High-altitude Archeological Investigations at Cedar Breaks National Monument, Utah

by

Timothy W. Canaday

No. 17
2001

CULTURAL RESOURCES SELECTIONS
Intermountain Region
National Park Service

REPORT DOCUMENTATION PAGE	1. REPORT NO.	2.	3. Recipients Accession No.
4. Title and Subtitle High-altitude Archeological Investigations at Cedar Breaks National Monument, Utah			5. Report Date March 2001 6.
7. Author(s) Timothy W. Canaday			8. Performing Organization Report No.
9 Performing Organization Name and Address			10. Project/Task/Work Unit No. 11. Contract © or Grant (G) No. (C) (G)
12. Sponsoring Organization Name and Address National Park Service Zion National Park Springdale, Utah 84767			13. Type of Report and Period Covered Final 14.
15. Supplementary Notes Cultural Resources Selections No. 17 Intermountain Region, National Park Service			

16..Abstract

This document is the final technical report of a cultural resources inventory and limited testing project in the Cedar Breaks National Monument area of the Markagunt Plateau, Utah. Elevations within the project area range from 7,800 ft (2,378 m) in the lower portions of the Monument to 11,278 ft (3,438 m). An intensive pedestrian survey of 2,318 acres within the monument, and additional acres surrounding the monument on lands administered by the Dixie National Forest resulted in the discovery of 99 archeological sites and 32 isolated occurrences. Four historical sites and 21 prehistoric isolates were documented in the lower portions of the monument. The remainder of the sites and isolates are located on the upper rim of the Markagunt Plateau. A 10% sample of these sites was tested to determine if significant subsurface deposits were present. These testing efforts indicated that the vast majority of the archeological sites discovered during the course of field work are surface manifestations. The majority of these sites appear to be associated with the prehistoric reduction of locally available Brian Head chert. Time-sensitive artifacts indicate prolonged and intensive use of high-altitude resources over the last 8,000 years or so.

X-ray flourescence analysis of obsidian artifacts indicate a decidedly Great Basin connection. Obsidian from four different locales are present at Cedar Breaks sites, dominated by obsidian from the Wild Horse Canyon area of the Mineral Mountains, Utah. Lesser amounts of obsidian were found to come from the Panaca, Nevada area; the Obsidian Butte source in Nye County, Nevada; and Black Mountain in southwestern Utah. Bristlecone pine stands within the monument and surrounding Dixie National Forest were analyzed to gain insights about paleoenvironmental conditions in the area during the last several thousand years. Additional paleoenvironmental studies focused on pollen and macrofossils extracted from lake and bog sediments. Fire history and possible beetle infestation are also documented.

17. Document Analysis a. Descriptors Archeological Studies/Field Investigations/Laboratory Analyses/Cultural Resources

b. Identifiers/Open-Ended Terms Cedar Breaks National Monument, Utah/High-altitude Archeology/Great Basin/Markagunt Plateau/Lithic Procurement Source/Hunter-Gatherers/Paleoenvironment

c. COSATI Field/Group Archeology

18. Availability Statement	19. Security Class (This Report)	21 No. of Pages
Available from the National Park Service	Unclassified	203
	20. Security Class (This Page)	22 Price
	Unclassified	N/A

(See ANSI-Z39.18) See Instructions on Reverse OPTIONAL FORM 272-(4-77) (Formerly NTIS-35) Department of Commerce

High-altitude Archeological Investigations at Cedar Breaks National Monument, Utah

by

Timothy W. Canaday

With contributions by

Edward F. Bakewell, Weng Chengyu, Peggy L. Corson, Dawna E. Ferris, Scott A. Elias, Gary S. Funkhouser, Richard E. Hughes, Stephen T. Jackson, David B. Madsen, Laureen Perry, Andrei Sarna-Wojciki, and Robert S. Thompson

U.S. Department of the Interior
National Park Service
Intermountain Region
Cultural Resource Selections Series
Denver, Colorado
2001

FORWORD

The National Park Service, Intermountain Region, is pleased to present this volume, as the latest in a series of reports concerning prehistoric and historic period cultural resources in regional parks. This volume is the final technical report of a multi-year cooperative cultural resources project focused on the Cedar Breaks National Monument and surrounding areas of the Markagunt Plateau in southwestern Utah. The project included studies by the National Park Service, the U.S. Forest Service, and the Utah Geological Survey. The goals of the project were to collect management, scientific, and interpretive data concerning the paleoecology and human uses of the study area.

The Cedar Breaks National Monument is located on the Markagunt Plateau, at elevations above 3,000 meters (10,000 feet). Prior to the current research, little scientific data had been collected about past environmental conditions or human adaptations to this high elevation zone. Dendroclimatic and peat bog studies by the Utah Geological Survey, reported in this volume, identify fluctuating wet and dry periods during the past 10,000 to 12,000 years on the Markagunt Plateau. These environmental changes influenced human land use patterns during prehistory, with an apparent concentration of use during the Late Archaic. Tool stone procurement and hunting appear to have been the primary human activities conducted within the study area. During Late Prehistoric and Protohistoric times, use of the area continues, but with less intensity. Evidence of historic period activities include logging and livestock production sites, as well as structures associated with early tourism to the national parks.

This report contains new information about long-term human adaptations to the somewhat inhospitable high elevation Markagunt Plateau of southwestern Utah. I take great pleasure in making this study of the Cedar Breaks National Monument available to the scientific community and to the public.

Karen P. Wade
Regional Director
Intermountain Region

Mission: As the Nation's principal conservation agency, the Department of the Interior has responsibility for most of our nationally-owned public lands and natural and cultural resources. This includes fostering wise use of our land and water resources, protecting our fish and wildlife, preserving the environmental and cultural values of our national parks and historical places, and providing for the enjoyment of life through outdoor recreation. The Department assesses our energy and mineral resources and works to assure that their development is in the best interests of all our people. The Department also promotes the goals of the Take Pride in America campaign by encouraging stewardship and citizen responsibility for the public lands and promoting citizen participation in their care. The Department also has a major responsibility for American Indian reservation communities and for people who live in Island Territories under U.S. Administration. NPS-D28.

ACKNOWLEDGMENTS

Funding for this project was provided by the National Park Service, Intermountain Support Office, under a Systemwide Archeological Inventory Program grant, and by a cooperative agreement with the Dixie National Forest and Utah Geological Survey.

Dr. Adrienne B. Anderson, National Park Service Intermountain Region Archeologist, was instrumental in securing funding for this project. It was Adrienne who first recognized the importance of the archeology of the area and without her drive and determination, this project may never have been initiated.

I'd especially like to thank Matt Betenson for promptly acting upon my constant requests for more data. Thanks, bud!

Laird P. Naylor, former Zion National Park Archeologist, acted as Project Director for this three-year field project. Jack Burns, Cultural Resource Specialist and Assistant Chief of Resource Management at Zion National Park, provided valuable editorial comments on earlier versions of this report.

I thank the Cedar Breaks National Monument Superintendent, Tom Henry, and Chief Ranger Steve Robinson for their ongoing interest in our work and their ever present willingness to help ensure a successful project. Monument personnel were also very helpful in many logistical aspects of the field work. In particular, Mike Ward, Jill Howard, Jerry Carpenter, Larry McNeil, and Troy Hunt provided valuable information and assistance.

Marian Jacklin, Dixie National Forest Archeologist, provided details on past Markagunt Plateau research.

The first season of field work was conducted by Barbara Frank (supervisor), Matthew Betenson, and Brian White. The second season of field work was conducted by Tim Canaday (supervisor), Matthew Betenson, Brian White, Brian Brownholtz, Connie VonSleichter, and Maggie Thurs. The crew for the third field season consisted of Tim Canaday (supervisor) and three student conservation assistants: Britt Hansen, Johnny Hartsfield, and Rebecca Janssen. Adrienne Anderson also assisted with field work during the second and third seasons. Volunteers included Peggy Corson, Paula Hungar, Dr. Patrick McCutcheon and Binny Westerhoff. Volunteers from the Southwestern Service Group of the Sierra Club assisted Dixie Forest Archeologist Marian Jacklin over the course of six summer field seasons.

This report is greatly improved by the artistic talents of Peggy Corson, who provided illustrations of the historic and prehistoric artifacts depicted here.

Laureen Perry performed analyses of the ceramics. Dr. David Madsen and his colleagues conducted the Markagunt Plateau paleoecology studies. Dr. Richard Hughes performed X-ray fluorescence analyses on the collected obsidian. Edward Bakewell conducted petrographic and geochemical analyses on the Brian Head chert samples. Gary Funkhouser performed the bristlecone studies. Gary Bowyer helped with some of the bottle identifications.

My thanks to writer-editor Jane Harvey of the NPS Intermountain Support Office in Santa Fe for improving the quality of this report. Matt Betenson, Jack Burns, Dawna Ferris, Dr. Pete Rowley, and Dr. Pat McCutcheon also reviewed earlier versions of this manuscript. Of course any errors or omissions are my responsibility, not theirs.

This technical report was prepared while I was employed by Death Valley National Park. I thank the Superintendent (Richard Martin) and the Chief of Resource Management (Linda Greene) for allowing me the time and resources to complete this report.

Timothy W. Canaday
Field Director
September 30, 2000

ABSTRACT

This document is the final technical report of a cultural resources inventory and limited testing project in the Cedar Breaks National Monument area of the Markagunt Plateau, Utah. Elevations within the project area range from 7,800 ft (2,378 m) in the lower portions of the Monument to 11,278 ft (3,438 m) at the summit of Brian Head Peak.

This project was conducted as part of a multi-year cooperative cultural resources program between the National Park Service, the U.S. Forest Service, and the Utah Geological Survey. The purposes of this multi-year effort are to provide management, scientific, and interpretive information on the prehistory, history, and paleoecology of the monument and surrounding area.

An intensive pedestrian survey of 2,318 acres within the monument, and additional acres surrounding the monument on lands administered by the Dixie National Forest resulted in the discovery of 99 archeological sites and 32 isolated occurrences. Four historical sites and 21 prehistoric isolates were documented in the lower portions of the monument. The remainder of the sites and isolates are located on the upper rim of the Markagunt Plateau.

A 10% sample of these sites was tested to determine if significant subsurface deposits were present. These testing efforts indicated that the vast majority of the archeological sites discovered during the course of field work are surface manifestations. The majority of these sites appear to be associated with the prehistoric reduction of locally available Brian Head chert. Time-sensitive artifacts indicate prolonged and intensive use of high-altitude resources over the last 8,000 years or so.

Several special studies were conducted in support of the Cedar Breaks archeological project. Petrographic and geochemical characterization of Brian Head chert suggests that this tool stone is an altered vitric tuff.

X-ray fluorescence analysis of obsidian artifacts indicates a decidedly Great Basin connection. Obsidians from four different locales are present at Cedar Breaks sites, dominated by obsidian from the Wild Horse Canyon area of the Mineral Mountains, Utah. Lesser amounts of obsidian were found to come from the Panaca, Nevada, area; the Obsidian Butte source in Nye County, Nevada; and Black Mountain in southwestern Utah.

Bristlecone pine stands within the monument and surrounding Dixie National Forest were analyzed to gain insights about paleoenvironmental conditions in the area during the last several thousand years. Additional paleoenvironmental studies focused on pollen and macrofossils extracted from lake and bog sediments. Fire history and possible beetle infestation are also documented. The presence of Mono Craters ash at Lowder Creek bog extends the known range of this volcanic ash hundreds of miles.

TABLE OF CONTENTS

Page

FOREWORD iii
ACKNOWLEDGMENTS v
ABSTRACT vii
LIST OF FIGURES xiii
LIST OF TABLES xvii

Chapter

1. PROJECT OVERVIEW AND RESEARCH DOMAINS
   - Introduction 1
   - Project Location 1
   - Present Environment 1
   - Research Design 7
   - Methods
     - Field Procedures 9
     - Definitions 10
     - Laboratory Procedures 11
     - Curation 11
   - Report Organization 11

2. BACKGROUND
   - Introduction 13
   - Prehistoric Overview 13
     - Paleoindian 13
     - Archaic 15
     - Formative
       - Fremont 15
       - Virgin Anasazi 17
     - Neo-Archaic and Protohistoric 18
   - Ethnographic Overview (by Dawna E. Ferris)
     - Introduction 19
     - Subsistence Strategies 19
     - Material Culture 21
     - Traditional Land Use Area 23
     - Cultural Change 25
   - Historical Overview (by Dawna E. Ferris)
     - Euro-American Exploration Period 28
     - Mormon Settlement Period 29
     - Federal Administration Period 32
   - Previous Archeological Research 36

Chapter		Page
3.	**SUMMARY OF FIELD WORK**	
	Introduction	39
	Archeological Resources of the Lower Breaks	39
	Archeological Resources of the Upper Breaks	42
	Archeological Testing Results	54
	Investigations at the North Point Site	58
4.	**MATERIAL CULTURE**	
	Introduction	65
	Projectile Points	
	Parowan Basal-notched	69
	Bull Creek	70
	Rosegate Series	70
	Gypsum	70
	Elko Series	72
	Northern Side-notched	72
	Humboldt Series	76
	Pinto Series	77
	Unknown Corner-notched	77
	Groundstone	77
	Other Stone Tools	
	Bifaces	78
	Scrapers	78
	Choppers	79
	Hammerstones	79
	Utilized Flakes	79
	Debitage	80
	Ceramics	81
	Historical Objects	84
5.	**SUPPORTING STUDIES**	
	Introduction	89
	Brian Head Chert Petrography	89
	Obsidian Sourcing	91
	Dendroclimatic Studies	102
	Markagunt Plateau Peat Bog Studies	103
6.	**SUMMARY AND CONCLUSIONS**	
	Introduction	107
	The Research Design Revisited	

Chapter **Page**

6 continued

Chronology 107
Settlement Patterns 108
Subsistence and Resource Procurement 111
Material Culture 112
Paleoenvironment 115
Future Research Directions 116

REFERENCES CITED 119

APPENDIX

A. Letter Reports on Cedar Breaks Obsidian Sourcing (by Richard E. Hughes) 145
B. Report on Cedar Breaks Ceramics (by Laureen Perry) 155
C. Petrographic Analysis of Brian Head Chert (by Edward F. Bakewell)
Introduction 162
Petrography 162
Geochemistry 162
D. Bristlecone Studies (by Gary S. Funkhouser)
Introduction 170
Bristlecone Pine South of the Cedar Canyon Highway 171
Navajo Ridge Stand 172
Mammoth Creek Stand 173
Chronology Development 174
Evaluating Autocorrelation 174
Climate Sensitivity of the Residual Chronology 175
Variation in the Reconstruction 177
Conclusions 182
E. Exploratory Paleoecology on the Markagunt Plateau: A Progress Report (by David B. Madsen, Scott A. Elias, Weng Chengyu, Stephen T. Jackson, Robert S. Thompson, and Andrei Sarna-Wojciki)
Introduction 184
Lowder Creek Bog 185
Introduction 185
The Markagunt Ash Bed 185
Red Valley Bog 193
Introduction 193
Plant Macrofossils 196
Insect Fauna 199
Fire History 202
Future Work 203

LIST OF FIGURES

Figure **Page**

1.1 Map of project area showing Cedar Breaks in relation to the physiographic Great Basin and Markagunt Plateau 2

1.2 Overview photograph of the Cedar Breaks plateau 5

1.3 Overview photograph of the Cedar Breaks amphitheater 6

1.4 Overview photograph of the Lower Breaks 6

2.1 Southern Paiute traditional use areas 25

2.2 Photograph of the CCC constructing the Cedar Breaks visitor center 35

2.3 Overview photograph of the CCC camp at Cedar Breaks 35

3.1 Project location and survey coverage map 40

3.2 Photograph of historic resources in the Lower Breaks 42

3.3 Illustrations of historical artifacts from Site 42In1524 48

3.4 Planview of site 42In1526 49

3.5 Photograph of rectangular feature at site 42In1526 50

3.6 Profile of test unit one at site 42In1526 52

3.7 Photograph of log structure at site 42In1573 53

3.8 A fingernail impressed Intermountain Brownware sherd and a Rosegate projectile point from site 42In1522 58

3.9 Photograph of the cleaned profile showing location of the pollen samples from the North Point site 62

3.10 Profile drawing of the North Point site 63

4.1 Parowan Basal-notched, Bull Creek, and Rosegate Projectile Point Illustrations From Cedar Breaks National Monument 69

4.2 Illustrations of Gypsum Series projectile points 71

Figure		Page

4.3 Illustrations of Elko Corner-notched projectile points....73

4.4 Illustrations of additional Elko Corner-notched projectile points....74

4.5 Illustrations of Elko Eared projectile points....75

4.6 Illustrations of Northern Side-notched, Humboldt and Pinto Series projectile points....76

4.7 Illustrations of unknown corner-notched projectile points....78

4.8 Illustrations of selected bifaces....79

4.9 Illustrations of a quartzite chopper from 42In1548 and a serrated scraper from 42In1135....80

4.10 Example of a debitage sample unit form....82

4.11 Medicine bottles from site 42In1543....84

4.12 Edelweiss beverage bottle from site 42In1543....86

4.13 Amethyst beverage bottle from site 42In1424....87

5.1 Brian Head chert source on Brian Head Peak....90

5.2 Brian Head chert boulders located just south of Cedar Breaks National Monument....90

5.3 Dr. Pat McCutcheon with an example of Brian Head chert collected from the Dixie National Forest....91

5.4 Obsidian source locales for all Cedar Breaks obsidian artifacts....98

5.5 Obsidian source locales for Cedar Breaks Elko Series projectile points....99

5.6 Obsidian source locales for Cedar Breaks Archaic projectile points....100

5.7 Obsidian source locales for Cedar Breaks late prehistoric projectile points....101

6.1 “Fluted” point from site 42In1135....113

Figure **Page**

D.1 Time series plot of Mammoth Creek tree-ring index chronology 176

D.2 Actual and reconstructed July to June precipitation for Utah climate division 4 178

D.3 Non-overlapping averages of July to June precipitation, Utah climate division 4; 5 and 25 year means and standard deviations 179

D.4 Non-overlapping averages of July to June precipitation, Utah climate division 4; 50 and 100 year means and standard deviations 180

D.5 Coefficient of variation for non-overlapping averages 181

E.1 Distribution of the Markagunt ash bed and other Mono Craters tephras 192

E.2 Mapped profile from Red Valley Bog, Utah...195

E.3 Plant macrofossils from Red Valley Bog, Utah 198

LIST OF TABLES

Table **Page**

1.1 Potential Aboriginally Utilized Plants Found at Cedar Breaks National Monument 4

1.2 Research Questions Guiding the Cedar Breaks National Monument Archeological Project 8

1.3 List of Cedar Breaks Isolated Artifacts 12

3.1 Cedar Breaks Archeological Sites with Historical Components 41

3.2 Cedar Breaks Prehistoric Site Characteristics 43

3.3 Testing Results for Cedar Breaks Sites 56

3.4 Description of Radiocarbon Dates from the North Point Site (42In1210) 61

4.1 Artifact Summary from Cedar Breaks National Monument 66

4.2 Projectile Point Measurements 67

5.1 Compilation of Cedar Breaks Obsidian XRF Data 93

A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area 149

B.1 Ceramic Analysis Worksheet 159

C.1 Petrographic Sample Correspondences for Cedar Breaks Specimens 163

C.2 Petrographic Descriptions of Cedar Breaks Specimens 164

C.3 Major Elements (Wt. % Oxide) Determined by X-Ray Fluorescence for Cedar Breaks Specimens 167

C.4 Trace Elements (ppm) Determined by Inductively-coupled Plasma Emmission Spectroscopy for Cedar Breaks Specimens 167

D.1 Tree-ring stand information and chronology dates 175

D.2 Statistical Characteristics of Actual and Reconstructed July – June Precipitation for Utah Climate Division 4 178

Table		Page

E.1 Results of Electron-microprobe Analysis of Volcanic Glass Shards from the Markagunt Ash Beds, Utah, with Comparison to Several Ash Beds Erupted from the Mono Craters of East-central California..187

E.2 Radiocarbon Age Estimates of Samples from Lowder Creek Bog 191

E.3 Radiocarbon Age Estimates of Plant Macrofossil Samples from Red Valley Bog 196

E.4 Insect and Arachnid Remains from Red Valley Bog 200

E.5 Fire History at Red Valley Bog 203

Chapter 1

PROJECT OVERVIEW AND RESEARCH DOMAINS

INTRODUCTION

This report documents archeological and paleoenvironmental investigations conducted in partnership by the National Park Service, the U. S. Forest Service, and the Utah Geological Survey on the Markagunt Plateau of southwestern Utah. Multi-disciplinary investigations were conducted over a 4-year period (1996 – 1999). This project was initiated through the NPS Servicewide Archeological Inventory Program to comply with Section 110 of the National Historic Preservation Act.

The objectives of this project are threefold: (1) to significantly strengthen and upgrade the monument's interpretive program concerning the prehistoric and historical use of the area; (2) to increase the scientific understanding of Cedar Breaks and the Markagunt Plateau with respect to prehistory and paleoecology; and (3) to provide direction for various management actions, such as compliance with Section 106 and Section 110 of the National Historic Preservation Act, National Register of Historic Places nominations, Resource Management Plans, Environmental Assessments, and other preservation efforts.

PROJECT LOCATION

Cedar Breaks National Monument is located on the southwestern edge of the Markagunt Plateau, which forms a transition between the Great Basin and Colorado Plateau physiographic provinces (Figure 1.1). The monument was established August 22, 1933, to preserve a natural amphitheater escarpment that has eroded into the Tertiary Claron (Wasatch) Formation, exposing bright bands of colorful freshwater limestone. A dramatic change in elevation of over 2,000 vertical feet occurs between the rim of the Breaks and the Ashdown Gorge below. Elevations in the lower portions of the monument range from 7,800 to 9,200 ft (2,378 – 2,805 m), while elevations on the upper rim range from 10,100 ft to a high of 11,278 ft (3,079 – 3,438 m) at Brian Head Peak, just north of the monument.

Cedar Breaks National Monument is located east of Cedar City, Utah. "It covers most of a spectacular erosional escarpment of the Tertiary Period Claron Formation (Wasatch Formation) exposed along the Hurricane fault" (Agenbroad, et al., 1992:41). The Markagunt Plateau is well watered, containing numerous springs, streams, and small lakes. Rose and Snedeker (1982:5) note that several major creeks rising from the Markagunt Plateau form the headwaters of the Sevier River drainage of the Basin and Range physiographic province, while the Markagunt Plateau itself forms part of the Colorado Plateau physiographic province.

PRESENT ENVIRONMENT

The following discussion is primarily taken from the Cedar Breaks Archeological Project Research Design (Frank and Betenson 1997).

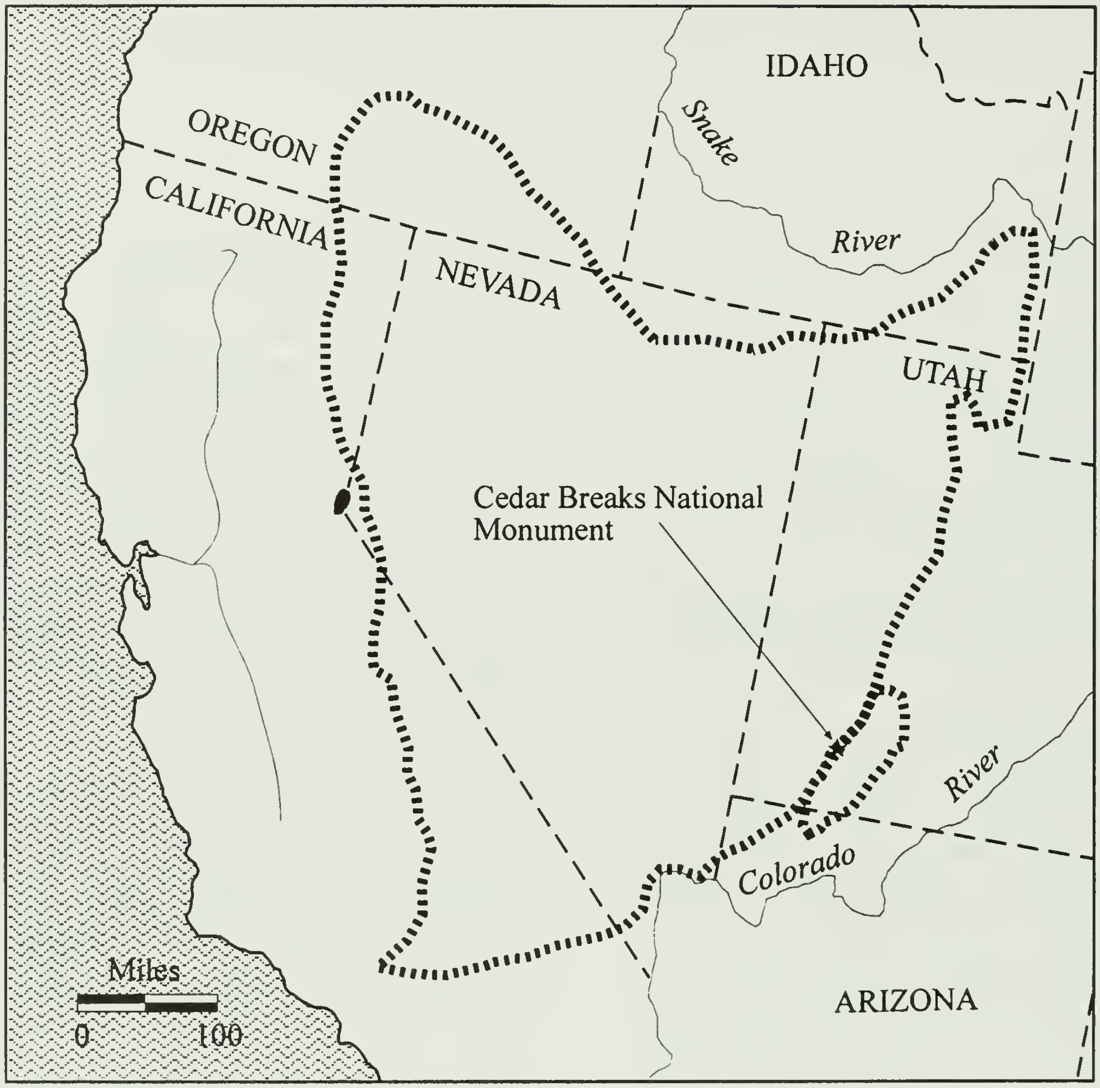

Figure 1.1 Cedar Breaks National Monument in relation to the physiographic Great Basin (red-dashed line after Hunt 1967) and the Markagunt Plateau (green-dashed line; after Arno and Hammerly 1984).

Climatic conditions vary across the study area, primarily as a function of elevation. The Markagunt Plateau has been classified as Humid Microthermal (Burnham 1950), which is characterized by cool, short, and often wet summers. Typically, the lower Ashdown Gorge area is drier, and is between 10° and 20° F warmer than the rim of the Breaks. Prevailing southwesterly winds push tropical moisture across the arid desert to the western side of the plateau. As the air is forced upward, heavy and intense showers are initiated.

Cedar Breaks may be best described as three separate geographical units. These units are differentiated by elevation as well as environmental type, and can be classified as the Markagunt Plateau, the Breaks, and the Ashdown Gorge drainage. Due to the diversity of environments, a broad range of floral resources were available to aboriginal populations (Table 1.1).

The high plateau environment is comprised of wide, undulating valleys and meadows; and forested hill slopes and ridges, with exposed knolls and peaks (Figure 1.2). Limestone sink holes and peat bogs are also features of the table-top land; surface water drains predominately to the east. The plateau section of the monument is within the Hudsonian-Canadian life zone, dominated by spruce (*Picea engelmanni*), alpine fir (*Abies lasiocarpa*), and aspen (*Populus tremuloides*), with some Douglas fir *(Pseudotsuga taxifolia*) and bristlecone pine (*Pinus artistata*). Arno and Hammerly (1984:172) note that the upper rim "supports a subalpine forest of Englemann spruce, subalpine fir, and clones of quaking aspen." Krummholz occasionally descends into the dry limestone amphitheater, and limber and bristlecone pines are present along the rim as well (Arno and Hammerly 1984). Basalt and rhyolite flows, and large areas covered by brecciated rhyolite are also features of the upper rim.

The Cedar Breaks highlands have also been modified by glacial and periglacial processes. Massive gravity slides during the Miocene probably resulted in the deposition of the Markagunt Megabreccia, "a structurally chaotic assemblage of angular clasts and broken masses of older rock units that is spread over the crest of the northern and central Markagunt Plateau" (Hatfield, et al., 2000:136; see also Sable and Anderson 1985; Anderson 1993; and Sable and Maldonado 1997a). Hatfield, et al. (2000), note that the origin of the Markagunt Megabreccia is speculative. A number of researchers (Anderson 1993; Maldonado, et al., 1990, 1992; Maldonado 1995; Hatfield, et al., 2000) have argued that the Markagunt Megabreccia originated as gravity slides triggered by slip surfaces within the Brian Head Formation.

Pleistocene glacial deposits are present in and near Cedar Breaks National Monument (Moore and Nealey 1993). Hatfield, et al. (2000), note that landslide deposits during the Pleistocene and Holocene are common and resulted in the formation of surface features such as Alpine Pond. In addition, Hatfield, et al. (2000:137), note that "Pleistocene and Holocene colluvium, alluvial fans, and alluvium are common." Bog deposits dating from the late Pleistocene and early Holocene are present within and near the monument (Hatfield, et al., 2000).

The Breaks of Cedar Breaks National Monument were formed by the headward erosion of the Ashdown Creek drainage. The term "breaks" refers to the abrupt edge of the Markagunt Plateau in this

TABLE 1.1 Potential aboriginally utilized plants found at Cedar Breaks National Monument.

SPECIES	COMMON NAME	EDIBLE/USABLE PART	SEASONAL AVAILABILITY
Acer glabrum	Rocky Mountain maple	Inner bark sap	Year-round
Allium cernuum	Wild onion	Roots, shoots	Early summer
Amelannchier sp.	Serviceberry	Berries	Late summer, fall
Artemisia frigida	Sagebrush	Seeds	Late summer, fall
A. ludoviciana	Sagebrush	Seeds, leaves	Late summer, fall
Balsamorhiza sp.	Balsam root	Roots, seeds	Early summer
Berberis repens	Oregon grape	Berries, roots, leaves	Late summer
Carex sp.	Sedge	Seeds	Spring, summer
Colochortis nuttallii	Mariposa lily	Roots	Summer, fall
Chenopodium album	Pigweed	Seeds, leaves	Fall
Cymopterus sp.	Spring parsley	Entire plant	Spring, summer, fall
Elymus sp.	Wild rye	Seeds	Late summer, fall
Eriogonum racemosum	Redroot wild buckwheat	Plant	Summer
Fragaria ovalis	Wild strawberry	Berries	Summer
Geranium fremontii	Fremont geranium	Leaves	Spring, summer
Helianthus	Sunflower	Seeds, tubers	Summer, fall
Iris missouriensis	Wild iris	Roots, flowers	Summer
Juniperus communis	Common juniper	Berries	Summer, early winter
Ligusticum porteri	Wild parsley	Greens	Summer
Mentha spp.	Field mint	Leaves, stems	Summer
Oenothera flava	Yellow evening primrose	Roots	Summer
Osmorhiza depauperata	Sweet cicely	Greens	Summer
Phaecelizi heterophylla	Phaecelia	Seeds	Summer
Pinus flexilus	Limber pine	Inner bark, seeds	Year-round
Pinus ponderosa	Ponderosa pine	Inner bark	Year-round
Populus tremuloides	Quaking aspen	Sap	Summer, fall
Potentilla anserina	Silverweed	Roots	Summer
Quercus sp.	Oakbush	Acorns	Fall
Ribes inebrians	Wax currant	Berries	Late summer, fall
Ribes mon-tigenum	Gooseberry currant	Berries	Late summer, fall
Rubus strigosis	Wild red raspberry	Fruits	Summer
Piimex occidentalis	Dock (sorrel)	Greens	Late spring, summer
Sambucus coerulea	Blueberry elder	Berries	Late summer, fall
Sambucus racemosa	Redberry elder	Berries	Late summer, fall
Trifolium longipes	Bighead clover	Roots	Summer
Zigadenus elegans	Mountain deathcamas	Roots	Summer-early winter

(Rose and Snedeker 1982; Simms 1979; from Frank and Betenson 1997)

Figure 1.2 Alpine meadows of the Cedar Breaks plateau; Brian Head Peak in the background.

region and was used by pioneers and settlers to describe high-elevation areas that quickly descend, or "break" to lower elevations (Harris, et al., 1997; Hatfield, et al., 2000). The Breaks are extremely steep and rugged, and are surpassed in their ruggedness only by their incredible beauty. Generally, the Breaks form a large amphitheater, which faces west, though it may be better described as two smaller, heavily dissected, scallop-shaped features separated by Chessman Ridge. The Breaks are a badlands -- an erosional feature of knifelike ridges, steep talus cones, and cliff bands of limestone (Figure 1.3). Due to the steep terrain and erosional instability of the Breaks, vegetation is limited to the thin ridge tops and benches. Water in this area of the monument drains to the west into the Great Basin proper.

The Ashdown Gorge section of the monument is an area of heavily forested ridges and steep slopes, which give way to flatter stream terrace remnants and other alluvial features. The drainage bottoms (Figure 1.4) contain perennial streams, most of which run off the plateau, wind through the Breaks, and finally reach the gorge bottom. These waterways are extremely active during the sudden and intense thunderstorms common to the area. This is reflected in the poorly sorted, highly diverse matrix of these stream beds. The two main drainages of Cedar Breaks are Ashdown Creek from the south, and Rattle Creek from the north. These two waterways merge just inside the monument's western boundary and continue west as Ashdown Creek.

The gorge and Lower Breaks environment can be classified as a high transitional zone dominated by ponderosa pine (*Pinus ponderosa*), aspen, mountain mahogany *(Cercocarpus ledifollius*),

Figure 1.3 Overview photograph of the Cedar Breaks amphitheater.

Figure 1.4 Overview photograph of the Lower Breaks.

Gambel oak (*Quercus gambelii*), and juniper (*Juniperus communis*). Stream terraces provide a majority of the flat areas, and as the drainage moves west the terraces become wider and more coherent.

The fauna of the Markagunt Plateau comprise species that are common to coniferous, cold-climate, high-elevation regions. Reptiles are not present at the higher elevations. Bears and beavers, which were fairly common to the area in the late 1800's (Durant 1952), are now practically exterminated. The gorge area below the Breaks provides a warmer climate where reptiles and other animal species adapted to the valleys, mesas, and canyons of southern Utah prevail (Barnes 1927; Gregory 1950).

Mammals found in the monument tend to follow seasonal migration patterns, feeding on the plateau's lush floral environment in the spring and summer, and moving off the cold plateau to the lower, more temperate valleys and basins through the winter. The monument reports 10 species of carnivores, including black bear (*Ursus americanus*); mountain lion (*Felis concolor*); bobcat (*Lynx rufus*); coyote (*Canis latrans*); and two species of fox -- the gray fox (*Urocyon cinereoargenteus*) and the red fox *(Vulpes fulva)*. Two species of Artiodactyla are common to the monument: elk (*Cervus canadensis*) and mule deer (*Odocoileus hemionus*). Small mammals of the region include 17 species of rodents such as marmots (*Marmota flaviventris*) and porcupine (*Erethizon dorsatum*), three species of shrews; three species of bats; and three Lagomorpha -- the pika (*Ochotona princeps*), cottontail (*Sylvilagus nuttallii*), and white-tailed jackrabbit (*Lepus townsendii*).

Game birds are sparse, and only three species have been recorded within Cedar Breaks: blue grouse (*Dendragapus obscurus*), wild turkey (*Meleagris gallopavo*) and mourning dove (*Zenaida macroura*). Waterfowl are seasonally present on the plateau, at Navajo and Panguitch Lakes, and at other smaller bodies of water.

RESEARCH DESIGN

Prior to the beginning of the project, a research design was formulated (Frank and Betenson 1997) to guide the field work. This research design addresses questions tied to a series of research domains, including Chronology, Settlement Patterns, Subsistence and Resource Procurement, Material Culture, and Paleoenvironment. Table 1.2 provides a list of research questions guiding this project. These questions are explored in the final chapter.

The research domains and the questions derived from them reflect the paucity of data available for this area of southwestern Utah. Frank and Betenson (1997) note that prior to this project, only limited survey-level data existed, and that the questions posed needed to establish a baseline from which finer grained questions could later be formulated. The main goal of the research design is to identify and explain past changes in prehistoric adaptations to the high-altitude environments of the study area.

Table 1.2. Research questions guiding the Cedar Breaks National Monument Archeological Project (from Frank and Betenson 1997).

Research Domain	Research Question
Chronology	1. Which cultural groups were utilizing the monument, and during what time periods were they there?
Settlement Patterns	1. What is the primary function(s) of prehistoric sites found within the monument?
	2. Are identified prehistoric site function(s) within Cedar Breaks similar to those observed outside of the monument?
	3. Is there spatial variability of prehistoric site function within the monument?
	4. During what season(s) were identified prehistoric sites used?
	5. What was the average size of prehistoric groups utilizing the monument?
	6. How do the prehistoric sites located in Cedar Breaks differ from those found at lower elevations, both in the mountains and valleys?
	7. What historic site function(s) are identifiable within Cedar Breaks?
	8. How does historic site function and location differ from prehistoric site function and location within the monument?
Subsistence and Resource Procurement	1. Why and how were prehistoric populations utilizing this region?
	2. Is there any variation in prehistoric resource procurement strategies through time?
Material Culture	1. Which local geologic resources were being utilized by prehistoric populations, and is there any variation in use through time?
	2. What kind of lithic reduction techniques were employed at prehistoric sites?
	3. Are lithic exotics, materials not immediately available, present on prehistoric sites, and what, if any, are the implications?
	4. Are prehistoric ceramic and/or ground stone artifacts found at these high-altitude sites within the monument?
Paleoenvironment	1. What was the paleoenvironment of the monument like, and how has it changed through time?
	2. How were the floral and faunal resources affected through time?
	3. Are changes in the paleoenvironment and climate reflected in prehistoric use of the area?

METHODS

With only minor variation, the field methods and analytical categories used during the course of the Cedar Breaks Archeological Project are the same as those described by Canaday (1998a, 1999). As a convenience to the reader, a brief overview of the procedures is provided in the sections to follow. Additional information on project methods and terminology is reviewed by Frank (1997) and Canaday (1998a, 1999).

Field Procedures

Survey within the monument was conducted using between four and eight individuals spaced approximately 15 meters apart. All terrain that was not too steep (usually >20° slope) to safely traverse was inspected for cultural resources. Limited collection of artifacts discovered on the surface of each site was initiated when time-sensitive artifacts (e.g., projectile points, ceramics) were encountered. Selected obsidian artifacts were also collected for x-ray fluorescence (XRF) analysis. In addition, selected chert artifacts and nodules were collected for petrographic analysis.

Prior to the beginning of field work, protocols were needed in order to effectively deal with the expected surface variability of extensive lithic scatters known to exist in the region. For instance, prehistoric site 42In1135 is an extremely large lithic scatter for which exact boundaries have yet to be determined. The majority of the site is located on land administered by the Dixie National Forest, though portions are known to extend into the northern section of the monument. Dixie National Forest Archeologist Marion Jacklin suggests (personal communication, July 8, 1997) that the scatter continues uninterrupted for approximately 3 miles, and is about a mile wide in places. At sites such as 42In1135, our first goal was to determine site boundaries within the Monument. *Site boundaries were based on the absence of cultural debris for at least 30 meters.* A second goal within 42In1135 was the identification of artifact concentrations. For management purposes, a number of strategies were employed. Segments (labeled A – M) were delineated based on easily recognizable topographic features on the 7.5' quadrangles (see discussion in Canaday 1998a). Temporary site numbers, sample units, and loci (discrete artifact concentrations) were assigned on the basis of survey segment.

Within each segment, loci were identified until boundaries could be ascertained. Normally, loci would equate to lithic reduction areas, quarries, or campsites, etc. Each identified locus within 42In1135 (and later within other large sites) was treated as if it were a discrete site. An Intermountain Antiquities Computer System (IMACS) form "B" was filled out and a sketch map prepared (to scale). Observations were recorded, including locus location; ground visibility (expressed in % of bare earth visible); rodent (or other) disturbance (expressed in general terms: low, moderate, high); vegetation associations; and approximate distance to adjacent loci or prominent features. Obsidian and diagnostic or unique artifacts were collected as outlined in the research design (Frank and Betenson 1997). Other tools such as bifaces, scrapers, etc., were sketched in the field and plotted on the locus map. Utilized flakes were described (length, width, and thickness) and the utilized margin measured.

Sample units within each locus were used to characterize and quantify the debitage present. Units of varying sizes were judgmentally placed within at least one portion of each locus, and each piece of debitage was tallied and characterized (material type, reduction sequence, etc.). A Debitage Sample Unit form (see Chapter 4) was designed to maintain consistency between loci and sample units. Within each sample unit, naturally occurring toolstone (cobbles, nodules, and chunks) was also tallied.

At site 42In1135, debitage was continuous between the 11 identified loci, though density dropped to between one and five artifacts per m^2. Debitage sample units were judgmentally placed in these non-locus areas in order to characterize density in these areas. When appropriate, each debitage sample unit also included a schematic sketch showing where tools or topographic features (drainages, slope, vegetation, etc.) are located. The southwest corner of each sample unit was mapped, as were datums and site and locus boundaries, using a Global Positioning System (GPS) unit. Differential correction of the GPS data was performed using Trimble® Pathfinder Office software and data downloaded from the public-access Cedar City base station operated by the Dixie National Forest. A field specimen log was maintained throughout the survey and each collected item (and each roll of film) was provenienced and assigned a unique field specimen number.

Definitions

A number of concepts guided the field work stages of this project. This high-elevation area contains an abundance of naturally occurring toolstone on the surface. Chert and chalcedony nodules, chunks, and shatter from the Brian Head formation are present throughout the area. Flake-like "artifacts" have been produced by freeze/thaw and other natural processes. Thus, prior to the initiation of field work, all field crew members underwent an orientation to the project area that included a review of basic chipped stone terminology and identification. In this way, all crew members were "on the same page" when distinguishing cultural material from naturally occurring debris. In order to be counted as a "flake," the item in question had to contain culturally induced flake attributes such as a bulb of percussion or a platform. Detailed discussions of our in-field debitage analyses are provided in Chapter 4. Other useful definitions guiding the field work are provided below.

An *Isolate* is defined as a single historic or prehistoric artifact not associated with a site. This definition was followed during the 1997 and 1998 field seasons. During the 1996 field work, 21 isolated "occurrences" were identified. Fourteen of these "isolated occurrences" contained between 2 and 8 artifacts. Table 1.3 contains a list of the isolates discovered during the 1996 - 1998 field seasons.

A *Site* is defined as more than 15 cultural items. Boundaries for sites were based on a 30-meter interval of barren ground containing no surface-visible artifacts. Documentation consisted of an IMACS form, (parts "A" and "B" for prehistoric sites; parts "A" and "C" for historic sites) and at least one debitage sample unit to characterize the surface artifact scatter. A site sketch map (compass and pace) was prepared and overview photographs were taken at each site.

During the course of investigations, limited use areas (LUA) were also identified consisting of between 2 and 15 historic or prehistoric artifacts. These extremely sparse scatters were later given permanent numbers because they could be interpreted when contrasted with the larger scatters and because they would have fallen through administrative cracks had they not been assigned individual Smithsonian trinomials. Documentation for LUAs initially consisted of a modified debitage sample unit form that described each of the 2-15 cultural items. A brief description of the landform, vegetation, visibility, location, etc., was also recorded to facilitate the conversion of LUAs into sites. Sketch maps were normally not completed for LUAs. A GPS reading was taken at the approximate center of each LUA.

Laboratory Procedures

Laboratory procedures were limited in scope because large quantities of artifacts were not collected during the course of the project. Generally, artifacts were *not* washed or subjected to special treatment. Most analyses were performed in the field as part of the general site documentation efforts. Those analyses are outlined in Chapter 4.

Specialists were utilized as much as possible for laboratory analyses. For instance, selected obsidian artifacts were submitted to Dr. Richard Hughes (Geochemical Research Laboratory) for non-destructive xrf analysis; chert samples were sent to Edward Bakewell (University of Washington) for petrographic and trace element analysis; ceramics were sent to Laureen Perry (University of Nevada, Las Vegas); and radiocarbon determinations for the North Point site (42In1210) were performed by Beta Analytic.

Curation

Maps, site forms, and original field notes for the Cedar Breaks Archeological Project are on file in the curation facility at Zion National Park, Springdale, Utah. Artifacts and samples not consumed during analyses are also curated at Zion National Park, along with original photographs and negatives (accession number CEBR 11).

REPORT ORGANIZATION

The current chapter has provided an overview of the project area and research domains relevant to the field work conducted between 1996 and 1999. Chapter 2 provides background information on the prehistory and history of the Cedar Breaks region of the Markagunt Plateau. Chapter 3 includes discussions on the results of archeological survey and testing within the monument and on Dixie National Forest lands. In Chapter 4, historic and prehistoric artifacts observed during the field work are described. Special studies supported by the Cedar Breaks Archeological Project are summarized in Chapter 5. Included in this chapter are discussions on obsidian sourcing; petrographic analysis of Brian Head chert; paleoecological investigations at several Markagunt Plateau locales; and dendroclimatic studies of bristlecone pine located within the monument and the surrounding area. Complete reports documenting these special supporting studies are included as appendices to this manuscript. Chapter 6 concludes this technical report by reviewing the project research design, assessing the merits of the design, and offering recommendations for future research.

Table 1.3 List of Cedar Breaks isolated artifacts.

Isolate #	Year Observed	Location	Description
IS-1	1996	Lower Breaks	6 Chert Flakes
IS-2	1996	Lower Breaks	1 Chert Core
IS-3	1996	Lower Breaks	2 Chert Flakes, 1 Chert Core and 1 Utilized Chert Flake
IS-4	1996	Lower Breaks	2 Chert Cores, 1 Chert Flake and 1 Utilized Chert Flake
IS-5	1996	Lower Breaks	6 Chert Flakes
IS-6	1996	Lower Breaks	4 Chert Cores, 2 Chert Flakes
IS-7	1996	Lower Breaks	7 Chert Flakes
IS-8	1996	Lower Breaks	4 Chert Cores
IS-9	1996	Lower Breaks	2 Chert Cores
IS-10	1996	Lower Breaks	2 Chert Flakes
IS-11	1996	Lower Breaks	1 Chert Core
IS-14	1996	Lower Breaks	1 Tested Chert Cobble with 8 Chert Flakes
IS-15	1996	Lower Breaks	1 Chert Scraper, 1 Chert Flake
IS-16	1996	Lower Breaks	2 Chert Flakes
IS-17	1996	Lower Breaks	4 Chert Cores, 1 Chert Flake
IS-18	1996	Lower Breaks	1 Chert Flake
IS-19	1996	Lower Breaks	1 Chert Core
IS-30	1996	Lower Breaks	1 Chert Scraper
IS-31	1996	Lower Breaks	6 Chert Flakes
IS-32	1996	Lower Breaks	2 Chert Flakes, Abundant Natural Toolstone Material
IS-33	1996	Lower Breaks	4 Chert Flakes
IO-D-1	1997	Upper Breaks	1 Chert Flake
IO-D-2	1997	Upper Breaks	1 Chert Flake
IO-E-1	1997	Upper Breaks	1 Chert Chopper
IO-G-1	1997	Upper Breaks	1 Chert Flake
IO-H-1	1997	Upper Breaks	1 Chert Gypsum Projectile Point
IO-H-2	1997	Upper Breaks	1 Chert Flake
IO-I-1	1997	Upper Breaks	1 Chert Flake
IO-K-1	1997	Upper Breaks	1 Chert Flake
IO-K-2	1997	Upper Breaks	1 Chert Flake
IO-K-3	1997	Upper Breaks	1 Chert Flake
IO-L-1	1997	Upper Breaks	1 Chert Biface

Chapter 2

BACKGROUND

INTRODUCTION

This chapter contains brief overviews of the prehistory, ethnography, and Euro-American history of the project area and is intended to provide a background for interpreting the results of the field and laboratory work . Also included here is a summary of previous archeological research conducted in the area.

PREHISTORIC OVERVIEW

Cedar Breaks National Monument lies in a transition between the Great Basin and the southern Colorado Plateau. The edge of the Markagunt Plateau in this part of southern Utah occurs along the rim of the Cedar Breaks escarpment. Looking west from Point Supreme at the Cedar Breaks Visitor Center, one is looking out at the eastern extreme of the Great Basin -- "an expansive area of internal drainage characterized by long, often massive, north-south-trending mountain ranges separated by substantial valleys" (Canaday 1997:1).

Given the geographic position of the project area, it would not be surprising, then, to find influences from a number of disparate cultural groups, both from the Great Basin and the Plateau. Thus the following discussion attempts to meld the culture histories of these two areas.

Paleoindian (12,500 – 8,000 B.P.)

The archeological record of southwestern Utah reveals a fairly uninterrupted era of human occupation beginning in the Paleoindian period. The dating of earliest human occupation in the New World is a matter of continuing debate among those in the archeological community. Sound evidence places human occupancy in the Americas by 12,500 B.P. Recent evidence suggests that occupations at Monte Verde, Chile, date to at least 12,500 B.P. and perhaps as early as 33,000 year B.P. (Dillehay 1989a, 1989b, 1997). The 12,500 B.P. date has now been generally accepted as valid while the earlier component at Monte Verde is still in need of verification (Meltzer, et al., 1997).

Utilizing analyses of ice cores, coral, ocean sediment, and lake beds from sites throughout the world, Fiedel (1999:95) contends that radiocarbon dates for the terminal Pleistocene are about 2,000 years too young. If this contention is correct, the first successful human colonization of the New World occurred by at least 13,500 years B.P., and perhaps by 14,400 B.P. at Monte Verde. Clearly, more research on this topic is needed in light of these new data. As such, the dates offered in the following discussion on Paleoindian occupation in the western United States should be viewed as potentially too young by 2,000 years or so. No attempt will be made to correct these dates following Fiedel (1999) until his data are subjected to careful scrutiny.

Only a few Paleoindian sites have been documented for southwestern Utah. The highly mobile hunting and gathering lifeway of the Paleoindian period do not provide for a site pattern that is well retained in the archeological record.

Historically, this period has been seen as one in which highly mobile hunters dispatched great quantities of megafauna. Paleoindian cultural types are therefore defined primarily by projectile point styles found in association with large megafauna remains (Fagan 1987).

Clovis and Folsom points were originally believed to have been contemporaneous functional variants (the former for mammoth, the latter for bison hunting) (Fiedel 1999:103; Haynes 1992:358). Both points are characterized by a basal fluting technology. Direct dates on fluted points are virtually unknown in the Great Basin (Jones, et al., 1996:60), but are believed to pre-date the Western Stemmed Tradition characterized by large stemmed points and crescent bifaces (e.g., Willig and Aikens 1988; Grayson 1993; but see Bryan 1980, 1988).

Clovis-style projectile points are often found in association with extinct mammoth remains. The large Clovis point is commonly fluted and triangular in shape, and contains a basal notch. During the end of the Llano period, North America was in transition as the retreating ice sheets were giving way to a more temperate climate. The warmer climate in which humans found themselves also brought with it a new type of large prey -- the bison (*Bison bison antiquus*). The Folsom point utilized by the bison hunters was smaller than the Clovis, and characterized by large medial flutes. The Folsom and related styles, Scottsbluff and Hell Gap, represent a highly mobile culture with a reliance on lithics and the hunt (Thompson and Thompson 1982). Both styles of points (Clovis and Folsom), although rare, have been documented in southwestern Utah (Walling, et al., 1986).

The late Paleoindian period (11,000-8,000 B.P.) is represented by a mobile culture, which maintains a high dependence on modern large fauna as the primary component of the diet. However, traditional big game was becoming scarce and the diet was beginning to change, encouraging a transition to more reliable flora and smaller fauna species. Temporally diagnostic artifacts of the period are the Great Basin Stemmed Point and crescent-shaped bifaces (Thompson and Thompson 1982). The late Paleoindian period of the eastern Great Basin has been termed the Western Pluvial Lakes Tradition (WPLT) -- an unfortunate misnomer, because not all WPLT sites are associated with pluvial lakes.

Bedwell (1970, 1973) originally defined the WPLT as including all cultural manifestations of the northern and western Great Basin dating from about 11,000 to 8,000 B.P. During this time, many valleys of the Great Basin held pluvial lakes or their remnants (Beck and Jones 1988). Hester (1973) expanded WPLT geographic coverage to include nearly all of the Great Basin. This view has been widely applied to the region (e.g., Aikens 1982; Price and Johnston 1988; York 1979; Willig 1984, 1985, 1986, 1988, 1989) and beyond (Moratto 1984). Beck and Jones (1988) suggest that Bedwell's original characterization of the WPLT as a lucustrine-oriented adaptation (as opposed to most of the subsequent Archaic) is a "highly, and perhaps overly, generalized picture of human adaptation" (1988:274). Thus, rather than the term WPLT, with its connotations of pluvial lakeside adaptation, Great Basin scholars interested in the early Holocene now generally refer to this period simply as the Western Stemmed Tradition (e.g., Jones, et al., 1996; see also discussion in Canaday 1997).

Archaic (8,000 – 1,500 B.P.)

Schroedl (1976) suggests that the Archaic lifeway of the northern Colorado Plateau is characterized by migratory hunting and gathering cultures that follow and exploit seasonally available plant and animal resources within differing environmental zones. The Archaic generally dates between 8,000 and 1,500 B.P., although there are differences of opinion concerning specific regional chronologies.

With the transition from Paleoindian to Archaic, hunting groups were becoming focused more on the regional exploitation of a variety of resources than solely on megafauna. Cultural groups were acquiring an intimate, operating knowledge of various species found within their home range. The Archaic is often viewed as an optimal foraging lifeway, centering on a mix of hunting and gathering to maximize the benefit received against the effort expended (Simms 1979). These people probably conducted seasonal rounds following and utilizing ripening resources and game before moving on to new areas. This migration would tend to be along the same general routes so that past knowledge of the area, and cached tools could be re-used. The accumulation of local environmental knowledge would eventually lead to the development of small garden plots in the late/terminal Archaic.

The Archaic in the Cedar Breaks National Monument area may be best termed the Desert Archaic, as identified by Jennings (1978). This is a subsistence adaptation associated with the Basin and Range geographic province. The material culture of the Desert Archaic consists of Pinto, Gypsum, Humboldt, and Elko series projectile points; fiber sandals; hide moccasins; various forms of cordage; and atlatls (c.f., Jennings 1978; Thompson and Thompson 1982).

Formative (1,500 – 650 B.P.)

The Cedar Breaks area is near a transitional zone for two distinct, yet contemporary, Formative strategies: the Parowan Fremont, and the Virgin Anasazi. Both cultures are sedentary horticulturists, but they may have had a seasonal interest in monument resources. The sedentary lifestyle of both cultures is reflected in the occurrence of permanent architecture; high concentrations of storage facilities; ceramics; and a material culture expressed in implements used for the processing of large quantities of seeds and other floral resources. Additionally, the Formative period is associated with the development of the bow and arrow, which replaces the atlatl.

Fremont (A.D. 500 – 1300)

The Fremont, an astoundingly diverse culture, appeared throughout much of Utah following the Archaic. As a cultural manifestation, they emerged around A.D. 500 and disappeared by A.D. 1300 (Marwitt 1970). Defining Fremont lifeways has generated much debate (see Madsen 1989). The Fremont cultural area encompasses the northern three-quarters of Utah and adjoining sections of Nevada, Idaho, Wyoming, and Colorado. Surviving in such diverse environments required regional adaptation. In the case of the Fremont, five sub-areas have been recognized, based upon material remains and the physiographic region in which they are found: Uinta, San Rafael, Great Salt Lake, Sevier, and Parowan. The material culture of the Fremont is broadly classified, due to a lack of true defining traits linking all the sub-areas. Rather, traits expressed in one subarea will likely be somewhat demonstrated in the surrounding sub-areas, but there appears to be no "diagnostic" trait(s) that permeates all of the sub-areas (Jennings 1978).

A highly general description of basic Fremont material culture includes pit houses; lack of a kiva; adobe or stone masonry granaries; flaked stone assemblages; plain gray ware pottery, often with extrusive coiled elements (corrugated and black painted wares appear after A.D. 1050); anthropomorphic figurines; and the unique Fremont Dent strain of maize. The Fremont Dent was evidently very prolific, resistant to drought and temperature extremes, and amenable to a short growing season. Thus, the Fremont were able take horticulture into marginal agricultural areas. While horticulture contributes to the definition of the Fremont, this was a highly adaptive culture in which foraging also played an extremely important role, perhaps more so than with the Anasazi (Thompson and Thompson 1982).

Grayson (1993) notes that Fremont sites are remarkably variable -- so much so that Madsen (1989:63) claims that "the key to understanding the Fremont is variation." Simms (1986, 1990) suggests that some of this variability reflects three very different adaptive strategies employed by the Fremont: Some may have lived the year-round in large horticultural villages while making short-term logistic forays for particular resources. Others may have been more mobile during periods when domestic crops were not being tended. Still other Fremont groups may have been full-time hunter-gatherers. Any or all of these strategies may have operated through time and across space within the Fremont area (Grayson 1993:267).

The area in which Cedar Breaks is situated is affiliated with the Parowan Fremont. This is apparently a late and short-lived Fremont manifestation dating between A.D. 900 and 1300. Differences between the Parowan and other Fremont sub-areas include architecture and artifact assemblages, with the latter taking on Virgin Anasazi styles reflecting interaction with neighboring cultures. Parowan pit dwellings are circular or quadrilateral, with ventilators and deflectors, and the few surface habitation structures that have been identified contain raised firebasins. Ceramics are of Snake Valley ware, including Snake Valley Gray, Snake Valley Black-on-gray, and Snake Valley Corrugated. The pottery is typically smooth, with little, if any, surface manipulation. Wide-mouth, globular jars are common, while they are practically nonexistent in other Fremont sub-areas. The Parowan lithic assemblage is dominated by Parowan Basal-notched and Cottonwood Triangular projectile points. Side-notched points are also present, although rare. Perforated bone gaming pieces are very common, along with a diverse assortment of bone artifacts, including awls, finger rings, and fleshers. Anthropomorphic clay figurines are common to the area and tend to be heavily decorated with fugitive-red pigment (Thompson and Thompson 1982).

The Parowan Fremont have been divided into two phases: the Summit Phase (A.D. 900 to 1050) and the Paragonah Phase (A.D. 1050 to 1300). There is no definitive break between the phases; rather, a gradual acceptance of new traits appears during the Paragonah phase. These new traits include corrugated ceramics, and a shift of dominance from circular to the square or quadrilateral pit dwellings. Paragonah sites also tend to be larger, which is attributed to longer habitation rather than to an increase in population (Marwitt 1970).

Virgin Anasazi (A.D. 1 – 1300)

The Anasazi are a group whose material culture is found throughout much of the desert Southwest. They are typified at their florescence as the builders of Mesa Verde and Chaco Canyon in the Four Corners area. The Virgin Anasazi are a branch of the Western expression of this culture, and date from around A.D. 1 to A.D. 1300.

Traditionally, the Virgin Anasazi homeland is centered on the Virgin River drainage. This clearly reflects a reliance on perennial water by a horticultural society, although upland dry farming was also practiced throughout the region. The Virgin Anasazi branch followed the other Anasazi traditions to the east, which were oriented primarily toward a horticultural subsistence base. Typically, the Grand Canyon provides the border to the south; the Muddy River, in Nevada, to the west; the Pink Cliffs of the Markagunt Plateau to the north; and the area west of Kanab is considered to be the eastern extreme of this cultural group.

The Virgin Anasazi inhabited the cold desert environments, ranging in elevation from around 2,500 to 6,000 ft. Hypothesized climate changes and population pressures may have driven the Anasazi into agriculturally marginal areas to practice dry farming on the higher mesas and valleys, while still utilizing the well-watered river valleys, as well as increasing their reliance on foraging (Walling, et al., 1986).

The Virgin Anasazi were an adaptable, dynamic cultural group, and this is reflected in their material culture (c.f., Fairley 1989; Lyneis 1982; 1984; Schroeder 1961; Shutler 1961;). The variety of artifacts and their temporal sensitivity have led to divisions of the Virgin Anasazi that are based upon the Pecos Classification. Basketmaker II (300 B.C. to A.D. 400/450) is identified as pre-ceramic, incorporating an extensive array of sandals and coiled baskets, with the atlatl and Elko Side- and Corner-notched points. At this time, the first evidence of corn and squash also appears. Basketmaker III (A.D. 450 to 750) reflects an expansion of horticulture, with the development of the two-handed mano and trough metates. The bow and arrow replace the atlatl, and Eastgate Expanding Stem and Rose Spring Side- and Corner-notched points appear. However, ceramics may be the best marker, as a plain gray (Mesquite Gray) and a black-on-gray (Mesquite Black-on-gray) are developed during this period. Pueblo I (A.D. 700 to 900) is difficult to distinguish from Basketmaker III, because many artifacts are common to both periods and plain gray pottery continues to dominate, although a finer and stylistically different painted ware -- Washington Black-on-gray -- occurs. Pueblo II (A.D. 900 to 1150, possibly as late as A.D. 1300) represents the florescence of the Virgin Anasazi in southwestern Utah. This period is marked with numerous styles of painted ceramics, which are characterized by blocky, geometric designs on a white slipped or unslipped gray pottery. St. George Black-on-gray emerges first, followed by North Creek Black-on-gray and Hurricane Black-on-gray. Redware and polychrome appear late, after A.D. 1050, and are limited in number. Corrugated utility ware provides a definitive diagnostic date between early and late Pueblo II, because it occurs after A.D. 1050 in this region. Projectile points change with the emergence of the Parowan Basal-notched and Bull Creek styles, demonstrating an interaction with the Fremont to the north and the Kayenta Anasazi to the east

(Walling, et al., 1986; Altschul and Fairley 1989).

