagebrush. The second and third most abundant types are Cheno-Ams (25-27%), and Poaceae (10-12%), Third, fourth and fifth ranked

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

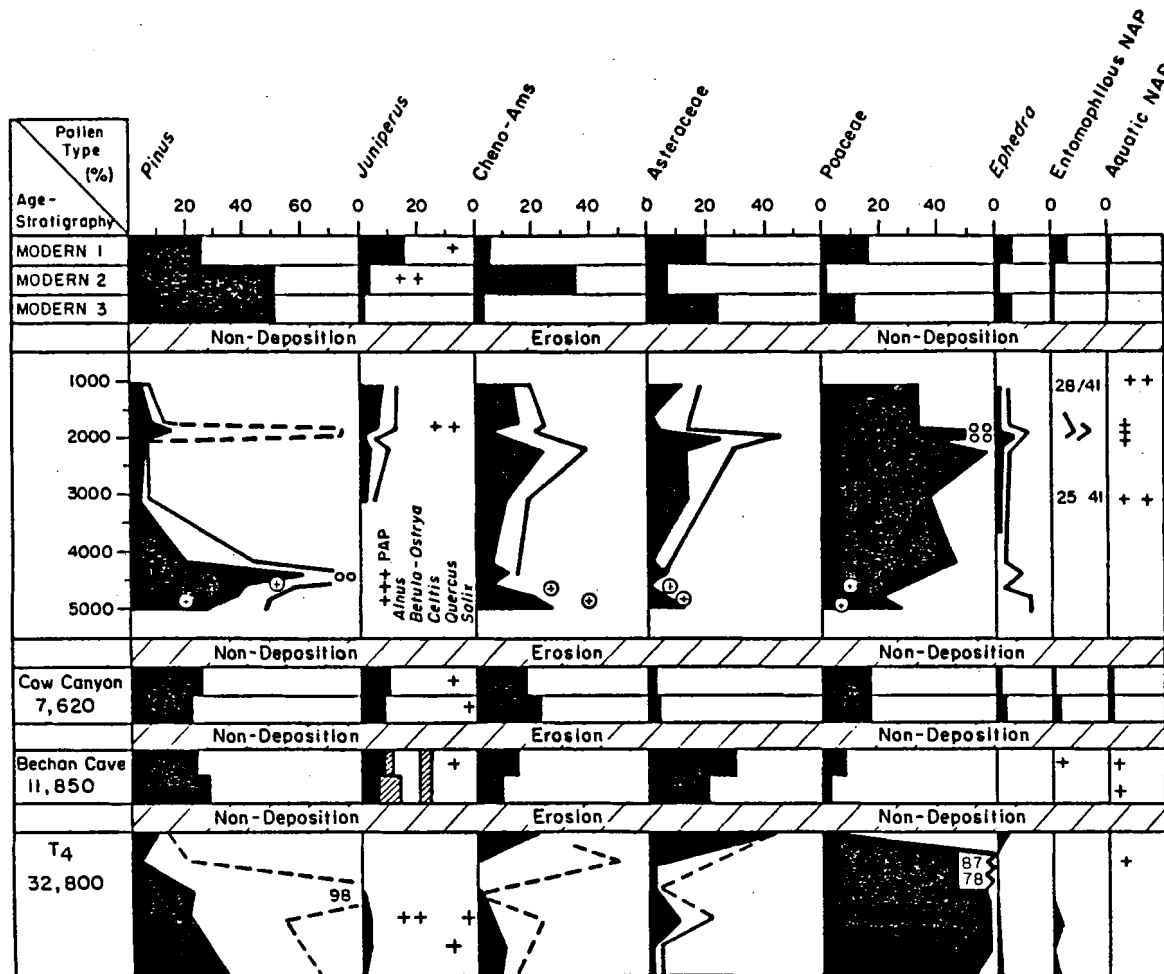


Figure 6. Diagram of pollen proportions (%) recovered from modern samples of the Bowns-Bechan drainage (in the sequence described in the text), fossil alluvial pollen samples from Terraces 2 and 4, and fossil aeolian pollen samples of Bechan Cave (27-39 and 29-40 cm samples from Davis et al 1984). Fossil alluvial pollen samples from Cow Canyon (temporally equivalent to Terrace III in Bowns Canyon) have been substituted for the inadequate pollen data from Terrace III of Bowns Canyon. Carbon-14 dates (*) are shown along the left hand margin of the diagram. Those C-14 dates to the left are from paleosols and snail or clam containing alluvial/lacustrine units (Fig. 5). Those C-14 dates to the right are from hearths buried within the alluvium (Fig. 5). Pollen types indicated by a (+) sign were rare (<1.5%) in the total pollen count. PAP designates a combination of arboreal pollen types (*Picea*, *Abies*, and *Pseudotsuga*). Cheno-Am designates a combination of non arboreal pollen types (Family Chenopodiaceae + *Amaranthus* of the Amaranthaceae). The first proportion (solid blocks) includes grass in the pollen sum. The second proportion (indicated by a line) excludes grass from the pollen sum. Fossil pollen data for Bechan Cave are derived from Davis et al. 1984. Pollen from archeological provenience are derived from Judges-Edwards (1990).

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

were Ephedra (3.3-7.6%), Pinus (4.6-5.9%) and Juniperus (3.3-4.6%).

In contrast to these modern samples which have 26.8% extra local pollen or less, the samples from the cliff-base pool and Terrace 2 soil-surface contain more than 50% extra-local pine pollen. The bedrock plunge pool occurs beneath the sagebrush dominated mesa top and is surrounded by grass. Its high pine pollen proportion may reflect wind and water transport and accumulation from the upland. The Terrace 2 soil-surface is developed in lacustrine sediments of a prehistoric temporary pond and its high pine proportions could reflect an ancient pollen assemblage at least in part. The pollen composition of this sample is otherwise characterized by unusually high Cheno-Am proportions (35.0%), perhaps reflecting the local abundance of salt brush (*Atriplex*).

Sediments of all alluvial units in the Bowns-Bechan drainage are very sandy and prior experience with similar sediments caused us to anticipate a poor pollen yield (Hevly 1979; Lipe et al 1975; West 1978). Nevertheless we proceeded to study the sediments with the hope that some data might be recovered.

A total of 119 samples were collected, extracted and counted from the alluvial profiles indicated in Figure 4: Terrace 4, n=24; Terrace 3, n=24; Terrace 2, n=81). Greater emphasis was placed on the sediments of Terrace 2 since they contained evidence of the prior existence of a temporary ponding unit, incipient paleosols and hearths of the prehistoric human occupants of the drainage. All alluvial units yielded pollen, but it was sparse and poorly preserved (Hevly and Clay-Poole 1986, 1987; Judges-Edwards 1990). Spores placed in the samples during extraction were abundant and well

preserved indicating that the sparsity and poor preservation of pollen was not an artifact of extraction.

Pollen was found in 21 of the 24 samples of Pleistocene alluvium from Terrace 4, but only six samples yielded more than 100 grains (Figure 6). The pollen was dominated in diminishing order by Poaceae, Pinaceae and Asteraceae (sunflower). Other arboreal (AP) and non arboreal (NAP) pollen types occurred only sporadically. Pine pollen proportions decrease upwards in Terrace 4 alluvium while Cheno-Am and Asteraceae pollen increase. These trends are reversed in samples of latest Pleistocene or earliest Holocene age (ca. 11,800 B.P.: 9850 B.C.) from Bechan Cave where also significant increases of PAP and Betulaceae (Birch family) pollen were also found (Davis et al. 1984). The pollen of Asteraceae is predominately that of *Artemisia* (sagebrush) in the Bechan Cave samples, a situation not found in either older or younger samples of the study area.

Pollen was found in 11 of the 14 samples of alluvium from Terrace 3, (1 sample with > 100 grains) but the only pollen type recovered was that of the Poaceae. These samples, dating between 5300 and 10020 B.P. (3350 and 8070 B.C.), might well reflect the previous existence of a temporary pond but the absence of other palynomorphs precluded further analysis. Therefore, temporally equivalent samples were substituted from nearby Cow Canyon (Figure 6). These samples are compositionally similar to those of Bechan Cave but differ in the absence of PAP and Betulaceae pollen as well as in greatly diminished proportions of *Artemisia* pollen.

Pollen was found in 65 of the 81 samples of alluvium from Terrace 2, but only 6 of the samples yielded more

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

that 100 grains. Therefore five archaeological pollen samples collected in association with hearths buried in Terrace 2 alluvium and in a contemporaneous alcove shelter were added to this survey (Figure 6). The pollen in Terrace 2 alluvium was dominated by Poaceae except in the oldest samples where pine proportions exceeded those of grass. Pine proportions diminish about 3000 B.P. (1050 B.C.) only to increase again very briefly about 2000 B.P. (50 B.C.) when also some increase in Chenopodiaceae and Asteraceae pollen were also observed. *Juniperus* pollen is very sparse in the fossil data, particularly in the older samples where occasional PAP pollen was found. Pollen of other wind-pollinated plants such as *Alnus* (alder), *Betula* (birch), *Quercus* (oak), and *Ephedra* (Mormon tea) were generally absent as well. Pollen of animal-transported pollen as well as wind-transported pollen from aquatic plants were found in some of the archaeological samples.

DISCUSSION

When compared with modern pollen sampled from the study area it is apparent that the fossil alluvial pollen of Terraces 1, 3 and 4 in Bowns Canyon is characterized by unusually high proportions of grass pollen (Figure 6). This high proportion of grass pollen probably reflects the previous existence of grass dominated communities in the Bowns-Bechan drainage associated perhaps with formation of temporary ponds whose existence is indicated by the occurrence of iron and manganese oxide stained sediments, incipient soil development as well as clam or snail shells and pollen of aquatic plants.

However, the over representation of grass pollen precludes direct comparison of the fossil data with modern pollen data and with prehistoric data from other localities. For that reason a second pollen sum (omitting grass) was prepared and the percentages of other pollen types recomputed (Figure 6). With the removal of grass pollen, significant increases in the proportions of Chenopodiaceae, Asteraceae and *Pinus* pollen occur. The proportions of Chenopodiaceae and Asteraceae are generally within the range of modern samples, but the proportions of *Pinus* in some samples in both the Terrace 2 and Terrace 4 alluvium rises to levels exceeding that found in modern samples and also not found in archaeological sites buried within the alluvium (Judges-Edwards 1990). The samples with very high proportions of pine pollen in each instance come from temporary pond units, and are otherwise characterized by the highest proportion of grass pollen found in this study. The grass pollen may have been produced locally but the pine pollen appears to be mostly long-distance transported ponderosa pine. This species occurs today on nearby mountain ranges such as Navajo Mountain (Figure 3) and does not appear to have occurred more than sporadically during the last 6000 years within the canyons of the study area since macrofossils are lacking in both human and packrat middens (Judges-Edwards 1990; Mead 1987). The occurrence of high proportions of grass and ponderosa pine pollen suggest rapid burial during or soon after the early June pollination season of pine. Sporadic grains of spring pollinating *Quercus* (oak), *Celtis* (hackberry) and *Salix* (willow) coupled with the scarcity of summer pollinating Chenopodiaceae and Asteraceae

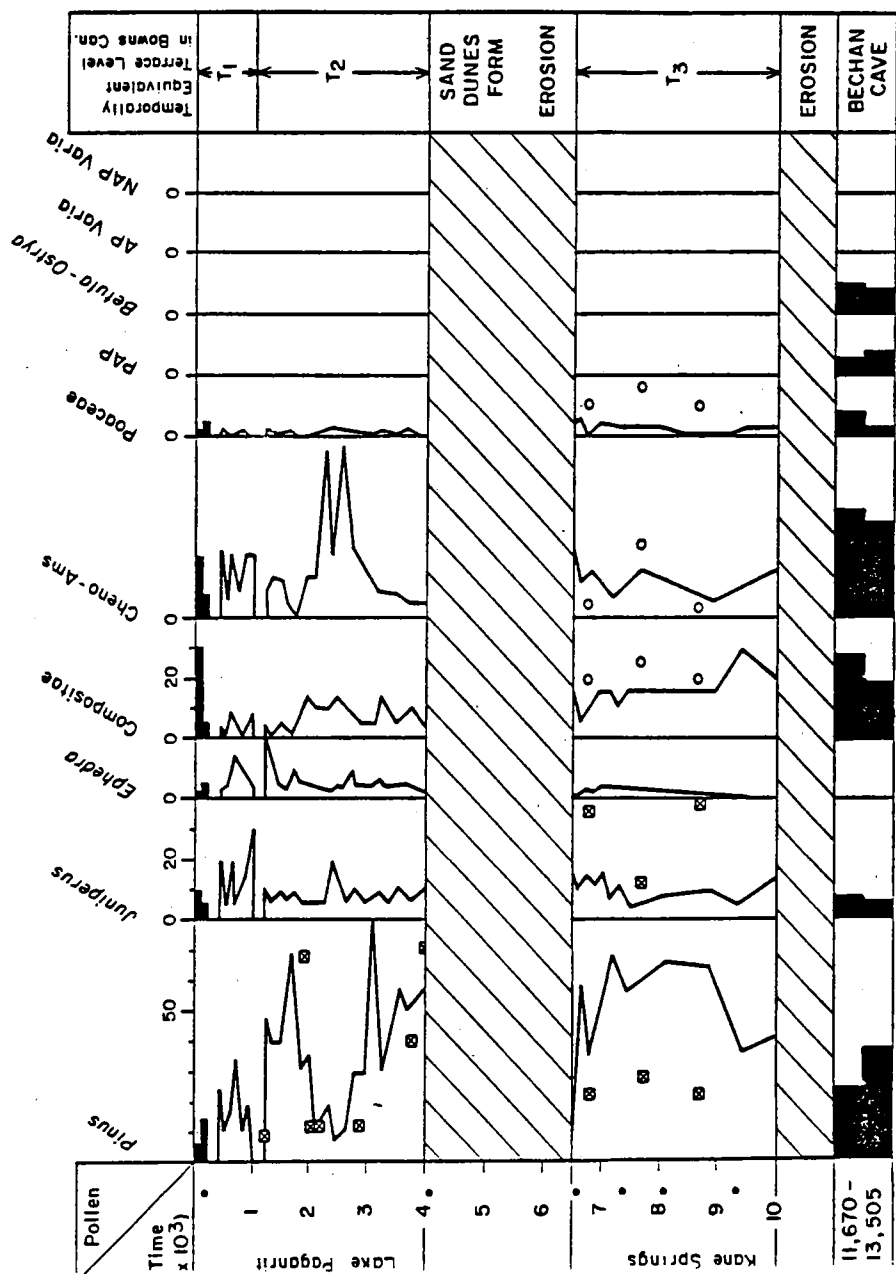


Figure 7. A comparison of the alluvial pine pollen records of Terrace II Bowns Canyon (squares 1-7) superimposed on the Lake Pagahrit pollen record (Lipe et al 1975) and Terrace III equivalents (squares 1-3) superimposed on the Kane Springs pollen record (West 1978; Agenbroad and Mead 1989). The Terrace III equivalents are derived from Sand Dune Cave, Navajo Mountain Desha cultural levels (squares 1 and 3) and from Cow Canyon (square 2) positioned according to available radiocarbon control (Hevly 1968; Judges-Edwards 1990). Lake Canyon, Cow Canyon and Bowns Canyon occur at about 4,000 feet elevation. Sand Dune Cave occurs at an elevation of 5,800 feet and Kane Springs occurs on Cedar Mesa at an elevation of about 6,350 feet. All localities occur within the Juniper woodland vegetation type and often have associated sagebrush or even pinyon pine. Radiometric dates (non-Bowns-Bechan records) are shown by black, solid circles in the time columns (radiometric dates for Bowns-Bechan are shown in Figure 5 and 6).

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

(sunflowers) lend support to this interpretation.

The alluvial samples yielding greater quantity, better preservation of pollen, and proportions of pollen taxa resembling the modern samples were usually obtained from sediments indicative of some environmental stability: e.g. incipient soil formation, pond units, and habitation surfaces with hearths. Such samples, particularly those associated with hearths, contained a greater diversity of pollen taxa than found in samples from non-stable environments (e.g. specifically aggrading alluvium since degradation of alluvium would not preserve a contemporaneous pollen record). Stable surfaces are more likely to preserve the pollen record of several seasons (hence a greater diversity of pollen taxa) while actively aggrading sediments may accumulate only the pollen from a particular season or even a particular flood event. Since a greater variety of plants may actually grow on a stable surface as opposed to an actively aggrading or even degrading surface, one anticipated the recovery of entomophilous (animal transported) and therefore locally produced palynomorphs such as those noted in the modern pollen samples and some prehistoric samples associated with hearths.

The trend of changing pollen proportions from Bowns Canyon was also compared with the only other alluvial pollen data from the southeastern Utah region: Kane Springs and Lake Pagahrit, located on or adjoining Cedar Mesa about 60 miles east of the Bowns/Bechan drainage (Figure 7). The purpose of the comparison was to ascertain of comparable changes occurred in other alluvial records at approximately the same time. If such changes did occur one could reasonably

conclude that regions with similar prehistoric alluvial histories were probably responding to similar environmental conditions.

The history of changing proportions of pine pollen in Terrace 2 alluvium of Bowns Canyon were chronologically superimposed on the temporally equivalent pollen record at Lake Pagahrit (Figure 7). A remarkable parallelism exists in the two records. Similar trends can also be observed to the west in the pollen record of Zion National Park (Hevly 1979) and to the south at Tsegi Canyon in northern Arizona (Clay-Poole 1989).

Sediments of Terrace 3 in Bowns Canyon did not yield any useful pollen data but the temporarily equivalent Kane Springs profile exhibits the trends which might be anticipated in future studies in or near the present study area (Figure 7). The Kane Springs pollen profile also provides a comparison for other contemporaneous data such as that from Cow Canyon to the immediate west and Sand Dune Cave on the flanks of Navajo Mountain to the south. It is immediately apparent that the high proportions of pine pollen found in the Kane Springs profile are not present in the pollen records of either Sand Dune Cave or the alluvium of Cow Canyon. Numerous samples in the Kane Springs profile failed to produce adequate pollen for analysis so the differences noted between these profiles may simply reflect data missing in one or the other data sources and are evidence of need for further work on this interesting interval of time little examined on the southern Colorado Plateau.

CONCLUSIONS

Basically the alluvial record consists of two types of environments: stable and non-stable. A non-stable environment is one in which either active aggradation or degradation is occurring. A stable environment is one in which these active alluvial processes are minimal. Degradation removes sediment and any potential fossil record. Aggradation may entrap biotic remains if their specific gravity and the velocity of water movement are suitable for deposition (e.g. slack water conditions behind temporary natural dams).

Because pollen usually floats, it will accumulate under slack water conditions and will occur abundantly with fine textured sediments such as silts and clays versus coarse textured sediments such as sand. Under conditions of temporary ponding sands may contain a pollen record; however, it is likely to be compositionally skewed toward higher proportions of the pollen types derived from plants which just had previously released pollen or were currently doing so upstream of the temporary dam. Because of the rapid accumulation of sediment within a short period of time the diversity of pollen types is likely to be low.

In this study the pollen records derived from sands of aggrading alluvial units were generally characterized by unusually high proportions of grass pollen. Grass pollen is relatively delicate and would not withstand much transport. Therefore grass probably grew locally in at least seasonally moist aggrading sediments behind temporary dams. Such local occurrence could therefore account for the high proportions of grass pollen in such sediments.

When other pollen types were present in the prehistoric samples, and adjusted pollen sum excluding grass, generally results in pine becoming the next most abundant type.

The proportions of pine in the adjusted pollen sum sometimes exceeded the proportions of pine in modern pollen samples of the study area and in adjoining areas where pine is a dominant tree. In some samples it even exceeded the proportions of total tree pollen found in the latest Pleistocene samples of Bechan Cave. Since it is unlikely that Holocene floristic changes of composition or density of individual taxa exceeded those of the Pleistocene or currently much higher elevation conifer dominated communities, it must be assumed that these episodes of high pine proportions do not reflect major change in the composition of local flora. Instead they must reflect increased production of anemophilous pine pollen upslope and upstream of the accumulating sediments within which pine pollen then became concentrated by secondary transport and deposition in water. Since these episodes of increased pine pollen occur synchronously at other localities it is reasonable to conclude that they do reflect climatic changes (e.g. increased effective moisture) which modified local edaphic and alluvial conditions. Under conditions of rapid aggradation alluvial surfaces would not have been suitable for human occupation or crop cultivation.

At any time in the history of a unit of alluvial aggradation temporary periods of stability may occur during which pedogenesis can occur and if any sediments are deposited at all they are of finer texture and more limited in volume. It is this kind of stable environment which would have been suitable for prehistoric human utilization of alluvial surfaces. The pollen record of such periods are characterized not only by abundant gymnosperm (pine and juniper) and grass pollen but also Chenopodiaceae, Asteraceae and NAP varia including pollen of aquatic macrophytes. These periods of stability seem to have been very similar to the present and three

ALLUVIAL POLLEN IN THE BOWNS-BECHAN DRAINAGE

of them (ca. 11,000-10,000, ca. 5300 and 1000 B.P.: ca. 9050-8050 B.C., ca. 3350 B.C. and 950 A.D.) culminated in major episodes of erosion. Such periods of instability were probably unsuitable for prehistoric human occupation of alluvial surfaces and people probably moved upslope or out of the drainage entirely.

The pattern of change noted in this study extends well beyond the study area, into adjoining regions of southern Utah, northern Arizona, northern New Mexico, and southwestern Colorado (Itall 1990; Hevly 1988; Peterson 1988; Schoenwetter and Eddy 1964; Hevly and Karlstrom 1974). The wide spread geographic and synchronetic change suggest primary climatic control of environments for which prehistoric peoples made cultureal decisions regarding potential habitations and exploitation of environmental resources.

CHAPTER 4

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES IN THE BECHAN CAVE AREA

Gloria Judges-Edwards and Richard H. Hevly

INTRODUCTION

For many decades archaeological research on the Colorado Plateau focused on prehistoric cultures evidenced by ceramic industries. Pre-ceramic sites were regarded as rare or even regionally lacking in areas such as the Glen Canyon (Sharrock et al. 1963). However, within the past two decades such sites are being recognized and described with increasing frequency (Lindsay et al. 1968; Jennings 1980; Jennings et al. 1980; Schroedel 1976). Recent studies have even revealed evidence of Archaic occupation in the Glen Canyon Area, e.g. Dust Devil and Sand Dune Caves on the Rainbow Plateau, and sites 42KA1706, 1708, and 1709 near Dangling Rope Canyon, and Captain's Alcove (Lindsay et al. 1968; Tipps 1983; Davis et al. 1984).

Increasing efforts have been made to elucidate paleoecological

information about the environment in which the prehistoric people lived and on which the available resources they subsisted. These questions are particularly pertinent when examining the Late Archaic/Early Basketmaker period during which the life-style of the prehistoric people evolved from nomadic hunting and gathering to sedentary agriculture. The purpose of the present study is to examine the macrobotanical remains recovered from recently discovered Late Archaic and Early Basketmaker sites in the Bowns/Bechan drainage, a tributary of the Colorado River in southeastern Utah (Davis et al. 1984; Geib et al. 1987).

DESCRIPTION OF STUDY AREA

The Glen Canyon Region is part of the Colorado River drainage on the southern Colorado Plateau (Figure 3).

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

The region is characteristically comprised of sandstone and siltstone plains. Laccolithic features such as the Henry Mountains to the north and Navajo Mountain to the south border a portion of Glen Canyon. Bowns/Bechan drainage is a minor tributary to the Glen Canyon. The Bowns-Bechan drainage is deeply entrenched into the Navajo and Kayenta Sandstones widely exposed in the area. The Bowns/Bechan drainage has experienced repeated episodes of cutting and filling as shown by the existence of several recognizable alluvial terraces.

Elevation in the Glen Canyon area ranges from 1000m-3400m (ca. 3000 to 10,000 feet). Topographically, four zones can be recognized: highlands (e.g. Navajo Mountain and the Henry and Abajo Mountains), plateau and mesa tops (e.g. Cedar Mesa, Rainbow Plateau), benchlands and valley bottoms. Due to the elevational differences and associated climatic gradients each zone has a characteristic type of climate and vegetation. The highland zone (which does not connect by direct drainage to the study area) is characterized by cool temperatures, a short growing season, and precipitation generally 37.5 cm/year (ca. 15 inches). Various associations of spruce (*Picea*), fir (*Abies* and *Pseudotsuga*) and pine (*Pinus*) compromise the dominants of local forests occurring in the highland zone between 2150 and 3400 m (ca. 6500 to 10000 feet). Plateau and mesa tops are characterized by warmer temperatures, a longer growing season and precipitation between 20.5 and 37.5 cm (ca. 10 to 15 inches). An association of *Pinus edulis* (pinyon pine) and *Juniperus osteosperma* (Utah juniper) generally occurs under this climatic regime, particularly on thin rocky soils. Where soils are deeper, sagebrush (*Artemisia tridentata*) and

grass dominated flats frequently occur.

In the study area the mesas have been deeply dissected forming a series of nearly bald Navajo sandstone benches. Upon these benchlands occurs a rich diversity of xerophytic desert scrub vegetation including such shrubs as blackbush (*Coleogyne*), mountain mahogany (*Cercocarpus montanus*), squawbush (*Rhus trilobata*), sagebrush (*Artemisia*), Mormon tea (*Ephedra*), saltbrush (*Atriplex*) and depauperate junipers. In the canyon bottoms such as those of the study area where water occurs at or near the surface, phreatophytes are common and include such woody plants as willow (*Salix*), cottonwood (*Populus*) and hackberry (*Celtis*). Other moisture-loving plants present in the study area include cattail (*Typha*), sedge (*Carex* and *Scirpus*) and rush (*Juncus*). At the elevation of the study area, 1300 m (ca. 4900 feet), the climate is characterized by mild winters and very hot summers with ca. 15 cm (6 inches) of precipitation per year. Precipitation occurs predominately during the winter months but summer precipitation may also occur with intervening dry spring and fall.

MATERIALS AND METHODS

Field Methods

Paleobotanical remains were found in alluvium, cultural features, and packrat (*Neotoma*) middens within the Bowns/Bechan Canyon complex during three field excursions between 1985 and 1987. Sampling localities chosen for study had been previously exposed by erosion of alluvium and of the aeolian fill of adjoining alcove shelters (Figure 8).

Flotation samples were obtained from cultural features during

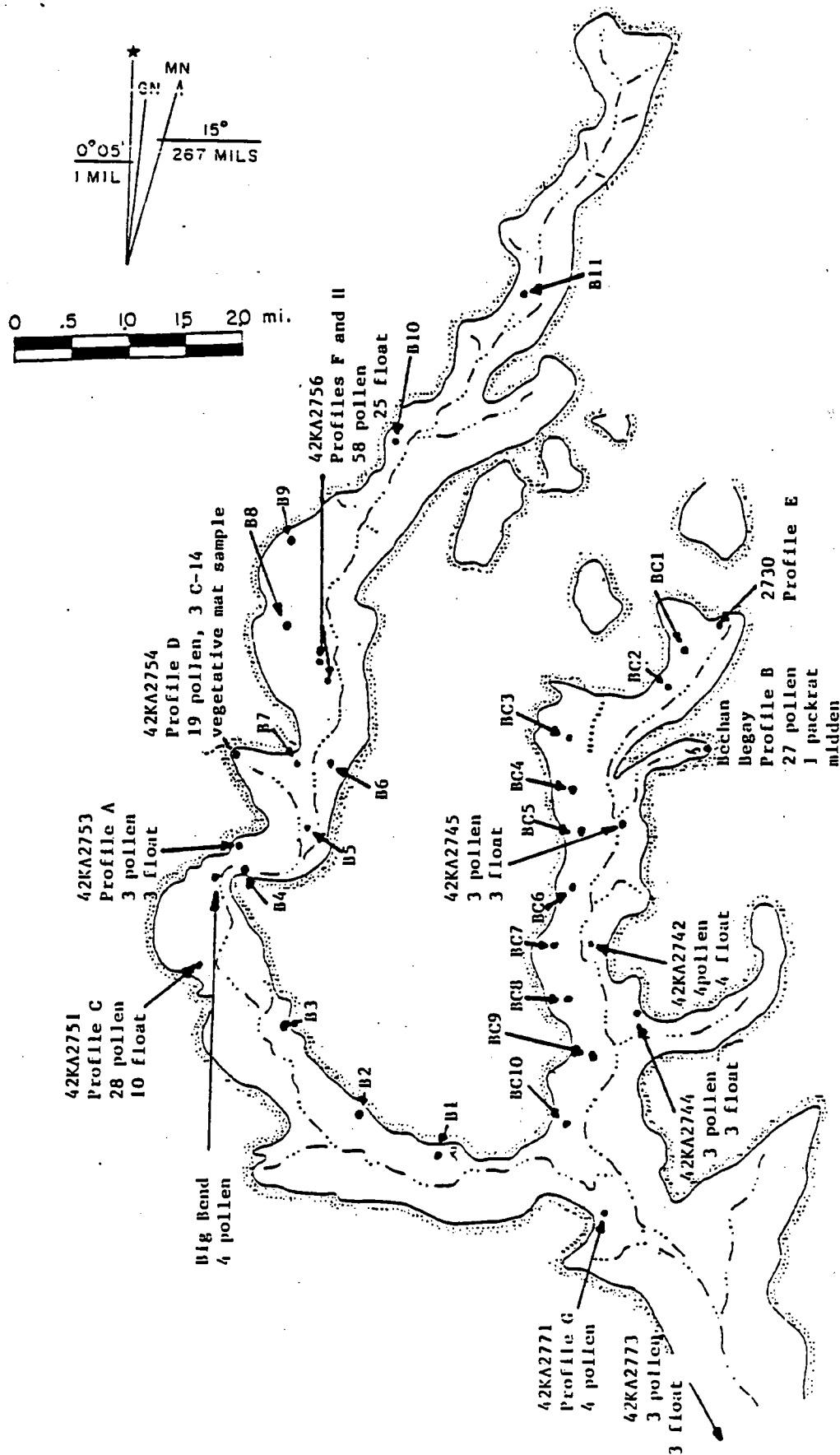


Figure 8. Map of the Bowns-Bechan drainage showing the sample localities for macroscopic plant remains and pollen profiles.

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

archaeological testing (Geib et al. 1987; Judges-Edwards 1990). Natural stratigraphy of the cleaned profile (previously exposed by erosion) was recorded. Flotation samples were removed from archaeological features and potential agricultural areas in amounts ranging from 1500 to 5000 ml. (Appendix I). These were placed in paper bags with provenience information carefully recorded on sample bag and field notes. Precautions were taken to prevent contamination of all samples and to insure careful handling of delicate materials. Comparative samples were also taken of modern soil surfaces and a packrat midden at site 42KA2730.

Laboratory analysis

In the present study 28 flotation samples were extracted following methods modified from Streuver (1968). Since calcium carbonate deposits might bind small seeds and other plant materials useful for identification, the samples were each mixed with 800 ml. of water and 10 ml. HCL in a 5 gallon bucket and stirred with additional water and acid as needed. The heavier fraction (lithics, and inorganic sediments) were allowed to settle for 90 seconds. The water and organic material were then poured through 0.5 and 0.1 mm sieves to separate large pieces of charcoal, twigs, bark, bones, and large seeds from smaller seeds and plant parts.

Plant remains were dried on paper toweling from which they were removed and placed in labeled storage vials. Plant remains were subsequently identified and counted using a dissecting microscope. A variety of keys, photomicrographs and drawings as well as comparative collections at the herbaria of Northern Arizona University and the Museum of Northern

Arizona were used for identification. Identified remains were recorded as to their number and type of remain as well as location from which they were recovered. To this tabulation was added data previously obtained from Van Ness (1987) in Bowns Canyon and by Nickens and Associates (1986) from nearby Cow Canyon.

RESULTS

The original samples, averaged about 2750 ml. (ca. 2.75 qts), usually yielded only very small volume (ca. 65 ml.) of organic remains, the weight of which averaged 29 grams (ca. 1 oz.). Charcoal was commonly recovered but in only one site, 42KA2730, was the charcoal large enough and sufficiently abundant for identification. The most common wood types were derived from dicotyledonous Angiosperm (flowering plant) woody shrubs and trees rather than Gymnosperms such as *Juniperus* or monocotyledonous Angiosperm herbs such as *Yucca* (Table 4).

Other plant remains were small (averaging less than 5 mm in greatest dimension) and of variable preservation. Nonetheless they were usually identifiable and were derived from a wide variety of plants (Table 4). Of the presently recognized 130 species (52 families) occurring locally, 46 taxa (24 families) were identified in the macrobotanical remains. These remains included cultigens such as corn, beans and squash, particularly in Basketmaker I and II horizons of Bechan Cave, and sites 42KA2756 and 42KA2773. Even a transitional late Archaic Basketmaker II site (42KA22730) yielded a possible fragment of a corn cob. However, the preponderance of identified materials were derived from native rather than cultivated taxa.

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

A single Middle Archaic vegetal mat from Bechan Cave dating 6750 B.P. yielded 20 different taxa, the most diverse sample among all those examined. These macroscopic plant remains were uncharred except for the following: juniper branchlets, oak acorns, prickly pear stems and seed, goosefoot or lambsquarter (*Chenopodium* spp.) seed, Indian rice grass (*Oryzopsis hymenoides*) seed and hackberry (*Celtis reticulata*) seed.

The most abundant plant remains were those of the Poaceae including stem, leaf and fruits of several different genera, particularly *Oryzopsis* and *Sporobolus*. Shredded *Apocynum* (dogbane) stems were found, indicating possible human utilization of this plant for its stem fibers. *Opuntia* (prickly pear) stem, areoles and spines were common. Other far less abundant plant remains included twig and leaf fragments of *Amelanchier* (service berry), *Betula* (birch), *Celtis* (hackberry), *Juniperus* (juniper), *Populus* (cottonwood), *Salix* (willow), *Rhamnus* (buckthorn) and *Rhus* (sumac). All but *Betula* occur within the drainage today and the single twig might well be reworked from older sediments where it is common (Davis et al. 1984).

DISCUSSION

Cave and alcove-shelter deposition environments differ significantly from the sand dune and alluvium buried sites in both the duration of site utilization and modes of plant transport into the sediments of the sites. The plant remains in the cave and alcove-shelter sites may have accumulated over longer periods of time than the open camp sites. Plant materials would have been transported into the cave and

alcove-shelter sites by humans, packrats, and in some instances by wind. In contrast, plants, if not actually growing on the open sand dune and alluvium sites, could have been transported by wind, water or humans. It is not therefore surprising that these two types of sites have yielded somewhat different plant records.

The cave and alcove-shelter sites yielded a greater amount and diversity of plant remains than open sites (Table 4). The cave and alcove shelter sites also manifested a larger proportion of uncharred plant remains (80-90 %) than found in open sites (40-70%). This pattern fits the expectation that some uncharred plant remains would perish in open sites while in dry, sheltered sites the uncharred plant remains would be protected to some degree from bacterial and fungal decomposition (Gasser and Adams 1981). Uncharred plant remains in sheltered sites could be contemporaneous with charred remains; however, they need not be so. The uncharred plant remains of open sites might be essentially contemporaneous with site occupation but, relative to human activity, have more to do with site disturbance than direct human utilization (Minnis 1978). Alternatively uncharred plant remains in open sites could also reflect more recent contamination due to undetected sediment mixing by wind, water or rodents (Hevly 1982).

Nevertheless, in the collective samples of the various sites there appears to be considerable continuity of the kinds of plant material utilized by the prehistoric people through time (Figure 9). However the relative importance of some plant groups vary between sites of comparable age and diminishes with the introduction of cultigens during the

Table 4. Comparison of plant taxa recovered from Archaic, Preformative (Basketmaker II) and Formative (Basketmaker III and Pueblo I-III) sites in the Bowns/Bechan drainage with the Desha levels of Dust Devil Cave, Navajo Mountain (Teufel 1985). All localities are hearths or other features buried in alluvium except Dust Devil Cave, Bechan Cave, and Pot hunters Shelter (42KA2730). Importance scale: + symbol = <10 specimens per sample; ++ symbol = >10 specimens per sample; @=charred remains. Presence of Radiocarbon dates summarized in Agenbroad et al. (1989) and Judges-Edwards (1990).

Localities:	Dust Devil	Bechan	2771	2756 LS21	2730	2744 2745 2751 2773 2756: LS76	2756 LS19 2752 74 Bechan
Age (B.P.)	6750- 8750	6750	5350	3000	2310	1500- 1800	1060- 1290
# of samples	29	1	3	3	7	19	3
1. <u>Edible, dry fruits and seeds</u>							
<u>Amaranthus</u>			+		+		
<u>Asteraceae</u> +					+	+	
<u>Astragalus</u> +					+	+	
<u>Carix</u>					+	+	
<u>Cercis?</u>						+	++
<u>Chenopodium</u> ++		+	+	+	+	++	+
<u>Curbita (w)</u> +						++	
<u>Juncus</u>					+		
<u>Mentzelia</u>						+	
<u>Phaseolus (w)</u> +							
<u>Phaseolus</u>						+	+
<u>Pinus edulis</u> +		+			+		
<u>Poaceae (w)</u> +		++	+	+	++	+	+
<u>Poaceae (Zea)</u>						+	+
<u>Quercus</u>						+	
2. <u>Edible, fleshy fruits</u>							
<u>Amerlanchier</u> ++					+	+	
<u>Celtis</u> ++			+	+	+	+	++
<u>Curbita (c)</u>							+
<u>Juniperus</u> ++					+		
<u>Opuntia</u> ++					+		+
<u>Sphepherdia</u> +							
<u>Yucca</u> +							

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

3. Edible Vegetative part of plants

<u>Allium</u>	++						
<u>Atriplex</u>						+	
<u>Boraginaceae</u>					+		
<u>Brassicaceae</u>					+		+
<u>Caryop.-Portul</u>						+@	
<u>Cymopterus?</u>	+						
<u>Echinocerus</u>	+					+@	
<u>Opuntia</u>	+	++			+@	+	+

4. Medicinal, Flavoring, tanning etc.

<u>Artemisia</u>	+				+		
<u>Asteraceae</u>	+	+					
<u>Eriogonum</u>	+						
<u>Ephedra</u>	++			+	+		
<u>Euphorb.-Croton</u>						+	
<u>Quercus & Celtis</u>							
leaves	+						
<u>Rhus</u>	+	+					
<u>Rumex</u>	+						
<u>Sphaeralcea</u>					+	+	

5. Technological: fiber, basketry, fuel etc.

<u>Apocynum</u>	++						
<u>Juniperus</u>	+	+			+@	+@	
<u>Poacea</u>	+	++					
<u>Typha</u>					+		
<u>Yucca</u>	+						
<u>Woody twigs</u>	+	+			+		
including:							
<u>Betula, Celtis, Populus,</u>							
<u>Quercus, Rhamnus & Salix</u>							

# of taxa	26	14	5	4	18	16	10
# of specimens	4109	174	30	17	855	764	29

Seeds of Chenopodium could reflect harvest of plants for vegetative parts as well as deliberate seed harvest. Edible fleshy fruits ~~are~~ not found-only their seeds. Edible vegetative parts were not found per se only their parts which preserve well such as seeds, spines, fiber. Suggested uses are derived from a number of modern ethnographies. See Judges-Edwards for actual numbers of specimens ~~are~~

Table 4.