High-altitude documentation of the Virgin Anasazi is virtually nonexistent, which may be a result of the type of use, rather than a lack of use. The traditional diagnostic indicator for the Virgin Anasazi is ceramics, and an aceramic toolkit may be the product of the temporary or specialized nature of high-altitude use by this culture (Frank and Betenson 1997).

Neo-Archaic (A.D. 1150 – 1300) and Protohistoric (A.D. 1300 – 1600)

Archeological evidence suggests that the Markagunt Plateau, Parowan Valley, and surrounding areas were utilized by the Southern Paiute from approximately A.D. 1100 until the present. Considerable speculation surrounds the apparent disappearance of Formative cultures in southern Utah, northwestern Arizona, and southeastern Nevada around A.D.1300. A variety of causal explanations have been advanced, including climatic and environmental change, demographic shifts, and assimilation or competition with the more mobile Numic-speaking groups that were present in the Great Basin and western Colorado Plateau by that time (Shutler 1961; Lyneis 1990, 1995; Ambler and Sutton 1989).

What is known about Neo-Archaic and Protohistoric period occupations in this region is derived from limited archeological evidence, generally surface finds or shallow deposit sites. Late prehistoric assemblages typically contain brownware ceramics, basketry, small side-notched or triangular projectile points, and unshaped ground stone. These artifact types are generally associated with Numic-speaking groups (linguistically related branches of the larger Uto-Aztecan language family). Their material culture appears to reflect a return to a broad-based foraging strategy similar to the Archaic (hence the term "Neo-Archaic"), supplemented in some areas by limited horticulture (Kelly et al., 1990; Ezzo 1996; Steward 1938, 1970). Site patterning suggests that groups exploited a wide range of ecological zones, relying on seasonal transhumance, vertical movement on the landscape, and caching to most effectively utilize unpredictable or seasonally available resources.

For several decades, archeologists have debated the time depth of the Numic occupation in the Great Basin and adjacent areas. Warren and Crabtree (1986) and Bettinger and Baumhoff (1982) have relied on multiple lines of evidence, including linguistic data (Lamb 1958), to support their hypothesis that Numic-speaking groups entered the southwestern Great Basin relatively late in time, around A.D. 1000. They postulate a gradual population expansion to the north and east, with Numic groups ultimately being distributed throughout much of the Great Basin and the western Colorado Plateau. According to this model, Numic speakers would have reached southern Utah by approximately A.D. 1100 or 1200, generally coinciding with the apparent abandonment of the region by the Formative period Virgin Anasazi and Parowan Fremont groups.

Goss (1977) and others have refuted this interpretation, arguing for an early or middle Archaic (by at least 7,000 B.P) Numic presence in the Great Basin and western Colorado Plateau. This viewpoint is echoed by many modern-day Numic speakers. As one member of the Kaibab Band of Paiutes has stated: "Southern Paiute people believe that we have lived in this area since the time of creation here and that we were that same people as, or have lived alongside, what anthropologists today call the Virgin Anasazi" (Stoffle, et al., 1997:72). While the "Numic expansion" has been the focus of considerable scientific inquiry, no unequivocal answers to basic questions about chronology and demographics are yet available. Madsen and Rhode (1994) provide detailed coverage of the Numic question in Great Basin prehistory.

ETHNOGRAPHIC OVERVIEW

By Dawna E. Ferris

Introduction

When Euro-Americans first explored southern Utah in the late 18th century, the only aboriginal people that they encountered were the Numic-speaking Southern Paiute. The Southern Paiute occupied a broad region that today encompasses southern Utah, portions of western Arizona, southern Nevada, and areas in California west of the Colorado River. They were organized into at least 16 identifiable groups, often referred to as "bands," which spoke mutually intelligible dialects, and recognized distinctive (and sometimes overlapping) territorial boundaries (Kelly 1934; Kelly and Fowler 1986). A number of prior ethnographic studies have described Southern Paiute territorial boundaries, socio-political organization, language, ideology, ceremonies, and material culture (Kelly 1934, 1938, 1939, 1964; Sapir 1930; Steward 1938; Kelly and Fowler 1986).

In place of a generalized ethnographic overview of the Southern Paiute, the following discussion will narrowly focus on those aspects of traditional culture that are most likely to have been preserved in the archeological record of the Cedar Breaks/Markagunt Plateau area. Topics are limited to subsistence practices, material culture, and traditional land uses by those Southern Paiute groups affiliated with the study area, using data derived from archival sources and prior ethnographic research. Where specific traditional uses of the study area have not been documented, more generalized information relating to Southern Paiute lifeways in southern Utah is provided. The concluding section describes the profound changes in Southern Paiute traditional lifeways that followed mid-19th-century Mormon settlement of the region. For a comprehensive account of Southern Paiute ethnohistory, the reader is referred to Holt (1992).

Subsistence Strategies

While archeological data offer limited insights into traditional Southern Paiute subsistence strategies, more complete reconstructions can be developed using archival sources and ethnographic studies. During the late 18th century, Euro-Americans made forays into southern Utah, encountering the Southern Paiute. The first direct contact occurred in 1776, when two Spanish friars, Dominquez and Escalante, attempted to locate an overland route between Santa Fe, New Mexico, and southern California. Velez de Escalante kept a daily journal of the expedition's trek, describing the physical environment and the native people encountered. His initial observations of Southern Paiute subsistence practices were made at a location approximately 50 km west of the Cedar Breaks/Markagunt Plateau. In October 1776, Escalante described a group of 20 Southern Paiute women collecting seeds in Cedar Valley, near modern-day Cedar City, Utah. Later that month, Southern

Paiute men approached the Spanish explorers in the vicinity of present-day Kanarraville, Utah, offering a basket of corn as a token of friendship. As Dominquez and Escalante traveled through southern Utah, they noted other evidence of Southern Paiute horticulture, including “well-dug irrigation ditches” being used to water small fields of corn, pumpkins, squash, and sunflowers (Warner 1976:79).

Other early explorers, including the American fur trapper Jedediah Smith, also provided accounts of traditional Southern Paiute subsistence practices in southern Utah. In August 1826, Smith reported being approached by Southern Paiute men, near modern day St. George, Utah, who were wearing clothing made from the skins of deer, antelope, and mountain sheep. They offered Smith a rabbit and an ear of corn, as tokens of friendship and peace (Hinton 1987:12). By the mid-1830s, the route pioneered by Dominquez and Escalante had become a regularly traveled Euro-American pack trail, known as the “Old Spanish Trail.” Brooks (1972) notes that nearly every traveler’s account made reference to fields cultivated by the Southern Paiute along Ash Creek, the Santa Clara River, and the Virgin River in southern Utah.

Mormon settlement of southern Utah began in earnest during the 1850s. The Southern Indian Mission was among the first sent to this region, with a dual purpose: to foster friendly relations with the Southern Paiute, and to convert them. The journal of this mission, kept by Thomas Brown between 1854 and 1857, provides several detailed descriptions of Southern Paiute subsistence practices and related material culture. As an example, on June 7, 1854, Brown and his companions shared an evening meal with a Southern Paiute extended family near modern-day Toquerville, Utah. He observed the women “grinding seeds by the light of the moon, and boiling a large potful of pottage--in a conical shaped dish made from clay and sand thin and hard” (Brooks 1972:44). This pottage, made from “seeds of grass” that had been “ground between two rocks,” was described as “darkish gray color with like chunks of bacon in it” (Brooks 1972:44). The mush was served on “wicker baskets... about 1 quart to each” (Brooks 1972:45). The horn of a bighorn sheep was used to ladle the mush from the ceramic boiling pot onto one of the baskets. A single basket was then passed from individual to individual, with each consuming his allotted portion of the meal. What Brown had thought to be chunks of bacon in the mush were, in fact, “bunches of matted ants” (Brooks 1972:45). The pottage was followed by “the head of roasted porcupine, brains and bones, added to an entire roasted sand lark” (Brooks 1972:45). While this meal consisted of native plants and wild game, Brown noted that the family cultivated small patches of corn and other crops “for miles” along Ash Creek, obviously also relying on these domesticated crops as part of their subsistence base (Brooks 1972:44).

Other 19th-century archival sources help to flesh out Southern Paiute traditional subsistence strategies in southern Utah (Hamblin 1951; Powell and Ingalls 1873, 1874). Subsistence tasks were divided along gender and age lines. Women and children were observed to be primarily responsible for the collection of seeds, nuts, and berries; these clearly formed the mainstay of the diet. Of particular importance were the seeds of Indian ricegrass and other grasses; seasonally abundant and carbohydrate-rich mesquite (honey bean and screwbean); piñon pine nuts; and the berries of upland shrubs like squawbush, serviceberry, and wolfberry. Seeds were winnowed, parched, or roasted, as well as ground, for preparation either as mush or baked bread. Berries were eaten fresh, and were also dried for later use. Many of the same plants were also sources for fiber, medicines, or other subsistence-related products (Bye 1972). The cultivation of domesticated plants was coordinated with the seasonal mobility required for this broad-based subsistence strategy. The Southern Paiute fields, after planting in the spring, were only given minimal attention during the remainder of the growing season (Ezzo 1996). The elderly tended the fields, while other family members hunted and collected resources elsewhere.

Men engaged in hunting and related tasks, such as tool production and maintenance. As noted by Smith and other explorers, the Southern Paiute hunted wild game for food and skins (Hinton 1987). Animal protein was obtained primarily from small game, especially rabbits and hares, as well as rodents, lizards, birds, and insects. According to Palmer (1928a), rabbits and hares were the chief source of food for the Wahnquint "clan," a group of Southern Paiute who asserted territorial claims to Cedar Valley and the surrounding uplands, including the Cedar Breaks/Markagunt Plateau. The Wahnquint were sometimes referred to as the "Kum-o-its," or rabbit eaters (Palmer, 1928b:41). Spring and fall hunting strategies were based on the seasonal migrations of large game, especially mule deer and elk, as the herds moved between the lowlands and the high plateaus. Native fish were caught in mountain streams and high-elevation lakes, such as Navajo and Panguitch Lakes.

Material Culture

The subsistence strategies of the Southern Paiute were reflected in their material culture. As Kelly and Fowler (1986) note, the Southern Paiute, unlike the Ute, never adopted the horse as part of their traditional culture. They remained on foot, carrying personal and subsistence items in lightweight baskets, nets, and skin-covered frames. Baskets were either coiled or twined, and served multiple subsistence-related functions. Each Southern Paiute woman had baskets in a variety of shapes and sizes. The baskets formed integrated sets, used for plant harvesting and processing, as well as meal preparation, food consumption, and storage. Women also sported baskets as part of personal attire, especially small conical baskets that served as head coverings. Willow and squawbush were commonly used as construction materials for baskets, with coiling being the earliest technique used for most vessels (Ezzo 1996: 64). Pitch-covered coiled baskets were used to carry and store water. Nets were used to transport equipment and to entrap rabbits. Other woven items included yucca-fiber sandals and cordage.

Pottery was made and used by some Southern Paiute groups, but was likely only a minor component of the material culture because of its bulk and fragility (Kelly 1964; Fowler and Fowler 1971). Considerable variability has been noted in the construction, vessel forms, and surface treatment of ceramics produced by the Southern Paiute. According to Baldwin (1942:187), Southern Paiute Utility Ware was composed of locally obtained clay that was ground and sometimes tempered with very coarse quartz sand containing conspicuous mica. Coiling and thinning with paddle and anvil were used to construct the vessels, which could vary considerably in form. Wide-mouthed conical jars, either with thick pointed or semi-pointed bases, are considered to be a diagnostic vessel form for Southern Paiute Utility Ware (Fowler and Matley 1978). Deep bowls, tall and narrow jars, and globular vessels with either rounded or pointed bottoms have also been attributed to the Southern Paiute (Janetski 1990). Kelly (1964) reports that an informant from Panquitch described flat-bottom vessels as having been made by that group. Firing was conducted in an apparently uncontrolled atmosphere, producing surface colors that ranged from dark gray-black to reddish brown. Surface treatments included fingernail indentations that were often limited to a narrow band of decoration just below the rim of the vessel.

Pippin (in Griset 1986:15) has argued that Southern Paiute Utility Ware "is not well, or even satisfactorily, dated," nor is its significance within the material culture of the Southern Paiute well understood. In southern Utah, sherds of Southern Paiute Utility Ware have generally been documented as surface finds. Those that have been recovered from dated archeological contexts suggest a time span from A.D. 1300 to the modern period for this ware (Walling, et al.,1986).

Bedrock or portable milling stones ("metates") and shaped or unshaped hand stones ("manos") were used for plant processing and other grinding tasks. Exposures of sedimentary and volcanic materials suitable for ground stone are abundant throughout southern Utah, including areas of the Markagunt Plateau (Averitt 1962).

Southern Paiute men hunted with bows made either from sinew-backed juniper staves or bighorn sheep horn. Arrows were fabricated using serviceberry, cane, or other materials for shafts, and then tipped with points of stone. After Euro-American contact, metal or bottle glass was often used as materials for projectile points (Fowler and Matley 1978). Projectile points of chipped stone are generally either small Desert Side-notched or Cottonwood Triangular types. Other chipped stone tools, including unifaces and bifaces, were produced from a variety of microcrystalline silicates or volcanic materials, and used for cutting, chopping, and perforation. Related hunting equipment included hide quivers; shaft straighteners, made either from horn or stone; and dead-fall trigger snares. A curved stick was also used to remove desert tortoises or chuckwallas from burrows or rock crevices.

Clothing, too, was lightweight, even during the winter months, when bark skirts and leggings were added to provide additional protection. Buckskin and other hides were used to make women's dresses, as well as the shirts, breechcloths, and leggings commonly worn by Southern Paiute men (Ezzo 1996). Rabbit skins were prepared and twisted into ropes; these were made into blankets that could double as capes (Intermountain Tribal Council of Nevada 1976).

Southern Paiute habitation varied according to the season. Brush structures were constructed during the summer months for sleeping and to serve as windbreaks. More substantial structures were built for use during the winter months. Referred to as "wickiups," these were conically shaped frames of willow or other sturdy wood, overlain by layers of brush, bark, grass, or other thatching material. In 1854, Brown describes several Southern Paiute wickiups, located along Ash Creek near Toquerville, Utah, as being constructed of

> willows, cottonwood, and stalks of corn, 3 of them-the willows stuck in the ground ... slanting so they meet at the top, the leaves of these and the neighboring ash tree was ... all the shelter from wind or rain (in Brooks 1972:44).

After 1855, some groups adopted the use of skin and canvas tipis from the Utes (Kelly and Fowler 1986). Southern Paiutes who settled near 19th-century agricultural settlements often modified the construction of their habitations to use canvas, woolen blankets, corrugated metal, and other materials salvaged from Euro-Americans. Rock shelters and caves also provided shelter, being used well into the 20th century in some areas.

Traditional Land Use Areas

Southern Paiute traditional land use patterns are incompletely understood, as a consequence of several factors. Few data were collected by Euro-Americans until after cultural disintegration had significantly altered traditional lifeways. Some researchers, including Dobyns (1983), suggest that cultural changes had begun prior to the first direct contacts in the 18th century. Euro-American diseases may have spread from Mexico to aboriginal populations living along the Colorado River (including its tributaries in southern Utah) between the 15th and 18th centuries, greatly reducing native populations. By the late 19th century, when a few scholars began to collect information, the cumulative impacts of biological, social, and cultural change had already profoundly modified Southern Paiute land use patterns.

During the early decades of the 20th century, ethnographers attempted to systematically collect information on areas traditionally used by Southern Paiute groups. Steward (1938), Kelly (1934), and others concluded that the Southern Paiute recognized territorial boundaries and "ownership" of natural resources within those territories. William R. Palmer, a lay historian from Cedar City, Utah, solicited information from different Paiute groups about their territorial boundaries and land uses in Utah and eastern Nevada. Figure 2.1 displays the traditional use areas of the Southern Paiute groups living near the Cedar Breaks/Markagunt Plateau, as they were identified to Palmer (1929, 1933). He, too, began his work during the early years of the 20th century, but as he lamented, "the task has been undertaken too late" (Palmer 1933:90). Palmer was frustrated to find that "there are very few Indians living today who can remember with clearness the days when the tribes were living on their own home lands" (*ibid.*). While territories were "claimed" by specific groups, certain inhospitable environmental zones, including the Cedar Breaks/Markagunt Plateau, may have been regarded as common use areas. According to Palmer (1933:91) "[t]he Markagunt and Kaibab Mountains, i.e. the high table lands, were reserved as common hunting and fishing grounds for all the Pahute [*sic*] clans." Other areas identified by Palmer (1933) as common hunting grounds in the region were the Pine Valley Mountains and the Mountain Meadows.

In the 1950s, informants from several Utah Paiute bands described their recollections of territorial boundaries and traditional use areas, as part of tribal efforts to forestall the termination of services by the federal government (Holt 1992). The Wahnguint (Kumoits) asserted that, historically, all game and wild fowl within their territory "belonged" to the group (Affadavit of Woots Parashont, May 1, 1950:1). The Wahnquint territory encompassed the Cedar Breaks/Markagunt Plateau, being bordered by Brian Head on the northeast ("around a big lava flow on the top of Ya-sump Quanimp"), Duck Creek on the east, and extending west across Cedar Valley and south to Pinto Canyon (Affadavit of Woots Parashont, May 1, 1950:1). According to this informant, other Indian people did not hunt or take other resources from within the boundaries of Wahnquint territory without permission from the group.

Other Paiute informants, born at the beginning of the 20th century, were also able to provide information about historic period Southern Paiute hunting and fishing activities in the study area. During the late 19th and early 20th centuries, the Wahnquint camped at Navajo Lake, along Duck Creek, and at nearby springs during the summer, in order to fish and hunt (Affadavit of Isaac Hunkup, March 23, 1950). Mable John Yellowjacket stated that "her family made long encampments in the summer months at the big spring called 'Pah-it-spikine' that was the head of the creek called ' Pah-in-quint' and that this creek is now called Duck Creek by the white people" (Affadavit of Mabel John Yellowjacket, March 1950:1).

Recent ethnographic data collection conducted for the National Park Service (Zion National Park) has yielded new information pertaining to traditional uses of the Cedar Breaks/Markagunt Plateau by Southern Paiute groups (Klein 1991; Stoffle, et al., 1997). An informant from the Paiute Tribe of Utah recalled that "Indians used to hunt and fish" near Webster Flats, in close proximity to Cedar Breaks (Stoffle, et al., 1997:80). According to an informant from Indian Peaks, the Southern Paiute would hunt mule deer in the spring on the Markagunt Plateau, when the deer moved upland from Zion Canyon. An informant from Koosharem recalled that she would often accompany her father to hunt deer and woodchuck near Cedar Breaks, living in a tent there during these trips. In 1991, an informant from Indian Peaks indicated that the colorful geologic formations of Cedar Breaks could confer "spiritual feelings" to the Southern Paiute who came to the mountain (Clifford Jake, oral history tape dated March 11, 1991). Spiritual leaders would request blessings for the Paiute Nation and gain spiritual power from the area.

The data available from ethnographic sources indicate that the Cedar Breaks / Markagunt Plateau area was encompassed within the territorial boundaries claimed by the Wahnquint (Kumoits), a Southern Paiute band generally associated with Cedar Valley. The Wahnquint traditionally collected wild foods throughout the valley, especially seeds from native plants. They also may have cultivated corn and other crops along Ash Creek and elsewhere within their territory. The Wahnquint hunted rabbits and hares (jackrabbits) in Cedar Valley; these were reported to be very numerous in the valley, prior to the Mormon settlement of Cedar City, Utah. They also exploited the surrounding upland areas of their territory, including the Cedar Breaks/Markagunt Plateau and Pine Valley Mountains, for seasonal hunting of deer, elk, and bear. Navajo and Panquitch Lakes, as well as the numerous mountain streams of the Markagunt, were favored fishing spots for

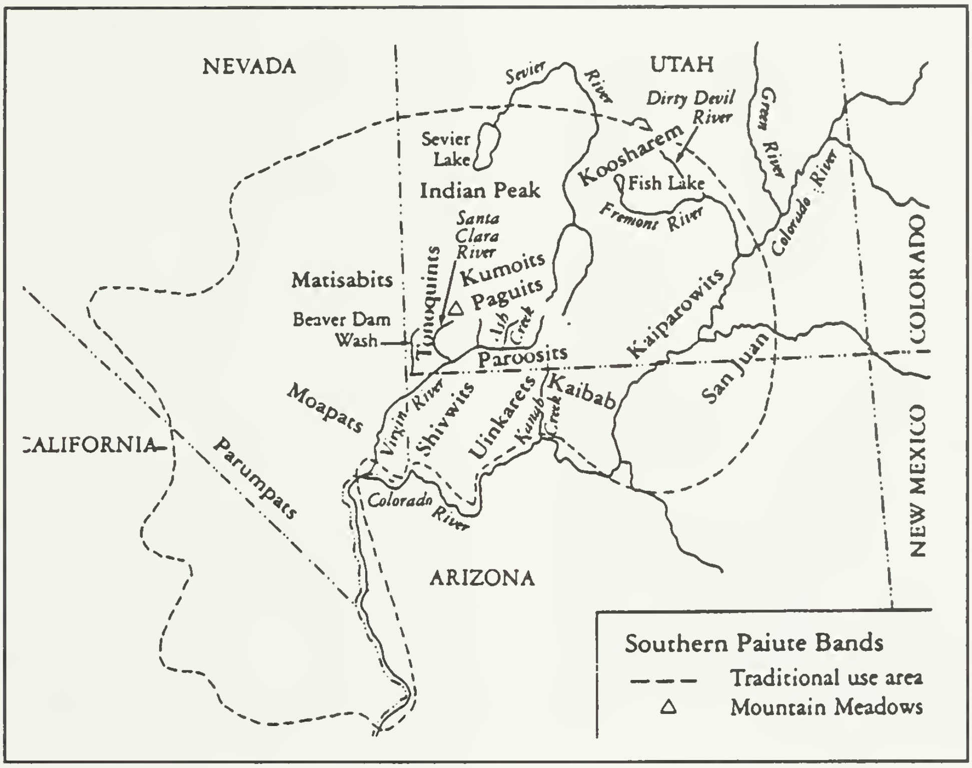

Figure 2.1. Southern Paiute traditional use areas (after Holt 1992).

the Wahnquint. During the summer months, families would camp along Duck Creek and near other springs. While it is likely that the Wahnquint conducted other traditional subsistence activities, like toolstone quarrying or tool production, during these summer encampments, the ethnographic and archival sources contain little information about such uses of the Cedar Breaks/Markagunt Plateau.

Cultural Change

During the first decades of the 19th century, Southern Paiute traditional lifeways were still being followed. In 1826, Jedediah Smith observed that Southern Paiute material culture appeared to have been little influenced by prior, albeit limited, encounters with Spanish explorers and traders. However, during their initial encounters with Smith, the Southern Paiute expressed great interest in trading for "pieces of iron" that could be used for tools (Alley 1982: 120). This interest in acquiring metal and other trade items indicates that they were already knowledgeable about Euro-American material culture and anxious to assimilate useful items into their culture.

By contrast, Ute lifeways were already markedly changed by late-18th-century contacts with Mexican traders and American fur trappers. Within a few decades, the Utes assimilated horses, firearms, metal tools, and other Euro-American goods. Under powerful leaders like Wakara, they negotiated trading alliances with the Mexicans and

Americans, exchanging furs and Indian captives for horses.

The Southern Paiute quickly became a source for these captives, with the Ute staging raids during the spring when the Paiute were "weakened by winter shortages" and most vulnerable (Snow 1929:70). Teenage girls were a particularly valuable commodity for sale, bringing as much as $100 in Santa Fe markets. Mexican traders also trafficked in Southern Paiute young women and children, capturing and transporting them to southern California on the Old Spanish Trail to sell or trade for horses, goods, or hard currency. The slave trade impacted Southern Paiute demographics and traditional lifeways, forcing the Southern Paiute to abandon their habitation sites or alter subsistence practices to avoid detection by the raiding parties.

American fur trappers who made forays into southern Utah at this time also contributed to the disruption of traditional Southern Paiute culture. In 1827, Jedediah Smith returned to an area on the Santa Clara River where, just one year earlier, he had observed cultivated fields, wickiups, and many Southern Paiute. "Not an Indian was to be seen, neither was there any appearance of their having been there in the course of the summer their lodges had burned down" (Alley 1982:120). Smith did not see any Southern Paiute during the remainder of his trip south. He later learned that another party of white trappers had recently traveled through the region, skirmishing with local Indian groups along the way.

Southern Paiute distrust of Euro-Americans was reinforced during subsequent decades, as the slave trade accelerated and conflicts between the two cultures became more commonplace. Unlike their more aggressive Indian neighbors, the Southern Paiute avoided direct confrontations. In 1854, James Bleak described a meeting near modern-day Toquerville, Utah, during which Mormons from the Southern Dixie Mission attempted to establish favorable relations with a Southern Paiute group. "The women and children secreted themselves in the brush while the men approached the newcomers in a very cautious hesitating manner, trembling while they shook hands with the whites" (Snow 1929:70). Thomas Brown's journal of June 10, 1854, describes a similar encounter with a group of Southern Paiute women and children who were picking berries along the Virgin River. As the white men approached one of the young women, "she trembled and sweat and [held] her limbs together as if required to keep her reins steady that there should be no apparent leakage" (Brooks 1972: 52).

As Smith observed in 1827, hostile encounters with the Ute and Euro-Americans often caused the Southern Paiute to abandon their cultivated fields and camps during the growing season. The establishment of Mormon settlements in southern Utah, beginning in the 1850s, reduced the number of traditional use areas available to the Southern Paiute. Agricultural communities, like Grafton, Washington City, and Santa Clara, Utah, were established along the same perennial streams and river courses that the Southern Paiute had traditionally utilized. Although the Southern Paiute were sometimes permitted to farm near the settlements or to glean from the Mormon fields, access to favorable areas was generally denied or severely curtailed by the Euro-Americans. Without domesticated crops to supplement their diets, the Southern Paiute were forced to rely on hunted and collected wild resources. Widespread livestock grazing and timber harvesting altered the native plant communities, further reducing the resources available to the Southern Paiute. In 1880, Jacob Hamblin wrote to John Wesley Powell describing the plight of the Southern Paiute in Utah: "The grass that product [*sic*] mutch [*sic*] seed is all et [*sic*] out. The sunflowere seed is all distroyed [*sic*] in fact thare [*sic*] is nothing for them to depend upon but beg or starve" (Fowler and Fowler 1971a:110).

As the Southern Paiute became increasingly marginalized, their traditional social organization, subsistence strategies, and material culture were profoundly changed. In order to survive, they developed new adaptations. A few groups were able to organize as small, widely scattered bands, attempting to exploit marginal areas that had no economic value for Euro-Americans. Others lived near Euro-American ranches, mining camps, and agricultural settlements, surviving on "Mormon welfare, odd jobs, and begging" (Holt 1992:35).

Beginning in 1865, Indian agents for the federal government attempted to put treaties in place with the Utah Indian tribes, in an effort to end their land claims and relocate them to reservations (Holt 1992). The Southern Paiute consistently refused to leave their homelands. Following the passage of the Indian Appropriation Act of 1871, they were left without recourse to negotiate treaties that would have protected their land claims.

Disease, starvation, alcoholism, and other factors contributed to a massive depopulation during the late 19th to early 20th centuries, with as much as a 60 percent decline in Southern Paiute populations noted in the U.S. census records (Stoffle, Olmstead, and Evan 1990). In Utah, the scattered Southern Paiute bands lived under deplorable conditions on four small reservations: Shivwits, Koosharem, Kanosh, and Indian Peaks. Members of the Cedar City (Wahnquint) Band were housed in shacks and tents at the edge of Cedar Canyon, receiving more assistance from the Mormon Church than from the federal government. In 1917, an Indian agent reported that "there were no infants" among the Indian Peaks, Kanosh, and Cedar City bands, since all were dying from disease in infancy (Holt 1992:159). While the Mormon Church in many cases provided wages, food, and clothing, neither the church nor the federal government was educating the Southern Paiute or providing adequate medical care. The federal work projects during the Great Depression did little to improve conditions for the scattered Southern Paiute bands in Utah.

The nadir of Southern Paiute relations with the federal government was reached on September 1, 1954, when President Eisenhower signed a termination order affecting four of the five Utah Paiute bands. Under termination, these bands lost 15,000 acres of reservation lands and all rights to federal services. The Cedar City Band was not included in the termination order, an oversight that allowed this group to remain eligible for federal services. Although the Southern Paiute initiated a campaign to reverse the termination order, more than 30 years of legal proceedings were required before the federal trust relationship was legislatively restored. In 1980, the Restoration Act was passed, awarding compensation to a newly consolidated tribal unit, the Paiute Tribe of Utah. Less than 50 percent of the 15,000 acres of reservation lands originally lost to termination were restored to the consolidated tribe, but a trust fund of $2.5 million dollars was set up, as part of the compromise developed to satisfy the terms of the legislation (Seegmiller 1997). Since restoration, the Southern Paiute bands of Utah have experienced improved living conditions, population growth, and greater financial security. An annual Restoration Gathering is held in Cedar City, Utah, to celebrate the restoration of federal services and to highlight Southern Paiute culture. As Holt (1992:154) has concluded, the Gathering is a forum for the Southern Paiute to express ethnic pride and demonstrate that "they have not vanished, that they are still living today in their homeland."

HISTORICAL OVERVIEW

By
Dawna E. Ferris

The Cedar Breaks/Markagunt Plateau continued to be the setting for human activities, after the arrival of Euro-Americans in the late 18th century. Hinton (1987) has researched the administrative history of the Dixie National Forest, under which the Cedar Breaks area was managed prior to its designation as a national monument in 1933. The reader is referred to Hinton's work for a comprehensive historical overview of the study area. The sections that follow will briefly summarize important events in regional history that may have contributed to the archeological record of the Cedar Breaks/Markagunt Plateau.

Euro-American Exploration Period (A.D. 1776 - 1850)

Euro-Americans did not explore southern Utah until the fall of 1776, when Spanish friars Dominquez and Escalante traveled south through the region, passing west of modern-day Cedar City, then south along Ash Creek to the Virgin River. The Dominquez-Escalante route was little used until the 1820s, when an expansion of the fur trade pushed American fur trappers into unexplored regions. Jedediah Smith in 1826, Thomas "Pegleg" Smith in 1827, and the Young-Wolfskill Party in 1829 blazed trails in western and southern Utah, as they searched for new trapping areas. While several Americans trapped beaver along the lower Virgin River, only "Pegleg" Smith obtained enough skins to make a profitable cargo from southern Utah (Hinton 1987:13).

Their explorations, generally following the track of the Dominquez-Escalante route through southern Utah, opened a commercial route between Santa Fe and southern California. By 1830, pack trains were making annual trips along "the Old Spanish Trail," transporting woolen blankets, Indian captives, and other goods to California for sale or trade. The traders returned to Santa Fe with herds of horses and mules. After 1847, the Old Spanish Trail became a well-developed wagon road, with Mormon settlers, traders, mail riders, and homesteaders all making their way to the Pacific coast along this route. Use of the trail surged in 1849, as news of the gold discoveries in California spread to the eastern states and "49ers" rushed west to make their fortunes.

During his explorations in Oregon, California, and the Great Basin between 1842 and 1844, John C. Fremont also followed the Old Spanish Trail through Utah. His party camped at Mountain Meadows for several days in May 1844. Fremont's diary included details about the local geology, native people, and other resources. On May 14, 1844, Fremont viewed the Markagunt Plateau (Cedar Mountain) and noted that it was covered with snow, as were the Pine Valley Mountains and surrounding peaks. Fremont observed that the region had "great pastoral promise, abounding with fine streams, rich bunchgrass, soil that would produce wheat and indigenous flax" (Hinton 1987:14). The report of Fremont's travels was published by the federal government and served as guide for growing numbers of emigrants traveling to Oregon and Washington. In 1846, members of the Church of Jesus Christ of Latter Day Saints, popularly called Mormons, studied Fremont's accounts of Utah. This information influenced their decision to leave Illinois for the Great Basin the following year.

Mormon Settlement Period (A.D. 1850 - 1890)

In 1847, Brigham Young led Mormon settlers to the Great Salt Lake Valley of northern Utah. Fleeing religious persecution in the Midwest, the group intended to settle in an "unoccupied" region. Envisioning a Mormon sphere of influence that would extend throughout the Great Basin and be linked to the California coast, Young and his followers began an aggressive exploration and settlement program. Between 1847 and 1850, Mormon parties explored southern Utah, investigating the feasibility of establishing permanent settlements there. Late in 1849, a party under the leadership of Parley P. Pratt explored the Little Salt Lake and Cedar Valleys, as well as portions of the Markagunt Plateau. They noted coal, iron ore, and other mineral resources in the mountains surrounding Cedar Valley and concluded that the area should be colonized for iron mining and manufacturing. In January of 1851, 167 Mormons were organized as the Iron Mission and sent to colonize the newly created Iron County. In short order, they established the communities of Parowan (Little Salt Lake City), Paragonah, and Cedar City.

During the 1850s, the Cedar Valley settlers struggled to fulfill the purpose of their mission: to mine and smelt iron ore. Despite the abundance of native iron ore and coal deposits, reduction of that ore proved to be more complex than anticipated. By 1854, a larger blast furnace and six charcoal kilns had been completed, and ore production was again underway. A total of 11 tons of iron ore were produced in 1855. However, natural disasters, including flooding, droughts, and grasshoppers, and the political turmoil of the Utah War (1857-58) and the Mountain Meadows Massacre (September 13, 1857) undermined the productivity of the Iron Mission. Iron production had ceased by 1858 and did not resume until a mid-20th-century revival of the Iron Mountain District.

Following the demise of the iron industry, Cedar City and surrounding communities lost population and experienced economic declines. According to Seegmiller (1997:74), two-thirds of the Cedar City pioneer population left the community, many heading to the new settlements of the Cotton Mission in Washington County. Efforts were made to replace iron manufacturing with viable agricultural and livestock enterprises. Local cooperative companies, like the Cedar Cooperative Mercantile and the Paragonah Co-op Company, were organized in the late 1860s, in an effort to develop industries where capital was limited. Associations like Parowan Co-op managed cattle herds or sheep flocks to maximize profits and minimize risk. Many of the cooperative livestock associations, as well as individual livestock producers, relied on the mountain pastures of the Markagunt Plateau for spring, summer, and early fall grazing.

During the Civil War period, the Mormons in Utah Territory faced confrontations with the neighboring Ute, Paiute, and Navajo, in part provoked by the Black Hawk War of 1865. Black Hawk, a Ute, refused forced settlement on the Uintah-Ouray Reservation and gained a following of several hundred other Indian militants. The "war" consisted of intermittent raids by Indians on frontier Mormon settlements during the remainder of the decade. In southern Utah, small bands of Indians, generally Navajos, stole horses, sheep, and cattle. During one year, livestock losses in Cedar City were estimated to be in excess of $28,000, as a result of the Indian raids (Seegmiller 1997:77). Seventy southern Utah settlers were killed during the raids, forcing the Mormon Church to take action (Hinton 1987). In May 1866, settlers in all the outlying Mormon communities were ordered to abandon their homes and move to larger towns that could be more easily defended. Following Black Hawk's death from tuberculosis in 1870, the conflicts began to diminish. Within a few years, the Mormons had reoccupied their abandoned settlements and also created a few new communities in southern Utah and western Arizona.

Mining booms in eastern Nevada and at nearby Silver Reef in Utah during the 1870s and 1880s created cash markets for southern Utah agricultural products, livestock, and timber. Many of the livestock enterprises were dependent on the use of the mountain pastures on the Markagunt Plateau for grazing. During the last half of the 19th century, nearly 30 families from Cedar City produced cheese and butter for sale to the mining camps. Their cows, ranging in numbers from a few to more than 50, were grazed during the summer months on Cedar and Parowan Mountains and along Mammoth Creek, in the vicinity of Cedar Breaks. The Cedar Co-op Herd was also grazed there after 1870.

McConnell (1962) and Lowder and Bruin (1964) provide details on these dairying operations. In late May, families would load their household goods and supplies into wagons and make the day-long trip east to the mountains. Cows were herded to these mountain "ranches," where they grazed on the high-elevation meadows during the day, but were returned to small, fenced corrals at night for milking. Women and children would spend the summer months tending the cows and calves and making cheese and butter. Three-room log cabins with sod roofs provided shelter for the families during the summer months. The families generally constructed a separate log milk house as close as possible to a spring or stream. In the milk house, cheese was stored and cured on swinging shelves suspended from the ceiling, and butter was kept in earthenware crocks at the proper temperature. Cheese-making equipment, including wooden hoops, tubs, presses, and boards, was carved from oak and juniper cut on the mountain. During the summer months, a family could produce "60-70 cheese, weighing from 30 to 40 pounds each," as well as several hundred pounds of heavily salted butter, stored in kegs or crocks (McConnell 1962:7). These were transported back to Cedar City, wrapped in damp cloths and wet willow leaves, for sale at the co-op store or for freighting to more distant markets. Cheese would be sold for 14 cents per pound, while butter could bring as much as 25 cents per pound (McConnell 1962:8). The sale of dairy products supplemented the family income and provided much needed hard currency. The local dairy industry persisted for several decades on the Markagunt Plateau, generally declining in importance in the 20th century, as a few large dairies assumed the role of the small family operations in cheese and butter production.

Sheep and beef cattle were also grazed on the Markagunt Plateau during the last decades of the 19th century. Cattle and horses had come with the pioneer Mormon settlers when they established Parowan and Cedar City in the 1850s; more than 500 head of livestock were counted in the herd at Parowan in 1852 (Hinton 1987:37). As grazing lands around the settlements were depleted, the mountain pastures became essential to livestock raising. When mining booms of the 1870s created a steady cash market for beef and lamb, livestock producers increased the size of their herds and became even more dependent on the high-elevation meadows of the Cedar Breaks/Markagunt Plateau.

Cooperative livestock associations, like the Parowan and Cedar Co-ops, herded sheep and cattle along Mammoth Creek. The herders generally lived in tents, although log cabins were sometimes used as more permanent quarters. Wooden corrals and fences were also constructed to facilitate herd management. Herd sizes ranged from a few animals to more than 2,000, whenever cooperative herds were moved from seasonal ranges or driven to market. In the 1890s, large transient herds of sheep were also common on the Markagunt Plateau (Hinton 1987).

The Cedar Breaks area was also harvested for timber. Prior to the enactment of legislation that established federal forest reserves and the national forests in the late 1890s, timber cutting on public domain lands was regulated by county authorities (Hinton 1987:34). During the initial period of Mormon settlement in the region, small portable sawmills were operated in nearly every suitable timber area, including the study area. Milled lumber was freighted to nearby communities for use in the construction of housing and public facilities. The eastern Nevada and Silver Reef mines also bought timbers and other building materials produced by southern Utah sawmills during the 1870s and 1880s.

A small sawmill operation was located on Mammoth Creek, a few miles to the east of the study area of Cedar Breaks. Known as the Jensen Sawmill, the mill was in operation intermittently during the last decades of the 19th century. Log roads, wooden bridges, and other related historic sites were constructed to support the mill along Mammoth Creek (Heath 1996). The Jensen Mill gained regional recognition during the winter months of 1898. Timber was harvested and lumber milled between January and March of 1898 by 35 loggers, sawyers, and haulers from Cedar City, in order to construct "Old Main," the first building on the campus of the newly established Branch Normal School (now Southern Utah University) in Cedar City. Had the building not been completed in time for fall classes in 1898, the Utah legislature had threatened to relocate the teachers' training school. The Cedar City community joined forces to meet the construction deadline, supporting the efforts of the sawmill operators to cut and mill lumber at high elevations under the most adverse winter conditions.

Federal Administration Period (1890 – present)

In the 1890s, the federal government began to assume a greater role in the management of public domain resources. Congress passed various pieces of legislation, including the General Revision Act of 1891 and the Organic Act of 1897, authorizing the creation of national forests. Dixie National Forest was established in 1905, and encompassed the Cedar Breaks area. Under the administration of the Department of Agriculture's U.S. Forest Service, land uses within the Dixie National Forest, including mining, grazing, and timber harvesting, became subject to federal regulations. Some traditional practices, such as informal homesteading by small dairy operators on the Markagunt Plateau, were not authorized in the new national forests. The loss of revenues based on public domain resources was offset, in part, by new economic opportunities created by the federal administration of national forests and national parks in southern Utah.

As an example, the first decades of the 20th century witnessed the growth of tourism -- first on horseback, then by rail, and eventually by automobile -- as a new source of revenue in the southern Utah economy. This opportunity was closely linked to the designation of national monuments (later national parks), like Zion (Makuntuweap) in 1909, and later Bryce Canyon (1928), and Cedar Breaks (1933). The Union Pacific Railroad attempted to capitalize on public interest in seeing these natural wonders by extending a spur line from Lund to Cedar City, Utah, in 1923. The Union Pacific and its subsidiary, the Utah Parks Company, promoted rail and bus excursions to regional scenic destinations like Zion, Bryce Canyon, and Cedar Breaks. The decade of the 1920s also witnessed the construction of roads and highways like the Zion-Mt. Carmel Highway and the Parowan Canyon to Brian Head Road, which improved visitor access to national forests and units of the National Park System.

The Utah Parks Company developed lodging and other essential visitor services within the national parks, as well as on lands administered by the U.S. Forest Service. In 1926, construction was begun on the Cedar Breaks Lodge, located near Point Supreme. Until 1971, when it was demolished, the lodge provided a lunch stop for Utah Parks Company tours traveling to Bryce Canyon. Rustic-style cabins adjacent to the Lodge were available for overnight guests, who could also savor the fried chicken dinners that made the lodge famous.

Recreational use of the Cedar Break/Markagunt Plateau increased in the 1920s. Residents of the small Utah communities of Parowan, Paragonah, and Cedar City had traditionally escaped the summer heat in these high-elevation zones. As road access to the Cedar Breaks area was improved during the first decade of the 20th century, the need for visitor services there became apparent. The first restaurant and lodge in the Cedar Breaks area was constructed in the 1920s, and operated by Miriam "Minnie" Adams Burton. Minnie was the daughter of Charles Adams, an Irish immigrant who, with his siblings and offspring, informally homesteaded around Cedar Breaks, using the meadows there for summer livestock grazing. The area became known as "Little Ireland."

According to a granddaughter of Charles Adams, the family had about seven log cabins in the area, as well as corrals for about 200 milk cows and calves in the Little Ireland area (Wright 1998:1). The women of the Adams clan made cheese and butter, with some producing as much as 2,000 pounds of cheese during a summer.

In 1921, Charles Adams began construction on a large wooden lodge, complete with a 40-foot-long dance hall, balcony, eight guestrooms, kitchen, and dining area, to provide food and lodging for travelers and workers in the area (Gilmore 1987). Two guest cabins were located to the north of the lodge building. Adams turned the management of the lodge over to his gregarious daughter Minnie, who ran the business for several seasons. During its brief period of operation, "Minnie's Mansion" housed and fed travelers, as well as local sheepherders. The "Mansion" was also the setting for summer celebrations, such as the July 24th Pioneer Day festivities.

Residents from the surrounding communities would travel on horseback and in wagons to the lodge to dance and enjoy firework displays, discharged over Cedar Breaks (Wright 1998:3). Because Minnie was not renowned for her own culinary skills, she employed Hattie Heaps to prepare the meals served in the lodge's dining area. Despite their combined efforts, the business could not be made profitable during the short summer seasons and was closed after 5 years. Winter snows caused the collapse of a portion of the lodge in the early 1930s. The National Park Service eventually removed most of the remains of "Minnie's Mansion" after designation of Cedar Breaks as a national monument.

Southern Utah's tourist industry, along with all other sectors of its economy, was devastated by the Stock Market Crash of 1929 and the onset of the Great Depression. Unemployment in Utah at the end of 1932 was more than one-third of the labor force (Baldridge 1971:11). Local and state governments were powerless to stop the worsening economic conditions. In 1933, President Franklin Roosevelt initiated the first of the New Deal programs, sending federal relief to local communities through various public works programs, including the Civilian Conservation Corps (CCC). The CCC (or the "Cs") employed young men, ages 17 to 28, on work projects to improve environmental conditions and recreational opportunities on federal and state lands. The program was in place from 1933 until 1942, directly benefiting more than 3 million enrollees, reserve officers, advisors, and staff nation wide.

CCC personnel were organized into more than 1,300 work camps throughout the United States. A total of 27 camps were eventually placed in Utah by the end of the CCC program. Food, clothing, shelter, and other services were purchased from local markets, helping to alleviate the economic impacts of the Depression on the communities near the camps. Many CCC projects were intended to improve the ecological condition of the national forests and national parks through soil stabilization, watershed erosion control, and revegetation. The enhancement of recreation opportunities on federal and state lands was another focus for CCC efforts.

In southern Utah, CCC work camps were established at Cedar City, Zion National Park (CC #1966), Pine Valley, Duck Creek, Henrieville, and Modena. Beginning in 1933, the 200-man CCC work camp at Zion spent the summer months working at Cedar Breaks, developing facilities there. The "Cs" constructed many of the visitor facilities still in use today at Cedar Breaks National Monument. They helped to prepare for and host the dedication ceremonies for the new national monument, held on August 22, 1933 (Klein 1991). During the 1935 summer season, work crews completed a wood and wire boundary fence around the perimeter of the monument. They also installed log guard rails around visitor parking areas; assembled picnic tables; and prepared 12 fire pits in the campground. In 1937, a group of 27 men was sent to Cedar Breaks as a sub-camp, to construct the rustic Cedar Breaks Visitor Center and Ranger Station (Figure 2.2). The logs were cut and shaped by enrollees from nearby Utah communities: Harry Foote of Orderville, and James Davenport from Panguitch. Johnny Excell from Springdale, Utah, directed work on the rock foundations and fireplaces (Davenport 1991). These buildings are still in use and are listed on the National Register of Historic Places.

During the summer months, the CCC camp was located approximately ½ mile northeast of the Cedar Breaks Lodge, in a grassy meadow. The enrollees lived in tents, supported by two mess tents (Figure 2.3). The camp was run under the direction of the U.S. Army, with a level of discipline similar to any military unit. Camp discipline was enforced by internal peer review boards, labeled "Kangaroo Courts," which meted out penalties for offenders that could be more severe than those of any local civic authority (Glass 1983:10). Enrollees were expected to work from 8 a.m. to 4 p.m. , then spend time cleaning common use areas, maintaining equipment, or assisting the mess crews. The evening hours, until lights out at 10:30 p.m., could be used for athletic events, with softball being the most popular sport. Teams were organized and competitions staged between CCC camps and community teams from Cedar City and Parowan. Other enrollees took advantage of the educational opportunities offered by the CCC program, many finishing high school courses during their enrollments. The young men of the camps also participated in social events in the local communities, including dances and musical events.

By 1942, the national economy had improved sufficiently to end the federally funded public works projects. In Utah alone, the CCC had planted more than three million trees, reseeded 200,000 acres of rangeland, and constructed 4,000 miles of trails and roads (Baldridge 1971). Tourism in the national forests and park systems had been enhanced through the construction of campgrounds, visitor centers, and other public facilities. The visitor facilities in use today at Cedar Breaks National Monument are part of the CCC legacy of hard work and pride in accomplishment.

The austere years of the Second World War were followed by a new resurgence in Southwest tourism. The automobile, bus, and airplane gradually replaced the rails as the preferred mode of travel to Zion, Cedar Breaks, and Bryce Canyon in southern Utah. The Union Pacific Railroad discontinued rail service to Cedar City in 1960. The Utah Parks Company struggled to continue operations until 1971

Figure 2.2 Photograph of the CCC construction of the Cedar Breaks Visitor Center.

Figure 2.3 Overview photograph of the CCC camp at Cedar Breaks.

when all of its facilities, including the Cedar Breaks Lodge, were donated to the government for a tax write off (Seegmiller 1997).

The demise of the Utah Parks Company marked the end of an era in southern Utah. For nearly half a century, local communities struggled to profit from the federal administration of the national forests, parks, and monuments that surrounded them. Over time, tourism and the recreational uses of federally administered lands grew to offset the loss of revenues from traditional historic period endeavors, like timber harvesting, lumber milling, or dairying operations. Today, southern Utah enjoys strong economic growth that can be attributed, in some measure, to tourism and federally administered scenic destinations like Cedar Breaks National Monument.

PREVIOUS ARCHEOLOGICAL RESEARCH

High-altitude areas in the western United States have only recently been the focus of scholars interested in prehistoric land use (e.g., Benedict 1975, 1981, 1985, 1992, 1996, 1999; Bettinger 1990, 1991; Bettinger and Oglesby 1985; Burge, et al., 1999; Burge and Mathews 2000; Canaday 1991, 1992a, 1992b, 1996, 1997, 1998a, 1998b, 1999; Canaday and Reutebuch 1994; Canaday, et al., 1997; Grayson 1988, 1990, 1991, 1993, n.d.; Kodack 1997; Madsen, et al., 2000; Mierendorf 1998, 1999; Mierendorf, et al., 1998; Simms 1979, 1993; Thomas 1982; Thomas and Pendleton 1990; Wickstrom 1993; Winter 1983; Zeanah 2000). Prior to the Cedar Breaks Archeological Project, the only prehistoric investigations conducted in the high country of the Markagunt Plateau were related to cultural resource management (CRM) projects (e.g., Craig 1977; Dykman 1976; Rose and Snedeker 1982; Sargent 1979).

Between 1974 and 1982, archeologists from the Dixie National Forest conducted 13 CRM projects on the Markagunt Plateau. The surveys covered some 2,180 acres, and a total of 45 sites were identified (Craig 1977; Dykman 1976; Rose and Snedeker 1982: Table 2). These sites consist of lithic scatters with no apparent subsurface cultural deposits. All seem to share similar characteristics, in that hearths, structural features, ground stone, and ceramics are absent, and the majority of the debitage is thought to be the locally available Brian Head chert and chalcedony. The only non-chert lithic materials on any of these sites are a very few pieces of obsidian (Rose and Snedeker 1982:9). Obsidian samples analyzed from four Markagunt Plateau sites (42In223, 229, 231, and 232) have been traced to the Mineral Mountains approximately 50 miles to the north (Nelson and Holmes 1979).

Several sites discovered during these CRM projects suggest that the prehistory of the Markagunt Plateau is both behaviorally and temporally complex. The Long Flat site (42In330), first reported by Dykman (1976), was added to the National Register of Historic Places in 1979. This site ranges in elevation from 10,000 to 10,200 ft, encompasses approximately 750,000 square m (1,500 x 500 m in some places), and is thought to date from the Archaic to Ethnohistoric period (Hawkins 1979). It was added to the National Register because of its importance as a chert quarry centered around four chert outcrops, its large size and intra-site complexity, and its high elevation (Rose and Snedeker 1982). This site is very similar to the large site (42In1135) reported for the Cedar Breaks Project (Chapter 3, this volume).

The Lowder Creek Bog site (42In461), tested by Sargent (1979), is perhaps more important for its paleoenvironmental potential than for its archeological significance. This site is located at the base of Brian Head Peak, at an elevation of 10,319 ft, approximately 2 miles northeast of Cedar Breaks, and seems to have served primarily as a quarry and associated tool manufacture site. Sargent (1979:25) suggests that much of the chert and chalcedony debitage recovered at the Lowder Creek Bog site had been heat treated. Recent paleoenvironmental research conducted at Lowder Creek Bog is summarized by Madsen (Appendix E, this volume).

Archeological survey on land administered by the Dixie National Forest, surrounding Cedar Breaks National Monument, has been conducted over the last 6 years. Aided by volunteers from the Southwestern Service Group of the Sierra Club, survey and data collection at 42In1135 continues (Marian Jacklin, personal communication, August 6, 1999). Individual forest service loci for this extremely large lithic scatter and procurement area have not been formally mapped at this time. A second stage of field work on the forest will follow protocols previously established for monument sites. Thus, sites extending onto lands administered by the Dixie National Forest, as well as adjacent sites, will ultimately receive the same level of documentation as described here for the monument.

The North Point site (42In1210), described by Agenbroad (1992, 1993), contains several deeply buried paleosols eroding from the edge of Cedar Breaks some 2 to 4m below the present ground surface. Dates recovered from these strata, respectively, were 7,650 +/- 90 years B.P. (Beta 21121) and 9,005 +/- 175 years B.P. (GX:11405). Limited cultural debris is present, including utilized flakes, tertiary flakes, and a one-hand, sandstone mano/hammer. Unfortunately, the association of the artifacts to the paleosols is not clear (Adrienne Anderson, personal communication, 1998), and much archeological research remains to be done at this site. Paleoenvironmental and archeological research at the North Point site is discussed in Chapter 3.

Two historic era sites within Cedar Breaks (the Visitor Center and the Caretaker's Cabin) were nominated to the National Register of Historic Places in 1983. These log structures, constructed in 1937 by the CCC (see discussion above), are set on shaped rock foundations. They were added to the National Register because of their relation to the CCC and because they serve as very good examples of the National Park Service rustic architectural style.

Chapter 3

SUMMARY OF FIELD WORK

INTRODUCTION

The archeological survey of Cedar Breaks National Monument and surrounding Dixie National Forest lands was accomplished over a 3-year period (1996 – 1998). A total of 2,318 acres were inspected (Figure 3.1), resulting in the discovery of 99 archeological sites and 32 isolated occurrences. The majority of these sites appear to be associated with the prehistoric reduction of locally available Brian Head chert. However, Euro-American influence is also present, especially on the upper plateau, where historic sites associated with early Mormon settlement, the CCC, and monument tourism are to be found.

The following pages summarize the archeological field work conducted within Cedar Breaks National Monument. Included herein are summaries of the surveys within the monument and adjacent Dixie National Forest. In addition, the results of test excavations at 13 historic and prehistoric sites are presented.

ARCHEOLOGICAL RESOURCES OF THE LOWER BREAKS

An intensive pedestrian survey of the Lower Breaks was conducted during the summer of 1996 using transects spaced approximately 15 m apart. A total of 915 acres were sampled in the lower portions of the monument (Frank 1997). Survey areas were determined by percentage of slope (less than 20 percent), thus omitting large sections of the rough and dissected terrain in the lower part of the Breaks. Compared to the number of archeological sites discovered on the upper rim of the Monument, surprisingly few cultural resources were encountered in the Lower Breaks. Four historic sites dating to the early 20th century and 21 isolated prehistoric occurrences were encountered in the Lower Breaks during the 1996 field season.

Three of the four historic sites are located just outside of the monument on U.S. Forest Service property, and all are associated with logging activities in the Ashdown Meadows region (Frank 1997). Two of the sites appear to be historic homesteads containing cabin remnants, corrals, and scatters of historic debris (Figure 3.2). One site is thought to be a logging camp, while the fourth site is a historic road linking several sites along Ashdown Creek. Table 3.1 provides a summary of the sites located within Cedar Breaks that contain historical components.

All of the isolated occurrences documented in the Lower Breaks consist of single flakes (seven occurrences) or small, discrete scatters of debitage, cores, or expedient tools (14 occurrences containing between two and eight artifacts). These isolates indicate limited prehistoric use of the Lower Breaks. No diagnostic, time-sensitive prehistoric artifacts were encountered in the lower portions of the monument. The limited prehistoric use of the Lower Breaks contrasts markedly from that observed on the upper rim.

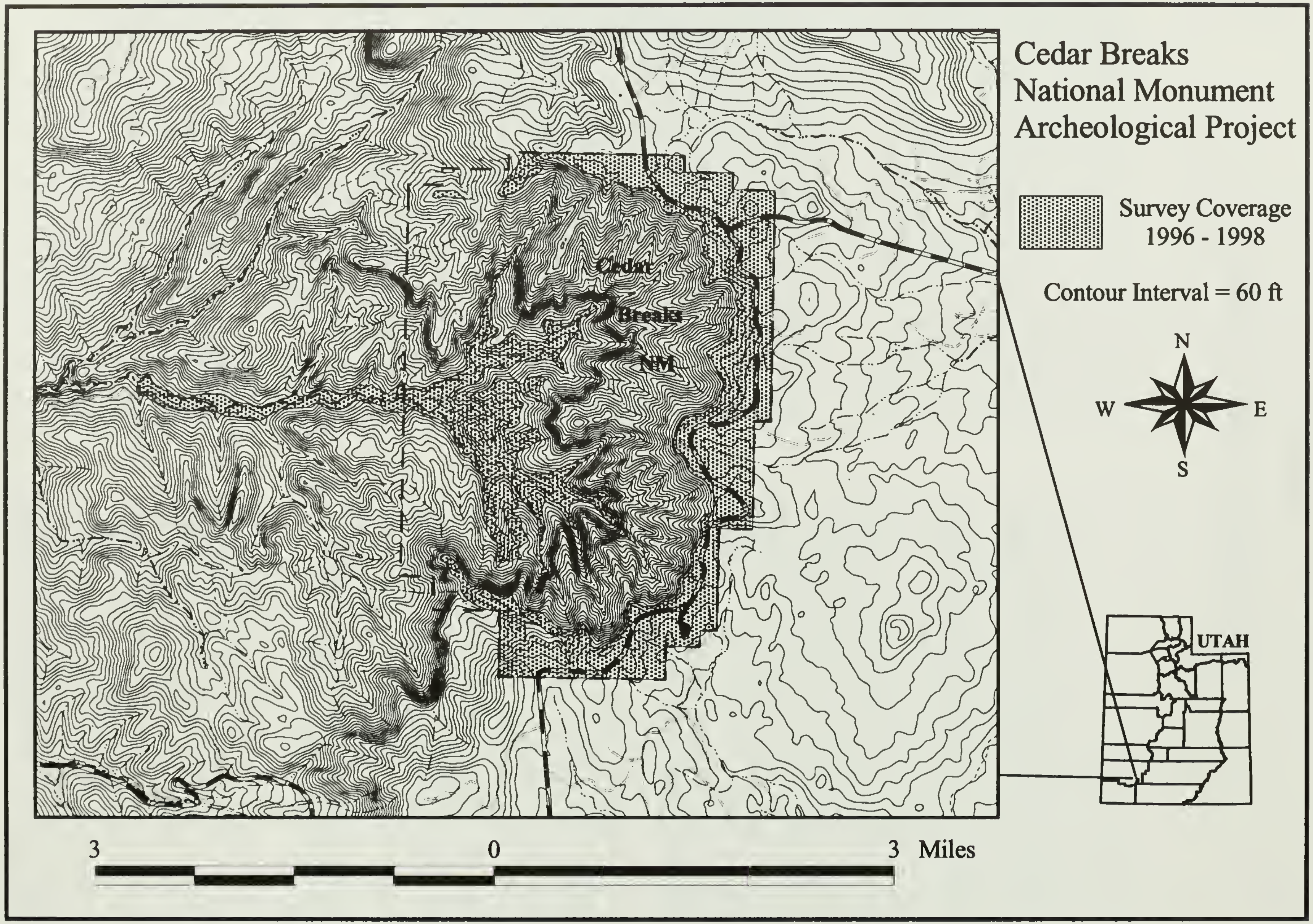

Figure 3.1 Project location and survey coverage map.

Table 3.1 Cedar Breaks archeological sites with historical components.