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

Late Archaic/Basketmaker II transition (Aasen 1984; Judges-Edwards 1990; Reinhard et al. 1985). Prior to the introduction of cultigens, important items of diet seem to have been the fleshy fruits of service berry (*Amelanchier*), hackberry (*Celtis*), prickly pear (*Opuntia*) and the fleshy cones ("berries") of *Juniperus*. Other important food sources included the small dry fruits of goose foot or lambsquarter (*Chenopodium*) and native grasses such as *Orzopsis* and *Sporobolus*. Vegetative plant parts, such as onion bulbs and prickly pear stems, also contributed to the prehistoric diet. Evidence that at least some of these were consumed has been found in the plant record of the alimentary canals of human mummies and of human coprolites dating from mid-Archaic Desha levels of Sand Dune Cave and Basketmaker II horizons on Cedar Mesa (Aasen 1984; Hevly 1990; Reinhard 1985; Van Ness 1986).

The importance of *Chenopodium* seed, native grass seed, onion bulbs and the stems and fruits of prickly pear as well as a variety of other taxa appear to diminish through time, particularly as cultigens appear in the record (Table 4). This trend may be more apparent than real since it could be a reflection of differences in site utilization, plant disposal patterns and differential preservation. Nevertheless the life style of the prehistoric people changes in the study area and on nearby Cedar Mesa about this time 1800-2300 B.P. (150 A.D.-350 B.C.), becoming more sedentary (Geib et al. 1987; see Appendix II, this report). In the study area this change is coincident with the existence of a temporary pond created by damming of the Bowns drainage by a falling sand dune (ca. 1970 B.P.) (20 B.C.). This change in life style (including

dietary preferences) was to have significant consequences relative to human health, at least elsewhere on the Colorado Plateau (Reinhard et al. 1985, 1987).

CONCLUSION

The vast majority of macroscopic plant remains recovered from archaeological contexts in the Bowns/Bechan drainage are derived from plants which presently occur there. Hence these remains are not indicative of any major change of vegetation during the past several thousand years. This finding is compatible with that derived from analysis of pollen in alluvium of the study area and nearby Tsegi Canyon as well as sediment from archaeological sites at nearby Cedar Mesa and Grand Gulch (Hevly, Appendix II and Hevly et al. Chapter 4, this volume; Lindsay 1974; West 1978). This conclusion in no way denies the occurrence of environmental change resulting from climatic perturbations and/or disturbance by humans.

Some macrobotanical remains from the Bowns/Bechan drainage archaeological sites are however, derived from plants which currently have not been observed in the study area. These include woody twigs of Birch (*Betula occidentalis*) and seeds of redbud (*Cercis occidentalis*) and of pinyon pine (*Pinus edulis*). Pinyon seeds have been recovered from Bechan Cave and the Pot Hunters Shelter. Macrobotanical remains of pinyon pine have not been recovered in packrat middens of the general area prior to 3990 B.P. (2040 B.C.) (Mead 1979). Thus the occurrence of the seed of this plant in the Pot Hunters Shelter at 2310 B.P. (360 B.C.) could represent actual occurrence in Bowns Canyon or

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

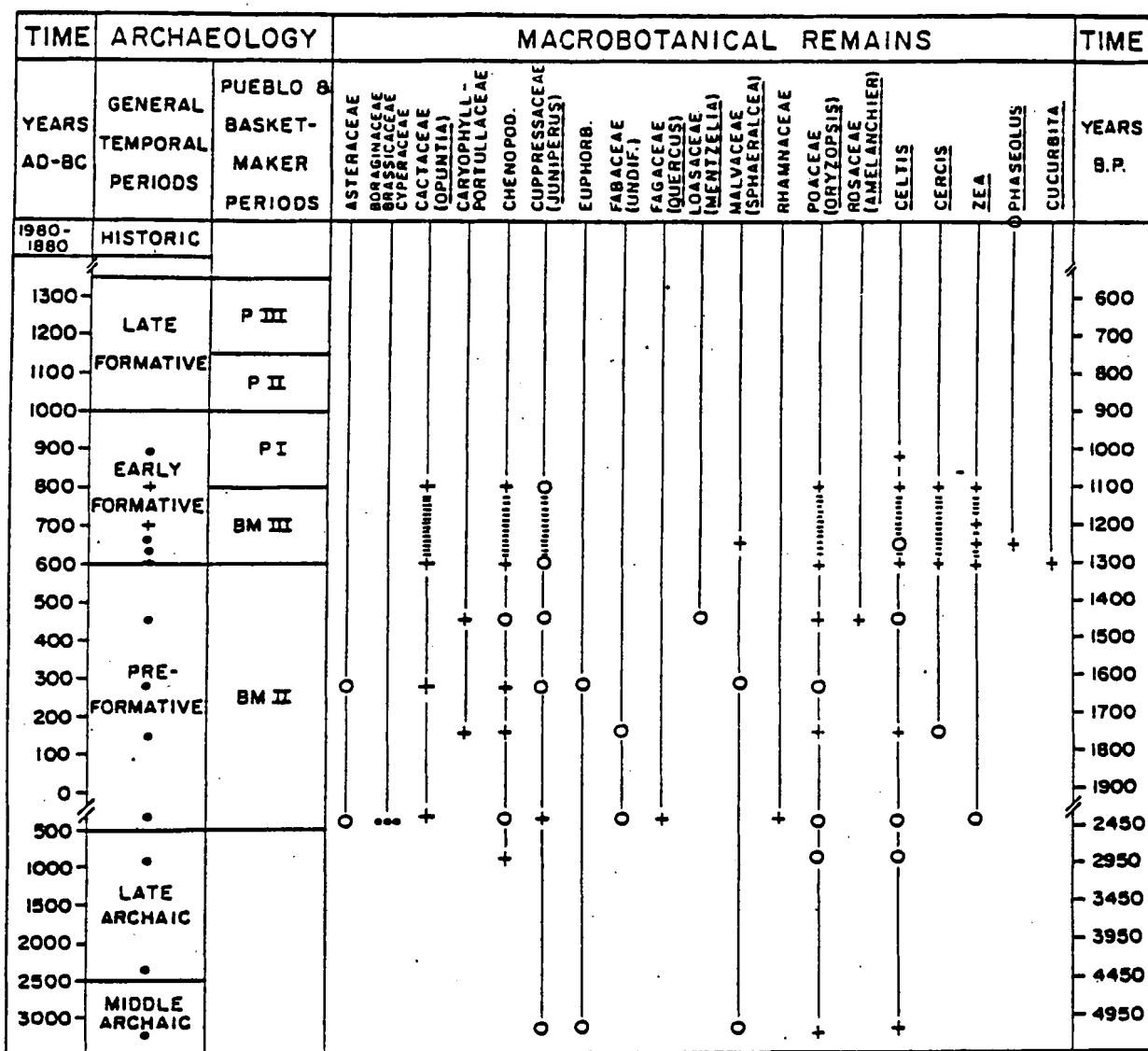


Figure 9. A summary of macroscopic plant remains from Bowns and Bechan Canyons. Data from Agenbroad et al. (1987), Edwards-Judges and Hevly (1987; 1988), and Ven Ness (1985). Solid circles in the chronology column indicate radiocarbon dates from Bowns and Bechan Canyon alluvial sites utilized for this summary. In the column of macroscopic remains plus signs indicated charred plant remains while open circles indicate uncharred plant remains. Broken vertical lines between + and o symbols indicate the temporal range of plant materials from sites that were based on artifact typology.

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

transport from nearby Cow Canyon where it now grows in great abundance. However, the occurrence of pinyon pine seed in Bechan Cave middle Archaic horizons dating 6750 B.P. (4800 B.C.) is more difficult to explain. Possibly pinyon did exist prior to 3990 B.P. (2040 B.C.) in the study area but was sufficiently scarce that it has not been recovered from pack rat middens.

Redbud and birch are sporadically distributed in the canyons tributary to the Colorado and Escalante Rivers but at somewhat higher elevations. The occurrence of redbud seeds in prehistoric archaeological proveniences dating 1290 to 1800 B.P. (660-150 A.D.) may simply reflect human transport from nearby areas of occurrence, if it did actually grow in the Bowns/Bechan drainage sometime in the past. Birch remains including stems, leaves and floral parts are common in older levels of Bechan Cave so its occurrence in younger levels may simply reflect mixing of sediment during subsequent occupation.

It can be seen that humans very likely moved plant materials from one locality to another. It is also likely that once they undertook a more or less sedentary life style that their ordinary activities including the gathering of firewood, gathering of materials for basketry, utilization of fruits and seeds, to say nothing of cultivation of domestic plants, had a profound effect on local vegetation and maybe even on the landscape itself. One can only wonder what environmental changes occurred which prompted the prehistoric people to leave the Bowns/Bechan drainage while nearby Cow Canyon in a similar environmental setting continued to be occupied.

A partial answer may be provided by a comparison of the macroscopic

plant, pollen and the geological records. Alluvium was deposited in the Bowns/Bechan drainage from 4200 B.P. to 950 (2250 B.C. to 1000 A.D.) (Agenbroad 1990). Occupation of the drainage occurred at least sporadically during this period of time but appears to have become more continuous, as evidenced by more sites, between 1800 and 1060 B.P. (150 and 890 A.D.) (Geib et al. 1987). This period of more continuous occupation is contemporaneous with the existence of a pond unit in Bowns Canyon and increased proportions of grass and pine pollen in both archaeological and alluvial sediments (Hevly et al. 1990; or Chapter 3, this report). It is also during this same period that the Basketmaker II and III archaeological sites of the Bowns/Bechan drainage contain macroscopic evidence of aquatic plants and of cultigens such as corn, bean and squash (Figure 10). At the end of this episode (*ca.* 1000 B.P. or 850-950 A.D.) climatic perturbation, dissection of the alluvium and lowering of water tables occurred at many localities on the Colorado Plateau (including the Bowns/Bechan drainage) greatly reducing the extent of arable land and lowering local water tables (Agenbroad 1975; Euler et al. 1979; Lindsay et al. 1980a, b; Matson and Lipe 1978; Matson et al. 1988; Peterson 1988; Plog et al. 1988). Dissection of alluvium was not universal at this time and in some areas reduced alluvial deposition and soil formation occurred instead (Karlstrom 1988). This may have been the case of the Bowns/Bechan drainage abandonment by the prehistoric people versus the continued occupation of Cow Canyon.

LATE HOLOCENE PALEOBOTANY FROM ALLUVIAL AND ARCHAEOLOGICAL SITES

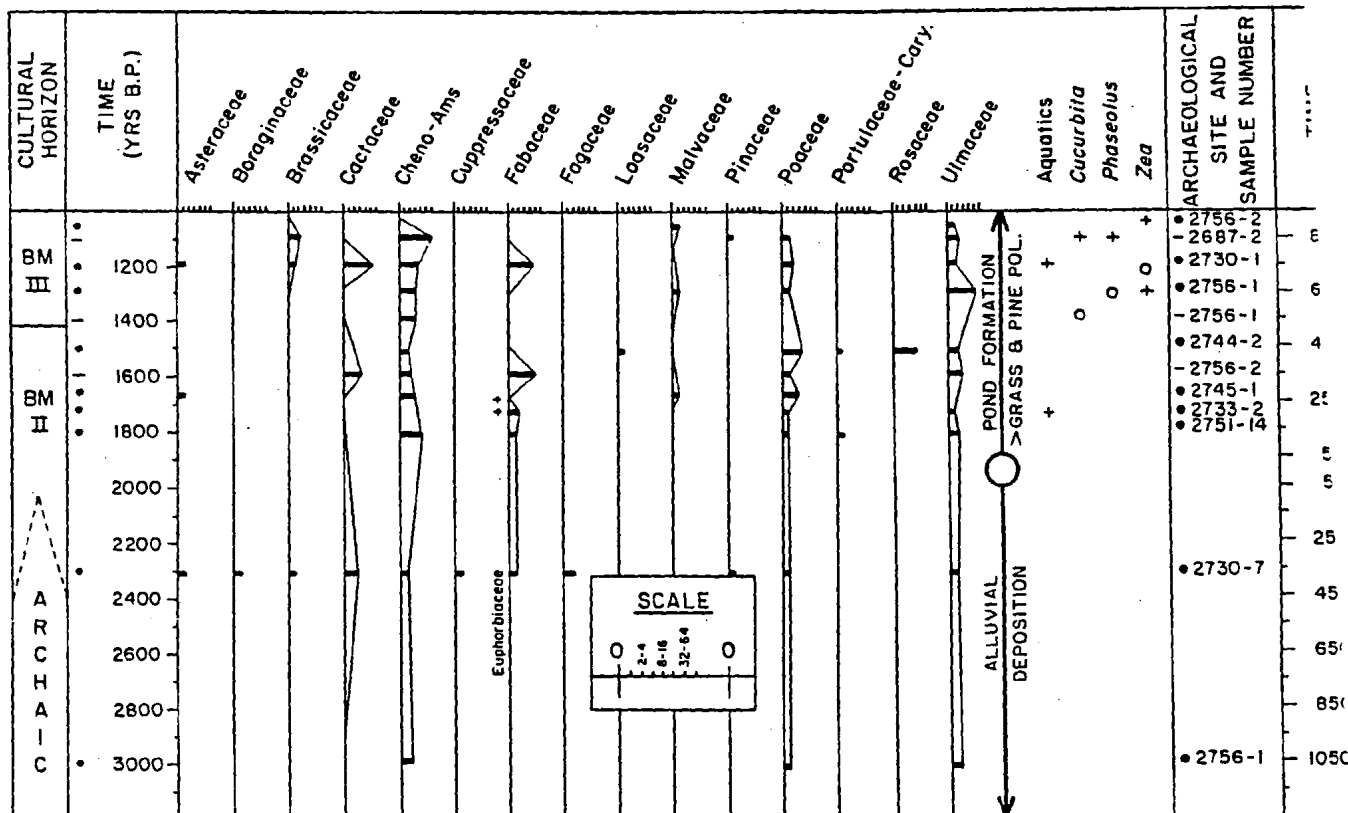


Figure 10. A comparison of the macroscopic plant, pollen, archaeological and geological records of the Bowns-Bechan drainage. Radiometric dates are indicated by a (.) symbol. Ages assigned on the basis of archaeological data are indicated by a (-) symbol. Scale of abundance (number/sample) shown below in the insert. Early pollen records (P) of corn from Cedar Mesa and Grand Gulch (Hevly, appendix II, this report) are included for comparative purposes.

CHAPTER 5

LATE PLEISTOCENE ALLUVIUM AND ORGANIC DEPOSITS OF THE CENTRAL COLORADO PLATEAU: NEW DATA AND A REVIEW

Larry D. Agenbroad and Jim I. Mead

Recently discovered (post-1983) dung deposits, derived from extinct Pleistocene megafauna and interbedded with cave sediments or capping alluvial deposits, have presented new unduplicated records of the Paleoenvironment of the central Colorado Plateau. The pre- and post-dung-deposit alluvium provides the medium in which records of paleohydrology, paleontology, palynology, and a C-14-controlled chronology are preserved. The alluvial record, combined with the botanical and faunal records from the dung beds, provides an opportunity to examine the pre-human condition of the late Pleistocene environment for the Colorado Plateau. These data provide an examination of the cause of the Pleistocene megafaunal extinction from "the far side," i.e., $\pm 40,000$ B.P. (38,050 B.C.) to the Pleistocene-Holocene boundary ($\pm 10,000$ B.P.: 8,050 B.C.). They also provide the oldest, nonduplicated

paleoenvironmental record of the central Colorado Plateau.

INTRODUCTION

The arid Southwest has been the focus of paleoenvironmental studies for approximately half a century (Antevs 1939). Early pollen work proved instrumental in developing a framework in which to begin a systematic reconstruction of the environments of the latest Pleistocene. (Martin 1963a & b; Martin and Mehringer 1965) illustrated that certain cienega bogs and pluvial-lake regions in southwestern Arizona contained a late Pleistocene pollen record. Mehringer (1967a & b; Mehringer and others 1967) found that certain limited pollen information could be covered from spring mounds and from occasional alluvial sections.

Central Colorado Plateau: NEW DATA AND A REVIEW

The advent of pack-rat (*Neotoma* spp.) midden analysis (Wells and Jorgensen 1964) provided a major thrust into the understanding of the late Pleistocene paleoenvironments of the Southwest. Arid climate coupled with the episodic fluctuating water tables proved detrimental to the preservation of most exposed fossil-pollen locations in the Southwest. However, the same xeric conditions, when coupled with a stable rock shelter, provided a unique situation--dry preservation. Such xeric locations provided not only the preservation of pollen and macrobotanical remains, but also the soft tissue and other usually biodegradable remains of animals (such as skin, hair, keratinous tissues, and dung; Wilson 1940). An entirely new area of research was opened to understanding the latest Pleistocene.

The study of pack-rat middens in the Southwest provided a reconstruction of the Wisconsin plant communities never before observable in such detail (Wells and Berger 1967; Mehringer and Ferguson 1969; Van Devender 1973; Phillips and Van Devender 1974; reviewed in Spaulding and others 1983). The dry cave deposits were quickly seen as a warehouse of late Pleistocene information. Gypsum Cave (near Las Vegas, Nevada) and Rampart Cave (Grand Canyon, Arizona) were the scenes of the first paleoecological studies utilizing dry preserved dung of an extinct animal. Laudermilk and Munz (1934, 1938) found a wealth of information preserved in the dung of the extinct Shasta ground sloth (*Northrotheriops shastensis*). Later studies expounded on the data available from the sloth dung (Martin and others 1961; Hansen 1978; Spaulding and Martin 1979; Thompson and others 1980). Dry cave deposits

were found to contain the occasional limited record of pollen (Schwartz and others 1958; Hevly 1964; Spaulding and Petersen 1980). Similar studies have begun on the dry preserved remains of the extinct mountain goat, *Oreamnos harringtoni* (Mead and others 1986; Mead and others, in press).

The study of the faunal remains of the latest Pleistocene in the Southwest has never received the full attention of paleontologists as it has in other regions of North America (Kurten and Anderson 1980). Lindsay and Tessman (1974) provided the first checklist of Pleistocene age localities in Arizona, and Harris (1977) provided the same for southern New Mexico/TransPecos Texas. Most fossil locations in studies during the early years were the records from alluvial locations, but there was the occasional report of animals from the dry cave (Harrington 1933; Wilson 1940). Pack-rat middens provided a wealth of information about the herpetofaunas of the arid Southwest that was not available in the alluvial records (Van Devender and others 1977; Van Devender and Mead 1978; Mead and Phillips 1981; Mead, ms. subm.).

The most recent reviews of the faunal record of the arid Southwest illustrate that although important and pertinent information is known, this information is spotty. There is a physical gap in the record--the majority of the Colorado Plateau (Lundelius and others 1983; Harris 1985; Agenbroad and Mead, in press). Some of the most complete information on animals, which was recovered in direct association with plant remains, comes from dry cave deposits in the Grand Canyon, which is ecologically atypical of the Colorado Plateau. The review of the vegetational history of the Southwest also points to a significant gap in the overall record

Central Colorado Plateau: NEW DATA AND A REVIEW

in the central Colorado Plateau (Spaulding and others 1983).

The alluvial record in the Southwest has received fair attention (Bryan 1928, 1950; Antevs 1939, 1952, 1954, 1955, 1962). Many of the alluvial stratigraphic studies have centered in the Basin and Range Province, those locations that also have the remains of paleo-Indians (Sayles and Antevs 1941; Haury 1950; Haury and others 1959; Haynes 1966, 1967, 1968, 1980; Waters 1985; to name a few). The alluvial record of the Colorado Plateau has received some attention (reviewed in Christenson 1985), although much of this record has centered on Holocene deposits (Hack 1942; Lance 1963; Agenbroad 1975; Lipe and Matson 1975; Lipe and others 1975). The most recent research on the central Colorado Plateau has occurred in the Escalante River drainage (Boisson and Patton 1985; Webb 1985).

OBJECTIVES, METHODS, AND BACKGROUND OF THE CURRENT RESEARCH ON THE CENTRAL COLORADO PLATEAU

Objectives

Our research focus is a reconstruction of the late Pleistocene and early Holocene paleoenvironments of the central Colorado Plateau. Of necessity, this reconstruction will include the fauna, flora, paleoclimatic, paleohydrologic, and geologic parameters.

Methods

Our approach entails the utilization and integration of a set of data derived from a variety of disciplines and subdisciplines, i.e., an integrated, multidisciplinary approach. To date, we have combined

archaeological, geological, macrobotanical, palynological, paleohydrological, and paleontological evidence to construct our working model. We have initiated the use of hair analysis of extinct fauna to supplement our osteological/dental faunal evidence. We have taken fecal analysis of extinct fauna to greater detail and results than prior investigations in this geographic area. We are attempting to initiate biochemical analyses that should produce new support for the paleontological data, as well as shed insight into the problems of dietary stress/nutritional aspects of the late Pleistocene paleoenvironment. The working model we have generated will be tested and revised as we acquire added information and investigate newly discovered and undiscovered site.

DUNG AND ALLUVIUM

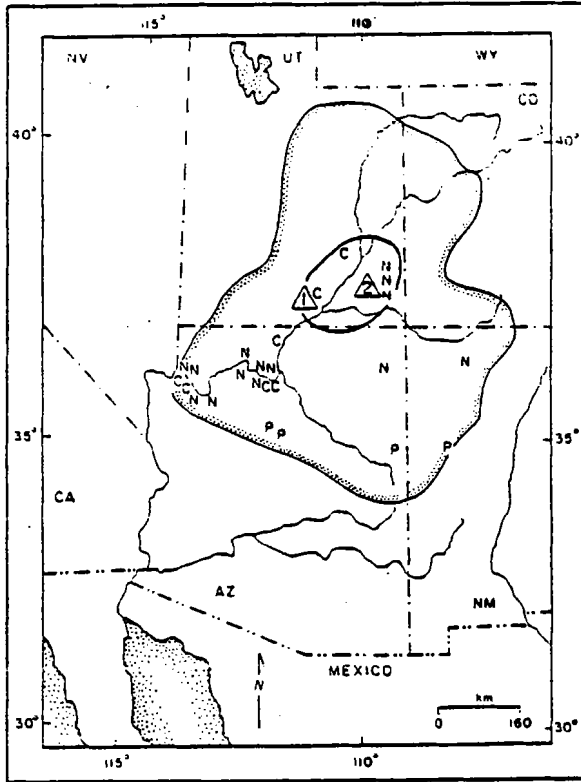
Pleistocene Dung Deposits

Cowboy Cave in south-central Utah (Figure 11) produced a large dung bed underlying the Holocene archaeological deposits (Jennings 1980). It contained the most complete chronological and paleoenvironmental data from a single locality for the late Pleistocene and Holocene of the Colorado Plateau. The dung bed was composed primarily of bison dung; however, mammoth, horse, ground-sloth, big-horn-sheep, deer, elk, and enigmatic "camel-elk" dung or dung fragments were also identified (Hansen 1980). Hairs attributed to bison, canids, and humans were collected from the dung bed; some hairs are still unidentified. Size-fraction analysis of the dung components, plus macrobotanical studies, produced floral information that would not

Central Colorado Plateau: NEW DATA AND A REVIEW

otherwise be evident.

dung, but contained boluses and pellets of other animals as well.



- | | |
|--------------------|---|
| △ = Proposed Study | P = Pollen |
| 1 - Alcove Canyon | N = <u>Neotoma</u> midden |
| 2 - White Canyon | C = Cave; dung, pollen, and/or <u>Neotoma</u> |

Figure 11. Index map of the Colorado Plateau showing study localities.

Investigations of a second dry-cave dung bed began in 1983 at Bechan Cave, (Figure 12) in the southern Utah canyonlands (Davis and others 1984). Beneath the Holocene-age geological and cultural deposits, an extensive dung bed was encountered (Figure 13), which was composed primarily of trampled mammoth

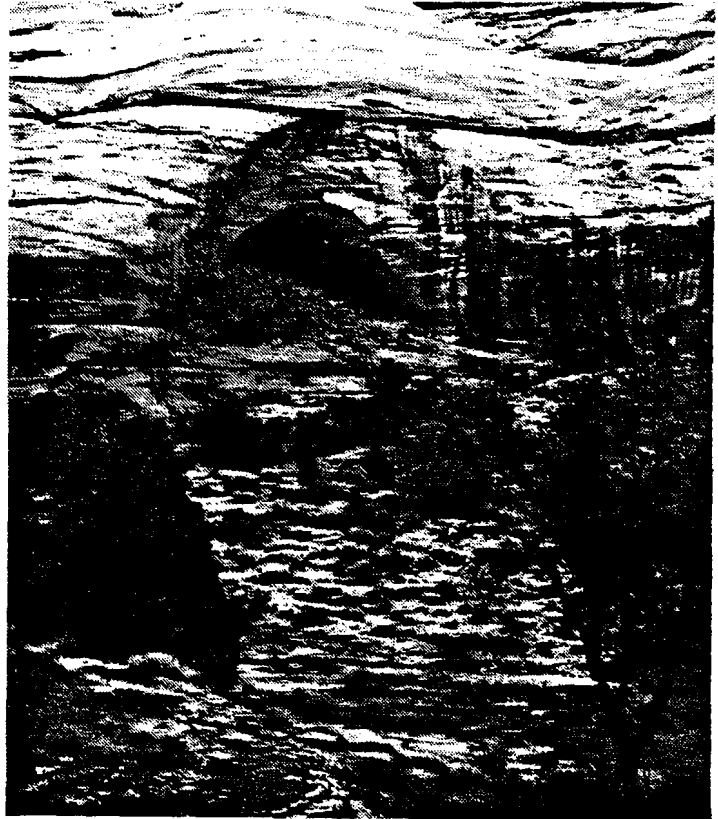


Figure 12. Bechan Cave entrance.

Analysis of the dung, hair, and skeletal components of the deposit provided a bestiary that would have been incomplete from one line of evidence alone. Micro- and macrobotanical samples from the dung bed produced an environmental reconstruction much different than the modern vegetation community.

October 1985 and 1986 produced the discovery and cursory surficial sampling of new dung beds overlying alluvial sequences in alcoves of a nearby canyon. An additional locality, in an alcove in a canyon of Natural Bridges National Monument, produced dung deposits of the extinct mountain goat.

Central Colorado Plateau: NEW DATA AND A REVIEW

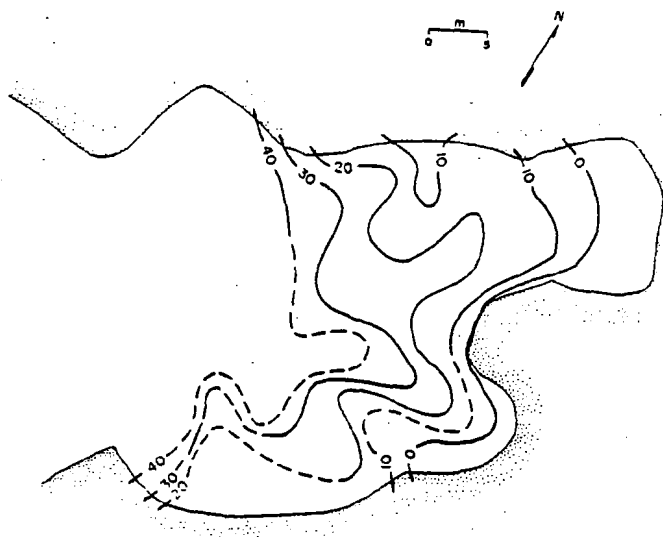


Figure 13. Contours of equal thickness of dung bed, Bechan Cave.

Chronology of Pleistocene Dung Deposits

Cowboy Cave (Jennings 1980) provided the first Utah example of a large-volume deposit of Pleistocene megafauna dung dating from 12,000-11,000 B.P. : 10,050-9050 B.C. (Table 5). The discovery and investigation of Bechan Cave in 1983 (Agenbroad and others 1984; Davis and others 1984; Mead and others 1986) provided another central Colorado Plateau deposit also dating $\pm$ 12,000 B.P. (10,050 B.C.). Newly discovered deposits capping Pleistocene alluvial sequences were located in alcoves within nearby canyons. Initial dates on the fecal material indicate a doubling of the recorded antiquity of such deposits on the central Colorado Plateau (back to $\pm$ 40,000 B.P.: 38,050 B.C.). These deposits also provide an unduplicated source of information for late Pleistocene megafauna--material critical to the investigations into the cause of extinction of these species.

Natural Bridges National Monument also provided new fecal, dietary, and paleoenvironmental information. The oldest layer of these deposits of extinct mountain-goat dung exceeds the limits of radiocarbon dating. For the first time, we can approach the late Pleistocene extinction controversy from "the far side," i.e., moving upward in time from the $\pm$ 40,000 B.P. (38,050 B.C.) limit of C-14 dating, to the extinction event at $\pm$ 11,000 B.P. (9050 B.C.), via the analysis of biological by-products of the extinct animals--the dung.

Alluvium

Bechan Cave occurs in a box-canyon system containing up to 20 m of alluvium. The recent erosion has exposed sections of the alluvium containing organic bands signifying high watertable conditions, favoring plant growth. It was apparent that a C-14-controlled analysis of the alluvium would produce a chronologic sequence of geologic, hydrologic, paleoclimatic events that might correlate to the cave-fill record. This type of correlation was not possible in the canyon in which Cowboy Cave occurs owing to the lack of significant alluvial deposits near the cave.

The alcove deposits are in the proximity of Bechan Cave and overlie alluvial sequences of up to 73-m thickness. Information to be derived from detailed studies of these sediments promises to extend our paleoenvironmental reconstruction of the central Colorado Plateau to unprecedented antiquity.

Alluvial Chronologic Framework

Discovery, investigation, and analysis of the unique dung deposits of Pleistocene megafauna in Bechan Cave (Agenbroad and others 1984; Davis and others 1984; Mead and others 1986) initiated a research effort to

Central Colorado Plateau: NEW DATA AND A REVIEW

<u>Locality</u>	<u>Mtl Dated</u>	<u>C-14 Age Span and Lab. Numbers</u>
Cowboy Cave	Artiodactyl dung	11,020±180 (A-1660) 13,040±440 (A-1654)
Bechan Cave	<i>Mammuthus</i> dung <i>cf. Euceratherium</i> dung	11,670±300 (A-3212) 13,505±580 (Gx-9371) 11,630±150 (Beta-18269)
Stanton Cave	<i>Oreamnos</i> dung and horn sheaths	10,870±200 (A-1155) 19,690±1200 (A-3083)
Natural Bridges	<i>Oreamnos</i> dung	23,350±1740, (Gx-11313) >39,800 (Gx-11312)
Rampart Cave	<i>Oreamnos</i> dung <i>Nothrotheriops</i> dung	18,430±300 (A-1278) 10,780±200 (A-1067) >40,000 (A-1042)
Muav Cave	<i>Nothrotheriops</i> dung	11,140±160 (A-1212) 11,290±170 (A-1213)
Tse'an Bida Cave	<i>Oreamnos</i> dung	11,850±750 (RL-1134) 24,190±4300 (A-2373) 2800
Tse'an Kaetan Cave	<i>Oreamnos</i> dung	14,220±320 (A-2835) 30,600±1800 (A-2722)
Grobot Grotto	<i>Mammuthus</i> dung Artiodactyl dung	28,290±2100 (Beta-14422) 20,930±400 (Beta-14420)
BF Alcove	<i>Pseudotsuga</i> and <i>Acer</i> needles and seeds in assoc. w/cf. <i>Camelops</i> dung	11,790±190 (Beta-14727)

Table 5. C-14 chronology of Pleistocene megafauna dung: Colorado Plateau

establish an alluvial chronology and paleoenvironmental sequence that could be correlated to the cave deposits. Research of the alluvial deposits in the canyon system containing Bechan Cave was begun with support from the National Park Service and the National Geographic Society. The results of the research includes an alluvial paleohydrologic model that extends

beyond 37,000 B.P.: 35,050 B.C. Figure 14 presents the absolute chronology derived from Holocene and Pleistocene alluvial deposits on the Colorado Plateau. Even cursory inspection of Figure 14 indicates that most of the dates are Holocene in age; in fact, 80% of these dates are late Holocene (<5000 B.P.: 3050 B.C.). Inspection of the Pleistocene alluvial

Central Colorado Plateau: NEW DATA AND A REVIEW

chronology ($\pm 10,000$ B.P.: 8050 B.C.) indicates that data are sparse, as compared to the Holocene, but that a record does exist to near the limit of radiocarbon dating.

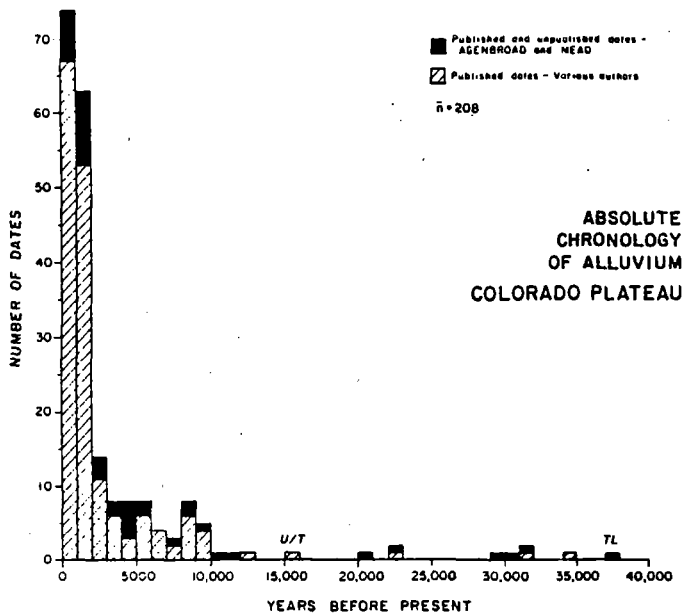


Figure 14. Histogram of alluvial C-14 dates.

We have demonstrated that we have at least five dung deposits (including the newly discovered Hoopers Hollow deposit) that date to greater than 10,000 B.P. (8050 B.C.). All but one of these (Bechan Cave) is intimately related to older underlying alluvial sequences. Even the alluvium outside Bechan Cave, but in the local canyon system, has yielded absolute dates of $10,020 \pm 1300$ (AA-1511), and $>37,500 \pm 7000$ (Alpha-3034) yr B.P. (8070 B.C.: 35,550 B.C.). The alluvial chronologic framework will be supplemented by fecal chronology and the pack-rat midden analysis. The pack-rat chronology has also been extended (2x-3x) temporally beyond

those data from the local study of Allen and Fishmouth caves (Betancourt 1984).

Palynological data from the C-14-controlled alluvial sequence will be cross-correlated to the paleobotanical records supplied by the dung deposits and the pack-rat middens. The integration of all lines of evidence will provide a more comprehensive synthesis of paleoecologic change, tied to an absolute chronology.

PALEONTOLOGY

Bechan Cave

Osteological/Dental remains.

Osteological and dental remains were sparse in the test excavations of 1983 and 1984 in Bechan Cave. Only one Pleistocene species, *Euceratherium collinum*, was positively identified from dental material.

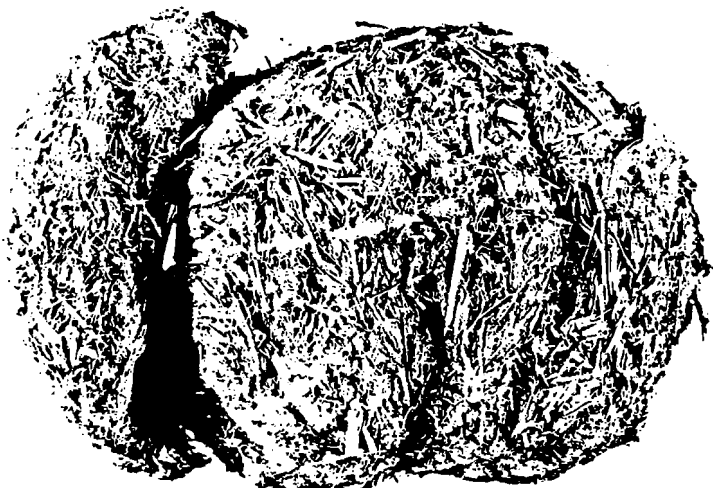
Dung Analysis.

The majority of the Bechan Cave dung bed was derived from *Mammuthus* dung. The mass of the deposit is represented by trampled, mixed mammoth dung, although 17 complete or nearly complete boluses were recovered in the limited testing of the deposit (Figure 15). Incorporated within the mass of mammoth dung, were the fecal pellets and boluses of additional species (Table 6).

Mammuthus sp. The size, shape, and bulk of the largest boluses plus the size-fraction analysis and composition of the material eliminated all but the proboscideans as the depositional agent from the Pleistocene megafauna. The composition (+95% grass, sedge, and rushes; Davis and others 1985) serves to segregate mammoth-derived material from that of the mastodon. (The

Central Colorado Plateau: NEW DATA AND A REVIEW

mammoth was adapted to grazing, whereas the mastodon was a browser).



0 10
cm



0 10
cm

Figure 15. Mammoth dung boluses, Bechan Cave.

Mammuthus sp.
cf. *Euceratherium* sp.
Nothrotheriops
Oreamnos harringtoni (?)
Equus (?) sp.

Table 6. Fauna present at Bechan Cave based on dung identification.

The paucity of mastodon material from the region as contrasted to mammoth remains, plus the dietary components of the dung and direct comparison with both zoo and wild African-elephant (*Loxodonta africana*) fecal material, allows us to identify *Mammuthus* as the major contributor to the deposit (Mead and others 1986). This conclusion is substantiated by hair analysis.

Size fraction analyses of mammoth boluses from Bechan Cave and *Loxodonta* dung are strongly similar (Figure 16), as contrasted to analyses of horse and ground-sloth dung. A similar analysis serves to differentiate among bighorn sheep (*Ovis canadensis*), extinct mountain goat, extinct musk ox (*Symbos*), elk (*Cervus*), and deer (*Odocoileus*) (Mead and others 1986).

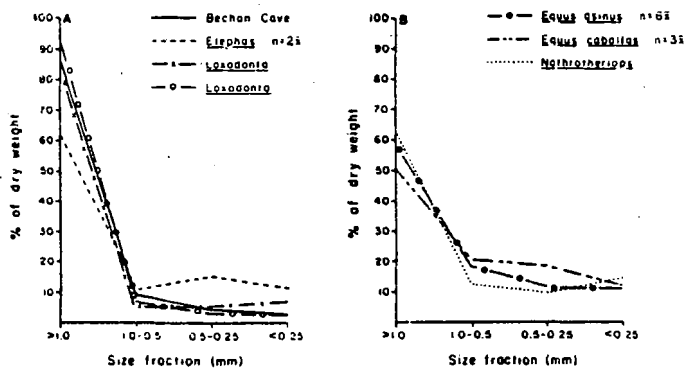


Figure 16. Size-fraction analyses of megefauna dung from Bechan Cave.

Central Colorado Plateau: NEW DATA AND A REVIEW

Euceratherium collinum. Analytic criteria applied to certain pellet-formed dung within the Bechan Cave deposit allowed us to identify a form of dung which is very similar to modern musk ox (*Ovibos moschatus*) winter pellets. The dental material, noted above, permitted a preliminary assignment to *Euceratherium collinum*.

Nothrotheriops shastensis. Shasta-ground-sloth dung boluses were recovered during the test excavations. Their coarser constituents and smaller fragments (or particles), plus sloth-dung-selective insect activity, did not allow the state of preservation shown in the mammoth boluses or animal pellets. We assign the material to *Nothrotheriops shastensis*, based on comparison with the Rampart Cave material.

The dung does not seem to belong to the larger mylodont ground sloth *Glossotherium harlani*, whose remains have been recovered near Shonto, Arizona (Agenbroad and Downs 1984).