Site Number	NRHP Eligibility	Elevation	Site Type	Associated Features and Artifacts
42In1424	NE	8,300 ft	Logging camp	Corral, structural remnants, debris
42In1425	E	8,000 ft	Homestead	Cabin foundation, collapsed corral, and structure
42In1426	E	7,860 ft	Logging camp	2 cabins, 2 corrals, possible barn, and can dump
42In1427	NE	8,000 ft	Historical road	None, road connects sites 1424, 1425, and 1426
42In1428	E	10,640 ft	Habitation	Cabin remnant, corral, fence, and debris
42In1429	E	10,560 ft	"Minnies Mansion"	Remnant of building, corral, and debris
42In1501	NE	10,480 ft	Benchmark	Brass cap cadastral (1936) set on a cement monument
42In1502	NE	10,520 ft	Fenceline	Wood pole construction; possibly part of original monument fenceline
42In1503	NE	10,480 ft	Fenceline	Wood pole construction; possibly part of original monument fenceline
42In1504	NE	10,480 ft	Fenceline	Wood pole construction; possibly part of original monument fenceline
42In1505	NE	10,560 ft	Borrow pit	None
42In1509	HIST – NE PREHIST – E	10,540 ft	Prehistoric lithic scatter & historical debris scatter	Historical component consists of widely scattered debris (cans, bottles, sign, cartridges) and a 1936 benchmark
42In1524	HIST – E PREHIST - E	10,300 ft	Prehistoric lithic scatter & historical debris scatter	CCC camp; historical debris includes a U.S. Army button and bottles
42In1526	NE	10,280 ft	Foundation	Stone feature; possible barbecue pit
42In1542	HIST – NE PREHIST – NE	10,360 ft	Prehistoric lithic scatter & historical debris scatter	Historical component consists of a structure, possible septic areas, and debris. Probably associated with Cedar Breaks Lodge (42In1573)
42In1543	HIST – NE PREHIST - E	10,300 ft	Prehistoric lithic scatter & historical debris scatter	Historical component consists of a scatter of cans and bottles
42In1544	NE	10,290 ft	Foundation	Unshaped dry-laid rock foundation of unknown function; no associated artifacts.
42In1553	NE	10,457 ft	Benchmark	Brass cap cadastral (1936) set on a cement monument
42In1562	NE	10,120 ft	Aspen art	10 carved aspen trees with names and dates ranging from 1909 to 1946
42In1564	HIST – NE PREHIST - E	10,520 ft	Prehistoric lithic scatter & historical debris scatter	Historical component consists of a borrow pit
42In1573	E	10,400 ft	Cedar Breaks Lodge	Most of the site was razed in 1971; severely disturbed; historical and recent debris scattered throughout; intact portions consist of a log cabin and several latrines
42In1576	NE	10,500 ft	Debris scatter and foundation	2 bottles (one dating to 1904 -1907), corral, foundation, and debris scatter of shingles and window glass
42In1582	NE	10,560 ft	State Route 143	1 abandoned road segment
42In1583	NE	10,325 ft	State Route 148	3 abandoned road segments

Key to abbreviations:
E = eligible; NE = not eligible; HIST = historic component; PREHIST = prehistoric component ***NOTE:*** NRHP eligibility assessments are preliminary – awaiting SHPO concurrence

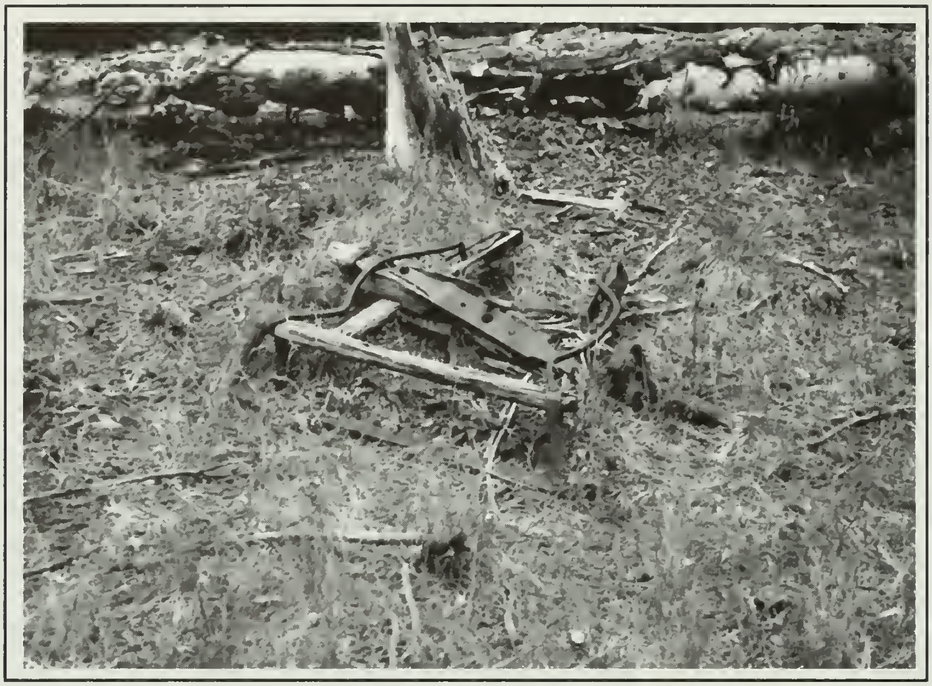

Figure 3.2 Example of historical resources from the Lower Breaks at site 42In1424.

ARCHEOLOGICAL RESOURCES OF THE UPPER BREAKS

A total of 1,403 acres in the upper section of the monument were sampled during the three seasons of field work. Ninety-five archeological sites and 11 prehistoric isolates were recorded during the survey. The majority of sites appear to be related to the primary reduction of locally available chert and chalcedony. Euro-American utilization of the monument was also documented (Table 3.1). Canaday (1998a, 1999) provides detailed discussion on each historic and prehistoric site encountered. Salient characteristics including National Register eligibility determinations for each site are provided in Table 3.2. Several of the upper rim historic sites, however, are worthy of extended discussion.

Site 42In1524 is a dual-component site containing an extensive prehistoric lithic scatter. Five Elko, one Gypsum, and one Pinto series projectile points, as well as several bifaces and abundant debitage are present. The site measures 220 x 200 m and is spread over two small parallel knolls separated by a drainage cutting to the east. The areas just north and east of the site are currently quite wet -- almost marshy. The consistent water supply in this area may have attracted prehistoric use, and definitely appears to have attracted historic and/or more recent use. A 1936 topographic map of Cedar Breaks National Monument shows this area as containing a Civilian Conservation Corps camp for workers involved with the early development of the monument. On the Dixie National Forest side of the site, broken glass, rusted metal, charcoal chunks, and cement nodules are common. Broken glass, cement, and rusted cans are also present on the Cedar Breaks side of the site. These materials may be the remains of the CCC camp. Unfortunately,

Table 3.2 Cedar Breaks prehistoric site characteristics.

Site Number	NRHP Elig.	Elev. (ft)	Site Type	Size (m^2)	Average Density (m^2)	Max. Density (m^2)	Quantity	Flake Types	Diagnostic Artifacts	Other Artifacts
42In1135 Locus A-1	E	10,480	LS	6,656	0.5	5	200+	secondary tertiary	2 Pinto, 2 Gypsum, 1 Elko	2 sc,1 bf, 2 uf
42In1135 Locus A-2	E	10,480	LS	8,050	0.25	25	2,000+	primary secondary	1 Gypsum	1 sc, 3 uf, 1 bf, tn
42In1135 Locus A-3	E	10,480	LS	3,534	0.3	10	1,000+	primary secondary	1 Elko	1 hm, 1 ch, 5 bf, 2 sc, 7 uf, 1 up, tn
42In1135 Locus B-1	E	10,440	LS	3,167	2.5	40	2,000+	primary secondary tertiary		6 bf, 8 uf, tn, cores
42In1135 Locus B-2	E	10,440	LS	2,474	2	4	100 - 500	primary secondary tertiary		1 bf, 2 sc, 8 uf, cores
42In1135 Locus B-3	E	10,520	LS	3,711	2	8	100 - 500	primary secondary tertiary		8 uf, 1 edge grinder, cores
42In1135 Locus B-4	E	10,600	LS	1,074	0.5	5	500+	primary secondary tertiary	1 Gypsum	1 bf, 7 uf, cores
42In1135 Locus B-5	E	10,435	LS	1,001	0.5	30	500+	primary secondary tertiary		2 grayware sherds, tn, cores
42In1135 Locus B-6	E	10,435	LS	311	1	21	100 - 500	primary secondary		1 hm, tn, cores
42In1135 Locus B-7	E	10,470	LS	4,536	2	3	100 - 500	primary secondary tertiary		14 uf, cores
42In1135 Locus B-8	E	10,470	LS	6,134	0.5	7	100 - 500	primary secondary tertiary	1 Elko 1 Parowan	2 hm, 1 sc, cores
42In1430	E	10,317	LS	4,923	>2	100	500+	primary secondary	1 Bull Creek 1 Snake Valley Black-on-gray	1 bf 2 concen.
42In1491	E	10,560	LS	1,689	0.3	6	80 -100	primary secondary tertiary		cores
42In1492	NE	10,440	LS	2,592	0.002	1	5	secondary		1 uf
42In1493	E	10,590	LS	5,655	0.1	27	500+	primary secondary tertiary		cores
42In1494	E	10,500	LS	1,308	1	4	75 -100	primary secondary tertiary		cores
42In1495	E	10,590	LS	3,255	0.03	2	25 -100	primary secondary tertiary		1 concen.

Table 3.2 Cedar Breaks prehistoric site characteristics.

Site Number	NRHP Elig.	Elev. (ft)	Site Type	Size (m^2)	Average Density (m^2)	Max. Density (m^2)	Quantity	Flake Types	Diagnostic Artifacts	Other Artifacts
42In1496	E	10,560	LS	60,384	0.1	8	100 - 500	primary secondary tertiary		tn, cores, 3 concen.
42In1497	E	10,350	LS	58,748	0.3	18	100 - 500	primary secondary tertiary		1 uf, cores, 3 concen
42In1498	E	10,520	LS	7,318	0.25	11	250 - 300	primary secondary tertiary		1 bf, 1 uf 1 concen.
42In1499	E	10,500	LS	25,447	0.46	13	500+	primary secondary		1 bf
42In1500	NE	10,500	LS	3,285	0.01	2	23	primary secondary tertiary		1 uf 1 concen.
42In1506	NE	9,600	LS	746	0.08	13	56	primary secondary tertiary		1 uf
42In1507	NE	10,620	LS	3.14	2	2	6	primary secondary		
42In1508	NE	10,520	LS	551	0.06	4	18	primary secondary tertiary		
42In1509	E	10,540	LS & HD	146,870	4	30	2,000+	primary secondary tertiary	1 Rosegate, 1 Bull Creek, 2 Elko, 1 Pinto	6 uf, 3 bf, 1 uniface, cores, 4 concen.
42In1510	NE	10,480	LS	3,142	0.01	3	32	primary secondary tertiary		
42In1511	NE	10,260	LS	738	0.01	1	9	secondary		
42In1512	NE	10,550	LS	18.8	0.32	2	6	primary secondary		
42In1513	E	10,480	LS	127,235	0.62	7	500+	primary secondary tertiary		3 bf, 7 uf, cores
42In1514	NE	10,430	LS	196	0.08	2	16	primary secondary tertiary		
42In1515	E	10,440	LS	141,372	0.17	6	100 - 500	primary secondary tertiary	3 Elko	4 bf, 5 uf, 1 sc, tn, cores 1 up
42In1516	NE	10.460	LS	340	0.09	4	30	secondary		1 bf
42In1517	E	10,490	LS	1,925	1.5	10	100 - 500	secondary tertiary		3 bf, cores
42In1518	NE	10,460	LS	85	0.16	2	14	primary secondary tertiary		
42In1519	NE	10,340	LS	3	2	2	6	secondary		
42In1520	NE	10,420	LS	18.8	0.21	1	3	secondary		1 uf

Table 3.2 Cedar Breaks prehistoric site characteristics.

Site Number	NRHP Elig.	Elev. (ft)	Site Type	Size (m^2)	Average Density (m^2)	Max. Density (m^2)	Quantity	Flake Types	Diagnostic Artifacts	Other Artifacts
42In1521	NE	10,380	LS	3.14	0.64	1	1	secondary	1 Elko	
42In1522	E	10,200	LS	10,681	0.04	10	100 - 500	primary secondary tertiary	1 Gypsum, 1 Elko, 1 Rosegate	5 bf, 1 metate cores, 1 ob concen, 2 cer concen.
42In1523	E	10,240	LS	25,526	0.17	2	100 - 500	primary secondary tertiary	1 Parowan 2 Humboldt	1 sc, 2 hm, 2 uf, 7 bf, cores
42In1524	E	10,300	LS	34,558	0.8	6	500+	primary secondary tertiary	7 Elko, 1 Gypsum, 1 Pinto	3 bf, cores
42In1525	NE	10,390	LS	1,558	0.03	4	48	primary secondary tertiary		1 bf
42In1527	NE	10,260	LS	118	0.03	1	3	secondary tertiary		
42In1528	NE	10,270	LS	1	2	2	2	primary secondary		
42In1529	NE	10,270	LS	491	0.01	1	3	secondary		1 bf
42In1530	NE	10,260	LS	39	0.08	1	3	secondary		
42In1531	NE	10,280	LS	1,728	0.01	1	13	secondary tertiary		
42In1532	NE	10,280	LS	1	2	1	1	primary		1 bf
42In1533	NE	10,300	LS	1,139	0.01	1	7	primary secondary tertiary		1 bf
42In1534	NE	10,350	LS	4	0.5	1	2	secondary tertiary		
42In1535	NE	10,340	LS	1,451	0.01	2	10	secondary tertiary		core
42In1536	NE	10,300	LS	2	1.0	1	1	tertiary		1 bf
42In1537	NE	10,360	LS	1,414	0.01	1	9	primary secondary tertiary	1 Gypsum	core
42In1538	NE	10,370	LS	2,686	0.01	3	31	primary secondary tertiary		2 uf
42In1539	E	10,340	LS	94,012	0.1	7	500+	primary secondary tertiary	1 Northern Side-notched	3 bf, 1 sc, 1 uf, cores 1 uniface
42In1540	E	10,380	LS	6,912	0.33	4	100-500	primary secondary tertiary	1 Pinto	4 bf, 1 uf, 2 concen.

Table 3.2 Cedar Breaks prehistoric site characteristics.

Site Number	NRHP Elig.	Elev. (ft)	Site Type	Size (m^2)	Average Density (m^2)	Max. Density (m^2)	Quantity	Flake Types	Diagnostic Artifacts	Other Artifacts
42In1541	E	10,260	LS	3,993	0.01	3	100-500	primary secondary tertiary		1 uf
42In1542	NE	10,360	LS & HD	2,325	0.01	2	14	primary secondary tertiary		
42In1543	E	10,300	LS & HD	8,934	0.1	2	10-25	primary secondary tertiary	1 Gypsum	1 uf, cores, 2 prehist concen.
42In1545	NE	10,360	LS	4.7	0.43	1	2	tertiary		
42In1546	NE	10,500	LS	3.8	0.08	1	3	secondary		
42In1547	E	10,450	LS	30,886	0.5	5	400-500	primary secondary tertiary		5 bf, 2 sc, 1uf, cores
42In1548	E	10,450	LS	632	0.04	2	23	tertiary		2 bf, 1 ch, 1 uf
42In1549	E	10,530	LS	3,584	0.01	3	42	primary secondary tertiary	1 Elko, 1 Pinto	3 uf, 1 bf cores, 2 concen.
42In1550	E	10,520	LS	1,100	0.02	3	15	secondary tertiary	1 Elko	1 up, 1 bf
42In1551	NE	10,520	LS	414	0.04	2	14	secondary tertiary		2 bf
42In1552	NE	10,520	LS	59	0.29	3	17	secondary tertiary		
42In1554	NE	10,480	LS	39	0.33	2	13	secondary tertiary		
42In1555	NE	10,520	LS	204	0.03	1	4	secondary tertiary	1 Elko	
42In1556	NE	10,520	LS	448	0.01	1	3	secondary tertiary	1 Elko	2 bf
42In1557	NE	10,520	LS	236	0.02	1	4	secondary tertiary		1 bf
42In1558	NE	10,520	LS	22	0.09	1	2	secondary		
42In1559	NE	10,520	LS	6	1.8	3	11	secondary tertiary		
42In1560	E	10,340	LS	4,595	0.01	6	150-200	primary secondary tertiary	1 Parowan 1 Elko	1 bf, cores 3 concen.
42In1561	NE	10,100	LS	2,686	0.75	4	50-75	primary secondary tertiary		cores, 2 concen.

Table 3.2 Cedar Breaks prehistoric site characteristics.

Site Number	NRHP Elig.	Elev. (ft)	Site Type	Size (m^2)	Average Density (m^2)	Max. Density (m^2)	Quantity	Flake Types	Diagnostic Artifacts	Other Artifacts
42In1563	E	10,480	LS	17,667	1	4	500+	primary secondary tertiary		1 bf, 1 uf, 1 sc
42In1564	NE	10,520	LS & HD	7,880	0.19	2	75-100	primary secondary tertiary		1 hm
42In1565	E	10,560	LS	21,991	0.17	8	300-500	primary secondary tertiary		1 up, 2 uf, 1 sc, 2 bf, cores
42In1566	E	10,600	LS	6,597	0.18	11	200+	primary secondary tertiary		1 bf, cores 1 concen.
42In1567	E	10,560	LS	11,231	0.4	6	300-400	primary secondary tertiary		1 uf, 1 bf, cores
42In1568	NE	10,500	LS	1,353	0.007	1	8	primary secondary	1 Gypsum	
42In1569	NE	10,520	LS	766	0.01	1	7	secondary tertiary		
42In1570	NE	10,500	LS	194	0.03	1	6	secondary tertiary		
42In1571	NE	10,560	LS	10	0.2	1	2	secondary tertiary		
42In1572	NE	10,560	LS	5	0.4	1	2	secondary		
42In1574	NE	10,200	LS	69	0.06	1	4	secondary tertiary		
42In1575	NE	10,580	LS	550	0.8	3	50-75	secondary tertiary		
42In1577	NE	10,560	LS	25	0.08	1	2	secondary		
42In1578	NE	10,560	LS	94	0.05	1	5	secondary		
42In1579	NE	10,480	LS	16	0.25	1	4	primary secondary		
42In1580	NE	10,480	LS	38	0.11	1	4	primary secondary		
42In1581	NE	10,480	LS	40	0.08	1	3	secondary		

Key to abbreviations:
LS = lithic scatter; HD =historical debris; bf = biface; sc = scraper; uf = utilized flake; hm = hammerstone; ch = chopper; tn = tested nodules; up = unknown point; E = Eligible, NE = Not Eligible. ***NOTE:*** NRHP eligibility assessments are preliminary -- awaiting SHPO concurrence.

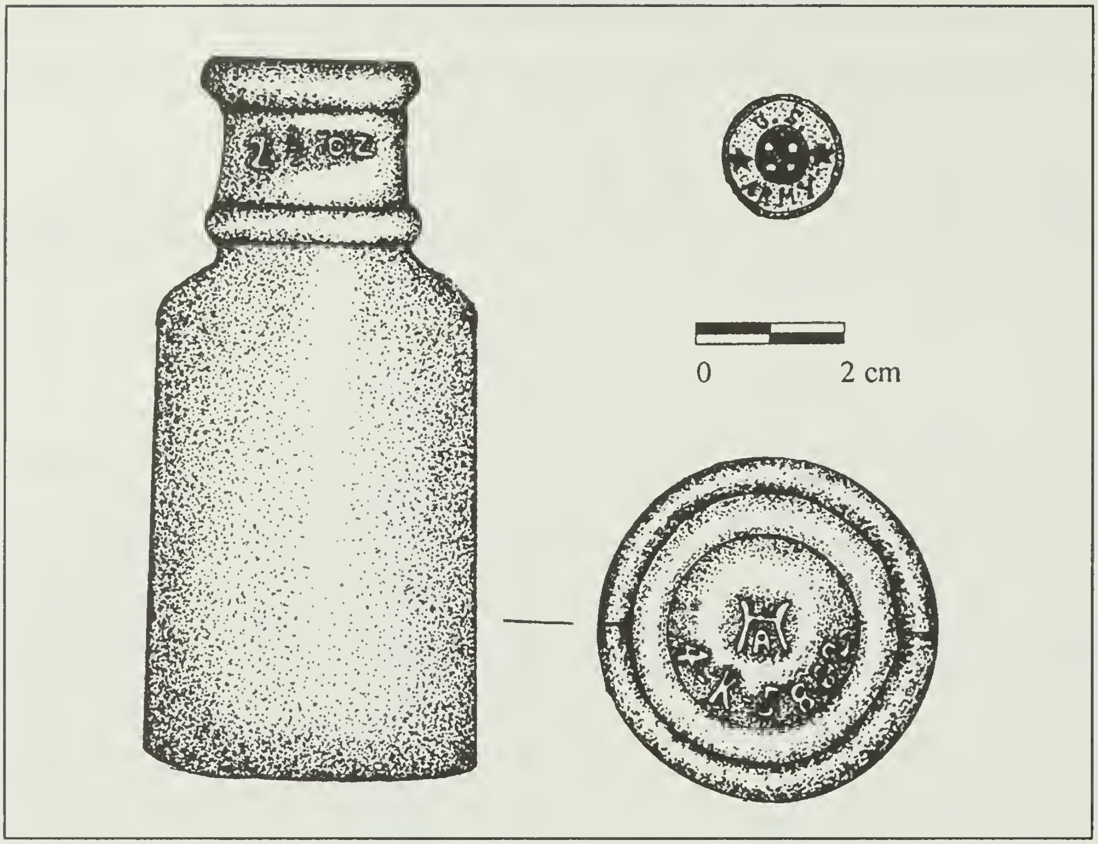

Figure 3.3 Illustrations of historical artifacts from site 42In1524.

many of the glass and plastic objects noted appear to date to between 1950 and 1970. Bits of coal and coke are present throughout the meadow, however, and may have been brought in for use by the CCC. Similarly, the milled wood fragments and concrete noted within the site could be the remnants of the camp, but this kind of debris cannot be easily assigned to the historic era.

Remains of tent platforms like those depicted in historical photos of the camp could not be discerned. A historic era medicine bottle with a Hazel-Atlas Glass Company maker's mark (1920 – 1964; Toulouse 1971) and a metal U.S. Army button (Figure 3.3) were discovered on the surface, and are probably associated with the CCC camp.

Site 42In1526 consists of a historic era foundation measuring 3.9 x 2.25 m (Figures 3.4 and 3.5). It is rectangular in shape and contains at least five courses of partially shaped rhyolite rock mortared with gray cement. The cement fully caps the tops of some of the top-most rocks, while most are left exposed. The foundation has been set into a pit, with the backdirt apparently primarily tossed along the north and south sides. The present ground surface meets the top of the foundation along its west, north, and south sides. The east end contains an opening that has subsequently been blocked by unshaped, non-mortared rhyolite cobbles. Recent fires have been set within the structure and one black Bic® lighter is present. The height of the inside walls from the top of the fill to the top of the wall is 57 cm and at least 50 cm of fill is

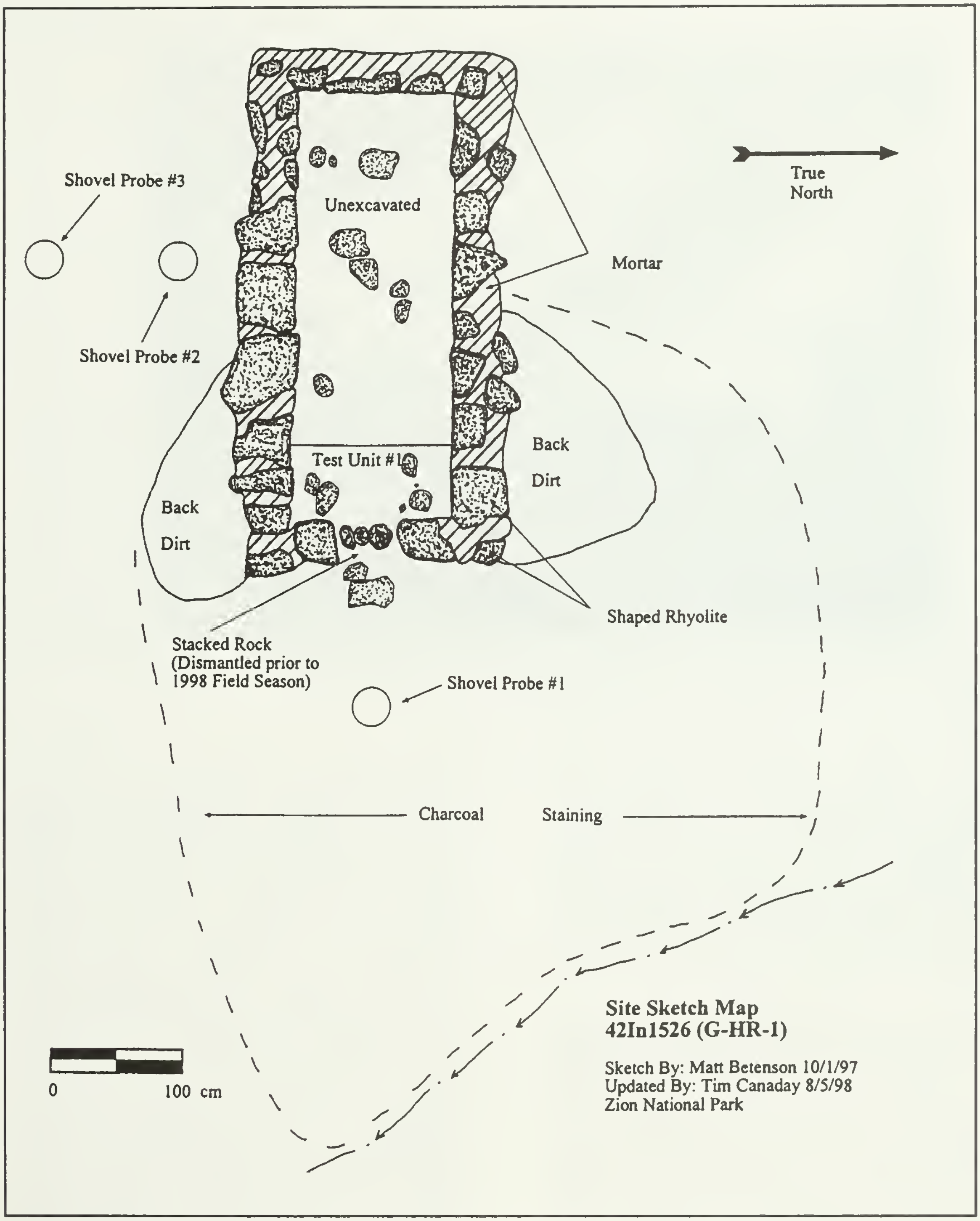

Figure 3.4 Plan view of site 42In1526.

Figure 3.5 Photograph of rectangular feature at site 42In1526.

present (based on a pin flag probe at the center of the feature). The eastern opening may have functioned as an outlet for cleaning out the interior of the feature. Burned sediment is present outside of this opening and continues for some 5 m to an ephemeral drainage.

Three shovel probes (SHP) and a 1.1 x 0.6 m unit were excavated. Shovel probe 1 was placed directly in front of the suspected doorway of the CCC-constructed foundation. Two stratigraphic layers were identified: The upper stratum contained a mottled, silty, coarse sand with abundant charcoal but no artifacts. The lower stratum (encountered at 30 cmbs) consisted totally of charcoal. Again no artifacts were observed. The charcoal stratum continues to 60 cmbs, where a slab of rhyolite terminated progress. We could not tell if the rhyolite slab was associated with the foundation or if it was merely a naturally occurring stone. Shovel probe 2 was placed on the south side of the feature about 55 cm from the wall. This unit was terminated almost immediately because rocks were encountered. Shovel probe 3 was placed 1 m south of SHP 2. No cultural material was encountered in this probe. However, we were able to demonstrate that the normal Cedar Breaks sediment (i.e., clayey silt) existed away from the feature. The sediment within the feature and within SHP 1 did not conform to the normal sediment for Cedar Breaks, being composed of coarse sand for the most part -- undoubtedly imported as part of the function for the site. We now believe it to have been a pit barbecue/earth oven.

A 110 x 60 cm test unit was placed within the interior of the structure at the far eastern end. The foundation is oriented along true north, with its long axis aligned east to west. Visitors had dismantled part of the stacked rock door that had been noted the previous year and a new fire had been started within the interior. A temporary datum was established outside the feature at 40 cm above interior ground surface. Levels of 10 cm increments were then removed and screened through 1/8–in mesh. The sediment consisted of mottled, silty, coarse sand with abundant charcoal. Recent debris (styrofoam, charcoal briquettes, plastic, and aluminum foil) was encountered (but not collected) in the upper levels. The lower levels contained lighter brown coarse sand and charcoal. Rodent disturbance was prevalent throughout the deposit. As noted above, the coarse sand looks to be an import, and it probably acted as a heat-retention device, if our guess is correct, and this is a pit barbecue/earth oven feature. Interestingly, the base of the feature consists of a single slab of rhyolite -- at least as far as it was exposed. Cement (using a coarse sand matrix) mortar is present at the base of the lowest partially shaped rhyolite rock securing the foundation to the basal slab. Cement mortar is used between each successive coarse of rock; between nine and 10 courses were employed. The door opening at the east end continues to the floor, and the rhyolite slab floor extends to the east, past the door opening for an unknown distance. Perhaps the rock terminating shovel probe 1 is part of this large slab. A profile of the east wall is presented in Figure 3.6. Two strata were identified, based on color difference. The sediment is basically the same throughout: coarse sand. The upper stratum is dark gray and contains abundant charcoal. The lower stratum is a lighter brown and contains lesser amounts of charcoal.

Site 42In1573 is the former location of the Cedar Breaks Lodge operated by the Union Pacific Railroad from the late 1920s to the late 1960s (Klein 1991). Very little cultural debris remains at this site, and what is present appears to date to the 1960s. The site was dismantled in 1971, and most of the debris hauled away.

Several suspected building sites remain, and a probable asphalt drive and parking lot could be discerned. Ceramic water and sewer pipe is present, along with wood shingle fragments, glass fragments, complete beverage (liquor and soft drink) bottles, and metal fragments. In addition to the severely disturbed portion of the site, an intact cabin is present, and a water tower (in use since the 1930s) is also associated. A variety of bottles (whole and broken) are present -- most appear to date to the 1950s and 1960s. Several road segments are present and contain decomposing asphalt and gravel leading to a possible parking area and to (presumably) the main lodge. A U.S. Geological Survey (USGS) benchmark dating to 1936 was used as the site datum. It contains a 3 ¾-inch-diameter brass cap on an 8-inch x 7 ¾-inch x 6 ¼-inch cement pedestal. The brass cap is inscribed:

"US GEOLOGICAL SURVEY BENCHMARK / FOR INFORMATION WRITE THE DIRECTOR WASHINGTON DC / COOPERATION WITH THE STATE / VS 16 / ELEVATION ABOVE SEA / 10399 / 1936."

An intact log structure is present (Figure 3.7). It measures 3.75 m north-south by 3.4 m east-west and is 2.86 m high at its peak. The structure contains a south-facing door and windows on the east and west sides. The logs are saddle notched

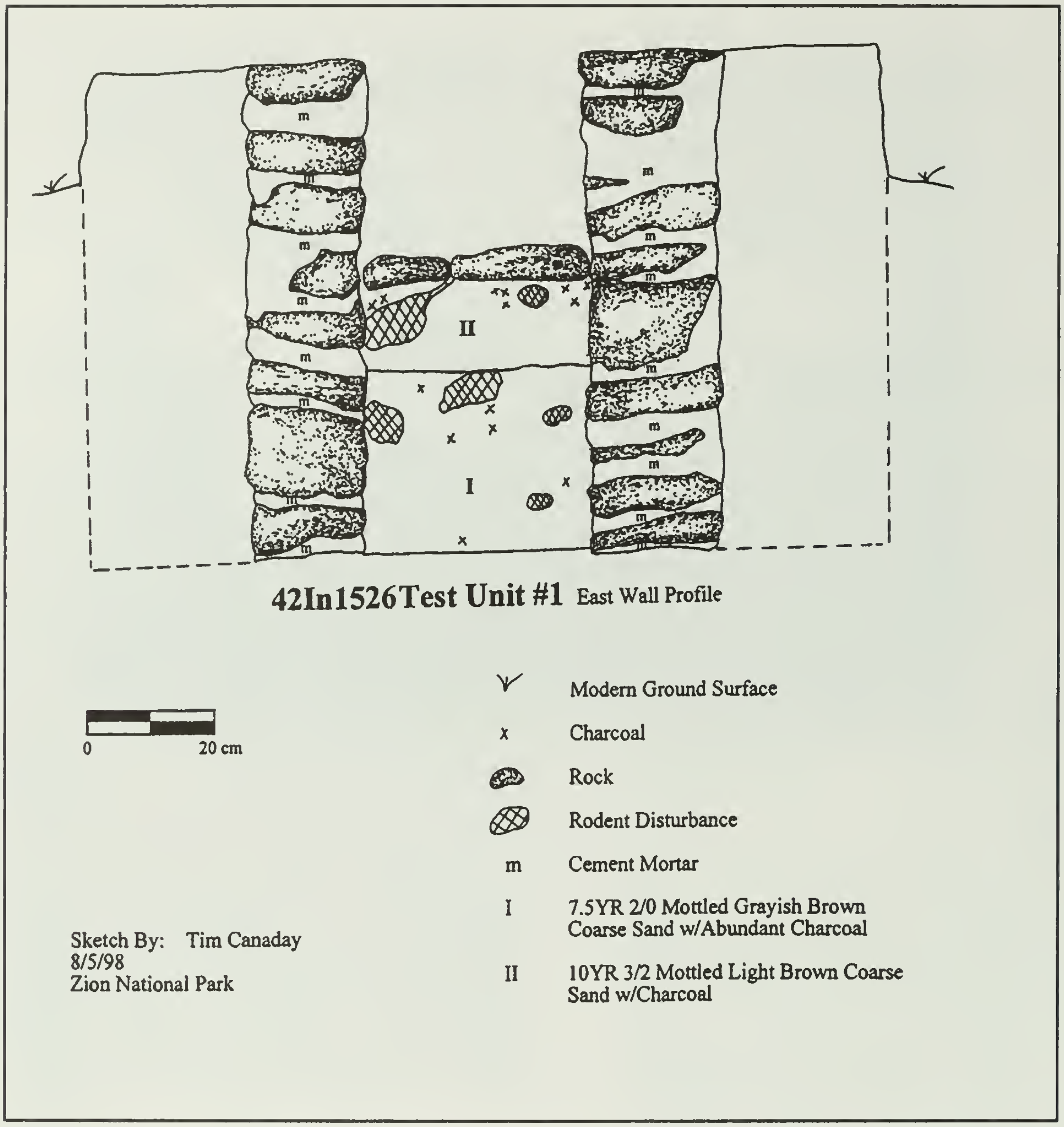

Figure 3.6 Profile of the east wall of test unit 1 from site 42In1526.

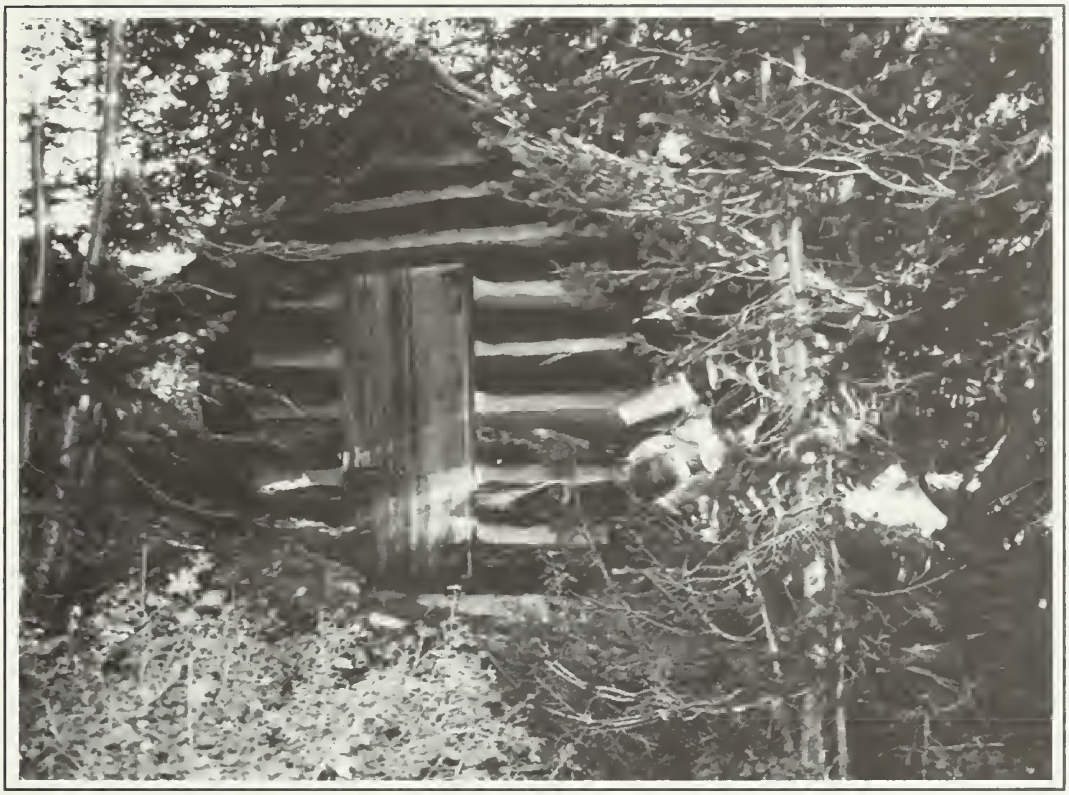

Figure 3.7 Log structure at site 42In1573.

and range from 10-13 inches in diameter. The pitched wood shingle roof is supported by a single log beam. An unshaped rock foundation with cement mortar is present. The interior of the structure contains a milled wood plank floor. A cement pad (29 ½ inches by 29 ½ inches) with four upright bolts is present along the western portion of the room (it probably held a stove). No stove pipe hole is present in the roof, but a small (2½-inch diameter) hole leads out the north wall of the structure and may have served as a stove vent. Electrical wiring is present in the northwest corner of the structure, and a metal garbage can lid, a dismantled wooden bed frame, a box spring, and six door screens of assorted sizes have been stored inside the structure. Cement mortar applied to metal grating is present between the logs on both the interior and exterior walls.

A possible outhouse foundation is present. It measures 46¼ inches long (oriented 40 degrees/220 degrees) and is possibly square. There are at least three courses of unshaped cement-mortared rock standing 12 inches high. The interior is completely filled in and undisturbed. Two fragments of a left humerus shaft (chicken?) are present on the surface of the interior. A depression measuring approximately 1 m^2 was also noted and may be the remnants of a second outhouse.

Two rock walls are present, with possible intact cultural deposits associated. Both walls are probably remnants of outbuildings associated with the main lodge. The first wall measures 100 inches long (oriented 14 degrees/194 degrees), has two to three courses of unshaped cement-mortared rock, and has dark-stained sediment extending from the wall for about 3m to the east. A marmot burrow is present. The second wall is more ephemeral than the first, and may not be in its original position. It measures about 80 inches long, and only one course of unshaped cement-mortared rock was observed.

Two water tanks (ca. 30,000-gallon capacity) are present on the edge of the Breaks along the western margin of the site. One of the water tanks was in use in the 1930s, while the second was added in the 1950s or 1960s. The northernmost tank is the earlier and contains a 25-inch-high (four to five course; approximately 7m long) retaining wall along the east side. A partial rock wall is visible on the west side (only 1m long is visible). A dirt berm surrounds the southern tank and part of the northern tank. Water to fill the tanks comes from a spring located about 1,000 meters to the west. Water pipes lead from the spring to a pump house midway between the spring and the tanks. The pump house appears to be of recent construction (1960s?) and pumps the water uphill to the tanks. The tanks then supply the monument buildings (and presumably the lodge, when it was in operation) with a gravity-fed supply of water.

Prehistoric use of the Cedar Breaks rim area has occurred for at least the last 7,000 to 8,000 years, based on projectile point types collected from the surface of these sites. The main use of the area appears to have occurred during the late Archaic (Gypsum, Humboldt, and Elko Series projectile points), though early Archaic (Pinto Series projectile points) use is indicated as well. In addition, late prehistoric utilization is suggested by the presence of Parowan Basal-notched and Bull Creek projectile points, as well as by the occurrence of ceramics (including one Fremont Black-on-gray sherd). Salient characteristics of the prehistoric sites discovered on the upper plateau are provided in Table 3.2. Several of these sites (42In1210, 42In1135 and 42In1522) are described in detail below.

ARCHEOLOGICAL TESTING RESULTS

Test excavation was conducted at 13 historic and prehistoric sites. Included were five of the 11 loci previously identified within site 42In1135. Test excavation was necessary in order to determine whether buried deposits were present, and to aid in the evaluation of these newly discovered cultural resources. The 13 sites chosen for testing exhibited the greatest potential for buried deposits or contained artifact diversity suggesting multiple use or activities. Unfortunately, each was found to contain little or no depth. One site (42In1522) was found to contain cultural debris up to 30 cm below the modern ground surface. The rest of the sites appear to be surface manifestations.

Shovel probes were excavated at each site as a means to quickly and efficiently determine whether buried deposits were present. The shovel probes measure about 30 cm in diameter, and were excavated in 20 cm increments. Notes for each 20 cm level were taken, and consist of sediment description (color, moistness, constituency – silt, sand, clay, gravels, etc.), disturbance (rodents, roots, etc.), and cultural material encountered. A field specimen (FS) number was assigned to each level when artifacts were found. All sediment was passed through 1/8-inch mesh.

Test excavation units (TU) measuring 1x1 m were utilized at several sites when the shovel probes indicated the possibility of buried cultural material. The 1x1 m units were excavated using arbitrary 10 cm levels, unless stratigraphic layers were encountered. As with the shovel probes, all sediment was passed through 1/8-inch mesh, and detailed notes were taken for each completed level or layer. Original excavation notes for shovel probes and units are archived with the rest of the Cedar Breaks collection. Canaday (1999) provides detailed shovel probe and auger data per each 20 cm level. Testing results for each site are presented in Table 3.3.

Roughly 13 percent of the known sites in Cedar Breaks National Monument were probed during the 1998 field season to determine whether subsurface cultural remains were present. Thirteen sites, including five loci from 42In1135, were tested. A total of 5.262 m^3 of sediment was passed through 1/8-inch screen. Shovel probes accounted for 2.974 m^3 while test units accounted for the remaining 2.288 m^3. The results of the 1998 field work clearly demonstrate that these high-elevation sites are, for the most part, surface manifestations. Of the 74 shovel probes excavated at these sites, a total of just 12 artifacts (11 flakes and a utilized flake) were recovered. Seven of the flakes and the utilized flake came from the first level (0-20 cmbs), and many of those were noted as having come from the upper 10 cm. Two sites (42In1522 and 42In1210) contain subsurface deposits and are discussed in detail below.

42In1522 contains fairly substantial subsurface deposits -- especially for this part of the Markagunt Plateau. This site consists of a scatter of lithics and ceramics measuring 170 x 80 m extending onto U.S. Forest Service land. Observed artifacts indicate both Archaic (Gypsum and Elko Series projectile points) and Late Prehistoric (Rosegate projectile point and ceramics) use of the site. The two most notable features of this site are the number of obsidian flakes, and the presence of ceramics (extremely rare in high-elevation settings in southern Utah). A possible fire hearth with an associated rhyolite slab metate is also present on the Forest Service side of the boundary fence. The possible hearth is a vague circular alignment of 14 rhyolite rocks. Rhyolite is not common in the immediate vicinity, and these rocks must have been transported to this location. There is no charcoal in or surrounding the feature. An extremely dense flake scatter (10/m^2) does surround it, however. The majority of the debitage represents late flaking stages, with cherts, chalcedony, and obsidian providing the material types. Three obsidian flakes (FS #s 97-106, -108, and -109) were submitted for XRF analysis. All three specimens were identified as coming from the Wild Horse Canyon area of the Mineral Mountains (Hughes 1997a).

All of the ceramics were contained within a 13m (north-south) X 19m (east-west) area. The scatter contained 23 grayware body sherds and a bowl rim sherd with a white slip. Perry (1997) concludes that these sherds are probably locally made but cultural affiliation is not definitive. She indicates that they are definitely *not* Snake Valley Gray nor are they Sevier Gray (Fremont pottery types), and they *do not appear* to be Virgin Anasazi. Perry's complete letter report (1997) is included as Appendix B. Additional work (subsurface testing) at this site was required to obtain a larger sample of sherds.

Table 3.3 Testing results for Cedar Breaks sites.

Site Number	#/Type Excavation Unit	Excavated Volume (m^3)	Cultural Material Encountered
42In1135 Locus A-1	6 shovel probes	0.236	1 flake in 0-20 cm level
42In1135 Locus A-3	5 shovel probes	0.163	1 utilized flake in 0-20 cm level
42In1135 Locus B-5	2 shovel probes	0.060	No cultural material
42In1135 Locus B-7	2 shovel probes	0.074	No cultural material
42In1135 Locus B-8	6 shovel probes	0.227	No cultural material
42In1210	5 shovel probes; extended with bucket auger	0.490	1 pressure flake in 180-200 cm level
42In1509 Locus #3	2 shovel probes	0.065	No cultural material
42In1515	6 shovel probes	0.202	No cultural material
42In1517	3 shovel probes	0.052	1 flake in 0-20 cm level
42In1522	13 shovel probes	0.666	1 flake in 0-20 cm level; 1 flake in 20-40 cm level; 1 flake in 40-60 cm level; 1 flake in 60-80 cm level
	4 test units (1x1 m)	1.100	Debitage, a biface and plain grayware ceramics within the upper 30 cm in TU #1 55 biface reduction and pressure flakes within upper 15 cm of TU #2 1 pressure flake and a metate within the upper 10 cm of TU #3 No cultural material recovered from TU #4.
42In1524	8 shovel probes	0.200	1 flake in 0-20 cm level
42In1526	3 shovel probes	0.113	No cultural material
	1 test unit (1.1x0.6 m)	0.700	Abundant charcoal to 30 cmbs; recent debris intermixed; no historical refuse
42In1538	2 shovel probes	0.027	No cultural material
42In1539	7 shovel probes	0.1900	2 flakes in 0-20 cm level
42In1544	2 test units (1x1 m)	0.410	1 mill-cut board with wire nails
42In1560	2 shovel probes	0.070	No cultural material
42In1576	2 shovel probes	0.049	1 flake in 0-20 cm level
	1 test unit (1x1 m)		Shingles & window glass abundant in upper 5cm

Thirteen shovel probes totaling 0.666 m^3 and four 1x1m units (1.1 m^3 excavated volume) were excavated during the 1998 field season. A total of four flakes were recovered from these subsurface probes (one each from SHP#1, #3, #7, and #13). Shovel probe numbers 1 and 7 were positioned in the southwestern portion of the site, near where the ceramics were located. Both probes indicated the possibility of buried cultural deposits; a flake was recovered from the 40-60 cm level in SHP #1, and from the 60-80 cm level in SHP #7. Based on the shovel probe data and the presence of the ceramics, a 1x1m test unit (TU #1) was placed immediately west of SHP #7.

TU #1 was excavated to 60 cm below present ground surface. Artifacts were encountered in the upper 30 cm of this unit, and include debitage, a biface, and several grayware sherds. An obsidian Rosegate projectile point (Figure 3.8) was found on the surface immediately north of TU #1 and was submitted for XRF characterization. This obsidian artifact was sourced to the Wild Horse Canyon area of the Mineral Mountains, Utah.

A second test unit (TU #2), located on a portion of 42In1522 on the Dixie National Forest, was excavated to determine whether the rock feature suspected to be a hearth contained any intact deposits -- especially datable material. A 1x1 m unit was placed so that approximately half of the feature would be cross-sectioned. Much of the sediment in this area appears to have been removed through deflation of the overlying dirt. Decomposing rhyolite bedrock was encountered within about 15 cm below modern ground surface. Fifty-five biface reduction and pressure flakes (including five pressure flakes and a piece of shatter from the surface) were collected from the shallow deposits of this unit. Based on the presence of the rocks observed on the surface, this feature was probably a deflated hearth. Unfortunately, because neither ash nor charcoal was encountered, a determination as to the actual function of this feature could not be made.

While researchers traveled back and forth between the two test units, additional artifacts were observed. Of greatest importance was a concentration of 11 Intermountain brownware sherds. Several of these sherds contain fingernail impressions (Figure 3.8). In close association with the sherds was a partially buried slab metate. Two additional 1x1 m test units were excavated in this area; one over the metate (TU #3), and one over the concentration of brownware ceramics (TU #4). Both units are located on the Dixie National Forest side of the boundary fence and both were in areas with limited depth potential.

One obsidian pressure flake was collected from the surface of TU #3. No other cultural material was encountered, except the slab metate. Decomposing rhyolite bedrock was encountered at about 10 cmbs and the unit was terminated at 16 cmbs. The rhyolite metate is minimally ground (18 x 9 <0.5 cm) on one surface, measures 34 x 24 x 11cm, and was found resting on a deflated surface only a couple of cm above the decomposing bedrock. This artifact was photographed, described, and sketched in the field, and then placed on the bottom of the unit and backfilled.

Test unit #4 was placed over the area of greatest brownware ceramic concentration. As with TU numbers 2 and 3, decomposing bedrock was encountered rather quickly. It was hoped that a 1x1 m unit in this

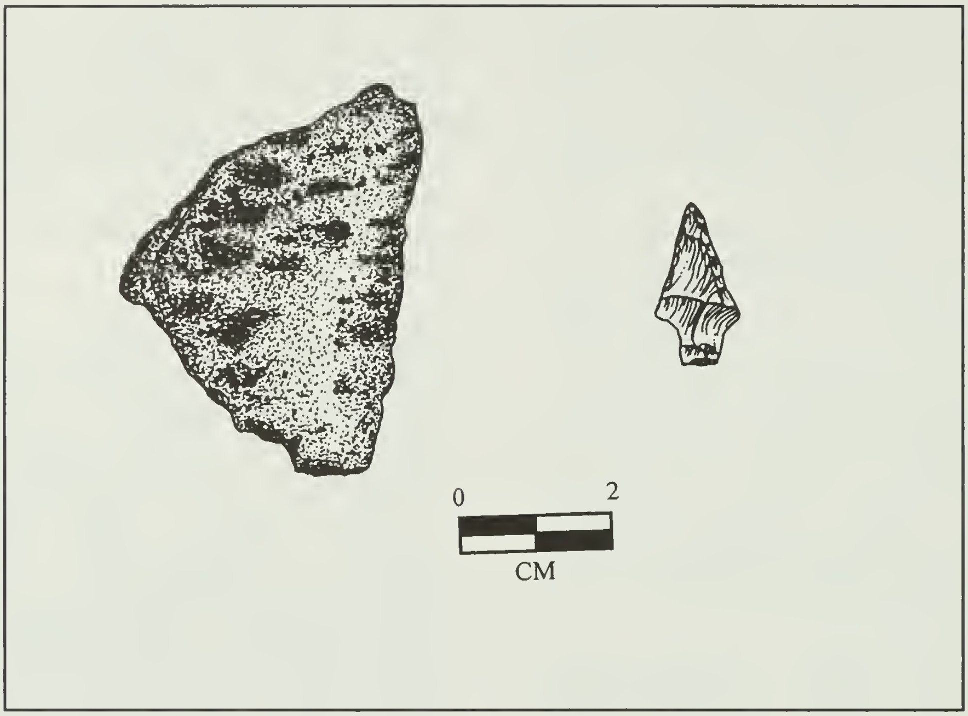

Figure 3.8 A Fingernail-impressed Intermountain Brownware sherd and a Rosegate projectile point from site 42In1522.

location would yield additional ceramics, and perhaps subsurface features. Unfortunately, no additional cultural material and no features were encountered.

INVESTIGATIONS AT THE NORTH POINT SITE

The North Point site (42In1210; elevation 10,450 ft) has been the focus of archeological and paleoenvironmental studies over the past 10 years or so. This site was first discovered in 1985 by National Park Service Archeologist Dr. Adrienne Anderson, who noted that slumping of the escarpment had exposed two deeply buried paleosols (1.7 and 2.25 m, respectively, below present ground surface). Cultural debris including debitage was noted within the slumped deposits. Dr. Anderson contracted with Dr. Larry Agenbroad from Northern Arizona University to investigate the cultural and paleoenvironmental potential of the site. The bulk of the North Point research remains unpublished and unavailable, though its potential is readily apparent. The following background discussion is summarized from several contract reports (Agenbroad, et al., 1992, 1993).

Research trips (including a geoarcheology class) were conducted to the site over the course of several years. During these investigations, a number of cultural items (approximately 10 flakes and an edge-modified tool) were collected from the slumped deposits at the base of the exposure. Only one artifact, a mano, was reportedly found *in situ*. This artifact was collected from the lower-most paleosol.

Radiocarbon determinations from the two paleosols yielded dates of 7,650 ± 90 years B.P. and 9,005 ± 175 years B.P. An additional date of 1,530 ± 130 years B.P. was obtained from charcoal within a cut-and-fill sequence above the two paleosols (Agenbroad, et al.,1992).

The deposits at the North Point site also contain pollen and fossil snail assemblages. Agenbroad, et al., (1992:48), reports that "the pollen spectra indicate a shift from spruce-juniper-currant-grass dominant (alpine forest) communities at, or before 9,005 B.P. to sagebrush parkland at, or about 7,650 BP (open shrubland), to an open forest habitat after 1,530 B.P."

A molluscan paleofauna (fossil snail) assemblage at North Point is present within nine of the 10 stratigraphic units identified by Agenbroad, et al. (1992), and represents a continuous molluscan community spanning nearly 10,000 years.

With good preservation and diverse species representation, terrestrial snails can be used as a site-specific paleoenvironmental indicator. Such is the case for the North Point snails where Agenbroad, et al. (1992:56), notes the presence of nearly 1,000 identifiable snail specimens representing seven families and nine genera. Comparison of the ratio between snails favoring dry conditions with those favoring wet conditions allows one way of monitoring climate change. Agenbroad, et al. (1992:60-61), notes that the fossil snail assemblage ratio between wet- and dry-loving species remained relatively constant through time, though fluctuations are noted that roughly correspond to mid-Holocene warming and drying.

During the course of the Cedar Breaks Archeological Project, the goal at the North Point site was to probe the deposits behind the exposed cliff face in preparation for possible stripping or stabilizing the overburden. Over the last 10 years or so, the face of the Cedar Breaks escarpment in this area has receded by approximately 5 m (Adrienne Anderson, personal communication, August 26, 1997). Slumping caused by the melting of massive amounts of snow appears to be the primary destructive agent. Concerns for the preservation of this important archeological and paleoenvironmental site led to the 1998 field activities.

A datum (metal rebar with identification tag) was established on the ridge above the exposure and a line of shovel probes was laid out from the edge of the escarpment. Five shovel probes totaling 0.49 m^3 were excavated east of the exposed cliff face. Each probe utilized a 15 cm diameter bucket auger to test deeply buried strata (up to 3.6 m below local ground surface) after the shovel probe reached its maximum depth (usually around 80 cmbs). Each auger encountered the dark paleosols, suggesting that the deposits continue eastward toward State Route 143 for at least 35 m. Time and resources prevented full subsurface mapping of the paleosols.

A white chalcedony pressure flake was discovered in the lowest level (180 – 185 cmbs) of SHP #1. Although this flake appears to be cultural, it must be noted that the rocks encountered at this same depth were probably Brian Head chert/chalcedony (based on specimens exposed in the face of the escarpment; see profile), so the possibility exists that the recovered flake was manufactured by the head of the auger. No other cultural material was encountered during the course of subsurface testing.

In addition to determining the subsurface extent of the buried paleosols, a detailed profile of the exposed face was prepared (Figure 3.9). A 2 m wide portion of the cliff face was cleaned, profiled, and described (Figure 3.10).

Three ^{14}C samples were collected from the freshly exposed profile for comparison with dates obtained from the same paleosols as were reported by Agenbroad, et al. (1992). Table 3.4 contains detailed descriptions of these radiocarbon determinations. An attempt was made to sample essentially the same strata as sampled by Agenbroad and his associates. Interestingly, the recently obtained dates do not fully correlate. The cut-and-fill sequence returned a conventional radiocarbon age of 690 ± 40 years B.P. and the upper paleosol yielded a date of 800 ± 40 years B.P. (as opposed to 1,530 ± 130 and 7,650 ± 90 years B.P., respectively). This discrepancy may be due to the material that we dated. Decayed peaty organics collected from these two strata were submitted to Beta Analytic, Inc., for radiocarbon (AMS) determination. As such, these samples may not represent a single event. Thus, these two dates should be considered as minimum ages (at least as old as indicated), with the true age possibly being older.

Charred plant remains were collected from the lower paleosol and submitted to Beta Analytic, Inc., for radiocarbon (AMS) determination. This sample yielded a conventional radiocarbon age of 8,770 ± 40 B.P., which roughly agrees with the age of 9,005 ± 175 years B.P. reported by Agenbroad, et al. (1992).

Pollen samples were collected (Figure 3.10) from the freshly exposed face for future processing. These samples are curated at Zion National Park's curatorial facility.

Clearly, the North Point site contains significant research potential. Unfortunately, the current round of investigations reported here fail to establish beyond a doubt that the lower paleosol (or the upper one for that matter) contains cultural material. The one pressure flake collected from the bucket auger occurred within the lower paleosol, but it could have been manufactured by the head of the auger as it churned through the deposit. A single ground stone artifact is reported to have been collected *in situ* from the lower layer, but was unavailable for inspection. Further, the debitage collected from the slumped deposits at the base of the exposed cliff face are out of context, and could have occurred in upper layers, or may even have washed in from the surface above.

Paleoenvironmental research potential at the North Point site is extremely high. Agenbroad, et al. (1992, 1993), have established that the deposits contain fossil snail communities spanning the last 10,000 years or so that can be used to reconstruct past environments of the area. Together with pollen studies and other paleoenvironmental research carried out in the area, important data on past climates and vegetation history can be obtained from this site.

Table 3.4 Description of radiocarbon dates from the North Point site (42In1210).

FS #	BETA #	Provenience	Conventional radiocarbon age BP	Calibrated age(s) 2 sigma, 95% probability	C13/C12 ratio	Intercept of radiocarbon age with calibration curve	1 sigma calibrated results
2	127222	Stratum VI; freshly exposed cliff face; decayed peaty organics (see profile in Figure 3.10); reported age is considered to be a minimum age – true age may be somewhat older.	690 +/- 40	cal A.D. 1270 to 1325 and cal A.D. 1340 to 1390	-22.7 o/oo	cal A.D. 1295	cal A.D. 1000 to 1040
3	127223	Stratum XII; freshly exposed cliff face; charred organic matter (see profile in Figure 3.10).	8770 +/- 40	cal B.C. 7945 to 7670	-25.3 o/oo	cal B.C. 7895 and cal B.C. 7775 and cal B.C. 7745	cal B.C. 7920 to 7855 and cal B.C. 7830 to 7710
4	127224	Stratum VII; freshly exposed cliff face; decayed peaty organics (see profile in Figure 3.10); reported age is considered to be a minimum age – true age may be somewhat older.	800 +/- 40	cal A.D. 1180 to 1285	-23.2 o/oo	cal A.D. 1250	cal A.D. 1220 to 1275

References for datasets and intervals used: Vogel, et al. (1993); Vogel and Kronfeld (1997); Talma and Vogel (1993); Stuiver, et al. (1993).

Dates are reported as radiocarbon years before present (“present” = 1950 A.D.)
1 sigma = square root of (sample standard deviation) + (curve standard deviation)
2 sigma = 2 x square root of (sample standard deviation) + (curve standard deviation)

Figure 3.9 Profile of exposed escarpment at the North Point site (42In1210), showing the location of pollen samples.

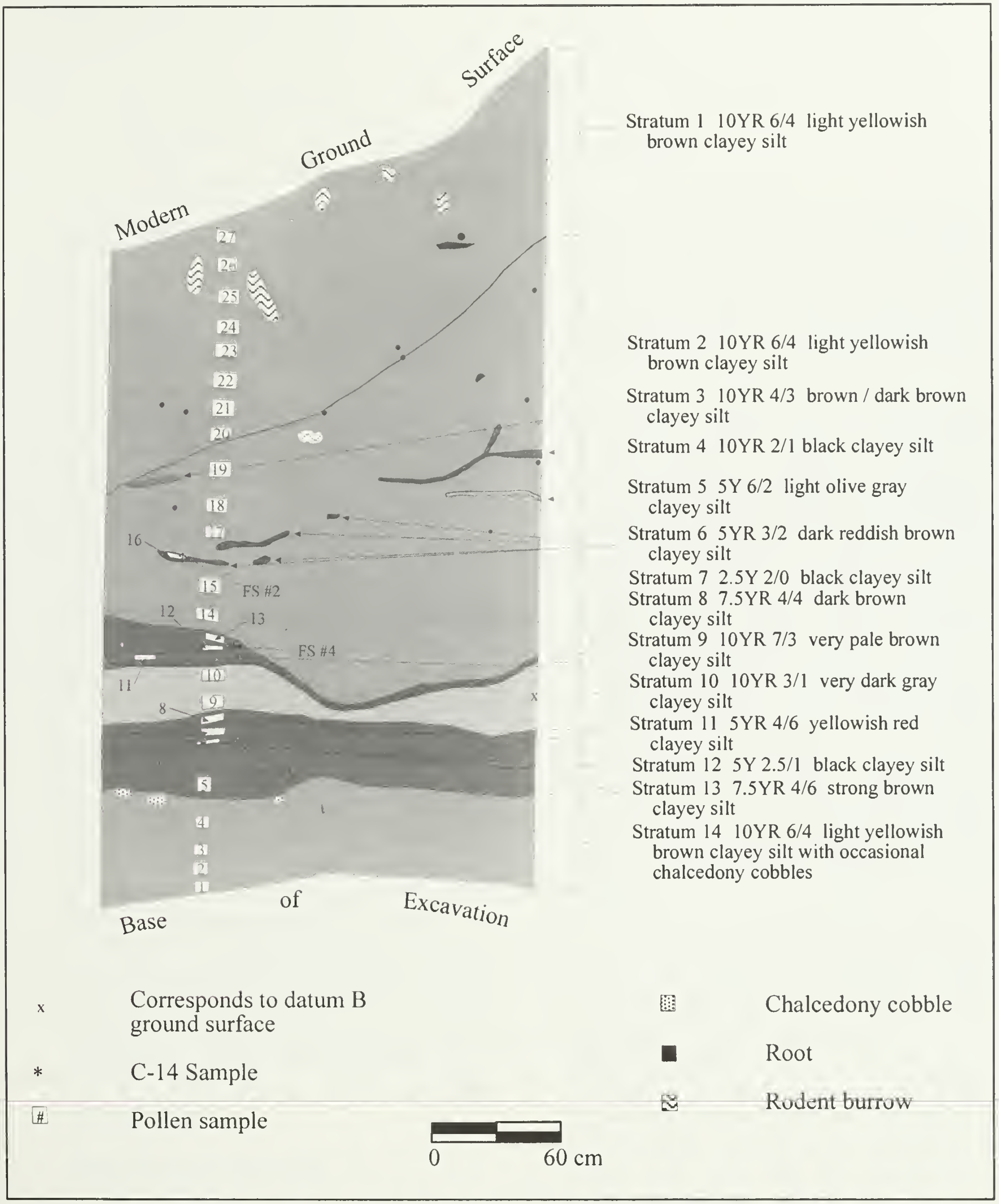

Figure 3.10 Profile of a section of the eastern exposure at site 42In1210.