Hair Analysis

The extremely dry conditions within Bechan Cave promoted the preservation of peltage within the dung bed. Techniques for the identification of modern species of fur-bearing animals are known. Using similar techniques and reference specimens, Bolen has identified both modern and extinct animals from Bechan Cave (Table 7; Bolen 1983).

Bechan Canyon Alluvium and Eolian Deposits

The alluvial deposits in the canyon containing Bechan Cave are thick (20 m) and extensive. It was realized early in our research in Bechan Cave that the alluvial fill might contain paleoenvironmental and paleoecological information that could be correlated to the cave record at both pre- and postdung depositional intervals.

Alluvium is well exposed due to the recent (<100 yrs) erosion cycle, which has incised the entire alluvial sequence to the bedrock floor of the canyon. These exposures of the alluvium reveal multiple organic bands (presumed to represent soil horizons), as well as datable materials at numerous localities.

Alluvial study in these canyons began in the latter half of 1984 and is continuing (Agenbroad and Elder 1985; 1986). A sequence of five terraces (T₄-T₀) was recognized and mapped (Figure 17).

Megafauna

<u>Species</u>	<u>Common Name</u>
• <i>Mammuthus</i> sp.	Mammoth
• <i>Glossotherium</i> sp.	mylodont sloth
* <i>Nothrotheriops shastensis</i>	Shasta ground sloth
• <i>Equus</i> sp.	horse
<i>Bison</i> sp.	bison
<i>Ovis</i> cf. <i>canadensis</i>	bighorn sheep
<i>Odocoileus</i> sp.	deer
<i>Ursus</i> sp.	bear
<i>Canis latrans</i>	coyote

Microfauna

<u>Species</u>	<u>Common Name</u>
<i>Sorex</i> sp.	shrew
<i>Neotoma</i> sp.	pack rat
<i>Myotis</i> cf. <i>leibii</i>	small-footed bat
<i>Peromyscus</i> cf. <i>maniculatus</i>	deer mouse
<i>Sciurus</i> cf. <i>aberti</i>	Abert's squirrel
<i>Perognathus</i> cf. <i>fasciatus</i>	olive-backed mouse

Table 7. Fauna from Bechan Cave based on hair analysis

The terrace profiles produced a sequence of alluvial events that could be tied to a radiocarbon-controlled chronology. From these data, a preliminary geologic-paleohydrologic

Central Colorado Plateau: NEW DATA AND A REVIEW

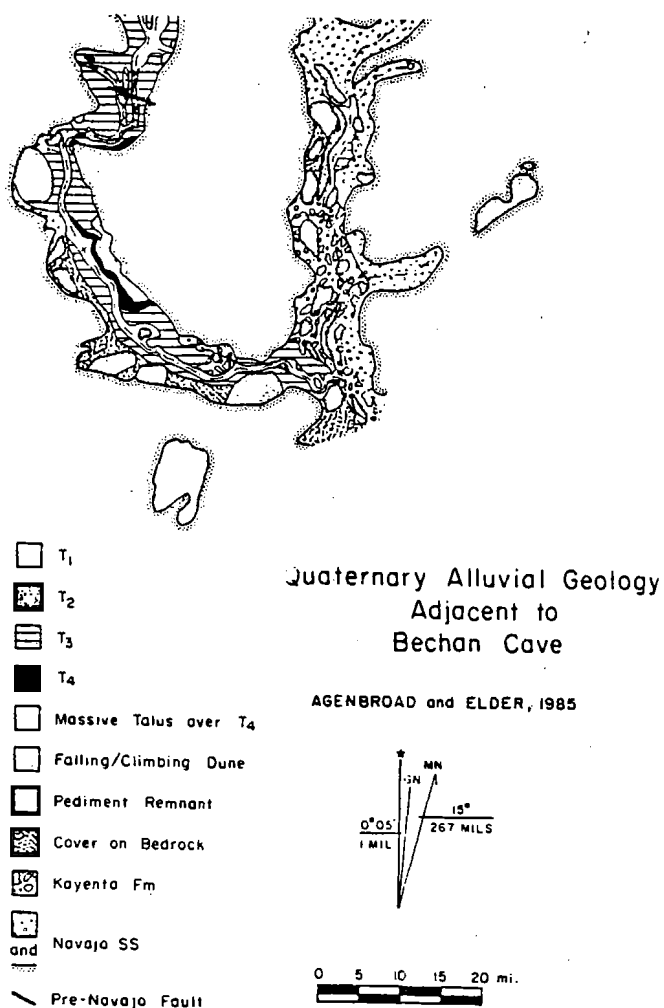


Figure 17. Quaternary alluvial geology adjacent to Bechan Cave.

model was constructed for the canyon alluvium (Figure 18). At present, we have 22 radiocarbon dates and 1 thermoluminescence (TL) date (Table 8) from the alluvial and eolian deposits, which provide the chronologic framework for the alluvial events. Of these, five dates are from buried archaeological sites extending back to 5300 B.P. (3350 B.C.)

Eolian deposits were probably accumulating during most of the

depositional history of the canyon. Remaining climbing and falling dunes, currently stabilized, attest to periods of more rapid accumulation than attested to by the small active dunes. Dates on charcoal from within the dunes and from dune modification attest to the antiquity of these deposits. There is geomorphic evidence that the entrance to Bechan Cave, during the use of the cave by the prehistoric fauna, was accessible via a climbing dune that has been partially destroyed by runoff over the canyon wall since that time.

Based on the currently available dates from the alluvium, the oldest unit in the canyon is T₄, as indicated by a TL date of >37,500 to <54,300 B.P. (35,550 to 53,350 B.C.) (Alpha-3034). This older alluvium is preserved as remnants beneath talus blocks, or as high terrace remnants against portions of the canyon wall. Repeated searching of the exposures failed to reveal material suitable for standard radiocarbon dating. Samples of a small bivalve, *Pisidium*, from the upper portion of T₄ produced a TAMS (tandem accelerator mass spectrometer) radiocarbon age of 32,000±1300 B.P. (30,050 B.C.) (AA-1511). This TAMS date refines the age of T₄ analyzed on TL and may well displace the later date.

Terrace 4 filled the canyon floor to as much as 20 m above the bedrock. This aggradation interval provides evidence of cyclic deposits indicative of high-energy flow (sand) separated by low-energy deposits (silts and clays). Sometime after the aggradation of T₄, erosional events initiated degradation at ± 11,000 B.P. (9050 B.C.) causing most of the T₄ sediments to be removed from the canyon during an arroyo-cutting episode. Between 11,000 and 10,500

Central Colorado Plateau: NEW DATA AND A REVIEW

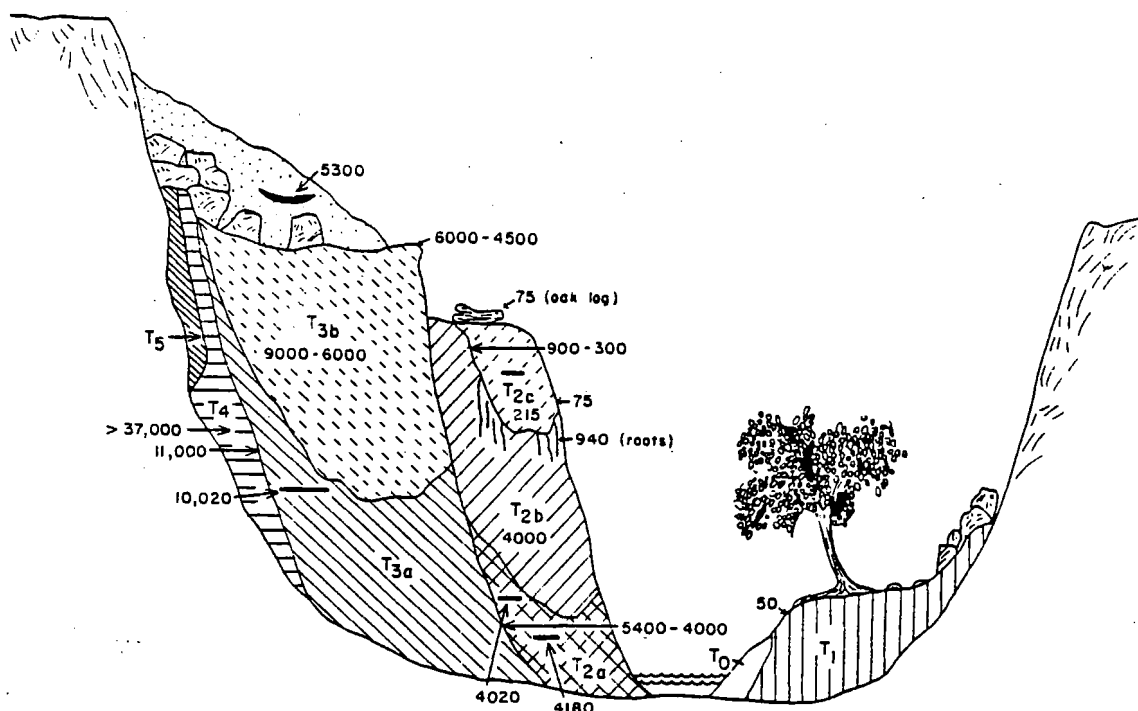


Figure 18. Schematic cross-section of alluvial fill(s) in the canyons adjacent to Bechan Cave.

Date (BP)	Lab No.	Material Dated	Strat Position	Field No.
0 ±75	Gx-10759	oak log	Top T2	85-2
215 ±80	Gx-11144	root	T2(c)	85-10
940 ±200	Gx-11431	charcoal	T2(b)	85-9
950 ±160	Gx-11018	charcoal (hearth?)	T2(b)	85-8
1290 ±75	Gx-11338	charcoal (hearth)	dune on T3	85-15
1315 ±75	Gx-11340	charcoal (hearth)	T2(b)	85-25
1525 ±130	Gx-11336	charcoal (hearth)	dune on T2	85-13
1600 ±60	Beta-15640	charcoal	T2(b)	86-1
1750 ±90	Beta-16587	charcoal	T2(b)	86-3
2510 ±80	Gx-11562	wood	T2(b)	85-19
2550 ±80	Gx-11561	wood	T2(b)	85-18
3000 ±145	Gx-11339	charcoal (hearth)	T2(b)	85-16
3750 ±165	Gx-11563	charcoal	T2(b)	85-20
4025 ±95	Gx-10939	root	T2(a)	85-4
4090 ±155	Gx-10758	charcoal & plant debris	T2(a)	85-1
4120 ±170	Gx-11564	charcoal	T2(a)	85-21
4165 ±95	Gx-11019	wood	T2(a)	85-3
4260 ±170	Gx-11337	root	T2(a)	85-14
5300 ±235	Gx-11146	charcoal (hearth)	dune on T3	85-12
10,020 ±270	Gx-11145	charcoal	T3(a)	85-11
32,800 ±1300	AA-1511	TAMS on <i>Pisidium</i>	T4	856-5
>37,500 ±7000	Alpha-3034	TL date on sediment	T4	86-4
<54,300 ±10500				

Table 8. C-14 dates from alluvium and eolian deposits near Bechan Cave.

Central Colorado Plateau: NEW DATA AND A REVIEW

B.P. (9050 B.C. and 8550 B.C.) an aggradation cycle began, filling the canyon with alluvium again (T_{3a}). Terrace 3 aggraded to, or nearly to, the level of T_4 and was then subjected to an erosion interval between 9000 and 6000 B.P. (7050 B.C. and 4050 B.C.) Aggradation of this arroyo system created T_{3b} which filled to ± 15 m above the canyon floor and comprises most of the alluvial terraces exposed in the canyon today (Figure 17). Between 6000 B.P. (4050 B.C.) and 4500 B.P. (2550 B.C.), T_3 was eroded to the bedrock of the canyon floor. By approximately 4500 B.P. (2550 B.C.) this episode reversed, causing deposition of T_2 , which appears to contain at least three units, one of which (T_{2a}) is older than 4000 B.P. (2050 B.C.), but younger than ± 4500 B.P. (2550 B.C.). T_{2b} represents a cut-and-fill that is younger than 4000 B.P. (2050 B.C.), but older than 900 B.P. (A.D. 1050). At approximately 900 B.P. (A.D. 1050), T_{2b} was eroded, to be filled before 300 B.P. (A.D. 1250). Based on the radiocarbon dates available, T_2 and other units were subjected to erosion at 100 to 75 B.P. (A.D. 1850 to 1875), judging from the age of the oak (*Quercus*) tree stand that covered T_2 and T_3 surfaces prior to that time. As the erosional interval continued, the water table was lowered, causing the death of the oak stand. This erosion interval again cut to the bedrock floor of the canyon and began deposition of T_1 between 100 and 50 B.P. (A.D. 1850 and 1900). Erosion of T_1 began at approximately 50 B.P. (A.D. 1900), leaving low T_1 terraces and reaching the bedrock floor of the canyon. Bedrock comprises most of the stream floor at the present time.

Radiocarbon dates on cultural material from the canyon fill adjacent to Bechan Cave appear to be

approximately 5300 B.P. (3350 B.C.), based on the dates submitted and returned from the laboratory at the time of this report. Dating still in process may extend the temporal range of cultural materials. The earliest cultural date in Bechan Cave is 7795 B.P. (5845 B.C.), which indicates that an Archaic culture was present in the canyon earlier than presently reflected by the analysis of the canyon alluvium. Arguments could be forwarded that evidence of earlier cultural presence was contained in the alluvium, but was removed by subsequent cut-and-fill cycles.

In considering cultural presence in the cave and adjacent canyons, an important tentative correlation can be made. If one assumes that Archaic peoples (and formative groups) were horticulture - and agriculture-dependent, the canyon floor would have been attractive to such groups as potential garden/farm land only during periods of relative stability, i.e., quiescent, high-water-table, soil-forming periods of time. Periods of either aggradation or degradation of the valley fill would be unsatisfactory to such subsistence techniques. Comparison of the dated events in Bechan Cave and the canyon alluvium tend to bear this out. Without the cave record, it could be argued that evidence of prior human presence was removed by erosional episodes. With the cave record, however, the correlation between human absence from these canyons and times of aggradation and degradation is supported.

SOILS

Soils preserved in the alluvium of the canyons in the vicinity of Bechan Cave have been studied by Anderson and

Central Colorado Plateau: NEW DATA AND A REVIEW

Karlstrom (1986) and Anderson (1985, 1987). Thirteen soil profiles have provided 198 samples from in and on the alluvial terraces. Laboratory analyses for particle size, percentage of calcium carbonate, percentage of organics, percentage of iron, manganese, and aluminum, pH, and clay mineralogy were utilized to determine the source of the material, stage of soil development, amount of soil zonation, and paleoenvironmental conditions of soil formation.

Results of the analyses indicate that all the soils in the canyon alluvium can be assigned to two soil orders, Entisols and Mollisols. Entisols are incipient soils with simple A/C horizons. They form the majority of soils in the canyon and are common in arid regions with perennial or ephemeral water sources. The incipient A horizons are repeatedly buried by accretion of the flood plain. The Entisols in the vicinity of Bechan Cave did not develop into more advanced soils because of rapid burial, a parent (source) material that is nearly pure quartz sand, small amounts of organic material, and lack of water. Minor Mollisols, reflecting high amounts of moisture with concomitant vegetational response provides more organic material. This prairie or grassland soil type is found in the desert Southwest in areas of higher soil moisture, as in riparian habitat.

Both soil types are present in the modern environment within the canyon. Periods of 50 to 100 years of stability could produce the modern and ancient soils. Rapid aggradation would bury such soils, thus providing the multiple organic horizons observed in the canyon alluvium.

The oldest soil sampled is dated at just over 4000 B.P. (2050 B.C.) The $\pm 37,000$ -year-old sediments of the T₄

remnants did not yield geosol information. On the basis of soil formation, soil chemistry, and mineralogy, it is inferred that the past 4,000 years of soil-forming conditions have changed little; they reflect conditions similar to the present, with intervals of wetter and drier conditions, as evidenced by the cut-and-fill cycles and terrace formation.

One soil in lower Bechan Canyon was identified as the "altithermal" soil during initial field inspection. The laboratory analysis combined with a TAMS (tandem accelerator mass spectrometer) C-14 date of 1750 $\pm$ 90 B.P. (A.D. 200) (Beta-16587), indicates that this soil instead reflects a larger influx of Kayenta Formation parent material, as determined by the clay mineralogy and the low percentages of iron, manganese, and aluminum present in the soil.

ALLUVIAL POLLEN

Palynological analysis of the alluvial fill of the canyons has been undertaken by R. Hevly and S. Clay-Poole (1985, 1986). The results presented here are preliminary, and analysis is still underway.

Terrace 4, dating to greater than 37,000 B.P. (35,050 B.C.), yielded pollen indicative of a plant community that included ponderosa pine, birch, juniper, Cheno-Ams, low-spine Asteraceae (including *Artemisia*), and grasses. The older portion ($\pm 10,000$ B.P.: 8050 B.C.) of T₃ contains only grass pollen. These samples support the botanical record derived from the Bechan Cave dung bed, which brackets an interval of 11,670-13,505 B.P. (9720-11555 B.C.). Early Holocene portions of T₃, as dated by

Central Colorado Plateau: NEW DATA AND A REVIEW

interpolation of sedimentation rates (Hevly and ClayPoole 1986), reflect an environment in which ponderosa pine, *Artemisia*, grass, ChenAms, low- and high-spine Asteraceae, and *Ephedra* were common, but which also contained some brief episodes of spruce, white fir, Douglas fir, and juniper. Upper T₃ and T₂ sediments, dating 2500-4100 B.P. (550-2,150 B.C.), indicate deceased proportions of Cheno-Am pollen, increasing grass pollen, and very little arboreal pollen.

Alluvial and cave pollen records indicate that the late Holocene pollen profiles demonstrate paleoenvironmental conditions similar to the present.

Canyon Alcoves

Deposits. The canyon deposits consist of a series of alcoves within the entrenched meanders of the canyon (Figure 19) that have preserved alluvial sediments capped by Pleistocene dung deposits and associated macrobotanical remains.

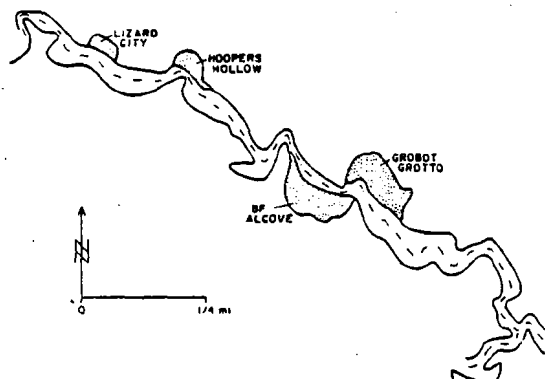


Figure 19. Canyon with alcoves containing fossil localities.

Two dung samples from one of the deposits date 20,930 and 28,290 B.P. (18,980 and 26,340 B.C.) (Table 9). Douglas-fir needles and maple seeds associated with possible camel dung

from another alcove date 11,790 B.P. (9840 B.C.)

Osteological/Dental Remains:

Locality	Mtl	Fauna
Hoopers Hollow	metapodial	<i>Oreamnos harringtoni</i>
Hoopers Hollow	tooth	<i>Squas</i>
Hoopers Hollow	mandible	<i>Marmota</i>

Fecal Remains:

Grobot Grotto	bolus	<i>Mammuthus</i>
	bolus	<i>Bison</i>
	pellet	<i>Oreamnos</i>
	pellet	cf. <i>Eucosatherium</i>
BF Alcove	pellet	cf. <i>Camelops</i>
Hoopers Hollow	pellet	<i>Oreamnos</i>
	pellet	cf. <i>Eucosatherium</i>

Table 9. Fauna from canyon alcoves.

Paleontology. The canyon-alcove deposits contain osteological, dental, and fecal remains. It is expected that hair will also be recovered, as excavations proceed. Thus far in our field investigations, identifiable osteological remains have been recovered only from Hoopers Hollow. Grobot Grotto has osteological material that will require stabilization prior to removal and identification. All the alcoves contain dung deposits. Mammoth and bison dung boluses have already been recovered from the alcove dung mats, as have the large pellets assigned tentatively to camel and the smaller pellets assigned to the shrub ox and Harrington's mountain goat. A series of controlled sampling excavations is underway in the alcoves. The faunal and botanical deposits overlie up to 23 m (76 ft) of stratified alluvium, preserved as remnants where sheltered

Central Colorado Plateau: NEW DATA AND A REVIEW

by alcove overhangs, at up to 73 m (238 ft) above modern base level (Figure 20).

data from these deposits is greater than for other deposits from the Plateau.

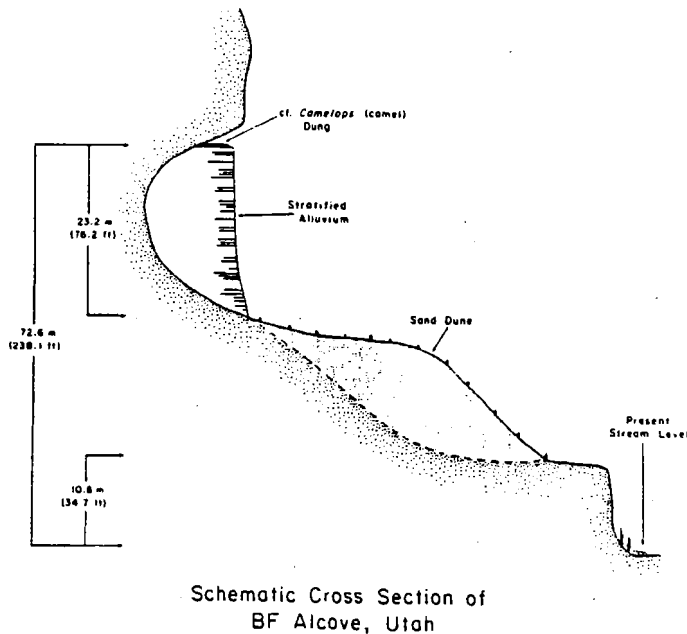


Figure 20. Schematic cross-section of BF alcove.

Alluvium. The five alcoves containing the elevated ancient sediments are being studied and compared to younger alluvial units within and upstream from the alcoves. The hydrologic-geologic history of the drainage is being interpreted from the evidence remaining in the deposits. It has become apparent that a younger, lower-elevation sequence of alluvial units is also preserved within the canyon. In alluvial studies on the Colorado Plateau, as discussed previously in this paper, post-10,000 B.P. (8050 B.C.) data are sparse. The canyon alcoves provide multiple exposure of a thick sequence of alluvium that has to predate the dung beds that cap it. The potential for retrieval of paleoenvironmental

DUNG, DIET, AND EXTINCTIONS

An estimated 300 m³ of Pleistocene dung forms the dung blanket at Bechan Cave (Davis and others 1984). The majority of this dung was deposited by mammoth. Analysis of the mammoth dung (Davis and others 1984, 1985; Mead and others 1986) reveals that more than 95% of the mammoth boluses are composed of a graminoid matrix. This reflects the analysis of 25 fragments of mammoth dung from complete, or nearly complete, boluses collected in 1984 test excavations.

The graminoid matrix is composed of grasses, sedges, and rushes indicative of riparian plants. Nonmatrix sections of the dung include saltbush, cactus, and sagebrush. Plant macrofossils from the dung bed include birch, rose, saltbush, sagebrush, blue spruce, wolfberry, and red osier dogwood (Davis and others 1985).

The paleoenvironment at Bechan Cave has been interpreted as a sagebrush-steppe upland with a riparian community near the streams. The Bechan Cave botanical community can be nearly duplicated in the nearby uplands of the Henry Mountains, or the Aquarius Plateau, ±1200 m (±4000 ft. higher in elevation than the cave. The upward migration (elevation) of the plant community can be roughly correlated with warming and seasonal precipitation changes near the cave during the past 11,000 years.

Comparison of the alluvial record from the canyons near Bechan Cave, the cave records from Bechan Cave and Cowboy Cave, an extended botanical record from pack-rat middens or

Central Colorado Plateau: NEW DATA AND A REVIEW

Natural Bridges National Monument (Mead and others, in press), and a developing chronology from nearby drainages has led to the development of a paleoenvironmental model tied to a C-14 chronologic sequence. Bechan Cave provides a large repository of mammoth dung dating just 670 years prior to the extinction. Grobot Grotto has supplied mammoth dung dating 28,290 yr B.P. (26,340 B.C.), which allows us to approach the extinction event from "the far side," with data from dietary samples dating prior to extinction, rather than work back in time from the Holocene record. If the chemical analyses fail to prove to be nondiagnostic, we will have from three repositories within the central Colorado Plateau the botanical record from dung deposits and pack-rat middens, as well as pollen analyses, for cross-correlation of paleobotanical records.

CHAPTER 6

INVESTIGATIONS OF A NEWLY DISCOVERED PLEISTOCENE MEGAFAUNAL DUNG BED AND ALLUVIAL SEQUENCES IN S. E. UTAH

Larry D. Agenbroad and Jim I. Mead

ABSTRACT

Thick deposits of stratified, alluvial sediments of suspected Quaternary age were observed during a helicopter flight over a portion of the Escalante River drainage of S.E. Utah. The preserved remnants of the canyon fill were at elevations up to 238 ft (72.6 m) above modern base level. Initial, on-site investigation of three alcoves provided dung of extinct Pleistocene fauna and macrobotanical sample of extralocal (higher elevation, or latitude) botanical remains. Subsequent field work has provided osteological and dental remains of Pleistocene fauna, plus an increasing number of alcoves yielding sediments and biological remains. The March 1987 field session produced skeletal remains of mammoth (*Mammuthus columbi*) from an alcove in a tributary drainage. These remains are in basal units of stratified

alluvium, (with mammoth dung in the upper meter of the deposits (± 42 ft; 13 m) above the osteological remains, Sedimentary analyses, radiocarbon dating, palynologic and macrobotanical analyses, biochemical analyses of dung, and the paleontological evidence combine to give us a multidisciplinary approach to reconstruction of the past 30,000 years within this canyon system. These data will then be combined with data from Bechan Cave and the canyon alluvial system containing that feature, to provide a more regional view of the late Pleistocene, and Holocene of the central Colorado Plateau. The research is on-going; this report provides the data generated with funding from National Geographic Society grant #3280-86 and NPS contract CX 1200-4-A062.

INVESTIGATIONS OF A PLEISTOCENE MEGAFaUNAL DUNG BED

INTRODUCTION

On September 9, 1985, during a helicopter flight over the western portion of the Escalante River drainage basin (Figure 21), an elevated deposit of stratified Quaternary alluvium was observed. The deposit suggested antiquity by its appearance in the eroded exposure, partial cover by a large, stabilized falling dune, and its elevated position relative to modern base level. Time and fuel restraints prevented visitation of the site on that trip. On October 15, 1985 we attempted to locate the alcoves on foot, by hiking downstream through the canyon of Fortymile Wash. We were prevented access by sheer, overhanging walls of the inner canyon, and a large waterfall in the extremely narrow inner canyon. Access, via helicopter, was possible on October 16. We first entered the most inaccessible alcove (BF Alcove), whose relative position with the other alcoves is depicted in Figure 22.

BF Alcove contained 76 feet (23 m) of stratified alluvial deposits, exposed by the erosion of the dripline of the alcove overhand (Figure 18). The top of these sediments was 238 ft (72 m) above the modern base level. Brief testing of surface layers provided dung of cf. *Camelops* and needles of Douglas fir (*Psuedotsuga menziesii*) and Rocky Mountain maple (*Acer glabrum*). A subsequent radiocarbon date from these samples provides an age of $11,790 \pm 190$ (Beta-14727) for the surficial deposits.

Across the canyon, a large alcove named Grobot Grotto (Figure 23) provided a large exposure of stratified sediments. A line of rockfall in the upper one-third of the deposit marks a zone of megafauna dung

interspaced with the sediments and rockfall, to the surface of the fill. Radiocarbon analysis of mammoth dung and artiodactyl dung provided dates of $28,290 \pm 2100$ (Beta-14422) and $20,930 \pm 400$ (Beta-14418) respectively, from the lower portions of the dung-bearing layers.

These specimens and the radiocarbon dates from the upper levels of the two alcoves prompted the search for funding, and the initiation of more detailed, long-term investigations of the deposits. National Geographic Society grant 3280-86 supplemented a research contract (CX1200-4-A062) with the National Park Service.

Field Research

During the fall of 1986, trips to the research area via boat on Lake Powell, and hiking up the canyons provided access to Grobot Grotto without use of helicopter support. One field visitation had planned helicopter support, which allowed us to enter a new alcove (Hooper's Hollow; Figure 22) containing sediments, osteological, dental, and fecal remains of a number of Pleistocene megafauna, including three new animals not previously found in the area: Mountain goat (*Oreamnos harringtoni*), marmot (*Marmota flaviventris*), and horse (*Eguus* sp.). The helicopter engine malfunctioned, requiring it to be shut down until repaired. Charcoal samples taken from younger, lower elevation, stratified deposits in the alcove known as Lizard City (Figure 22) provided dates of $1,180 \pm 70$ (Beta-14360) and $1,970 \pm 90$ (Beta 14361), indicative of at least two periods of fill in the canyon, one Pleistocene and one Holocene, with corresponding intervals of dissection.

INVESTIGATIONS OF A PLEISTOCENE MEGAFaUNAL DUNG BED

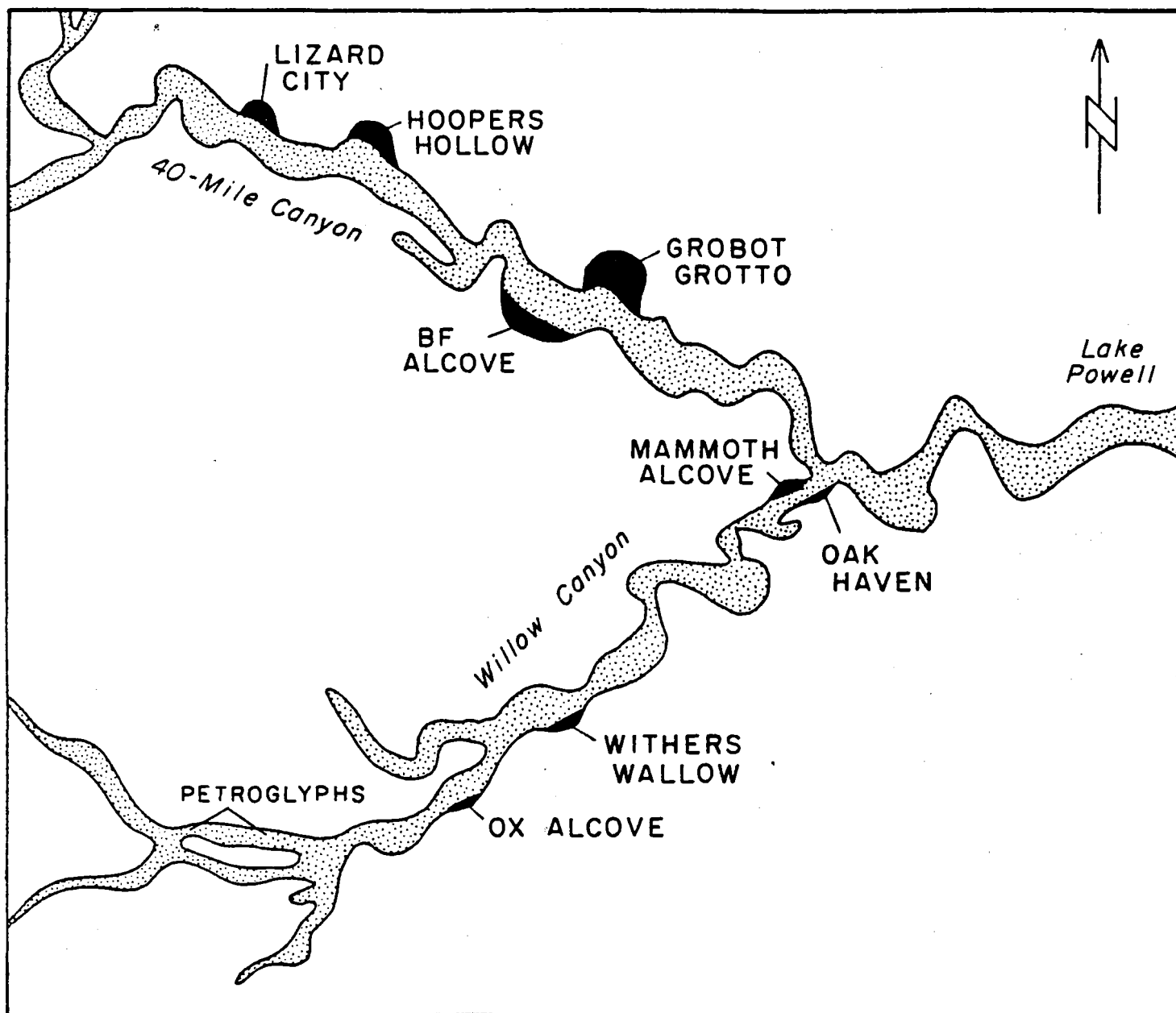


Figure 21. Location map of the Fortymile study area.

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

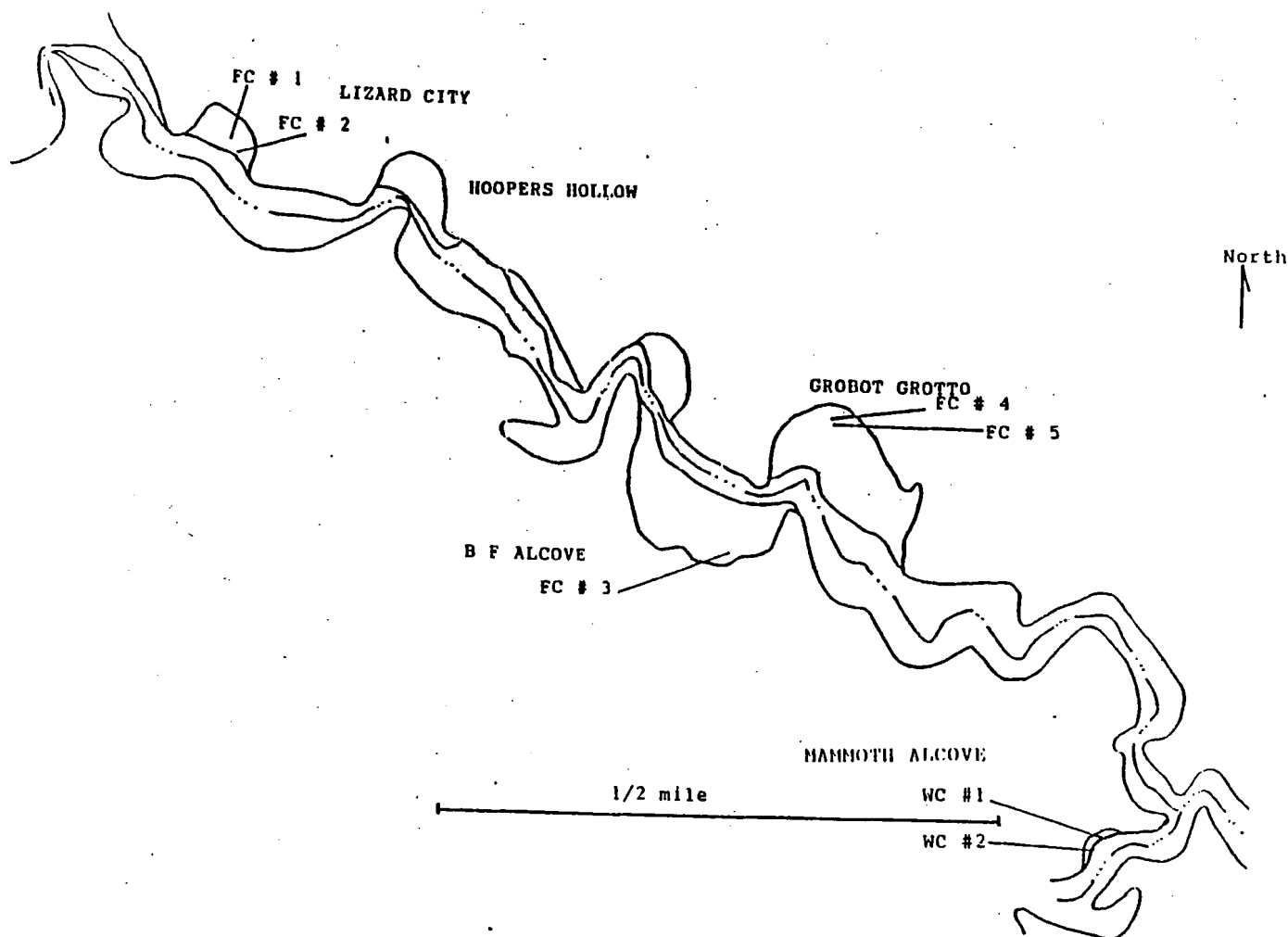


Figure 22. Documentation map of the Fortymile study area with C-14 samples by field number.

INVESTIGATIONS OF A PLEISTOCENE MEGAFaUNAL DUNG BED

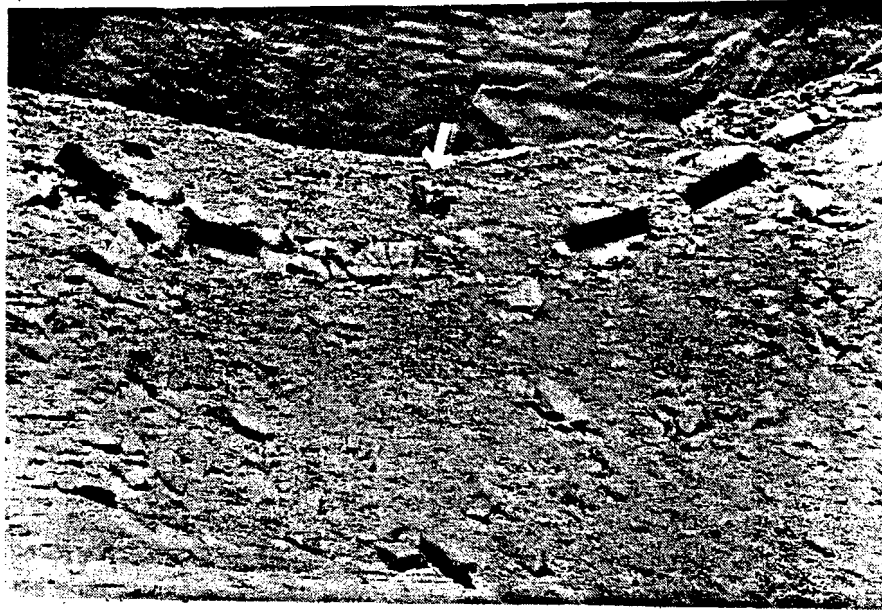


Figure 23. Grobot Grotto; arrow and dashed line locate the lower limits of mammoth and shrub ox dung.

Field efforts in the spring of 1987 were hampered by the loss of helicopter source. Rope access to BF Alcove was established and minor test sampling of near surface material was conducted. Examination of the underlying stratified sediments yielded no material suitable for radiocarbon dating. Sediment samples for thermoluminescence dates were collected, and are currently in process of being dated. Preliminary sedimentary analysis and descriptions of sections of exposed sediments were begun. Grobot Grotto was sampled by elevation/stratigraphic control, after initial tests by trenching proved to be extremely difficult due to NPS requirements and the nature of the fill. Surface collections were made in Hooper's Hollow alcove, as it was

not discovered at the time of submission of the NPS work plan.