Chapter 4

MATERIAL CULTURE

INTRODUCTION

The vast majority of prehistoric sites discovered during the Cedar Breaks Archeological Project contained stone tools (Table 4.1) and debitage identified in the field as chert or chalcedony. This material ranges from opaque chert to cloudy or translucent chalcedony. Multi-hued (white, pink, yellow, brown) chert and chalcedony in this portion of the Markagunt Plateau is often referred to as "Brian Head Chert."

Luedtke (1992) notes that nomenclature in quartzose rocks has varied over time and across analyst and thus simply uses the term "chert," defined as "a sedimentary rock composed primarily of microcrystalline quartz along with lesser amounts of quartz crystals, opal, and impurities (1992:149). Edward Bakewell (Appendix C, this volume) has analyzed rocks collected from the Brian Head source using petrographic and geochemical techniques, and has suggested that the Brian Head material might better be classified as altered vitric tuff. Because this cannot be determined macroscopically, and funds are not available for an artifact-by-artifact petrographic analysis, I follow Luedtke in the following sections in my use of the word "chert" for all quartzose lithic materials.

PROJECTILE POINTS

Sixty typable projectile points were collected during the course of the field work. Each was located on the surface; none were discovered during subsurface testing. These projectile points span the last 8,000 years. Nearly every recognized projectile point type known from the Great Basin and Colorado Plateau, except for the very earliest fluted and stemmed forms, has been documented in the alpine meadows of Cedar Breaks National Monument.

The recent tendency is to use central Nevada projectile point chronologies, especially those reported by Thomas (1981, 1988) and Thomas and Bierworth (1983) from the Monitor Valley, and extrapolate southward (Buck, et al., 1998:9). Thomas himself cautions, however, that the Monitor Valley chronology may not be relevant outside of the central Nevada area. The problem of a "short" chronology in the central Great Basin when compared to the longer chronology of many point styles in the eastern Great Basin (i.e., Danger Cave [Jennings 1957], Hogup Cave [Aikens 1970], and perhaps even O'Malley shelter [Fowler, et al., 1973]), has not been resolved.

I follow Thomas (1981, 1988; Thomas and Bierworth 1983) for *measuring* the projectile points discovered during the Cedar Breaks Archeological Project, not because the Monitor Valley typology is the best for this part of southwestern Utah, but because his measurements are well defined and are easily repeated in the laboratory. I simply note here that the standardized metric guidelines offered by Thomas (1981, 1988; Thomas and Bierworth 1983) are preferred insofar as they are easily replicable. Table 4.2 presents metric data for each collected projectile point.

Table 4.1 Artifact summary from Cedar Breaks National Monument.

Artifact Type	Dates (B.P.)*	# of Sites	# Obsidian	# Chert / Chalcedony	# Other	Artifact Total
Projectile Points						
Pinto Series	8250 – 6150	6	5	3	-	8
Humboldt Series	7950 – 5950	1	-	2	-	2
Northern Side-notched	7450 – 3450	1	-	1	-	1
Elko Series	7950 – 950	11	11	16	1 silicified sediment	28
Gypsum	4450 – 1450	6	2	11	-	13
Rosegate Series	1650 – 1050	3	2	1	-	3
Bull Creek	1100 – 800	2	-	2	-	2
Parowan Basal-notched	950 – 750	3	1	2	-	3
Ceramics						
Snake Valley B/G	1050 – 750	1	-	-	black-on-gray	1
Intermountain Brownware	500 – 200	1	-	-	fingernail - impressed	11
Unknown Grayware	1550 – 700	2	-	-	plain grayware	37
Other Stone Tools						
Large Corner-notch		4	1	3	-	4
Biface		32	14	75	-	89
Uniface		4	-	3	1 quartzite	4
Scraper		7	-	16	-	16
Utilized flake		19	19	93	-	112
Hammerstone		4	-	-	2 rhyolite 2 sandstone 3 quartzite	7
Edge grinder		1	-	-	1 rhyolite	1
Groundstone-slab		2	-	-	3 rhyolite	3

* Projectile point dates based on Holmer (1986, 1995); ceramic dates based on Fairley (1989), R. Madsen (1977), and Lockett and Pippin (1990).

The appearance of some point styles in a given area may be correlated with local environmental changes due to Holocene climatic factors. However, in individual regions, the succession of point styles appears to be the same, providing some measure of chronological control even if the precise time span has not been determined (Buck, et al., 1998:10). Some Great Basin researchers have claimed that changes in dart point morphology cannot be considered primarily chronological (Fleniken and Raymond 1986; Fleniken and Wilke 1989). However, the arguments of Bettinger, et al. (1991), and Yohe (1992) convincingly show that dart point styles are temporally sensitive. Beck (1998) offers a functional explanation for the abundance and distribution of corner-notched and side-notched dart points in the Great Basin, involving both the abandonment of the central, western, and southwestern areas during the mid-Holocene and a better cost-benefit ratio for corner-notched points.

The Monitor Valley typology does not include a number of projectile point types common to the Cedar Breaks area. For instance, the Pinto series, Bull Creek,

Table 4.2 Projectile point measurements.

Site #	FS #	Material	Max.[c] Length	Max. Width	Max. Thickness	Base Width	Neck Width	Blade Length	Weight	BIR[b]	PSA[b]	DSA[b]	Type
42In1135	15	chalcedony	(47.5)[a]	20.0	4.4	9.8	9.8	(44.2)	3.9	1.0	71	165	Gypsum
42In1135	3	chert	(41.6)	22.7	4.9	13.2	13.2	(34.4)	4.8	1.0	82	180	Gypsum
42In1135	5	chert	40.5	22.3	5.4	11.7	11.7	34.3	3.9	1.0	70	183	Gypsum
42In1135	7	obsidian	(29.4)	21.2	4.6	8.0	11.5	(25.0)		1.0	212	-	Gypsum
42In1135	2	obsidian	32.0	20.6	6.8	19.1	18.2	32.0	4.7	0.97	84	-	Pinto
42In1135	1	chert	38.4	23.5	7.5	16.8	1.7	29.8	6.1	1.0	90	220	Pinto
42In1135	4	obsidian	(27.1)	28.6	6.8	26.2	23.4	(15.5)	6.3	1.0	116	232	Unknown Corner-notched
42In1135	246	obsidian	(40.9)	(28.2)	7.3	21.0	14.6	(30.1)	8.8	0.92	129	164	Elko Eared
42In1135	245	obsidian	(35.8)	24.8	5.3	17.9	12.3	(26.0)	4.35	0.98	121	164	Elko Corner-notched
42In1135	244	obsidian	(44.5)	24.8	5.2	13.1	13.1	(38.6)	5.4	1.0	62	196	Gypsum
42In1135	30	obsidian	(9.6)	21.6	4.4	21.6	10.1	-	0.5	0.73	125	-	Elko Earred
42In1135	250	chalcedony	36.8	23.6	6.1	4.0	11.7	34.2	3.9	1.0	71	155	Gypsum
42In1135	252	chert	(45.8)	21.0	5.6	18.4	10.6	(43.5)	5.85	1.0	90	161	Gypsum
42In1135	28	chert	(16.4)	22.9	3.7	8.8	22.9	-	1.25	-	94	149	Parowan
42In1135	251	chert	23.8	15.5	2.5	(4.9)	-	22.4	1.0	1.0	-	161	Rosegate
42In1135	98-4	obsidian	35.0	19.0	3.2	(15.0)	13.0	24.5	-	0.94	147	196	Elko Corner-notched
42In1135	98-3	obsidian	28.5	16.5	4.5	10.5	10.0	20.0	-	0.89	99	209	Pinto
42In1135	98-5	mud stone	(35.5)	26.0	3.2	15.5	12.2	(25.5)	-	1.0	127	147	Elko Corner-notched
42In1135	omar 2	obsidian	(32.5)	25.0	-	11.0	13.0	(27.0)	-	1.0	122	155	Elko Corner-notched
42In1135	omar 1	obsidian	(29.5)	(25.5)	-	(15.0)	14.0	20.5	-	1.0	136	163	Elko Corner-notched
42In1135	omar 4	obsidian	36.0	(26.0)	-	(9.0)	(10.2)	28.9	-	1.0	108	154	Elko Corner-notched
42In1135	18	obsidian	(25.4)	22.8	5.1	19.5	16.0	(13.0)	4.15	1.0	108	190	Elko Corner-notched
42In1135	229	chalcedony	29.6	20.4	4.8	7.0	9.9	22.0	2.45	1.0	82	180	Gypsum
42In1430	254	chert	38.4	18.2	4.5	18.0	15.0	38.4	2.55	0.86	100	-	Bull Creek
42In1509	51	obsidian	(23.4)	14.5	4.1	(5.0)	7.1	(21.0)	1.0	-	91	196	Rosegate
42In1509	42	chert	(26.8)	18.0	4.0	15.6	14.4	(21.4)	1.9	0.91	92	-	Bull Creek
42In1509	45	chert	(37.6)	23.2	7.5	19.1	17.8	(28.2)	7.3	1.0	113	208	Elko Corner-notched
42In1509	46	chert	37.7	19.7	4.4	11.9	14.8	29.4	3.0	0.92	96	216	Pinto
42In1509	48	chert	(37.7)	28.4	6.9	22.4	14.2	(27.2)	8.05	1.0	127	155	Elko Corner-notched
42In1515	75	chert	(47.2)	29.3	6.2	-	-	(43.2)	10.25	-	-	118	Elko Corner-notched
42In1515	76	chert	(51.3)	27.7	4.6	-	19.2	(45.0)	6.5	-	122	169	Elko Series
42In1515	77	chert	(29.4)	17.4	4.6	-	12.8	30.4	2.5	-	-	167	Unknown Corner-notched
42In1515	98-1	chert	(15.0)	17.5	4.5	14.0	11.5	-	-	0.87	125	206	Elko Corner-notched
42In1521	74	chert	(56.4)	20.5	5.3	1.91	9.3	(50.8)	6.6	1.0	99	156	Elko Corner-notched
42In1522	102	chert	(23.1)	22.4	4.8	22.4	14.6	(15.0)	2.3	1.0	72	173	Gypsum
42In1522	103	chert	(34.8)	23.1	6.6	(13.5)	(13.0)	(28.2)	6.5	0.95	134	-	Elko Corner-notched
42In1522	98-1	obsidian	21.0	11.0	3.0	5.0	5.9	15.0	-	1.0	77	220	Rosegate
42In1523	118	obsidian	(30.9)	20.8	3.8	20.8	9.5	(31.4)	1.8	0.97	52	125	Parowan
42In1523	117	chert	(62.4)	26.0	8.0	12.2	5.6	(62.4)	13.7	0.96	75	-	Humboldt
42In1523	120	chert	(24.5)	34.9	5.7	29.7	12.4	(25.5)	6.05	0.90	84	-	Humboldt?
42In1524	23	chert	(28.0)	(21.6)	5.0	(12.6)	11.8	18.0		0.96	112	158	Elko Corner-notched

Table 4.2 Projectile point measurements.

Site #	FS #	Material	Max.[c] Length	Max. Width	Max. Thickness	Base Width	Neck Width	Blade Length	Weight	BIR[b]	PSA[b]	DSA[b]	Type
42In1524	125	chert	(32.4)	20.4	5.3	15.6	12.7	(23.4)	4.35	1.0	135	190	Elko Corner-notched
42In1524	126	chert	(29.2)	26.0	5.1	21.9	15.6	(16.4)	4.05	0.91	118	-	Elko Eared
42In1524	127	chert	(11.6)	(19.9)	4.7	19.5	13.0	-	0.95	1.0	154	170	Elko Corner-notched
42In1524	129	chert	(25.5)	24.6	4.3	20.5	11.8	(20.4)	2.7	0.90	135	147	Elko Eared
42In1524	130	chert	(26.3)	(21.8)	5.4	(9.9)	(14.2)	(18.4)	3.4	0.99	125	146	Elko Corner-notched
42In1524	131	chert	(39.4)	(21.2)	4.9	7.0	11.0	(35.8)	4.95	1.0	63	-	Gypsum
42In1524	133	obsidian	(10.9)	22.4	6.7	22.4	16.0	-	1.45	1.0	112	-	Elko Corner-notched
42In1524	98-3	chalcedony	(31.7)	20.0	5.0	17.2	16.0	(17.0)	-	0.91	94	-	Pinto
42In1537	137	chert	(27.2)	24.2	4.6	24.2	14.8	(18.2)	4	1.0	88	206	Gypsum
42In1539	140	chert	(42.4)	(24.4)	6.0	(24.4)	13.4	(16.0)	5.6	0.83	111/169	210	Northern Side-notched
42In1540	230	obsidian	(25.0)	27.2	6.2	17.7	18.9	(10.3)	3.55	0.84	82	178	Pinto
42In1543	157	chert	(38.4)	23.1	6.4	3.0	17.0	(30.4)	5.7	1.0	57	-	Gypsum
42In1549	180	obsidian	(32.3)	27.7	6.4	-	15.0	(30.9)	6.15	1.0	-	151	Elko Corner-notched
42In1549	179	obsidian	31.7	18.1	4.5	15.5	13.3	21.6	1.5	0.82	95	216	Pinto
42In1550	184	obsidian	(10.3)	(11.6)	4.8	11.6	9.5	-	0.6	1.0	125	-	Elko Corner-notched
42In1550	183	chert	(35.1)	19.4	5.1	-	13.5	(33.9)	3.8	-	-	165	Unknown Corner-notched
42In1555	178	chert	(30.3)	(24.1)	6.0	20.3	18.4	(20.0)	3.4	1.0	127	206	Elko Corner-notched
42In1556	181	chert	(40.5)	(22.8)	5.4	14.8	12.4	31.5	5	0.98	135	143	Elko Corner-notched
42In1560	188	chalcedony	36.0	19.8	4.8	19.8	9.2	34.6	2.1	1.0	79	139	Parowan
42In1560	189	chert	(21.6)	21.1	4.1	11.2	14.7	(15.5)	1.8	0.97	139	197	Elko Corner-notched
42In1565	203	chert	37.5	(16.0)	3.6	(10.0)	9.1	32.8	2.4	1.0	129	-	Unknown Corner-notched
FS-ISO-1	-	obsidian	(45.0)	20.1	6.0	14.8	12.5	(30.5)	-	0.88	113	216	Pinto
IO-H-1	154	chert	(21.1)	20.4	4.9	20.4	9.6	(17.7)	2.65	1.0	40	178	Gypsum

a Variates in parentheses are the actual measurements for broken artifacts

b PSA = Proximal Shoulder Angle; DSA = Distal Shoulder Angle; BIR = Basal Indentation Ratio; PSA and DSA are measured in degrees

c Dimensions are measured in mm; weight is measured in grams

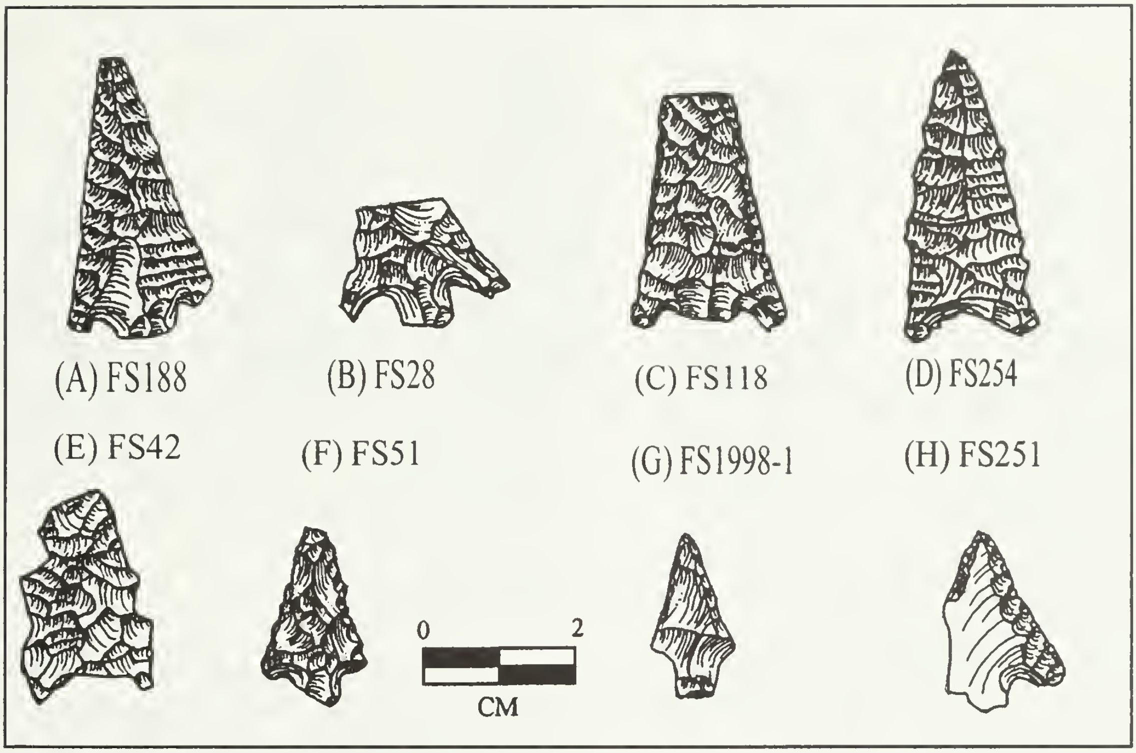

Figure 4.1 Illustrations of Parowan Basal-notched (A – C), Bull Creek (D & E), and Rosegate (F – H) projectile points.

and Parowan Basal-notched points are not discussed. For these types, I refer to Holmer (1986, 1995) and Holmer and Weder (1980). Similarly, for purposes of assigning dates to the Cedar Breaks projectile points, I refer to the work of Holmer (1986, 1995), since dates for the Monitor Valley typology are suitable only for the central Great Basin.

Parowan Basal-notched

Three projectile points were identified as Parowan Basal-notched (Figure 4.1). Each was found at three different sites (42In1135, 42In1523, and 42In1560). Two appear to be fashioned from local Brian Head chert, while the third (FS 118) is obsidian, sourced to the Wild Horse Canyon area of the Mineral Mountains, Utah (see Chapter 5 for a discussion on obsidian sourcing).

Parowan Basal-notched points are shaped like an elongate isosceles triangle and have shallow basal notches that form tangs and a slightly contracting, wide stem (Tipps and Hewitt 1989).

Parowan Basal-notched points are most common in Fremont sites in the Parowan Valley, but are also found in Virgin Anasazi sites along the Virgin and Santa Clara rivers, as well as in Johnson Canyon in extreme southwestern Utah (Holmer and Weder 1980). These arrow points are thought to date between A.D. 950 and 1150 in the Parowan and Virgin regions (Holmer and Weder 1980:67).

Bull Creek

Two projectile points were identified as Bull Creek (Figure 4.1). Both look to be fashioned from Brian Head chert and each was found at separate sites (42In1430 and 42In1509).

Bull Creek points are small, triangular arrow points with straight margins, and a concave base that emphasizes basal corners (Tipps and Hewitt 1989). Bull Creek points are common in late Formative contexts. This type has been found "in Fremont sites in central Utah and on both Mesa Verde and Kayenta Anasazi sites along the Colorado, Escalante, and Dirty Devil rivers in southeastern Utah" (Holmer and Weder 1980:Figure 10). They date between A.D. 1100 and 1250 in the project area (Holmer and Weder 1980:61).

Rosegate Series

Three Rosegate projectile points (Figure 4.1) were found at three different Cedar Breaks sites (42In1135, 42In1509, and 42In1522). One of these points is apparently made of the local Brian Head chert, while the other two are made of obsidian. Both obsidian artifacts were sourced to the Wild Horse Canyon area of the Mineral Mountains, Utah.

The Rosegate Series combines the Rose Spring type defined by Lanning (1963:252) and the Eastgate type defined by Heizer and Baumhoff (1961). Thomas (1981:19) suggests that Rose Spring and Eastgate are morphological rather than differentiated temporal types and that a single type with temporal meaning is thus appropriate. Holmer (1986:107) concurs. Rosegate projectile points are small with a basal width less than or equal to 10mm. They are corner-notched and have a PSA between 90 degrees and 130 degrees. In addition, Rosegate points have an expanding stem with a neck width less than or equal to its basal width plus 0.5mm (Thomas 1981).

Rosegate points date between approximately A.D. 300 and 925 on the northern Colorado Plateau, and are reported in very late Archaic and Fremont contexts (Holmer and Weder 1980). Holmer (1986:107) notes that the Rosegate Series seems to be the point style associated with the initial spread of the bow and arrow.

Gypsum Series

Thirteen Gypsum Series (Figure 4.2) points from six different sites are present in the Cedar Breaks assemblages. Eight of these large contracting stem dart points were noted within 42In1135. Of these eight points, six are apparently made of the local chert or chalcedony. The remaining two are obsidian from the Wild Horse Canyon area of the Mineral Mountains, Utah. The additional Gypsum points (all chert) were located at 42In1522, 42In1524, 42In1537, 42In1537, and isolate IO-H-1.

Gypsum points were initially described by Harrington (1933). Holmer (1986) notes that large contracting stem points from the Intermountain West have been variously classified as Elko Contracting Stem (Heizer and Baumhoff 1961), Gypsum Cave (Harrington 1933), or Gatecliff Contracting Stem (Thomas 1981). Holmer (1986:105) reports that regardless of the name, the dates for these large contracting stem points is "…remarkably consistent – always between 2,500 B.C. to A.D. 500."

Many of the Cedar Breaks Gypsum points contain distinct serrations along the length

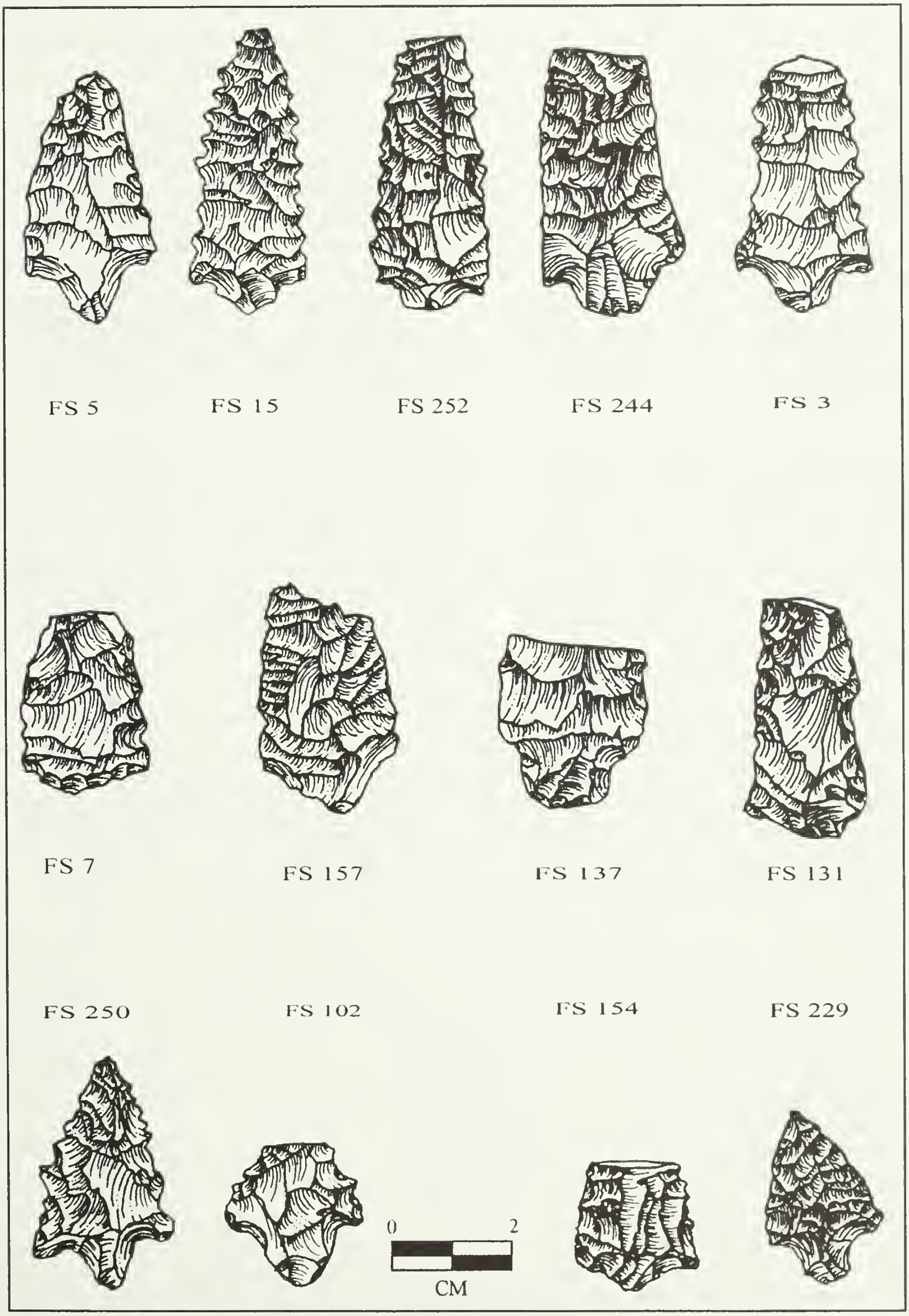

Figure 4.2 Illustrations of Gypsum Series points.

of their blade. Possible explanations for this phenomenon include increased blood-letting when striking prey, or use as a scraping tool, or perhaps the serrations are associated with plant-gathering procurement strategies. Regardless of use, these serrations effectively increase the available cutting edge of the tool, thereby making more efficient use of the raw material. Clearly, a detailed functional study of this phenomenon is in order.

Elko Series

Twenty-eight Elko Series projectile points from 11 sites have been identified from the Cedar Breaks assemblages. These points account for fully 47 percent of the projectile points documented from this high-elevation setting. Sixteen of these large corner-notched dart points are made of chert or chalcedony and one is made of a tan silicified sediment. The remaining 11 are obsidian. Ten of the 11 obsidian points identified as belonging to the Elko Series were submitted for XRF analysis. One was sourced to the Panaca Summit area of southeastern Nevada; one to Obsidian Butte, Nye County, Nevada; and the rest to the Wild Horse Canyon area of the Mineral Mountains, Utah.

The Elko Series has been described both temporally and spatially in some detail, though with variations from the Monitor Valley typology, by a number of researchers (Heizer and Baumhoff 1961; Heizer, Baumhoff, and Clewlow 1968; Lanning 1963; Hester and Heizer 1973; O'Connell 1967; Holmer 1986, 1995; Elston, Katzer, and Currey 1988; Buck and DuBarton 1994; Lohse 1995; Beck 1995; and Hockett 1995). According to Thomas (1981), the Elko Series in the central Great Basin dates to between 1300 B.C. and A.D. 700 (3,250 B.P. and 1,250 B.P.), though Aikens (1970) and Holmer (1986) have shown that they date much earlier (back to at least 7,000 B.P.) in the eastern Great Basin. The sturdy base of the Elko Series may have made it desirable as a hafted knife in Late Prehistoric contexts (Walling, et al., 1986; Altshul and Fairley 1989). Two essentially coeval forms are recognized: Elko Corner-notched and Elko Eared. A third form, Elko Side-notched, has essentially been subsumed by the Elko Corner-notched form (Holmer 1986).

Elko Corner-notched projectile points are large, with a basal width greater than 10 mm and are corner-notched having a PSA ranging between 110 degrees and 150 degrees. Twenty-three of the 28 Cedar Breaks points assigned to the Elko series are identified as Elko Corner-notched (Figures 4.3 and 4.4).

Elko Eared projectile points differ from Elko Corner-notched by having a Basal Indentation Ratio (BIR; see Thomas 1970, 1981; Thomas and Bettinger 1976) of less than or equal to 0.93 (Elko Corner-notched points do not have such a deep indentation). Figure 4.5 illustrates the four Elko Eared projectile points from the Cedar Breaks assemblages. One point was too fragmentary to be assigned to either the corner-notched or eared forms of the Elko Series, but it does contain corner-notches with a PSA within the range of the Elko Series. Thus, this point fragment (Figure 4.5) is included in this series.

Northern Side-notched

One projectile point collected during the Cedar Breaks Archeological Project is a large side- and basal-notched artifact. This chert dart point (Figure 4.6) contains

Figure 4.3 Illustrations of Elko Corner-notched projectile points.

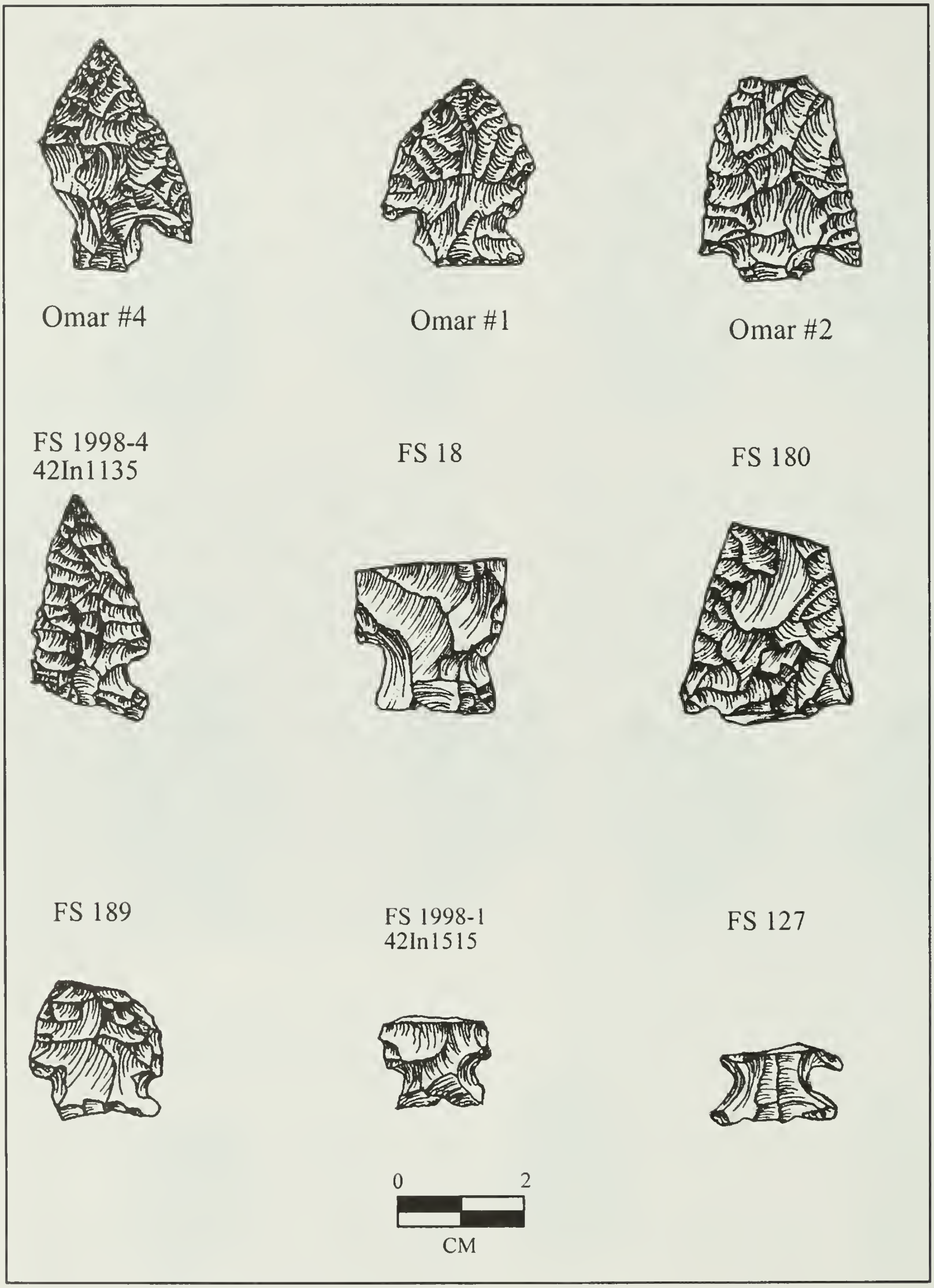

Figure 4.4 Illustrations of additional Elko Corner-notched projectile points.

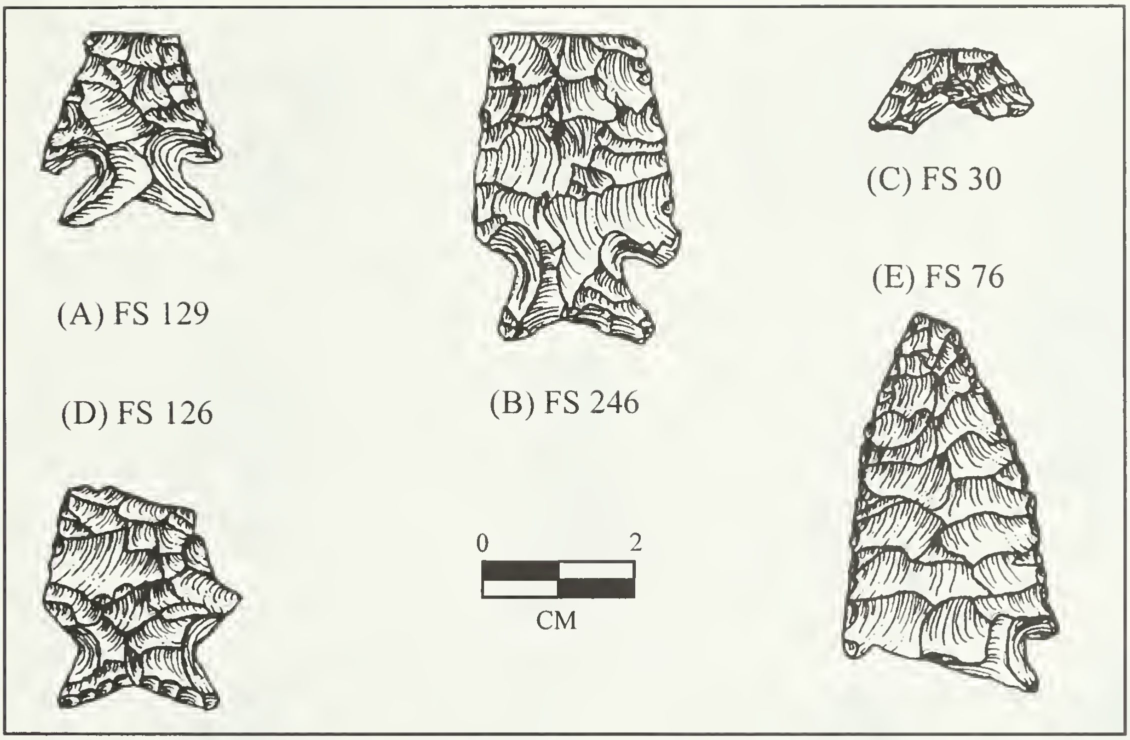

Figure 4.5 Illustrations of Elko Eared (A – D) and Elko Series (E) projectile points.

notches high along its margins and exhibits a pronounced basal indentation.

The Monitor Valley key does not recognize Northern Side-notched projectile points; rather, Thomas (1981) lumps into his "Large Side-notched" group a number of previously defined forms, including Northern Side-notched, Elko Side-notched, and Rose Spring Side-notched (Canaday 1997).

I have tentatively identified the large side-notched projectile point from site 42In1539 as Northern Side-notched. I make this identification based on Holmer (1986:104), who notes that the most commonly applied name for large side-notched points in the Intermountain West is Northern Side-notched. Concerning the Northern Side-notched point, Holmer makes the following observations: "If we separate the points notched high enough on the side to leave a straight edge below the notch from those notched so low that the portion below forms a point with the base, [a] pattern becomes clear. The chronologies of the 'low' side-notched points are identical to those of Elko Corner-notched ; the 'high' side-notched points, conversely, all occur between 5500 and 1500 B.C." (Holmer 1986:104).

Holmer (1986:104) notes that the early "high" side-notched points are classic Northern Side-notched as originally defined by Gruhn (1961). Spatially, Northern Side-notched points occur everywhere in the Intermountain West except in the southwestern portion (Holmer 1986).

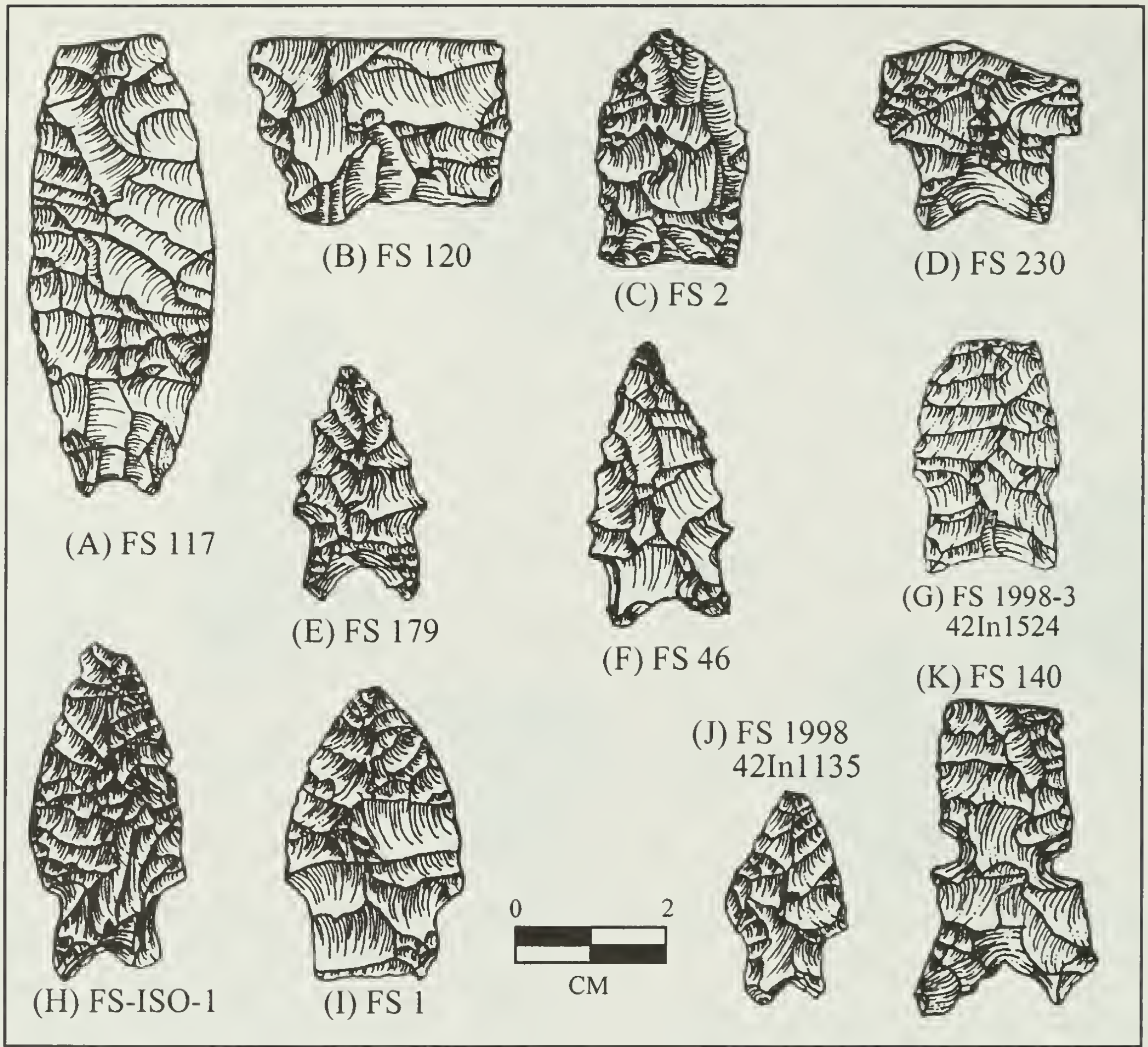

Figure 4.6 Illustrations of Humboldt (A & B), Pinto Series (C – J), and Northern Side-notched (K) projectile points.

Humboldt Series

Two chert points from site 42In1523 have been identified as belonging to the Humboldt Series (Figure 4.6). One (FS 116 and 117) was found in two pieces separated by several meters. Only in the lab were these two pieces found to conjoin.

The Humboldt Series includes three point types: Humboldt Basal-notched, Humboldt Concave Base A, and Humboldt Concave Base B. Rhode (1987) notes that they are all lanceolate, unshouldered points of variable size. They were first defined by Heizer and Clewlow (1968), on the basis of artifacts collected from the surface of the Humboldt Lakebed site. These points are relatively scarce from the stratified deposits of Monitor Valley, so Thomas (1981:17) operationally defines only the series, leaving the individual types undefined. The basal width / maximum width ratio for the Humboldt series is less than or equal to 0.90, and the BIR is less than 0.98. Size is variable, with weight tending to be greater than or equal to 1.5g, and length tending to be greater than or equal to 40mm. Humboldt Series points tend to have a thickness greater than or equal to 4.0mm. In the central Great Basin, these points are poor time markers, because their distribution appears to span at least the last 5,000 years or so (Thomas 1981; Heizer and Hester 1978). However, Holmer (1986:100-101) contends that in the eastern portion of the Intermountain West, a shorter span for Humboldt points (between 6000 and 4000 B.C.) is apparent.

Pinto Series

Eight Pinto points (Figure 4.6) from six different sites were identified from the Cedar Breaks assemblages. Three of these Early Archaic dart points were apparently fashioned from locally available chert or chalcedony. The remaining five Pinto points are made of obsidian. XRF analysis indicates that three of these points (FS# 98-3 from 42In1135, FS#179 from 42In1549, and Forest Service Isolate 98-1) were made from obsidian traced to the Wild Horse Canyon area of the Mineral Mountains, Utah. The other two (FS#2 from 42In1135 and FS# 230 from 42In1540) originated from the Panaca Summit source in southeastern Nevada.

Perhaps no other projectile point style of the Intermountain West has created as much controversy and confusion as the Pinto Series. The Pinto Series was first defined at Pinto Basin (Campbell and Campbell 1935; see also Rogers 1939) in the Mojave Desert (Sutton 1996). Harrington (1957) describes five types from the Stahl site. The "Pinto Problem" (Warren 1980) arose because points assigned to the Pinto Series fall into two different, non-overlapping temporal groups: one from 6300 to 4200 B.C. and the other from 3000 to 1300 B.C. (Holmer 1986).

In short, the later group is now recognized as Gatecliff Split-stem (Thomas 1981), whose spatial distribution includes most of Nevada and large parts of southeastern Oregon and southern Idaho. Holmer (1986) describes three types included in the earlier group: Pinto Shouldered, Pinto Shoulderless, and Pinto Single-shouldered. These "true" Pinto types (dating from 6300 to 4200 B.C.) are found throughout Utah, far eastern Nevada, far western Colorado, and southern Idaho (Holmer 1986).

Unknown Corner-notched

Four projectile points (three chert and one obsidian) could not be grouped into existing typological frameworks and are simply referred to by their gross morphological attributes. These projectile point fragments (Figure 4.7) contain vestiges of corner-notches, and I have thus simply called them "Unknown Corner-notched." The obsidian artifact (FS 4) was traced to the Wild Horse Canyon area of the Mineral Mountains, Utah.

GROUNDSTONE

Groundstone artifacts are rare at Cedar Breaks archeological sites. Groundstone observed (but not collected) during the Cedar Breaks project includes three slab metates, and one mano at three different sites. Each of these artifacts are made of locally available rhyolite. Two of the metates were noted at site 42In1522, where the majority of the ceramics were also noted. Both of these rhyolite metates are only minimally ground on one surface. The third metate is also only minimally utilized. The mano has use-wear on two surfaces.

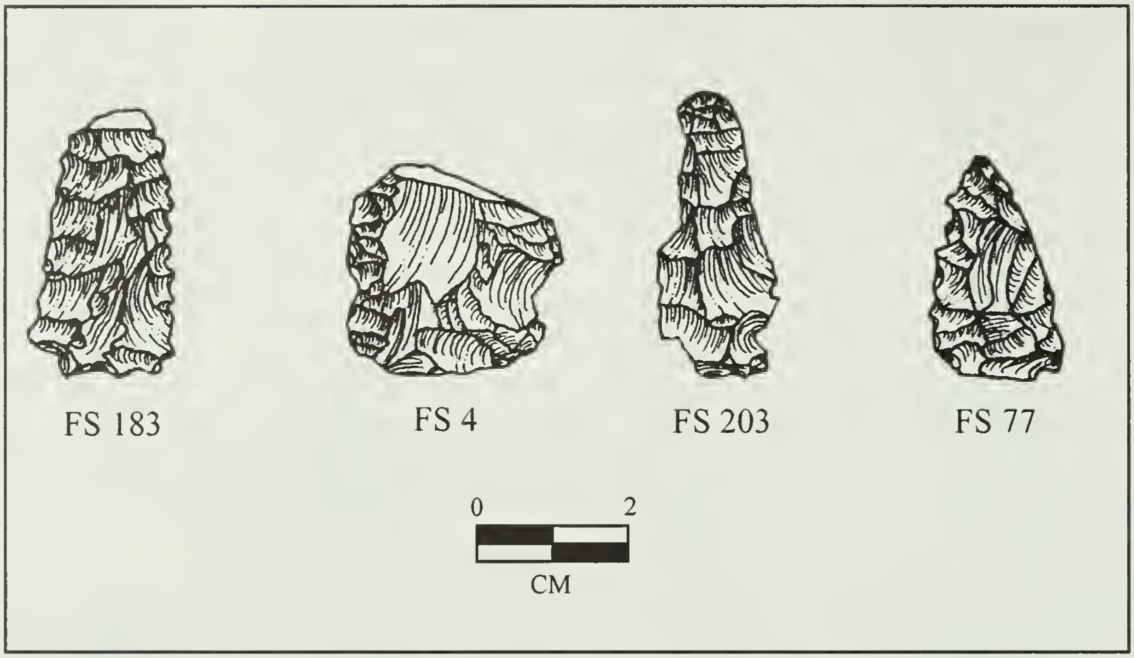

Figure 4.7 Illustrations of Unknown Corner-notched projectile points.

OTHER STONE TOOLS

A number of other stone tool classes were encountered, including bifaces, scrapers, choppers, hammerstones, and utilized flakes:

Bifaces

A total of 89 biface fragments were observed over the course of the 3-year project (see Figure 4.8 for illustrations of selected bifaces). Only one of these tools was collected in subsurface deposits (site 42In1522), with the remainder observed on the surface. Thirty-two different sites contained at least one biface fragment. Chert and chalcedony (apparently from local sources) dominate the biface material type, accounting for 75 of the artifacts. The additional 14 were made of obsidian. Eleven of these obsidian tool fragments were submitted for XRF analysis (see discussion in Chapter 5). Interestingly, 10 of the 11 artifacts were sourced to the Wild Horse Canyon area of the Mineral Mountains, Utah. One biface fragment (FS#184) from site 42In1541 was sourced to the Panaca Summit area of southeastern Nevada.

Scrapers

Sixteen scrapers from seven sites were noted from the Cedar Breaks region. Most of these tools were end scrapers, and all were apparently made of local chert or chalcedony. One rather unique scraper (Figure 4.9) from site 42In1135, contains serrations similar to those observed along the margins of many of the Cedar Breaks Gypsum points.

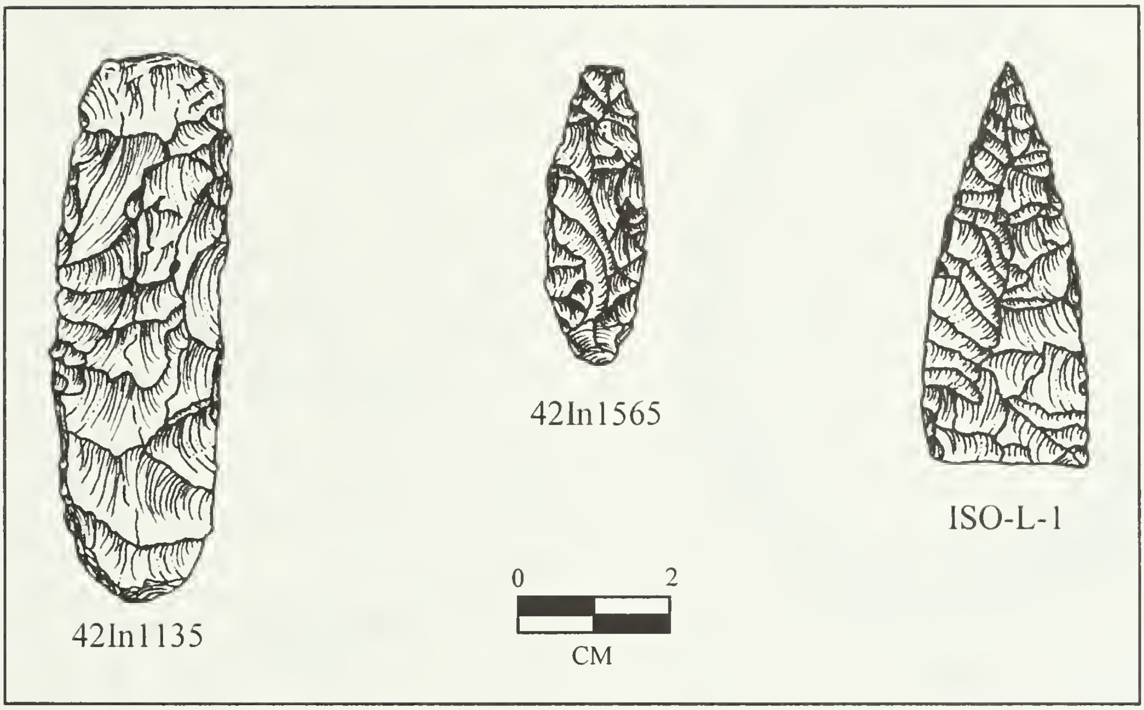

Figure 4.8 Illustrations of selected bifaces.

Choppers

Three choppers from three different sites (42In1135, 42In1509, and 42In1548) were noted. Two of these large stone tools were made of white chalcedony, probably from local outcrops. The third (FS#173 from site 42In1548) was fashioned from a split quartzite cobble (Figure 4.9).

Hammerstones

Seven hammerstones from four different sites were observed. The majority of these edge- and end-battered artifacts were made of non-local material. Three of the hammerstones were made of quartzite, two were of sandstone and two were of locally available rhyolite.

Utilized Flakes

The term "utilized flake" was used to describe debitage that exhibited edge damage attributable to minor intentional retouch and/or intentional use (cf. Buck, et al., 1998). Both of these characteristics are inferred to be related to plant or animal processing. Utilized flakes comprise a significant percentage (38 percent) of the flaked stone tool assemblage (112 of 296 stone tools; Table 4.1). In fact, after debitage, utilized flakes account for more of the flaked stone artifact assemblage than any other category. Possible reasons for this are complex, and involve many potential biases, including site transformation processes and analyst identification (Buck, et al., 1998). Most of

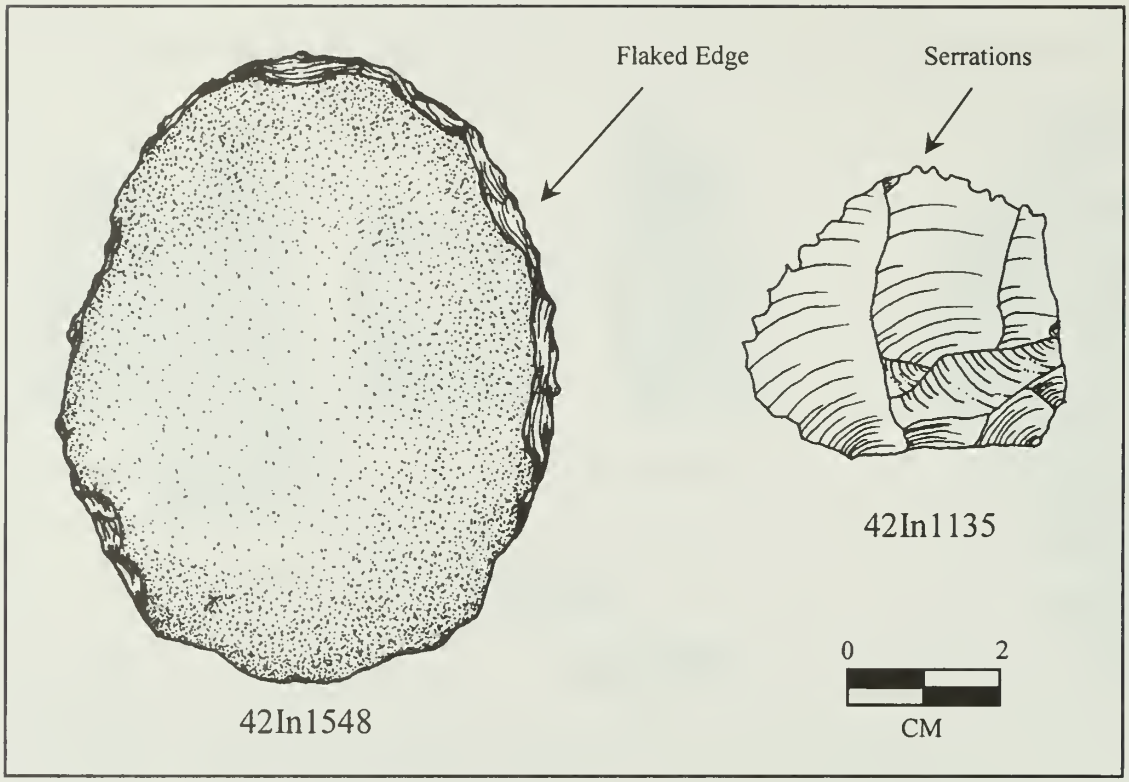

Figure 4.9 Illustrations of a quartzite chopper from site 42In1548 and a serrated scraper from site 42In1135.

these expedient tools were noted while debitage sample units (see discussion below) were being inspected, when crew members were intent on looking at and categorizing each piece of stone located within a particular unit.

DEBITAGE

Debitage is the most common artifact class observed in the Cedar Breaks assemblages. This artifact type, the residual lithic material resulting from tool manufacture and repair, was classified in the field according to definitions presented in the IMACS manual (IMACS 1992) and Tipps and Hewit (1989). Four main types of debitage are defined: primary, secondary, tertiary, and shatter.

Primary flakes or decortication flakes consist of flakes from the early stages of reduction; that is, when the unusable cortex and mass are removed from the object piece. These flakes are usually thick and angular, and exhibit a considerable amount of cortex on the dorsal surface.

"Secondary flake," as defined for this project, refers to bifacial thinning flakes that are slightly curved from the proximal to the distal end; are relatively thin in cross section; are longer than they are wide; and often exhibit parallel flake scars on the dorsal surface. These flakes rarely exhibit cortex, and may have prepared platforms.

Tertiary flake refers to flakes detached during final shaping. They are usually small and thin, and may be produced by pressure flaking or direct freehand percussion. Most tertiary flakes have abraded platforms and lack cortex. Shatter consists of the angular and irregular pieces of stone that are products of flint knapping, but lack distinctive flake attributes.

While these categories give a general idea of flaking stages present at a particular site, they are not appropriate for identifying the various technologies that were used to produce tools (Tipps 1995). Concerning the inadequacies of debitage data on the IMACS forms, Tipps (1995:61) notes that "flake types are too general and all-inclusive; many diagnostic types are missing. Compounding the problem, the frequency categories are not mutually exclusive, for example, there can be three common types at a site and no rare types, or two codominant types and one rare type. As a result, the IMACS data set does not provide the types of data needed to address research questions concerning differences in lithic procurement and technology through time, on various site types, or on various local and non-local materials, each of which bear on adaptational strategies and mobility." In order to begin to address this issue, in-field analyses were conducted at each site or locus encountered during the Cedar Breaks Archeological Project.

Debitage is present on every site containing a prehistoric component. Indeed, the only sites where debitage is not present are single-component historic sites. Debitage sample units were judgmentally placed within at least one portion of each prehistoric site or locus, and within each unit, each piece of debitage was tallied and characterized (material type, reduction sequence, etc.). These units were used to characterize and quantify the debitage present. Within each sample unit, naturally occurring toolstone was also tallied. A Debitage Sample Unit form (Figure 4.10) was designed to maintain consistency between loci and sample units.

For example, within the extremely large site (42In1135), debitage appeared to be continuous over many hundreds of acres. As noted earlier, the majority of this site is contained within land administered by the Dixie National Forest, though a small portion extends into Cedar Breaks National Monument. Within the monument, 11 discrete concentrations (loci) were identified, in which debitage density ranged from one to over 40 flakes per square meter. Outside of these high-concentration areas, density dropped to the 1/5-10 m^2 range. Debitage sample units were judgmentally placed in these non-locus areas in order to characterize densities between concentrated areas. Debitage density data per site is presented in Table 3.2.

CERAMICS

Ceramics are uncommon in the Cedar Breaks site assemblages. Three sites (42In1430, 42In1135, and 42In1522) contained ceramics. Only site 42In1522 contained sherds in any appreciable quantity. The single ceramic artifact collected from site 42In1430 has been identified as a Snake Valley Black-on-gray jar sherd. This sherd contains abundant quartz, feldspar, and biotite temper in a light gray clay. A partial wide stripe of black mineral paint is present on the exterior surface. R. Madsen (1977:5) suggests that this pottery type dates from about A.D. 900 to 1200 and is affiliated with the Parowan Fremont. Three extremely small grayware body sherds were collected from site 42In1135. Analysis of these tiny (<1cm) sherds was inconclusive (Perry 1997).

CEBR-97

DEBITAGE SAMPLING FORM

Site No. ____________ Date _______
Segment _____________ Locus __________ Sample Unit _______

____m X ____m Sample Unit/Transect Unit Recorded By _____________

Material:	White Chert	Chalcedony	Obsidian	Jasper	Other
Primary					
Secondary					
Tertiary					
Core					
Shatter					
Utilized					
Tools					
Other					
Natural					

Comments: (observations, vegetation cover, debitage percentage, ground visibility/disturbance, etc.; draw sketch map on back if appropriate).

Figure 4.10 Example of a Debitage Sampling Unit form used for in-field analysis.

At site 42In1522, the majority of the ceramics were contained within a 13m (n/s) X 19m (e/w) area. The surface scatter contained 23 grayware body sherds and a bowl rim sherd with a white slip. The pieces were very small, and varied in thickness. All of these ceramics were collected and submitted to Ms. Laureen M. Perry (Department of Anthropology, University of Nevada, Las Vegas) for analysis. Her complete report can be found in Appendix B.

The ceramic assemblage from site 42In1522 contained plain jar and plain bowl sherds. The vessels were created with a coil-and-scrape method of construction, using a light gray firing clay and two temper categories. Eight of the sherds have quartz as the primary temper agent, while 13 contain a dark red brown to black, sometimes crumbly, rock with attached quartz grains as the main temper component. Some of the quartz-tempered sherds have lesser amounts of this dark rock.

Perry (1997) concludes that these sherds are probably locally made (southwestern Utah), but cultural affiliation is not definitive. She indicates that they are definitely *not* Snake Valley Gray, nor are they Sevier Gray, and they *do not appear* to be Virgin Anasazi. Her main contention behind not assigning these grayware sherds to a Virgin Anasazi series is that they are outside of the known geographic range. Additional work (subsurface testing) at this site was proposed in order to obtain a larger sample of sherds.

Test excavations here in 1998 (see Chapter 3) resulted in the recovery of only 11 additional grayware sherds. These sherds are identical in paste, temper, and composition to the sherds analyzed by Perry (1997). No additional defining characteristics are present, leaving us with the distasteful conclusion that, at least for the present, these grayware sherds cannot be assigned to a known ceramic type.

In addition to the untyped plain grayware ceramics, a concentration of 11 Intermountain Brownware sherds was discovered during the 1998 field season. These sherds were located on the surface of 42In1522 on land administered by the Dixie National Forest. Each was discovered within a several-square-meter area and several contain fingernail impressions.