Crew not committed to efforts to establish rope access in difficult alcoves surveyed additional alcoves in Fortymile Canyon and Willow Creek Canyon. Willow Creek Canyon contains numerous alcoves with stratified sediments, at a variety of elevations above modern base level. One alcove (Mammoth Alcove; Figure 24) contains skeletal elements of mammoth (*Mammuthus columbi*) in the lowermost sediments. Dung of bison (*Bison* sp.) and mammoth (*M. columbi*) occurs in the upper layers of the ± 42 ft (13 m) of stratified sediment in this alcove (Figure 25). Radiocarbon dating from the mammoth dung provides an age of $16,630 \pm 280$ (Beta-20705) for this near-surface level.

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

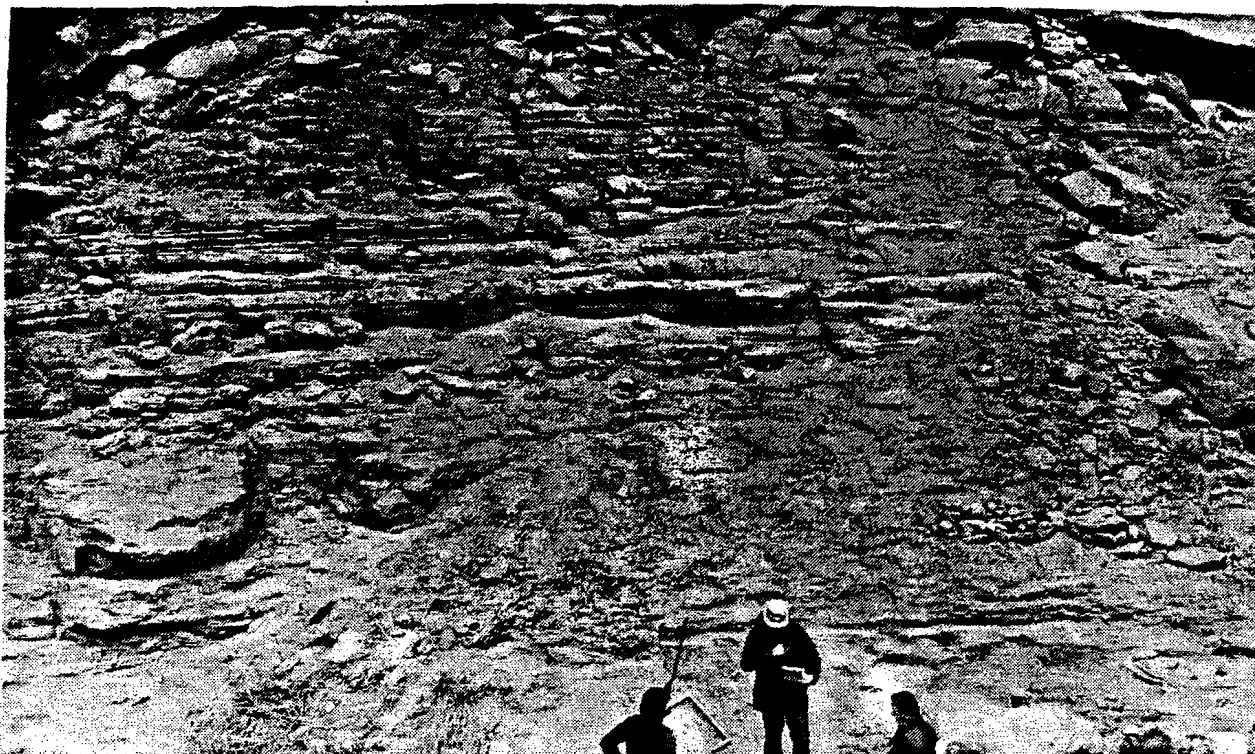


Figure 24. View of Mammoth Alcove; bones exposed at lower right.

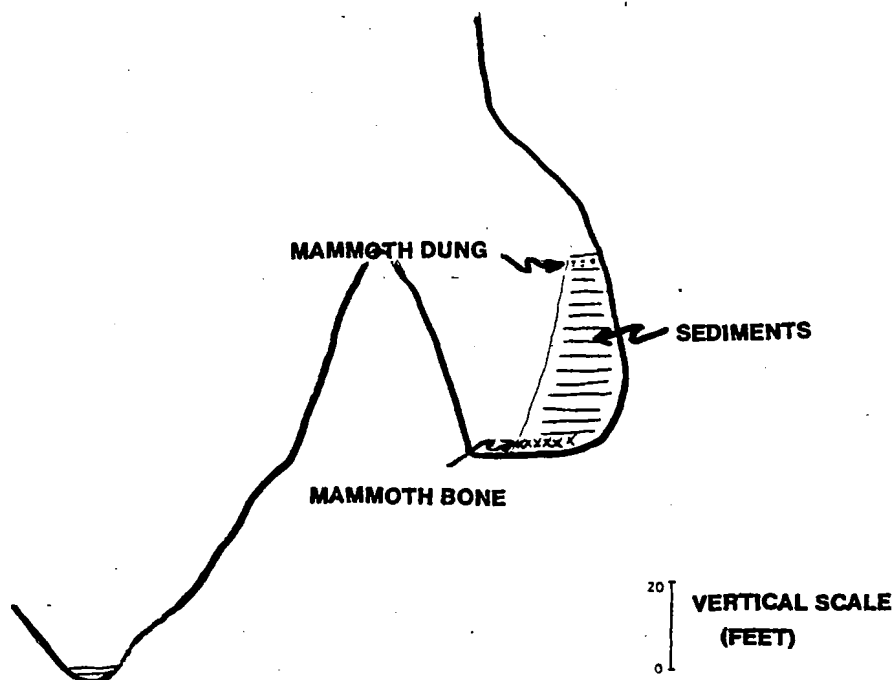


Figure 25. Schematic cross-section of Mammoth Alcove.

INVESTIGATIONS OF A PLEISTOCENE MEGAFaUNAL DUNG BED

Alcoves on Willow Creek Canyon, with the exception of Mammoth Alcove, do not seem to be rich in the dung deposits. From the alluvial sediment analysis perspective, and potentially from pollen studies, they may be equally informative as the Fortymile Canyon alcoves. Access to several of these deposits will require helicopter support.

Dung Analyses

Four of the five alcoves which have been tested, at least at preliminary levels of analysis have produced dung from a variety of Pleistocene megafauna (Table 10). Dates from these dung deposits range from 28,290 to 11,790 B.P. (26,340 to 9840 B.C.) In all cases the dung is in the upper units of the stratified sediments. In addition to species identification and radiocarbon dating of the fecal material, we have initiated analyses at two additional levels.

Date (BP)	Lab No.	Material Dated	Strat Position	Field No.
0 ±75	Gx-10759	oak log	Top T2	85-2
215 ±80	Gx-11144	root	T2(c)	85-10
940 ±200	Gx-11431	charcoal	T2(b)	85-9
950 ±160	Gx-11018	charcoal (hearth?)	T2(b)	85-8
1290 ±75	Gx-11338	charcoal (hearth)	dune on T3	85-15
1315 ±75	Gx-11340	charcoal (hearth)	T2(b)	85-25
1525 ±130	Gx-11336	charcoal (hearth)	dune on T2	85-13
1600 ±60	Beta-15640	charcoal	T2(b)	86-1
1750 ±90	Beta-16587	charcoal	T2(b)	86-3
2510 ±80	Gx-11562	wood	T2(b)	85-19
2550 ±80	Gx-11561	wood	T2(b)	85-18
3000 ±145	Gx-11339	charcoal (hearth)	T2(b)	85-16
3750 ±165	Gx-11563	charcoal	T2(b)	85-20
4025 ±95	Gx-10939	root	T2(a)	85-4
4090 ±155	Gx-10758	charcoal & plant debris	T2(a)	85-1
4120 ±170	Gx-11564	charcoal	T2(a)	85-21
4165 ±95	Gx-11019	wood	T2(a)	85-3
4260 ±170	Gx-11337	root	T2(a)	85-14
5300 ±235	Gx-11146	charcoal (hearth)	dune on T3	85-12
10,020 ±270	Gx-11145	charcoal	T3(a)	85-11
32,800 ±1300	AA-1511	TAMS on <i>Pisidium</i>	T4	856-5
>37,500 ±7000	Alpha-3034	TL date on sediment	T4	86-4
<54,300 ±10500				

Table 10. C-14 dates from the Fortymile study area.

INVESTIGATIONS OF A PLEISTOCENE MEGAFaUNAL DUNG BED

Dr. J. Lowenstein of the University of California School of Medicine is doing biochemical analyses of the dung types as a method of determining taxonomic affinity from dung "types" or forms, as well as from fragmental material. Dung samples have been forwarded to Colorado State University for phytolith and cuticle analyses. Comparison of the microhistological data, directly from the dung, will allow comparison with palynological data derived from the sediments, and macrobotanical remains from the dung beds.

Sediment Analyses

The thickness and anomalous elevation of stratified sediments, preserved in the alcoves was the first clue to antiquity for the deposits, as seen from the air on the discovery flight. On-site examination of the original, and subsequent, alcoves confirmed the initial estimates. At least seven alcoves are known to contain large volumes of stratified, Pleistocene alluvium in the confines of Fortymile and Willow Creek Canyons. Of these, five have been

examined in preliminary investigations. Lizard City is Holocene in age, but the four additional investigated alcoves presented in Table 11 contain thick sequences of Pleistocene sediments. Additional alcoves in Willow Creek Canyon have been visited, or observed.

The conclusion drawn from the initial testing, dating, and analyses is that these narrow canyons have been dammed, repeatedly, by as-yet-unknown mechanisms. This base level change resulted in standing bodies of water (lakes) within the canyons, which were sites of deposition of silt-laden stream flow, creating the stratified sediments, preserved as remnants of these deposits, in the alcoves. On the basis of preliminary assessment of the elevation of "top-of-fill" deposits, and the radiocarbon chronology we have obtained thus far, it appears that there were a minimum of two, and perhaps three or four episodes of damming, infilling, stability, and down-cutting within these canyons. It appears that one or more episodes occurred in late Pleistocene time, and at least one episode is evident in the late Holocene.

<u>Locality</u>	<u>Thickness of Stratified Deposit</u>		<u>Elevation of Top of Depos:</u> <u>Above Modern Base Level</u>	
	<u>ft</u>	<u>m</u>	<u>ft</u>	<u>m</u>
Lizard City	14.5	5.0	*16.5	5.0
Hooper's Hollow	60.8	18.5	(not yet established)	
BF Alcove	76.2	23.2	238	72.6
Grobot Gratto	106.8	32.5	(not yet established)	
Mammoth Alcove	42.0	12.8	90	27.4

*Height above fall in base level.

Table 11. Alluvial sequences from the Fortymile study area.

INVESTIGATIONS OF A PLEISTOCENE MEGAFUNAL DUNG BED

Damming mechanisms that suggest themselves follow: (1) Falling dunes choking the narrow canyons, as eolian sediment transport is increased by increased aridity, loss of vegetative cover, or a combination of these events in the surrounding uplands. Immense falling dunes are evident in the canyons, at present. (2) Landslides along the northeast front of the Kaiparowits Plateau providing "slugs" of sediment input into one or more tributaries, causing earthen dams, or "plugs," in the narrow canyons. (3) Driftwood and debris dams in the constricted portions of the canyons, which become silt traps and effective dams until the decay of the original. 4) Rock-fall from the canyon walls, plugging restricted portions of the canyon.

The sediments should yield pollen and macrofossil material. The upper portions contain dung and bones of extinct Pleistocene megafauna, and at least Mammoth Alcove contains skeletal remains of *Mammuthus* in its lower strata. The bones of this specimen were only partially exposed, stabilized, and covered due to the National Park Service request at the time of discovery. One small bone, a sesamoid, was sacrificed for radiocarbon dating. There was insufficient collagen in the sample for a collagen date, so a whole bone date was run, even knowing it would probably be young. The results of the dates on the bone and the overlying dung sample from Mammoth Alcove indicate an inverse chronology and suggest the bone date is considerably in error.

Detailed analyses of the sediments in the alcoves has just been initiated. Comparison of the units in individual alcoves will necessitate accurate elevation control, to be established by detailed surveying.

Temporal control will be provided by current and future radiocarbon dating and thermoluminescent dating of sediment samples.

Chronologic Analyses

To date, we have a total of seven radiocarbon dates from the alcoves of Fortymile and Willow Creek Canyons. These dates reflect NPS and NGS funding and cover a temporal span of 1180 ± 70 to $28,290 \pm 2100$ B.P. (A.D. 770 to 26,340 B.C.). An additional five dates are in progress.

Radiocarbon dating has been restricted to the upper levels of the alcove deposits, due to the apparent lack of datable material below the dung and macrobotanical levels of the deposits. The lowest date yet processed is from approximately 1/3 of the depth of the deposits at Grobot Grotto (Figure 23). The date is from mammoth dung collected just above the rock-fall line in the deposits and has an antiquity of 28,290 B.P.: 26,700 B.C. Using the dung bolus as a temporal marker, the underlying stratified sediments should be 40,000 to 50,000 years old.

Lacking datable material below the dung levels, TL (thermoluminescence) samples of marker beds in BF, Grobot, and Mammoth Alcoves have been collected and are in process. There has been delay in processing due to a change in location of the TL laboratory. TL dating of T_4 (terrace 4) in the alluvium near Bechan Cave was in good agreement with C-14 dates that were stratigraphically superior, in the same terrace. Chronologic refinement of each alcove and marker beds within the sediments is a goal of the on-going research. Additional dates on fecal material from these, and additional alcoves will more precisely bracket the temporal affinity of the Pleistocene fauna, in

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

general, and individual species, in particular.

Figures 26 and 27 present graphic data indicating the range of published and unpublished chronologies of the alluvial deposits and the dung and packrat deposits of the Colorado Plateau. Even cursory examination of these graphs indicates that most of the effort, in each category, has been expended on Holocene and terminal Pleistocene material. The extension of the chronologies is limited somewhat by the $\pm 40,000$ B.P. range of radiocarbon dates, but has the potential of being extended further with TL dating. Dates from the Bechan Cave and vicinity studies and the canyon alcoves provide the majority of dates greater than 10,000 B.P. (8050 B.C.) in the alluvial studies. A similar statement can be made for the dung and packrat dates. In this category, we have tripled the chronology.

The importance of the extended chronologies lies in the ability to approach the Pleistocene extinction event at $\pm 11,000$ B.P. (9050 B.C.) extinction, not from the present back in time to the extinction event. Fecal, osteological, and botanical records can be correlated in a temporal framework for the past 40,000 years, giving an unduplicated paleoenvironmental reconstruction for the Colorado Plateau.

Faunal Analyses

Faunal evidence is present in the canyon alcoves in three categories: 1) dung; 2) osteological material; 3) dentition, in about that order of relative abundance. Pellets of the mountain goat-sheep-deer-oxen are the most abundant paleontological remains in any single alcove. Boluses of bison and mammoth are relatively common based on minimal subsurface

testing and surficial collection. Bones of extinct mountain goat (*Oreamnos harringtoni*), mammoth (*Mammuthus columbi*), and marmot (*Marmota flaviventris*) have been recovered, primarily from surface exposure, although some excavation of the mammoth in Mammoth Alcove was accomplished. Dentition of horse (*Equus* sp.) and marmot were collected at the surface of Hooper's Hollow sediments. Packrat middens occur in the alcove fill, and are being analyzed for botanical and zoological information.

Table 12 indicates the paleontological remains recovered to date, and their location. Bechan Cave provided the first occurrence of the shrub ox (*Euceratherium collinum*) for the state of Utah, by dentition, and possibly by dung, and possibly by hair analysis. Recognition of the origin of the dung allows us to assign the presence of this species at Grobot Grotto and Hooper's Hollow. More detailed investigation will undoubtedly prove its presence at other alcoves, as well. Harrington's mountain goat is known by bone and dung, from all but BF Alcove. Mammoth is known from Grobot and Mammoth Alcove; it is suspected at Hooper's Hollow. Camel has only been identified by dung at BF Alcove thus far. Bison is present at Grobot and Mammoth, and expected at Hooper's Hollow.

Hair analyses, when completed, should independently confirm the presence of the known species, plus add additional fauna not yet recognized by bone, teeth, or dung. The success of this method led to identification of several species at Bechan Cave, that were unknown from "standard" paleontological evidence.

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

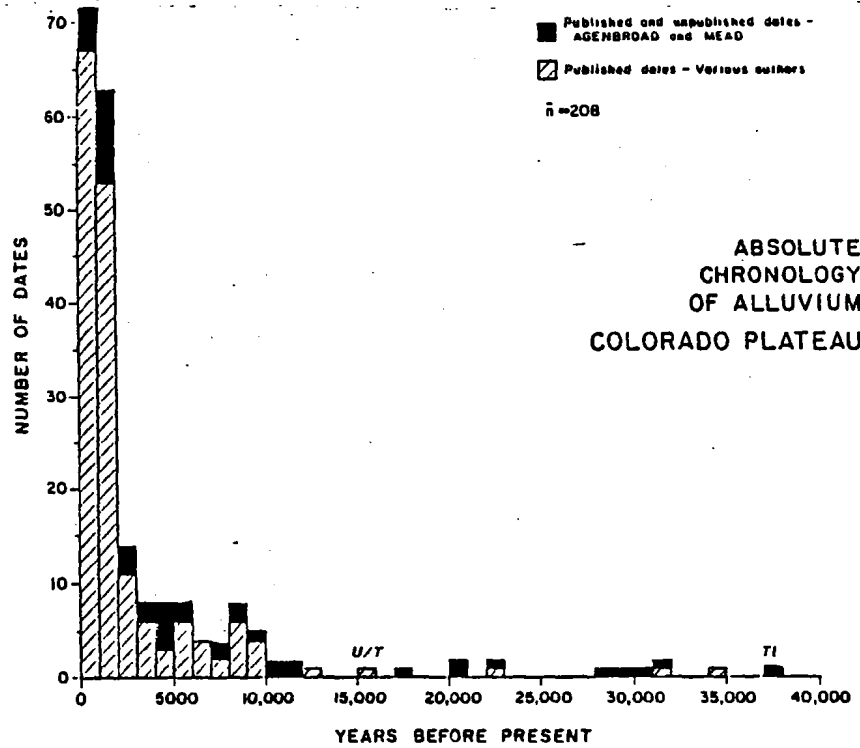


Figure 26. Absolute chronology of alluvium.

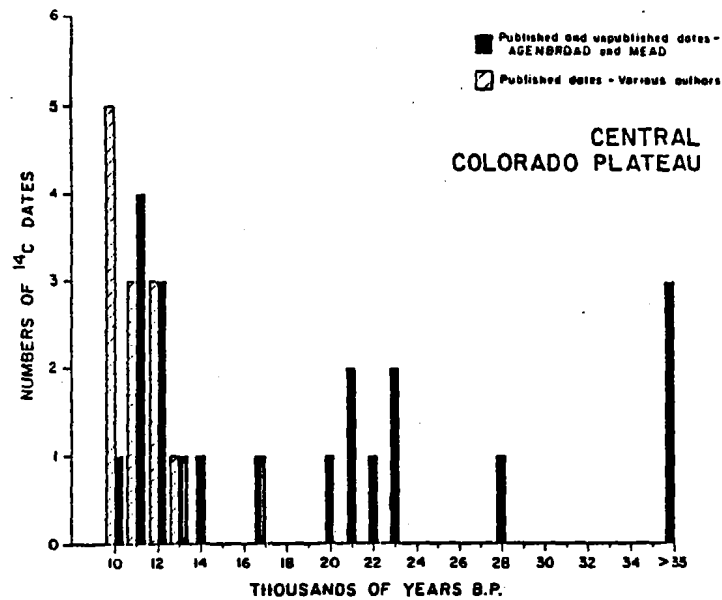


Figure 27. Absolute chronology of dung and packrat middens.

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

To date, several extralocal species are known, such as Douglas fir (*Psuedotsuga menziesii*) and Rocky Mountain maple (*Acer glabrum*). A modern botanical sample is in progress, both in the canyons and alcoves, and on the adjacent uplands. Further studies of the botanical communities from the highlands of the Kaiparowits Plateau are probable.

Macrobotanical, palynological, and microhistological data from the dung pellets and boluses will provide detailed dietary analyses for the identified species, with radiocarbon temporal control.

Conclusions

Fortymile Canyon and Willow Creek Canyon are southwestern tributaries to the Escalante River. These deep, narrow canyons have numerous large alcoves. Many of these alcoves contain sedimentary, botanical, and paleontological remains. The chronology established for the deposits exceeds 28,000 B.P. (26,050 B.C.) based on C-14 dates from the upper third of the deposits.

The protected, dry environment has preserved botanical and zoological materials (especially dung) of extinct Pleistocene fauna. With tight control by radiocarbon dates, the paleoenvironment of this portion of the Colorado Plateau can be established. Correlation of this record with the cave fill and canyon alluvium at Bechan Cave will allow a more regional reconstruction.

Sedimentary and botanical chronologies have been expanded up to three-fold, allowing detailed analyses throughout the last 30,000-40,000 years. This in turn, will allow investigation of the possible causes of Pleistocene extinction at $\pm 11,000$ B.P. (9050 B.C.) for the 20,000 years preceding the event.

Osteological/Dental Remains:

<u>Locality</u>	<u>Mtl</u>	<u>Fauna</u>
Hoopers Hollow	metapodial	<i>Oreamnos harringtoni</i>
Hoopers Hollow	tooth	<i>Equus</i>
Hoopers Hollow	mandible	<i>Marmota</i>

Fecal Remains:

Grobot Grotto	bolus	<i>Mammuthus</i>
	bolus	<i>Bison</i>
	pellet	<i>Oreamnos</i>
	pellet	cf. <i>Euceratherium</i>
BF Alcove	pellet	cf. <i>Camelops</i>
Hoopers Hollow	pellet	<i>Oreamnos</i>
	pellet	cf. <i>Euceratherium</i>

Table 12. Fauna from the canyon alcoves.

Pollen and Macrobotanical Analyses

Palynologic analyses of several alcoves are in progress, from dated horizons, as well as earlier material. Macrobotanical collections from dung, packrat middens, and stratified plant litter are in process.

INVESTIGATIONS OF A PLEISTOCENE MEGAFAUNAL DUNG BED

Note: Funding by the National Science Foundation, the National Geographic Society and the National Park Service has allowed initial investigation of these unique deposits, and discovery of new ones. Results obtained from these studies have been instrumental in the successful application to the National Science Foundation, for multiple-year funding to investigate these deposits, and expand the research

CHAPTER 7

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK, SOUTHEASTERN UTAH

Jim I. Mead and Larry D. Agenbroad

Since 1985 the Quaternary Studies Program at Northern Arizona University has been conducting multidisciplinary research on the central Colorado Plateau, Arizona-Utah. Work is ongoing in both Glen Canyon National Recreation Area and Canyonlands National Park (CANY). Salt Creek, CANY, has been the site of an intensive survey and data gathering project incorporating archaeology, Quaternary geology, and paleoecology. This is a report of the molluscs recovered from radiocarbon-dated alluvium in the upper portion of Salt Creek.

Studies of the modern malacology of the Southwest have been numerous and intensive since the early 1900's, albeit rare in some local areas. Much of the Colorado Plateau has gone largely untouched, especially for the arid central region (Bequaert and Miller 1973; Chamberlin and Roscoe 1948). Late Pleistocene and early Holocene age malacofaunas are largely unknown or inadequately understood for the majority of the Colorado Plateau.

CENTRAL COLORADO PLATEAU

The central Colorado Plateau is a region of flat and fold oriented Permian, Triassic, Jurassic, and Cretaceous sedimentary formations. Elevations of much of this region range from 1220 m to 2290 m. Tertiary volcanic intrusions (predominately diorite porphyry) have produced mountains (Abajo, Henry, La Sal, and Navajo) protruding through the sedimentary rocks (Figure 28). Now these mountains are boreal-montane "islands", producing elevations of up to 3540 m, which are surrounded by sagebrush/blackbrush steeps and pinyon-juniper woodlands.

The following is a discussion of the localities on the central Colorado Plateau that have a published record of Quaternary molluscs. Surrounding this region are a few additional late Quaternary molluscan studies including Chaco Canyon, New Mexico (Drake 1948; Hall 1980), Sudden Shelter, Utah (Baerreis 1980), and Winona (Batchelder and Reger 1968; Colton

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

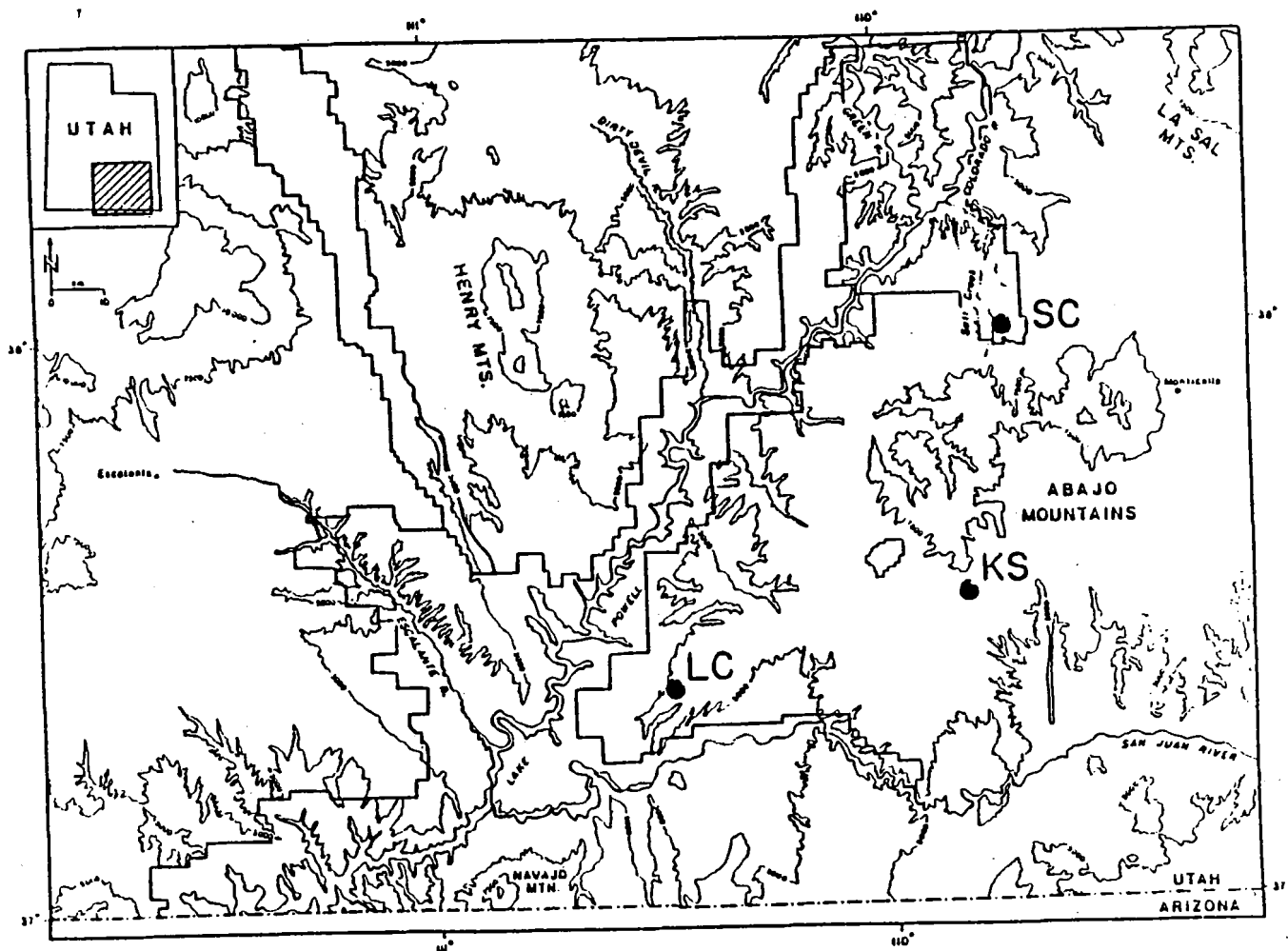


Figure 28. Southeastern Utah showing locations for Snail Knob on Salt Creek (SC), Kane Springs (KS), Lake Canyon (LC) and various mountains of the central Colorado Plateau.

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

1929), Meteor Crater (Reger and Batchelder 1971), and Tsegi Canyon (Briscoe 1974), Arizona.

Henry Mountains

The Henry Mountain range in elevation from 1830 m to 3540 m and are comprised of at least five major peaks (Figure 28). Chamberlin and Berry (1930) collected molluscs from the mountains and the immediate surrounding region. A modified list of their findings is presented in Table 13. Although one considers the mountains part of an arid region, aspen and birch forests, riparian woodlands, and numerous springs provide habitat for a wide variety of terrestrial and aquatic gastropods and pelecypods. Within 40 km to the west is the high lake country of Boulder Mountains (3350 m elevation). The collection from the Henry Mountains is the only highland record of modern molluscs from the central Colorado Plateau.

Kane Springs

Kane Springs is located in Kane Gulch, in the northern end of Cedar Mesa, immediately south of Natural Bridges National Monument (Figure 28). The elevation of the springs is approximately 2005 m, but within about five kilometers to the north the land abruptly rises to 2440 m elevation on Elk Ridge. The springs provided a 5.4 m soil column which was samples for molluscs (Salkin 1975; Table 13).

The molluscs recovered from Kane Springs are all sub-fossil in age and are grouped into eight zones. One radiocarbon date was analyzed on Zone 3 (4.6 to 4.1 m below the surface), indicating an age 7385 ± 80 B.P.: 5435 B.C. (years before present; Wis-742) (Salkin 1975). Assuming a possible constant deposition rate and a terminal date for the column (surface of Zone 8) of a modern (Agenbroad, personal communication in Salkin

1975), a deposition rate of approximately 0.06 cm per year is determined. With this assumption, an extrapolated maximum age for the bottom of the column, at 5.4 m, is approximately 8718 B.P. (6768 B.C.)

Lake Pagahrit

Lake Pagahrit is presently a dry and incised playa in Lake Canyon (Figure 28); however, in 1879 Mormon pioneers were able to observe a substantial lake (Lyman 1963). The lacustrine deposits are located on Red Rock Plateau at an elevation of 1220 m. Lyman (1963) described the lake of 1891 as having a green meadow extending up from the south where two springs emptied into the lake. In November 1915, the dam was breached and arroyo cutting began. The thickness of the lacustrine deposits vary, a radiocarbon age on peat at the base of one section is 4010 ± 100 B.P.: 2060 B.C. (I-8632) (Lipe et al. 1975). However, other sections of the canyon system indicate that many more stratified meters occur below the 4000 year date. Lipe et al. (1975) provide a preliminary report of the molluscs recovered from a 10 m column (Table 13).

Salt Creek

The Salt Creek drainage is a 40 km long drainage beginning on the northwest side of Shay Mountain (Abajo Mountains) at 3045 m elevation and terminates at 1195 m elevation along the Colorado River. Along the main channel system are two major side drainages, Salt Creek Pocket, in the low reaches, and Big Pocket, near the headwaters.

Snail Knob is in the upper Salt Creek and has a drainage of at least 47 km², above the confluence with Big Pocket. The combination of high elevations, steep slopes, and relatively impermeable surficial geology (Cutler Group) provides large

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

	Henry Mts. Modern	Lake Pagahrit ≤ 4000 B.P.	Kane Springs ≤ 8000 BP	Snail Knob			
				Top	8600	Sand	11,000
<i>V. gouldii</i>			x				
<i>V.g. coloradensis</i>	x						
<i>V. modesta</i>	x						
<i>V. binneyana</i>			x				
<i>V. sayi</i>	x						
<i>Vallonia</i> sp.			x				
<i>V. perspectiva</i>			x				
<i>V. cyclophorella</i>	x						
<i>V. gricilocosta</i>	x		x	x	x	x	
<i>Stagnicola</i> sp.			x				
<i>S. elodes nuttalliana</i>	x						
<i>S. caperata</i>	x						
<i>Possaria</i> sp.					x	x	x
<i>P. obrussa</i>	x						
<i>F. parva</i>						x	
<i>F. modicella</i>	x					cf	
<i>Physa virgata</i>	x	cf.					
<i>Gyraulus parvus</i>	x	x	x				
<i>Helisoma tenue</i>	x	x					
<i>Drepanotrema aeruginosum</i>	x						
<i>Laevapex fragilis</i> (= <i>californica</i>)		x					
<i>Valvata humeralis</i>	x	x					
<i>Sphaerium</i> sp.	x						
<i>Pisidium</i> sp.	x	x				x	x
<i>P. casertanum</i>							x
<i>P. walkeri</i>						x	cf

Table 13. Mollusc samples from several localities designated in Figure 28.

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

amounts of runoff, resulting in high discharge. Flash flood events, scouring major portions of drainage, have been numerous since the middle Holocene, contrasting to ponding regimes that have occurred during the early Holocene and late Pleistocene (Figure 29).

Although major scouring of the early Holocene and late Pleistocene sediments has occurred, remnants still exist such as Snail Knob, the upper portion of Terrace 6 (T_6) (Figure 29). Four samples of sediments were removed from T_6 for the recovery of molluscs (Table 13). The fossil locality consists of a multiple stratified layers of silt and clay ('Top' and '8600' samples), with a bottom unit of coarse-medium sand ('Sand' sample). Radiocarbon analysis of carbon from the middle of Snail Knob produced a date 8680 ± 120 B.P.: 6730 B.C. (Beta-16593; '8600' sample). This indicates that T_6 dates no younger than approximately 8500 to 8000 B.P. (6550 to 6050 B.C.), beginning the middle Holocene Altithermal. Stratigraphically below Snail Knob but still within T_6 we recovered charcoal that produced an age of $11,170 \pm 300$ B.P.: 9220 B.C. (Beta-19283; '11,000' sample), indicating a late Pleistocene-age terrace sequence.

MOLLUSCS

The following is an annotated list of the molluscs recovered from Snail Knob. The ordering of the species follows Bequaert and Miller (1973) and is so indicated by the number after the name of the species. Table provides the species list from Snail Knob and the other molluscan localities on the central Colorado Plateau mentioned above.

Phylum Mollusca
Class Gastropoda

Subclass Pulmonata
Order Stylommatophora
Family Oreohelicidae

Oreohelix sp.

Correct identification of *Oreohelix* requires dissection of the genitalia (Bequaert and Miller 1973), which is not preserved in fossil form, thus the specific status of the Snail Knob specimens is uncertain. This genus is the largest land snail presently living in the region and is primarily native to the Rocky Mountain and Great Basin regions. *Oreohelix* is not known to inhabit the immediate area of Snail Knob, but it is reported from the Henry Mountains (Chamberlin and Berry 1930) and probably lives in the Abajo Mountains above the headwaters to Salt Creek. Because the species identification is not known, we do not have a detailed habitat reconstruction. The genus does require rocky substrate.

Family Euconulidae

Euconulus fulvus (Muller 1774) 83

Euconulus fluvus is a boreal species indicator occurring in the Canyonlands region above approximately 1525 m elevation. It is found on the Henry Mountains in wooded leaf litter habitats (Chamberlin and Berry 1930).

Family Zonitidae

Hawaiiia minuscula (Binney 1841) 86

Bequaert and Miller (1973) indicate that *Hawaiiia minuscula* is probably the most common snail in the arid Southwest. Although not reported alive in the Canyonlands region, this eurytopic species is found in the mesic and relatively xeric habitats in Arizona.

Family Endodontidae

Discus cronkhitei (Newcomb 1865) 91

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

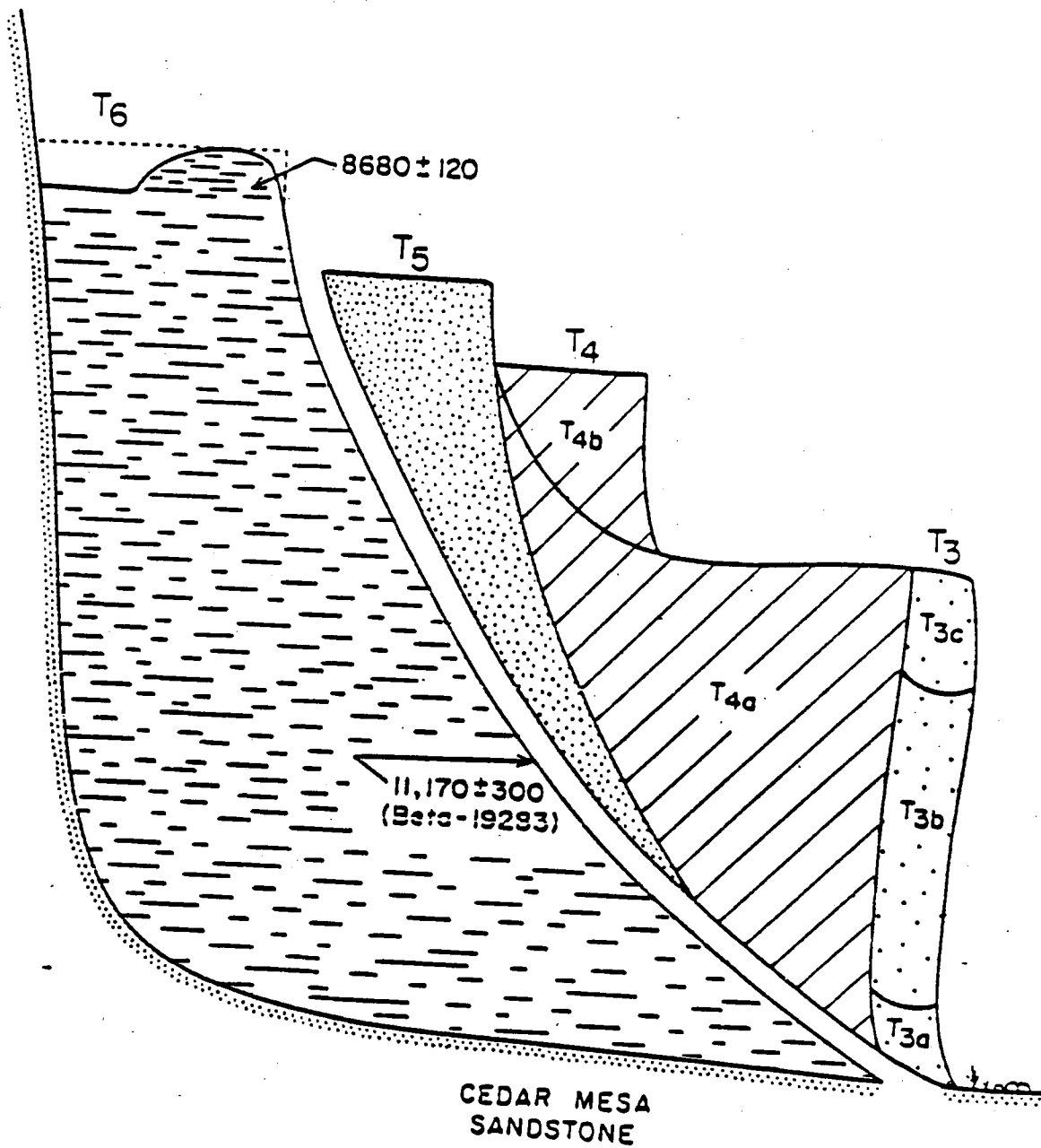


Figure 29. Stylized cross-section of alluvium containing molluscs, Upper Salt Creek (Snail Knob) with terrace sequences, C-14 dates, and snail sample localities.

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

Discus cronkhitei is a widely distributed species occurring from 840 m to 3,660 m elevation in Arizona (Bequaert and Miller 1973). Although typically found in woodlands and forests, *D. cronkhitei* does live in a densely vegetated areas in xeric habitats. The species is known to live in the Canyonlands region (Chamberlin and Berry 1930; Salkin 1975).

Family Succineidae

Succinea cf. *S. avara* (Say 1824) 100

Identifying the shells of the members within this genus is full of difficulties and therefore the specific identity is referred. The shells recovered appear most similar to those described as *S. avara*. The species is presently living in the Henry Mountains and is known from the late Holocene of Lake Pagahrit and Kane Springs (Chamberlin and Berry 1930; Lipe et al. 1975; Salking 1975). The snails live under debris near bodies of water or in leaf material in forested habitats.

Succinea cf. *S. grosvenorii* (Lea 1864) 101

Identifying the shells of the members within this genus is full of difficulties and therefore the specific identity is referred. Some shells from Snail Knob had inflated and strongly convex whorls, with deep sutures and coarse sculpture, being similar the tests of *S. grovenorii*. This species frequents leaf debris and bodies of water. Additional shells were recovered that could not be

referred to the species level.

cf. *Oxyloma* sp.

A shell fragment is identified as *Oxyloma*. *Oxyloma* is a genus with a distinctive shell and anatomy, which is required for specific

identification. *Oxyloma* is widespread in the Holocene of the Holarctic but is considered extirpated in Arizona (Bequaert and Miller 1973). However, it is known as a fossil in southeastern Arizona (Mead 1979) and to occur, both fossil and living, in western New Mexico (Ashbaugh and Metcalf 1986; Franzen 1964). *Oxyloma* is not known to presently live in the region of the Canyonlands. Typically the genus is found living along river and lake banks or on vegetation within water.

Family Pupillidae (including Vertiginidae)

Pupilla muscorum (Linne 1758) 117

Shells of *Pupilla muscorum* recovered in Canyonlands are typical pupillids in shape but do not have any teeth in the aperture. This species is found living in the Henry Mountains and was recovered at Kane Springs (Chamberlin and Berry 1930; Salkin 1975). In Arizona and New Mexico the snail is usually found at higher elevations (Agassizi Peak, 3,690 m elevation, northern Arizona), but it can occur in more arid habitats (Ashbaugh and Metcalf 1986; Bequaert and Miller 1973; Pilsbry 1948).

Vertigo sp.

Shells of *Vertigo* are typical pupillids in shape, small, and contain a wide array of teeth and tooth configurations (Pilsbry 1948). Unfortunately the *Vertigo* from Canyonlands could not be readily identified. The shells recovered are cylindrical-oblong in shape, 1.75 to 2.10 mm long, and are weakly striate. There are four teeth; the parietal is long, the columellar is blunt, the lower-palatal is large to small, and the basal fold is almost indistinguishable to small and blunt. These specimens are grouped here as *Vertigo* Species A. A few other

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

Vertigo shells were fragments that could not be identified.

Vertigo gouldii and *V. binneyana* are known from Kane Springs (Salkin 1975) and *V. g. coloradensis*, *V. sayi*, and *V. modesta* are known to live in the Henry Mountains (Chamberlin and Berry 1930).

Family Valloniidae

Vallonia gracilicosta (Reinhardt 1883)

Shells identified as belonging to *Vallonia gracilicosta* had many striae, a wide umbilicus and a broad peristome, which permitted differentiation from *V. perspective* and *V. cyclophorella*. Although the species is not known to live in Arizona at present, it is recorded from most of the Southwest (Bequaert and Miller 1973). *V. gracilicosta* is reported from the Henry Mountains and Kane Springs (Chamberlin and Berry 1930; Salkin 1975). The species is found in cienegas, on floodplains, riparian forests, and mountain canyons (Ashbaugh and Metcalf 1986).

Order Basommatophora

Family Lymnaeidae

Fossaria parva (Lea 1841) 134

Shells of this *Fossaria* had the inner lip markedly reflected over the umbilicus allowing the specific identification. Although not recorded from the immediate area of Canyonlands, *F. parva* is common in the Southwest (Ashbaugh and Metcalf 1986; Bequaert and Miller 1973). This species is considered an aquatic snail; however, it is a lung-breather and is found near wet, marshy places, invariably just out of the water (Baker 1911; Russell 1967).

Fossaria cf. *F. modicella* (Say 1825) 135

A single shell of *Fossaria* is referred to *F. modicella* for the following reasons: the first whorl is small and the second is large, and the peristome is thin and reflected over the umbilical region, being rolled at the contact on the parietal wall, but is more erect below. The species is common in the Southwest (Bequaert and Miller 1973), being found in muddy regions along water bodies (Baker 1928). *F. modicella* is presently living in the Henry Mountains (Chamberlin and Berry 1930) and probably can be found in the Abajo Mountains adjacent to Salt Creek. Additional specimens of *Fossaria* were not complete enough to permit specific identification.

Class Bivalvia

Order Heterodonta

Family Sphaeriidae

Pisidium casertanum (Poli 1795) 149

Identification of the *Pisidium* species follows the criteria in Herrington (1962). *P. casertanum* is widespread in Arizona and New Mexico, and it is found living in the region west of the Abajo Mountains (Ashbaugh and Metcalf 1986; Bequaert and Miller 1973; Chamberlin and Berry 1930). Numerous remains of *Pisidium* were recovered from the sediments of Lake Pagahrit; however, they were not identified to species. This species of the clam lives in lentic and lotic waters and can withstand muddy habitats and dessication.

Pisidium walkeri (Sterki 1895) 152

Identification of the *Pisidium* species follows the criteria in Herrington (1962). *P. walkeri* does live in the Southwest, but it does not seem to be as common as *P. casertanum*. It is not known whether or not it presently lives in the region of Canyonlands. More specimens identified as *P. walkeri*

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

were recovered at Snail Knob than were remains of *P. casertanum* (11 vs. 3 respectively). Additional specimens of *Pisidium* were not identified to species. Typically *P. walkeri* lives in rivers, creeks, and small lakes.

DISCUSSION AND CONCLUSIONS

Four sedimentary units in the Snail Knob locality of T₆ were sampled for molluscs. Twelve species were identified (2 clams and 10 snails), representing both aquatic and terrestrial habitats. Aquatic habitats are represented by *Pisidium casertanum*, *P. walkeri*, *Fossaria modicella*, and *F. parva*. Paludal (marsh) habitats are represented by *Vertigo* and *Oxyloma*. Terrestrial habitats are represented by *Pupilla muscorum*, *Vallonia gracilicosta*, *Succinea avara*, *S. grosvenorii*, *Oreohelix*, *Hawaiiia minuscula*, and *Discus cronkhitei*.

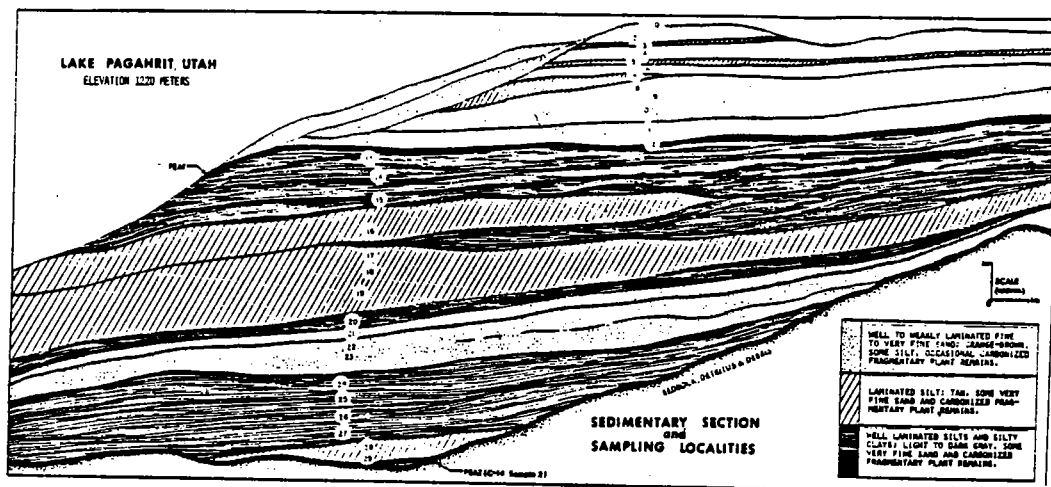
For the most part of the two lower samples represent periods of time (late Pleistocene and early Holocene) in the canyon when much of the habitat above Big Pocket had wet marshy regions and possibly areas of open water, although this latter habitat may have only been seasonal. By approximately 8600 B.P. (6650 B.C.) it appears that much of the area was drying to the point where the clams and most of the aquatic snails (only one shell of *Fossaria* sp.) are not represented in the unit. Although probably not an open body of water during this time, the species present do indicate that at least a paludal environment was in existence, probably in the middle of the canyon. All implications are that by the time the top of T₆ is deposited, the canyon was drying out, but moisture and possibly even a paludal environment was still

prevalent. In summary, a marsh environment with varying degrees of available water were in existence throughout the upper Salt Creek, above Big Pocket, from at least the late Pleistocene (11,170 B.P.: 9220 B.C.) to approximately 8500 to 8000 B.P. (6550 to 6050 B.C.), when the canyon experienced an arroyo cutting phase. At this point and time, the canyon bottom lost all effective water resource.

The molluscan data present in the Snail Knob locality does not directly imply climate, but merely record the availability of local water. One possible scenario is that the molluscan sequence is recording a change in the local climatic regime, culminating in a shift at (or by) approximately 8000 B.P. (6050 B.C.). Although the entire Salt Creek may have experienced the above-described environment, it is only known for that area above Big Pocket. As an alternative scenario, it is possible that a sand dune and/or beaver dam at the confluence of Big Pocket and upper Salt Creek created the paludal environment. Whatever mechanism dammed the Salt Creek created the local water resource. Removal of the dam at approximately 8500 to 8,000 B.P. (6550 to 6050 B.C.) provided the termination of the paludal environment.

The Snail Knob molluscan sequence is one of but a few molluscan sequences on the central Colorado Plateau. Although molluscs were recorded from the Lake Pagahrit sequence (Figure 30), the section sampled dated back only to 4010 B.P.: 2060 B.C. (Lipe et al. 1975). All the molluscs were aquatic, except for the rare terrestrial (near shore) species. The great quantities of

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK



SAMPLE NO.	TAXA		
3.	<i>Physa</i> cf. <i>P. virgata</i> <i>Succinea</i> sp. <i>Valvata humeralis</i>	Gould, 1855 Say, 1829	(juveniles) (juveniles)
5.	<i>Valvata humeralis</i> <i>Physa</i>	Say, 1829	(many juveniles) (juveniles)
6.	<i>Gyraulus parvus</i> <i>Ferrissia fragilis</i>	(Say, 1817) (Rowell, 1863)	
7.	<i>Valvata humeralis</i> <i>Physa</i> (fragments) <i>Physa</i> cf. <i>P. virgata</i>	Say, 1829 Gould, 1855	
8.	<i>Valvata humeralis</i> <i>Ferrissia fragilis</i>	Say, 1829 (Rowell, 1863)	
9.	<i>Physa</i> cf. <i>P. virgata</i>	Gould, 1855	
12.*	<i>Valvata humeralis</i> fragments of: <i>Physa</i> , <i>Valvata</i> perhaps <i>Planorbella</i> <i>Physa</i> cf. <i>P. virgata</i> <i>Planorbella</i> <i>Gyraulus parvus</i>	Say, 1829 Gould, 1855	(juveniles)
13.	<i>Valvata humeralis</i> <i>Planorbella</i> sp. <i>Physa</i> cf. <i>P. virgata</i> <i>Gyraulus parvus</i> <i>Valvata humeralis</i>	Say, 1829 Gould, 1855	
14.	<i>Gyraulus parvus</i> <i>Valvata humeralis</i> <i>Physa</i> , sp.	(Say, 1817) Say, 1829	(juveniles)
15.*	<i>Physa</i> fragments <i>Physa</i> cf. <i>P. virgata</i> <i>Gyraulus parvus</i>	Gould, 1855 (Say, 1817)	(juveniles)
16.*	<i>Physa</i> cf. <i>P. virgata</i> <i>Gyraulus parvus</i>	Gould, 1855 (Say, 1817)	(juveniles)
20.*	<i>Gyraulus parvus</i> <i>Valvata humeralis</i> <i>Physa</i> cf. <i>P. virgata</i>	(Say, 1817) Say, 1829 Gould, 1855	
23.*	<i>Physidium</i> sp.		
24.	<i>Physa</i> cf. <i>P. virgata</i>	Gould, 1855	(juveniles)
25.	<i>Gyraulus parvus</i> <i>Planorbella</i> sp. <i>Physa</i> cf. <i>P. virgata</i>	(Say, 1817) Gould, 1855	
26.	<i>Gyraulus parvus</i> <i>Planorbella</i> sp.	(Say, 1817)	(juveniles)
27.	<i>Gyraulus parvus</i> <i>Planorbella</i> sp. <i>Physa</i> cf. <i>P. virgata</i>	(Say, 1817) Gould, 1855	
28.*	<i>Physidium</i> sp.		

Samples marked with * contain one or more species of *Physidium* to be identified at a later date.

Figure 30. Molluscan sequence and locality at Lake Canyon (Lipe et al, 1975)

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

Pisidium valves were not identified to species level.

The Kane Springs molluscan sequence (Figure 31) is more similar to that recovered at Snail Knob than to the Lake Pagahrit fauna. The oldest direct date is 7385 B.P. (5435 B.C.), with the extrapolated age of possibly 8718 B.P. (6768 B.C.) for the bottom of the profile (Salkin 1975). From Zone 1 to 3 (5.4 to 4.1 m deep; dating $\geq$ 7385 B.P.: 5435 B.C.) the sequence records a wet period, one with possibly a shallow pool of water. In contrast to the Snail Knob paludal sequence that appears to terminate at about 8000 B.P. (6050 B.C.), the Kane Springs wet environment seems to build uninterrupted until the top of Zone 6 (1.3 m deep, age unknown) when there appears to be an onset of drier conditions and a period of erosion (Zone 7; 1.3 to 0.1 m deep; Salkin 1975). The important factor between the two molluscan localities seems to be that the local climate permitted the establishment of water resources, although the actual governing mechanism seems to have been different (establishment of a spring vs a dammed stream).

Although the molluscan data from both Snail Knob and Kane Springs do not dictate that the local climate was wetter during the late Pleistocene and early Holocene, that is one of the possible mechanisms. On the southwest side of the Abajo Mountains, Betancourt (1984) recovered a sequence of predominantly Holocene packrat middens (Mammalia: Rodentia: *Neotoma*). The late Pleistocene is observed via the packrat middens as a time when there was a cooling of the mean annual temperature of 3 to 4°C and an increase of a mean annual precipitation estimated at from 35 to 60% (compared to today) (Betancourt

1984). These estimates are based on elevational analogs, projecting the present back into the late Pleistocene. The plant remains in the middens record a major local community reorganization in the early Holocene. Betancourt (1984) believes that between 10,000 and 8000 B.P.: 8050 and 6050 B.C. (the time equivalent to the upper Snail Knob sequence) that the present monsoonal boundary began to approach its present position; therefore, an increase in summer temperatures and intensified summer precipitation occurred (at least by middle Holocene). The packrat midden sequence from Salt Creek, dating from approximately 700 to $\geq$ 38,000 B.P.: 36,050 B.C. (12 midden units), does not record the period from 10,800 to 4000 B.P.: 2050 B.C. (Mead et al. 1987).

Did the change in climate make the paludal environment in upper Salt Creek by merely adding more water to the canyon, or did it permit a dam to form, thereby enabling a paludal habitat to form? Possibly the shift of intensified summer precipitation during the beginning of the middle Holocene (Betancourt 1984) actually eroded the dam to the upper Salt Creek marsh.

Either scenario seems plausible based on the previous evidence. In either case, paludal habitats were in existence in upper Salt Canyon during the late Pleistocene and into the early Holocene. It is at this time that the Archaic peoples were visiting the upper Salt Creek. Remnant fires and even camping areas are preserved along the canyon edges of upper Big Pocket. Although we do not know for sure that these hunter-gatherers were using the paludal resources in the nearby upper Salt Creek, certainly they knew that they existed. Such an environment certainly provided water

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

for the people as it may have for big game mammals, fur-bearing mammals, and water fowl.

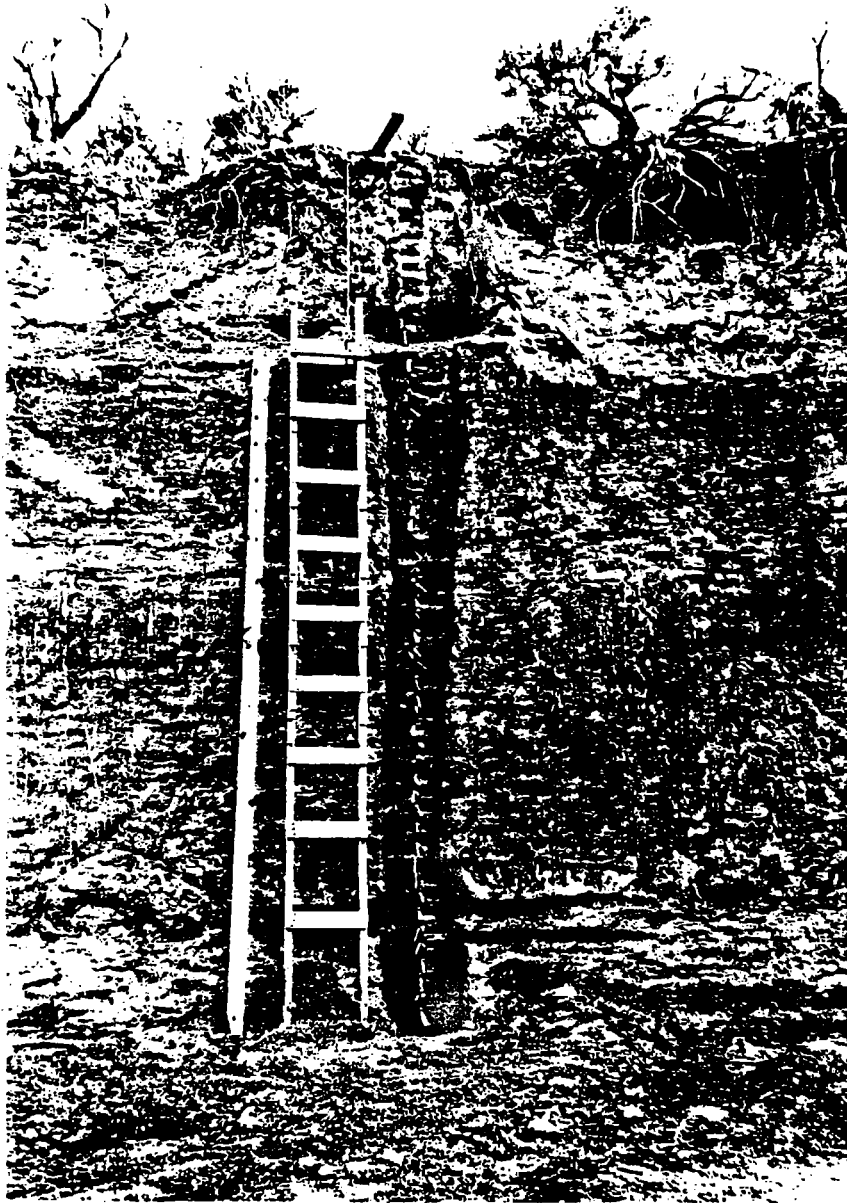


Figure 31. Molluscan sequence at Kane Springs (Agenbroad, 1975, Salkin 1975)

MOLLUSCA FROM SNAIL KNOB, CANYONLANDS NATIONAL PARK

	LEVEL	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	
<i>Deroceras laeve</i>																																						
<i>Discus cronkheiti</i>			1													1	2	4	41	18	15	4	6															
<i>Gastropoda pellucida hordacella</i>																																						
<i>Euconulus fulvus</i>										2																												
<i>Helicodiscus eigenmanni eigenmanni</i>											1																											
<i>Helicodiscus parallelus</i>											2						1																					
<i>Pupilla Hebes</i>																				1																		
<i>Pupilla muscorum</i>											1												1															
<i>Purpoides hordaceus</i>																																						
<i>Stagnicola sp.</i>																	4	6	4	19			98															
<i>Punctum minutissimum</i>																		2	5		186	1																
<i>Succineidae</i>																		26	16	23	11	6	14															
<i>Vallonia gracilicosta</i>																		7	83	45	5	2																
<i>Vallonia perspectiva</i>																																						
<i>Vallonia sp.</i>																																						
<i>Vertigo binneyana</i>																																						
<i>Vertigo gouldi</i>																			1																			
<i>Vertigo sp.</i>																																						
<i>Zonitoides arborea</i>																																						
<i>Ostracoda</i>																																						
Unidentified hellform																																						
Unidentified succiform																																						
Unidentified specimen																																						
<i>Gyraulus parva</i>																																						
TOTAL	0	0	7	12	10	23	43	10	14	17	28	34	80	89	48	45	82	553	401	285	30	138	660	48	591	57	35	48	321	268	98	15	15	66	442	669		

Correlation of Level Numbers and Depth Below Datum

Level No.	Depth (meters)
1	Surface
2	0.0-0.1
3	0.1-0.2
4	0.2-0.3
5	0.3-0.4
6	0.4-0.5
7	0.5-0.6
8	0.6-0.7
9	0.7-0.8
10	0.8-0.9
11	0.9-1.0
12	1.1-1.2
	1.2-1.3
	1.3-1.4
	1.4-1.5
	1.5-1.6
	1.7-1.8
	1.9-2.0
	2.1-2.2
	2.3-2.4
	2.5-2.6
	2.7-2.8
	2.9-3.0
	3.1-3.2
	3.3-3.4
	3.5-3.6
	3.7-3.8
	3.9-4.0
	4.1-4.2
	4.3-4.4
	4.5-4.6
	4.7-4.8
	4.9-5.0
	5.0-5.1
	5.1-5.2
	5.3-5.4

Figure 31 (continued): Species Recovered From The Kane Springs Column by Level

CHAPTER 8

SUMMARY AND CONCLUSIONS

L. D. Agenbroad

Investigations of Quaternary resources in Glen Canyon National Recreation Area (GLCA) and Canyonlands National Park (CANY) during our third contract year have enhanced and expanded the results of the previous seasons. Several accomplishments have been made, in line with the scope of work for the contract, and the research design and hypotheses used in assessing the Quaternary resources of these National Park Service lands.

Initially, we established that both study areas (GLCA and CANY) have extensive Quaternary resources, much of which has been previously unknown, or poorly understood. Secondly, these resources provide large quantities of data, with minimal impact on the resource, to establish paleoenvironmental and paleoclimatic information prior to, and after the impact of human presence on these resources.

We have documented the presence, and relative abundance of now extinct Pleistocene animals- many of which served as the primary resource base for the earliest human migrants, the Clovis and Folsom groups. In fact, the relative abundance of both faunal

resource base and the scatter of diagnostic artifactual material, characteristic of these groups, has helped shatter a myth regarding the Paleoindian period on the Colorado Plateau (Figures 32 and 33). There were Paleoindians on the Plateau, and their distribution corresponds with the known distribution of their major prey animals, the mammoth and bison.

Analysis of dung deposits from Pleistocene animals, pollen preserved in alluvial and paludal sequences, and the independent analysis of packrat middens has documented major paleoenvironmental and paleoclimatic changes in the past 11,000 years. A radiocarbon controlled alluvial and paleohydrologic sequence has further documented cycles of erosion and deposition- as consequences of changing moisture conditions through the Holocene (last 10,000 years).

Extinction of the Pleistocene fauna, major changes in floristic communities, changing water availability, and other environmental factors greatly influenced the cultural adaptations and change, on the Plateau.

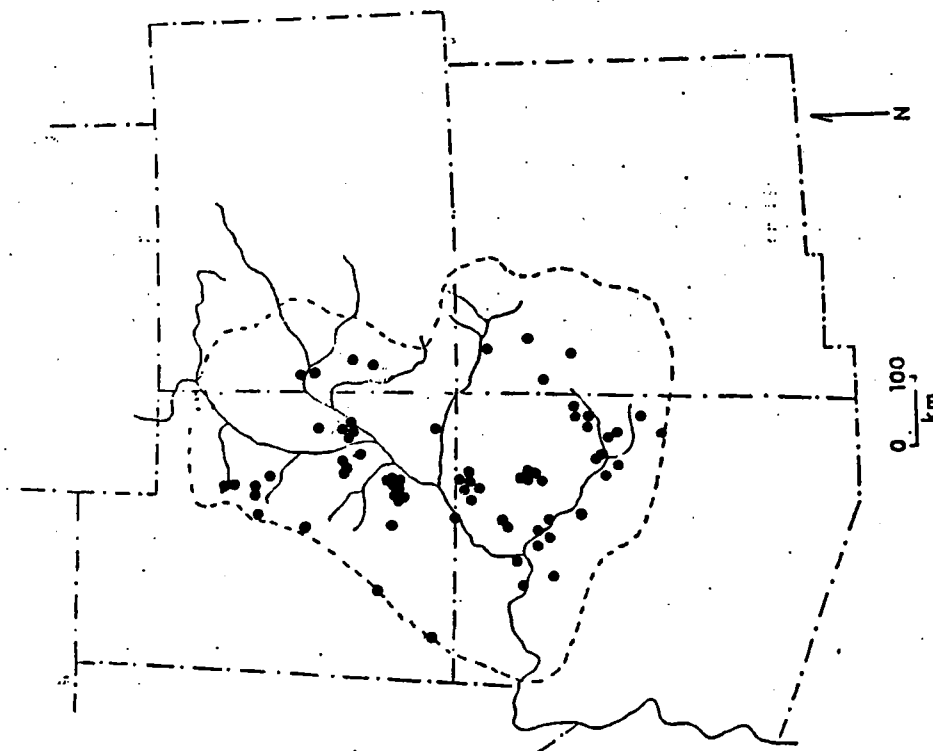


Figure 32. Distribution of reported mammoth and bison localities on the Colorado Plateau.

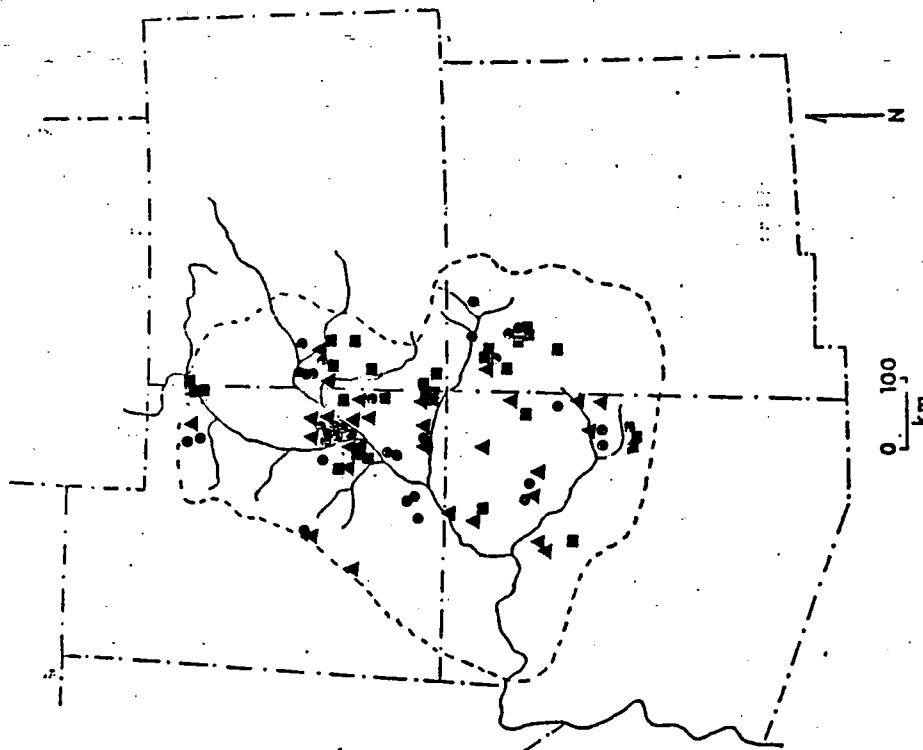


Figure 33. Distribution of reported Clovis, Folsom and Plano projectile points on the Colorado Plateau.

SUMMARY AND CONCLUSIONS

In addition to the paleoenvironmental and paleoclimatic information, the Quaternary investigations of the paleoenvironmental record preserved in GLCA and CANY have established a long cultural presence and chronology. These data have been provided to the archaeological contractors, but are outside the archaeological survey boundaries, in some cases. These data added to and incorporated in the archaeological syntheses document the presence of human cultures in the study area from Paleoindian time through protohistoric and historic groups such as the Ute and Navajo. In particular, the Archaic people can be documented to have been present in the Salt Creek drainage (CANY) and Bowns-Bechan drainage (GLCA). Of these cultural dates generated in our investigation (Table 14) 71% of the CANY alluvial dates with cultural affiliation are Archaic; in GLCA the Archaic represents 50% of the dated material with cultural affiliation.

Llano and Plano artifacts were recovered by P-III (archaeologic contractors - CANY) in the Lower Salt Creek survey. A possible Llano point was found near Orange Cliffs (GLCA) by the NAU Archaeological survey. These isolate finds plus the numerous stratified sites listed in Table 14, added to the Pueblo structures in the study area attest to more than 11,000 years of human prehistory in these (CANY and GLCA) National Park Service lands on the Colorado Plateau. Previously, too little attention has been focused on the pre-Basketmaker entities in the region. Combined results of the archaeological contractors and the Quaternary Studies research have aptly documented the presence of pre-ceramic cultures within the study areas.

Paleontologically, Year III investigations in the Fortymile Canyon Area of GLCA provided fecal remains of shrub ox (*Euceratherium*), mountain goat (*Oreamnos*), mammoth (*Mammuthus*), camel (*Camelops*), and bison (*Bison*). In addition, we recovered dentition from horse (*Equus*) and marmot (*Marmota*). Osteological remains of mountain goat (*Oreamnos harringtoni*) and mammoth (*Mammuthus columbi*) were also recovered. The newly discovered deposits at Mammoth Alcove contain the skeletal elements of a mammoth in the lower alluvial fill, and mammoth dung in the upper meter of the same fill. The mammoth dung dated to 16,630 B.P. (14,680 B.C.); a uranium-thorium analysis of the skeletal material produced a date of 19,300 $\pm$ 600 B.P. (17,350 B.C.) for the skeletal remains.

Paleoenvironmental information has been compiled from several lines of research and field evidence. In particular, the studies by Hevly, Clay-Poole and Judges-Edwards have yielded paleobotanical refinement to the Archaic and Pre-formative periods of cultural visibility on the central Colorado Plateau - in GLCA. These data, tied to the chronology of the alluvial/paleohydrologic record of Bowns/Bechan Canyons provide a model for human occupation/utilization of these canyons. That model can be cross checked with the data from the post-dung fill deposits of Bechan Cave (Agenbroad et al. 1989). Hevly's work on Cedar Mesa (Appendix II) is drawn on, to illustrate similar phenomena is being recorded on a regional basis.

Data generated for the alluvium of Salt Creek (CANY) and its chronology in the second year of contract work (Agenbroad and Elder, 1986) has been expanded and enhanced by malacological analysis (Mead and Agenbroad, this report) as well as

SUMMARY AND CONCLUSIONS

**TABLE 14. RADIOCARBON DATES WITH CULTURAL AFFILIATION,
FROM THE QUATERNARY STUDIES CONTRACT (all dates in years B.P.)**

<u>Site #</u>	<u>Material</u>	<u>GCA</u>	<u>Site #</u>	<u>Material</u>	<u>CANY</u>	<u>Cultural Stage</u>
42KA 2548	wickiup	570 ±130	42GR XXXX	resin	590 ±65	F
42KA 2548	charcoal	950 ±160		artifact		O
42KA 2548	corn	1240 ±180				R
42KA 2756	charcoal	1290 ±75				M
42KA 2548	bean	1310 ±100				A
42KA 2775	charcoal	1315 ±75				T
42KA 2548	squash	1400 ±150	42WN 1666	charcoal	1160 ±60	I
42KA 2745	charcoal	1525 ±130	42SA 21117	charcoal	1670 ±80	V
			42SA 17216	charcoal	1720 ±80	E
42KA 2548	charcoal	2080 ±140	42SA 21091	charcoal	2070 ±70	
42KA 2730	charcoal	2310 ±90				
42KA 2548	charcoal	2640 ±50	42WN 1666			A
42KA 2756	charcoal	3000 ±145	(not numbered)	charcoal	4510 ±130	R
			42SA 17107	charcoal	5890 ±70	
42KA 2771	charcoal	5300 ±235	42SA 21095	charcoal	6290 ±110	C
42KA 2548	charcoal	5500 ±80				H
42KA 2548	sandal	6750 ±120				A
42KA 2548	reed mat	7525 ±220				I
42KA 2548	charcoal	7795 ±230	42SA 17122	charcoal	8100 ±220	C
			42SA 17216	charcoal	8330 ±110	

42KA 2548 = See Agenbroad et al. 1989 for sample provenience.

42GR XXXX = Bison Alcove, Arches N.P.

Table 14.

SUMMARY AND CONCLUSIONS

cross correlated with the efforts of the archaeological contractor (P-III).

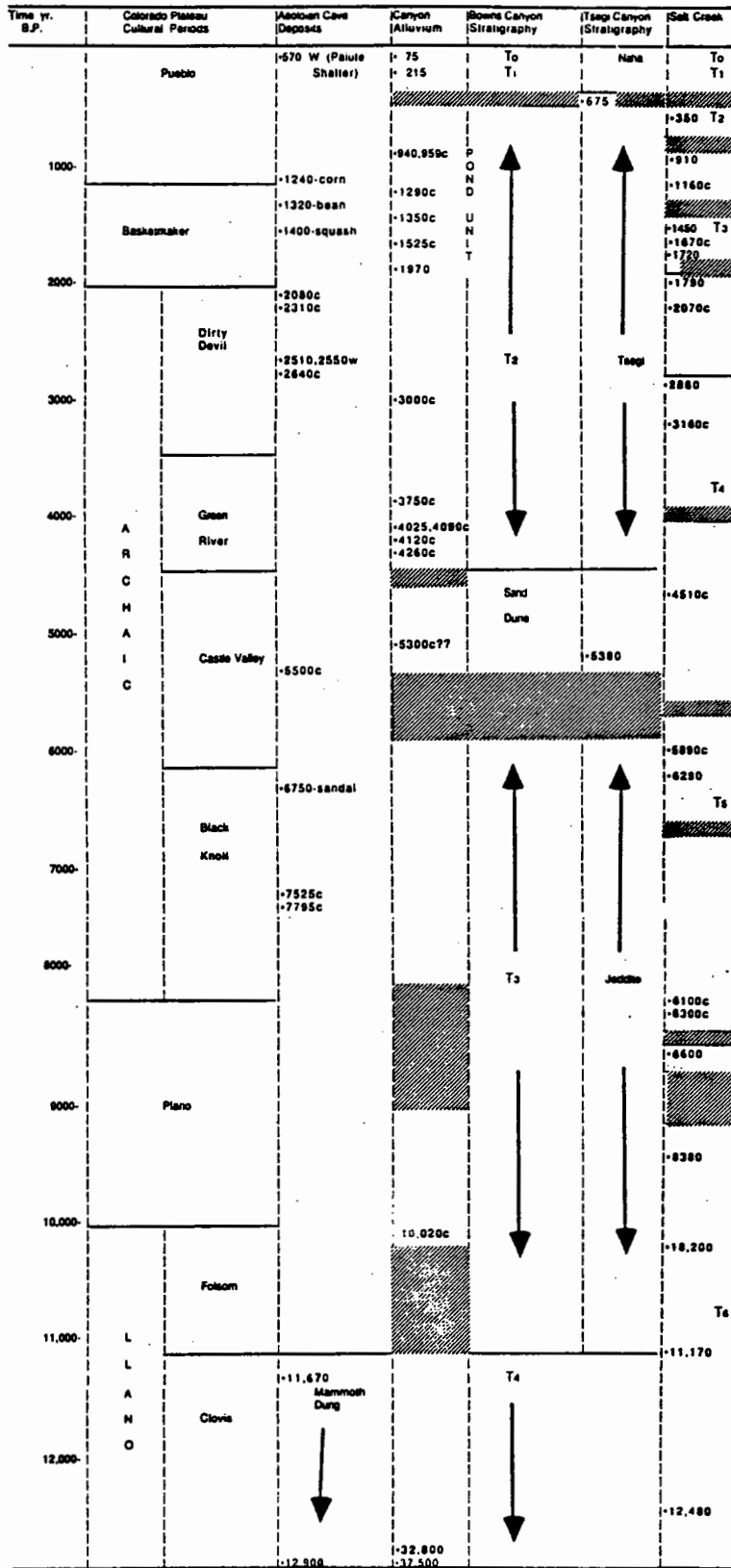
Local and regional syntheses have been made (Figures 34 and 35). We can now incorporate and cross-check the information from the Big Pocket portion of Salt Creek (CANY) with the data from Bowns/Bechan (GLCA), as well as the wider region (Figure 35). The cut-and-fill sequence can easily be spotted as a synchronous set of events in Bowns/Bechan, Tsegi Canyon, and Salt Creek. Salt Creek has one additional degradational event, at 1500 B.P. (450 A.D.). On the basis of radiocarbon dates from buried hearths located in Terrace 6 in the southeastern portion of Big Pocket (Figure 36), early Archaic (Black Knoll) people were camped near the marsh and open water impoundment evidenced for that reach of Salt Creek from Big Pocket to the vicinity of Kirk's Cabin. One late Archaic hearth (Dirty Devil) was also dated (by us) in the same portion of Big Pocket. Our alluvial studies did not produce stratified evidence of middle Archaic occupation of the area, but we only had one such locality in Bowns Canyon, and only one cultural date from that interval in Bechan Cave. Using our tentative alluvial/hydrologic model, the middle Archaic temporal span witnessed rapid cycles of degradation and aggradation - at least as evidenced by the current state of knowledge in Bowns/Bechan; Tsegi; and Salt Creek Canyons.

In summary, we have been able to enhance and refine studies initiated in previous years, by continued laboratory analyses and increased radiocarbon dating control. We are able to initiate a tentative model, on a regional scale (Figure 35) for synchronicity of aggradational and degradational events, which in turn enhanced or detracted from a

particular location desirability for cultural entities.

SUMMARY AND CONCLUSIONS

RADIOCARBON CHRONOLOGY OF SEDIMENTS FROM THE BOWNS-BECHAN DRAINAGE COMPARED WITH THE CHRONOLOGY OF THE COLORADO PLATEAU CULTURAL PERIODS AND THE STRATIGRAPHIC RECORDS OF BOWNS AND TSEGI CANYONS



Episodes of erosion are indicated by hatched blocks. Chronology of Bowns Canyon alluvium and Bechan cave deposits adapted from Agenbroad et al (1989).

Figure 34.