In this portion of southwestern Utah, this type of Late Prehistoric pottery is often referred to as Southern Paiute Fingernail Impressed and suggests a Numic affiliation. However, because this term conjures up certain ethnic connotations and since we are not certain which ethnic group actually left these artifacts at this site, I follow Pippen (1986; Lockett and Pippen 1990) in referring to them as "Intermountain Brownware." Using ethnic labels for some eastern Great Basin ceramics may be appropriate in certain instances but, as Janetski (1990:63) notes, "it is not always justifiable given the current state of knowledge for this time period and for this area."

Tuohy (1990) notes considerable confusion in the classification of brownware ceramics of the Great Basin. The current trend has Intermountain Brownware replacing three previously described wares: Owens Valley Brown, Shoshonean Ware, and Southern Paiute Utility Ware (Pippen 1986:19).

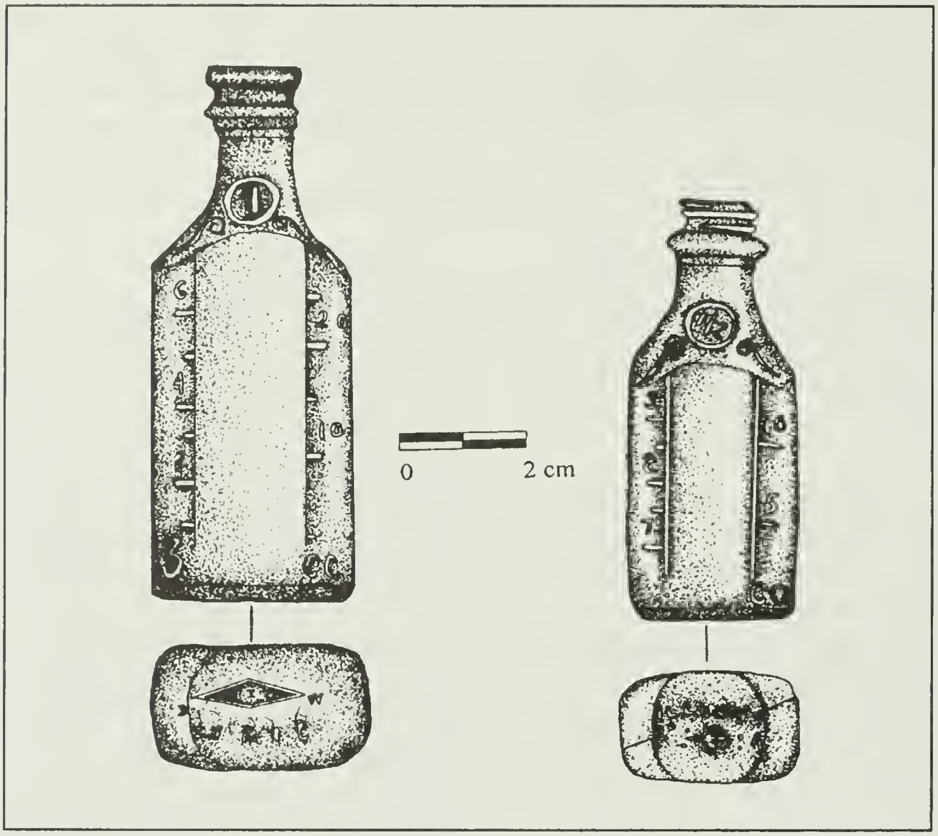

Figure 4.11 Medicine bottles from site 42In1543.

Although some argue that brownware ceramics are poorly dated in the Great Basin (Pippen 1986), they have generally been considered to date from A.D. 1300 into historic times (Bettinger and Baumhoff 1982:493; Thomas and Bettinger 1976:346). Recent thermoluminescence data suggest, however, that brownware may have appeared in the southeastern Great Basin "as early as the 800's" (Rhode 1994:129).

HISTORICAL OBJECTS

A grab sample of historical objects was collected from Cedar Breaks sites during the course of investigations. Of particular interest were complete specimens that could provide temporal information such as a maker's mark. Most collected historical specimens were complete beverage or medicine bottles.

At site 42In1524 (a dual-component prehistoric lithic scatter and historical CCC camp; see Chapter 2 for a discussion of CCC activities in the Cedar Breaks region), a complete clear glass medicine bottle and a metal button were collected (Figure 3.3). The medicine bottle has a capacity of 2½ ounces, and was presumably closed by a glass stopper (not recovered). A maker's mark on the base of this bottle indicates manufacture by the Hazel-Atlas Glass Company, dating from 1920 to 1964 (Toulouse 1971). The metal button contains two embossed stars and the words "U. S. ARMY." Both the button and the bottle are undoubtedly related to the CCC encampment.

Two clear glass medicine bottles were collected from site 42In1543 (Figure 4.11). One of these artifacts is a complete stopper-top bottle. A maker's mark on the base of this bottle shows an "I" in a triangle (Illinois Glass Company, 1916 to 1929; Toulouse 1971); "3" and "W" on either side of the triangle; and "LYRIC" below the triangle. The second bottle has a screw-top and an Owens Illinois, maker's mark on its base (post 1930; Toulouse 1971). Both of these medicine bottles contain embossed graduations on their faces.

Site 42In1543 also contained a nearly complete light green glass bottle (Figure 4.12). Presumably, this bottle once contained some sort of alcoholic beverage, probably beer or ale. "Edelweiss" is embossed on the side of this 13 ounce bottle. On its base is a maker's mark of "SCHOENHOFEN," "CHICAGO," and "602" is embossed on the side near the bottom of the bottle. Peter Schoenhofen (1827 – 1893) was a Prussian-born brewer and owner of one of the largest breweries in Chicago in the 1880s (Internet search on "Chicago Breweries"). Repeated efforts to identify this particular bottle have so far failed. Based on other artifacts observed at the site, this bottle probably dates to the mid-1930s and may be associated with CCC activities in the monument.

A complete purple glass (amethyst) beverage bottle (Figure 4.13) was collected from site 42In1424 in the lower portion of the Breaks. A maker's mark of "B" "34" is present on the base of this flask-shaped bottle. This mark probably refers to the Buck Glass Company of Baltimore, Maryland, which marked many of its bottles with "B" between 1909 and 1961.

Because this artifact has turned purple, a tighter date of 1909 – 1917 can be inferred. Berge (1980:77) notes that manganese was used in bottle glass up to about 1917 in order to give the glass a clearer effect. The sun's ultraviolet rays cause bottles containing manganese to turn purple. With America's entry into World War I, our main source of manganese (Germany) was cut off, prompting American bottle makers to use selenium instead (Kendrick 1966; cited in Berge 1980:7). Thus, purple glass (also referred to as "amethyst" glass) found on historic sites within the United States is generally considered to have been manufactured prior to 1917.

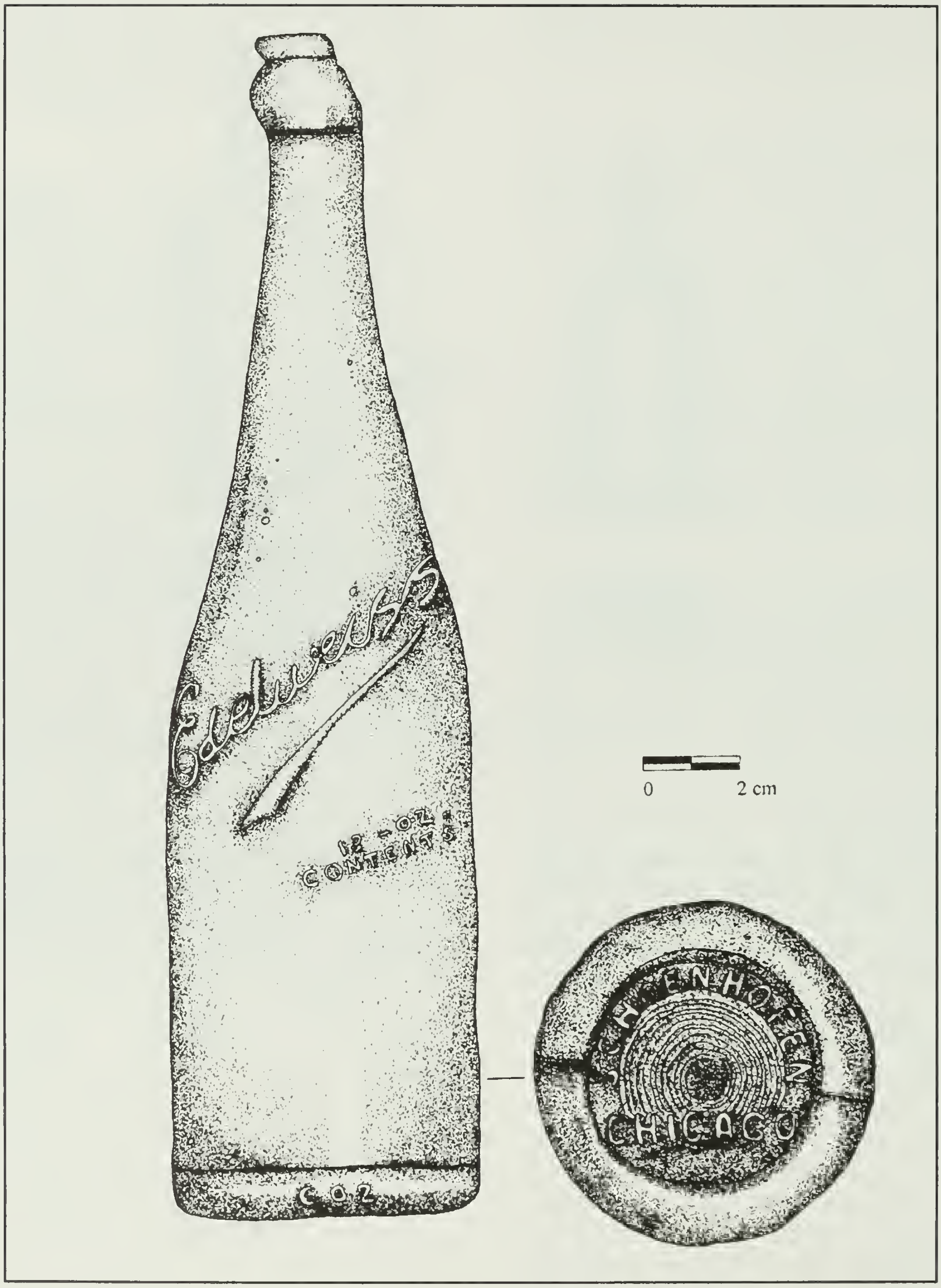

Figure 4.12 Edelweiss beverage bottle from site 42In1543.

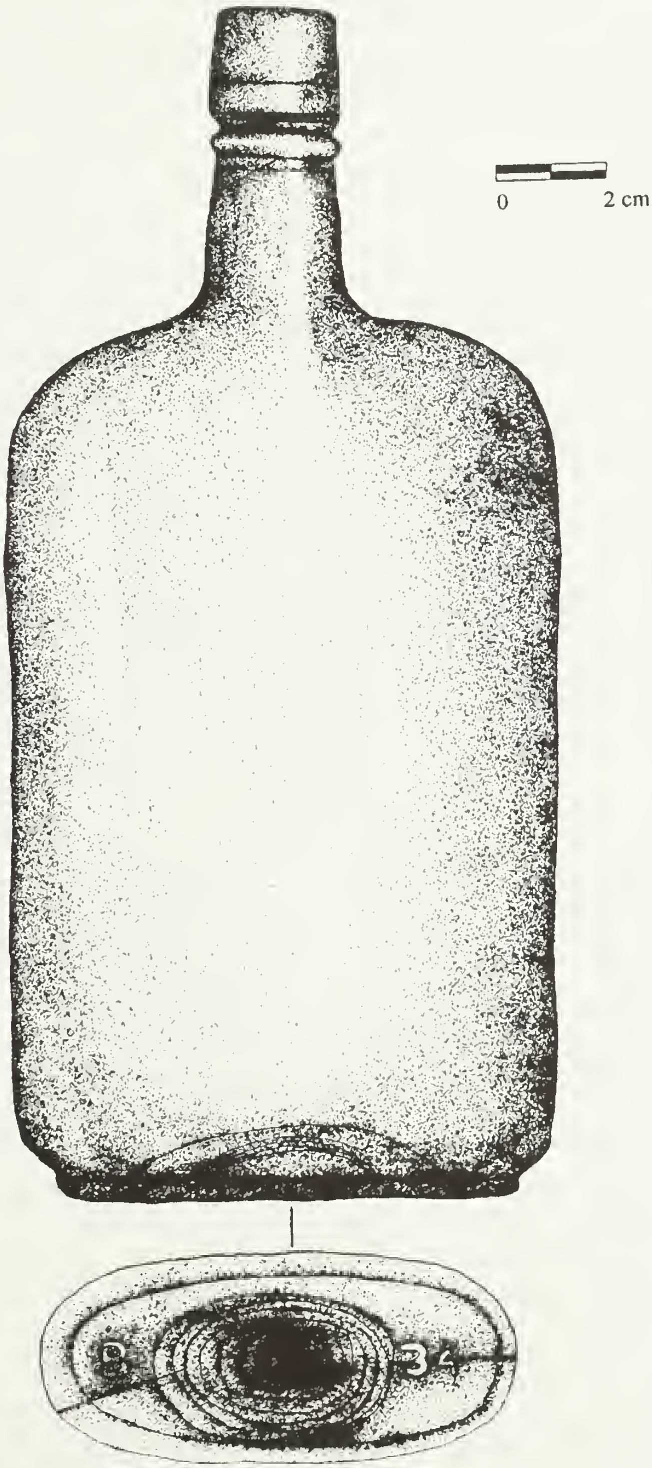

Figure 4.13 Amethyst beverage bottle from site 42In1424.

Chapter 5

SUPPORTING STUDIES

INTRODUCTION

A number of ancillary studies were initiated in support of the Cedar Breaks Archeological Project. These include: (1) petrographic analyses of locally available chert source areas; (2) x-ray fluorescence analysis of obsidian artifacts; (3) dendroclimatic studies of bristlecone pines located within the monument and surrounding areas; and (4) studies of the paleoecology of the Markagunt Plateau including coring of bogs (with associated pollen, fossil beetle, and fire history analyses) located on adjacent U.S. Forest Service lands. Complete reports detailing these investigations are included as appendices to this document. Summaries of these studies are provided below.

BRIAN HEAD CHERT PETROGRAPHY

The geology of Cedar Breaks is similar to that of Bryce Canyon in that both areas are erosional features of the Claron Formation (Makin 1947)). Limestone, deposited in shallow freshwater lakes during the early Tertiary Period (55 million years ago), was subsequently eroded to form the features present today (cf., Stokes 1986). Volcanic ash was deposited in the lake at Cedar Breaks, forming the Brian Head Formation, which overlies the Claron. This formation contains beds of cherty material that were later extensively utilized by prehistoric people. During the later portions of the Tertiary, the lakes dried up, and extensive volcanic rhyolite ash-flow tuffs were deposited over the landscape (Gregory 1950).

The cherty materials originating from the Brian Head Formation are exposed in the south face of Brian Head Peak (Figure 5.1). This material can also be found within a 22 – 20 Ma gravity slide (Anderson 1993; Hatfield, et al., 2000) deposited along the rim of the Breaks below Brian Head Peak. Some of this material can also be found in stream gravels within the Breaks. Large cobbles are continually being exposed and can be easily collected from the surface (Figure 5.2). Much of this material is of such a high quality (Figure 5.3) that it has been utilized as a lithic resource by prehistoric populations for a considerable period.

Petrographic analysis of Brian Head Chert was initiated in order to begin the characterization process of this locally available resource. It was hoped that baseline data would be generated that would assist in current and future field and/or laboratory identifications. Samples of chert from several locales were collected and described following guidelines set forth in Luedtke (1992), McCutcheon (1997), and McCutcheon and Dunnell (1998). Specimens were collected from five chert ledges on Brian Head Peak, and from chert boulders and nodules discovered within the monument, as well as from locales south of Cedar Breaks. Petrographic and geochemical analyses were conducted by Mr. Ed Bakewell of the University of Washington, in order to compare the chemical composition of the naturally occurring tool stone with

Figure 5.1 Example of Brian Head Chert ledge on Brian Head Peak.

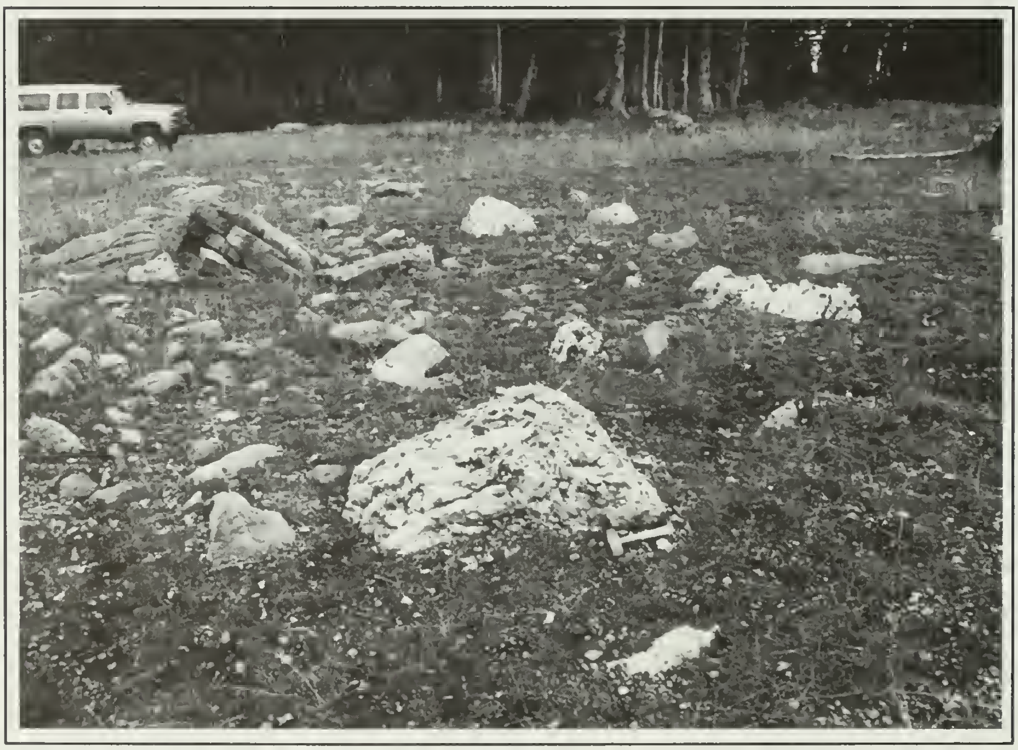

Figure 5.2 Brian Head Chert boulders located just south of Cedar Breaks National Monument.

Figure 5.3 Dr. Pat McCutcheon with an example of Brian Head Chert collected from the Dixie National Forest.

probable Brian Head Chert artifacts collected from Cedar Breaks archeological sites. Thin section photos showing salient characteristics were not prepared in time for inclusion in this report. Appendix C contains Mr. Bakewell's complete report. It should be noted that at least one reviewer expressed strong misgivings concerning the thin section analysis and descriptions presented by Bakewell.

Petrographic analysis was conducted on 31 samples. Geochemistry (XRF) was conducted on 10 specimens. Two rock specimens were identified as silicified wood and the remainder were classified as altered pyroclastic rocks (crystal vitric tuff). Two of the altered pyroclastic specimens have progressed to porcellainite. Bakewell (Appendix C), suggests that the porcellainites can be distinguished from each other petrographically. In addition, the Brian Head Peak altered vitric tuff is petrographically distinct from samples collected south of the monument. This would seem to indicate a second toolstone source located somewhere to the south. Another distinct possibility is that our sample sizes are too small and thus we just don't know the full extent of variability present in the Brian Head toolstone.

OBSIDIAN SOURCING

Obsidian artifacts were collected from the Cedar Breaks locale in order to determine the source or sources from which prehistoric visitors to the monument obtained their obsidian. Appendix A contains two letter reports by Dr. Richard E. Hughes documenting the results of X-ray fluorescence (XRF) analysis on Cedar Breaks material. The following paragraphs summarize his findings.

Obsidian is a naturally occurring volcanic glass that is formed from rapidly cooled

Obsidian is a naturally occurring volcanic glass that is formed from rapidly cooled lava. Obsidian was favored by many Native American groups because of its hardness and the ease and predictability with which it can be flaked into dart and arrow points, knives, scrapers, and other usable tools. Numerous obsidian outcrops have been identified in the Great Basin, Colorado Plateau, and surrounding regions. Kodack (1997) provides a thorough summary of obsidian use in the Great Basin and surrounding region.

Most obsidian outcrops differ from one another in their geochemical composition, particularly in quantities of trace elements such as rubidium (Rb), strontium (Sr), yttrium (y), zirconium (Zr), barium (Ba), and others. These trace elements are readily measured using X-ray fluorescence spectroscopy, and the resulting trace element constituents can be compared with the composition of known obsidian sources to determine where the raw materials for particular tools were obtained (Buck, et al., 1998:220).

Thirty of the 82 prehistoric sites documented at Cedar Breaks contained obsidian artifacts. A combination of debitage and tools from each Cedar Breaks site or isolate containing obsidian was submitted to Geochemical Research Laboratory. Results of those analyses are presented in Table 5.1.

The 66 artifacts submitted for analysis come from four distinct chemical types (Figure 5.4). The vast majority of these artifacts (79 percent) have the same trace element fingerprint as geologic obsidians from the Wild Horse Canyon source in the Mineral Mountains, Utah, located about 90 km north of Cedar Breaks. Ten artifacts (15 percent) match the chemical profile of obsidian of the Panaca Summit chemical type located in southeastern Nevada, about 100 km west of the project area.

Three of the artifacts (5 percent) have a trace element composition most similar to volcanic glass from the vicinity of Obsidian Butte in Nye County, Nevada, over 350 km to the west. Hughes (1997a) notes that artifacts made from Wild Horse Canyon obsidian have been identified from archeological sites not too distant from the Obsidian Butte, Nevada, source (e.g., at 26CK5423, Hughes 1997b).

Interestingly, the only obsidian cobble (unworked) discovered at Cedar Breaks sites has a trace element composition that matches volcanic glass from Black Mountain, located just south of the town of Beaver, Utah, about 80 km north of Cedar Breaks. No tools or debitage collected from Cedar Breaks sites match Black Mountain volcanic glass, even though this source is closest to the project area.

Sample numbers are too small for meaningful statistical comparisons. However, it is interesting to note that of the eight obsidian Elko Series points submitted for analysis, all but one come from Wild Horse Canyon (Figure 5.5). In fact, if we group the projectile points into gross temporal categories such as Archaic and Late Prehistoric, a pattern emerges (Figures 5.6 and 5.7). Clearly, Wild Horse Canyon obsidian is preferred, no matter what the time period. Elko Series points are not included in this analysis because their chronology encompasses both the Archaic and Late Prehistoric in this part of the Great Basin. Seven obsidian projectile points were identified as belonging to the Archaic (five Pinto and two Gypsum) time period (Figure 5.6). These point styles are

Table 5.1 Compilation of Cedar Breaks Obsidian XRF Data.*

	Trace and Selected Minor Element Concentrations											Ratio	
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1135	46	16	191	76	26	112	17	487	nm	nm	nm	nm	Panaca Summit, NV
FS #2	±5	±3	±4	±3	±3	±4	±3	±14					**Pinto Series**
42In1135	48	16	191	39	19	107	22	nm	nm	nm	nm	nm	Wild Horse
FS #4	±5	±3	±4	±3	±3	±4	±3						Canyon, UT
													Large C-notched
42In1135	45	18	170	56	20	125	19	350	nm	354	0.89	nm	Obsidian Butte, NV
FS #7	±6	±3	±4	±3	±3	±4	±3	±14		±8	±0.08		Variety H-3
													Gypsum
42In1135	46	17	190	39	21	109	20	nm	nm	nm	nm	nm	Wild Horse
FS # 18	±5	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched
42In1135	45	14	193	39	19	109	19	nm	nm	nm	nm	nm	Wild Horse
FS #20	±5	±3	±4	±3	±3	±4	±3						Canyon ,UT
													Biface
42In1135	48	20	191	37	20	107	21	nm	nm	nm	nm	nm	Wild Horse
FS #24	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Biface
42In1135	47	18	191	39	20	112	23	nm	nm	nm	nm	nm	Wild Horse
FS #30	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko Eared
42In1135	45	16	197	39	19	106	20	nm	nm	nm	nm	nm	Wild Horse
FS#244	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Gypsum
42In1135	44	14	186	37	18	105	19	nm	nm	nm	nm	nm	Wild Horse
FS#245	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched
42In1135	52	18	189	38	20	105	22	nm	nm	nm	nm	nm	Wild Horse
FS#246	±5	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko Eared
42In1135	49	19	188	36	19	107	19	nm	nm	nm	nm	nm	Wild Horse
FS#98-3	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Pinto Series
42In1135	45	14	185	39	19	104	20	nm	nm	nm	nm	nm	Wild Horse
FS#98-4	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched
42In1135	41	14	140	53	24	151	21	449	1468	351	1.25	nm	Black Mountain, UT
FS#98-6	±6	±3	±4	±3	±3	±4	±3	±14	±19	±8	±0.08		**Small cobble; not utilized**
42In1135	42	13	182	38	18	104	20	nm	nm	nm	nm	nm	Wild Horse
Omar 1	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched
42In1135	55	16	190	39	20	108	23	nm	nm	nm	nm	nm	Wild Horse
Omar 2	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched

Table 5.1 Compilation of Cedar Breaks Obsidian XRF Data.*

	Trace and Selected Minor Element Concentrations											Ratio	
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1135 Omar 3	45 ±6	16 ±3	183 ±4	36 ±3	19 ±3	104 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1135 Omar 4	46 ±6	17 ±3	187 ±4	72 ±3	25 ±3	114 ±4	13 ±3	515 ±14	nm	nm	nm	nm	Panaca Summit, NV **Elko C-notched**
42In1135 Omar 5	44 ±6	17 ±3	179 ±4	36 ±3	18 ±3	103 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1135 Omar 6	47 ±5	15 ±3	185 ±4	38 ±3	19 ±3	107 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
Forest Service Iso-98-1	45 ±6	17 ±3	185 ±4	40 ±3	18 ±3	106 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Pinto Series**
42In1493 FS #31	51 ±5	13 ±3	187 ±4	37 ±3	18 ±3	103 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1494 FS #34	60 ±6	18 ±3	200 ±4	41 ±3	19 ±3	112 ±4	25 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1509 FS #44	49 ±5	13 ±3	196 ±4	78 ±3	24 ±3	118 ±4	14 ±3	492 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1509 FS #51	51 ±6	17 ±3	196 ±4	41 ±3	21 ±3	110 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Rosegate Series**
42In1509 FS #243	43 ±7	21 ±3	193 ±4	40 ±3	18 ±3	103 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1513 FS #62	51 ±5	15 ±3	178 ±4	60 ±3	23 ±3	126 ±4	19 ±3	323 ±14	nm	352 ±8	0.91 ±0.08	nm	Obsidian Butte, NV Variety H-3 **Flake**
42In1513 FS #63	50 ±5	17 ±3	202 ±4	38 ±3	19 ±3	109 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1514 FS #68	52 ±5	17 ±3	202 ±4	40 ±3	20 ±3	111 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1515 FS #70	44 ±5	13 ±3	198 ±4	76 ±3	23 ±3	118 ±4	16 ±3	537 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1515 FS #72	49 ±7	19 ±3	211 ±4	82 ±3	27 ±3	122 ±4	16 ±3	491 ±15	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1515 FS #73	47 ±6	14 ±3	187 ±4	38 ±3	19 ±3	102 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**

Table 5.1 Compilation of Cedar Breaks Obsidian XRF Data.*

	Trace and Selected Minor Element Concentrations										Ratio	
Site/Cat Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source / Artifact Type
42In1517 FS #80	54 ±6	17 ±3	195 ±4	39 ±3	21 ±3	108 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1517 FS #78	46 ±6	13 ±3	190 ±4	40 ±3	21 ±3	108 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1517 FS #81	46 ±6	16 ±3	192 ±4	38 ±3	20 ±3	106 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1522 FS# 98-1	47 ±6	12 ±3	183 ±4	35 ±3	18 ±3	105 ±4	16 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Rosegate Series**
42In1522 FS #98-9	42 ±6	15 ±3	178 ±4	34 ±3	16 ±3	101 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1522 1998-10	45 ±5	15 ±3	189 ±4	73 ±3	24 ±3	111 ±4	15 ±3	520 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1522 FS #106	46 ±6	13 ±3	190 ±4	36 ±3	18 ±3	106 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1522 FS #108	49 ±6	15 ±3	194 ±4	39 ±3	20 ±3	108 ±4	17 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1522 FS #109	61 ±5	16 ±3	201 ±4	41 ±3	24 ±3	108 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1523 FS #111	51 ±6	23 ±3	200 ±4	40 ±3	21 ±3	108 ±4	17 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1523 FS #112	48 ±6	15 ±3	191 ±4	39 ±3	21 ±3	106 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1523 FS #118	46 ±6	14 ±3	191 ±4	38 ±3	19 ±3	106 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Parowan Series**
42In1523 FS #119	42 ±6	17 ±3	166 ±4	53 ±3	21 ±3	121 ±4	18 ±3	307 ±14	nm	354 ±8	1.03 ±0.08	nm	Obsidian Butte, NV Variety H-3 **Flake**
42In1524 FS #133	49 ±5	17 ±3	193 ±4	39 ±3	19 ±3	108 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1524 FS #134	50 ±6	17 ±3	196 ±4	39 ±3	22 ±3	107 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**

Table 5.1 Compilation of Cedar Breaks Obsidian XRF Data.*

	Trace and Selected Minor Element Concentrations										Ratio	
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1524 FS #87	46 ±6	17 ±3	192 ±4	37 ±3	18 ±3	102 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1527 FS #85	54 ±6	15 ±3	197 ±4	37 ±3	17 ±3	103 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1532 FS #123	54 ±6	17 ±3	196 ±4	38 ±3	20 ±3	111 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1537 FS #138	43 ±6	15 ±3	185 ±4	37 ±3	17 ±3	103 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1539 FS #144	48 ±5	15 ±3	182 ±4	37 ±3	17 ±3	106 ±4	17 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1540 FS #148	46 ±5	16 ±3	191 ±4	37 ±3	19 ±3	108 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1540 FS #230	47 ±5	16 ±3	194 ±4	77 ±3	26 ±3	116 ±4	16 ±3	494 ±14	nm	nm	nm	nm	Panaca Summit, NV **Pinto Series**
42In1540 FS #232	57 ±6	17 ±3	202 ±4	81 ±3	28 ±3	122 ±4	15 ±3	473 ±16	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1541 FS #153	51 ±6	13 ±3	195 ±4	40 ±3	20 ±3	108 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1541 FS #184	48 ±6	19 ±3	200 ±4	78 ±3	26 ±3	123 ±4	17 ±3	540 ±15	nm	nm	nm	nm	Panaca Summit, NV **Biface**
42In1542 FS #155	46 ±5	16 ±2	191 ±4	39 ±3	20 ±3	108 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1547 FS #168	45 ±6	19 ±3	199 ±4	76 ±3	24 ±3	116 ±4	16 ±3	489 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1548 FS #172	45 ±5	14 ±3	183 ±4	37 ±3	20 ±3	104 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1548 FS #174	46 ±5	17 ±3	193 ±4	39 ±3	18 ±3	107 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1549 FS #179	47 ±6	14 ±3	194 ±4	39 ±3	18 ±3	105 ±4	24 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Pinto Series**
42In1549 FS #180	40 ±6	15 ±3	192 ±4	38 ±3	20 ±3	105 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**

Table 5.1 Compilation of Cedar Breaks Obsidian XRF Data.*

	Trace and Selected Minor Element Concentrations										Ratio		
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1551 FS #185	48 ±6	17 ±3	191 ±4	40 ±3	20 ±3	106 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1556 FS #182	55 ±5	14 ±3	190 ±4	38 ±3	21 ±3	107 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1563 FS #195	50 ±6	16 ±3	198 ±4	39 ±3	18 ±3	109 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1563 FS #196	45 ±5	18 ±2	201 ±4	77 ±3	25 ±3	119 ±4	16 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**

*Data compiled from Hughes (1997a and 1998; see Appendix A). Site numbers and artifact types have been incorporated into the original data fields for presentation here.

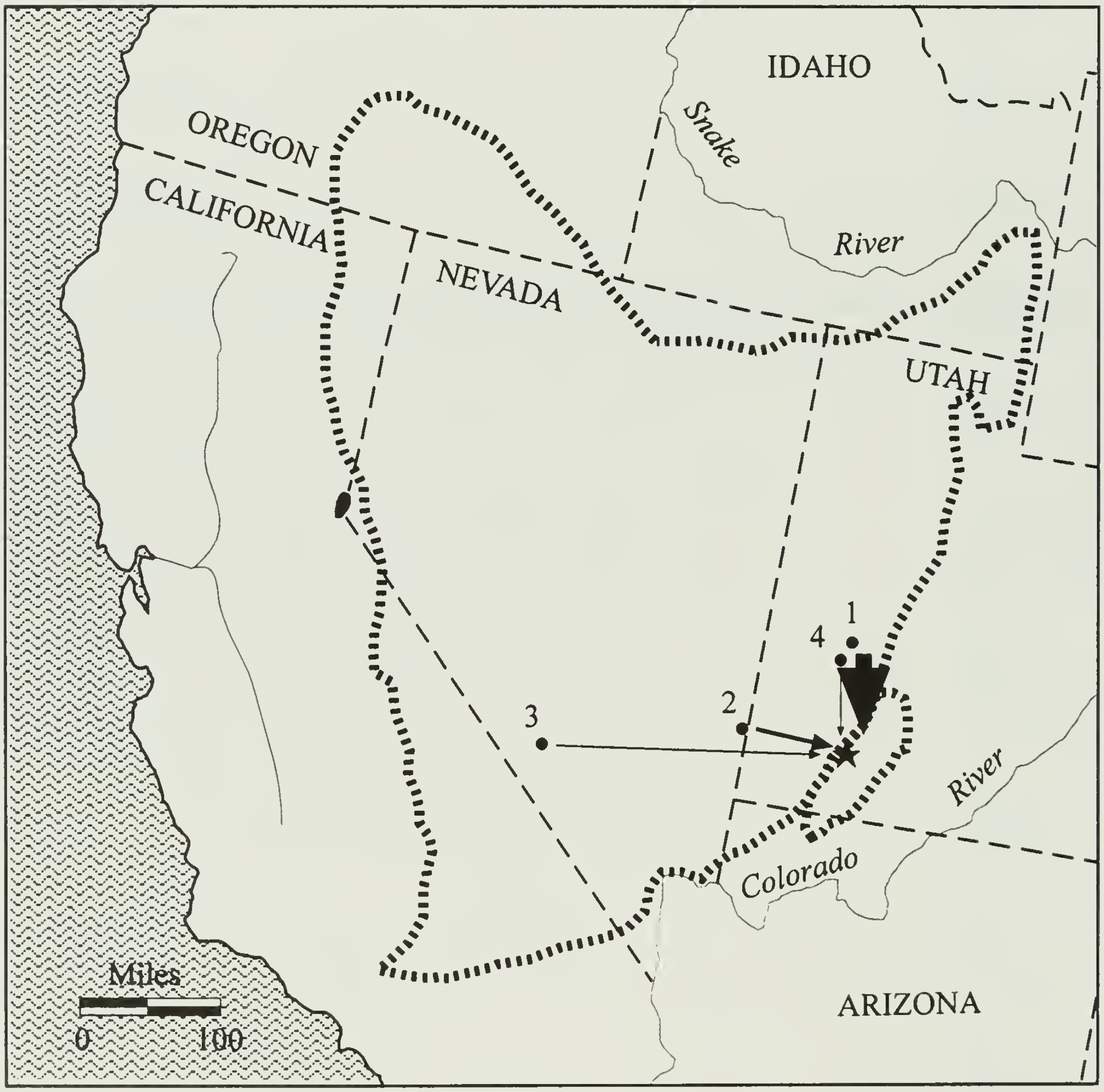

Figure 5.4 Obsidian source locales for all Cedar Breaks obsidian artifacts.

(1) Wild Horse Canyon (n=52); (2) Panaca Summit (n=10); (3) Obsidian Butte (n=3); (4) Black Mountain (n=1).

★ = Cedar Breaks National Monument.

Figure 5.5 Obsidian source locales for Cedar Breaks Elko Series projectile points. (1) Wild Horse Canyon (n=7); (2) Panaca Summit (n=1). ★ = Cedar Breaks National Monument.

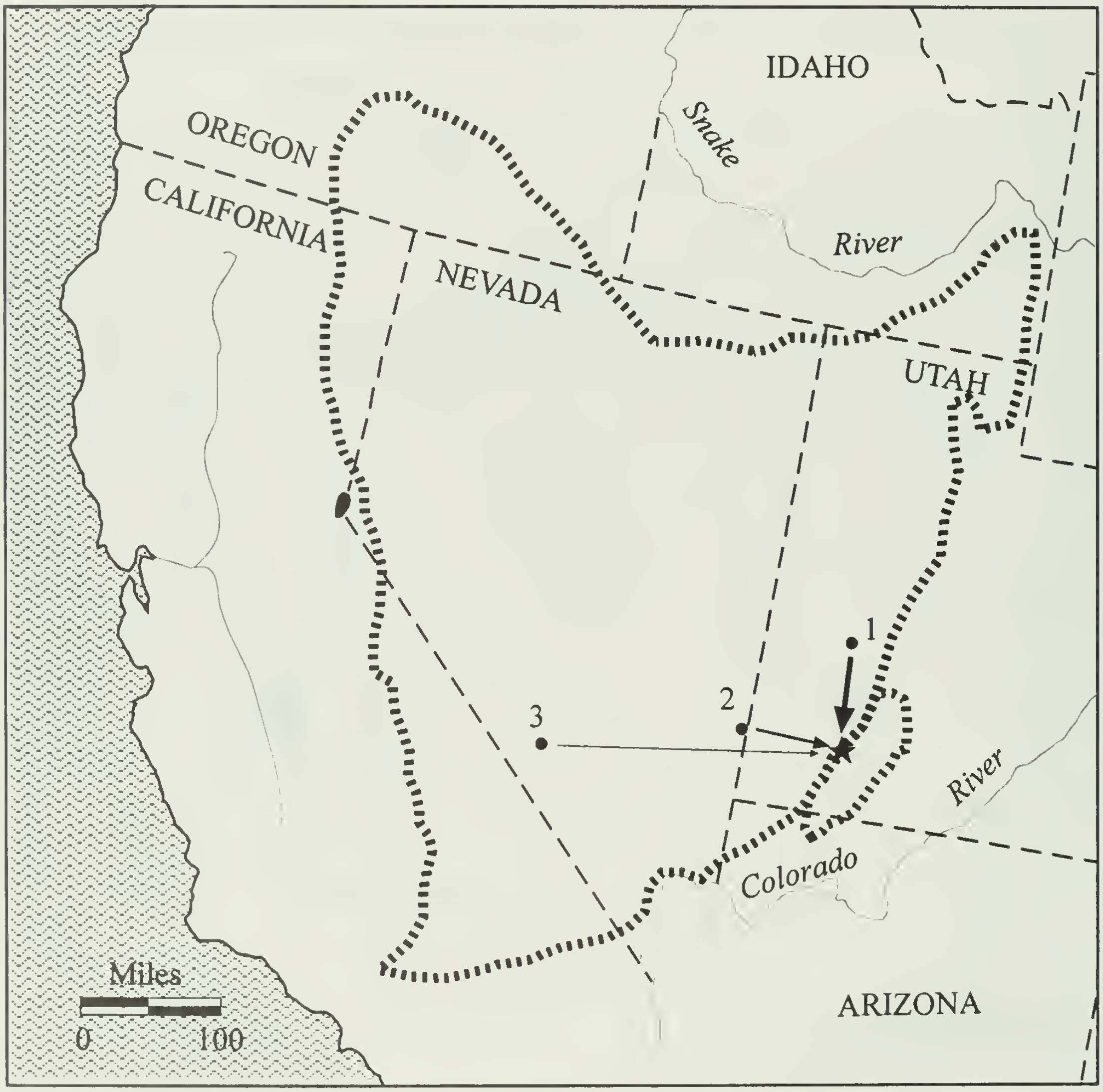

Figure 5.6 Obsidian source locales for Cedar Breaks Archaic projectile points.

(1) Wild Horse Canyon (n=4); (2) Panaca Summit (n=2); (3) Obsidian Butte (n=1).

★ = Cedar Breaks National Monument.

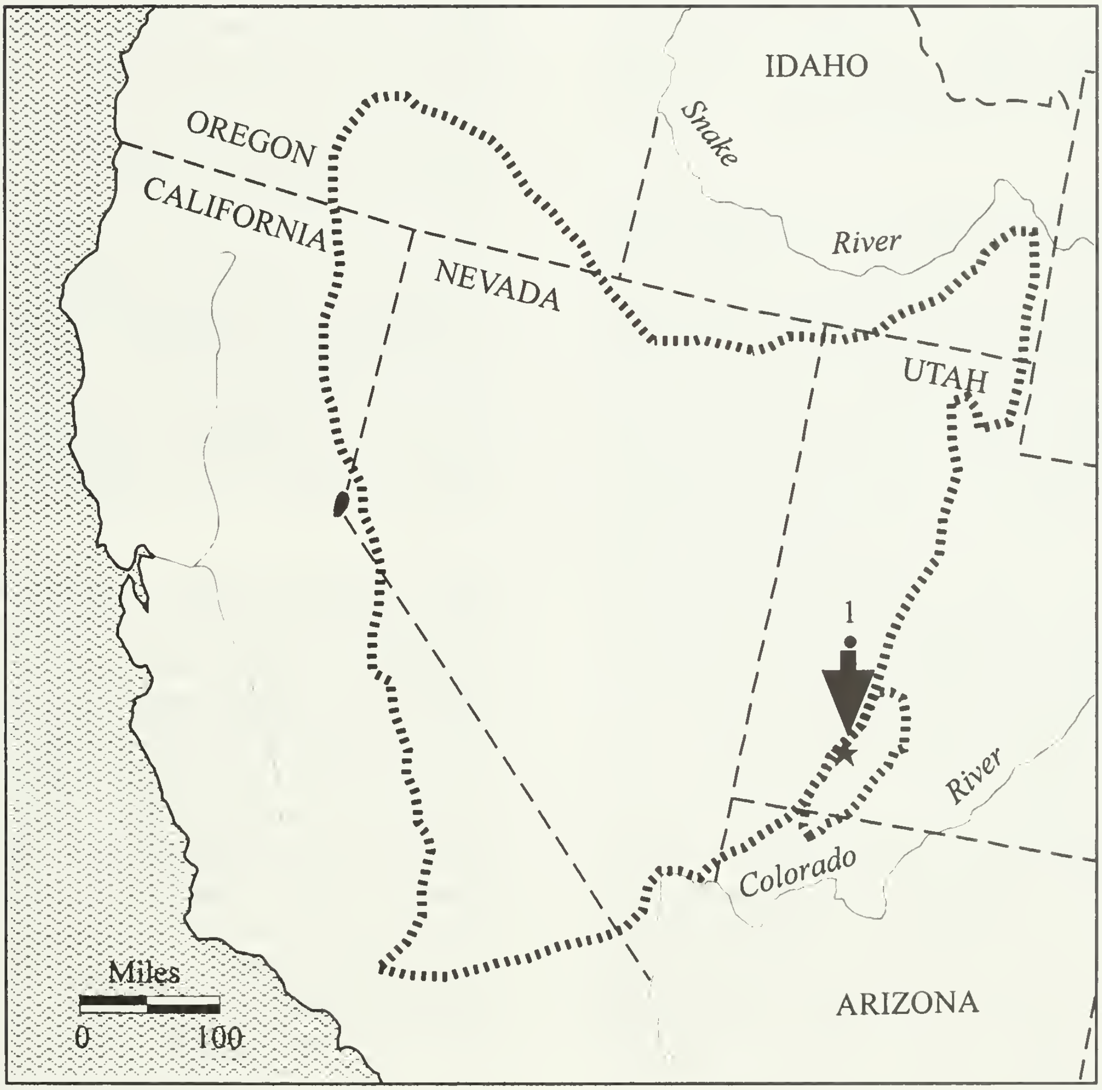

Figure 5.7 Obsidian source locale for Late Prehistoric obsidian projectile points.

(1) Wild Horse Canyon (n=3)

★ = Cedar Breaks National Monument.

generally thought to have been used to tip atlatl darts. Three of the Pinto points and one of the Gypsum points are made from volcanic glass matching the Wild Horse Canyon source. Two Pinto points come from the Panaca, Nevada, source, and a single Gypsum point comes from Obsidian Butte, Nevada. Though Wild Horse Canyon appears to be the favored source for these Archaic dart points, multiple sources are represented.

With the introduction of the bow and arrow in the Late Prehistoric, the only obsidian source to be utilized by visitors to the Cedar Breaks region is the Wild Horse Canyon glass (Figure 5.7). Three obsidian projectile points were identified as belonging to the Late Prehistoric time period (two Rosegate and one Parowan Basal-notched). All three of these small projectile points were fashioned from volcanic glass matching the Wild Horse Canyon fingerprint. Subsidiary sources are dropped from the obsidian toolstone pool in the Late Prehistoric.

DENDROCLIMATIC STUDIES

Cedar Breaks National Monument and the upper elevations of the Markagunt Plateau contain a number of bristlecone pine (*Pinus longaeva*) groves. These extremely long-lived trees are useful for constructing dendrochronologies, as well as for providing insights into past climates. The oldest living example is thought to have been over 4,900 years old before being inadvertently cut down in 1964 (Lanner 1983). Using both live and dead standing trees, and fallen bristlecone snags, scientists have established a chronology extending over 9,000 years in the White Mountains of eastern California. Bristlecone pines grow at the upper limit of the tree line, mainly between 9,000 and 11,500 ft, though a solitary individual is known to exist as low as 5,800 ft along the eastern flank of the Snake Range in eastern Nevada (Grayson 1993; Lanner 1983). These trees inhabit extreme environments and flourish, in part, because they are free of competition from other tree species. Bristlecone pine favor limestone substrates and under favorable conditions can reach heights of more than 60 ft. Lanner (1983:26) notes that as the tree grows, it endures all of the extreme conditions of its environment, and the correlation of annual ring width to precipitation allows scientists to make inferences about past climates. Such scientifically based inferences are useful to archeologists attempting to explain how past cultures interacted with their environment.

Three bristlecone pine stands were investigated by Mr. Gary Funkhouser for their potential to provide paleoenvironmental information for the Cedar Breaks region. Mr. Funkhouser's complete report is provided in Appendix D. Included in his dendroclimatic investigations were two trees located south of the Cedar Canyon highway near the visitor center, 12 trees located on Navajo Ridge, and 32 trees (along with three remnant samples) located along Mammoth Creek.

The two trees sampled near the visitor center yielded dendrochronological dates of A.D. 1299 and A.D. 720. These dates are considered to be close to the true dates when the trees began to grow. However, since the extracted cores did not reach the true center of the trees, the actual ages may be several decades older than reported (perhaps as much as 200-300 years for one individual).

The Navajo Ridge stand had previously been sampled in 1982 by researchers from the Laboratory of Tree Ring Research. The oldest of these trees has been dated at A.D. 311. Unfortunately, the Navajo Ridge trees consistently lacked annual growth rings -- perhaps as much as a decade is missing from each century of recorded tree growth. Thus, Mr. Funkhouser determined that the Navajo Ridge stand was not suitable for dendroclimatic analysis.

The Mammoth Creek stand had also been previously sampled, so data collection during the present analysis focused on updating the previous research by covering the period from A.D. 1980 to 1998. The oldest living tree in this grove has been dated at 747 B.C.

Although trees in this stand have been dated well into the B.C. time period, time series precipitation profiles start at A.D. 489. This is due to an instability in the earlier portion of the reconstruction. Thus, the Mammoth Creek stand was able to provide precipitation estimates for the last 1,500 years or so. Based on these precipitation reconstructions, several inferences regarding prehistoric use of the area can be offered.

Between about A.D. 800 to 1000 and A.D. 1250 to 1450, moisture availability was either low or declining. Conversely, during the periods between A.D. 1000 to 1250, and from about A.D. 1450 to 1650, more favorable conditions existed. Funkhouser (Appendix D) suggests that secondary periods of severe conditions also occurred around A.D. 1150 and A.D. 1700.

MARKAGUNT PLATEAU PEAT BOG STUDIES

Additional investigations into past environments of the Cedar Breaks region were conducted by David B. Madsen of the Utah Geological Survey. Dr. Madsen and his colleagues studied the deposits of two peat bogs (Lowder Creek and Red Valley) adjacent to Cedar Breaks National Monument. Their complete progress report is provided in Appendix E.

Approximately 17,000 years of forest history are present within the deposits of Lowder Creek and Red Valley bogs. Included is evidence of environmental change, fire frequency, and perhaps even a history of beetle infestations affecting the forests of the region. In addition, work at these bogs suggests revisions will need to be made regarding past glacial and volcanic activity in the area.

Madsen and his colleagues first went to Lowder Creek Bog, where they collected core samples from the deepest part of the bog. Lowder Creek Bog is located about 2.45 miles (2.9 km) east of Cedar Breaks National Monument at an elevation of 10,317 ft (3,145 m). The bog was originally a lake that eventually became a sedge marsh. The main goal at Lowder Creek Bog was to retrieve samples of the lowest lake deposits, since the upper deposits had been previously sampled and analyzed by Mulvey, et al. (1984), and Anderson, et al. (1999). One of the objectives was to obtain samples of volcanic ash known to exist in the lowest portions of the lake bed deposits. A second objective was to collect and analyze pollen from the cores. Results of the first objective are presented in Appendix E. Madsen, et al. (Appendix E), believe the pollen sequence from their core samples will extend the Anderson, et al. (1999), sequence back to about 17,000 B.P. However, the analysis and interpretation of the pollen samples is on-going and will be reported at a later time.

The volcanic ash recovered from Lowder Creek Bog deposits is similar in chemical composition to those erupted from the Mono Craters in east-central California. The age of the primary ashfall layer was determined by dating organically enriched silty clays from immediately above and below the tephra layer. Pollen, wood, and plant material recovered from the lucustrine clays was also dated. Together, these samples lead Madsen, et al. (Appendix E), to conclude that the tephra identified from Lowder Creek Bog was deposited around 14,000 ± 500 B.P. Interestingly, the Markagunt ash bed occurs fully 450 km east of the previously known distribution of Mono Craters tephra. Based on the amount of clean tephra present in the Lowder Creek deposits, Madsen, et al. (Appendix E), contend that the Markagunt ash bed likely extends a considerable (but presently unknown) distance to the east. Given its late Pleistocene age, the Markagunt ash bed will prove to be an important chrono-stratigraphic marker for the west-central Colorado Plateau and the southern Great Basin.

Basal gravels at Red Valley Bog date to about 11,700 B.P., so the Markagunt ash bed could not be analyzed at a second regional bog. However, the deposits at Red Valley Bog contain a rich paleoenvironmental record, including macrobotanical remains and fossil insect remains, as well as a stratified record of fire history.

Red Valley Bog is located at an elevation of 9,260 ft (2,822 m). This bog marks the current ecotone between the spruce/fir forests common in the upper elevations of the region and ponderosa pine occurring at lower elevations. Madsen and his colleagues chose to investigate this bog not only because of its ecotonal position, but because much of the bog has drained, allowing large exposures to be profiled and sampled for macrobotanical, pollen, and fossil insect remains.

Macrofossils obtained from Red Valley Bog suggest that both climate and plant association elevations fluctuated during the late last Glacial and the Holocene. In summary, Madsen, et al., suggest that the late Glacial and early Holocene was wetter than today. It was warmer and probably drier during the early-mid Holocene, and the climate during the late Holocene was cooler.

Thirty-three insects and arachnid taxa are reported from the Red Valley Bog samples. Beetles dominate the assemblage. Since the samples were obtained from near the center of the bog where open water conditions occurred, taxa representing adjacent habitats are under represented. However, based on the insect remains collected from the bog deposits, Madsen, et al. (Appendix E), are able to offer some paleoecological data. For instance, bark beetle and carpenter ant remains suggest that trees (particularly spruce) once grew next to the bog.

The beetles themselves are useful for interpreting the environment of the bog. Some beetles live in open water habitats, while others prefer damp leaf litter and emergent vegetation at the bog edge. Many of these insects also exist within rather narrowly defined temperature regimes. Thus, analysis of beetle diversity through time can provide insights into past environmental conditions. Madsen, et al. (Appendix E), suggest that mean summer temperatures at Red Valley Bog were warmer during the late Wisconsin. By the mid-Holocene, summer temperatures were nearly the same. Too few insect fossils were present in the late Holocene samples for useful paleoclimatic reconstructions.

The final avenue of research at Red Valley Bog was an analysis of fire history of the region. Over the last 5,300 years, 16 fire events were noted in the Red Valley deposits. Madsen, et al. (Appendix E), note that the fire events appear to be uniformly distributed. They suggest that the deposits at Red Valley Bog record a cyclical pattern of forest growth and forest maturity, followed by forest fire. It is unknown at this time whether this pattern is related to beetle infestation such as is occurring within the spruce/fir community of the region today.

Chapter 6

SUMMARY AND CONCLUSIONS

INTRODUCTION

The archeological research documented in this report was conducted as part of the Cedar Breaks Archeological Project, a multi-year cultural resource study carried out as a system-wide archeological inventory program for the National Park Service's Intermountain Region. These investigations were part of a larger, multi-year, multi-disciplinary endeavor that also included paleoenvironmental research. In many respects, this project must be seen as a baseline study in which more questions are posed than are answered. Indeed, data required to address every question is not yet available. However, the results of this effort will provide a solid foundation for modifying the current research design and learning more about aboriginal and historical use of the Markagunt Plateau in the years to come.

THE RESEARCH DESIGN REVISITED

This section reviews what was learned through the Cedar Breaks area investigations relative to the research issues presented in Chapter 1. These discussions represent a summary and review of the research conducted over the last couple of years in support of the project. More detailed information and justifications for the conclusions can be found in the various chapters.

Chronology

Prior to the field work conducted as part of the Cedar Breaks Archeological Project, exceedingly little was known about the prehistory and history of the area. What was known was that the Cedar Breaks area had probably been visited by humans for thousands of years. Specifics, especially in terms of prehistoric uses, were lacking. Historical use was thought to revolve around logging and ranching, as well as early tourism and CCC activities. Thus, basic questions concerning *when* the area was utilized needed to be addressed.

1 *Which cultural groups were utilizing the monument, and during what time periods were they there?*

The lower portions of Cedar Breaks National Monument contain very limited evidence of prehistoric utilization. Isolated prehistoric occurrences consisting of between one and eight artifacts were documented in the Lower Breaks. None of these artifacts are diagnostic, so time depth is not known. Historical use of the lower portions of the Monument consists of two logging camps, a homestead, and traces of a two-track road. These sites are believed to be related to Euroamerican use and date to the late 19th and early 20th centuries.

In stark contrast to the limited use of the Lower Breaks are the upper plateau portions of the monument. Over 8,000 years of land use have been documented in the alpine meadows and spruce/fir forests of Cedar Breaks National Monument, where 77 prehistoric and 13 historical sites are present. An additional five sites contain both prehistoric and historical components.

Heaviest use of monument lands appears to have occurred during the Late Archaic, though at least six sites contain evidence of Early Archaic use. During Late Prehistoric and Protohistoric times, use of the area continues, though intensity of use seems to decline. Evidence of historical use of the upper rim is present in the form of logging, cattle and sheep ranching sites, CCC-related sites, and sites associated with early tourism.

Settlement Patterns

Questions relative to Markagunt Plateau and Cedar Breaks settlement patterns (both prehistoric and historical) were posed in order to begin to understand such basic research domains as site function and regional land use patterns.

1. *What is the primary function(s) of prehistoric sites found within the monument?*

Toolstone procurement and hunting undoubtedly were the biggest draws for prehistoric peoples utilizing the Markagunt Plateau during the Archaic period. Though only a few Formative period sites were documented in the high country, toolstone procurement is assumed to have also been important. Utilization of floral resources is suggested at only a few sites. The majority of prehistoric sites located on monument lands appear to be related to the reduction of locally available toolstone. Cores, tested nodules, and debitage relating to initial reduction of Brian Head chert are common at many of these sites. Untested nodules, cobbles, and boulders are strewn throughout the upper reaches of the monument and surrounding region. Some sites also contain evidence of tool manufacture and maintenance, though this seems to be a subsidiary effort at smaller, low-density sites.

The importance of the alpine meadows and spruce/fir forests of the upper plateau cannot be discounted. These areas were home to a variety of game animals. Deer, elk, and possibly bighorn sheep and marmot were the most likely prey items targeted by prehistoric hunters. Projectile points spanning the last 8,000 years are present. Most are fragmentary, probably due to impact trauma and use. It is assumed that these stone tools were lost or discarded during hunting-related activities. Bifaces, scrapers, and expedient tools such as utilized flakes are also prevalent at these sites, suggesting that processing of prey occurred here as well.

Hunting in the upper reaches of the Markagunt Plateau appears to be on an encounter basis, as opposed to using intercept strategies (Binford 1978, 1983; Canaday 1997; Pendleton and Thomas 1993; Thomas 1983). Rock-constructed hunting facilities such as hunting blinds and drivelines are not present at any of the Cedar Breaks sites. The absence of such features is interesting in light of recent high-altitude research in other parts of the Great Basin (Bettinger 1991; Canaday 1997; Thomas 1982), where stacked rock hunting blinds are the norm.

Structures of any kind, in fact, are lacking in the Cedar Breaks area during the prehistoric period. Structural features such as hearths, cists, or room blocks common to the Virgin Anasazi to the south or the Fremont to the north and west were not encountered during the Cedar Breaks investigations. The lack of such features may be due to several factors. Trips to the Brian Head region were probably short term in nature. Harsh weather in the high country can occur during nearly any month of the year. Early snow fall in the autumn months together with late spring storms allow just a short window of opportunity for high-country utilization lasting perhaps three or four months. Thus, shelters were probably temporary affairs leaving faint archeological signatures difficult to detect after a few seasons.

2. *Are identified prehistoric site function(s) within Cedar Breaks similar to those observed outside of the monument?*

Prehistoric site functions at monument locales appear to mirror those seen at surrounding Markagunt Plateau sites. Previous research, consisting mainly of cultural resource management projects on land administered by the Dixie National Forest indicate a preponderance of sites associated with toolstone procurement. Many of these sites also contain hunting losses, such as projectile points, bifaces, and scrapers. Trips to the high country must have been viewed by prehistoric visitors as an opportunity to (1) replenish stone for tool making, (2) procure fresh meat, and (3) escape the hotter temperatures of the lower elevations. Though the procurement of floral resources is assumed, very little evidence has been documented for this activity.

It was our hope at the beginning of this undertaking to combine the findings of the Cedar Breaks Archeological Project with data collected from the Dixie National Forest. Inventory of the regions surrounding the Monument was planned and partially carried out (Marion Jacklin, personal communication). A more regional view of prehistoric (as well as historical) land use would have then been possible. Unfortunately, the Dixie Forest data was not available at the time of this writing, so a regional synthesis will have to wait for another time.

3. *Is there spatial variability of prehistoric site function within the monument?*

As noted previously, a stark disparity between use of the heavily dissected lower amphitheater and the upper rim is readily apparent. Fully 95 of the 99 sites recorded as part of the Cedar Breaks Archeological Project are located within the alpine meadows and spruce/fir forest of the upper plateau.

4. *During what season(s) were identified prehistoric sites used?*

Site-specific information relative to addressing this research question was not present from the limited testing conducted during the Cedar Breaks project. Further, survey data is generally not useful in answering this kind of inquiry. It is generally assumed that these sites were occupied during the late spring through early fall, when game animals would be present, toolstone would be available on the surface, and weather patterns would be favorable. Winter snows generally begin early and persist late in this region. In short, the upper reaches of the Markagunt Plateau were not conducive to year-round prehistoric habitation or use.

5. *What was the average size of prehistoric groups utilizing the monument?*

Estimating group size on the basis of prehistoric lithic scatters is a daunting task, indeed -- perhaps impossible. These sites are a consequence of multiple depositional events. Palimpsest deposits such as those seen within the monument and surrounding region are not unique to this high-elevation setting. Lowland sites are beset with this same problem.

Multiple visits resulting in multiple depositional episodes have undoubtedly occurred at many Cedar Breaks sites. Indeed, the recurrent use of this area since the Early Archaic is one of the most intriguing aspects discovered during this project. While individual loci and concentrations representing single lithic reduction events are present, determining group size on the basis of such data seems futile. Time and resources would be better spent investigating inter- and intra-site variability. The research potential of Cedar Breaks sites along these lines would appear to be great, and awaits only an enterprising individual willing to invest the time and effort needed to search for these patterns.

6. *How do the prehistoric sites located in Cedar Breaks differ from those found at lower elevations, both in the mountains and valleys?*

Comparison with other sites in the region, from both lower elevations and mountainous contexts, would yield data pertinent to regional land use patterns. Such analysis has yet to be initiated. However, at the most general level, it is apparent that Cedar Breaks prehistoric sites were short-term, seasonal affairs, while prehistoric sites at lower elevations contain evidence such as habitation structures, storage cists, and other features indicating long-term occupation.

Frank and Betenson (1997:24) suggest that one fruitful avenue of inquiry would be to look at the lithic sources of the Mineral Mountains (obsidian) and along the eastern edges of the Cedar and Parowan Valleys (outwash chert sources). Comparisons of lithic procurement and reduction strategies on a regional scale are now possible. Data on specific site constituencies and locations are available in Federal and SHPO files, and these can be accessed through the IMACS data base at the Utah SHPO. This information could then be compared to the Cedar Breaks data, in order to assess variations in the uses of these source areas.

As mentioned previously, the lower portions of Cedar Breaks National Monument contain little evidence of prehistoric utilization. This is especially apparent when compared to prehistoric site density observed within the meadows of the upper plateau. The lack of prehistoric sites in the lower portions of the monument may be due to the erosional forces dominant here. Scouring of the drainage bottoms continues to occur each spring. Prehistoric sites that may have existed here have either been washed away or are buried under many meters of alluvial debris.

7. *What historic site function(s) are identifiable within Cedar Breaks?*

In the lower portions of the monument, historical site function appears to be restricted to logging activities. Two logging camps have been identified, and a homestead is probably associated with the logging industry as well. The fourth site in the Lower Breaks is an old road connecting the homestead with other logging-related sites known to exist on private lands adjacent to the surveyed area.

Historical site functions in the upper elevations of the monument are much more varied. Included here are sites relating to historic logging and ranching practices prior to the establishment of Cedar Breaks as a national monument in 1933. With the establishment of the monument, historical sites relating to the CCC become common, and include the camp used by the workers while constructing much of the infrastructure needed for administration of the new monument. Work conducted out of this camp included the construction of many of the scenic overlooks located along the rim of the Cedar Breaks escarpment, the visitor center, and a ranger residence. These last two were placed on the National Register in the 1970s as representatives of NPS rustic-style architecture.

Tourism in the region began before the monument was federally recognized. Motorcade expeditions sponsored by the

Union Pacific Railroad brought visitors to the high country once a viable road had been constructed in the 1920s. Present-day SR 143 and SR 148 for the most part follow this original road. Remnants of the old road (recorded as historical linear features; 42In1582 and 42In1583) are still present in the monument where curves have been realigned. Cedar Breaks Lodge was established in 1924 by the Union Pacific and its subsidiary Utah Parks Company. The lodge provided a place where visitors could relax, eat, and find overnight accommodations.

Historic era Paiute sites were not encountered, although the few fingernail-impressed Intermountain Brownware sherds documented at site 42In1522 could be attributed to the Paiute.

8. *How does historic site function and location differ from prehistoric site function and location within the monument?*

The Markagunt Plateau in general, and Cedar Breaks National Monument in particular, have been utilized by prehistoric, historic, and modern populations. As noted previously, a marked contrast is seen when comparing the cultural resources of the Lower Breaks with the upper plateau. The Lower Breaks contain logging-related historical sites and isolated prehistoric occurrences. In the alpine meadows and spruce/fir forests of the upper plateau, prehistoric lithic procurement sites are dominant. These sites are located throughout the monument but seem to be larger and more complex toward the north end, closer to the source of the toolstone. The majority of historic sites are located nearer to the scenic Cedar Breaks escarpment, where visitor/tourism use is concentrated. The meadows of the upper plateau were also utilized by historic residents, but for different reasons than their prehistoric predecessors. Much of the area was utilized as summer grazing lands by Mormon settlers.

Subsistence and Resource Procurement

Issues concerning subsistence and resource procurement are important in any attempt to understand past human behavior. It is usually assumed that finding and obtaining both food and necessary tool-making resources guided much of past human activities, and thus serve as an important focus of research (cf., Simms 1979). In general, this research domain is intimately connected with the previous one, in that the availability of these resources frequently affects resulting prehistoric and historical settlement patterns, site function, and general land use. Questions concerning subsistence and resource procurement generally centered on attempting to delineate what resources were available to concerned populations and how they were utilized (Frank and Betenson 1997).

1. *Why and how were prehistoric populations utilizing this region?*

This question is effectively covered by discussions of site function (Settlement Pattern questions #1 and 2). In short, this region was utilized for its ready access to high-quality toolstone, as well as for access to prime hunting habitat. It is assumed that relatively small, mobile groups utilized the Markagunt Plateau, primarily during the hotter summer months. Large, elaborate village sites are not present in the high elevations of the Markagunt Plateau and few sites contain pottery or groundstone artifacts. Rather, repeated use of the area has produced a number of extremely large lithic scatters reflecting multiple depositional episodes.

Evidence that plant processing occurred at these sites is rare, even though abundant plant resources are present that would have matured in the late summer/early fall. Limited testing at the one site that contained both groundstone and pottery failed to encounter intact hearths or midden deposits. A deflated hearth that was discovered on the surface did not contain charcoal or undisturbed charcoal fill, so pollen and macrobotanical analyses could not be performed.

2) *Is there any variation in prehistoric resource procurement strategies through time?*

Use of Brian Head Chert resources begins in the Early Archaic and continues through the Late Prehistoric. Procurement strategies appear to remain the same during these time periods. Toolstone was gathered either at the source along the flanks of Brian Head Peak or from the many nodules, cobbles, and boulders strewn (perhaps via glaciation, as suggested by Agenbroad, et al., 1992) throughout the upper plateau.

Evidence of Paleoindian use of this area was not substantiated. At the North Point site, Agenbroad, et al. (1992), suggest that cultural material is associated with a deeply buried paleosol dated at 9005 B.P. However, it remains unclear whether the few flakes and the mano reported to have been collected from the exposed deposit were actually associated with the 9005 B.P. stratum. Limited auger probes failed to confirm the presence of cultural material within this stratum, though the paleosol was found to extend at least 35 m east of the exposed face.

Marian Jacklin claims (personal communication) to have found a possible fluted point (Figure 6.1) made of Brian Head Chert from site 42In1135, but this assignment is questioned by the senior author. While one face contains a possible flute, the opposite side does not. Further, this artifact does not exhibit the edge grinding prevalent on most paleoindian points, nor does it contain evidence that the "flute" was prepared late in the reduction sequence (see Warren and Phagen 1988:121). Rather, it looks to be a fortuitous channel flake removed during an earlier biface reduction sequence.

Material Culture

Material culture, or what is left behind by both prehistoric and historical occupants of a region, generally serves as an archeologist's primary data base, particularly when dealing with survey projects such as this. Items of material culture can tell us when people occupied an area, and may tell us what their principal activities in an area were; and they may also reflect a group's movement throughout a larger region (Frank and Betenson 1997).

1. Which local geologic resources were being utilized by prehistoric populations, and is there any variation in use through time?

As noted above, Brian Head Chert appears to have been utilized from the Early Archaic through the Late Prehistoric. Sample sizes are too small to make meaningful comparisons, so discussion relative to variation through time is not yet possible. However, a preference for Brian Head Chert during the Middle and Late Archaic is suggested. Thirteen (13) Gypsum points from six sites were collected from Cedar Breaks. Eleven (11) of these contracting stem points appear to be made from Brian Head Chert. The remaining two were fashioned from obsidian.

The Elko Series is not a very good temporal indicator in this portion of the Intermountain West, because it spans some 7,000 years (7,950 – 950 B.P.) of prehistory. Use of Brian Head chert for knapping Elko Series

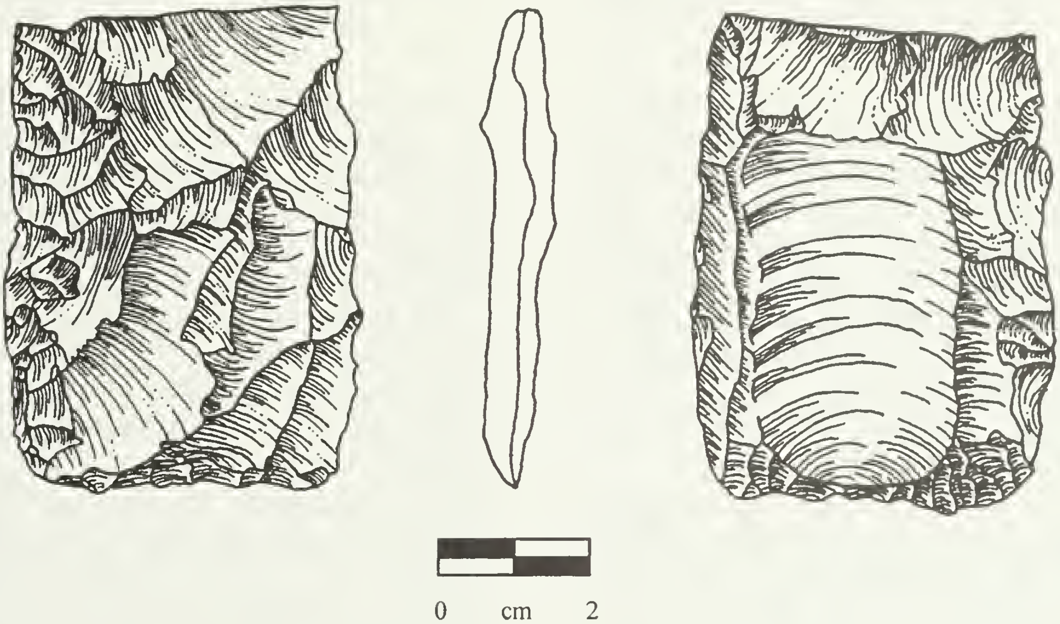

Figure 6.1 "Fluted" point from 42In1135.

points seems to be preferred, though not overwhelmingly so. Of the 28 points assigned to this series from 11 different sites, 16 look to have been made from Brian Head Chert, 11 are obsidian, and one is from a non-local (and unknown) silicified sediment source.

The few minimally ground metates identified at Cedar Breaks sites are made from locally available rhyolite. In addition to being a source for chipped stone tools, the flanks of Brian Head Peak also contain abundant rhyolite for groundstone tools.

2. *What kinds of lithic reduction techniques were employed at prehistoric sites?*

Material testing and core reduction were the dominant activities at many of the Cedar Breaks sites. This is especially the case at larger sites located within the northern portion of the monument, closest to the toolstone source. Tool production and maintenance are evident at these sites, but these activities are masked by massive amounts of debitage generated through initial reduction strategies. A number of smaller sites and limited use areas contain later stage reduction debitage indicative of biface thinning and maintenance. The presence of tool production and maintenance debitage suggests that procurement of high-quality stone was not the only reason to travel to the high country. As has been suggested, hunting for large and small prey undoubtedly occurred here as well -- at least on an encounter basis.

3. *Are lithic exotics, materials not immediately available, present on prehistoric sites, and what, if any, are the implications?*

Obsidian tools and debitage are fairly common at the sites discovered within the alpine meadows of Cedar Breaks National Monument. Thirty of the 82 upper plateau sites contain obsidian artifacts. A number of these artifacts were submitted for XRF analysis. A decidedly Great Basin influence is apparent from the results of this analysis. Four separate obsidian sources were identified.

The majority (79 percent) of the obsidian comes from the Wild Horse Canyon area of the Mineral Mountains, Utah, located about 90 km north of he project area. An additional 15 percent (10 artifacts) have been identified to the Panaca Summit, Nevada source, located about 100 km west of Cedar Breaks. Three artifacts (5 percent) come from the Obsidian Butte, Nevada, source located over 350 km to the west. A single unworked obsidian cobble was sourced to the Black Mountains of Utah, located about 80 km northwest of Cedar Breaks.

Analysis of obsidian sources utilized through time can provide us with insights into the mobility range of foraging groups and how group mobility changed through time (Buck, et al., 1998). During the Archaic period, three obsidian sources were being utilized by Cedar Breaks foraging groups: the Wild Horse Canyon area of the Mineral Mountains, Utah; Panaca Summit, Nevada; and Obsidian Butte, Nevada. With the introduction of the bow and arrow in the Late Prehistoric, Panaca Summit and Obsidian Butte obsidian is no longer used. Only obsidian from Wild Horse Canyon is utilized to make arrow points.

4. *Are prehistoric ceramic and/or groundstone artifacts found at these high-altitude sites within the monument?*

Ceramic and groundstone artifacts are rare in Cedar Breaks sites. Ceramics were found at three monument sites. Several extremely small grayware sherds were discovered on the surface of site 42In1135. Unfortunately, they were too small for meaningful interpretation. A single Parowan Fremont, Snake Valley Black-on-gray sherd, was discovered at site 42In1430. One site (42In1522) contained a substantial (>30) amount of indeterminate grayware sherds. Test excavation indicates limited subsurface deposits are present, including additional pottery fragments. Unfortunately, none of these artifacts could be positively identified. At this same site, 11 Intermountain Brownware sherds (several containing fingernail impressions) were discovered on the surface. Test excavation failed to recover additional artifacts or features associated with these late prehistoric / protohistoric sherds.

Groundstone artifacts are present in the form of three metates, a mano, and an edge grinder. An additional mano is reported from the North Point site, but was unavailable for analysis as part of this study. In addition, a few groundstone artifacts are reported to be present at Markagunt Plateau sites located on lands administrated by the Dixie National Forest (Marian Jacklin, personal communication).

The scarcity of ceramic and groundstone artifacts at these high-elevation sites suggests either limited utilization of plant resources, or use of a toolkit that is not visible in the archeological record. Wood or bone artifacts could have been used to procure plant resources with processing perhaps occurring at lower elevations. This may be the case, since plant resources would have been plentiful in the summer and fall when it is suspected that prehistoric use was most intensive.

Paleoenvironment

Environmental conditions during the past 10,000 to 12,000 years have been crucial factors affecting the prehistoric use of this high-altitude area. Various studies conducted throughout the Intermountain West and on the Colorado Plateau suggest that there have been fluctuating wet and dry periods, which would have affected populations living in the area. These factors would have played an important role in the utilization of upland resources by prehistoric groups (Frank and Betenson 1997). Information on Cedar Breaks and Markagunt Plateau paleoenvironments is available from several different studies (Appendix D and E; this volume) conducted in support of the Cedar Breaks Archeological Project. Anderson, et al. (1999), provide additional paleoenvironmental data for the Markagunt Plateau.

1. *What was the paleoenvironment of the monument like and how has it changed through time?*

Paleoecological work at Red Valley Bog produced a forest history spanning some 17,000 years. Changes in the environment, evidence of fire frequency, and perhaps even evidence of previous beetle infestations were documented. Additional analyses of pollen extracted from cores at Lowder Creek Bog are on-going and are expected to add to the growing body of work on the paleoecology of the Markagunt Plateau.

Macrofossil analyses at Red Valley Bog suggest that moisture was probably higher than today during the late Glacial and early Holocene. During the early to mid Holocene, conditions were warmer and probably dry. Preliminary data suggests that fire frequency may have increased during this period. The late Holocene climate appears to have been cooler.

Analysis of bristlecone pine data for the last 2,700 years or so suggests that between A.D. 800 to 1000 and between A.D. 1250 to 1450, moisture availability was either low or declining. More favorable conditions appear to have existed between A.D. 1000 to 1250 and between A.D. 1450 and 1650.

2. *How were the floral and faunal resources affected through time?*

Data pertaining to changes in faunal resources through time is not available. Sites containing well-dated faunal assemblages were not discovered during the Cedar Breaks Archeological Project. It is assumed that deer and elk, and perhaps bighorn sheep, had been available throughout the area since at least the early Holocene.

Macrofossil data from Red Valley Bog indicates that floral resources have undergone substantial change over the last 12,000 years or so. This change is reflected in the up-and-down elevational shift of spruce/fir and ponderosa pine communities in response to changing climatic conditions.

Presently, the area surrounding Red Valley Bog marks a transition between the spruce/fir dominated forests of the higher portions of the Markagunt Plateau and an ecosystem dominated by ponderosa pine found on upper mid-slope areas. In the immediate vicinity of the bog, a mixed aspen/Douglas fir community with some subalpine fir and Engelmann spruce is present. During the late Glacial and early Holocene, the area was surrounded by a spruce-fir forest. Ponderosa pine and Douglas fir colonized the Red Valley Bog area during the late early Holocene and mid-Holocene. By about 3,000 years ago, ponderosa pine and Douglas fir had shifted their elevational limits to lower elevations, being replaced in the Red Valley Bog area by spruce/fir communities.

3. *Are changes in the paleoenvironment and climate reflected in prehistoric use of the area?*

Documented use of the Cedar Breaks area begins about 6,000 to 8,000 years ago, when visitors equipped with darts tipped with Pinto-style projectile points utilized the area's toolstone resources. Hunting is also assumed to have occurred during these toolstone procurement forays. At about this same time, ponderosa pine and Douglas fir are established in the Red Valley Bog area. Use of the highlands continues even after changes in the environment force the ponderosa pine/Douglas fir community to shift its upper elevational limits downward around 3,000 B.P. During this time, high-country visitors carrying darts tipped with Gypsum-style projectile points continue to procure tool stone and engage in other activities. Change in the forest communities during the later stages of the Archaic does not appear to have affected prehistoric use of the Cedar Breaks area.

During the Late Prehistoric -- the period essentially covered by Gary Funkhouser's dendroclimatic data -- use of the Markagunt Plateau and Cedar Breaks areas appear to decline. A decline in effective moisture during this period may have been a contributing factor to the apparent decline in Late Prehistoric utilization of the area -- a trend that seems to continue into the Protohistoric period.

FUTURE RESEARCH DIRECTIONS

Despite the lack of sites with subsurface deposits, the sheer number of sites in this high-elevation setting is remarkable. Human use of this area has been documented spanning the last 6,000 to 8,000 years, based on time-sensitive projectile points collected from the surface of these sites. The vast majority of these sites appear to be related to quarrying and the primary reduction of locally available chert. Although hunting activity undoubtedly occurred as well, this activity appears to have been secondary. Plant procurement also occurred, but evidence of this activity is rare.

Many of the questions posed in the Research Design (Frank and Betenson 1997) guiding the Cedar Breaks Archeological Project were, by necessity, coarse-grained in nature and scope. Now that we have concluded 3 years of research, finer-grained questions can be asked. For its part, the research design was successful, because we were able to establish a basic cultural and chronological framework in a basically unknown area. We were also able to address, to some degree, questions on site function and resource procurement. Of particular interest was the discovery that Great Basin influences far outweigh Colorado Plateau influences. Obsidian was found to come from four different Great Basin sources. Limited ceramic evidence also points to a Great Basin origin. Virgin Anasazi use of this high-altitude area was not documented.

Additional obsidian studies should be conducted to supplement the existing data base. Because nearly all of the Cedar Breaks sites are surface manifestations, tighter chronological control is needed. Presently, only cross-dating using time-sensitive projectile points is available to place these sites into a rough chronological framework.

Hydration analysis of obsidian artifacts may offer an additional dating device. Such a study would need to address local environmental factors affecting hydration rind growth on high-altitude surface artifacts.

Detailed analysis of debitage from these sites would also be a fruitful avenue of research. Time and resources prevented detailed analysis during the present study. Of particular interest would be a detailed analysis of the debitage located at the source areas for the Brian Head material. At least five primary quarry sites were identified along the flanks of Brian Head Peak; many more undoubtedly exist.

One of the unstated goals of this project was to ascertain the cultural resource potential at the North Point site. This goal was not met. Bucket augers established that the deeply buried paleosols extend at least 35 m east of the present escarpment. Unfortunately, only one pressure flake was recovered, and it could have been produced by the head of the auger as it encountered natural chert nodules at the base of the lowest paleosol. Establishing, once and for all, the association of the paleosols with human use of the upper plateau is imperative.

Regardless of the question of human association with the paleosols at the North Point site, the paleoenvironmental research potential is unquestioned. Additional work building on the studies by Agenbroad and his students should be pursued. As a start, pollen samples obtained as part of our efforts at the North Point site should be processed, analyzed, and interpreted, in light of the important work being conducted at Lowder Creek and Red Valley bogs by Madsen and his colleagues.

In summary, the prehistoric and historical resources of Cedar Breaks National Monument include artifacts, features, and deposits that can be used to further our understanding of the past. These sites and loci should be preserved and protected so that the important information will be available for future scholars to ponder.

REFERENCES CITED

Agenbroad, L. D., J. I. Mead, and R. S. Anderson

1992 Quaternary Paleoenvironmental Studies of the Colorado Plateau, Year I, National Park Service Contract RMR-R91-0176. Quaternary Studies Program, Department of Geology/Department of Environmental Studies, Northern Arizona University, Manuscript on file, Zion National Park, Springdale, Utah.

1993 Quaternary Paleoenvironmental Studies of the Colorado Plateau, Year II, National Park Service Contract RMR-R91-0176. Quaternary Studies Program, Department of Geology/Department of Environmental Studies, Northern Arizona University, Manuscript on file, Zion National Park, Springdale, Utah.

Aikens, C. M.

1970 *Hogup Cave*. University of Utah Anthropological Papers, Number 93. University of Utah, Salt Lake City.

1982 Archaeology of the Northern Great Basin: An Overview. In *Man and Environment in the Great Basin*, edited by D.B. Madsen and J. F. O'Connell, pp. 139-155. SAA Papers No. 2, Society for American Archaeology.

Altschul, J. H., and H. C. Fairley

1989 *Man, Models Management: An Overview of the Archeology of the Arizona Strip and the Management of its Cultural Resources.* Report Prepared for USDI Bureau of Land Management. Manuscript on file at Zion National Park, Springdale, Utah.

Alley, J. R.

1982 Prelude to Dispossession: The Fur Trade's Significance of the Northern Utes and Southern Paiutes. In *Utah Historical Quarterly* 50 (2): 104-123.

Ambler, J. R., and M. Q. Sutton

1989 The Anasazi Abandonment of the San Juan Drainage and the Numic Expansion. *North American Archeologist* 10:39-53.

Anderson, J. J.

1993 The Markagunt Megabreccia--Large Miocene gravity slides mantling the northern Markagunt Plateau, southwestern Utah. *Utah Geological Survey Miscellaneous Publication* 93-2.

Anderson, J. J., and P. D. Rowley

1975 Cenozoic geology of southwestern High Plateaus of Utah. In, Anderson, J.J., Rowley, P.D., Fleck, R.V., and Nairn, A.E.M., Cenozoic geology of southwestern High Plateaus of Utah. *Geological Society of America Special Paper* 160: 1-51.

Anderson, R. S.

1990 Holocene forest development and paleoclimates within the central Sierra Nevada, California. *Journal of Ecology* 78: 470-489.

Anderson, R. S.

1993 A 35,000 year vegetation and climate history from Potato Lake, Mogollon Rim, Arizona. *Quaternary Research* 40:351-359

Anderson, R. S., J. Hasbargen, P. A. Koehler, and E. J. Feiler
1999 Late Wisconsin and Holocene Subalpine Forests of the Markagunt Plateau of Utah, Southwestern Colorado Plateau, U.S.A. *Arctic, Antarctic and Alpine Research* 31:366-378.

Arno, S. F., and R. P. Hammerly
1984 *Timberline: Mountain and Arctic Forest Frontiers.* The Mountaineers, Seattle, Washington.

Averitt, P.
1962 *Geology and Coal Resources of the Cedar Mountain Quadrangle, Iron County, Utah.* U. S. Geological Survey Professional Paper 389, Washington, D.C. Government Printing Office.

Bacon, C. R.
1983 Eruptive history of Mount Mazama and Crater Lake Caldera, Cascade Range, U.S.A. *Journal of Volcanology and Geothermal Research* 18: 57-115.

Bailey, R. A.
1989 "Geologic map of the Long Valley caldera, Mono-Inyo Craters volcanic chain, and vicinity, eastern California." U. S. Geological Survey Miscellaneous Investigations Map I-1933, scale 1:62,500.

Baldridge, K.
1971 *Nine Years of Achievement: the CCC in Utah.* Dissertation in partial fulfillment of the requirements for the Ph.D., Brigham Young University, Provo.

Baldwin, G. T.
1942 Archeology in Southern Nevada. *The Kiva 7(1): 13-16.*

1950 The Pottery of the Southern Paiute. *American Antiquity 16:*50-56.

Barnes, C. T.
1927 *Utah Mammals.* Bulletin of the University of Utah. Salt Lake City.

Beck, C.
1995 Functional Attributes and the Differential Persistence of Great Basin Dart Forms. *Journal of California and Great Basin Anthropology* 17:222-243.

1998 Projectile Point Types as Valid Chronological Units. In *Unit Issues in Archaeology: Measuring Time, Space, and Material (Foundations of Archaeological Inquiry)*, edited by A. Ramenofsky and A. Steffen, pp. 21-40. University of Utah Press, Salt Lake City.

Beck, C., and G. T. Jones
1988 Western Pluvial Lakes Tradition Occupation in Butte Valley, Eastern Nevada. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J. A. Willig, C. M. Aikens, and J. L. Fagan, pp. 273-301. Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

Bedwell, S. F.
1970 *Prehistory and Environment of the Pluvial Fort Rock Lake Area of Southcentral Oregon.* Ph.D. Dissertation, University of Oregon, Eugene, University Microfilms, Ann Arbor, Michigan.

1973 *Fort Rock Basin Prehistory and Environment*. University of Oregon Books, Eugene.

Benedict, J. B.
1975 The Murray site: a Late Prehistoric game drive system in the Colorado Rocky Mountains. *Plains Anthropologist 20*:161-174.

1981 *The Fourth of July Valley: Glacial Geology and Archaeology of the Timberline Ecotone*. Center for Mountain Archaeology, Research Report No. 2, Ward , CO.

1985 *Arapaho Pass: Glacial Geology and Archeology at the Crest of the Colorado Front Range*. Center for Mountain Archeology, Research Report No. 3 Ward , CO.

1987 A Fasting Bed and Game Drive Site on the Continental Divide in the Colorado Front Range. *Southwestern Lore 53*: (3) 1-27.

1992 Foot Prints in the Snow: High-altitude Cultural Ecology of the Colorado Front Range, U.S.A. *Arctic and Alpine Research 24*:1-16.

1996 *The Game Drives of Rocky Mountain National Park*. Center for Mountain Archeology, Research Report No.7, Ward, CO.

1999 Effects of Changing Climate on Game Animal and Human Use of the Colorado High Country (U.S.A.) Since 1,000 BC. *Arctic, Antarctic, and Alpine Research* 31:1-15.

Benson, L.V., J.W. Burdett, M. Kashgarian, S. P. Lund, F. M. Phillips, and O. R. Rye
1997 Climatic and hydrologic oscillations in the Owens Lake Basin and adjacent Sierra Nevada, California. *Science* 272: 746-749.

Benson, L. V., D.R. Currey, R.I. Dorn, K.R. Lajoie, C.G. Oviatt, S.W. Robinson, G. Smith, and S. Stine.
1990 Chronology of expansion and contraction of four Great Basin lake systems during the past 35,000 years. *Palaeogeography, Palaeoclimatology, Palaeoecology* 78:241-286.

Berge, D. L.
1980 *Simpson Springs Station: Historical Archaeology in Western Utah*. Bureau of Land Management, Cultural Resource Series Number 6.

Bettinger, R. L.
1990 Alpine Villages of the White Mountains of California. Paper Presented at the 55th Annual Meeting of the Society for American Archaeology, Las Vegas, Nevada.

1991 Aboriginal Occupation at High Altitude: Alpine Villages in the White Mountains of Eastern California. *American Anthropologist 93*:656-679.

Bettinger, R. L., and M. A. Baumhoff
1982 The Numic Spread: Great Basin Cultures in Competition. *American Antiquity* 47:485-503.

Bettinger, R. L, J. F. O'Connell, and D. H. Thomas
1991 Projectile Points as Time Markers in the Great Basin. *American Anthropologist* 93:166-172.

Bettinger, R. L., and R. Oglesby
1985 Lichen Dating of Alpine Villages in the White Mountains, California. *Journal of California and Great Basin Anthropology* 7:202-224.

Biondi, F., and T. W. Swetnam
1987 Box-Jenkins Models of Forest Interior Tree-ring Chronologies. *Tree-Ring Bulletin 47*:71-96.

Binford, L. R.
1978 *Nunamiut Ethnoarchaeology: A Case Study in Archaeological Formation Processes.* Academic Press, New York.

1983 *In Pursuit of the Past: Decoding the Archaeological Record.* Thames and Hudson, New York.

Box, G. E. P., and G. M. Jenkins
1976 *Time Series Analysis: Forecasting and Control.* Holden-Day, San Francisco.

Bradbury, J. P., R. M. Forester, and R.S. Thompson
1989 Late Quaternary paleolimnology of Walker Lake, Nevada. *Journal of Paleolimnology* 1:249-267.

Brooks, J. A.
1972 *Journal of the Southern Indian Mission: Diary of Thomas D. Brown.* Utah State University Press, Western Text Society, No. 4, Logan, Utah.

Brown, T.A., D.E. Nelson, R.W. Mathewes, J.S. Vogel, and J.R. Southon
1989. Radiocarbon dating of pollen by accelerator mass spectrometry. *Quaternary Research* 32(2):205-212.

Bryan, A. L.
1980 The Stemmed Point Tradition: An Early Technological Tradition in Western North America. In Anthropological Papers in Memory of Earl H. Swanson, Jr., edited by L. B. Harten, C.N. Warren, and D. R. Touhy, pp. 77-107, Special Publications of the Idaho State University Museum of Natural History, Pocatello.

1988 The Relationship of Stemmed Point and the Fluted Point Traditions of the Great Basin. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 53-74, Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

Buck, P. E., D. S. Amick, and W. T. Hartwell
1994 *The Midway Valley Site (26NY4759): A Prehistoric Lithic Quarry Near Yucca Mountain, Nye County, Nevada.* Topics in Yucca Mountain Archaeology Number 1. Desert Research Institute, Las Vegas, Nevada.

Buck, P. E., and A. DuBarton
1994 Archeological Investigations at Pintwater Cave, Nevada During the 1963 – 64 Field Season. *Journal of California and Great Basin Anthropology* 16:221-242.

Buck, P. E., W. T. Hartwell, G. Haynes, and D. Rhode
1998 *Investigations at Two Early Holocene Sites Near Yucca Mountain, Nye County, Nevada.* Topics in Yucca Mountain

Archaeology, Number 2. Desert Research Institute, Las Vegas, Nevada.

Burge, T. L., W. Matthews, and N. Stevens
1999 High Sierra Surveys in Kings Canyon National Park: 1997 and 1998. Paper Presented at the California Archaeological Annual Meeting, April 23 – 25, 1999, Sacramento, California.

Burge, T.L., and W. Matthews
2000 High Sierra Surveys in Kings Canyon National Park: 1997, 1998, and 1999. Paper presented at the 27th Great Basin Anthropological Conference, October 5-7, 2000, Ogden, Utah.

Burnham, R. C.
1950 The Climates of Utah. M. S. Thesis, Department of Geography, University of Utah.

Bye, R. A.
1972 Ethnobotany of the Southern Paiute Indians in the 1870s: with a Note on the Early Ethnobotanical Contributions of Dr. Edward Palmer. *Great Basin Cultural Ecology: A Symposium.* D. D. Fowler, editor. Desert Research Institute Publications in the Social Sciences, Reno.

Campbell, E. W. C., and W. H. Campbell
1935 The Pinto Basin Site. *Southwest Museum Papers Number 9.*

Canaday, T. W.
1991 Evaluating the Prehistoric Use of Great Basin Alpine Environments by Photogrammetric Means. Paper Presented at the Workshop on Remote Sensing and Mapping, U.S. Forest Service, Region 4, Ogden, Utah.

1992a. Aerial Photos as an Aid to Alpine Archaeology. Paper Presented at the 1992 Great Basin Anthropological Conference, Boise, Idaho.

1992b Archaeology at Altitude: Prehistoric Hunting Patterns in the Toiyabe Range, Nevada. Paper Presented at the 57th Annual Meeting, Society for American Archaeology, Pittsburgh, Pennsylvania.

1996 Alpine Hunting Patterns in Central and Eastern Nevada. Paper Presented at the 61st Annual Meeting of the Society for American Archaeology, New Orleans, Louisianna.

1997 *Prehistoric Alpine Hunting Patterns in the Great Basin.* Ph.D. Dissertation, Department of Anthropology, University of Washington, University Microfilms, Ann Arbor, Michigan.

1998a Cedar Breaks National Monument Archeological Survey – 1997 Summary Report. Manuscript on file at Zion National Park, Springdale, Utah.

1998b Results of Great Basin Alpine Surveys. Paper presented at the 63rd Annual Meeting of the Society for American Archaeology, Seattle, Washington.

1999 Cedar Breaks National Monument Archeological Survey – 1998 Summary Report. Manuscript on file at Zion National Park, Springdale, Utah.

Canaday, T. W., M. J. Betenson and L. P. Naylor, II
1999 Recent High Altitude Archaeological Surveys at Cedar Breaks National Monument. In, *Proceedings of the*

Fourth Biennial Conference of Research on the Colorado Plateau, edited by Charles van Riper III and Maureen A. Stuart, pp. 163 – 181, U. S. Geological Survey / FRESC Report Series, USGSFRESC / COPL / 1999 / 16.

Canaday, T. W., L. P. Naylor, II, and J. Burns
1997 High Altitude Surveys in Cedar Breaks National Monument, Southwestern Utah. Paper Presented at the 50th Annual Pecos Conference, Chaco Canyon National Park, August 14-17, 1997. Manuscript on File at Zion National Park, Springdale, Utah.

Canaday, T. W. and S. E. Reutebuch
1994 Searching for the Past: Aerial Photography and Alpine Archaeology on the Toiyabe National Forest. In *Remote Sensing and Ecosystem Management: Proceedings of the Fifth Forest Service Remote Sensing Applications Conference*, edited by Jerry Dean Greer, pp. 232-243, American Society for Photogrammetry and Remote Sensing, Bethesda, Maryland.

Cook, E. R., and L. A. Kairiukstis
1990 *Methods of Dendrochronology: Applications in the Environmental Sciences*. Kluwer, Boston.

Craig, C. A.
1977 Archaeological Investigation of the Cascade Falls Timber Sale, Cedar City Ranger District, Dixie National Forest. Manuscript on File at Dixie National Forest, Cedar City, Utah.

Currey, D.
1990 Quaternary palaeolakes in the evolution of semidesert basins, with special emphasis on Lake Bonneville and the Great Basin, U.S.A. *Palaeogeography, Palaeoclimatology, Palaeoecology*, 76: 189-214.

Davenport, J. B.
1991 Oral history tape, March 11, 1991. Transcription on file, Cedar Breaks National Monument.

Davis, J. O.
1978 "Quaternary Tephrachronology of the Lake Lahontan Area, Nevada and California." Nevada Archaeological Survey Research Papers 7.

Davis, O. K.
1999 Pollen analysis of Tulare Lake, California: Great Basin-like vegetation in central California during the full-glacial and early Holocene. *Review of Palaeobotany and Palynology* 107:249-257.

Deal, K.
1987 Cultural Resource Management Plan for Death Valley National Monument. Western Archeological and Conservation Center, National Park Service, Tucson, Arizona.

Dean, J. S.
1988 A Model of Anasazi Behavioral Adaptation. In *The Anasazi in a Changing Environment*, edited by Goerge Gummerman, pp. 25-44, Cambridge University Press, Cambridge.

Dean, J. S., and Gary S. Funkhouser
1994 Dendroclimatic Reconstructions for the Southern Colorado Plateau, In *Climate Change in the Four Corners and Adjacent Regions.* U.S. Department of Energy.

DeBloois, E. I.
1983 High Altitude Sites in Utah. In, High-Altitude Adaptations in the Southwest, edited by J. C. Winter, pp. 53-68, Cultural Resources Management Report No. 2, U. S. Forest Service, Southwestern Region.

Dillehay, T. D.
1989a *Monte Verde: A Late Pleistocene Settlement in Chile: Paleoenvironment and Site Context.* Volume I, Smithsonian Institution Press, Washington, D.C.

1989b Monte Verde. *Science* 245:1436.

1997 *Monte Verde: A Late Pleistocene Settlement in Chile: The Archaeological Context.* Volume II, Smithsonian Institution Press, Washington, D.C.

Dobyns, H. F.
1983 *Their Numbers Became Thinned: Native American Population Dynamics in Eastern North America.* University of Tennessee Press, Knoxville.

Draper, N., and H. Smith
1981 *Applied Regression Analysis.* Wiley, New York.

Durrant, S. D.
1952 *Mammals of Utah: Taxonomy and Distribution.* University of Kansas Publications, Museum of Natural History 6.

Dykman, J. L.
1976 Lowder Creek Timber Sale, Dixie National Forest, Cedar City Ranger District. Manuscript on File at Dixie National Forest, Cedar City, Utah.

Elston, R. G., K. L. Katzer, and D. R. Currey
1988 Chronological Summary. In *Preliminary Investigations at Stillwater Marsh: Human Prehistory and Geoarchaeology*, edited by Christopher Raven and Robert G. Elston, pp. 373 – 384, Cultural Resources Series Number 1, U. S. Department of the Interior, U. S. Fish and Wildlife Service, Region 1.

Earle, C. J., and H. C. Fritts
1986 Reconstructing Riverflow in the Sacramento Basin Since 1560. *Technical Report to California Department of Water Resources*, Sacramento.

Ezzo, J. A.
1996 *A Class I Cultural Resources Survey of the Moapa and Virgin Valleys, Clark County, Nevada Report submitted to the Bureau of Reclamation, Lower Colorado Region Office, Boulder City, NV 89006-1470.*

Fagan, B. M.
1987 *The Great Journey: The Peopling of Ancient America.* Thames and Hudson, New York.

Fairley, H. C.
1989 Culture History. In J. H. Altschul and H. C. Fairley, editors, *Man, Models and Management: An Overview of the Archaeology of the Arizona Strip and the Management of its Cultural Resources*, pp. 85 - 152, United States

Forest Service and United States Bureau of Land Management.

Fiedel, S. J.
1999 Older Than we Thought: Implications of Corrected Dates for Paleoindians. *American Antiquity* 64:95-115.

Fleniken, J. J., and A. W. Raymond
1986 Morphological Projectile Point Typology: Replication, Experimentation, and Technological Analysis. *American Antiquity* 51:603-614.

Fleniken, J. J., and P. J. Wilke
1989 Typology, Technology, and Chronology of Great Basin Dart Points. *American Anthropologist 91*:149-158.

Foster, R. H.
1968 *Distribution of the Major Plant Communities in Utah.* Ph.D. dissertation, Brigham Young University, University of Michigan Microfilms, Ann Arbor.

Fowler, D. D., and C. S. Fowler (editors)
1971a *Anthropology of the Numa: John Wesley Powell's Manuscripts on the Numic Peoples of Western North America, 1868-1880.* Smithsonian Contributions to Anthropology No. 14. Smithsonian Institution Press, Washington, D.C.

Fowler, C. S., and D. D. Fowler
1971b Notes on the History of the Southern Paiute and Western Shoshonis. In *Utah Historical Quarterly* 39:95-113.

Fowler, D., D. B. Madsen, and E. M. Hattori
1973 Prehistory of Southeastern Nevada. Desert Research Institute Publications in the Social Sciences, Number 6, University of Nevada, Reno.

Fowler, D. D., and J. F. Matley
1978 The Palmer Collection from Southwestern Utah 1875. Miscellaneous Collected Papers No. 20. University of Utah Anthropological Papers No 99, Salt Lake City.

Frank, B. W.
1997 Cedar Breaks National Monument Archeological Survey - 1996 Summary Report. Manuscript on file at Zion National Park, Springdale, Utah.

Frank, B. W., and M. J. Betenson
1997 A Research Design for the Archeological Survey of Cedar Breaks National Monument. Manuscript on file at Zion National Park, Springdale, Utah.

Fritts, H. C.
1976 *Tree Rings and Climate.* Academic Press, New York.

Fritts, H. C., D. G. Smith, J. W. Cardis, and C. A. Budulsky
1965 Tree-ring Characteristics Along a Vegetation Gradient in Northern Arizona. *Ecology 46*:393-401.

Funkhouser, G.
1999 Cedar Breaks Bristlecone Study. Manuscript on file at Zion National Park, Springdale, Utah.

George (Hunkup), I..
1950 Affadavit dated March 23, 1950. Unpublished document Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Gilmore, Richard
1987 Brian Head Remembers the Dance Hall Days. *The Daily Spectrum,* Saturday September 19, 1987:6-7.

Glass, R.
1983 CCCs in Iron County, paper presented to Iron County Historical Society, March 8, 1983.

n.d. Unpublished manuscript on file, Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Goss, J. A.
1977 Linguistic Tools for the Great Basin Prehistorian. In *Models and Great Basin Prehistory: A Symposium,* edited by D. D. Fowler, pp. 49-70. Publications in the Social Sciences, No. 12. Desert Research Institute, Reno, Nevada.

Graybill, D. A.
1979 Revised Computer Programs for Tree-ring Research. *Tree-Ring Bulletin 39*:77-82.

1982 Chronology Development and Analysis. In *Climate from Tree Rings*, edited by M. K. Hughes, P. M. Kelly, J. R. Pilcher, and V. C. LaMarche, Jr., University of Arizona Press, Tucson.

1985 Western U.S. Tree Ring Index Chronology Data for Detection of Arboreal Response to Increasing Carbon Dioxide. *US Department of Energy Green Book Reports on the Response Of Vegetation top Carbon Dioxide Series*, No. 26. Laboratory of Tree-Ring Research, University of Arizona, Tucson.

1987 A Network of High-Elevation Conifers in the Western United States for Detection of Tree-ring Growth Response to Increasing Carbon Dioxide. In *Proceedings of the International Symposium on Ecological Aspects of Tree-Ring Analysis*, complied by G. C. Jacoby and J. W. Hornbeck, pp. 463-474, U.S. Department of Commerce, Springfield, Virginia.

1989 The Reconstruction of Prehistoric Salt River Stream-flow. In *The 1982-1984, Excavations at Las Colinas, Environment and Subsistence*, by D. A. Graybill, D. A. Gregory, F. L. Nials, S. K. Fish, R.E Gasser, C.H. Miksicek, and C. R. Szuter, Archaeological Series 162, Volume 5, Part 1. Cultural Resource Management Division, Arizona State Museum, University of Arizona, Tucson.

Graybill, D. A., and M. R. Rose
1989 Analysis of Growth Trends in Conifers From Arizona and New Mexico. In *Effects of Air Pollution on Western Forests*, edited by R.K. Olson and A.S. Lefohn, pp. 395-407. Transactions of the Air and Waste Management Association.

Graybill, D.A., S. G. Shiyatov, and V. F. Burmistrov
1992 Recent Dendrochronological Investigations in Kirghizia USSR. In *Tree Rings and Environment: Proceedings of the International Symposium, Ystad, South Sweden, 3-9 September, 1990,* edited by T.S. Bartholin, B.E. Berglund, D. Eckstein, F.H. Schweingruber, and O. Eggertsson, pp. 123-127. Department of Quaternary Geology, Lund University. "Lundqua Report" 34.

Grayson, D. K.
1988 High Elevation Village Faunas From the White Mountains, California. Paper Presented at the 21st Great Basin Anthropological Conference, Park City, Utah.

1990 Great Basin Alpine Village Faunas. Paper Presented at the 55th Annual Meeting of the Society for American Archaeology, Las Vegas, Nevada.

1991 Alpine Faunas From the White Mountains, California: Adaptive Change in the Late Prehistoric Great Basin? *Journal of Archaeological Science*, 18:483-506.

1993 *The Desert's Past: A Natural Prehistory of the Great Basin.* Smithsonian Institution, Washington, D.C.

n.d. The Alta Toquima Village vertebrate fauna. In *The Archaeology of Monitor Valley 4, Alta Toquima Village*, edited by D. H. Thomas, Anthropological Papers of the American Museum of Natural History, New York. In preparation.

Gregory, H. E.
1950 Geology of Eastern Iron County, Utah. University of Utah and United States Geological Survey.

Griset, S. (editor)
1986 Pottery of the Great Basin and Adjacent Areas. University of Utah Anthropological Papers, Number 111. Salt Lake, Utah.

Gruhn, R.
1961 *The Archeology of Wilson Butte Cave, Southcentral Idaho.* Occasional Papers of the Idaho State College Museum 6.

Hamblin, J.
1951 *Journal of Jacob Hamblin.* Typed transcription of original, copy on file at the Utah State Historical Society, Salt Lake City.

Harrington, M. R.
1933 Gypsum Cave, Nevada. *Southwest Museum Papers*, Number 8, Los Angeles.

1957 A Pinto Site at Little Lake, California. *Southwest Museum Papers*, Number 17, Los Angeles

Harris, A.G., E. Tuttle, and S.D. Tuttle
1997 *Geology of the National Parks*, 5th Edition. Kendall / Hunt Publishing Company, Dubuque, Iowa.

Hatfield, S.C., P.D. Rowley, E.G. Sable, D.J. Maxwell, B.V. Cox, M.D. McKell, and D.E. Kiel
2000 Geology of Cedar Breaks National Monument, Utah. In, *The Geology of Utah Parks and Monuments*, edited by D.A. Sprinkel, P.B. Anderson, and T.C. Chidsey, Jr., Utah Geological Association Publications, 28:129-144.

Haynes, C. V.
1992 Contributions of Radiocarbon Dating to the Geochronology of the Peopling of the New World. In *Radiocarbon after Four Decades*, edited by R. Kra, pp. 355-374. Springer-Verlag, New York.

Hawkins, B.
1979 National Register of Historic Places Inventory Nomination Form for the Long Flat Site (42In330). Manuscript on File at Zion National Park, Springdale, UT.

Heath, S. H.
1996 *The Historic Old Sorrel Log Road of 1896.* Brochure published by by Southern Utah University and the Cedar Breaks District of the Boy Scouts of America, Cedar City.

Heizer, R. E., and M. A. Baumhoff
1961 The Archaeology of Two Sites at Eastgate, Churchill County, Nevada: Wagon Jack Shelter. *University of California Anthropological Records* 20:119 –149.

Heizer, R. E., M. A. Baumhoff, and C. W. Clewlow, Jr.
1968 Archaeology of South Fork Rock Shelter (NV El 11), Elko County, Nevada. *University of California Archaeological Survey Reports* 71:1 – 58, Berkeley.

Heizer, R. E., and C.W. Clewlow, Jr.
1968 Projectile Points from Site NV-CH-15, Churchill County, Nevada. *University of California Archaeological Survey Reports* 71:13 – 18, Berkeley.

Heizer, R. E., and T. R. Hester
1978 Great Basin Projectile Points: Forms and Chronology. Ballena Press, Socorro, New Mexico.

Hester, T. R.
1973 *Chronological Ordering of Great Basin Prehistory.* Contributions of the University of California Archaeological Research Facility, No. 17, Berkeley, California.

Hester, T. R., and R. E. Heizer
1973 *Review and Discussion of Great Basin Projectile Points.* University of California Research Facility, Berkeley.

Hinton, W. K.
1987 *The Dixie National Forest: Managing an Alpine Forest in an Arid Setting.* U.S. Forest Service, Washington, D.C.

Hockett, B. S.
1995 Chronology of Elko Series and Split Stemmed Points from Northeastern Nevada. *Journal of California and Great Basin Anthropology* 17:41 – 53.

Holmer, R. N.
1986 Common Projectile Points of the Intermountain West. In *Anthropology of the Desert West: Essays in Honor of Jesse D. Jennings*, edited by Carol J. Condie and Don D. Fowler, pp. 89 – 115, University of Utah Anthropological Papers, Number 110, Salt Lake City, Utah.

1995 Projectile Point Classification. *Tebiwa* 25:115-121.

Holmer, R. N., and D. G. Weder
1980 Common Post-Archaic Projectile Points of the Fremont Area. In *Fremont Perspectives*, edited by David B. Madsen, pp. 55 – 69. Utah State Historical Society, Antiquities Section Selected Papers 7(16), Salt Lake City.

Holmes, R. L.
1983 Computer-assisted Quality Control in Tree-ring Dating and Measurement. *Tree-Ring Bulletin 43:*69-78.

Holt, R. L.
1992 *Beneath These Red Cliffs An Ethnohistory of the Utah Paiutes.* University of New Mexico Press, Albuquerque.

Hughes, M. K., P. M. Kelley, R. J. Pilcher, and V.C. LaMarche, Jr.
1982 *Climate From Tree-Rings.* Cambridge University Press, Cambridge, Massachusetts.

Hughes, R. E.
1982 Age and Exploitation of Obsidian from the Medicine Lake Highland, California. *Journal of Archaeological Science* 9: 173-185.

1983 X-ray Fluorescence Characterization of Obsidian. In The Archaeology of Monitor Valley: 2. Gatecliff Shelter. Edited by David Hurst Thomas *Anthropological Papers of the American Museum of Natural History* 59: 401-408.

1984 Obsidian Sourcing Studies in the Great Basin: Problems and Prospects. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes. *Contributions of the University of California Archaeological Research Facility*, No. 45: 1-19.

1985 Obsidian Source Use at Hidden Cave. *In* David Hurst Thomas, The Archaeology of Hidden Cave, Nevada. *Anthropological Papers of the American Museum of Natural History* 61: 332-353.

1986 Diachronic Variability in Obsidian Procurement Patterns in Northeastern California and Southcentral Oregon. *University of California Publications in Anthropology* 17, Berkeley.

1988 The Coso Volcanic Field Reexamined: Implications for Obsidian Sourcing and Hydration Dating Research. *Geoarchaeology* 3: 253-265.

1990 Obsidian Sources at James Creek Shelter, and Trace Element Geochemistry of Some Northeastern Nevada Volcanic Glasses. In The Archaeology of James Creek Shelter, edited by Robert Elston and Elizabeth E. Budy. *University of Utah Anthropological Papers*, No. 115, pp. 297-305.

1993 Trace Element Geochemistry of Volcanic Glass from the Obsidian Cliffs Flow, Three Sisters Wilderness, Oregon. *Northwest Science* 67: 199-207.

1994a X-ray Fluorescence Analysis of Geologic Obsidian Samples and Artifacts from the Kern River Gas Transmission Project, Utah. *In* Kern River Pipeline Cultural Resources Data Recovery Report: Utah. Volume I, Research Context and Data Analysis. Report submitted by Dames & Moore to Kern River Gas Transmission Company, January 31, 1994.

1994b Intrasource Chemical Variability of Artifact-Quality Obsidians from the Casa Diablo Area, California. *Journal of Archaeological Science* 21:263-271.

1997a Results of X-Ray Fluorescence Analysis of Obsidian Samples from Cedar Breaks National Monument Archeological Sites, Iron County, Utah. Letter Report 97-107, Geochemical Research Laboratory, Portola Valley, California. On file, Zion National Park, Springdale, Utah.

1997b On Reliability, Validity, and Scale in Obsidian Sourcing Research. In *Unit Issues in Archaeology: Measuring Time, Space, and Material*, edited by Ann F. Ramenofsky and Anastasia Steffen pp. 103-114. University of Utah Press, Salt Lake City.

1997c X-ray Fluorescence Analysis of Obsidian from 26CK5423, Clark County, Nevada. Geochemical Research Laboratory Letter Report 97-5 submitted to Robin McMullen, Dames & Moore, February 10, 1997.

1998 Results of X-Ray Fluorescence Analysis of Obsidian Samples from Cedar Breaks National Monument Archeological Sites, Iron County, Utah. Letter Report 99-9, Geochemical Research Laboratory, Portola Valley, California. On file, Zion National Park, Springdale, Utah.

n.d. Geochemical Identification of the Sources for Alta Toquima Obsidian Artifacts. In The Archaeology of Monitor Valley: 4. Alta Toquima and the Mt. Jefferson Complex, edited by David Hurst Thomas. *Anthropological Papers of the American Museum of Natural History*. In press.

Hunkup, I.
1950 Affidavit dated March 23, 1950. Unpublished document, Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Hunt, C. B.
1967 *Physiography of the United States*. W. H. Freeman, San Francisco.

IMACS
1992 Intermountain Antiquities Computer System. University of Utah and Bureau of Land Management.

Inter-Tribal Council of Nevada
1976 *Nuwuvi: A Southern Paiute History*. Intertribal Council of Nevada.

Jacoby, G. C., and J. W. Hornbeck
1987 *Proceedings of the International Symposium on Ecological Aspects of Tree-Ring Analysis*. U.S. Department of Commerce, Springfield, Virginia.

Jake, C.
1991 Oral history, taped on March 11, 1991. Typwritten transcript on file, Cedar Breaks National Monument.

Janetski, J.
1990 Ethnicity and Post-Formative Ceramics in the Eastern Great Basin, p. 53-66, In *Hunter-Gatherer Pottery in the Far West*, edited by Joanne M. Mack. Nevada State Museum Papers No. 23. Carson City, Nevada

Jennings, J. D.
1957 *Danger Cave*. University of Utah Anthropological Papers, Number 27. Salt Lake City, Utah.

1978 *Prehistory of Utah and the Eastern Great Basin*. University of Utah Anthropological Papers, Number 98, Salt Lake City, Utah.

Jones, G. T., C. Beck, F. L. Nials, J. Neudorfer, B. J. Brownholtz, and H. B. Gilbert
1996 Recent Archaeological and Geological Investigations at the Sunshine Locality, Long Valley, Nevada. *Journal of California and Great Basin Anthropology* 18:48-63.

Karl, T. R., L. K. Metcalf, M.L. Nicodemus, and R.G. Quayle
1983 *Statewide Average Climatic History.* National Climatic Data Center, Asheville, North Carolina.

Karlstrom, T.N.V.
1988 Alluvial Chronological and Hydrologic Change of Black Mesa and Nearby Regions. In *The Anasazi in a Changing Environment*, edited by G. J. Gummerman, pp. 45-91. Cambridge University Press, Cambridge.

Kelly, I. T.
1934 Southern Paiute Bands. *American Anthropologist* 36:548-560.

1938 Band Organization of the Southern Paiute. *American Anthropologist* 40: 633-634.

1939 Southern Paiute Shamanism. *University of California Anthropological Records* 2:151-167.

1964 *Southern Paiute Ethnography* University of Utah, Department of Anthropology Papers, Salt Lake City.

Kelly, I. T., and C. S. Fowler
1986 Southern Paiute. *Handbook of North American Indians: Great Basin.* Smithsonian Institution, Washington, D.C.

Kelly, M. S., J. H. Cleland, K. L. Hull, A. J. MacDougall, and P. Friedman
1990 *Kern River Gas Transmission Company: Kern River Pipeline Cultural Resource Survey Report, Nevada.* Dames and Moore, San Diego.

Klein, A.
1991 Cedar Breaks National Monument, National Park Service: A Report of its Human History, On the Occasion of the 75th Anniversary of the National Park Service. Manuscript on File at Zion National Park, Springdale, Utah.

Kodack, M.
1997 *Environmental Structure and its Effects on Hunter-Gatherer Organizational Strategies in Eastern Nevada.* Ph.D. dissertation, University of California, Santa Barbara, University Microfilms, Ann Arbor.

Lajoie, K.R.
1968 "Late Quaternary stratigraphy and geologic history of Mono Basin, Eastern California." Unpublished Ph.D. dissertation, University of California-Berkeley, Berkeley.

LaMarche, V.C., Jr.
1974 Frequency Dependent Relationships Between Tree-ring Series Along an Ecological Gradient and Some Dendroclimatic Implications. *Tree-Ring Bulletin 34*:1-20.

Lamb, S. M.
1958 Linguistic Prehistory in the Great Basin. *International Journal of American Linguistics* 29:95-100.

Lanner, R. M.
1983 *Trees of the Great Basin: A Natural History.* University of Nevada Press, Reno.

Lanning, E. P.
1963 Archaeology of the Rose Spring Site INY-372. *University of California Publications in American Archaeology and Ethnology* 49:237 – 336.

Litwin, R. J., J.P. Smoot, N.J. Durika, and G.I. Smith
1999 Calibrating late Quaternary terrestrial climate signals: radiometrically data pollen evidence from the southern Sierra Nevada, U.S.A. *Quaternary Science Reviews* 18:1151-1171.

Lockett, C. L., and L. C. Pippin
1990 Re-examining Brownware Ceramics in the Central and Southern Great Basin. In *Hunter-Gatherer Pottery from the Far West*, edited by Joanne M. Mack, pp. 67 – 82, Nevada State Museum Anthropological Papers Number 23, Carson City, Nevada.

Lohse, A. E.
1995 Northern Intermountain Projectile Point Chronology. *Tebiwa* 25:3 – 51.

Lowder, M. E., and E. G. Bruin
1964 John and Emily Lowder's Range. Unpublished manuscript in George A. Croft Collection, MS 8, Special Collections, Gerald E. Sherratt Library, Southern Utah University, Cedar City, Utah.

Lowenstein, T. K., L. Jianren, C. Brown, S.M. Roberts, T.L. Ku, S. Luo, and W. Yang
1999 200 k.y. paleoclimate record from Death Valley salt core. *Geology* 27, 3-6.

Luedtke, B. E.
1992 *An Archaeologist's Guide to Chert and Flint.* Institute for Archaeology, University of California, Los Angeles.

Lyneis, M. M.
1982 Prehistory in the Southern Great Basin. In *Man and Environment in the Great Basin*, edited by David B. Madsen and James F. O'Connell, pp. 172-185. Society of American Archaeology Papers No. 2. Washington, D.C.

1984 The Western Anasazi Frontier: Cultural Processess along a Prehistoric Boundary. In *Exploring the Limits*, edited by Suzanne P. DeAtley and Frank J. Findlow, pp. 81-92. B.A.R. International Series No. 223. Oxford, England.

1990 Buff and Brown Wares at Lost City: A Fresh Look at Intrusives. *Nevada Archaeologist* 8:25-34.

1994a Chapter 9-Ceramics. In *Kern River Pipeline Cultural Resources Data Recovery Report: Utah Volume I*, W. G. Spaulding (Senior Editor), prepared for Kern River Gas Transmission Company, Salt Lake City.

1994b East and Onto the Plateaus? An Archeological Examination of the Numic Expansion in Southern Nevada, Northern Arizona, and Southern Utah. In *Across the West: Human Population Movement and the Expansion of the Numa,* edited by David B. Madsen and David Rhode, pp. 141-149. University of Utah Press, Salt Lake City.

1995 Virgin Anasazi, Far Western Puebloans. *Journal of World Prehistory* 9: 199-241.

Mackin, J.H.
1947 Some Structural Features of the Intrusions in the Iron Springs District. *Utah Geological Society Guidebook 2.*

Madsen, D. B.
1989 *Exploring the Fremont.* University of Utah Occasional Paper Number 8, Salt Lake City.

1997 Exploratory Paleoecology on the Markagunt Plateau: A Cooperative Project Between the National Park Service, the U.S. Forest Service and the Utah Geological Survey; Initial Report of 1997 Fieldwork. Manuscript on File at Zion National Park, Springdale, Utah.

Madsen, D.B. and D. Rhode (editors)
1994 *Across the West: Human Population Movement and the Expansion of the Numa.* University of Utah Press, Salt Lake City.

Madsen, D.B., A. Sarna-Wojciki, and R.S. Thompson
n.d. The Markagunt Ash Bed: A Widespread Late Pleistocene Tephra in the Southern Great Basin and Colorado Plateau. *Quaternary Research* (in review).

Madsen, D.B., T.R. Scott, and B. Loosle
2000 Differential Transport Costs and High-Altitude Occupation Patterns in the Uinta Mountains, Northeastern Utah. In *Intermountain Archaeology*, edited by David B. Madsen and Michael D. Metcalf, pp. 15-24, University of Utah Anthropological Papers Number 122, Salt Lake City.

Madsen, R. E.
1977 *Prehistoric Ceramics of the Fremont.* Museum of Northern Arizona Ceramic Series No. 6. Flagstaff.

Maldonado, F.
1995 Decoupling of mid-Tertiary rocks, Red Hills – western Markagunt Plateau, Southwestern Utah. In, Geologic Studies in the Basin and Range – Colorado Plateau Transition in Southeastern Nevada, southwestern Utha, and northwestern Arizona, edited by R.B. Scott and W.C. Swadley, *U.S. Geological Survey Bulletin 2056*:233-254.

Maldonado, F., E.G. Sable, and J.J. Anderson
1990 Shallow detachment of mid-Tertiary rocks, Red Hills (Basin and Range), with implications for a Regional Detachment zone in the Adjacent Markagunt Plateau (Colorado Plateau), Southwestern Utah. Geological Society of America Abstracts with Programs, 22(3):94.

1992 Evidence of Tertiary Low-angle Shear Zone, Red Hills, with Implications for Regional Shear Zone in the Adjacent Colorado Plateau. In, *Engineering and Environmental Geology of Southwestern Utah*, edited by K.M. Harty, Utah Geological Association Publication 21, pages 315-323.

Marwitt, J. P.
1970 *Median Village and Fremont Culture Regional Variation.* University of Utah Anthropological Papers, Number 95, Salt Lake City.

McConnell, G.
1962 Pioneer Dairying. Unpublished manuscript in George A. Croft Collection, MS 8, Special Collections, Gerald E. Sherratt Library, Southern Utah University, Cedar City.

McCutcheon, P. T.
1997 *Archaeological Investigations of Stone Tool Heat-Treatment Technology in Southeastern Missouri: An Experimental Approach.* Ph.D. dissertation, University of Washington, University Microfilms, Ann Arbor, Michigan.