UPPER SALT CREEK CANYONLANDS NATIONAL PARK

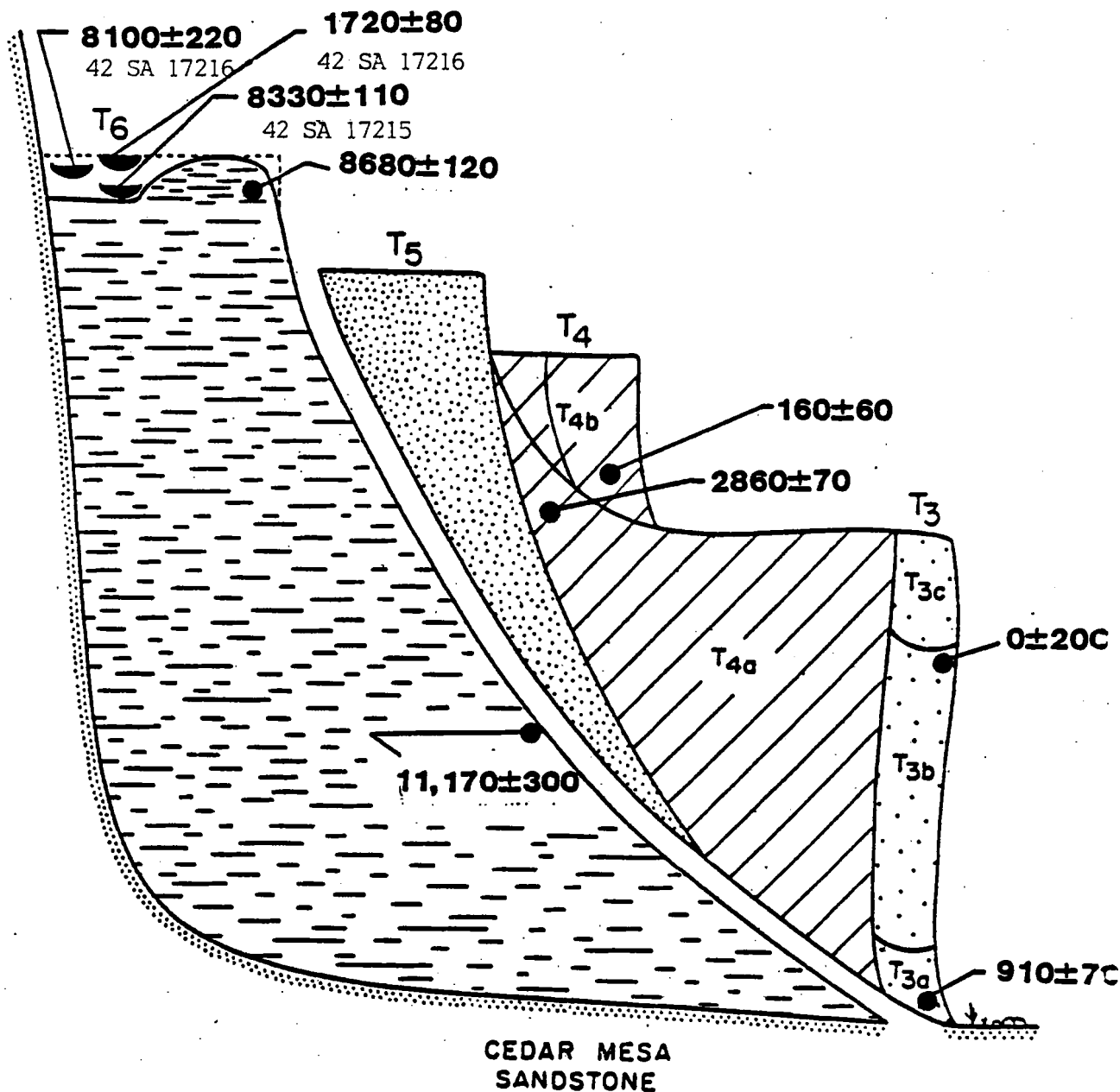


Figure 35.

REFERENCES CITED

- Aasen, D.K.
1984 *Pollen, Macrofossil and Charcoal Analysis of Basketmaker Coprolites from Turkey Pen Ruin, Cedar Mesa, Utah.* Unpublished Master's thesis, Washington State University.
- Adam, D.P., Fergusson, C.W. and LaMarch, V.C. Jr.
1967 Enclosed bark as a pollen trap. *Science* 157:1067-1068.
- Adam, D.P. and Mehringer, P.J., Jr.
1975 Modern Pollen Surface Samples: An Analysis of Subsamples. *Journal of Research, U.S. Geological Survey* 3:733-736.
- Agenbroad, L.D.
1975 The Alluvial Geology of Upper Grand Gulch, Utah; Its relationship to Anasazi Inhabitation of the Cedar Mesa Area. In *Canyonlands County, Four Corners Geological Society Guidebook, 8th Field Conference*, edited by J.E. Fassett, pp. 63-66.
1986 *Quaternary Studies: Phase I Report, Glen Canyon National Recreation Area and Canyonlands National Park.*, edited by L.D. Agenbroad. National Park Service Report, Contract CX-1200-4-A062.
1986 *Quaternary Studies: Phase II report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L.D. Agenbroad. National Park Service Report, Contract CX-1200-4-A062.
- Agenbroad, L.D. and Downs, W.R.
1984 A Robust Tapir from Northern Arizona. *Journal of the Arizona-Nevada Academy of Science* 19:91-100.
- Agenbroad, L.D., and Elder, D.I.
1986 Alluvial Studies. In *Quaternary Studies: Phase I Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L.D. Agenbroad, pp. 31-43. National Park Service Report, Contract CX-1200-4-A062.
1986 Alluvium and Chronology. In *Quaternary Studies: Phase II Report, Glen Canyon National Recreation Area and Canyonlands National Parks*, edited by L.D. Agenbroad, pp. 84-97. National Park Service Report, Contract CX-1200-4-A062.
- Agenbroad, L.D., and Mead, J.I.
1987 Late Pleistocene Alluvium and Megafauna Dung Deposits of the Central Colorado Plateau. In *Geologic Diversity of Arizona and Its Margins: Excursion to Choice Areas, Geological Society of America, 100th Annual Meeting. Field Trip Guidebook*. Arizona Bureau of Geology and Mineral Technology Special Paper 5, pp.68-84.
1989 Late Pleistocene and Holocene Transition on Cedar Mesa, and the Re-

REFERENCES CITED

- evaluation of Kane Springs, southeastern Utah. *Current Research in the Pleistocene* 6: 83-85.
- Agenbroad, L.D., Mead, J.I. and Martin, P.S.
 1984 Chronology and Diet of Mammuthus from Eurasia and Temperate North American. Abstract from the 27th International Geological Congress, Moscos, USSR, Lithosphere Institute, p. 33.
- Agenbroad, L.D. Mead, J.I., Mead, E.M. and Elder, D.I.
 1988 Archaeology, Alluvium and Cave Stratigraphy: the Record from Bechan Cave. *The Kiva*. 54:335-350.
- Anderson, K.
 1986 Soil Analysis. In *Quaternary Studies: Phase I Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L.D. Agenbroad, pp. 43-62. National Park Service Report, Contract CX-1200-4-A062.
- 1986 Soils analysis. *Quaternary Studies: Phase II Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L.D. Agenbroad, pp. 8-22. National Park Service Report, Contract CX-1200-4-A062.
- 1988 Soils and Alluvial Stratigraphy in Bowns Canyon, Southeastern Utah. Unpublished M.S. thesis; Quaternary Studies Program. Northern Arizona University, 121 p.
- Anderson, K.C., and Karlstrom, E.T.
 1986 Paleoclimatic Implications of Geosols in the Bechan Canyon Area, Southern Utah. Paper presented at the Geological Society of America. *Abstracts with Programs*, pp.337. Flagstaff, Arizona.
- Antevs, E.
 1939 Studies on the Past Climate in Relation to Man in the Southwest. *Carnegi Institution of Washington Year Book* 38:317-319.
- 1952 Arroyo-cutting and Filling. *Journal of Geology* 60:375-385.
- 1954 Climate of New Mexico During the Last Glaciopluvial. *Journal of Geology* 62:182-191.
- 1955 Geologic-climate Dating in the West. *American Antiquity* 20:317-335.
- 1962 Late Quaternary Climates in Arizona. *American Antiquity* 28:193-198.
- Ashbaugh, K.M., and Metcalf, A.L.
 1986 Fossil Molluscan Faunas from Four Springs-Related Deposits in the Northern Chihuahuan Desert, Southern New Mexico and Westernmost Texas. *New Mexico Bureau of Mines and Mineral Resources*, 200. Socorro.

REFERENCES CITED

- Baerreis, D.A.
 - 1980 Molluscan Remains from Sudden Shelter. In *Sudden Shelter*, edited by J.D. Jennings, pp. 243-259. University of Utah Anthropological Papers 103.
- Baker, F.C.
 - 1911 The Lymnaeidae of North and Middle America, Recent and Fossil. *Chicago Academy of Science, Special Publication* 3:1-539.
 - 1928 The Freshwater Mollusca of Wisconsin, Part 1, Gastropoda. *Wisconsin Geological and Natural History Survey Bulletin* 70:1-507.
- Batchelder, G.L. and Reger, R.D.
 - 1968 New Evidence for a Late Pleistocene or Early Recent Lake Near Winona, Coconino County, Arizona. *Journal of the Arizona Academy of Science Supplement* 5:9.
- Bequaert, J.C. and Miller, W.B.
 - 1973 *The Mollusks of the Arid Southwest*. University of Arizona Press, Tucson.
- Berlin, G.L., Ambler, J.R., Hevly, R.H. and Sharber, G.G.
 - 1977 Identification of a Sinagua Agricultural Field by Aerial Thermography, Soil Chemistry, Pollen/Plant Analysis and Archaeology. *American Antiquity* 42:588-600.
- Betancourt, J.L.
 - 1984 Late Quaternary Plant Zonation and Climate in Southeastern Utah. *Great Basin Naturalist* 44:1-31.
- Bohrer, V.L.
 - 1972 Paleoeecology of the Hay Hollow Site. *Fieldiana (Field Museum of Natural History) Anthropology* 63:1-30.
- Boison, P.J., and Patton, P.C.
 - 1985 Sediment Storage and Terrace Formation in Coyote Gulch Basin, Southcentral Utah. *Geology* 13:31-34.
- Bolen, C.W.
 - 1983 Mammal Hair as a Paleoenvironmental Indicator in the Pryor Mountains, Montana. *Proceedings Supplement of the Journal of the Arizona-Nevada Academy of Science* 18:47-48.
- Bradfield, M.
 - 1973 Rock-cut Cisterns and Pollen "Rain" in the Vicinity of Old Oraibi, Arizona. *Plateau* 46:68-71.
- Briscoe, M.
 - 1974 *An Investigation of the Invertebrate Paleontology of the Tsegi and Naha Formations in Tsegi Canyon, Arizona*. Unpublished Master's thesis. Northern Arizona University.

REFERENCES CITED

- Byran, K.
 - 1928 Historic Evidence on Changes in the Channel of Rio Puerco, A Tributary of the Rio Grande in New Mexico. *Journal of Geology* 36:265-282.
 - 1950 Geologic Interpretation of the Deposits. In *The Stratigraphy and Archaeology of Ventana Cave, Arizona*, edited by E.W. Haury, pp. 75-126. University of New Mexico Press, Albuquerque.
- Bye, R.A., Jr.
 - 1979 Incipient Domestication of Mustards in Northeast Mexico. *The Kiva* 44:237-256.
- Chamberlin, R.V. and Berry, E.
 - 1930 Mollusca from the Henry Mountains and Some Neighboring Points in Utah. *Bulletin of the University of Utah* 21:3-7.
- Chamberlin, R.V. and Roscoe, E.J.
 - 1948 Checklist of Recent Utah Mollusca. *Bulletin of the University of Utah* 39:1-16.
- Christenson, G.E.
 - 1985 Quaternary Geology of the Montezuma Creek, Lower Recapture Creek Area, San Juan County, Utah. In *Contributions to Quaternary Geology of the Colorado Plateau*, edited by G.E. Christenson and others, pp. 3-31. Utah Geological and Mineral Survey, Special Studies 64.
- Chronic, H.
 - 1983 *Roadside Geology of Arizona*. Mountain Press. Missoula, Montana pp. 314.
- Clay Poole, S.T.
 - 1989 *Pollen Flora and Paleoecology of the Holocene Alluvial Tsegi and Naha Formations in Tsegi Canyon, Arizona*. Unpublished M.S. thesis. Department of Geology, Northern Arizona University.
- Colton, H.S.
 - 1929 Fossil Fresh Water Shells from Winona, Coconino County, Arizona. *Nautilus* 42:93-94.
- Cully, A.C.
 - 1979 Some Aspects of Pollen Analysis in Relation to Archaeology. *The Kiva* 44:237-256.
- Davis, O.K. Agenbroad, L.D., Martin, P.S. and Mead, J.I.
 - 1984 The Pleistocene Dung Blanket of Bechan Cave, Utah. In *Contributions in Vertebrate Paleontology: A volume in memoriam to John E. Guilday*, edited by H.H. Genoways and R.R. Dawson. A special publication of Carnegie Museum of Natural History 3:267-282.
- Davis, O.K. Mead, J.I., Martin, P.S. and Agenbroad, L.D.
 - 1985 Riparian Plants Were a Major Component of the Diet of Mammoths of Southern Utah. *Current*

REFERENCES CITED

- Research in the Pleistocene* 2:81-82/
- Dean, J.S.
1988 Dendrochronology and Paleoenvironmental Reconstruction on the Colorado Plateau. In *The Anasazi in a Changing Environment*, edited by G.J. Gumerman, pp. 119-167. Cambridge University Press.
- Dickey, A.M.
1971 *Palynology of Hay Hollow Valley*. Unpublished master's thesis, Department of Biology, Northern Arizona University.
- Diggs, R.D.
1980 *Ten Thousand Years of Land Use at the Hall Ranch Locality Near Springerville, Arizona*. Unpublished M.S. thesis, Department of Anthropology, Northern Arizona University.
- Dixon, H.N.
1962 *Vegetation, Pollen Rain and Pollen Preservation, Sangre de Cristo Mountains, New Mexico*. Unpublished M.S. thesis, University of New Mexico, Albuquerque.
- Dobyns, H.
1974 Altitude Sorting of Ethnic Groups in the Southwest. *Plateau* 47:42-48
- Drake, R.J.
1948 Mollusca of the Eastern Basin of the Chaco River, New Mexico. *Nautilus* 62:5-8.
- Euler, R.C., Gumerman, G.J., Karlstrom, T.N.V., Dean, J.S., and Hevly, R.H.
1979 The Colorado Plateaus: Cultural Dynamics and Paleoclimate. *Science* 205:1089-1101.
- Faegri, K. and Iverson, J.
1950 *Textbook of Modern Pollen Analysis*. Munksgaard, Copenhagen
1964 *Textbook of Modern Pollen Analysis*. 2nd ed. Hafner Press, New York.
- Fall, P.L.
1981 Modern Pollen spectra and their application to alluvial pollen sedimentology. Unpublished M.S. thesis, Department of Geosciences, University of Arizona, Tucson.
1987 Pollen taphonomy in a canyon stream. *Quaternary Research* 28:393-406.
- Ford, R.I.
1983 Ecological Consequences of Early Agriculture in the Southwest. In *Papers on the Archaeology of Black Mesa Vol. 2.*, edited by S. Plog and S. Powell. Southern Illinois University, Carbondale.
- Fish, S.K.
1985 Prehistoric disturbance floras of the lower Sonoran Desert and their

REFERENCES CITED

- implications. *AASP Contribution Series* 16:77-88.
- Frazen, D.S.
 - 1964 Anatomy of the Succineid Gastropod *Oxyloma haydeni*. *Nautilus* 77:73-81.
- Funkhauser, J.W., and Evitt, W.R.
 - 1959 Preparation Techniques for Acid-Insoluble Microfossils. *Micropaleontology* 5:369-375.
- Gasser, R.E. and Adams, C.
 - 1981 Aspects of Deterioration of Plant Remains in Archaeological sites: The Walpi Archaeological Project. *Journal of Ethnobiology* 1:182-192.
- Gasser, R. and Scott, L.
 - 1982 Pollen Analysis in Selected Rooms at Walpi and Along Modern Transects Near First Mesa. In *Walpi Archaeological Project: Phase II Archaeobotanical remains, Vol. 7* Museum of Northern Arizona, Flagstaff.
- Geib, P.R., Bungart, P.W., and Fairley, H.C.
 - 1987 Archaeological Investigations along the Lower Escalante drainage. In *Northern Arizona University Archaeological Report 1000: Glen Canyon Year II Report, 1985-1986*.
- Gish, J.
 - 1982 Pollen Results. In *The Specialists' Volume: Biocultural Analysis*, edited by R. Gasser. Museum of Northern Arizona Research Paper 24, Flagstaff.
- Gray, J.
 - 1965 Palynological Techniques. In *Handbook of Paleontological Techniques* edited by B. Kummel and D. Raup. Freeman and Co., San Francisco.
- Hack, J.T.
 - 1942 The changing physical environment of the Hopi of Arizona. *Peabody Museum Papers* 35:45-69.
- Halbirt, C.D.
 - 1985 Archaeobotanical Remains. In *The Ord Mane Project* by R.S. Ciolek-Torrello. Museum of Northern Arizona Research Paper 33:96-224, Flagstaff.
- Hall, S.A.
 - 1980 Snails from Quaternary Valley Fill and Chaco Canyon, New Mexico. *Nautilus* 94:60-63.
 - 1981 Deteriorated pollen grains and the interpretation of Quaternary pollen diagrams. *Review of Paleobotany and Palynology* 32:193-206.
 - 1989 Pollen analysis and paleoecology of Alluvium. *Quaternary Research* 31:435-438.

REFERENCES CITED

- 1990 Holocene landscapes of the San Juan Basin, New Mexico; geomorphic, climatic and cultural dynamics. *Geological Society of America Centennial Special Volume* 4:323-334.
- Hansen, R.M.
 - 1980 Late Pleistocene Plant Fragments in the Dungs of Herbivores at Cowboy Cave. In *Cowboy Cave*, edited by J.D. Jennings, pp. 179-189. University of Utah Anthropological Papers 104.
- Harrington, M.R.
 - 1933 *Gypsum Cave, Nevada*. Southwest Museum Publication 8.
- Harris, A.
 - 1977 Wisconsin-age Environments in the Northern Chihuahuan Desert. In *Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico*, edited by R.H. Wauer and D.H. Riskind, pp. 23-52. Transactions and Proceedings of the National Park Service, Series 3.
 - 1985 *Late Pleistocene Vertebrate Paleoecology of the West*. University of Texas Press, Austin.
- Haury, E.W.
 - 1950 *The Stratigraphy and Archaeology of Ventana Cave, Arizona*. University of New Mexico Press, Albuquerque.
- Haury, E.W., Antevs, E. and Lance, J.F.
 - 1959 The Lehner Mammoth Site, Southeastern Arizona. *American Antiquity* 25:2-30.
- Havinga
 - 1971 An Experimental Investigation into the Decay of Pollen and Spores in Various Soil Types. In *Sporopollenin*, edited by Brooks et al. Academic Press, New York.
- Haynes, C.V.
 - 1966 Elephant-Hunting in North America. *Scientific American* 214:104-112.
 - 1967 Carbon-14 Dates and Early Man in the New World. In *Pleistocene Extinctions*, edited by P.S. Martin and H.E. Wright, pp. 267-286. Yale University Press, New Haven.
 - 1968 Preliminary Report on the Late Quaternary Geology of San Pedro Valley, Arizona. In *Southern Arizona Guidebook III*, edited by S.R. Titley, pp. 79-96. Arizona Geological Society.
 - 1980 The Clovis Culture. *Canadian Journal of Anthropology* 1:115-121.
- Herrington, H.B.
 - 1962 A Revision of the Sphaeriidae of North America (Mollusca: Pelecypoda). *University of Michigan Miscellaneous*

REFERENCES CITED

- Publications 118. Ann Arbor.
- Hevly, R.H.
 1964 *Pollen Analysis of Quaternary Archaeological and Lacustrine Sediments of the Colorado Plateau*. Unpublished Ph.D. dissertation. University of Arizona, Tucson.
- 1968a Sand Dune Pollen Studies. *Museum of Northern Arizona Bulletin* 45, *Glen Canyon Series* 8:393-397.
- 1968b Studies of the Modern Pollen Rain in Northern Arizona. *Journal of the Arizona-Nevada Academy of Science* 5:116-127.
- 1979 Paleocology of Holocene and Pleistocene Lacustrine Sediments From Zion National Park, Utah. In *Proceedings of the First Scientific Conference on Scientific Research in the National Parks Vol. 1*, edited by R.M. Linn, National Park Service Transactions and Proceedings Series 5:151-158.
- 1981 Pollen Production, Transport and Preservation: Potentials and Limitations in Archaeological Palynology. *Journal of Ethnobiology* 1:39-54.
- 1982 Analysis of Flotation Samples from the Colorado Transmission Line Corridor. In *The Specialists' Volume: Biocultural Analysis*, edited by R.E. Gasser. Museum of Northern Arizona Research Paper 23:225-243.
- 1988 Prehistoric vegetation and paleoclimates on the Colorado Plateau. In *The Anasazi in a Changing Environment*, edited by G.J. Gumerman, pp. 92-118. Cambridge University.
- Hevly, R.H., and Clay-Poole, S.
 1986 Pollen Analysis. *Quaternary Studies: Phase I Report, Glen Canyon National Recreation Area and Canyonlands National Parks*, edited by L. Agenbroad, pp. 62-68. National Park Service, Contract CX-1200-4-A062.
- 1986 Alluvial Holocene Pollen and Paleocology of Bowns Canyon, Glen Canyon National Recreation Area, South-Central Utah. In *Quaternary studies: Phase II Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L. Agenbroad, pp. 38-70. National Park Service, Contract CX-1200-4-A062.
- Hevly, R.H., Clay-Poole, G.S. and Judges-Edwards, G.
 1990 Alluvial Pollen in the Bowns/Bechan Drainage and on the Southern Colorado Plateau. In *Quaternary Studies: Phase III Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L.D. Agenbroad. National Park Service Contract CX-1200-4-A-062.

REFERENCES CITED

- Hevly, R.H., Mehrgner, P.J. Jr. and Yokum, H.G.
 1965 Modern pollen rain in the Sonoran Desert. *Journal of the Arizona Academy of Science* 3:1223-135
- Hill, J. and Hevly, R.H.
 1968 Pollen at Broken K. Pueblo: Some New Interpretations. *American Antiquity* 33:200-210.
- Hintze, L.F.
 1975 *Geology of Utah*. Brigham Young University Special Publication 3. Hunt, C.B.
 1967 *Physiography of the United States*. W.H. Freeman and Co., San Francisco.
- Jennings, J.D.
 1980 *Cowboy Cave*. University of Utah Anthropological Papers 104.
- Jones, W.D. and Newell, L.C.
 1946 Pollination cycles and Pollen Dispersal in Relation to Grass Improvement. *University of Nebraska Agricultural Experiment station Research Bulletin* 148.
 1990 *Paleobotany and Paleoecology of Archaic Basketmaker Cultural Horizons in the Bechan Cave Area south central Utah*. Unpublished M.S. thesis. Department of Biological Sciences, Northern Arizona University.
- Jennings, J. D., Shroedl, A. R. and Holmer, R. N.
 1980 *Sudden Shelter*. University of Utah Anthropological Papers 98
- Judges-Edwards, G.
 1990 *Paleobotany and Paleoecology of Archaic-Basketmaker Cultural Horizons in the Bechan Cave Area, Southcentral Utah*. Unpublished M.S. thesis, Department of Quaternary Studies Program, Northern Arizona University, pp. 156.
- Kapp, R. O.
 1968 *How to know Pollen and Spores*. W.M. C. Brown Co., Dubuque, Iowa.
- Karlstrom, T. N. V.
 1988 Alluvial chronology and hydrologic change on Black Mesa and nearby regions. In *The Anasazi in a Changing Environment*, edited by G.J. Gumerman, Chapter 3. Cambridge University Press.
- Kelso, G.
 1970 *Hogup Cave, Utah: Comparative pollen analysis of human coprolites and cave fill*. In *Hogup Cave* edited by C.M. Aikens, pp. 251-262. University of Utah Anthropological Papers 93:1-286.
- Kurten, B., and Anderson, E.
 1980 *Pleistocene Mammals of North America*. Columbia

REFERENCES CITED

- University Press, New York.
- Lance, J. F.
 1963 Alluvial Stratigraphy in Lake and Moqui Canyons. In 1961 *Excavations, Glen Canyon Area*, edited by F. W. Sharrock et al. pp. 347-346.
- Laudermilk, J. D., and Munz, P. A.
 1934 *Plants in the Dung of Nothrotherium from Gypsum Cave, Nevada*, pp. 29-37. Carnegie Institute Publications 453.
- 1938 *Plants in the Dung of Nothrotherium From Rampart and Muav Caves*. Carnegie Institution of Washington Publication 487 pp. 271-281.
- Lindsay, L. W.
 1974 Preliminary Palynological Studies on Cedar Mesa. In *Hiway US-95 Archaeology: Comb Ridge to Grand Flat Vol. 2, a Special Report*. University of Utah Department of Anthropology.
- Lindsay, A. J., Ambler, J. R. Stein, M. A., Hobler, P. M.
 1968 Survey and Excavations North and East of Navajo Mountain, Utah, 1959-1962. *Museum of Northern Arizona Bulletin* 45, *Glen Canyon Series* 8.
- Lindsay, E. H., and Tessman, N.
 1974 Cenozoic Vertebrate Localities and Faunas in Arizona. *Arizona Academy of Sciences* 9:3-24.
- 1980a Pollen Analysis of Sudden Shelter Site deposits, pp. 261-271 in: J.D. Jennings, A.R. Schroedl and R.N. Holmer (eds) *Sudden Shelter*. University of Utah Anthropological Papers 103.
- 1980b Pollen Analysis of Cowboy Cave cultural deposits, pp. 213-224 in: J.D. Jennings (ed) *Cowboy Cave*. University of Utah Anthropological Papers 104.
- Lipe, W. D., Breed, W. J., West, J., Batchelder, G. and Pollen Research Associates
 1975 Lake Pagahrit, Southeastern Utah a Preliminary Research report. In *Canyonland Country: Four Corners Geological Society Guidebook 8th Field Conference*, edited by J.E. Fasset, pp. 103-110.
- Lipe, W. D. and Matson, R. G.
 1971 Human Settlement and Resources in the Cedar Mesa Area, Southeastern Utah. In *The Distribution of Prehistoric Population Aggregates*, edited by G.J. Gumerman. Prescott College Anthropology Reports 1:120-151.
- 1975 Archaeology and Alluvium in the Grand Gulch-Cedar Mesa Area, Southeastern Utah. In *Canyonlands Country: Four Corners Geological Society Guidebook 8th Field*

REFERENCES CITED

- Conference edited by J.E. Fassett, pp. 67-71.
- 1988 Adaptional Continuities and Occupational Discontinuities: The Cedar Mesa Anasazi. *Journal of Field Archaeology* 15:245-264.
- Lundelius, E., and others
1983 Terrestrial Vertebrate Faunas. In *Late Quaternary Environments of the United States Vol. 1, The Late Pleistocene*, edited by S.C. Porter, pp. 311-353. University of Minnesota Press, Minneapolis.
- Lyman, A. R.
1963 Memories of the Pagahrit. *Desert Magazine* 26:24-25.
- Maher, L. J., Jr.
1963 Pollen Analysis of Surface Materials from the southern San Juan Mountains, Colorado. *Geological Society of American Bulletin* 74:1485-1504.
- Martin, P.S.
1963a Geochronology of Pluvial Lake Cochise, Southern Arizona. *Ecology* 44:436-444.
- Martin, P.S., and Mehringer, P.J.
1965 Pleistocene Pollen Analysis and Biogeography of the Southwest. In *The Quaternary of the United States*, edited by H.E. Wright and D. G. Frey, pp. 433-451. Princeton University Press, Princeton.
- Martin, P. S., Sables, B. E. and R. Shutler
1961 Rampart Cave Coprolite and Paleoecology of the Shasta Ground Sloth. *American Journal of Science* 259:102-12.8
- Martin, P. S., and Sharrock, F. W.
1964 Pollen Analysis of Prehistoric Human Forces: A New Approach to Ethnobotany. *American Antiquity* 30:168-180.
- Matson, R. G. and Lipe, W. D.
1978 Settlement Patterns on Cedar Mesa: Boom and Bust on the northern Periphery. In *Investigations by the southwestern Anthropological Research Group: An Exercise in Archaeological Cooperation*, edited by R. Euler and G. Gumerman. Museum of Northern Arizona Bulletin 50:1-12.
- Mead, J. I.
1979 *Molluscs of the Lehner Ranch and Murray Springs Clovis Sites, Southeastern Arizona*. Unpublished Master's thesis. University of Arizona, Tucson.
- 1986 Packrat Middens: Paleoenviromental Reconstructions in Canyonlands. In *Quaternary Studies: Phase II Report, Glen Canyon National Recreation Area and Canyonlands National Park*, edited by L. D. Agenbroad. National Park

REFERENCES CITED

- Service Report, Contract
CX-1200-4-A062.
- Mead, J. I. and Agenbroad, L. D.
1987 *Packrat Middens and Late Pleistocene Environments of Salt Creek, Canyonlands National Park, Southeastern Utah*. Manuscript in possession of author.
- Mead, J. I., Agenbroad, L. D., Davis, O. K. and Martin, P. S.
1986 Dung of *Mammuthus* in the Arid Southwest, North America. *Quaternary Research* 25:121-127.
- Mead, J. I., Agenbroad, L. D., Middleton, L. and Phillips, A. M.
1987 Extinct Mountain Goat (*Oreamnos harringtoni*) in Southeast Utah. *Quaternary Research* 25:121-127.
- Mead, J. I., Agenbroad, L. D., Middleton, L. and Phillips, A. M.
1987 Extinct Mountain Goat (*Oreamnos harringtoni*) in Southeast Utah. *Quaternary Research* 27:323-331.
- Mead, J. I., Martin, P. S., Euler, R. C., Long, A., Jull, J.T., Toolin, L. J., Donahue, D. J., and Linick, T. W.
1986 Extinction of Harrington's Mountain Goat. *Proceedings of the National Academy of Science* 83:836-839.
- Mead, J. I., O'Rourke, M. K. and Foppe, T.
1986 Dung and Diet of the Extinct Harrington's Mountain Goat (*Oreamnos harringtoni*). *Journal of Mammalogy* 67:284-293.
- Mead, J. I., and Phillips, A. M.
1981 The Pleistocene and Holocene Fauna and Flora of Vulture Cave, Grand Canyon, Arizona. *Southwestern Naturalist* 26:257-288.
- Mehringner, P. J.
1967a Murray Springs, a Mid-Postglacial Pollen Record From Southern Arizona. *American Journal of Science* 265:786-797.
1967b Pollen Analysis and the Alluvial Chronology. *Kiva* 32:96-101.
1967c Pollen Analysis of the Tule Springs Area, Nevada. In *Pleistocene Studies in Southern Nevada*, edited by H. M. Wormington and D. Ellis, Nevada State Museum Anthropological Papers 13:130-200.
1981 The Late Pleistocene and Holocene Gauna and Flora of Vulture Cave, Grand Canyon Arizona. *Southwestern Naturalist* 26:257-288.
- Mehringner, P. J., and Ferguson, W.
1969 Pluvial Occurrence of Bristlecone Pine (*Pinus aristata*) in a Mohave Desert Mountain Range. *Journal of the Arizona Academy of Science* 5:284-292.
- Minnis, P. E.
1978 Paleoethnobotanical Indicators of Prehistoric

REFERENCES CITED

- Environmental Disturbance:
A Case Study. In *The
Nature of Status of
Ethnobotany*, edited by R.
I. Ford. University of
Michigan Anthropological
Papers 67:347-366.
- Peterson, K. L.
1988 *Climate and the Dolores
River Anasazi*. University
of Utah Anthropological
Papers 113.
- Phillips, A. M.
1977 *Packrats, Plants and the
Pleistocene in the lower
Grand Canyon*. Unpublished
Ph.D. dissertation,
Department of Biological
Sciences, University of
Arizona, Tucson.
- Phillips, A. M. and Van Devender, T.
R.
1974 Pleistocene Pack-Rat
Middens from the lower
Grand Canyon of Arizona.
*Journal of the Arizona
Academy of Science* 9:117-
119.
- Pilsbry, H. A.
1984 Land Mollusca of North
America. *Academy of
natural Sciences
Monograph* 3(2).
Philadelphia.
- Plog, F., Gumerman, G. J., Euler, R.,
Dean, J., Hevly, R., and Karlstrom,
T.N.V.
1988 Anasazi Adaptive
Strategies: The Model,
Predictions, and Results.
In *The Anasazi in an
Changing Environment*,
edited by G. J. Gumerman,
pp. 230-281. Cambridge
University Press.
- Potter, L. D.
1967 Differential Pollen
Accumulation in Water-
Tank Sediments and
Adjacent Soils. *Ecology*
48:1041-1043.
- Raynor, G. S., Ogden, E. C. and
Hayes, J. V.
1972 Dispersion and Deposition
of Corn Pollen from
Experimental Sources.
Agronomy Journal 64:420-
427.
- Reger, R. D. and Batchelder, G. L.
1971 Late Pleistocene Molluscs
and a Minimum Age of
Meteor Crater, Arizona.
*Journal of the Arizona
Academy of Science* 6:190-
195.
- Reinhard, K. J.
1985 *Recovery of Helminths
from Prehistoric Feces:
The Cultural Ecology of
Ancient Parasitism*.
Unpublished M.S. thesis,
Department of Biological
Sciences, northern
Arizona University.
- Reinhard, K., Ambler, J. R. and
McGuffie, M.
1985 Diet and Parasitism at
Dust Devil Cave. *American
Antiquity* 50:20-24.
- Reinhard, K. J., and Hevly, R. H.
1984 Phytoliths from Dust
Devil Cave Feces. Paper
presented at the 19th
Biennial Great Basin
Anthropological

REFERENCES CITED

- Conference, Boise, Idaho,
pp. 102-107.
- Reinhard, K. L., Hevly, R. H. and
Anderson, G.
1987 Helminth Remains from
Prehistoric Coprolites on
the Colorado Plateau.
Journal of Parasitology
73:630-639.
- Reinhard, K. J., Hevly, R. H., Clay-
Poole, S. and Halbirt, C.
1985 Pollen Analysis of Dust
Devil Cave Feces. Pater-
presented at the 19th
Biennial Great Basin
Anthropological
Conference, Boise, Idaho,
pp. 93-101.
- Russell, R. H.
1967 *Freshwater Snails of the
Family Lymnaeidae
(Mollusca:
Basommatophora) from
western Montana.*
Unpublished Master's
thesis, University of
Montana.
- Salkin, P. H.
1975 The Malacology of the
Kane Springs Column and
the Paleocology for Cedar
Mesa, Southeastern Utah.
In *Canyonlands County:
Four Corners Geological
Society Guidebook, 8th
Field Conference*, edited
by J. E. Fassett, pp. 73-
79.
- Sayles, E. B., and Antevs, E.
1941 The Cochise Culture.
Medallion Papers 29, Gila
Pueblo, Globe.
- Schoenwetter, J.
1962 The Pollen Analysis of
Eighteen Archaeological
Sites in Arizona and New
Mexico. In *Chapters in
the Prehistory of Eastern
Arizona I*, by P.S. Martin
et al. Fieldiana (Chicago
Natural History Museum)
Anthropology 53:168-209.
- 1964 The Palynological
Research. In *Alluvial and
Palynological
Reconstruction of
Environments, Navajo
Reservoir District*, by J.
Schoenwetter and F.
Eddey. Museum of New
Mexico Papers in
Anthropology 113:63-107.
- Schwartz, D. W., Lange, A. L. and
Desaussre, R.
1958 Split-Twig Figurines in
the Grand Canyon.
American Antiquity
23:264-274.
- Scott, L. J.
1979 Dietary Interferences
from Hoy House
Coprolites: A
Palynological
Interpretation. *The Kiva*
44:257-281.
- Sharrock, F. W., Day, K. C. and
Dibble, D. S.
1963 1961 *Excavations in the
Glen Canyon Area.*
University of Utah
Anthropological Papers
63, Glen Canyon Series 8.
- Shroedl, A. R.
1976 Prehistoric Cultural
Resources of lake and
Moqui Canyons, Glen
Canyon National

REFERENCES CITED

- Recreation Area: Report and Recommendations. Unpublished report on file, Midwest Archaeological Center, Lincoln.
- 1980 *Sudden Shelter*. University of Utah Anthropological Papers 103.
- Solomon, A. M., Blasing, T. J. and Solomon, J. A.
1982 Interpretation of Floodplain Pollen in Alluvial Sediments from an Arid Region. *Quaternary Research* 18:52:71.
- Spaulding, W. G., Leopold, E. B. and Van Devender, T. R.
1983 Late Wisconsin Paleoeecology of the American Southwest. In *Late Quaternary Environments of the United States Vol 1, The Late Pleistocene*, edited by S. C. Porter, pp. 259-293. University of Minnesota Press, Minneapolis.
- Spaulding, W. G., and Martin, P. S.
1979 Ground Sloth Dung of the Guadalupe Mountains. In *Biological Investigations in the Guadalupe Mountains National Park, Texas*, edited by H. H. Genoways and R. J. Baker, pp. 259-269. National Park Service, proceedings and Transaction Series 104.
- Spaulding, W. G., and Petersen, K. L.
1980 Late Pleistocene and early Holocene Paleoeecology of Cowboy Cave. In *Cowboy Cave*, edited by J. D. Jennings, pp. 163-177. University of Utah Anthropological Papers 104.
- Streuver, S.
1968 Flotation Techniques for the Recovery of Small Scale Archaeological Remains. *American Antiquity* 33 (3):353-362.
- Teufel, N.
1985 Midden Plant Remains from Dust Devil Cave. Paper presented at the 19th biennial Great Basin Anthropological Conference, Boise, Idaho, pp. 129-130.
- Thompson, R. S., Van Devender, T. R., Martin, P. S., Foppe, T. and Long, A.
1980 Shasta Ground Sloth (*Nothrotheriops shastense Hoffstettler*) at Shelter Cave, new Mexico; Environment, Diet, And Extinctions. *Quaternary Research* 14:360-376.
- Tipps, B. L.
1983 *Test Excavations at Captains Alcove: A Multicomponent Site in Lower Glen Canyon, Kane County, Utah*. Unpublished M.S. thesis, National Park Service Midwest Archaeological Center, Lincoln, Nebraska.

REFERENCES CITED

- Van Devender, T. R.
1973 *Late Pleistocene Plants and Animals of the Sonoran Desert*. Unpublished Ph.D. dissertation. University of Arizona, Tucson.
- Van Devender, T. R., and Mead, J. I.
1978 Early Holocene and late Pleistocene Amphibians and Reptiles in sonoran Desert Packrat Middens. *Copeia* 1978:464-475.
- Van Devender, T. R., Phillips, A. M. and Mead, J. I.
1977 Late Pleistocene Reptiles and Small Mammals From the Lower Grand Canyon of Arizona. *Southwestern Naturalist* 22:66.
- Van Ness, M.
1986 *Macrobotanical Remains from Dust Devil Cave, Utah*. Unpublished M.S. thesis, Northern Arizona University.
1987 Macrobotanical remains. In *Northern Arizona University Archaeological Report 1000: Glen Canyon Year II Report, 1985-1986*. (by Geib et al.), pp. 98-109.
- Waters, M. R.
1985 Late Quaternary Alluvial Stratigraphy of White Water Draw, Arizona: Implications for Regional Correlation of Fluvial Deposits in the American Southwest. *Geology* 73:705-708.
- West, G. J.
1978 *Recent Palynology of the Cedar Mesa Area, Utah*. Unpublished Ph.D. dissertation, University of California, Davis.
- Webb, R. H.
1985 *Late Holocene Flooding on the Escalante River, South-central Utah*. Unpublished Ph.D. dissertation. University of Arizona, Tucson.
- Wells, P. V., and Berger, R.
1967 Late Pleistocene History of Coniferous Woodland in Mohave Desert. *Science* 155:1640-1647.
- Wells, P.V., and Berger, R.
1967 Late Pleistocene History of Coniferous Woodland in Mohave Desert. *Science* 155:1640-1647.
- Welsh, S. L., and Taft, C. A.
1981 Biotic Communities of Hanging Gardens in Southeastern Utah. *National Geographic Society Research Reports, 1972 Projects*, pp. 662-668.
- West, G. J.
1978 *Recent Palynology on the Cedar Mesa Area*. Unpublished Ph.D. dissertation, University of California, Davis.
- Wilson, R. W.
1940 Preliminary Study of the Fauna of Rampart Cave, Arizona. In *Contributions to Paleontology*, Carnegie

REFERENCES CITED

Institute of Washington
Publication 530:169-185.

Withers, K.

1989 Late Quaternary
Vegetation and Climates
of 40-Mile Canyon and
Willow Gulch, on the
Central Colorado Plateau.
Unpublished M.S. thesis.
Quaternary Studies
Program. Northern Arizona
University.

APPENDIX I
PALEONTOLOGICAL DATA SHEETS

PALEONTOLOGICAL DATA SHEETS

Part D - Paleontology Locality

Locality No.(s) Hooper's Hollow

1. Type of Locality: ☐ Invertebrate ☐ Plant ☒ Vertebrate ☐ Trace ☐ Other
2. Formation/Horizon/Geologic Age: Quaternary sediments in alcove
3. Description of Geology and Topography: ~~preserved in dry (overhanging) alcove on North side of~~
40 Mile canyon (GCA)
4. Location of Outcrop: N side 40 Mile canyon
5. Map Ref.: USGS Quad: Seones Bench Scale 1:24,000 Min. 7.5 Ed. 1968
NE 1/4 of SW 1/4 of of Sec. 11 T. 40 S R. 8 E Meridian
6. County Kane 7. Federal Admin. Unit(s) GCA-NPS
8. Specimens Collected and Field Accession No.: horse tooth (Equus); marmot jaw (Marmota flaviventris);
shrub ox dung (Euceratherium); mt. goat dung (Oreamnos)
9. Repository: NAU/MNA
10. Specimens Observed and Disposition:
11. Ownership: ☐ Priv. ☐ State ☐ BLM ☐ USFS ☒ NPS ☐ Ind. ☐ Mil. ☐ Other
12. Recommendations for Further Work or Mitigation: testing
13. Type of Map made by Recorder: photo and sketch map
14. Published References: Agenbroad and Mead 1987
15. Remarks: new localities for the above fauna
16. Sensitivity: ☐ Critical ☒ Significant ☐ Important ☐ Insignificant
17. Recorded by: Agenbroad and Mead

PALEONTOLOGICAL DATA SHEETS

Part D - Paleontology Locality

Locality No.(s), _____

Grobot Grotto

1. Type of Locality: ☐ Invertebrate ☐ Plant ☒ Vertebrate ☐ Trace ☐ Other

2. Formation/Horizon/Geologic Age: Quaternary alcove fill

3. Description of Geology and Topography: preserved in the dry (overhang area) of alcove in deep canyon in Navajo ss. + 240 ft above modern base level to top of the deposits. Fill is + 100 ft thick. Contains rockfall level with dung and bones of extinct fauna above the fall.

4. Location of Outcrop: N. wall of 40 mile canyon GLCA

5. Map Ref.: USGS Quad: Seonor bench Scale 1:24,000 Min. 7.5 Ed. 1962
SE of SW of SE of Sec. 11 T. 40 S R. 8 E Meridian

6. County Kane 7. Federal Admin. Unit(s) GLCA-NPS

8. Specimens Collected and Field Accession No.: _____

9. Repository: NMNH/USNM

10. Specimens Observed and Disposition: dung of mammoth (Mammuthus); bison (Bison); mountain goat (Oreamnos); shrub ox (Euceratherium).

11. Ownership: ☐ Priv. ☐ State ☐ BLM ☐ USFS ☒ NPS ☐ Ind. ☐ Mil. ☐ Other

12. Recommendations for Further Work or Mitigation: possible testing; mapping; do not make known as a public visitation locality. We can detect heavy traffic during periods that we are not in the field ???NPS personnel???hikers???

13. Type of Map made by Recorder: photograph from helicopter, location map from air photo

14. Published References: Aganbroad and Mead 1987; Mead and Aganbroad 1986

15. Remarks: new locality for all the listed fauna. detailed analyses of fauna and geology underway.

16. Sensitivity: ☐ Critical ☒ Significant ☐ Important ☐ Insignificant

17. Recorded by: Aganbroad & Mead

PALEONTOLOGICAL DATA SHEETS

Part D - Paleontology Locality

Locality No.(s)

BF Alcove

1. Type of Locality: ☐ Invertebrate ☐ Plant ☒ Vertebrate ☐ Trace ☐ Other
2. Formation/Horizon/Geologic Age: Quaternary sediments in alcove
3. Description of Geology and Topography: preserved in dry (overhang) alcove in deep canyon in Navajo sandstone. +240 feet to top of deposits from modern base level. Fill is + 100' thick.
4. Location of Outcrop: South wall of 40 Mile canyon GLCA
5. Map Ref.: USGS Quad: Sonner Bench Scale 1:24 000 Min. 7.5 Ed. 1968
S4 of of SE 1/4 of Sec. 11 T. 40 S R. R E Meridian
6. County Kane 7. Federal Admin. Unit(s) GLCA-NPS
8. Specimens Collected and Field Accession No.:
9. Repository: NAU/MNA
10. Specimens Observed and Disposition: lung of (Camelops) camel; needles of Douglas fir (Pseudotsuga menziesii) and seeds of Rocky Mountain maple (Acer glabrum)
11. Ownership: ☐ Priv. ☐ State ☐ BLM ☐ USFS ☒ NPS ☐ Ind. ☐ Mil. ☐ Other
12. Recommendations for Further Work or Mitigation: possible testing
13. Type of Map made by Recorder: photo from helicopter and field notebook sketch
14. Published References: Agenbroad and Mead 1987, Mead and Agenbroad 1986
15. Remarks: new locality for plants that are extralocal, today
16. Sensitivity: ☐ Critical ☒ Significant ☐ Important ☐ Insignificant
17. Recorded by: Agenbroad and Mead

PALEONTOLOGICAL DATA SHEETS

Part D - Paleontology Locality

Locality No.(s) Mammoth alcove

1. Type of Locality: ☐ Invertebrate ☐ Plant ☒ Vertebrate ☐ Trace ☐ Other
2. Formation/Horizon/Geologic Age: Quaternary alluvium in alcove
3. Description of Geology and Topography: alcove in W wall of Willow canyon
4. Location of Outcrop: _____
5. Map Ref.: USGS Quad: Rincon Scale 1:62500 Min. 15 Ed. 1953
_____ of _____ of C of Sec. 13 T. 40 S R. 9E Meridian _____
6. County Kane 7. Federal Admin. Unit(s) GLCA NPS
8. Specimens Collected and Field Accession No.: mammoth (Mammuthus) bones and dung; Bison (Bison) dung
9. Repository: NAIT/NAIT
10. Specimens Observed and Disposition: _____
11. Ownership: ☐ Priv. ☐ State ☐ BLM ☐ USFS ☒ NPS ☐ Ind. ☐ Mil. ☐ Other
12. Recommendations for Further Work or Mitigation: testing and Qual geology/palynology
13. Type of Map made by Recorder: photo from helicopter
14. Published References: Agenbroad and Mead 1987
15. Remarks: new locality for FAUNA
16. Sensitivity: ☐ Critical ☒ Significant ☐ Important ☐ Insignificant
17. Recorded by: Agenbroad and Mead

Appendix II

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA AND MUMMIES FROM GRAND GULCH, UTAH

Richard H. Hevly

Sediments from Basketmaker II pithouse sites on Cedar Mesa and mummies from caves in nearby Grand Gulch were subjected to pollen analysis for reconstruction of paleoecology and elucidation of prehistoric ceremonial (or medicinal) and dietary practices (Figure 1). The pithouse samples have associated C-14 dates of 340 ± 100 , 440 ± 100 A.D. (1610 B.P., 1510 B.P.) (GG-70-187A and C respectively) and 250 ± 160 A.D. (1700 B.P.) (GG-69-1) (Lipe and Matson 1971, 1975; Matson and Lipe 1978). Both archaeological and paleoenvironmental data for this time period are limited on the Colorado Plateau, yet the Basketmaker II episode is the time period during which the prehistoric peoples' mode of subsistence changed from nomadic hunting and gathering to more sedentary agriculture. Sites GG-69-1, 18 and 20 are located within Pinyon-Juniper Woodland approximately 1/2 mile to the north and west of Sites GG-187-A, B, C, and D which are

located at the edge of or within a Sage-Grassland or Savanna (Sheiks Flat) bordered by Pinyon-Juniper woodland between 6300 and 6400 feet in western San Juan County, Utah (Figure 1). The pithouse samples were obtained from a variety of proveniences. By far the majority of them were obtained from the middens, floors and archaeologically sterile fills, but some were also obtained from hearths, mortar and burned adobe, permitting comparison of roughly contemporaneous samples from different proveniences. The mummy samples were recovered from Grand Gulch caves in the 1890's by members of the Wetherill family and are part of the current American Museum of Natural History Collections. The caves from which they were removed have been recently re-examined and demonstrated to be Basketmaker II age, but assignment of specific mummies to specific caves has not been possible (Aasen, 1984; Lipe and Matson, 1988).

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

All samples submitted for analysis were extracted utilizing standard Hydrofluoric Acid-Acetolysis methods (Gray 1965). All samples proved to be very sandy, necessitating the use of a large volume of sediment (ca. 150 g) and use of the swirl technique of Funkhouser and Evitt (1959) to separate the large volume of inorganic sediment from the organic pollen containing fraction. This fraction, while of considerable volume due to the presence of much charcoal, contained only small amounts of pollen which had to be concentrated by repeated digestion with 5% KOH, 10% HNO₃ and Acetolysis mixture. Despite these rather severe treatments, pollen from modern samples and from cave samples appeared to be rather well preserved; however, that from the Basketmaker pithouses was poorly preserved. Pollen recovered from pithouse floors and floor features (such as pits) was most poorly preserved, while that from fills was better preserved, nearly approaching in quality of preservation that of modern surface samples.

MODERN SAMPLES

Multiple pinch soil-surface samples (n=10) were collected from the Pinyon-Juniper Woodland, Sage-Grassland and ecotone areas between the two major communities of the study area following standard techniques (Adam and Mehringer 1975; Hevly et al. 1965). These samples, which were collected in the fall, were analyzed and their pollen composition (%) was graphed along with samples of other plant associations from northern Arizona (Figure 2). Analysis of these samples followed standard procedures as outlined in Faegri and Iversen (1975) but were supplemented by the

use of ratios of selected environmental indicators shown to be of value in previous studies (Dixon 1962; Hevly 1968; Mahr 1963; West 1978). Identification of pollen employed both a small reference collection in the Department of Biological Sciences as well as standard keys such as that by Kapp (1968).

Examination of Figure 2 permits one to make certain general conclusions concerning the relationships of pollen and vegetation. Arboreal pollen (AP) comprises 50% or more of the total pollen composition in all samples from the forest, woodland and ecotone communities with grassland. Pine pollen decreases in relative abundance and is replaced by a high relative abundance of juniper pollen in the Pinyon-Juniper woodland. In ecotone communities of grassland and woodland, pine and juniper percentages are generally lower than in woodland or forest but can be high if the samples were collected in close proximity to abundant pollen producers such as pine or juniper (Hevly 1968). Separation of the Woodland, Woodland-Grassland ecotone and Sage-Flat communities is indicated by increasing nonarboreal (NAP) composition within the total pollen record of samples from such communities as well as ratios of such indicators as Sagebrush (*Artemisia*), Chenopods (Chenopodiaceae + *Amaranthus*), Grass (Gramineae), and Mormon Tea (*Ephedra*) (Figure 2).

Potential sources of bias exist in the suit of modern samples from the study area. Such sources of bias include human disturbance of the habitat by domestic livestock grazing, building of water tanks and clearing native vegetation for seeding. Disturbance of sediments normally

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

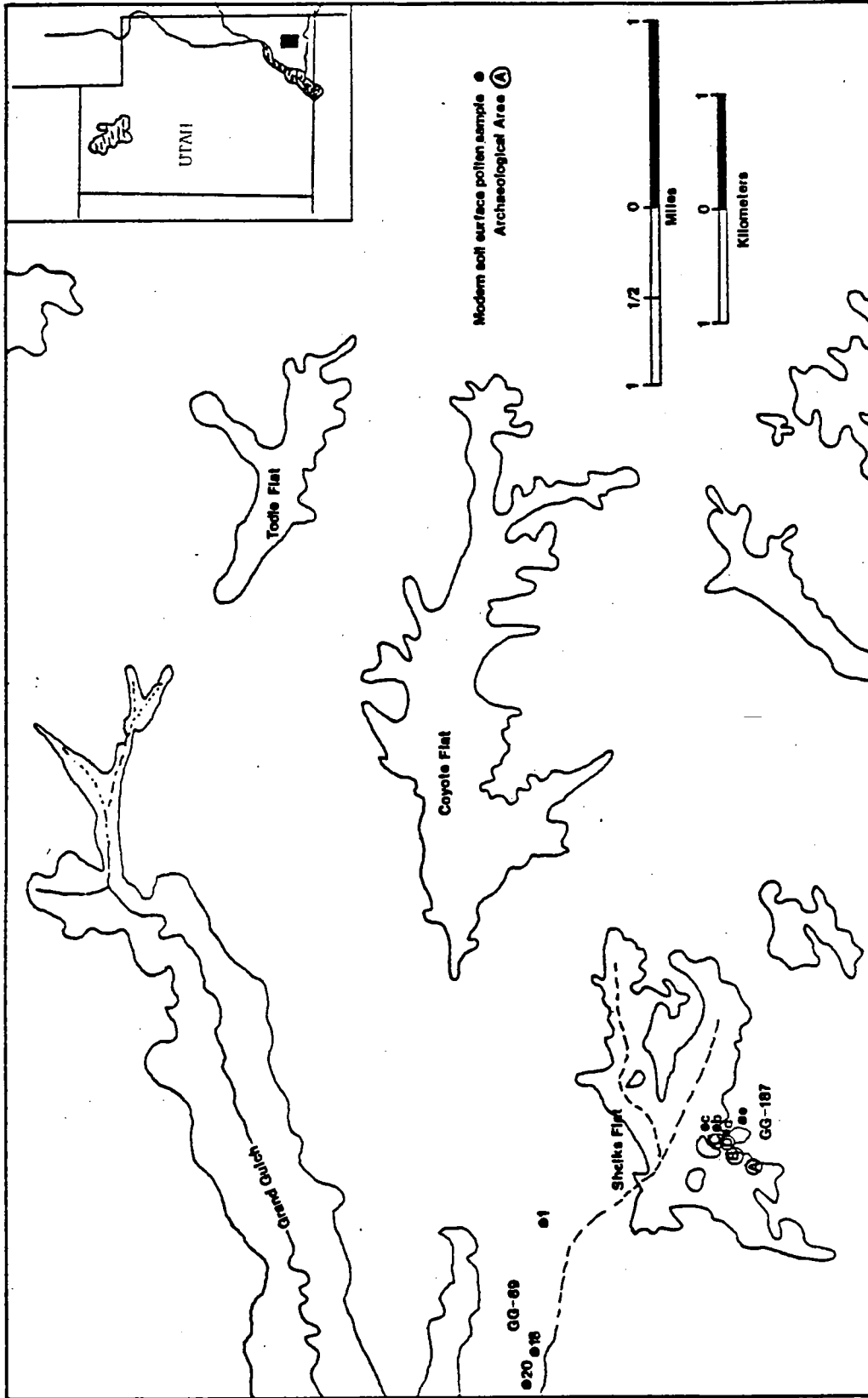


Figure 1. Map of Utah showing location of the study area (inset) and map of the study area showing the location of archaeological sites and modern soil surface localities sampled for pollen. The various flats are open areas with abundant sage brush and grass bordered by Pinyon-Juniper Woodland.

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

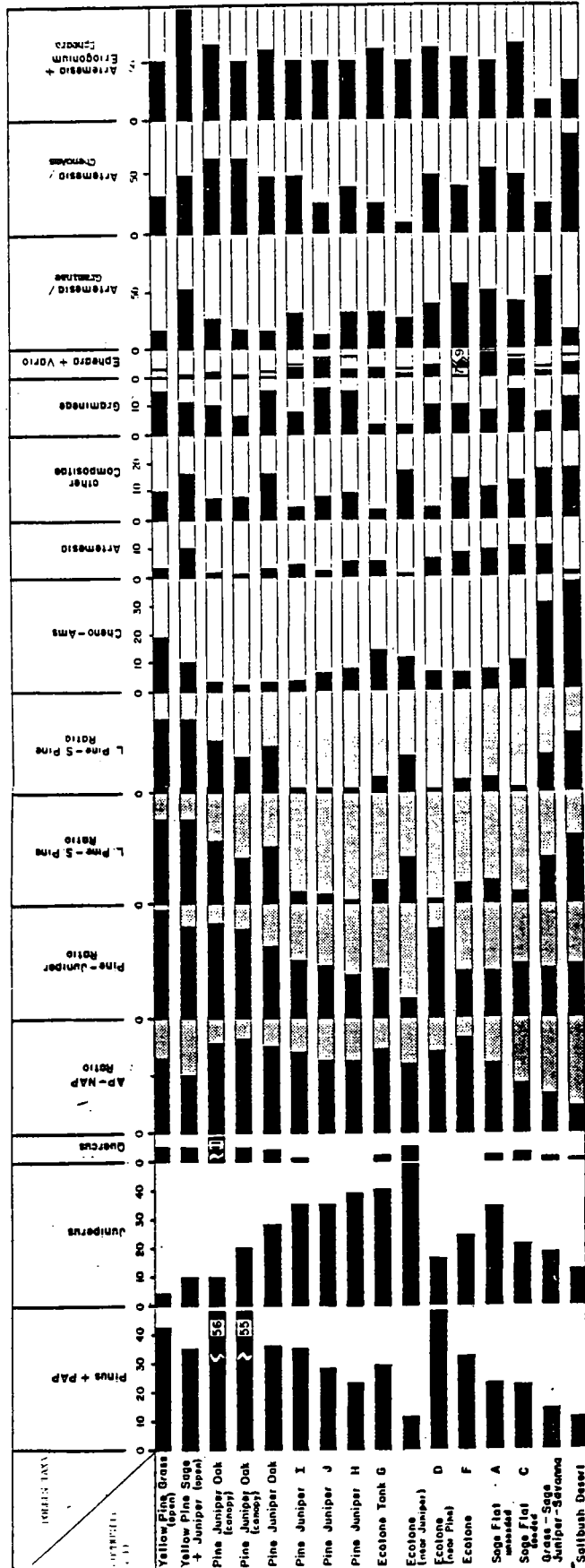


Figure 2. Pollen proportions from modern soil surfaces in Utah and Arizona. Samples A-F were collected in Utah study area (see Fig. 1). Other samples were collected on the Colorado Plateau in Arizona (Hevly 1968). Also shown are ratios of selected pollen types: arboreal pollen (AP) and non arboreal pollen (NAP) in a sum of all pollen, pine in a sum of pine and juniper, large pine (mostly ponderosa pine) and small pine (mostly pinyon pine) in a sum of all pine, and Artemisia relative to other NAP types.

results in poorer preservation of pollen already incorporated in such sediments and also mixture of pollen from pioneer species favored by disturbance (Hevly 1968; Martin 1963; Bohrer 1972). Disturbance about the cattle tank is reflected by slightly higher proportions of Cheno-Am pollen, but other proportions remain about the same as those observed in nearby woodland samples (Figure 2). Clearing and seeding of a sage-flat seem also to have had relatively minor effects on the pollen record in the present study area. The pollen record from the cleared and seeded sage-flat is distinguishable from the pollen sample obtained from nearby undisturbed sage-flat by 15% less arboreal pollen (13% less juniper) and more nonarboreal pollen (8% more gramineae). Sagebrush proportions appear to be relatively undiminished by disturbance, suggesting little differential destruction of pollen resulting from modern disturbance or compensation by transport from nearby undisturbed areas. Similar results were obtained by West (1978).

Sampling methods may also contribute to bias in samples of the modern pollen rain. Multiple pinch techniques tend to minimize local over-representation (Adam and Mehringer 1975). The significance of this technique can be observed by comparing surface pollen samples obtained from archaeological sites (tops of profiles) with nearby multiple pinch techniques. In the former samples all exhibit a two- or three-fold increase of particular nonarboreal pollen types; however, all samples are still assignable to proper plant community types utilizing arboreal pollen ratios, except, of course, the AP/NAP ratio (Figures 2-4).

Examination of the fossil pollen records, particularly of the arboreal proportions and ratios, reveals a very consistent departure from modern samples, namely a much lower relative abundance of arboreal pollen or conversely a much greater relative abundance of nonarboreal pollen in both floor and fill samples (Figures 3 and 4).

BASKETMAKER PITHOUSE SAMPLES

Thirty percent (n=25) of the 81 extracted pollen samples from pithouses on Cedar Mesa were productive. This yield is about the same as has been obtained at other early pithouse villages (Bohrer 1972). Pollen in general was not well preserved in either floor or fill samples raising some concern as to the effect of pollen preservation on pollen proportions since several investigators have presented data purporting to demonstrate differential preservation of arboreal pollen (Bradfield 1973; Hall 1981; Potter 1967). Comparison of pollen proportions and preservation in modern and fossil samples does indeed reveal a general pattern of diminishing proportions of pine and juniper pollen with increasing percentages of pine breakage (Figures 3 and 4). In modern samples approximately a 4% reduction of pine and juniper proportions occurs as pine breakage increases to about 10%. In general the diminishing proportions of pine and juniper closely parallel one another suggesting similar preservation properties as shown in an experimental study by Havinga (1971). The data therefore suggest that while proportions of pine and juniper may be

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

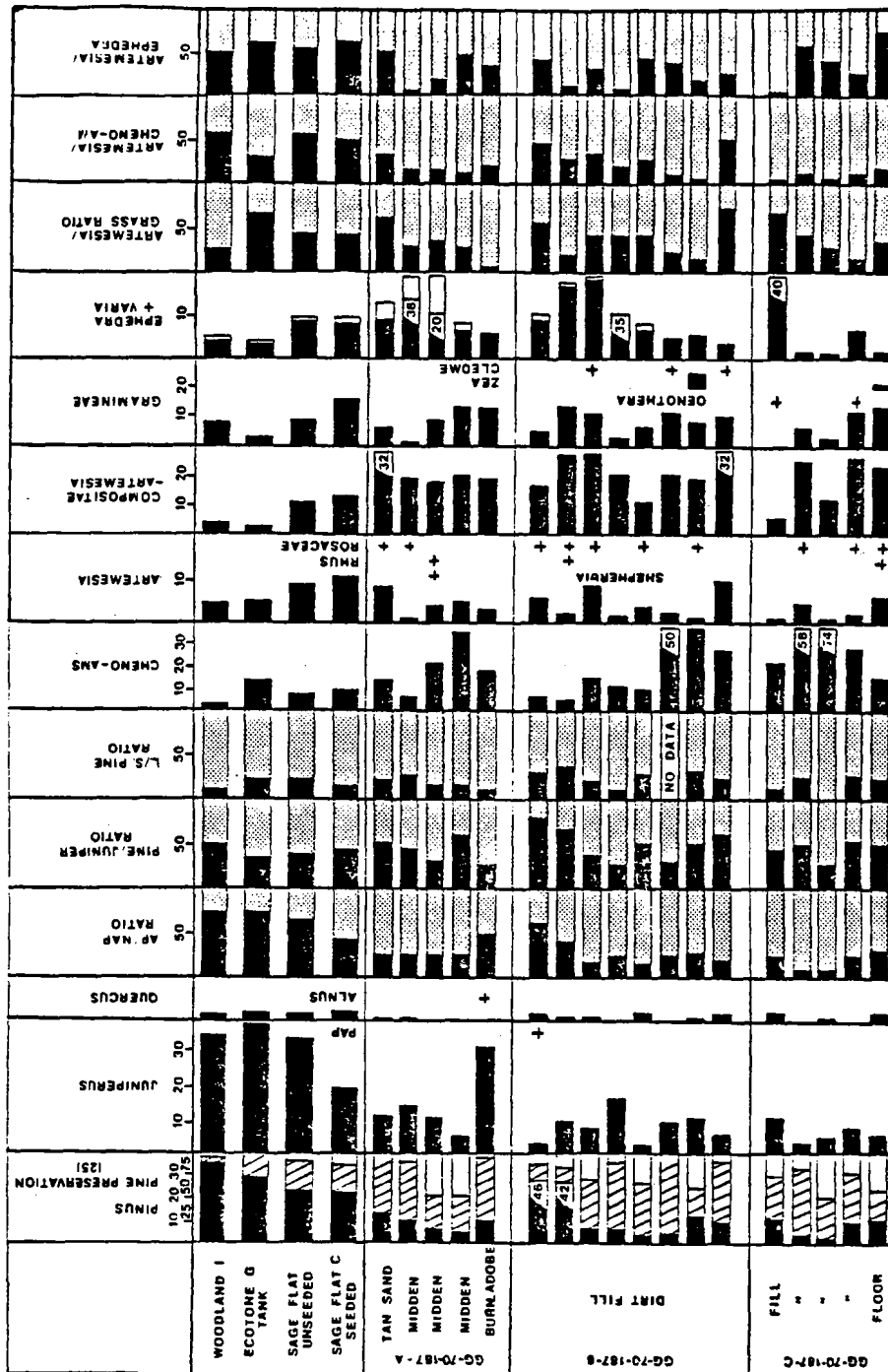


Figure 3. A comparison of the pollen proportions in modern samples and those found in archaeological site: GG-70-187. The solid portion of each histogram shows the proportion of that pollen type in a sum of all pollen or in a sum of the stated types in pollen ratios (solid and stippled histograms). In the *Pinus* histogram, the proportion of intact pine pollen grains (higher percentage values) is shown by the hatched portion of each histogram (Σ broken grains is shown by the clear portion). Compare the floor sample in GG-70-187C with the burnt adobe and midden samples of GG-70-187A (sites dating A.D. 440- and 340 ± 100 respectively) for a comparison of interior and exterior samples which are roughly contemporaneous.

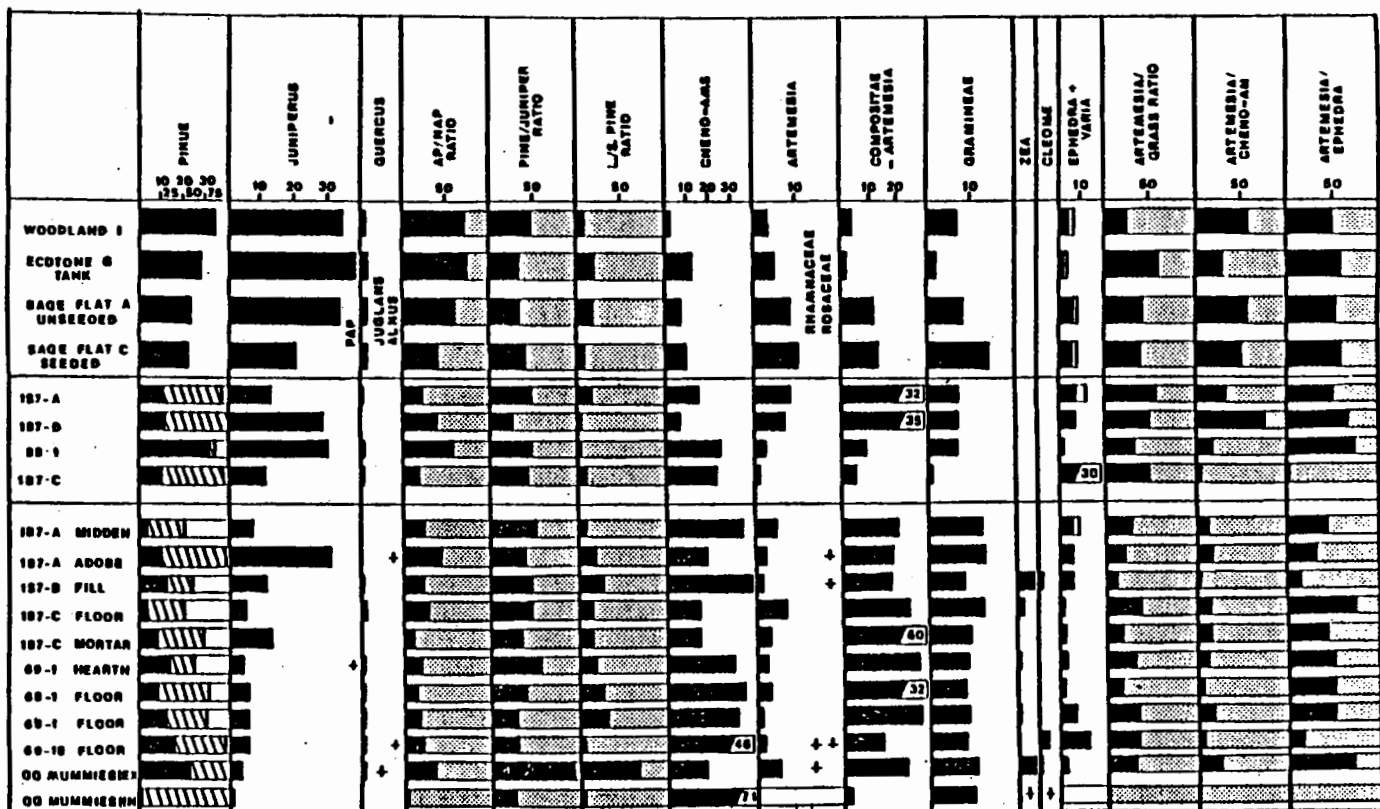


Figure 4. A comparison of modern samples from the study area (multiple pinch soil samples - upper four and single bulk soil samples from the surface of archaeological sites - second four) with prehistoric midden, adobe, mortar, hearth and floor samples from sites GG-187 and GG 69 as well as contemporaneous prehistoric mummy samples from Grand Gulch. Pollen data from the mummies is detailed in Tables 1, 2, and 3.

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

diminished by poor preservation, the relative proportions of these arboreal pollen types are probably not significantly altered, permitting the use therefore of arboreal pollen ratios in the reconstruction of past environments.

Potentially the fossil samples could be biased by such problems as differential pollen transport. Fortunately the suit of fossil samples includes a variety of proveniences which permit assessment of the influence of the structural and human contributions to prehistoric adulteration of the pollen record. Hearth and floor of the same room may be regarded as roughly contemporaneous and both represent interior samples. Midden samples on the other hand are post occupation samples and may be either interior or exterior samples depending on the site of deposition. Adobe samples, while recovered from structure interiors originated on the outside but may be regarded as roughly contemporaneous with floors and hearths. In most instances the adobe or mortar samples from GG-69 and GG-187 all exhibit more juniper pollen than any of the floor, hearth, or interior midden samples suggesting that juniper pollen does not in fact enter archaeological sites as well as certain other pollen types noted elsewhere (Hevly 1981). In addition, pine pollen may be represented a little better in hearth samples than in floor, midden or mortar samples perhaps reflecting bark storage of pollen and human manipulation (Adam, Fergusson and LaMarch 1967). In any case the magnitudes of these problems appears to be less than a 10% modification of the pollen record as the result of differential transport of arboreal pollen.

Unfortunately, nonarboreal pollen presents an entirely different

picture. The departure of fossil pollen proportions noted above appears to be entirely due to increased relative abundance of nonarboreal pollen since arboreal pollen ratios remain indicative of woodland and near-woodland conditions. The principal nonarboreal pollen types exhibiting excessive proportions included wind transported grass, Cheno-Am, sunflower (Compositae) and Mormon Tea pollen. The unusually high proportions of nonarboreal pollen resemble the effects of local over-representation normally occurring when abundant pollen producers grow near or on a sample locus (Bohrer 1972; Diggs 1980; Gasser and Scott 1982). Since plants could not grow within the occupied structures, the increased proportions of nonarboreal pollen could be attributable to an immediately adjoining local abundance of wind pollinated pioneer taxa. A local abundance of such taxa could be the result of local community disturbance by man favoring pioneer taxa, tolerance of such taxa in garden plots where they could provide insurance against the failure of cultigens or even encouragement of semi-domesticated taxa (Bye 1979; Dobyns 1974; Ford 1983; Minnis 1978).

The unusually high proportions of wind transported NAP types could also result from human manipulation of pollen bearing plant parts within the prehistoric structures (Bohrer 1981; Cully 1979; Fish 1985; Hevly 1981). The recovery of corn (*Zea*) pollen within structures or in middens probably reflects this later phenomena, for while wind dispersed, the pollen travels but a few yards from the fields in which it is grown and vegetative plant parts can be observed to have much adherent pollen (Berlin et al. 1977; Jones and Newell 1946; Raynor et al. 1972).

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

The occurrence in structures and middens of NAP pollen, which is normally insect transported, may also reflect human manipulation pollen bearing plant parts. Insect transported NAP pollen from potential food and medicinal plants in prehistoric samples from Cedar Mesa included buffalo berry (*Shepherdia*), squawberry (*Rhus*), evening primrose, (*Oenothera*), beeweed (*Cleome*), Rosaceae and Rhamnaceae. These are plants which grow today in the woodland and sage-flat communities of the study area and so like the arboreal pollen are indicative of environments similar to those which now prevail.

The recovery in structures and middens of normally insect transported NAP pollen also yields useful information regarding seasons of human occupation of the sites based on the flowering seasons of the plants. A late spring to early summer occupation is indicated by pollen of *Shepherdia*, *Rhus*, Rosaceae and Rhamnaceae. A late summer to early autumn occupation is also suggested by the recovery of pollen from *Oenothera*, *Cleome* and *Zea*. It is not known whether the prehistoric occupants remained at the mesa top sites year around or whether they spent portions of the year on the canyon slopes and bottoms of nearby Grand Gulch. Nevertheless, the occupation of the mesa tops was in all probability related to cultivation of crops and exploitation of natural resources such as wild game and the nut and berry crops.

Cultivation of domestic crops probably necessitated clearance of land of the sagebrush which grows on the better soil of the study area. This cultural activity probably best explains the low relative abundance of *Artemisia* pollen throughout the occupation period represented by the

samples of this study compared with modern values. The clearance of sagebrush was of longer duration and perhaps greater areal extent than that undertaken by twentieth century man. Occupation of the mesa top may have been occasioned by alluvial aggradation of degradation within Grand Gulch since only during periods of relative alluvial stability could crops be raised with some probability of success within this narrow, steep-sided canyon (Agenbroad 1975).

The regional climate as reflected by prehistoric arboreal pollen appears similar to that of today or perhaps a little drier since the archaeological sites which today are covered by woodland (GG-69-1, 18, and 20) yield a pollen record characterized by pine-juniper pollen ratios more like those obtained today from adjoining sage-flat communities. The diminished AP proportions in all pollen and the diminished proportions of pine pollen in pine-juniper ratios could reflect differential prehistoric human exploitation of trees for lumber, firewood, food and medicine. However, AP and pine-juniper trends are paralleled in roughly contemporaneous sites elsewhere in southern Utah, northern Arizona and New Mexico, suggesting a regional climatic trend of slightly more xenic conditions (Bohrer 1972; Dickey 1971; Hevly 1988; Lipe et al 1975; Schoenwelter 1962, 1964).

GRAND GULCH MUMMY SAMPLES

Pollen samples (n=20) were obtained from 14 mummies in the Grand Gulch collections of the American Museum of Natural History by Dr. William Lipe (Table 1). External

Table 1. Pollen recovered from various external and internal portions of Grand Gulch mummies from the Museum of Natural History with collection accession numbers, Sex/Age (σ = adult male, σ = adult female, $\pm$ = child) and body location sampled. Note the 10 fold greater quantity of pollen from the internal samples compared to the external samples although only half as many internal samples were sampled as were obtained externally. Note also the consistent differences between internal and external Cheno-Am pollen proportions.

Provenience		External Samples													
Pollen Types	Sex	B-2	B-3	562-1	H-122	H-122	H-134	H-134	H-134	H-134	H-164	H-164	H-164	H-164	H-164
	Age	♂	♂	♂	95-1	95-3	85-1	85-2	85-3	97-3	03-2	03-3	03-4	03-5	09-1
		Feet	Buttocks	Back	Feet	Feet	Buttocks	Cradle Board	Juniper Pad	Head	Legs	Feet	Head	Back	Crutch
Pinus (L.)					1	14	4	3			6	6			1
Pinus (S)			1		1	31	7	14	7		12	17			16
Juniperus						10	5	5	1		7	7			13
Quercus						5	5	1			2	1			5
Juglans													1		
Ephedra						2	2	2			2	2			1
Shepherdia						1									1
Rhamn.-Vitaceae							1								
Cheno-Ams			9	6	2	15	10	7	5	3	4	20	13		20
Plantago												1			
L.S. Compositae					2	7	7	6	3			10	18		15
Artemisia						2	2	2	2			7	10		6
H.S. Compositae			9	4		5	2		5	3	4	20	15		8
Gramineae					4	12	5	5	2			10	10		15
Zea							2	2	5			11	1		5
Cleome								1					1		
Opuntia						1									
Sphaeralcea							1						1		
Total Number of Pollen Counted		0	19	10	10	104	53	49	30	6	8	108	103	0	106

Provenience	Internal Samples						External		Internal	
	H-134	H-164	A-1	H-122	B-1	H-122				
	97-2 ±	03-1 ♀	♂	93-4 ♂	♂	93-1 ♂	Σ		Σ	
Pollen Types	Rectum	Pelvis	Pelvis	L. Intestine	Stomach & S. Intestine	Stomach				
<u>Pinus (L)</u>	1						35	5.8	1	0.0
<u>Pinus (S)</u>	9	3	1	3	1	1	106	17.6	18	0.2
<u>Juniperus</u>				21	11	35	48	8.0	67	1.1
<u>Quercus</u>							19	3.1	0	0.0
<u>Juglans</u>							1	0.1	0	0.0
<u>Ephedra</u>							11	1.8	0	0.0
<u>Shepherdia</u>							2	0.3		
<u>Rhamn.-Vitaceae</u>							1	0.1	0	0.0
<u>Cheno-Ams</u>	2189	410	950	575	435	135	114	18.9	4694	71.3
<u>Plantago</u>							1	0.1	0	
<u>L.S. Compositae</u>	3	9	2	297	449	183	68	11.3	943	14.6
<u>Artemisia</u>							31	5.2	0	
<u>H.S. Compositae</u>	2	3	1	51	70	25	75	11.6	152	2.4
<u>Gramineae</u>	1	3	3	349	122	181	63	10.5	659	10.2
<u>Zea</u>	3		2				26	4.3	5	
<u>Cleome</u>				3			2	0.3	3	
<u>Opuntia</u>							1	0.1	0	
<u>Sphaeralcea</u>							2	0.3	0	
Total Number of Pollen Counted	2198	428	959	1299	1128	560	606		6541	

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

Table 2. Analysis of the pollen composition on the various external parts of mummies from Grand Gulch Caves. No significant differences are to be noted.