McCutcheon, P. T., and R. C. Dunnell
1998 Variability in Crowleys Ridge Gravel. In, *Recent Research in the Central Mississippi River Valley*, edited by M. J. O'Brien and R. C. Dunnell, pp. 258-280, University of Alabama Press, Tuscaloosa, AL.

Meko, D. M., C.W. Stockton, and W. R. Boggess
1980 A Tree-ring Reconstruction of Drought in Southern California. *Water Resources Bulletin 16*:594-600.

Meltzer, D. J., D. K. Grayson, G. Ardila, A. W. Barker, D. F. Dincauze, C. V. Haynes, F. Mena, L. Nuñez, and D. J. Stanford
1997 On the Pleistocene Antiquity of Monte Verde, Southern Chile. *American Antiquity* 62:659-663.

Mensing, S. A., and J.R. Southon
1999 A simple method to separate pollen for AMS radiocarbon dating and its application to lacustrine and marine sediments. *Radiocarbon* 41:1-8.

Michaelson, J., L. Hasten, and F. W. Davis
1987 400 Years of Central California Precipitation Variability Reconstructed From Tree-rings. *Water Resources Bulletin 23:*809-818.

Mierendorf, R. R.
1998 Modeling Prehistoric Forager Use of Alpine Tundra Zones of the Northern Cascades Range, Pacific Northwest. Paper presented at the 63rd Annual Meeting, Society for American Archaeology, Seattle, Washington.

1999 Precontact Use of Tundra Zones in the Northern Cascades Range of Washington and British Columbia. *Archaeology in Washington* 7:3-23.

Mierendorf, R. R., D. J. Henry, and G. M. Sullivan
1998 *An Archaeological Site Survey and Evaluation in the Upper Skagit River Valley, Whatcom County, Washington.* North Cascades National Park Service Complex Technical Report, Sedro Wooley, Washington.

Monserud, R. A.
1986 Time Series Analysis of Tree-ring Chronologies. *Forest Science 32*:349-372.

Montgomery, D. C., and E.A. Peck
1992 *Introduction to Linear Regression Analysis*. Wiley, New York.

Moore, D.W., and L.D. Nealey
1993 Preliminary Geologic Map of Navajo Lake Quadrangle, Kane and Iron Counties, Utah. *U.S. Geological Survey Open-File Report 93-190*, 20 p., Scale 1:24,000.

Moratto, M. J.
1984 *California Archaeology*. Academic Press, San Diego.

Mulvey, W.E., D.R. Currey, and L.W. Lindsay
1984 Southernmost Occurrence of Late Pleistocene Glaciation in Utah: Brain Head-Sidney Peaks Areas, Markagunt Plateau. *Encyclia* 61: 97-104

Naylor, L. P., II, T. W. Canaday, and J. Burns
1997 Preliminary Results of Archaeological Surveys at Cedar Breaks National Monument. Paper Presented at the Fourth Biennial Conference of Research on the Colorado Plateau, Flagstaff, AZ, September 16-18, 1997. Manuscript on File at Zion National Park, Springdale, Utah.

Nelson, F. W., Jr.
1984 X-ray Fluorescence Analysis of Some Western North American Obsidians. In Obsidian Studies in the Great Basin, edited by Richard E. Hughes. *Contributions of the University of California Archaeological Research Facility*, No. 45: 27-62.

Nelson, F. W., and R. D. Holmes
1979 *Trace Element Analyses of Obsidian Sources and Artifacts from Western Utah.* Antiquities Section Selected Papers, Volume 6, No. 15, Salt Lake City.

National Park Service (NPS)
1991 *How to Apply the National Register Criteria for Evaluation.* National Register Bulletin 15, Department of the Interior, National Park Service, Washington D.C.

1997 *National Park Service Cultural Resource Management Guidelines.* Department of the Interior, National Park Service, Washington, D.C.

O'Connell, J. F.
1967 Elko Eared / Elko Corner-notched Projectile Points as Time Markers in the Great Basin. *University of California Archaeological Survey Reports* 70:129–140, Berkeley.

Oviatt, C. G., D. R. Currey, and D. Sack
1992 Radiocarbon Chronology of Lake Bonneville, Eastern Great Basin, USA.

Palmer, W. C.
1965 Meteorological Drought. *U. S. Weather Bureau Research Paper 45.* U. S. Weather Bureau, Washington, D.C.

Palmer, W. R.
1928a Utah Indians Past and Present. In *Utah Historical Quarterly* 1(2):35-52.

1928b Indian Names in Utah Geography. In *Utah Historical Quarterly* 1(1):5-25.

1929 Pahute Indian Government and Laws. In *Utah Historical Quarterly* 2:35-42.

1933 Pahute Indian Homelands In *Utah Historical Quarterly* 6 (1):33-102.

1936 Journal (untitled). Unpublished manuscript, Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

1946 A Report on the Wahnquint Band of Paiute Indians located at Cedar City, Utah. Unpublished manuscript, Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City

Parashont, W.
1950 Affadavit, dated May 1, 1950. Unpublished document Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Pendleton, L. S.A., and D. H. Thomas
1983 *The Fort Sage Drift Fence, Washoe County, Nevada.* Anthropological Papers of the American Museum of Natural History, 58(2):1-38, New York.

Perry, L. M.
1997 Pottery From the Cedar Breaks Survey. Letter Report on file at Zion National Park, Utah.

Pippen, L. C.
1986 Intermountain Brownwares: An Assessment. In *1983 Great Basin/California Pottery Workshop*, edited by S. Griset, University of Utah Anthropological Papers, Number 111. Salt Lake City.

Powell, J. W., and G.W. Ingalls
1873 Special Commissioners Report, dated June 18, 1873 to Howard P. Smith, Commissioner of Indian Affairs

1874 Report of J.W. Powell and G.W. Ingalls, Special Commissioners to enumerate Indians in Nevada and adjacent places. *Annual Report of the Commissioner of the Interior for the Year 1873*. Pp. 41-58. Washington, D.C.:GPO

Price, B. A. and S. E. Johnston
1988 A Model of Late Pleistocene and Early Holocene Adaptation in Eastern Nevada. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 231-250, Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

Reheis, M. C., J.L. Slate, and T.L. Sawyer
1995 "Geologic map of late Cenozoic deposits and faults in parts of the Mt. Barcroft, Piper Peak, and Soldier Pass 15' quadrangles, Esmeralda County, Nevada, and Mono County, California." U.S. Geological Survey Miscellaneous Investigations Series Map I-2264, scale 1:24,000.

Reheis, M. C., J.L. Slate, C.K. Throckmorton, J.P. McGeehin, A.M. Sarna-Wojcicki, and L. Dengler
1996 Late Quaternary sedimentation on the Leidy Creek fan, Nevada-California: geomorphic responses to climate change. *Basin Research* 12:279-299.

Rhode, D.
1987 *The Mountains and the Lake: Prehistoric Lacustrine - Upland Settlement Relationships in the Walker River Watershed, Western Nevada.* Ph. D. Dissertation, University of Washington. University Microfilms, Ann Arbor, Michigan.

1994 Direct Dating of Brown Ware Ceramics Using Thermoluminescence and its Relation to the Numic Spread. In *Across the West: Human Population Movement and the Expansion of the Numa*, edited by David B. Madsen and David Rhode, pp. 124 – 130, University of Utah Press, Salt Lake City.

Rogers, M.
1939 Early Lithic Industries of the Lower Basin of the Colorado River and Adjacent Desert Areas. *San Diego Museum of Man Papers Number 3*.

Rose, J. A., and R. J. Snedeker.
1982 High Altitude Archaeology: the Markagunt Plateau. Manuscript on file at the U.S. Forest Service, Intermountain Region, Ogden, Utah.

Rose, M. R.
1983 Time Domain Characteristics of Tree-ring Chronologies and Eigenvector Amplitude Series From Western North America. *Laboratory of Tree-Ring Research Technical Notes, Number 25,* University of Arizona, Tucson.

Sable, E.G., and J.J. Anderson
1985 Tertiary Tectonic Slide Megabreccia, Markagunt Plateau, Southwestern Utah. *Geological Society of America Abstracts with Programs*, 17(4):263.

Sable, E.G., and F. Maldonado
1997a Breccias and Megabreccias, Markagunt Plateau, Southwestern Utah – Origin, Age, and Transport Directions. In Geologic Studies in the Basin and Range-Colorado Plateau Transition in Southeastern Nevada, Southwestern Utah, and Northwestern Arizona, 1995, edited by F. Maldonado and L.D. Nealey. *U.S. Geological Survey Bulletin* 2153-A.:151-176. U.S. Government Printing Office. Washington, D.C.

1997b The Brian Head Formation (Revised) and Selected Tertiary Sedimentary Rock Units, Markagunt Plateau and Adjacent Areas, Southwestern Utah. In Geologic Studies in the Basin and Range-Colorado Plateau Transition in Southeastern Nevada, Southwestern Utah, and Northwestern Arizona, 1995, edited by F. Maldonado and L.D. Nealey. *U.S. Geological Survey Bulletin* 2153-A:5-26. U.S. Government Printing Office. Washington, D.C.

Sapir, E.
1930 The Southern Paiute Language. *Proceedings of the American Academy of Arts and Sciences* 65 (1-3), Boston.

Sargent, K.
1979 Archaeological Testing at the Lowder Creek Bog Site (42IN461), Dixie National Forest, Iron County, Utah. Manuscript on File at the Dixie National Forest, Cedar City, Utah.

Sarna-Wojcicki, A. M., H.R. Bowmun, C.E. Meyer, P.C.Russell, M.J. Woodward, G. McCoy, J.J. Rowe, Jr., P.A. Bacdecker, F. Asaro, and H. Michael
1984 Chemical analyses, correlations, and ages of upper Pliocene and Pleistocene ash layers of eastcentral and southern California. *U.S. Geolological Survey Professional Paper* 1293, 40 p.

Sarna-Wojcicki, A. M., K.R Lajoie, C.E. Meyer, D.P. Adam, S.W. Robinson, and R.S. Anderson
1988 Tephrochronologic studies of sediment cores from Walker Lake, Nevada. U.S. Geological Survey Open-File Report 88-548, 25 p.

Sarna-Wojcicki, A., and J. Davis
1991 Quaternary Tephrochronology, In Quaternary Nonglacial Geology: Conterminous United States, edited by R.B. Morrison. *Geological Society of America, DNAG Series, V. K-2:* 93-116.

Sarna-Wojcicki, A. M., C.E. Meyer, H.R. Bowman, N.T. Hall, P.C. Russell, M.L. Woodward, and J.L. Slate
1985 Correlation of the Rockland ash bed, a 400,000-year-old stratigraphic marker in northern California and western Nevada, and implications for middle Pleistocene paleogeography of central California. *Quaternary Research* 23: 236-257.

Schroeder, A. H.
1961 *The Archaeological Excavations at Willow Beach, Arizona, 1950.* University of Utah Anthropological Paper No. 50. University of Utah Press, Salt Lake City.

Schroedl, A. R.
1976 *The Archaic of the Northern Colorado Plateau.* Ph.D. dissertation, University of Utah, Salt Lake City, University Microfilms, Ann Arbor, Michigan.

Seegmiller, J. B.
1997 *A History of Iron County: Community Above Self.* Utah Centennial County History Series, Utah State Historical Society, Salt Lake City.

Shutler, R,
1961 *Lost City: Pueblo Grande de Nevada.* Anthropology Papers No. 5. Nevada State Museum, Carson City.

Siegel, S.
1956 *Nonparametric Statistics for the Behavioral Sciences.* McGraw Hill, New York.

Sieh, K., and M. Bursik
1986 Most recent eruption of the Mono Craters, eastern central California. *Journal of Geophysical Research* 91 (B12):12,539-12,571.

Simms, S. R.
1979 *High Altitude Archaeology in Utah: A Cultural Resource Inventory of 11 Projects and a Test Excavation (42SV1357) in the Fishlake National Forest.* Archaeological Center, Department of Anthropology, University of Utah, Reports of Investigations, No. 79-36.

1986 New Evidence for Fremont Adaptive Diversity. *Journal of California and Great Basin Anthropology* 8:204-216.

1990 Fremont Transitions. *Utah Archaeology* 3:1-18.

1993 Archaeological Investigations in the Jarbidge Mountains, Humboldt National Forest, Nevada, Progress Report, 1992 Season. Utah State University Contributions to Anthropology 4.

Smith, G.I., and J.L. Bischoff (Editors)
1997 An 800,000-Year Paleoclimatic Record from Core OL-92, Owens Lake, Southeast California. *Geological Society of America Special Paper* 317. Boulder, Colorado.

Smith, S.
1990 Swamp Lake volcanic ash analysis. Final Report, the Yosemite Association, Yosemite National Park, Calif., April 18, 12 p.

Snow, W. J.
1929 Utah Indians and the Spanish Slave Trade. In *Utah Historical Quarterly* 2(3):67-90

Spencer, R.J., M.J. Baedecker, H.P. Eugster, R.M. Forester, M.B. Goldhaber, B.F. Jones, K. Kelts, J. Mckenzie, D.B. Madsen, S.L. Rettic, M. Rubin, and C.J. Bowser
1984 Great Salt Lake, and precursors, Utah: the last 30,000 years. *Contributions to Mineralogy and Petrology,* 86: 321-334.

Steward, J. H.
1938 *Basin-Plateau Aboriginal Sociopolitical Groups.* Smithsonian Institution Press, Washington, D.C.

1970 The Foundations of Basin-Plateau Shoshonean Society. In *Languages and Cultures of Western North America: Essays in Honor of Sven S. Liljeblad*, Caldwell, Idaho.

Stockton, C.W.
1975 Long-term Streamflow Records Reconstructed From Tree Rings. *Papers of the Laboratory of Tree-Ring Research, Number 5.* The University of Arizona Press, Tucson.

Stoffle, R., D. E. Austin, D. B. Halmo, and A. M. Phillips III
1997 Ethnographic Overview and Assessment: Zion National Park and Pipe Springs National Monument. Submitted to the Rock Mountain Regional Office, National Park Service, Denver, Colorado.

Stoffle, R. W., D. B. Halmo, J. E. Olmstead, and M. J. Evans
1990 Native American Cultural Resource Studies at Yucca Mountain, Nevada. The Institute for Social Research, University of Michigan, Ann Arbor.

Stokes, W.L.
1986 The Geology of Utah. *Occasional Papers of the Utah Museum of Natural History* 6. Salt Lake City.

Stokes, M. A., and T. L. Smiley
1968 *An Introduction to Tree-Ring Dating.* The University of Chicago, Press, Chicago.

Stuiver, M., A. Long, R. S. Kra, and J. M. Devine
1993 Calibration – 1993. *Radiocarbon* 35 (1).

Stuiver, M., P.J. Reimer, E. Bard, J.W. Beck, G.S. Burr, K.A. Hughen, B. Kromer, F.G. McCormac, J. Plicht, and M. Spurk
1998 INTCAL98 Radiocarbon age calibration 24,000 - 0 cal BP. *Radiocarbon* 40, 1041-1083.

Sutton, M. Q.
1996 The Current Status of Archeological Research in the Mojave Desert. *Journal of California and Great Basin Anthropology* 18:221-257.

Talma, A. S., and J. C. Vogel
1993 A Simplified Approach to Calibrating C14 Dates. *Radiocarbon* 35:317-322.

Thomas, D. H.
1970 Archaeology's Operational Imperative: Great Basin Projectile Points as a Test Case. *University of California Archaeological Survey Report* 12:27-60.

1981 How to Classify the Projectile Points From Monitor Valley, Nevada. *Journal of California and Great Basin Anthropology* 3:7 – 43.

1982 *The 1981 Alta Toquima Village Project: A Preliminary Report.* Desert Research Institute, University of Nevada System, Social Sciences Center Technical Report Series, No. 27, Reno, Nevada.

1983 The Archaeology of Monitor Valley, 1. Epistomology. *Anthropological Papers of the American Museum of Natural History,* Volume 58, Part 1:1 – 194, New York.

1988 The Archaeology of Monitor Valley, 3. Survey and Additional Excavations. *Anthropological Papers of the American Museum of*

Natural History, Volume 66, Part 2:131 – 633, New York.

Thomas, D. H., and S. L. Bierworth
1983 Material Cultural of Gatecliff Shelter: Projectile Points. In The Archaeology of Monitor Valley, 2. Gatecliff Shelter, edited by David H. Thomas, pp. 177 – 211, *Anthropological Papers of the American Museum of Natural History,* Volume 59, Part 1:1 – 552. New York.

Thomas, D. H., and R. L. Bettinger
1976 Prehistoric Pinon Ecotone Settlements of the Upper Reese River Valley, Central Nevada. *Anthropological Papers of the American Museum of Natural History,* Volume 53, Part 3, New York.

Thomas, D. H., and L. S. A. Pendleton
1990 High Altitude Archaeology at Alta Toquima Village, Nevada. Paper Presented at the 55th Annual Meeting of the Society for American Archaeology, Las Vegas, NV.

Thompson, R. A., and G. B.
1982 The Prehistory and Environment of Southwest Utah. Ms. Intersearch, Cedar City, Utah.

Thompson, R. S.
1992 Late Quaternary environments in Ruby Valley, Nevada. *Quaternary Research* 37:1-15.

Thompson, R. S., and C.G. Oviatt
1999 "Tephrochronology and radiocarbon dating of Holocene sediments from Great Salt Lake, Utah." Geological Society of America, Annual Meeting, Denver, CO. Abstracts with Program.

Thompson, R.S., C.G. Oviatt, A.P. Roberts, J.Buchner, R. Kelsy, C. Bracht, R.M. Forester, and J.P. Bradbury
1995 Stratigraphy, Sedimentology, Paleontology, and Paleomagnetism of Pliocene-Early Pleistocene Lacustrine Deposits in Two Cores from Western Utah. *U.S. Geological Survey Open-File Report* 95-1.

Tipps, B. L
1995 Holocene Archeology Near Squaw Butte, Canyonlands National Park, Utah. Selections from the Division of Cultural Resources, Number 7. Rocky Mountain Region, National Park Service, Denver, Colorado.

Tipps, B. L., and N. J. Hewitt
1989 *Cultural Resource Inventory and Testing in the Salt Creek Pocket and Devils Lane Areas, Needles District, Canyonlands National Park, Utah.* Selections from the Division of Cultural Resources, Number 1, Rocky Mountain Region, National Park Service, Denver, Colorado.

Toulouse, J. H.
1971 B*ottle Makers and Their Marks.* Thomas Nelson Inc., Nashville, Tennessee.

Tuohy, D. R.
1990 Second Thughts on Shoshoni Pots From Nevada and Elsewhere. In *Hunter-Gatherer Pottery from the Far West,* edited by Joanne M. Mack, pp.83 – 105, Nevada State Museum Anthropological Papers Number 23, Carson City, Nevada.

Vogel, J. C., A. Fuls, E. Visser, and B. Becker
1993 Pretoria Calibration Curve for Short Lived Samples. *Radiocarbon* 35:73-86.

Vogel, J. C., and J. Kronfeld
1997 Calibration for Radiocarbon Dates for the Late Pleistocene Using T/Uh Dates on Stalagmites. *Radiocarbon* 39:27-32.

Walling, B. A., R. A. Thompson, G. F. Dalley, and D. G. Weder
1986 *Excavations at Quail Creek.* Utah Bureau of Land Management Cultural Resource Series, No. 20, Salt Lake City.

Warner, T. (editor)
1976 *The Dominquez-Escalante Journal.* Brigham Young University Press, Provo.

Warren, C. N.
1980 Pinto Points and Problems in Mojave Desert Archeology. In *Anthropological Papers in Memory of Earl H. Swanson, Jr.,* edited by L. B. Harton, Claude N.Warren, and Donald R. Tuohy, pp. 67 – 76, Idaho Museum of Natural History, Pocatello.

Warren, C. N. and R. H. Crabtree
1986 Prehistory of the Southwest Area. In *Great Basin,* edited by Warren L. D'Azevedo, pp. 183-193. Handbook of North American Indians, Vol. 11, William C. Sturtevant, general editor. Smithsonian Institution, Washington, D.C.

Warren, C. N., and C. Phagen
1988 Fluted Points in the Mojave Desert: Their Technology and Cultural Context. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J.A. Willig, C.M. Aikens, and J.L. Fagan, pp. 121-130, Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

Weng, C., and S. T. Jackson
1999 Late glacial and Holocene vegetation history and paleoclimate of the Kaibab Plateau, Arizona. *Palaeogeography, Palaeoclimatology, Palaeoecology* 153: 179-201.

Wickstrom, C. K. R.
1993 Spatial and Temporal Characteristics of High Altitude Site Patterning in the Southern Sierra Nevada. Center for Archaeological Research at Davis, Publication No. 11.

Wigley, T.M.L., K.R. Briffa, and P.D. Jones
1984 On the Average Value of Correlated Time Series With Applications in Dendroclimatology and Hydrometeorology. *Journal of Climate and Applied Meteorology 23*:201-213.

Willig, J. A.
1984 Geoarchaeological Research at the Dietz Site and the Question of Clovis Lake/Marsh Adaptation in the Northern Great Basin. *Tebiwa* 21:56-69.

1985 Paleo-Indian Occupation in the Alkili Lake Basin of South-Central Oregon: Current Status of Geoarchaeological Research. Paper presented at the 38th Annual Northwest Anthropological Conference, Ellensburg, Washington.

1986 Lakeside Settlement Pattern in the Dietz Sub-basin: A summary of 1984-1996 Research. Paper presented at the 50th Biennial Great Basin Anthropological Conference, Las Vegas, Nevada.

1988 Paleo-Archaic Adaptations and Lakeside Settlement Patterns in the Northern Alkili Basin. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J. A. Willig, C. M. Aikens, and J. L. Fagan, pp. 417-482, Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

1989 *Paleo-Archaic Broad Spectrum Adaptations at the Pleistocene-Holocene Boundary in Far Western North America.* Ph.D. Dissertation, University of Oregon, Eugene, University Microfilms, Ann Arbor, Michigan.

Willig, J. A., and C. M. Aikens
1988 The Clovis-Archaic Interface in Far Western North America. In *Early Human Occupation in Far Western North America: The Clovis-Archaic Interface*, edited by J. A. Willig, C. M. Aikens, and J. L. Fagan, pp. 1-40, Nevada State Museum Anthropological Papers, Number 21, Carson City, Nevada.

Winter, J. C.
1983 Introduction: High-Altitude Resource Use in the Southwest. In *High-Altitude Adaptations in the Southwest*, edited by J. C. Winter, pp. 1 - 11, Cultural Resources Management Report No. 2, U.S.D.A. Forest Service, Southwestern Region.

Wood, S. H.
1977 Distribution, correlation, and radiocarbon dating of late Holocene tephra, Mono and Inyo Craters, eastern California. *Geological Society of America Bulletin* 88:89-95.

Wonnacott, R. J., and T. H. Wonnacott
1981 *Regression: A Second Course in Statistics.* Wiley, New York.

Wright, C. A.
1998 Oral history Tape-S, February 6, 1998. Transcript on file in Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Yellowjacket, M. J.
1950 Affadavit Unpublished document on file at Special Collections, Gerald Sheratt Library, Southern Utah University, Cedar City.

Yohe, R. M., II
1992 *A Reevaluation of Western Great Basin Cultural Chronology and Evidence for the Timing of the Introduction of the Bow and Arrow to Eastern California Based on New Excavations at the Rose Spring Site (CA-INY-372).* Ph. D. dissertation, University of California, Riverside. University Microfilms, Ann Arbor, Michigan.

York, R.
1979 The Long Valley Archaeological Study: Fitting it all Together. Paper presented at the 44th Annual Meeting of the Society for American Archaeology, Vancouver, B.C., Canada.

Zeanah, D. W.
2000 Transport Costs, Central-Place Foraging, and Hunter-Gatherer Alpine Land-Use Strategies. In *Intermountain Archaeology*, edited by David B. Madsen and Michael D. Metcalf, pp. 1-14, University of Utah Anthropological Papers Number 122, Salt Lake City.

Editing services provided by Recreation and Partnership Program
Intermountain Support Office-Santa Fe
National Park Service
Year 2001

APPENDIX A

Letter Reports on Cedar Breaks Obsidian Sourcing

by

Richard E. Hughes
Geochemical Research Laboratory
Portola Valley, CA 94028

Geochemical Research Laboratory Letter Report 97-107

December 10, 1997

Mr. Laird Naylor, Archeologist
National Park Service
Zion National Park
Springdale, Utah 84767

Dear Mr. Naylor:

Enclosed with this letter you will find a four-page table presenting x-ray fluorescence (xrf) data generated from the analysis of 55 obsidian artifacts from archaeological sites in the Cedar Breaks Archaeological Project, Zion National Park, Utah. Although 67 specimens were sent for analysis, eight of them (field specimen numbers 36, 38, 52, 60, 66, 122, 124, and 187) were too small (i.e.< ca. 9-10 mm diameter) and/or too thin (i.e. < ca. 1.5 mm thick) for generating reliable quantitative data by xrf. This research was conducted pursuant to letter requests from Superintendent Donald A. Falvey, dated October 15 and 21, 1997, and Zion National Park purchase order number PX 1590-7-0289.

Analyses of obsidian are performed at my laboratory on a Spectrace™ 5000 (Tracor X-ray) energy dispersive x-ray fluorescence spectrometer equipped with a rhodium (Rh) x-ray tube, a 50 kV x-ray generator, with microprocessor controlled pulse processor (amplifier) and bias/protection module, a 100 mHz analog to digital converter (ADC) with automated energy calibration, and a Si(Li) solid state detector with 160 eV resolution (FWHM) at 5.9 keV in a 30 mm^2 area. The x-ray tube is operated at 34.0 kV, .25 mA, using a .127 mm Rh primary beam filter in an air path to generate x-ray intensity data for elements zinc (Zn Kα), gallium (Ga Kα), rubidium (Rb Kα), strontium (Sr Kα), yttrium (Y Kα), zirconium (Zr Kα), and niobium (Nb Kα). Barium (Ba Kα) intensities are generated by operating the x-ray tube at 50.0 kV, .35 mA, with a .63 mm copper (Cu) filter, while those for titanium (Ti Kα), manganese (Mn Kα) and total iron ($Fe_2O_3^T$) are generated by operating the x-ray tube at 15.0 kV, .28 mA with a .127 mm aluminum (Al) filter. Iron vs. manganese (Fe Kα/Mn Kα) ratios are computed from data generated by operating the x-ray tube at 15.0 kV, .30 mA, with a .127 mm aluminum (Al) filter. Deadtime-corrected analysis time for each sample appears in the data table.

After x-ray spectra are acquired and elemental intensities extracted for each peak region of interest, matrix correction algorithms are applied to specific regions of the x-ray energy spectrum to compensate for inter-element absorption and enhancement effects. After these corrections are made, intensities are converted to concentration estimates by employing a least-squares calibration line established for each element from analysis of up to 30 international rock standards certified by the U.S. Geological Survey, the U.S. National Institute of Standards and Technology, the Geological Survey of Japan, the Centre de Recherches Petrographiques et Geochimiques (France), and the South African Bureau of Standards. Further details pertaining to x-ray tube operatingconditions and calibration appear in Hughes (1988, 1994). Extremely small/thin specimens are analyzed using a .25 mm^2 primary beam collimator, and resulting data normalized using a sample mass-correction algorithm. Deadtime-corrected analysis time is greatly extended in all instances when primary beam collimation is employed.

Trace element measurements on the xrf data tables (except Fe/Mn ratios) are expressed in quantitative units (i.e. parts per million [ppm] by weight), and matches between unknowns and known obsidian chemical groups were made on the basis of correspondences (at the 2-sigma level) in diagnostic trace element concentration values (in this case, ppm values for Rb, Sr, Y, Zr, Nb and, when necessary, Ba, Ti, Mn and $Fe_2O_3^T$) that appear in Hughes (1983, 1984, 1985, 1986, 1990, n.d.), Nelson (1984), Nelson and Holmes (1979) and certain other unpublished data in my possession on other northern Nevada obsidians. Artifact-to-obsidian source (geochemical type) correspondences were considered reliable if diagnostic mean measurements for artifacts fell within 2 standard deviations of mean values for source standards. I use the term "diagnostic" to specify those trace elements that are well-measured by x-ray fluorescence, and whose concentrations show low intra-source variability and marked variability across sources. In short, diagnostic elements are those whose concentration values allow one to draw the clearest geochemical distinctions between sources (Hughes 1990, 1993). Although Zn, Ga and Nb ppm concentrations also were measured and reported for each specimen, they are not considered "diagnostic" because they don't usually vary significantly across obsidian sources (see Hughes 1982, 1984). This is particularly true of Ga, which occurs in concentrations between 10-30 ppm in nearly all parent obsidians in the study area. Zn ppm values are infrequently diagnostic; they are always high in Zr-rich, Sr-poor peralkaline volcanic glasses, but otherwise they do not vary significantly between sources in the study area.

Composition measurements are reported to the nearest ppm (or, for $Fe_2O_3^T$, to nearest hundredth wt. %) to reflect calibration-imposed resolution capabilities of non-destructive energy dispersive x-ray fluorescence spectrometry. The resolution limits of the present x-ray fluorescence instrument for the determination of Zn is about 3 ppm; Ga about 2 ppm; for Rb about 4 ppm; for Sr about 3 ppm; Y about 3 ppm; Zr about 4 ppm; and Nb about 3 ppm (see Hughes [1988, 1994b] for other elements). When counting and fitting error uncertainty estimates (the "±" value in the table) for a sample are greater than element-specific resolution limits given above, the larger number is a more conservative indicator of composition variation and measurement error arising from differences in sample size, surface and x-ray reflection geometry.

The artifact-to-source (i.e., chemical type; see Hughes [1997a] for discussion) attribution for each specimen appears on the data table, and the locations of some of the source types identified appear in Hughes (n.d.), and Nelson (1984: Figure 1). Interestingly, only three chemical varieties of obsidian were identified in this sample from Cedar Breaks. The vast majority of samples (43 of 55; 78% of the sample total) have the same trace element fingerprint as geologic obsidians from the Wild Horse Canyon source in the Mineral Mountains, about 90 km north of the project area. Nine artifacts (16% of the sample total) match the chemical profile of obsidian of the Panaca Summit chemical type, nodules of which occur over 100 km to the west of Cedar Breaks. I use the term, Panaca Summit in concert with Nelson's (1984) 'Modena area' because my own reference collections made from geologic occurrences in the Panaca Summit area (east of Panaca, Nevada) document that glass of this chemical type occurs in geologic contexts beyond the immediate vicinity of Modena. Finally, three artifacts have a trace element composition most similar to volcanic glass from the vicinity of Obsidian Butte in Nye County, Nevada, over 350 km to the west. Although this is a considerable distance, it is perhaps worth noting here that a few artifacts made from Wild Horse Canyon obsidian have been identified in archaeological sites not too distant from Obsidian Butte, Nevada (e.g. at 26CK5423, Hughes 1997b).

I hope this information will help in your analysis of these site materials. As you requested, I have enclosed a computer disk with copies of this letter report and accompanying data table. Please contact me at my laboratory ([650] 851-1410) if I can be of further assistance.

Sincerely,

[Signed original]

Richard E. Hughes, Ph.D.
Director, Geochemical Research Laboratory

encl.

Geochemical Research Laboratory Letter Report 99-9

February 5, 1999

Dr. Tim Canaday, Archaeologist
National Park Service
Zion National Park
Springdale, Utah 84767

Dear Tim:

Enclosed with this letter you will find two tables presenting x-ray fluorescence (xrf) data generated from the analysis of 34 obsidian artifacts from archaeological sites in the-Cedar Breaks Archaeological Project (n= 13) and from Zion National Park, Utah (n= 21). Although 36 specimens were sent for analysis, two of them (field specimen numbers 83a and 97 from Zion N.P. site 42Inl342) were too small (i.e. < ca. 9-10 mm diameter) and/or too thin (i.e. c ca. 1.5 mm thick) for generating reliable quantitative data by xrf. This research was conducted pursuant to a letter request from Superintendent Donald A. Falvey, dated January 5, 1999, and Zion National Park purchase order number PX 1590-8-0140. Laboratory analysis conditions, artifact-to-source (geochemical type) attribution procedures, element-specific measurement resolution limits, and literature references applicable to analyses of these samples follow those I reported previously for obsidian from the Cedar Breaks Archaeological Project (Hughes 1997).

As was the case with the previous sample of artifacts analyzed from the Cedar Breaks project (Hughes 1997), the majority of specimens (10 of 13; 77% of this sample total) have the same trace element fingerprint as geologic obsidians from the Wild Horse Canyon source in the Mineral Mountains. Two other artifacts match the chemical profile of obsidian of the Panaca Summit chemical type (nodules of which occur over 100 km to the west of Cedar Breaks), and one specimen has a trace element composition that matches volcanic glass from Black Mountain, located just south of the town of Beaver, Utah (cf. Hughes 1994: Table XRF- 1).

Fourteen of 21 artifacts analyzed in the Zion National Park sample match the Panaca Summit chemical type, six conform to the Wild Horse Canyon trace element signature, and one specimen matches the fingerprint of Black Mountain volcanic glass.

I hope this information will help in your analysis of these site materials. As requested, I have enclosed a computer disk with copies of this letter report and accompanying data tables. Please contact me at my laboratory ([650] 851-1410; e-mail: rehughes@silcon.com) if I can be of further assistance.

Sincerely,

[signed original]

Richard E. Hughes, Ph.D.
Director, Geochemical Research Laboratory

encl.

Table A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area.

Site/Cat Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source / Artifact Type
	Trace and Selected Minor Element Concentrations											**Ratio**	
42In1135 FS #2	46 ±5	16 ±3	191 ±4	76 ±3	26 ±3	112 ±4	17 ±3	487 ±14	nm	nm	nm	nm	Panaca Summit, NV **Pinto Series**
42In1135 FS #4	48 ±5	16 ±3	191 ±4	39 ±3	19 ±3	107 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Large C-notched**
42In1135 FS #7	45 ±6	18 ±3	170 ±4	56 ±3	20 ±3	125 ±4	19 ±3	350 ±14	nm	354 ±8	0.89 ±0.08	nm	Obsidian Butte, NV Variety H-3 **Gypsum**
42In1135 FS # 18	46 ±5	17 ±3	190 ±4	39 ±3	21 ±3	109 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1135 FS #20	45 ±5	14 ±3	193 ±4	39 ±3	19 ±3	109 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon ,UT **Biface**
42In1135 FS #24	48 ±6	20 ±3	191 ±4	37 ±3	20 ±3	107 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1135 FS #30	47 ±6	18 ±3	191 ±4	39 ±3	20 ±3	112 ±4	23 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko Eared**
42In1135 FS#244	45 ±6	16 ±3	197 ±4	39 ±3	19 ±3	106± 4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Gypsum**
42In1135 FS#245	44 ±6	14 ±3	186 ±4	37 ±3	18 ±3	105 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1135 FS#246	52 ±5	18 ±3	189 ±4	38 ±3	20 ±3	105 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko Eared**
42In1135 FS#98-3	49 ±6	19 ±3	188 ±4	36 ±3	19 ±3	107 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Pinto Series**
42In1135 FS#98-4	45 ±6	14 ±3	185 ±4	39 ±3	19 ±3	104 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1135 FS#98-6	41 ±6	14 ±3	140 ±4	53 ±3	24 ±3	151 ±4	21 ±3	449 ±14	1468 ±19	351 ±8	1.25 ±0.08	nm	Black Mountain, UT **Small Cobble; not utilized**
42In1135 Omar 1	42 ±6	13 ±3	182 ±4	38 ±3	18 ±3	104 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1135 Omar 2	55 ±6	16 ±3	190 ±4	39 ±3	20 ±3	108 ±4	23 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**

Table A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area.

	Trace and Selected Minor Element Concentrations										Ratio		
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1135 Omar 3	45 ±6	16 ±3	183 ±4	36 ±3	19 ±3	104 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1135 Omar 4	46 ±6	17 ±3	187 ±4	72 ±3	25 ±3	114 ±4	13 ±3	515 ±14	nm	nm	nm	nm	Panaca Summit, NV **Elko C-notched**
42In1135 Omar 5	44 ±6	17 ±3	179 ±4	36 ±3	18 ±3	103 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1135 Omar 6	47 ±5	15 ±3	185 ±4	38 ±3	19 ±3	107 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
Forest Service Iso-98-1	45 ±6	17 ±3	185 ±4	40 ±3	18 ±3	106 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Pinto Series**
42In1493 FS #31	51 ±5	13 ±3	187 ±4	37 ±3	18 ±3	103 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1494 FS #34	60 ±6	18 ±3	200 ±4	41 ±3	19 ±3	112 ±4	25 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1509 FS #44	49 ±5	13 ±3	196 ±4	78 ±3	24 ±3	118 ±4	14 ±3	492 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1509 FS #51	51 ±6	17 ±3	196 ±4	41 ±3	21 ±3	110 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Rosegate Series**
42In1509 FS #243	43 ±7	21 ±3	193 ±4	40 ±3	18 ±3	103 ±4	18 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1513 FS #62	51 ±5	15 ±3	178 ±4	60 ±3	23 ±3	126 ±4	19 ±3	323 ±14	nm	352 ±8	0.91 ±0.08	nm	Obsidian Butte, NV Variety H-3 **Flake**
42In1513 FS #63	50 ±5	17 ±3	202 ±4	38 ±3	19 ±3	109 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1514 FS #68	52 ±5	17 ±3	202 ±4	40 ±3	20 ±3	111 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1515 FS #70	44 ±5	13 ±3	198 ±4	76 ±3	23 ±3	118 ±4	16 ±3	537 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1515 FS #72	49 ±7	19 ±3	211 ±4	82 ±3	27 ±3	122 ±4	16 ±3	491 ±15	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1515 FS #73	47 ±6	14 ±3	187 ±4	38 ±3	19 ±3	102 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1517 FS #80	54 ±6	17 ±3	195 ±4	39 ±3	21 ±3	108 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**

Table A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area.

	Trace and Selected Minor Element Concentrations										**Ratio**		
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1517	46	13	190	40	21	108	20	nm	nm	nm	nm	nm	Wild Horse
FS #78	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Biface
42In1517	46	16	192	38	20	106	20	nm	nm	nm	nm	nm	Wild Horse
FS #81	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1522	47	12	183	35	18	105	16	nm	nm	nm	nm	nm	Wild Horse
FS# 98-1	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Rosegate Series
42In1522	42	15	178	34	16	101	19	nm	nm	nm	nm	nm	Wild Horse
FS #98-9	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1522	45	15	189	73	24	111	15	520	nm	nm	nm	nm	Panaca Summit, NV
1998-10	±5	±3	±4	±3	±3	±4	±3	±14					**Flake**
42In1522	46	13	190	36	18	106	19	nm	nm	nm	nm	nm	Wild Horse
FS #106	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1522	49	15	194	39	20	108	17	nm	nm	nm	nm	nm	Wild Horse
FS #108	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1522	61	16	201	41	24	108	22	nm	nm	nm	nm	nm	Wild Horse
FS #109	±5	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1523	51	23	200	40	21	108	17	nm	nm	nm	nm	nm	Wild Horse
FS #111	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1523	48	15	191	39	21	106	19	nm	nm	nm	nm	nm	Wild Horse
FS #112	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1523	46	14	191	38	19	106	19	nm	nm	nm	nm	nm	Wild Horse
FS #118	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Parowan Series
42In1523	42	17	166	53	21	121	18	307	nm	354	1.03	nm	Obsidian Butte, NV
FS #119	±6	±3	±4	±3	±3	±4	±3	±14		±8	±0.08		Variety H-3
													Flake
42In1524	49	17	193	39	19	108	20	nm	nm	nm	nm	nm	Wild Horse
FS #133	±5	±3	±4	±3	±3	±4	±3						Canyon, UT
													Elko C-notched
42In1524	50	17	196	39	22	107	19	nm	nm	nm	nm	nm	Wild Horse
FS #134	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Flake
42In1524	46	17	192	37	18	102	20	nm	nm	nm	nm	nm	Wild Horse
FS #87	±6	±3	±4	±3	±3	±4	±3						Canyon, UT
													Biface

Table A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area.

Site/Cat Number	Zn	Ga	Rb	Sr	Y	Zr	Nb	Ba	Ti	Mn	$Fe_2O_3^T$	Fe/Mn	Obsidian Source / Artifact Type
	Trace and Selected Minor Element Concentrations										**Ratio**		
42In1527 FS #85	54 ±6	15 ±3	197 ±4	37 ±3	17 ±3	103 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1532 FS #123	54 ±6	17 ±3	196 ±4	38 ±3	20 ±3	111 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1537 FS #138	43 ±6	15 ±3	185 ±4	37 ±3	17 ±3	103 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1539 FS #144	48 ±5	15 ±3	182 ±4	37 ±3	17 ±3	106 ±4	17 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1540 FS #148	46 ±5	16 ±3	191 ±4	37 ±3	19 ±3	108 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1540 FS #230	47 ±5	16 ±3	194 ±4	77 ±3	26 ±3	116 ±4	16 ±3	494 ±14	nm	nm	nm	nm	Panaca Summit, NV **Pinto Series**
42In1540 FS #232	57 ±6	17 ±3	202 ±4	81 ±3	28 ±3	122 ±4	15 ±3	473 ±16	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1541 FS #153	51 ±6	13 ±3	195 ±4	40 ±3	20 ±3	108 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1541 FS #184	48 ±6	19 ±3	200 ±4	78 ±3	26 ±3	123 ±4	17 ±3	540 ±15	nm	nm	nm	nm	Panaca Summit, NV **Biface**
42In1542 FS #155	46 ±5	16 ±2	191 ±4	39 ±3	20 ±3	108 ±4	19 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1547 FS #168	45 ±6	19 ±3	199 ±4	76 ±3	24 ±3	116 ±4	16 ±3	489 ±14	nm	nm	nm	nm	Panaca Summit, NV **Flake**
42In1548 FS #172	45 ±5	14 ±3	183 ±4	37 ±3	20 ±3	104 ±4	21 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**
42In1548 FS #174	46 ±5	17 ±3	193 ±4	39 ±3	18 ±3	107 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1549 FS #179	47 ±6	14 ±3	194 ±4	39 ±3	18 ±3	105 ±4	24 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Pinto Series**
42In1549 FS #180	40 ±6	15 ±3	192 ±4	38 ±3	20 ±3	105 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Elko C-notched**
42In1551 FS #185	48 ±6	17 ±3	191 ±4	40 ±3	20 ±3	106 ±4	22 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**

Table A.1 X-Ray Fluorescence Data of Obsidian Artifacts from the Cedar Breaks Area.

Trace and Selected Minor Element Concentrations											**Ratio**	
Site/Cat Number	**Zn**	**Ga**	**Rb**	**Sr**	**Y**	**Zr**	**Nb**	**Ba**	**Ti**	**Mn**	**$Fe_2O_3^T$**	**Fe/Mn**	**Obsidian Source / Artifact Type**
42In1556 FS #182	55 ±5	14 ±3	190 ±4	38 ±3	21 ±3	107 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1563 FS #195	50 ±6	16 ±3	198 ±4	39 ±3	18 ±3	109 ±4	20 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Biface**
42In1563 FS #196	45 ±5	18 ±2	201 ±4	77 ±3	25 ±3	119 ±4	16 ±3	nm	nm	nm	nm	nm	Wild Horse Canyon, UT **Flake**

Values in parts per million (ppm) except total iron (expressed in weight percent) and Fe/Mn intensity ratios; ± = estimate (in ppm) of X-ray counting uncertainty and regression fitting error at 300 and 600 (*) seconds livetime; nm = not measured. [Data compiled from letter reports (Hughes 1997a, 1998); site numbers and artifact type added]

APPENDIX B

Report on Cedar Breaks Ceramics

by

Laureen M. Perry
Department of Anthropology
University of Nevada
Las Vegas, NV 89132

A sample of twenty-five potsherds was collected from a recent survey from different areas in Cedar Breaks, Utah. In this area, cultural affiliation would be the principle question of interest since this area falls near both Virgin Anasazi and Fremont cultural regions. The main characteristics of analysis used to determine production areas are methods of construction, inclusion composition, painted design elements, and clay composition. Both Fremont and Virgin Anasazi pottery was made using the coil-and-scrape method of construction and clay colors and surface finishing overlap. This presents difficulty in distinguishing between the two cultural pottery wares unless distinct characteristics are present. Based on the analysis of these twenty-five sherds, only one of the sherds can be definitely assigned to a cultural group while the other twenty-four sherds present more difficult considerations.

The sherd collected from the Maintenance yard is a Fremont Snake Valley Black-on-gray jar sherd. This sherd has the characteristic abundant quartz, feldspar, and biotite temper in a light gray firing clay with one partial wide stripe of black mineral paint on the exterior surface (R. Madsen 1977:5). Madsen lists a date range of A.D. 900-1200 for Snake Valley Black-on-gray (1977:5) but a chronological sequence for Fremont design styles has yet to be developed (Lyneis 1994:9-49 – 9-51).

The other twenty-four sherds collected during this survey come from two areas and are all from plain vessels. Two plain jar sherds and one sherd too small to determine vessel form are from 42In1135. Seventeen plain jar sherds, three plain bowl sherds, and one sherd too small to determine vessel form are from site 1-G [42In1522]. Only one of these bowl sherds is a rim sherd. The sherds from these two sites are very similarly made using the coil-and-scrape method with a light gray firing clay and two temper categories. One of the sherds from 42In1135 and eight sherds from Site 1-G have quartz as the primary temper component. These sherds do not contain the Snake Valley Gray tempering agents. Thirteen of the sherds have a dark red-brown to black, sometimes crumbly, rock with attached quartz grains as the main temper component. Individual clear quartz grains are also present. Some of the quartz tempered sherds have lesser amounts of this dark rock. This suggests that these sherds represent a range of temper percentages from primarily quartz to primarily the dark rock. This dark rock could be better identified through thin-section analysis. These sherds are probably locally made sherds but cultural affiliation is not definitive.

The Fremont made Snake Valley Gray would be expected to be found in this area. The plain sherds from this survey definitely are not Snake Valley Gray. Another possible Fremont variant for this area would be Sevier Gray which is tempered with medium to extremely coarse angular dark or gray basalt and quartz (Madsen 1977:15). Lyneis defined the Sevier Gray along the Kern River pipeline study as having blocky, angular, dark (almost black) inclusions that often appear vesicular on breaks (1994:951). The dark rock temper of the Cedar Breaks Survey does not quite resemble this basalt temper in hardness and surface appearance.: The Virgin Anasazi North Creek Gray pottery is known to have variations in temper that somewhat depends on the local area. This pottery is not definitely Virgin Anasazi partly because of the location of the site. Although this sounds like a round-about conclusion, the vagueness of pottery types in this area does not lead to definite conclusions on variations of defined pottery types. Further site information may be combined to determine a cultural affiliation.

Dating of these sherds is also ambiguous. Corrugated pottery appears in the Virgin Anasazi area around A.D.1050. Corrugated pottery is thought to have appeared in the Fremont area about the same time although this date is not as definitive as in the Virgin Anasazi area (Lyneis 1994:9-48-9-49). The lack of corrugated sherds in the Cedar Breaks Survey might indicate pre-A.D.1050 dating but this collection is such a small number that this conclusion should be used with caution.

Ceramic Analysis Codes

FS#	The field specimen number was assigned in the field.
ST	Surface treatment refers to the appearance of the surfaces of the sherd.
	P= Plain BG= Black paint present I= Indeterminate
VF	Vessel form refers to the type of vessel the sherd was a part of.
	B= Body sherd R= Rim sherd
RE	Rim eversion is the amount of curvature between the rim edge and the vessel wall.
	A= No eversion
T	The temper is the major constituent of the non-plastic inclusions.
	B= Basalt Q= Quartz sand/sandstone; greater than or equal to 50% quartz U= Unidentified
DE	Design elements include a brief description of the painted designs.
DS	Design style refers to the Kayenta painted design style observed (not applicable for this project).
WARE	The ware of the sherd is based on the above information.
	FBG= Fremont Black-on-gray UI= Unidentifiable
COMMENTS	Additional notes are in this column

Table B.1 Ceramic Analysis Worksheet.

FS #	Provenience	ST	VF	VP	RE	T	DE	DS	WARE	TYPE	Comment
NA	42In1430	BG	J	B		QB	Wide solid line-exterior	UI	FBG	SVB	
25	42In1135; Segment B	P	J	B		U			UI	UI	Quartzite? tool
27	42In1135; Segment B	P	J	B		U			UI	UI	Could be same as 1
27	42In1135; Segment B	P	J	B		Q			UI	UI	Maybe bowl; small sherd
88	42In1522; Ceramic #1	P	J	B		U			UI	UI	
89	42In1522; Ceramic #2	P	B	B		Q			UI	UI	
90	42In1522; Ceramic #3	P	J	B		Q			UI	UI	
91	42In1522; Ceramic #4	P	J	B		U			UI	UI	
92	42In1522; Ceramic #5	P	J	B		Q			UI	UI	
93	42In1522; Ceramic #6	P	J	B		U			UI	UI	
94	42In1522; Ceramic #7	P	J	B		U			UI	UI	
95	42In1522; Ceramic #8	P	J	B		U			UI	UI	
96	42In1522; Ceramic #9	P	J	B		Q			UI	UI	Combo of Q and dark
97	42In1522; Ceramic #10	P	J	B		U			UI	UI	
98	42In1522; Ceramic #11	P	J	B		U			UI	UI	
99	42In1522; Ceramic #12	P	J	B		U			UI	UI	
100	42In1522; Ceramic #13	P	J	B		U			UI	UI	
101	42In1522; Ceramic #RS1	P	B	R	A	Q			UI	UI	Very fine clay-surf cra
114	42In1522; Ceramic #14	I	I	B		Q			UI	UI	Spalled; small
115	42In1522; Ceramic #15	P	B	B		U			UI	UI	Fine BR/Gray clay fire
190	42In1522; Ceramic #19	P	J	B		U			UI	UI	Neck
190	42In1522; Ceramic #20	P	J	B		U			UI	UI	
191	42In1522; Ceramic #21	P	J	B		U			UI	UI	
192	42In1522; Ceramic #22	P	J	B		Q			UI	UI	
193	42In1522; Ceramic #23	P	J	B		Q			UI	UI	

APPENDIX C

Petrographic Analysis of Brian Head Chert

by

Edward F. Bakewell
Department of Anthropology
University of Washington
Seattle, WA 98195

INTRODUCTION

The purpose of this study is to document the petrographic and geochemical properties of field samples from sites and sources in the Cedar Breaks National Monument, collected by Tim Canaday, Pat McCutcheon, and Matt Betenson in September of 1997 (Table C.1). Results are presented in two sections: petrography and geochemistry.

PETROGRAPHY

This section includes descriptions of both the macroscopic and microscopic characteristics of each specimen (Table C.2). These descriptions are presented in separate paragraphs, with the macroscopic features listed first. Thin section analyses were conducted, using standard 30-micron sections inspected with a polarizing microscope.

Results of the petrographic analyses suggest that, with the exception of the silicified woods (5, 6), all of the specimens are altered pyroclastic rocks. In two cases from the Brian Head Formation (7, 8) alteration has progressed to porcelanite.

The nine samples from the Brian Head Formation are of three distinctive types: the silicified woods, the porcelanites, and altered crystal vitric tuff (1, 2, 3, 4, 9). The porcelanite outcrops (outcrops 2 and 3) may be distinguished petrographically from each other. The Brian Head Formation altered crystal vitric tuff is petrographically distinct from the Dixie Forest Boulder material, with the boulder material more accurately described as altered clastic vitric tuff, because rock fragments are/were present.

Of the 19 remaining samples attributed to sites, four (13, 14, 23, 31) appear to be Brian Head Formation altered crystal vitric tuff of the type found in outcrops 1 and 5. Five other samples (11, 12, 17, 19, 28) differ from Brian Head Formation altered crystal vitric tuff only by the presence of fragmented opaline clasts (porcelanite?), and might be from an unknown outcrop in that formation. The only other rock type at the sites is an altered vitric tuff (10, 15, 16, 18, 20, 21, 22, 24), which seems too fine-grained in texture to be from any of the sampled Brian Head outcrops. These eight samples might possibly be from a single unknown outcrop or source.

GEOCHEMISTRY

Major element concentrations (Table C.3) in this study were determined by X-ray fluorescence (XRF). Trace element concentrations were determined by inductively-coupled plasma (ICP) emission spectroscopy, using the multi-acid extraction method.

Only 10 specimens (1, 7, 8, 9, 11, 16, 18, 25, 27, 28) were analyzed geochemically, so it is impossible to say anything with reasonable statistical confidence either supporting or denying group membership or distinctions made using petrographic data. However, certain observations in major and trace element concentrations (Tables C.3 and C.4) do lend credence to some of the conclusions based on petrographic data, and hold promise for future research.

Table C.1 Petrographic sample correspondences for Cedar Breaks samples.

Specimen Number	FS #	Lab #	Area	Outcrop/site
1 (*)	205	U-1	BH	1B
2 (*)	206		BH	1B
3 (*)	207		BH	1A
4 (*)	208		BH	1A
5 (*)	209		BH	1A
6 (*)	210		BH	1A
7 (*)	211	U-7	BH	2
8 (*)	212	U-8	BH	3
9 (*)	213	U-9	BH	5
10 (-)	214		CBN	42In1135/A-2
11 (*)	215	U-11	CBN	42In1135/A-2
12 (*)	216		CBN	42In1135/A-2
13 (-)	217		CBN	42In1135/B-5
14 (-)	218		CBN	42In1135/B-5
15 (+)	219		CBN	42In1135/B-5
16 (*)	220	U-16	CBM	42In1509
17 (*)	221		CBM	42In1509
18 (*)	222	U-18	CBM	42In1509
19 (*)	223		CBM	42In1517
20 (+)	224		CBM	42In1517
21 (+)	225		CBM	42In1517
22 (*)	226		CBS	42In1539
23 (+)	227		CBS	42In1539
24 (*)	228		CBS	42In1539
25 (*)	235	U-25	CBS	Dixie Forest #1
26 (*)	236		CBS	Dixie Forest #2
27 (*)	237	U-27	CBS	Dixie Forest #3
28 (*)	238	U-28	CBN	42In1577
29 (-)	135		CBM	42In1524
30 (+)	136		CBM	42In1524
31 (+)	202		CBM	42In1567

*/+/- (abundant/minimal/none) refers to the amount of the specimen remaining after analysis; BH = Brian Head Formation; CBN = Cedar Breaks North; CBM = Cedar Breaks Middle; CBS = Cedar Breaks South

Table C.2. Petrographic descriptions of Cedar Breaks specimens.

Specimen #	Classification	Description
1	Altered crystal vitric tuff	**Rock:** Translucent to opaque/cloudy, white-clear in color, stained with yellow. Opaque angular white clasts. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration, micaceous splotches.
2	Altered crystal vitric tuff	**Rock:** Layered cloudy/white and greenish brown, streaked and marbled with black. Angular white clasts. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration, micaceous splotches. Heavily veined with vuggy opaques.
3	Altered crystal vitric tuff	**Rock:** Translucent/opaque clear-cloudy with reddish highlights and murky angular clasts. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration.
4	Altered crystal vitric tuff	**Rock:** Dominantly reddish with clear to cloudy patches, speckled with whitish specks. Vuggy texture. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration. Dense concentrations of spherical aggregates of opaques.
5	Petrified wood	**Rock:** Parallel-grained texture; opaque ochre, stained with black. Tan/buff orbicular structures. **Thin Section:** Parallel-grained structure, transverse fractures.
6	Jet	**Rock:** Dense opaque black with dull luster, occasional ochre spots. **Thin Section:** Parallel-grained structure, transverse fractures.
7	Porcelanite	**Rock:** Uniform opaque white, gritty texture, veined with denser, slightly iridescent streaks. **Thin Section:** Micaceous minerals, rimmed ghosts of clasts and crystals, vuggy texture, opaline extinction under polarized light.
8	Porcelanite	**Rock:** **Thin Section:** Micaceous minerals, rimmed ghosts of clasts and crystals, vuggy texture, opaline extinction under polarized light. Large micaceous patches with uniform extinction.
9	Altered crystal vitric tuff	**Rock:** Cloudy-opaque white, uniformly stained or veined with yellowish and reddish streaks. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration.
10	Altered crystal vitric tuff	**Rock:** Translucent to cloudy or opaque white, lightly stained or veined with yellowish and reddish streaks. Numerous white specks. Heavily patinated. **Thin Section:** Relict ashy texture, micaceous minerals, very fine parallel fractures.
11	Altered crystal vitric tuff	**Rock:** Translucent to cloudy or opaque white, lightly stained or veined with yellowish and reddish streaks. Numerous white specks. Heavily patinated. Areas of concentrated opaque, white, fragmentally textured matrix and concentrations of angular white clasts. **Thin Section:** Fragmented opaline clasts in a matrix of relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration.
12	Altered crystal vitric tuff	**Rock:** Translucent to opaque, mottled grayish or yellowish, fragmentally textured, dense concentrations of angular white clasts; speckled with red and black. **Thin Section:** Fragmented opaline clasts in a matrix of relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches.

Specimen #	Classification	Description
13	Altered crystal vitric tuff	**Rock:** Cloudy-opaque white, uniformly stained or veined with yellowish and reddish streaks. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches. Micro potlidding with stained fractures, patination rim.
14	Altered crystal vitric tuff	**Rock:** Cloudy-opaque white, uniformly stained or veined with yellowish and reddish streaks, but with greasy/waxy luster and a light patina. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches. Patination rim.
15	Altered vitric tuff	**Rock:** Opaque, cloudy white, with dendritic reddish black oxides and yellowish highlights. **Thin Section:** Relict pumaceous texture with extensive alteration.
16	Altered vitric tuff	**Rock:** Opaque vuggy white texture, marbled with gray. **Thin Section:** Relict ashy texture, cryptocrystalline quartz.
17	Altered crystal vitric tuff	**Rock:** Translucent to opaque white with iridescence and ashy brownish or grayish inclusions. **Thin Section:** Fragmental opaline clasts in a matrix of relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches. Shattered crystals.
18	Altered vitric tuff	**Rock:** Opaque uniform white **Thin Section:** Relict pumaceous texture with extensive alteration.
19	Altered clastic vitric tuff	**Rock:** Opaque reddish, sublaminar structure, pinkish weathering or patina. **Thin Section:** Fragmental opaline clasts in a matrix of relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches. Severely burned and discolored.
20	Altered crystal vitric tuff	**Rock:** Translucent-opaque; fragmental texture with a rusty white patina. **Thin Section:** Relict pumaceous texture with shattered crystals and an oxidized rim.
21	Altered vitric tuff	**Rock:** Translucent-opaque; sandy clastic texture with grayish specks and a rusty white patina. **Thin Section:** Relict ashy texture, micaceous minerals, isotropic with burned rim and fine patina.
22	Altered vitric tuff	**Rock:** Clear to translucent with ashy inclusions, heavily weathered or patinated exterior surfaces. **Thin Section:** Relict ashy texture, extensive alteration.
23	Altered crystal vitric tuff	**Rock:** Murky white translucent to opaque; exterior surfaces more opaque, yellowish highlights. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches. Burned.
24	Altered vitric tuff	**Rock:** Cloudy to opaque; angular white clastic inclusions. Yellowish or gray flecks. **Thin Section:** Relict ashy texture, lined vugs, cryptocrystalline quartz.
25	Altered clastic vitric tuff	**Rock:** Cloudy to opaque; angular white clastic inclusions. Yellowish or gray flecks. Large, white-speckled, pinkish-reddish clastic inclusions. **Thin Section:** Opal-rimmed argillite clasts in matrix of fragmentally textured, crystal vitric tuff. Large, unaltered crystal shards.
26	Altered clastic vitric tuff	**Rock:** Cloudy to opaque; angular white clastic inclusions. Yellowish or gray flecks. Large, white-speckled, pinkish-reddish clastic inclusions. Large, vuggy structures. **Thin Section:** Opal-rimmed argillite clasts in matrix of fragmentally textured, crystal vitric tuff. Large, sericitized crystal shards. Chalcedony-filled vugs.

Specimen #	Classification	Description
27	Altered clastic vitric tuff	**Rock:** Cloudy to opaque; angular white clastic inclusions. Yellowish or gray flecks. Large, white-speckled, pinkish-reddish clastic inclusions. **Thin Section:** Fragmented opaline clasts, micaceous minerals, chalcedony-filled vugs.
28	Altered clastic vitric tuff	**Rock:** Clear-translucent, mottled with opaque white regions. Yellowish and reddish highlights. **Thin Section:** Fragmental opaline clasts in a matrix of relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration and micaceous splotches.
29	Altered clastic vitric tuff	**Rock:** Seriated clastic texture with oxidized angular clasts, rimmed brown. Veined with white and streaked with brown or black. **Thin Section:** Fragmented opaline clasts, micaceous minerals, chalcedony-filled vugs. Burned. Spherical aggregates of opaques.
30	Altered clastic vitric tuff	**Rock:** Translucent-opaque, fine-grained clastic texture, flecked with white-black inclusions, reddish-orangish highlights, resulting in an overall brown-olive color. **Thin Section:** Fragmented opaline clasts, micaceous minerals, chalcedony-filled vugs. Burned. Spherical aggregates of opaques.
31	Altered crystal vitric tuff	**Rock:** Opaque, cloudy white, with dendritic reddish black oxides and yellowish highlights. **Thin Section:** Relict fragmental/pumaceous texture, secondary fractures, vuggy opaques, extensive alteration, micaceous splotches.