Provenience Body Parts All Sexes Sample No.	Feet and Legs n=5		Back Crotch Buttocks n=5		Head n=2		Total	
Pollen Type								
<u>Pinus</u> (Large)	21	9.1%	5	2.7%	6	5.5%	33	6.1%
<u>Pinus</u> (Small)	44	19.1	24	12.8	17	15.6	85	16.1
<u>Juniperus</u>	17	7.4	18	9.5	7	6.4	42	8.0
<u>Quercus</u>	7	3.0	10	5.3	1	0.9	18	3.4
<u>Juglans</u>	0		0		1	0.9	1	0.2
<u>Ephedra</u>	4	1.7	3	1.6	2	1.8	9	0.2
<u>Shepherdia</u>	1	0.4	1	0.5	0		2	1.7
Rhamn.-Vit.	0		1	0.5	0		1	0.2
Cheno-Ams	41	17.8	45	23.9	16	14.7	102	19.4
<u>Plantago</u>	1	0.4	0		0		1	0.2
Low-Sp. Comp.	19	8.3	22	11.7	18	16.5	59	11.2
<u>Artemisia</u>	9	3.9	8	4.3	10	9.2	27	5.1
High Sp. Comp.	29	12.6	23	12.2	18	16.5	70	13.3
Gramineae	26	11.3	20	10.6	10	9.2	56	10.6
<u>Zea</u>	11	4.8	7	3.7	1	0.9	19	3.6
<u>Cleome</u>	0		0		1	0.9	1	0.2
<u>Opuntia</u>	0		1	0.5	0		1	0.2
<u>Sphaeralcea</u>	0		0		1	0.9	1	0.2
Total	230	100%	188	100%	109	100%	528	100%

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

Table 3. Analysis of the pollen composition of the Grand Gulch Mummies according to sex using both external and internal samples. Roman numerals = # of individuals; Roman numerals = # of samples, no apparent differences exist externally; however, internal pollen composition is quite different from the external composition.

Provenience		External						Internal					
Mummies: Samples	Pollen Types	Male		Female		Child		Male		Female		Child	
		IV: 5		I: 4		III: 5		III: 4		I: 1		I: 1	
		n	(%)	n	(%)	n	(%)	n	(%)	n	(%)	n	(%)
	<u>Pinus</u> (Large)	15	10.8	12	5.5	8	3.2			0	0.0	1	
	<u>Pinus</u> (Small)	33	23.7	29	13.2	44	17.7	15	0.2	3	0.7	9	
	<u>Juniperus</u>	10	7.2	14	6.4	24	9.7	67	1.1	0			
	<u>Quercus</u>	5	3.6	3	1.4	11	4.4	0		0			
	<u>Juglans</u>	0		1	0.5	0		0		0			
	<u>Ephedra</u>	2	1.4	4	1.8	5	2.0	0		0			
	<u>Shepherdia</u>	1	0.7	0		1	0.4	0		0			
	Rhamn.-Vit.	0		0		1	0.4	0		0			
	Cheno-Ams	29	20.8	37	16.9	48	19.4	4284	70.0	410	95.8	2189	
	<u>Plantago</u>	0		1	0.9	0		0		0			
	Low Sp. Comp.	9	6.5	28	12.8	31	12.5	934	15.3	9	2.1	3	
	<u>Artemisia</u>	2	1.4	17	7.8	12	4.8	0		3	0.7		
	High Sp. Comp.	17	12.2	39	17.8	19	7.7	149	2.4	3	0.7	2	
	Gramineae	16	11.5	20	9.1	27	10.9	656	10.7	3	0.7	1	
	<u>Zea</u>	0		12	5.5	14	5.6	5	0.1	0		3	
	<u>Cleome</u>	0		1	0.5	1	0.4	3	0.1	0			
	<u>Opuntia</u>	0		0		1	0.4	0		0			
	<u>Shaeralea</u>	0		1	0.5	1	0.4	0		0			
Total		139		219		248		6113		428		2207	

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

samples (n=14) were taken of sediment and fabric debris at different areas on eight mummies originally interned in baskets in pits sunken in cavefill. Internal samples (n=6) were obtained from H-134-97 and H-164-03 and four additional mummies. External samples yielded little pollen (n=606 grains) compared to the internal samples (=6541 grains). The external pollen samples individually exhibited no unusually high proportions of particular pollen types and collectively were composed of pollen types and proportions of types similar to the prehistoric pollen rain, differing only in lower proportions of juniper pollen. However, the co-occurrence of spring pollinating juniper, oak, and Mormon Tea found on the surfaces of only three of the 13 mummies sampled may reflect season of burial.

The cradle board and juniper pad associated with an infant burial (H-134-85) did not manifest any different proportions of pollen than found elsewhere on the infant surface (Table 1). More pollen was found on the feet and legs of adult mummies than on the head, but proportions of pollen types were similar on all external surfaces of adult bodies (Table 2). Less pollen was recovered from the surfaces of the male mummies than recovered from the surfaces of the female and child mummies, but the samples were compositionally very similar, except that the male mummies yielded slightly more pine pollen (Table 3). Since external samples were compositionally and proportionately similar to contemporaneous pollen (from nearby occupational features), no evidence was found to indicate either uncontained mortuary offerings of plants or pollen on the external body surfaces.

The internal samples on the other hand do not compare well with any modern samples or with the external mummy samples. The internal samples contained essentially no pollen derived from trees, but did contain unusually large proportions of Cheno-Am pollen in all six samples examined. Three of the four samples obtained from males also contained large numbers of pollen grains derived from the compositae (sunflowers) and gramineae (grasses). Extreme departure of pollen percentages associated with burials and fecal samples has been observed previously (Gish 1980, 1987; Halbirt 1980; Hill and Hevly 1968; Kelso 1976) and was attributed to ceremonial or medicinal practices. Since the departures in these instances are from samples obtained from the mummy interiors, it may be assumed that they reflect a medicinal practice and not a ceremonial practice associated with interment. It may also be possible that the departure of internal mummy samples is simply unvoided fecal matter as fecal samples also contain unusual concentrations of particular pollen types and macroscopic plant remains (Kelso 1970; Martin and Sharrock 1964; Reinhard et al. 1985; Scott 1979). In conclusion, it may be stated that the Grand Gulch mummy samples do not reveal any pattern of ceremonial use of pollen or plant parts containing pollen associated with interment of the dead but may have a record of medicinal practice or prehistoric dietary information.

Of particular interest in this study was the recovery of corn (*Zea*) pollen from Basketmaker II mummies (internal samples H-134 and A-1 and external samples of H-134 and H-164). Corn pollen was also recovered from the Basketmaker II pithouses: Both the floor and the dirt fill of

PALYNOLOGY OF BASKETMAKER SITES ON CEDAR MESA

GG-70-187B, the floor and dirt fill of GG-70-187C and the hearth samples of GG-69-1. Pithouse GG-70-187C has a C-14 date of 440 ± 100 A.D.(1510 B.P.) While GG-69-1 has a C-14 date of 250 ± 160 A.D.(1700 B.P.). These dates are compatible with previous macroscopic evidence of early corn cultivation on the Colorado Plateau (Berry 1982)

Appendix III
Radiocarbon Data Sheets

Radiocarbon Data Sheets

Table III-1. Compilation of radiocarbon dates from Canyonlands (CANY) National Park

<u>Field #</u>	<u>Arch site # (a)</u>	<u>Lab #</u>	<u>¹⁴C Age (Yr. R.P. (b))</u>	<u>Material</u>	<u>Calibrated date (A.D.-B.C.)</u>
SC#1/85		GX 11228	0 ± 200	alluvial organic	A.D. 1750
SC #1		Beta 16593	8,680 ± 120	organics w/snail	A.D. 6730 B.C.
SC #3		Beta 19282	16 ± 60	packrat	A.D. 1934
SC #4		Beta 19283	11,170 ± 300	Alluvial organics	9220 B.C.
SC #7		Beta 16594	910 ± 70	alluvial charcoal	A.D. 1040
SC #12		Beta 16595	2,860 ± 70	alluvial charcoal	910 B.C.
SC #13	42 SA 17215	Beta 16596	8,330 ± 110	hearth	6380 B.C.
SC #14	42 SA 17216	Beta 19285	8,100 ± 220	hearth	6150 B.C.
SC #15		Beta 16597	1,450 ± 80	alluvial charcoal	A.D. 500
SC #17	42 SA 17216	Beta 19284	1,720 ± 80	hearth	A.D. 230
SC-SN-JIM-S		Beta 28789 (ETH 4764)	12,480 ± 130	alluvial charcoal	10,530 B.C.
SC-SN-JIM-C ₂		Beta 28787	9380 ± 70	alluvial charcoal	7430 B.C.
SC-SN-Island		Beta 28786	350 ± 70	alluvial charcoal	A.D. 1600
SC-SN-7860 <C ₃		Beta 28788	10,200 ± 110	alluvial charcoal	8250 B.C.
SC-89-T5		Beta 31790	5,890 ± 70	alluvial charcoal	3940 B.C.
SC-LSC-89-2		Beta 33356	1,790 ± 90	alluvial organics	A.D. 160
SC-US-5:9-F ₃	42 SA 21091	Beta 31962	2,070 ± 70	hearth	120 B.C.
SC-US-5:35-F ₂	42 SA 21117	Beta 31964	1,670 ± 80	hearth	A.D. 280
SC-US-5:13	42 SA 21095	Beta 31963	6,290 ± 110	hearth	4340 B.C.
SC-LSC-89-1	(no site No.)	Beta 33355	4,510 ± 130	hearth	2560 B.C.
SC-Hoodoo #1		Beta 27213	27,660 ± 340	packrat	25,710 B.C.
Deadowl-a		Beta 18267	3,830 ± 70	packrat	1,880 B.C.
Deadowl-b		Beta 18268	22,320 ± 260	packrat	20,370 B.C.
SC-PBP-1		Beta 15964	14,970 ± 150	packrat	13,020 B.C.
SC-SCP-3		Beta 15965	10,820 ± 140	packrat	8,870 B.C.

Radiocarbon Data Sheets

SC-SCP-4a		Beta 15966	38,150 ± 1050	packrat	36,200 B.C.
SC-SCP-4b		Beta 15967	>35,500	packrat	>33,500 B.C.
SC-TA-1		Beta 16658	3,990 ± 70	packrat	2,040 B.C.
SC-B-16		Beta 16659	23,900 ± 180	packrat	21,950 B.C.
SC-BP-16		Beta 16660	1,440 ± 60	packrat	A.D. 510
SC-W-1		Beta 16661	480 ± 70	packrat	A.D. 1,470
SC-B-2		Beta 16662	13,300 ± 110	packrat	11,350 B.C.
SC-B-4		Beta 16664	21,600 ± 160	packrat	19,650 B.C.
HC-1	42-WN-1666	Beta 16666	1,160 ± 60	hearth	A.D. 790
HC-3	42-WN-1666	Beta 16667	3,180 ± 140	hearth	1,230 B.C.
Woodensoe #1		Beta 27214	6,980 ± 120	packrat	5,030 B.C.
BA -1 (AM5)		Beta 32292 (ETH 5666)	405 ± 60	horn-sheep	A.D. 1,545
BA-2 (AM5)		Beta 32293 (ETH 5667)	355 ± 60	bison	A.D. 1,595
BA-3 (AM5)		Beta 32294 (ETH 5668)	590 ± 65	resin	A.D. 1,360
BA-4 (AM5)		Beta 32295 (ETH 5669)	405 ± 65	horn-bison	A.D. 1,545
SC-89-T ₅	42 SA 17107	Beta 31790	5890 ± 70	hearth	3,940 B.C.

- a) not all ¹⁴C samples related directly to known archaeological site
b) dates in ¹⁴C years before A.D. 1950

Radiocarbon Data Sheets

Table III-2. Compilation of absolute dates from Glen Canyon National Recreation Area (GLCA); dates funded by NPS, NSF, NGS

<u>Field #</u>	<u>Arch site # (a)</u>	<u>Lab #</u>	<u>¹⁴C Age (Yr. B.P. (b))</u>	<u>Material</u>	<u>Calibrated date (A.D.-B.C.)</u>
BC-1		GX-10758	4090 ± 115	alluvial charcoal	2,140 B.C.
BC-2		GX-10759	0 ± 75	oak	A.D. 1,875
BC-3	42 KA 2751	GX-10938	no date, insuf. C	disseminated charcoal	— — —
BC-4		GX-10939	4025 ± 95	T ₃ root	2,075 B.C.
BC-5		GX-11017	insuf. C	soil	— — —
BC-6		GX-11020	insuf. C	tree cast	— — —
BC-7		GX-11019	4165 ± 95	alluvial charcoal T ₃	2,215 B.C.
BC-8		GX-11018	950 ± 160	"hearth"	A.D. 1,000
BC-9		GX-11143	940 ± 200	T _{3a} alluvial charcoal	A.D. 1,010
BC-10		GX-11144	215 ± 80	T _{3a} alluvial charcoal	A.D. 1,740
BC-11		GX-11145	10,020 ± 270	T ₄ alluvial charcoal	8,070 B.C.
BC-12	42 KA 2771	GX-11146	5,300 ± 235	arch site hearth in dune	3,350 B.C.
LC-1		GX-11192	14,860 ± 460	packrat	12,910 B.C.
LC-2		GX-11193	6,640 ± 190	packrat	4,690 B.C.
LC-3		GX-11194	7,635 ± 290	packrat	5,685 B.C.
LC-4		GX-11195	2,540 ± 140	packrat	590 B.C.
LC-5		GX-11196	5,240 ± 190	packrat	3,290 B.C.
LC-6		GX-11197	17,430 ± 770	packrat	15,480 B.C.
LC-7		GX-11198	9,545 ± 370	packrat	7,595 B.C.
BC-13	42 KA 2745	GX-11336	1,525 ± 130	T ₂ cultural charcoal	A.D. 425
BC-14		GX-11337	4,260 ± 170	T ₃ alluvial charcoal	2,310 B.C.
BC-15	42 KA 2756	GX-11338	1,290 ± 75	hearth in dune	A.D. 660
BC-16	42 KA 2756	GX-11339	3,000 ± 145	hearth in T ₃	1,050 B.C.

Radiocarbon Data Sheets

BC-17	42 KA 2775	GX-11340	1,315 ± 75	hearth @ falling dune	A.D.	635
BC-18		GX-11561	2,550 ± 80	alluvial charcoal		600 B.C.
BC-19		GX-11562	2,510 ± 80	alluvial charcoal		560 B.C.
BC-20		GX-11563	3,750 ± 165	alluvial charcoal		1,800 B.C.
BC-21		GX-11564	4,120 ± 170	alluvial charcoal		2,170 B.C.
CC-1		Beta 14978	840 ± 100	alluvial charcoal	A.D.	1,110
CC-5		Beta 14979	1,320 ± 80	alluvial charcoal		630 B.C.
CC-9		Beta 14980	1,100 ± 60	alluvial charcoal	A.D.	850
CC-10		Beta 14981	7,620 ± 100	alluvial charcoal		5,670 B.C.
FC-1		Beta 14360	1,180 ± 70	alluvial charcoal	A.D.	770
FC-2		Beta 14361	1,970 ± 90	alluvial charcoal		20 B.C.
FC-3		Beta 14727	11,970 ± 190	BF maple		10,020 B.C.
FC-4		Beta 14422	28,290 ± 2100	GG dung		26,340 B.C.
FC-5		Beta 14420	20,930 ± 400	GG dung		18,980 B.C.
BC-86/1		Beta 15640	1,600 ± 60	alluvial charcoal	A.D.	350
BC-96/2		Beta 15641	modern	alluvial charcoal		modern
BC-T ₄		AA 1511	32,800 ± 1300	<u>pisidium</u>		30,850 B.C.
BC-A84-6		Beta 16025	6,750 ± 120	packrat		4,800 B.C.
Waterfall #1		Beta 16661	480 ± 70	packrat	A.D.	1,470
BC-BS 2		Beta 16663	880 ± 70	packrat	A.D.	1,070
BC-# alti		Beta 16587	1,750 ± 90	alluvial charcoal	A.D.	200
BC-TL 2		Alpha 3034	>37,500 < 54,300	alluvial silt		35,550-52,350 B.C.
WC-87-B1		Beta 20704	10,500 ± 260	bone		8,550 B.C.
WC-87-D1		Beta 20705	16,630 ± 280	dung		11,680 B.C.
RC-2		Beta 20243	710 ± 100	alluvial charcoal	A.D.	1,240

Radiocarbon Data Sheets

BC-87-1		Beta 20241	4,080 ± 70	alluvial charcoal		2,130 B.C.
BC-87-2		Beta 20242	1,970 ± 80	alluvial charcoal		20 B.C.
BC-2730-5A	42 KA 2730	Beta 19514	2,310 ± 90	charcoal		360 B.C.
BF-2-3		Beta 20995	12,130 ± 170	douglas fir		10,180 B.C.
GG-M		Beta 20996	26,140 ± 670	dung		24,190 B.C.
GG-Oak		Beta 20997	9,920 ± 100	oak		7,970 B.C.
GG-Oak-2		Beta 20998	9,730 ± 170	oak		7,780 B.C.
GG-Oak 205		Beta 20999	7,510 ± 160	oak		5,560 B.C.
GG-SO-3M		Beta 23322	18,320 ± 290	dung		16,370 B.C.
GG-Bi-3M		Beta 22999	15,270 ± 120	dung		13,320 B.C.
HH-bison		Beta 23323	18,840 ± 350	dung		18,645 B.C.
CCYN-4		Beta 37044	1,020 ± 60	packrat		
CCYN-7		Beta 37045	1,580 ± 90	packrat		
CC-3		Beta 37046	2,070 ± 90	packrat		
FC-1		Beta 37047	3,760 ± 80	packrat		
87-1 (BC-9)	42-KA-2548	GX-10503	570 ± 130	juniper wickiup	A.D.	1380
87-1 (BC-28)	42-KA-2548	AA-4174	1,240 ± 180	corn	A.D.	710
87-1 (BC-26)	42-KA-2548	AA-4172	1,310 ± 100	bean	A.D.	640
87-1 (BC-27)	42-KA-2548	AA-4173	1,400 ± 150	squash	A.D.	550
87-1 (BC-8)	42-KA-2548	GX 10501	2,080 ± 140	charcoal		130 B.C.
87-1 (BC-16)	42-KA-2548	A-3516	2,640 ± 50	charcoal		690 B.C.
87-1 (BC-11)	42-KA-2548	A-3313	5,500 ± 80	charcoal		3,550 B.C.
87-1 (BC-25)	42-KA-2548	Beta 16025	6,750 ± 120	sandal fragment		4,800 B.C.
87-1 (BC-9)	42-KA-2548	GX 10502	7,525 ± 220	charcoal		5,575 B.C.
87-1 (BC-7)	42-KA-2548	GX 10500	7,795 ± 230	charcoal		5,845 B.C.
87-1 (BC-3)	42-KA-2548	A-3212	11,670 ± 300	dung		9,720 B.C.
87-1 (BC-4)	42-KA-2548	A-3296	11,850 ± 160	dung		9,900 B.C.
87-1 (BC-25)	42-KA-2548	AA-1123	11,870 ± 140	dung		9,920 B.C.

Radiocarbon Data Sheets

87-1 (BC-17)	42-KA-2548	AA-1113	12,090 ± 210	dung		10,140 B.C.
87-1 (BC-18)	42-KA-2548	AA-1114	12,320 ± 160	dung		10,370 B.C.
87-1 (BC-14)	42-KA-2548	AA-1110	12,390 ± 120	dung		10,440 B.C.
87-1 (BC-24)	42-KA-2548	AA-1122	12,390 ± 140	dung		10,440 B.C.
87-1 (BC-5)	42-KA-2548	A-3297	12,400 ± 250	dung		10,450 B.C.
87-1 (BC-16)	42-KA-2548	AA-1112	12,430 ± 300	dung		10,480 B.C.
87-1 (BC-13)	42-KA-2548	AA-1109	12,470 ± 140	dung		10,520 B.C.
87-1 (BC-26)	42-KA-2548	AA-1124	12,570 ± 100	dung		10,620 B.C.
87-1 (BC-23)	42-KA-2548	AA-1121	12,570 ± 130	dung		10,620 B.C.
87-1 (BC-20)	42-KA-2548	AA-1116	12,610 ± 140	dung		10,660 B.C.
87-1 (BC-21)	42-KA-2548	AA-1117	12,620 ± 130	dung		10,670 B.C.
87-1 (BC-6)	42-KA-2548	A-3298	12,620 ± 220	dung		10,670 B.C.
87-1 (BC-22)	42-KA-2548	AA-1120	12,880 ± 140	dung		10,930 B.C.
87-1 (BC-2)	42-KA-2548	A-3213	12,900 ± 160	dung		10,950 B.C.
87-1 (BC-15)	42-KA-2548	AA-1111	13,040 ± 280	dung		11,090 B.C.
87-1 (BC-1)	42-KA-2548	GX-9371	13,505 ± 580	dung		11,555 B.C.
OC-CYN-1A		Beta 35693	730 ± 60	packrat	A.D.	1220
OC-CYN-1B		Beta 35694	570 ± 70	packrat	A.D.	1380
OC-CH-1		Beta 35695	1,570 ± 70	packrat	A.D.	380
OC-CH-2		Beta 35696	410 ± 60	packrat	A.D.	1540
OC-CH-3A		Beta 35697	890 ± 60	packrat	A.D.	1060
OC-D-3		Beta 35698	110 ± 70	packrat	A.D.	1840
OC-SF-1A		Beta 35699	1,690 ± 80	packrat	A.D.	260
OC-SF-1B		Beta 35700	1,180 ± 80	packrat	A.D.	770
OC-SF-2		Beta 35701	710 ± 60	packrat	A.D.	1240
OC-SF-6		Beta 35702	1,610 ± 60	packrat	A.D.	340
OC-CYN-4		Beta 37044	1,020 ± 60	packrat	A.D.	930
OC-CYN-7		Beta 37045	1,580 ± 90	packrat	A.D.	370
OC-CC-3	42-WN-420	Beta 37046	2,070 ± 90	packrat		120 B.C.
OC-FC-1		Beta 37047	3,760 ± 80	packrat		1810 B.C.

Appendix IV

Macrobotanical Data Sheets

Table IV-1: Descriptions and measurements for flotation samples from the Bechan Cave area.

BECHAN CAVE

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 1	Grass mat and vegetal remains excavated from Archaic level in Bechan Cave	15-165 cm on 00 line, Archaic level	100	N/A	100	92	6750

Site 42KA2771

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 2	Subsampled for pollen, reddish-brown sand, charcoal flecks and ashes	Fea. 1, hearth	3500	3498	2	5	5300 ± 235
F.S. 3	Subsampled for pollen, reddish-brown sand, some gravel, roots.	Fea. 1, stratum assoc. with mid-Archaic hearth	4450	4447.5	5	2.5	5300 ± 235

Site 42KA2730

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
1	Orange-red sand, calcareous, flecks of charcoal.	Stratum 1, 0-5 cm BGS	1700	1100	600	46	NONE
2	Orange-red sand, chunks of charcoal, roof spall, very calcareous.	Stratum 2, cultural layer, 5-10 cm BGS (hearth)	2200	2171.1	28.9	28.9	2310 ± 90
3	Orange-red sand, contains charcoal and sandstone chunks, calcareous.	Stratum 2, cultural layer, 10-15 cm BGS (hearth)	2000	2000	>1.0	>1.0	2310 ± 90

Table IV-1: (continued)

4	Same as above, more charcoal	Stratum 2, cultural layer, 40-45 cm BGS (hearth)	1800	1768.1	32	32	2310 ± 90
5	Light orange-red sand, charcoal	Stratum 3, 45-50 cm BGS	2200	2158	42	42	NONE
6	Brownish-orange sand, contains charcoal, calcified sand	Stratum 2, hearth 1m. to the SE	2000	1600	400	37.4	2310 ± 90
7	Charcoal bits evident, more ashy than #6, much darker supernatant, calcareous, distinctive foul odor, contains bone and microflakes	Stratum 2, hearth 1m. to the SE	3000	1500	1500	320.2	2310 ± 90
F.S. 14 (Packrat midden)	Mostly grass fragments, stems, leaves, woody twigs, cactus remains, feces, and foul odor	In wall in alcove, near trench	1500	0	1500	1300	1200 ± 70

Site 42KA2751

SAMPLE #	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 53	Subsampled from pollen sample, light brownish-red sand, some ash and charcoal.	Locus A, N5, W4 (1x1m), level 2 22-32 cm BGS	1600	1600	>1.0	>1.0	Site dated to 1800 ± 100
F.S. 54	Subsampled for pollen, light brownish-red sand with some charcoal and ash.	Locus A, N5, W4 (1x1m), level 3 32-42 cm BGS	1600	1598.5	2	1.5	
F.S. 63	Dark reddish-orange sand with charcoal stain, some roots present.	N6, W4, (1X1m) Stratum III A, Locus A	3250	3246	4	4	

Table IV-1: (continued)

F.S. 64	Reddish-brown sandy soil, ashy, charcoal stained, roots present.	Locus A N6, W4, (1x1m) Stratum III B	3010	3008.5	1.5	1.5
F.S. 65	Reddish-brown sand, contains ash and flecks of charcoal.	Locus A N6, W4, (1x1m) Stratum III C	1900	1893	10	7
F.S. 66	Reddish-brown sand, contains ash and flecks of charcoal.	Locus A N6, W4, (1x1m) Stratum III D	2600	2595	5	6.3
*F.S. 67	See Van Ness, 1987	Fill from unlined basin-shaped hearth, 50-60 cm BGS.	3000	N/A	N/A	50
F.S. 81	Reddish-brown sand with root fragments and flecks of charcoal.	Locus A N6, W4, (1x1m) Stratum III E NW 1/4	3150	3148	2	2.5
F.S. 82	Orange-red sand, no charcoal stain or ashes, mostly sand and root castings.	N6, W4, (1x1m) NE 1/4 Stratum III E (arbitrary)	2570	2570	>1.0	>1.0
F.S. 83	Dark brownish-red sand, charcoal, ash, contains some root castings.	Locus? N5, W4, (1x1m) Fea. 1, hearth F 11, East 1/2	1500	1500	>1.0	>1.0
*F.S. 107	See Van Ness, 1987	Hearth 1, from upper fill, 50 cm BGS	3500	N/A	N/A	80

Table IV-1: (continued)

F.S. 117	Subsampled for pollen, dark ashy brown sand from hearth, very calcareous, increased clay content.	Fca. 6 (hearth)	3250	3250	>1.0	>1.0
*F.S. 118	See Van Ness, 1987	Hearth 5, present ground surface	5000	N/A	N/A	75
*F.S. 119	See Van Ness, 1987	Hearth 4, in arroyo cut near ground surface	3500	N/A	N/A	70
*F.S. 120	See Van Ness, 1987	Hearth 3, @ 50 cm BGS	3500	N/A	N/A	75

Site 42KA2744

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 1	See Van Ness, 1987	Isolated slab-lined hearth; upper fill, 10-20 cm BGS	3250	N/A	N/A	325	1500
F.S. 2	See Van Ness, 1987	Isolated slab-lined hearth; lower fill, 20-30 cm BGS	2750			675	1500

Site 42KA2745

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 6	See Van Ness 1987	Slab-lined hearth					1525 ±130

Table IV-1: (continued)

Site 42KA2756

SAMPLE #	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 18	Reddish-brown sand, hearth sample, flecks of ash and charcoal.	Locus B, S. profile stratum 4, level B, N30, E13	3550	3547	3	3	3000 ± 145
*F.S. 19	See Van Ness, 1987	Hearth 1, in arroyo cut, 15-20 cm BGS	3750	N/A	N/A	200	1290
*F.S. 21	See Van Ness, 1987	Hearth 2, 25 cm BGS	6250	N/A	N/A	90	3000 ± 145
F.S.21A	Very dark sand, chunky, ash, with flecks of charcoal.	Fea. 2, Archaic hearth	3000	2998	2	2	3000 ± 145
F.S. 21C	Reddish-brown sand with ash and flecks of charcoal, grass roots, calcareous	Fea.2, Archaic hearth	6500	6500	>1.0	>1.0	3000 ± 145
*F.S. 25	See Van Ness, 1987	BMIII, Stratum 2 in arroyo cut	5750	N/A	N/A	220	?
*F.S. 52	See Van Ness, 1987	Hearth 4,50-60 cm BGS	2250	N/A	N/A	50	1060
F.S. 61	Reddish-brown sand, calcareous, ashes and some charcoal.	Fea 5, hearth III	5200	5198	2	2	Below 3000, above 4330
*F.S. 75	See Van Ness, 1987	Locus C, 10 cm BGS	2500	N/A	N/A	15	?
*F.S. 76	See Van Ness, 1987	Locus C, 30 cm BGS	4000	N/A	N/A	40	?

Table IV-1: (continued)

F.S. 77	Reddish-brown sand, calcareous	Locus B, S. profile N30, E14 Stratum 4 Level B	2000	1980	20	28	?
---------	--------------------------------	---	------	------	----	----	---

Site 42KA2773

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 4	Subsampled for pollen, very dark hearth material, sandy, charcoal and roots.	Hearth fill, SW 1/4, lower level, charcoal layer	3000	2975	25	37.5	1730 ± 70
F.S. 5	Subsampled for pollen, reddish-brown sand with some sandstone pieces and charcoal flecks, some ash and roots.	SW 1/4 of hearth upper fill	2300	2290	10	17	1730 ± 70

Site 42KA2687

(Perfect Ruin)

SAMPLE#	DESCRIPTION	PROVENIENCE	DRY VOL (ML)	VOL HEAVY FRACTION	VOL LIGHT FRACTION	DRY ORGANIC MATERIAL (WT/G)	ASSOC. C-14 DATE
F.S. 12 Bulk soil #3	See Nickens and Assoc. 1985, sample analyzed from nearby Cow Canyon, no weight or size data available	EU1, S1/2 level 2					None
F.S. 13 Bulk soil #4	See Nickens and Assoc, 1985, same as above	EU1, S1/2 level 3					None

Table IV-2: Raw pollen counts from sites in the Bechan Cave area.

MODERN POLLEN TRANSECT: BECHAN CANYON

RAW COUNTS

	Sample 1	Sample 3	Sample 5	Sample 7	Sample 9
TAXA					
Abies	3	1	3	6	10
Betula	1	0	0	2	1
Juniperus	29	37	38	27	30
Pinus					
large	18	20	18	23	27
small	52	27	14	23	37
1/3	3	2	0	3	1
Quercus	1	2	5	3	2
Agave	0	0	1	0	0
Allium	3	3	9	3	2
Asteraceae					
Low	3	12	7	7	5
High	10	2	5	2	1
Artemesia	41	21	18	33	20
Ambrosia	3	5	3	4	2
Brassicaceae	0	4	1	0	0
Cheno-Am	9	9	26	9	6
Ephedra					
torreyana	0	2	1	14	2
viridis	5	3	10	15	8
Malvaceae	0	0	0	2	0
Mimosoideae	4	0	0	0	0
Nyctaginaceae	1	0	0	0	0
Opuntia	1	0	0	0	0
Plantago	0	1	0	2	0
Poaceae	15	44	40	42	42
Rhus spp.	0	0	0	2	2
Sarcobatus	0	1	1	0	0
Saxifragaceae	0	0	0	0	1
Shepherdia	0	1	1	0	0
Typha	5	4	9	1	5
TOTAL	207	201	210	223	204
Unidentified	9	9	6	4	7
Eucalyptus	20	5	9	2	11
Anemophilous	81	103	116	127	90
Entomophilous	19	9	16	9	6
Total NAP	100	112	132	136	96

Table IV-2: (continued)

Site 42KA2751

TAXA	RAW COUNTS			FS 53	FS 54
	Sample 1	Sample 12	Sample 15		
Celtis	1	0	0	0	0
Juniperus	0	3	4	0	0
Pinus					
large	0	2	1	0	0
Quercus	4	5	3	0	26
Agave	0	0	0	0	10
Allium	3	1	2	0	5
Asteraceae					
Low	9	7	18	0	1
High	2	0	4	0	6
Artemisia	1	4	5	1	95
Cheno-Am	19	21	53	1	5
Ephedra					
torreyana	0	0	2	0	0
viridis	0	1	3	0	0
Iris-type	0	0	2	0	0
Mimosoideae	0	3	0	0	0
Poaceae	60	48	94	3	51
Polypodiaceae	0	2	0	0	0
Sarcobatus	1	0	1	0	0
Shepherdia	0	0	2	0	0
Tradescantia	0	3	6	0	0
Typha	0	0	0	0	5
TOTAL	100	100	200	5	204
Unidentified	40	15	49	5	12
Eucalyptus	37	7	39	6	15
Anemophilous	90	83	178	5	157
Entomophilous	5	7	14	0	21
Total NAP	95	90	192	5	178

Macrobotanical Data Sheets

Table IV-2: (continued)

Site 42KA2730								
TAXA	RAW COUNTS							F.S.14
	Sample 1	Sample 2	Sample 5	Sample F	Sample G	Sample H	Sample I	
Abies	0	0	0	3	0	2	7	7
Celtis	0	0	1	1	0	0	1	1
Juniperus	0	1	1	3	2	1	1	1
Pinus								
large	0	19	0	5	21	19	14	6
small	0	12	0	11	18	23	21	4
1/3	0	1	0	1	0	4	0	3
Quercus	0	6	0	5	4	4	5	3
Salix exigua	0	3	0	0	0	0	0	0
Allium	2	2	0	0	4	3	2	1
Asteraceae								
Low	0	4	1	1	14	11	10	9
High	0	1	0	5	18	4	12	19
Artemisia	2	4	1	15	25	21	19	36
Ambrosia	0	0	0	0	4	8	1	10
Boraginaceae	0	0	0	0	0	0	0	1
Cheno-Am	1	3	6	6	34	15	11	34
Ephedra								
torreyana	0	1	3	2	6	2	3	3
viridis	0	0	0	1	3	6	2	3
Euphorbiaceae	0	0	0	0	0	0	0	2
Fabaceae	0	0	0	0	6	7	7	1
Iris-type	0	0	0	1	0	0	0	0
Malvaceae	0	0	0	1	0	0	0	20
Mimosoideae	0	1	0	2	0	0	0	0
Oenothera	0	0	0	0	1	0	0	0
Poaceae	1	20	4	34	28	59	76	35
Polypodiaceae	0	3	0	0	8	2	0	0
Shepherdia	0	1	0	0	0	0	0	0
Typha	0	2	1	3	11	6	7	2
Urtica	0	0	0	0	0	0	5	0
TOTAL	6	84	18	100	207	197	204	201
Unidentified	1	11	10	10	34	24	23	8
Eucalyptus	0	0	12	5	25	17	10	47
Anemophilous		38		62	133	130	134	132
Entomophilous		4		9	29	14	21	44
Total NAP		42		71	142	144	155	176

Table IV-2: (continued)

Site 42KA2756

TAXA	RAW COUNTS		
	FS 65	FS 74	FS 76
Juniperus	1	12	6
Pinus			
large	0	1	4
small	0	1	4
Agave	0	3	0
Allium	0	0	5
Asteraceae			
Low	0	7	10
High	0	5	0
Artemesia	0	5	9
Atriplex	0	0	2
Brassicaceae	0	0	7
Cheno-Am	0	18	17
Cyperaceae			
Carex	0	0	8
Ephedra			
torreyana	0	2	2
viridis	0	1	0
Euphorbiaceae	0	0	7
Gilia	0	12	14
Iris-type	0	4	2
Malvaceae	0	4	0
Mimosoideae	0	4	0
Oenothera	0	0	1
Opuntia	0	1	0
Parietaria	0	45	25
Plantago	0	5	2
Poaceae	0	48	62
Polypodiaceae	0	4	7
Rosaceae	0	1	0
Sarcobatus	0	1	0
Selaginella	0	1	0
Sphaeralcea	0	0	5
Solidago	0	1	0
Typha	1	6	2
TOTAL	1	192	201
Unidentified	0	39	1
Eucalyptus	2	29	12
Anemophilous		143	151
Entomophilous		35	36
Total NAP		178	187

Table IV-2: (continued)

BECHAN BEGAY					
RAW COUNTS					
	Sample	Sample	Sample	Sample	Sample
	B2	B6	B7	B11	B17
TAXA					
Juniperus	34	20	54	20	3
Pinus					
large	7	3	2	1	1
small	6	3	3	1	0
1/3	0	15	3	0	0
Quercus	16	10	14	18	3
Salix edgwa	1	0	0	0	0
Agave	1	0	0	0	0
Allium	4	3	10	4	3
Asteraceae					
Low	14	18	4	10	6
High	15	9	6	18	1
Artemesia	15	8	5	3	7
Cheno-Am	46	32	45	46	20
Ephedra					
torreyana	18	1	4	7	7
viridis	0	3	2	1	0
Iris-type	1	2	1	5	2
Malvaceae	0	0	2	0	0
Mimosoideae	0	0	2	0	0
Poaceae	30	62	41	60	36
Polypodiaceae	0	0	0	0	1
Sarcobatus	0	3	2	0	0
Shepherdia	0	1	0	0	0
Tradescantia	0	0	0	3	7
Typha	1	9	0	3	3
TOTAL	209	202	200	200	100
Unidentified	54	51	39	37	35
Eucalyptus	13	45	33	36	13
Anemophilou:	124	137	103	130	80
Entomophilou:	21	14	21	30	13
Total NAP	145	151	124	160	93

Table IV-2: (continued)

SITE 42KA2771

TAXA	RAW COUNTS	
	FS 2	FS 3
Asteraceae		
Low	1	0
Artemesia	1	0
Cheno-Am	7	0
Pinus		
small	0	1
Poaceae	5	0
TOTAL	14	1
Unidentified	3	0
Eucalyptus	0	1

SITE 42KA2744

TAXA	RAW COUNTS	
	FS 4	
Abies	1	
Compositae		
Artemesia	3	
Cheno-Am	2	
Juniperus	1	
Pinus		
large	2	
Poaceae	7	
TOTAL	16	
Unidentified	3	
Eucalyptus	1	

SITE 42KA2773

TAXA	RAW COUNTS	
	FS 4	FS 5
Juniperus	0	17
Pinus		
large	0	4
small	0	10
1/3	0	3
Allium	0	9
Asteraceae		
Low	0	10
Artemesia	0	19
Cheno-Am	1	35
Cruciferae	0	1
Ephedra		
viridis	0	13
Gilia	0	1
Iris-type	0	1
Malvaceae	0	3
Mentha		1
Mimosoideae	0	1
Plantago	0	3
Poaceae	2	66
Typha	0	5
TOTAL	3	202
Unidentified	0	19
Eucalyptus	10	51
Anemophilous		151
Entomophilous		17
Total NAP		168

BOWNS CANYON LAKE UNIT

TAXA	RAW COUNTS	
	Sample A	Sample B
Asteraceae		
Low	0	5
Artemisia	1	1
Ambrosia	0	1
Cheno-Am	8	3
Ephedra		
torreyana	0	1
viridis	0	1
Gilia	0	1
Juniperus	2	7
Pinus		
large	1	1
1/3	0	1
Poaceae	4	10
Typha	0	2
TOTAL	16	34
Unidentified	7	3
Eucalyptus	5	18

Macrobotanical Data Sheets

Table IV-3: Results of Charcoal analysis from site 42KA 2730.

SITE SAMPLE #	ANGIOSPERM DICOT RING POROUS	ANGIOSPERM DICOT DIFFUSE POROUS	ANGIOSPERM MONOCOT	GYMNOSPERM	UNIDENTIFIED	TOTAL
42KA2730						
#1	4	2	2	0	2	10
#2	17	2	1	4	0	25
#3	11	5	2	7	0	25
#4	9	14	2	0	0	25
#5	15	10	0	0	0	25
#6	11	14	0	0	0	25
#7	13	9	0	3	0	25
PACKRAT	none identifiable					