The porcelanites are distinguishable from each other and the other rock types by having the lowest silica concentrations and correspondingly higher concentrations of other major elements. They may represent two distinct members of the Brian Head Formation. Dixie National Forest boulders seem to have significantly more berylium than the other types. Aside from these features, the remaining six samples seem to be distinguished by their geochemical similarity rather than any difference. Outcrops 1 and 5 in the Brian Head (both altered crystal vitric tuff) look virtually identical, geochemically, and do not differ geochemically from the material with the fragmented opaline clasts, or that with the fine-grained ashy texture. It could be argued geochemically, and supported petrographically, that the three types are variations at the outcrop scale of a single member of the Brian Head Formation.

Table C.3. Major elements (wt. % oxide) determined by X-ray fluorescence for Cedar Breaks specimens.

	Rock Type/Specimen Number									
Element	BHT U-1	POR U-7	POR U-8	BHT U-9	BHT U-11	BHT U-16	BHT U-18	DFT U-25	DFT U-27	BHT U28
Si	98.1	96.4	92.6	98.5	97.8	98.1	97.7	97.3	97.7	97.5
Al	0.20	0.70	0.80	0.10	0.10	0.20	0.10	0.20	0.30	0.10
Ti	0.01	0.01	0.02	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Fe	0.05	0.04	0.36	0.08	0.04	0.30	0.16	0.08	0.13	0.08
Mg	0.01	0.08	2.31	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Mn	0.01	0.01	0.10	0.01	0.01	0.01	0.01	0.01	0.01	0.01
K	0.01	0.03	0.10	0.01	0.01	0.01	0.01	0.01	0.02	0.01
Na	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ca	0.07	0.30	0.13	0.05	0.06	0.07	0.07	0.08	0.08	0.69
P	0.02	0.03	0.03	0.02	0.02	0.03	0.03	0.03	0.03	0.03

BHT = Brian Head Tuff; DFT = Dixie Forest Tuff; POR = Porcelanite

Table C.4: Trace elements (ppm) determined by inductively-coupled plasma emission spectroscopy for Cedar Breaks specimens.

	Rock Type/Specimen Number									
Element	BHT U-1	POR U-7	POR U-8	BHT U-9	BHT U-11	BHT U-16	BHT U-18	DFT U-25	DFT U-27	BHT U-28
Zr	42	14	31	18	17	14	15	17	15	18
Zn	<0.5	2.4	7.7	1.7	1.5	2.3	1.8	1.7	1.6	1.2
Y	<0.5	<0.5	0.7	<0.5	<0.5	<0.5	<0.5	1.6	0.5	<0.5
Cr	4	<1	<1	1	4	4	4	1	<1	2
V	2	6	17	4	2	9	5	3	4	3
Be	0.6	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	1.3	2	<0.5
Ba	6	66	225	18	4	5	12	19	28	7
Ni	4	4	11	3	3	4	3	4	3	2
Sr	2.1	9.2	8.0	1.0	0.9	3.9	1.8	2.8	3.7	3.1
Cu	1.3	2.4	7.7	1.7	1.5	2.3	1.8	1.7	1.6	1.2
Sc	0.7	0.8	1.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
As	<3	<3	<3	6	4	<3	<3	<3	<3	<3
Mo	<1	<1	1	<1	<1	<1	<1	<1	<1	<1
Ag	0.3	0.2	0.3	0.4	<0.2	0.2	<0.2	<0.2	0.3	<0.2
Cd	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Sn	<10	<10	<10	<10	<10	<10	<10	<10	<10	<10
Sb	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
Pb	<2	<2	<2	<2	<2	<2	<2	<2	3	19
Bi	<5	<5	<5	<5	<5	<5	<5	<5	<5	<5
La	0.7	0.6	2.4	<0.5	<0.5	<0.5	<0.5	1.2	0.7	0.6

BHT = Brian Head Tuff; DFT = Dixie Forest Tuff; POR = Porcelanite

APPENDIX D

Bristlecone Studies

by

Gary S. Funkhouser
Laboratory of Tree-ring Research
University of Arizona
Tucson, AZ 85721

INTRODUCTION

At least three basic sets of issues underlie the development of reliable dendroclimatic reconstructions. They are summarized here for the non-specialist, so that the research framework and directions described below may be placed in useful perspective. Organization simply follows the order of tasks in the actual research process. The first issue concerns stand and sample selection. What guides collection efforts? The second issue pertains to the accurate assignment of calendar dates to a chronology. How do we know the dates are accurate? The third set of issues involves basic numerical transformations of tree-ring series deemed necessary in view of current biological knowledge and the requirements of statistical tests. How, for example, do we deal with violations of statistical requirements of independence when tree-ring series are not usually serially independent? This appendix is necessarily a sketch, and various references are noted that consider these topics in greater detail. Three particularly useful works are edited or compiled collections of papers by Hughes, et al. (1982), Jacoby and Hornbeck (1987); and Cook and Kairiukstis (1990).

The goal in sampling, including both stand and tree selection, is to obtain tree-ring series with high degrees of common variation that are strongly driven by climate. Although the common signal from a stand can be maximized by increasing sample size, we have found that not all stands are equal in this regard. First, stands where extensive competition, fire history, infestation, or human activity have significantly influenced tree growth are not optimal because such disturbances can obscure the common growth signal and, consequently, the common response to climatic variation. Such stands are sometimes excluded from dendroclimatic investigation, although this is not always possible or desirable. Various analytical techniques can be used to limit or control the effects of these factors. Individual trees that show evidence of damage (e.g., from lightning strikes or other unique events) are also generally avoided during data collection. Second, stands located where climate factors are most limiting to growth frequently provide tree-ring chronologies with strong common signals. The biological basis for this is moderately well understood (Fritts 1976).

In semi-arid mountainous regions, such as the southwestern United States, tree-ring chronologies with strong common variance are frequently found at elevational extremes, often near the lower forest border or upper treeline limits of a species (Fritts, et al., 1965; LaMarche, 1974; Graybill, 1985; Graybill, et al., 1992). Moisture-related signals, such as (1) seasonal and annual precipitation, (2) drought measures that integrate the effects of temperature and precipitation on moisture availability (e.g., the Palmer Drought Severity Index; PDSI; Palmer, 1965), and (3) streamflow, are most commonly found in chronologies from lower forest border settings (Michaelsen, et al., 1987; Meko, et al., 1980; Earle and Fritts, 1986; Stockton, 1975; Graybill, 1989).

The second set of important issues underlying dendroclimatic reconstructions concerns the accurate assignment of calendar dates to the ring-widths in individual series. If done incorrectly, an averaged set of series provides only confused signals, which are essentially useless for dendroclimatic research. Accurately dated chronologies are developed through the process of cross-dating (Stokes and Smiley 1968). Confidence in this accuracy is gained in part (1) by experience; (2) by applying multiple laboratory cross-checking procedures; and (3) by building a repertoire of tree-ring chronologies on a regional scale that evidence similar and synchronous annual changes due to commonly recorded climate signals. The importance of accurate cross dating cannot be overstated. If any of our analysts suspects that an insoluble dating problem exists, all or part of the series in question is rejected for use.

A third set of issues is embodied in "standardization." This involves the removal of variation in individual ring-width series that may be due to non-climatic factors such as aging, competition, or injury. Potential problems associated with standardization include accidental (or, naive) removal of climate signals or, conversely, failure to remove significant disturbance signals. Recognizing and solving these problems is in part a function of experience in terms of (1) collecting samples and observing growth conditions in the field; (2) working with the wood in the cross dating process; and (3) evaluating variation in numerous measured time series.

Further transformation of tree-ring time series derived from the standardization process is sometimes necessary if the series possesses a significant persistence (autocorrelation) structure. Temporal persistence in a tree-ring chronology is present when successive values in the series are not independent. That is, any value (observation) in the series can be partially predicted from (is a function of) one or more previous values (past observations). This autocorrelation in the annual values of a single or averaged set of series violates the assumption of independence in many statistical procedures; adds unknown bias to hypothesis tests; and results in unreliable variance estimates (Graybill and Rose 1989; Monserud 1986; Wonnacott and Wonnacott 1981). Because regression-based statistics are extremely sensitive to these issues, and such statistics are commonly used to develop climate and tree-growth relationships, the autocorrelation is sometimes removed. This is usually accomplished with procedures known as "ARMA" modeling (Box and Jenkins 1976). Autocorrelation is often thought to be non-climatic or biological in origin so that its removal does not affect the "true" frequency domain characteristics of past climate in a subsequent reconstruction.

BRISTLECONE PINE SOUTH OF THE CEDAR CANYON HIGHWAY

Two trees were sampled south of the Cedar Canyon highway near the observation deck located along the Bristlecone trail. Three cores were taken from each tree in order to get as close to the pith (center of the tree) as possible to establish or approximate their true ages. Current knowledge concerning the age of one or both of the trees is based on information apparently provided by researchers from the University of California at Los Angeles (UCLA). We have been unable, however, to find any documentation of this, or to locate any individual who is either aware of or familiar with it.

The earliest date from the tree closest to the observation deck is A.D. 1299. We also obtained dates of A.D. 1333 and 1344. Although we did not reach the true center of the tree, the structure of the rings confirms that this date is probably within a few decades of when the tree began to grow. We did not observe any evidence that this tree had been previously sampled.

The second tree displayed small wound scars that may indicate a prior attempt to estimate its age. Our analysis provided dates of A.D. 720, 721, and 723. Again, we did not obtain the first year of growth for the tree, and it may, in fact, be 200 or 300 years older than these dates suggest. Any reported dates earlier than approximately A.D. 400 are likely inaccurate.

Estimating the exact age of a tree without properly cross dating the tree rings and identifying the first year of growth can lead to misleading results. This may provide one possible explanation for dates that differ significantly from those provided in this report. For example, if someone samples a tree, simply counts the rings, and then attempts to estimate its age by extrapolation based on the tree's size (radial length), the result is inherently inaccurate because ring-width is not exact and uniform throughout the tree's life.

This would be the case particularly if the age of the older tree were estimated in this manner. The outside (most recent) rings are extremely suppressed (small) and atypical of most of those produced by this tree. A determination of tree age based on this evidence would be highly inflated and greatly overestimate the tree's true age.

NAVAJO RIDGE STAND

The Navajo Ridge stand of bristlecone pine consists primarily of trees whose severely stunted growth resembles that found at the very upper elevation limits of the species. It is unusual for a single stand to be so dominated by this particular growth morphology, which results from extreme environmental stress throughout the life of a tree. Our experience with such trees is that they are difficult to cross date and do not correlate well with major climatic variables.

Our initial observation of the site revealed that core samples had been taken on at least two previous occasions, including one by the Laboratory of Tree-Ring Research. Based on this information, even though the material previously collected had never been used in climatic analysis, new samples were taken from a limited number (12) of these trees. The trees were tagged with the following identification numbers: 97-660, 97-661, 97-662, 97-663, 97-664, 97-665, 97-666, 97-667, 97-672, 97-674, and 97-675.

Subsequent investigation confirmed that samples from 23 trees had been examined by researchers at the Laboratory of Tree-Ring Research in 1982. Although the documentation of this analysis indicated that cores from 18 of the trees were of sufficient quality to be dated and measured, none of this material has ever been used in the study of past climatic change or environmental variability. Fortunately, these tree-ring series were measured, recorded, and stored in the laboratory's archives. The archived data were retrieved and examined in order to make a preliminary assessment of the potential for developing a climate reconstruction from the Navajo Ridge stand. The earliest date for any of the living trees is A.D. 311. No remnant or subfossil wood was available for analysis.

One feature of long-lived trees such as the bristlecone pine is the narrowness of their ring widths, which are typically no more than a few mm in size. Additionally, such trees frequently evidence a high number of "missing" rings. This occurs when the conditions for tree growth are so poor that the tree simply does not produce an annual growth ring for that year. As a result, dating and measuring bristlecone pine is more difficult than for most, if not all, species used in dendrochronological analysis.

For the Navajo Ridge tree-ring series, missing rings occur at a frequency of over 12 percent. This means that, on average, more than a decade is missing from each century of recorded tree growth. By comparison, the rate of missing rings in the Mammoth Creek chronology is less than 2 percent. As a result, it is impossible to accurately date a significant percentage of trees from the Navajo Ridge stand.

Tree-ring measurements for the remaining series were plotted for visual inspection, and tested to establish their fundamental mathematical properties and statistical significance. The series do not correlate well with each other (approximately 25 percent common variance), which suggests that tree-growth in the stand is not dominated by any single climatic variable. Again, by comparison, the same measure for the Mammoth Creek chronology is 60 percent. Additionally, only two of the series could be standardized using simple deterministic curves that mimic the natural growth trend of most trees. Standardization of the remaining series could only be accomplished with the use of filters that, by definition, remove low frequency signals from the series.

Based on the available evidence, it was determined that using the Navajo Ridge data for dendroclimatic analysis could not be justified at this time. Much of the material is problematic, and its removal from the collection leaves too few samples to ensure reliability. Any climatic reconstruction based on this material would be of questionable statistical significance and scientific validity.

MAMMOTH CREEK STAND

The Mammoth Creek site is located on National Forest Road 068, ½ mile south of its junction with Road 406. The majority of trees are located immediately to the east of the road, although the site crosses the road, and a few trees are located on the west side. Thirty-two trees and three remnant samples were collected.

The Mammoth Creek stand is well defined spatially, covering only a few acres, and all of the bristlecone pine determined to be valuable for dendrochonological analysis were sampled. Metal tags were used to identify the sampled trees, and they are numbered consecutively: 97-605 though 97-610; 97-612 through 97-624; 97-633 through 97-638; and 97-640 through 97-646. The cross sections are identified as 97-630, 97-631, and 97-632. Due to the limited spatial scope of the site and the ease of identifying the trees, a site map is not necessary to identify the sampled material.

Because the site has been collected numerous times in the past, the current exercise consisted primarily of updating previous research to cover the period from A.D. 1980 to 1998. This is a significant improvement in terms of our ability to calibrate the tree-rings with modern climate records, and, hence, our ability to development a climate reconstruction from the site. Conversely, some of the material, including the three remnant sections, only duplicated previous data, and, although dated, is not used in the new chronology.

CHRONOLOGY DEVELOPMENT

Eighteen trees were collected, dated, measured, and added to the existing Mammoth Creek bristlecone (*Pinus longaeva* D.K. Bailey) tree-ring chronology (Table D.1). Cross dating of all tree-ring time series was accomplished and cross-checked by skilled analysts. Ring width measurements to the nearest .01mm were made by well-trained technicians. Measurement accuracy was spot-checked, and each series was subjected to a battery of computerized cross-checks (Holmes 1983). Each series was plotted and examined for outliers or aberrations. Evaluation of all these data resulted in the rejection of a few whole and partial series from further use.

For any individual specimen, let $R(t) = C + B + D_1 + D_2 + E$

where R(t) is the measured ring width in year t; C is the macroclimatic signal common to trees at a site; B is the biological growth curve as a function of increasing tree age; D_1 is the tree-disturbance signal unique to a single specimen or tree due to random events that affected its growth; D_2 is the tree-disturbance common to most or all specimens in a stand due to fire, insect damage, or other disturbance; and E is the random growth signal unique to each specimen (Graybill 1982).

In chronology development, every effort is made to maximize the macroclimatic signal, and remove or minimize the others. Disturbance factors were minimized by tree selection, or by rejection of samples with anomalous growth characteristics. Non-stationary growth characteristics were removed by fitting either a straight line or negative exponential function to each ring width series (R_t) and calculating tree-ring indices (I_t):

$$I_t = R_t / Y_t$$

where Y_t is the expected annual growth, determined by curve fitting. This removes most non-stationarity in ring width and variance that are products of tree age (Fritts 1976) and, unavoidably, any monotonic trend over the full length of a series. The tree-ring index chronology was then computed as an average of the individually indexed series (Graybill 1979, 1982). This averaging process reduces localized noise in a tree-ring series by minimizing error variance due to individual tree or sample variation, thereby emphasizing the common macroclimatic signal. A time-series plot of the tree-ring index chronology is shown in Figure D.1.

EVALUATING AUTOCORRELATION

Statistically significant autocorrelation was found in the Mammoth Creek index chronology. Standard Box-Jenkins (1976) protocol was used to examine the structure of this process. Procedures for finding the "best-fit" model initially involved fitting several low order AR, MA, and mixed ARMA models to the chronology. Several diagnostic evaluations of each fit were used as guidelines for final model selection. These included (1) significance (or, nonsignificance) of model parameter(s); (2) minimization of the residual sums of squares; (3) "penalties" for overfitting; and (4) determining whether significant autocorrelation remained

Table D.1. Tree-ring stand information and chronology dates.

Site Name	Site Code	Genus & Species[1]	Location Lat. N	Long. W	Elevation (m)	Dates
Mammoth Creek, UT	MAM	pl	37° 39'	112° 40'	2590	747 BC - AD 1997

1. Pl = Bristlecone pine, Great Basin variant *Pinus longaeva*
2. Negative sign indicates dates B.C.

in the residual series (the difference of subtracting model fit values from index series values) computed for each model fit.

Because there are usually fewer older than younger trees at a site, sample depth normally decreases toward the beginning of a chronology. As a result, the strength of the common signal exhibited by an "optimal" number of series may not be well approximated in the early part of a chronology. In order to avoid instability in the modeling process resulting from low sample depth, where there may be real or quasi non-stationarity, models for the chronology were fit beginning in the year where subsample signal strength (SSN; Wigley, et al., 1984) was at least 90 percent. This represented a starting sample depth of eight individual tree-ring series. Modeling procedures usually showed that an ARMA(1,1) fit was best. This is not uncommon (Biondi and Swetnam, 1987; Graybill 1985, 1989; Graybill and Rose 1989; Monserud 1986; Rose 1983). The residual series produced from this filtering process is referred to as a "residual tree-ring chronology."

CLIMATE SENSITIVITY OF THE RESIDUAL CHRONOLOGY

Two levels of climatic sensitivity were evaluated for the residual tree-ring chronology. First, correlations were reviewed between the chronology and data from the nearest climate station for (1) monthly, seasonal, and annual precipitation totals; (2) monthly, seasonal, and annual temperature averages; and (3) monthly and seasonal PDSI values. To examine the regional generality of such signals, similar correlations were computed using NOAA (National Oceanographic Atmospheric Administration) state divisional climate data for Utah Division 4 (South Central). Correlations of climate series with divisional data were calculated for the post-1930 period, because the earlier values (beginning in 1895) are estimates (Karl, et al., 1983), and prior work in the region (Graybill 1987) has shown that they may be unreliable for dendroclimatic research. Correlation and response function analysis (Fritts 1976) of numerous seasonal and annual series with the residual tree-ring chronology indicated that a prior July (July of the previous year) through current June annual precipitation transfer function could be developed ($r = 0.65$, $p < .001$) that would provide a comprehensive view of regional precipitation. Additionally, such a reconstruction derived from this equation would be comparable to many others that have developed in the Southwest (Dean and Funkhouser 1994).

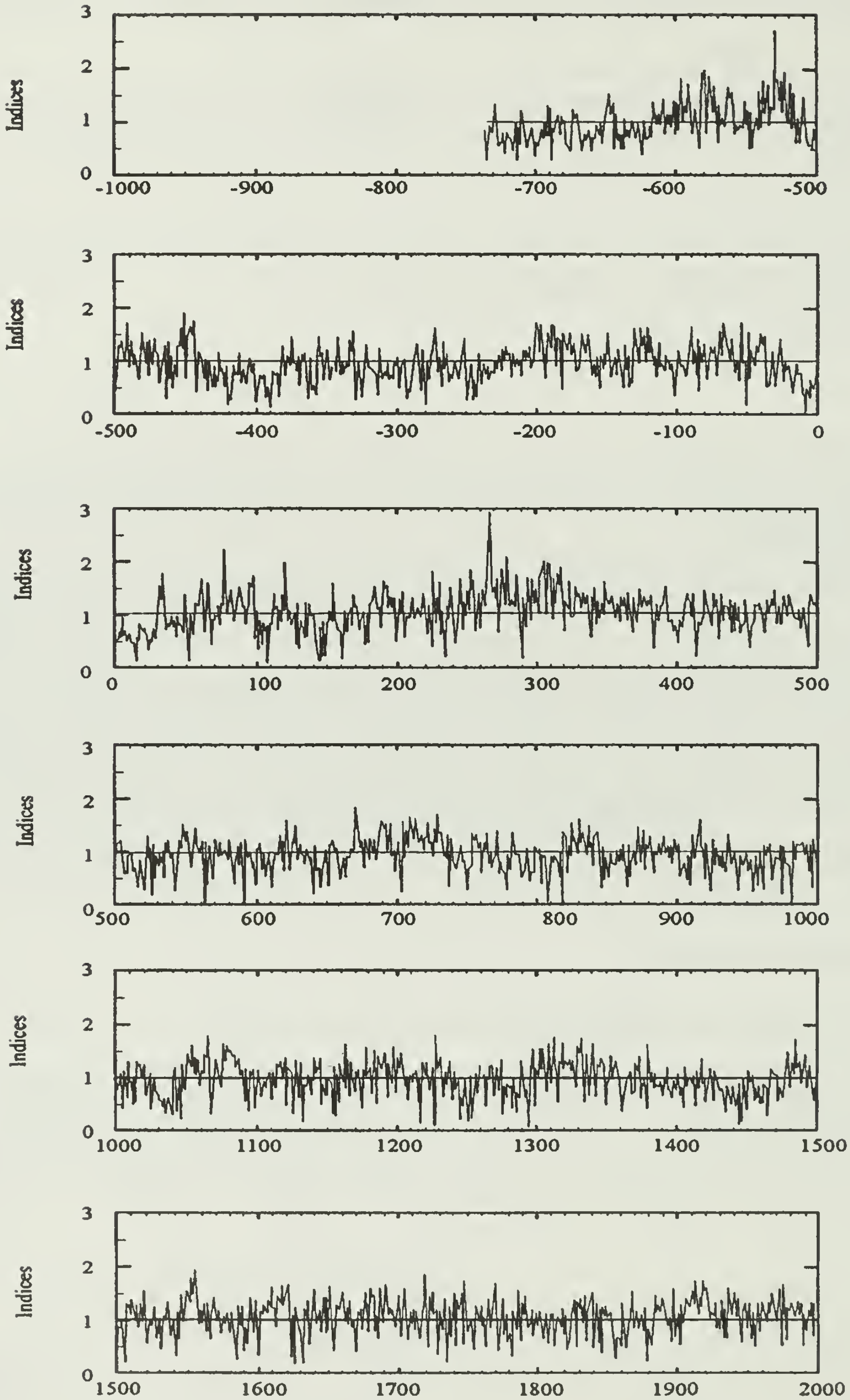

Figure D.1 Time series plot of Mammoth Creek tree-ring index chronology.

Quantitative dendroclimatic reconstructions should be undertaken only after reliable statistical relationships between climate and tree growth records are established. Linear regression procedures (Draper and Smith 1981) were used to develop (calibrate) a statistical model to describe the climate-tree growth relationship. The dependent variable (predictand) was the precipitation total described above. The residual chronology was the single independent variable (predictor).

Verification of the calibration equation was accomplished by calculating the prediction error sum of squares (PRESS) and evaluating each ($R^2_{prediction}$) relative to the variance explained (R^2) by the regression equation (Montgomery and Peck 1992). This measure is derived by removing one observation from the calibration period; calculating a new regression equation with the remaining n-1 observations (where n equals the total number of observations in the full calibration equation); and then using the new equation to predict the observation that was removed. This is repeated for each of the n observations, and provides a useful statistic for determining how well the full-period regression equation predicts new values.

For Utah Climate Division 4, annual July to June precipitation calibration R^2 was 0.42 and $R^2_{prediction}$ was 0.39. This suggests that our model is satisfactory. A time series plot of the actual and reconstructed climate series is shown in Figure D.2. A reconstruction for Utah Division 4, July to June annual precipitation, was developed for the period 735 B.C to A.D. 1997. Distributional characteristics of the climate data, and of the calibration and full period reconstruction are shown in Table D.2. The series are normally distributed according to Kolmogorov-Smirnov one-sample tests (Siegel 1956). The long-term reconstructed mean value does not differ remarkably from those of the calibration period. The reduced standard deviation in the calibration period reconstruction compared to that of the climate data reflects the fact that not all climate variance was modeled. The underestimation of skewness is partially a reflection of the inability to reconstruct some high extreme values (Figure D.3).

VARIATION IN THE RECONSTRUCTION

Archeology, as well as the study of climate dynamics, can benefit from long-term records of both the parameters and the variability of climate processes. Graphic summaries of changes in the means and standard deviations of the reconstructions for 5-, 25-, 50-, and 100-year non-overlapping periods allow discussion of changes in those variables (Figures D.4 and D.5). Five-year averages were arbitrarily selected as a unit that allows recognition of most trends, while simultaneously avoiding the visual pollution of high frequency variation that often results when a millennial-age reconstruction is plotted on a single page. The 25-, 50-, and 100-year periods allow recognition of longer trends and deviations about normal levels. In addition, the 25-year period was included because it is generally taken to approximately represent a "generation" in much archeological literature. Although the reconstruction extends well into the B.C. time period, the plots begin in A.D. 489. This was done because of instability in the early part of the reconstruction due to low sample depth as discussed previously. The original instrumental units are also used in these presentations. This is preferable to the use of deviations from a climatic "normal" period, because there is not always agreement across disciplines and bureaucracies about what such a period should be. The central horizontal line in each graph represents the long-term reconstructed mean, and, as

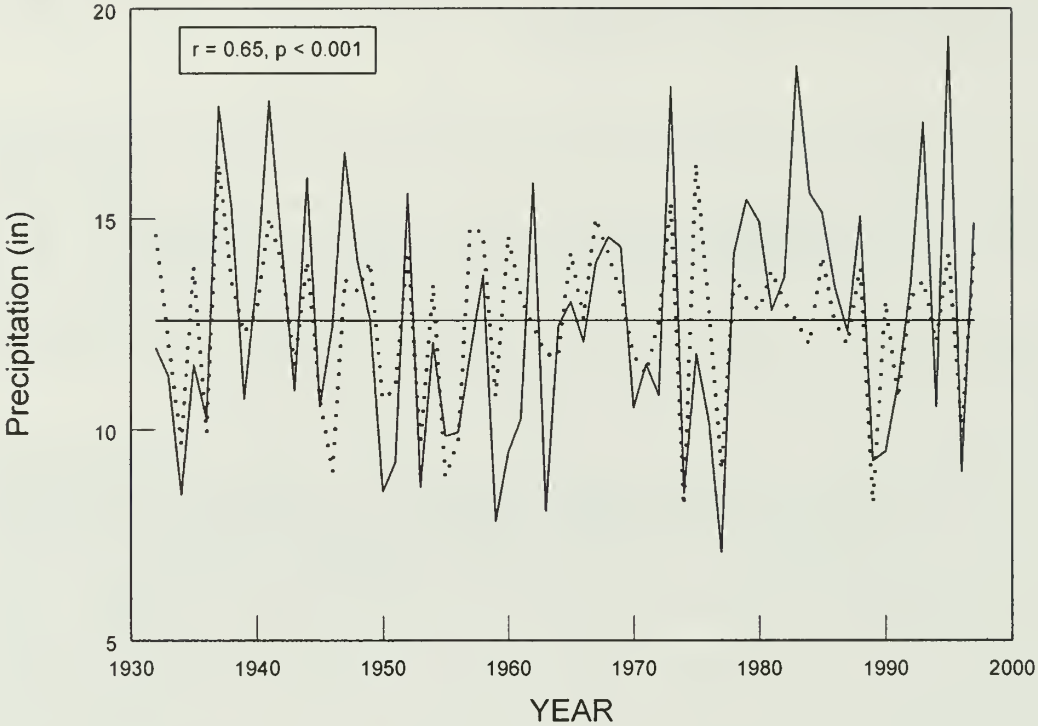

Figure D.2 Actual (solid) and reconstructed (dash) July-to-June precipitation for Utah Climate Division 4.

Table D.2. Statistical characteristics of actual and reconstructed July-June precipitation (in) for Utah climate division 4.

	Actual 1932-1997	**Reconstructed 1932-1997**	**Reconstructed 735 B.C - A.D. 1997**
Mean	12.59	12.59	12.31
Std. dev.	2.93	1.91	2.00
Skewness	0.28	-0.51	-0.09
Kurtosis	-0.63	-0.25	0.39

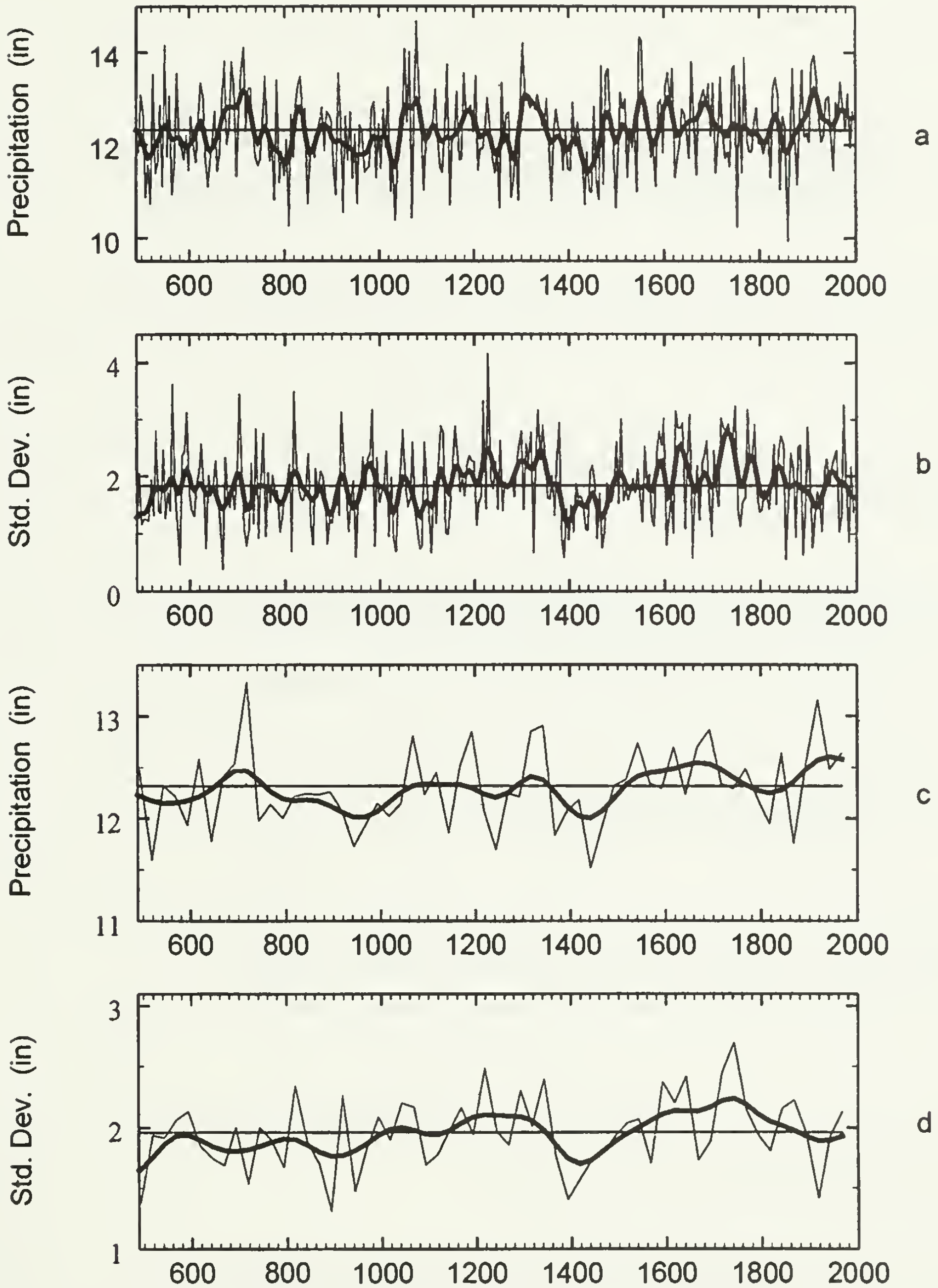

Figure D.3 Non-overlapping averages of July-to-June precipitation, Utah Climate Division 4: (a) 5-year means; (b) 5-year standard deviation values; (c) 25-year means; (d) 25-year standard deviation values. The smoothed line is a low-pass filter with a 50 percent response over eight data points.

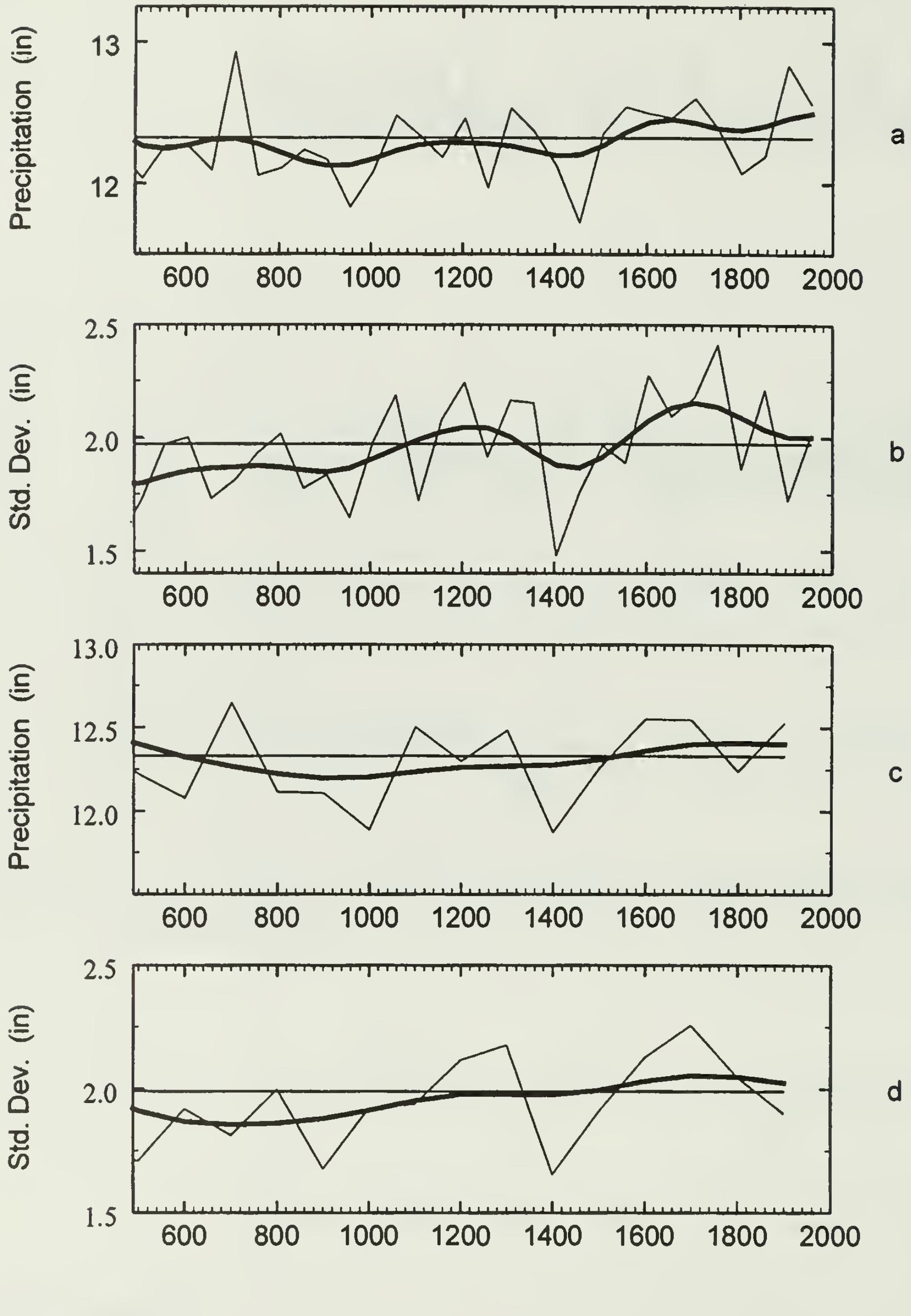

Figure D.4 Non-overlapping averages of July-to-June precipitation, Utah Climate Division 4: (a) 50-year means; (b) 50-year standard deviation values; (c) 100-year means; (d) 100-year standard deviation values. The smoothed line is a low-pass filter with a 50 percent response over eight data points.

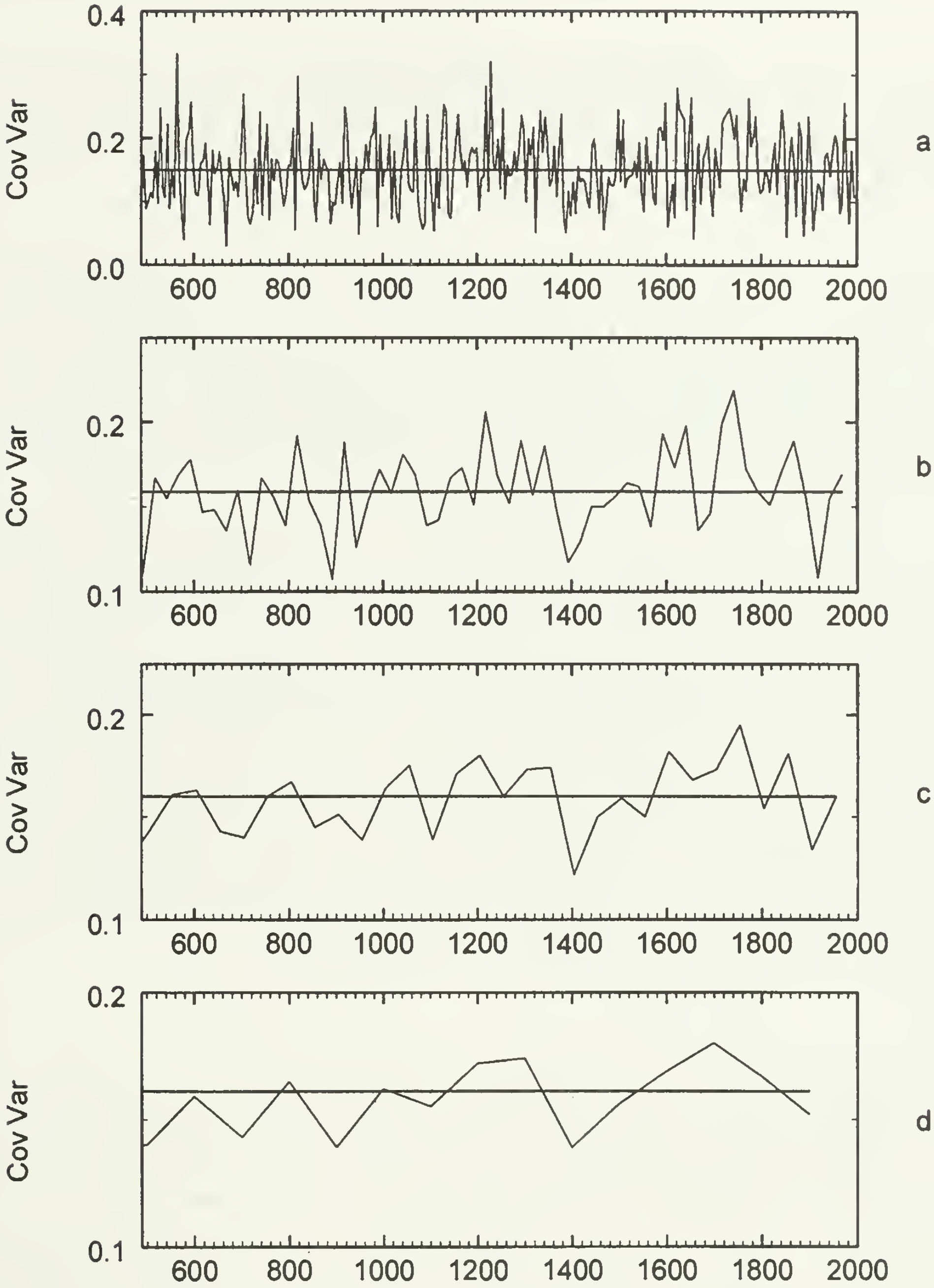

Figure D.5 Coefficient of variation for non-overlapping averages for July-to-June precipitation for Utah Climate Division 4: (a) 5-year means; (b) 25-year means; (c) 50-year means; (d) 100-year means.

noted above, it is in all cases approximately equal to the mean value of the instrumental series record.

Deviations and trends relative to those means are thus of some interest. Most of the individual tree-ring series span the greater portion of their respective mean chronology. Standardization techniques were designed to maintain a wide spectrum of variation. Trends and variation on the order of 400-600 years should be preserved in the reconstruction.

Two kinds of natural processes that can produce environmental change are (1) low-frequency processes (LFP) that operate with periodic cycles greater than 25 years in length (again, approximately one human generation), and (2) high-frequency processes (HFP) characterized by shorter period periodicities (Dean 1988). In some sense, then, human behavioral adaptation represents a response to multiple periodic environmental variables that operate, simultaneously, on time scales that (1) can be recognized and responded to by a single human generation; and (2) cannot be recognized and responded to by a single human generation.

LFP precipitation variability evident in the Mammoth Creek reconstruction that may have influenced human adaptation in the region occurred between A.D. 800 and 1000 and A.D. 1250 to 1450 when moisture availability was either low or declining. These periods are coincident with known episodes of hydrologic stress characterized by stream-course erosion and low or declining water tables (Karlstrom 1988). The intervening period from A.D. 1000 to 1250 would have provided more favorable conditions, as would the subsequent period from A.D. 1450 to 1650. HFP would have (1) reinforced unfavorable conditions during the late 1200s and middle 1400s; (2) moderated unfavorable conditions in the early 1400s; (3) reinforced favorable conditions in the early 1100s and early 1200s; and (4) moderated favorable conditions in the middle and late 1000s. Clearly, the most severe periods in terms of human behavior and adaptation occur from approximately A.D. 800 to 1000 and A.D. 1250 to 1450, with secondary periods occurring around A.D. 1150 and 1700.

CONCLUSIONS

Extending annual instrumental climatic records via dendrochronology provides new perspectives on the level, variability, and duration of past climatic trends. There is no compelling reason to believe that lengthy and substantial deviations in climate, such as the periods of low and high precipitation in south-central Utah, might not recur. Based on the analyses undertaken here, it can be inferred that available instrumental records do not provide an adequate sample of the trends or variability in climate required for accurately evaluating the nature of climatic processes and what bearing they might have on human behavior. Widespread spatial coverage of dendroclimatic reconstructions would be useful for those needs. The promise of this research, and the presence of many yet-unstudied forest stands in several mountain ranges in the western United States suggest that this is an attainable goal.

APPENDIX E

Exploratory Paleoecology on the Markagunt Plateau: A Progress Report

by

David B. Madsen, Scott A. Elias, Weng Chengyu, Stephen T. Jackson, Robert S. Thompson, and Andrei Sarna-Wojciki

AUTHOR'S NOTE: *This appendix contains a summary of research in progress, and is therefore subject to modification. Some of the material included in this section was taken from Madsen, et al. (n.d.)*

INTRODUCTION

Initial work at Lowder Creek and Red Valley bogs near Cedar Breaks National Monument has produced a forest history spanning the last ~17,000 years. Pollen, plant macrofossil, and insect sample analyses are ongoing, but suggest that the two bogs provide an extraordinary record of the changing environmental conditions facing prehistoric people in the area; evidence of fire frequency; and, possibly, the nature of previous beetle infestations, which may have affected regional forest ecosystems. These records also indirectly affect the interpretation of glacial events and recent volcanic activity on the Colorado Plateau.

The project is a joint undertaking involving the Utah Geological Survey (UGS), the National Park Service (NPS), the U.S. Forest Service (USFS), the U.S. Geological Survey (USGS), the Department of Botany University of Wyoming, and the Institute of Arctic and Alpine Research at the University of Colorado. Field work was carried out in 1997 and 1998, with analyses continuing through 1999 and 2000. In August 1997, personnel of the UGS, with the assistance of staff from the USFS and NPS, conducted exploratory investigations of several bogs to determine the depths of deposits and the time-span they represent. The results of this exploratory work, together with previous research conducted in the area (e.g., Mulvey, et al., 1984; Anderson, et al., 1999), led us to select two bogs southwest of Brianhead, at 3,446 m (11,306 ft) -- the highest point on the Markagunt Plateau. We collected an exploratory core from Lowder Creek Bog to investigate the early post-glacial environmental record on the plateau. We were particularly interested in retrieving and analyzing a volcanic ash that reportedly occurred in the bog sequence between ~14,000 and ~10,000 radiocarbon years ago (Mulvey, et al., 1984). This ash was not reported in a second pollen sequence taken from the bog (Anderson, et al., 1999), and no other reports exist for an ash of this age in this area. We felt that if such an ash deposit could be recovered, identified, and dated, it could prove to be an important chrono-stratigraphic tool, useful in correlating paleoenvironmental and archaeological sequences on the plateau. We also thought that if it could be related to a previously recognized ash fall, it would also be possible to directly relate the Markagunt Plateau sequences to those outside the immediate area. We also hoped to retrieve pollen samples from the lower part of the Lowder Creek Bog sequence to extend the sequence reported by Anderson, et al. (1999). Pollen analyses of samples from the cores reported in Mulvey, et al. (1984), were never completed, but preliminary results suggest that several thousand years of deposits predating the earliest deposits reported by Anderson, et al. (1999), occur in the deeper areas of the bog.

We also explored the deposits at Red Valley Bog. The bog was selected for investigations for two principal reasons. First, the bog is perched on a slope, and change in the drainage pattern of the spring feeding the marsh has caused it to largely dry up. As a result, it was possible to create a large exposure of the bog deposits and to sample the deposits directly from this profile. This allowed us to avoid problems with differential compression, which commonly plague samples taken with cores, and to obtain large samples through which changes in plant macrofossils and insect faunas could be detected. Second, the bog is near the current ecotone between the spruce/fir forest dominating the higher regions of the Markagunt Plateau, and the ponderosa pine dominated ecosystems found on upper mid-slope areas. This makes the bog sensitive to up and down slope movements of these forest types and allows us to detect even minor changes in environmental conditions over the period spanned by the bog record.

LOWDER CREEK BOG

Introduction

The Markagunt Plateau, at an elevation of ~3,000-3,400m (~9,800-11,000 ft), lies in the Basin and Range/Colorado Plateau Transition zone of southwestern Utah (Stokes 1986; Sable and Maldonado, 1997b), immediately east of Cedar Breaks National Monument (Figure E.1). The plateau is capped by Tertiary volcanic tuffs, lavas, and "megabreccea" of the Mount Dutton Formation, Quicapa Group, Isom Formation, and Needles Range Group (Anderson 1993; Anderson and Rowley 1975; Sable and Maldonado 1997b). The highest point on the plateau is the Brian Head (3446m/11,306ft)/Sidney Peaks (3,378m/11,082ft) area, where late Wisconsin glaciers formed in shallow valley heads along the southeastern margin of the crest. Lowder Creek Bog (UTM: 342040 easting, 4170790 northing, zone 12; ne 1/4, nw 1/4, ne 1/4, section 19, T36S, R8E; Brianhead 7.5" quadrangle) lies near the mid-point of the Lowder Creek glacier in a small moraine-dammed basin. The basin was ice-free by at least ~14 ka, and most likely by ~15 ka (Mulvey, et al.,1984).

In 1997, using a 2-inch Livingston piston coring device, we retrieved two cores from locations near those from which the Mulvey, et al., cores were taken. Lowder Creek Bog was originally a lake, which, through time, gradually evolved into a sedge marsh. Because our goal was to investigate the lower deposits, we ignored the peat deposits that overlie the deeper lacustrine clays, and, in both cores, kept only the sequence of lake clays. In both cases, we penetrated what appears to be the volcanic ash reported by Mulvey, et al. (1984). The age of the tephra was initially determined by dating pollen extracted from 1cm samples collected immediately above and below the ash. Because it is not yet clear how reservoir effects, slope wash, and other potential problems affect the accuracy of such pollen dates, we returned to the bog in 1998 to collect a third core, from which additional samples of both wood and pollen were taken to evaluate the consistency of the pollen-based chronology. Analysis of this tephra and its age is now complete and results can be reported here. Pollen analyses of samples collected at 2cm intervals from the core taken in 1998 are on-going and will be reported at a later date. This should extend the pollen sequence reported by Anderson, et al. (1999), back to ~17.5 ka.

Markagunt Ash Bed

Here we describe the identification, composition, and age of a widespread, but previously unrecognized, Late Pleistocene volcanic ashfall from the western United States. During the first 6,000 to 7,000 years of its history, Lowder Creek Bog was a small, open, shallow lake fringed with sedge-dominated marsh vegetation. By ~9 ka, sedge growth had completely eliminated open water. The depositional sequence in the lake reflects this history, with sedge peats overlying finely laminated silty, lacustrine clays. The tephra reported by Mulvey, et al., was in the lacustrine clays at a depth of 6.12-6.25m, ~50-150cm above basal gravels of Lowder Creek glacial till (multiple cores taken at various locations in the bog produced slightly different depth measurements). In 1997, and again in 1998, we penetrated what appears to be the ash reported by Mulvey, et al. (1984). The tephras are comprised of 2mm-thick layer initial airfall ash overlain by a 8mm-thick zone of alternating laminae composed of silty clays from local parent material and reworked tephra derived from the tributary drainage basin.

The tephra layers in the cores are thin, light gray in color, and very fine-grained (very-fine-sand- to silt-sized). The lower layer is about 2mm thick, pure, homogenous in grain size, and uniform in thickness. The upper layer is composed of several very thin (<1mm) lamellae of ash that contained variable amounts of detrital sediment and tephra from one lamellae to the next. The stratigraphic characteristics and stratigraphic order of the two thin tephra layers in the core, as well as their essentially identical chemical compositions, suggest that the lower, 2mm-thick tephra layer was formed by direct airfall of ash into the pond. They also suggest that the 8mm-thick, compound layer consisting of several less pure microlamellae of ash and sediment just above the first ash resulted from several episodes of reworking of the ash by runoff within that part of the Lowder Creek basin tributary to the pond. The volcanic ash layers were composed of ~80 percent pumiceous glass shards with spindle-shaped vesicles or pipe-shaped capillaries. The shards were angular and unaltered. The ash contained about 10 percent biotite, 5 percent volcanic lithic fragments, and 5 percent tectosilicates (feldspar and quartz). Traces of etched hornblende were also present. There was also a small percentage of diatoms of at least two different species.

Volcanic ash layers in the core were sampled, and volcanic glass shards from these were separated and analyzed using methods described by Sarna-Wojcicki, et al. (1984). In brief: samples were wet-sieved with water in plastic sieves fitted with nylon screens, retaining the 200 to 100 mesh size fraction (~80 to ~150 μm, respectively) for separation of glass shards. This fraction was placed in an ultrasonic vibrator in water, then treated with a 10 percent solution of HCl for a few minutes, to remove authigenic carbonate adhering to the glass particles, and with an 8 percent solution of HF for about 30 seconds to 1 minute, to remove other coatings or altered rinds that may have been present on the glass shards. The glass shards were then separated from other components of the tephra sample, using (1) a magnetic separator; and (2) heavy liquids of variable density made from mixtures of methylene iodide and acetone.

The glass separates were mounted in epoxy resin in shallow holes drilled into Plexiglass slides. The slides were then ground down and polished with diamond paste to expose the shards and to prepare a smooth, uniform surface for analysis. The polished sample was coated with carbon, and individual shards were analyzed by electron-microprobe, using the JEOL 8900 instrument. See Sarna-Wojcicki, et al. (1984), and Sarna-Wojcicki, et al. (1985), for specifics of analytical conditions. Some of the tephra layers used for comparative purposes (Table E.1) were analyzed previously by other instruments.

The polished glass shards were analyzed for Si, Al, Fe, Mg, Mn, Ca, Ti, Na, and K. Approximately 15 to 20 shards were analyzed from each sample. Results of analyses were compared with our data base of approximately 4,200 previously analyzed samples of volcanic glasses from upper Neogene tephra layers collected within the conterminous western U.S. and from bottom sediments of the adjacent Pacific Ocean. The best matches were identified using

Table E.1 Results of electron-microprobe analysis of volcanic glass shards from the Markagunt ash beds, Utah, with comparison to several ash beds erupted from the Mono Craters of east-central California.

	SiO^2	Al^2O^3	FeO	MgO	MnO	CaO	TiO^2	Na^2O	K^2O	Total
1. BH-Dm-1 Lower Markagunt Ash										
Average	**72.822**	**12.156**	**0.920**	**0.031**	**0.040**	**0.570**	**0.054**	**3.343**	**4.395**	**94.330**
±1s.d.	0.474	0.186	0.068	0.008	0.024	0.024	0.040	0.207	0.157	0.731
Range	1.622	0.598	0.228	0.030	0.086	0.083	0.165	0.777	0.666	2.784
Low	71.942	11.798	0.809	0.013	0.012	0.521	0.000	2.922	4.145	92.752
High	73.564	12.396	1.037	0.043	0.098	0.604	0.165	3.699	4.811	95.356
No. of Shards	19	19	19	19	19	19	19	19	19	19
2. BH-DM-2 Upper Markagunt Ash										
Average	**72.979**	**12.132**	**0.913**	**0.029**	**0.056**	**0.556**	**0.061**	**3.458**	**4.362**	**94.545**
±1s.d.	0.801	0.220	0.054	0.010	0.027	0.032	0.035	0.186	0.202	1.017
Range	3.584	0.893	0.195	0.034	0.089	0.140	0.109	0.681	0.851	3.784
Low	70.504	11.507	0.834	0.015	0.017	0.482	0.012	3.093	3.781	92.287
High	74.088	12.400	1.029	0.049	0.106	0.622	0.121	3.774	4.632	96.071
No. of Shards	17	17	17	17	17	17	17	17	17	17
3. KRL7982-3 Wilson Creek Ash 3										
Average	**74.282**	**12.536**	**0.916**	**0.013**	**0.034**	**0.580**	**0.040**	**3.904**	**4.508**	**95.949**
±1s.d.	0.520	0.226	0.053	0.004	0.027	0.045	0.013	0.116	0.180	n.d.
4. KRL7982L Wilson Creek Ash 4 (Lower)										
Average	**72.212**	**12.069**	**0.925**	**0.025**	**0.041**	**0.590**	**0.032**	**3.663**	**4.196**	**93.753**
±1s.d.	0.470	0.280	0.065	0.010	0.031	0.067	0.013	0.139	0.170	n.d.
5. KRL7982U Wilson Creek Ash 4 (Upper)										
Average	**74.468**	**12.548**	**0.926**	**0.019**	**0.046**	**0.573**	**0.033**	**3.814**	**4.401**	**96.828**
±1s.d.	0.557	0.239	0.058	0.007	0.027	0.053	0.017	0.085	0.142	n.d.
Samples Recalculated to 100%										
1A. BH-DM-1										
Recalculated	**77.200**	**12.887**	**0.975**	**0.033**	**0.042**	**0.604**	**0.057**	**3.544**	**4.659**	**100.00**
2A. BH-DM-2										
Recalculated	**77.190**	**12.832**	**0.966**	**0.031**	**0.059**	**0.591**	**0.065**	**3.658**	**4.614**	**100.00**
Similarity Coefficient (5 oxides)	1.000	0.996	0.991	[0.909]	[0.711]	0.978	[0.877]	[0.969]	0.990	0.991
3A. KRL7982-3										
Recalculated	**77.418**	**13.065**	**0.955**	**0.014**	**0.035**	**0.604**	**0.042**	**4.069**	**4.698**	**100.00**
Similarity Coefficient (5 oxides)	0.997	0.986	0.979	[0.424]	[0.712]	1.000	[0.737]	[0.877]	0.992	0.991
4A. KRL7982L										
Recalculated	**77.024**	**12.873**	**0.987**	**0.027**	**0.043**	**0.629**	**0.034**	**3.907**	**4.476**	**100.00**
Similarity Coefficient (5 oxides)	0.998	0.999	0.987	[0.818]	[0.977]	0.960	[0.596]	[0.907]	0.961	0.981
5A KRL7982U										
Recalculated	**76.908**	**12.959**	**0.956**	**0.020**	**0.048**	**0.592**	**0.034**	**3.939**	**4.545**	**100.00**
Similarity Coefficient (5 oxides)	0.996	0.994	0.981	[0.606]	[0.875]	0.960	[0.596]	[0.899]	0.996	0.981
6A. SL-673 Swamp Lake										
Recalculated	**76.860**	**12.990**	**0.973**	**0.030**	**0.050**	**0.610**	**0.050**	**3.700**	**4.750**	**100.01**
Similarity Coefficient (5 oxides)	0.995	0.992	0.998	[0.909]	[0.840]	0.990	[0.877]	[0.958]	0.981	0.985
7A. FLV-145A-VS										
Recalculated	**76.940**	**13.110**	**0.946**	**0.030**	**0.040**	**0.600**	**0.070**	**3.700**	**4.550**	**99.99**
Similarity Coefficient (5 oxides)	0.997	0.983	0.970	[0.909]	[0.952]	0.993	0.814	[0.958]	0.977	0.984

Data obtained on analysis are given for samples 1 – 5. These are recalulated to a fluid-free basis (100%), in 1A – 5A. The similarity coefficient is calculated between the lower (primary ash fall?) Markagunt ash bed (1A) and the remaining samples (2A – 5A). A similarity coefficient of 1.000 represents a perfect match (Sarna-Wojcicki, et al., 1984) Matches with two other tephra layers, derived from the Mono Craters source but found at more distal sites, are also presented (6A from Swamp Lake, Sierra Nevada, California; and 7A, from Fish Lake Valley, California – Nevada). C.E. Meyer and J.P. Walker, analysts, U.S. Geological Survey, Menlo Park California, 1978 – 1999.

numerical and statistical programs (SIMANAL; Sarna-Wojcicki, et al., 1984). The best matches were then examined for petrographic similarities and for stratigraphic position and sequence (Sarna-Wojcicki and Davis 1991). Possible correlative layers are identified on the basis of three main criteria: (1) chemical composition of volcanic glass; (2) petrographic characteristics of shards and mineralogy; and (3) stratigraphic position or related age. Comparisons of tephra layers for the purpose of correlation were made with several different combinations of elements, excluding those elements that are present in concentrations close to the detection limit when comparing sample groups.

Evaluation of the chemical analyses of the volcanic glass shards from the ash layers in the core indicate that the shards are very similar in composition to several distinct ash layers erupted from the Mono Craters in east-central California. The Mono Craters are a volcanic field comprised of volcanoes, volcanic vents, explosion pits, and products of their eruptions aligned along an arcuate range of hills extending from the south shore of Mono Lake to Wilson Butte, in the south, a distance of about 17 km, east of the central Sierra Nevada in eastern California. This volcanic field has produced multiple eruptions of rhyolitic lavas, pumice and ash (Lajoie 1968; Bailey 1989). Many of the eruptions have been explosive, Plinian, scattering ash over a wide area to the west, in the high Sierra Nevada and its western foothills; to the north, in the Carson Sink, and Pyramid Lake areas; and as far east as the Toiyabe Range, in central Nevada.

Stratigraphic sections containing multiple tephra layers from the Mono Craters are found near both the north and south shores of Mono Lake. At least 18 tephra layers spanning a time frame of ~36,000 to 13,000 ^{14}C yr B.P. have been documented at these sites (Lajoie 1968). Tephra layers as old as ~50,000 ^{14}C yr B.P. have been described from the briefly-exposed causeway between the north shore and Negit Island of Mono Lake during a lake low stand in the 1980s, and in cores taken from Walker Lake (Sarna-Wojcicki, et al., 1988). Activity at the Mono Craters has continued throughout most of Holocene time. Approximately 10 tephra layers that span an age range of 11,100 to 10,000 ^{14}C yr B.P. have been described (Lajoie, unpublished data, 1979). Additional late Holocene tephra layers, presumed to have been derived from the northernmost Panum Crater and a nearby explosion pit, have been correlated to layers dated variously from ~860 to ~540 ^{14}C yr B.P. (Wood 1977; Sieh and Bursik 1986).

The exact number of tephra layers erupted from the Mono Craters is not well determined, but at least ~35 major tephra layers have been identified spanning the last ~40 ka. The identification of these units is made difficult by their strong chemical and petrographic similarities. Closest matches to the Markagunt ash are the uppermost tephra layers exposed in the Wilson Creek beds north of Mono Lake. Specifically, the best matches on the basis of chemical composition of the volcanic glass shards are to Wilson Creek ash beds #3 and #4 (Table E.1). Other close matches are to a tephra layer at 6.73 m in the Swamp Lake core (Table E.1, #6A), Sierra Nevada (Smith 1990), and to a tephra in Fish Lake Valley, east of the White Mountains in western Nevada (Table E.1, #7A) (Reheis, et al., 1995, 1996). It is not possible in the present case to select a best correlative match with any great degree of certainty, because of the great similarity of the Mono Craters ash beds to each other. These similarities appear to be on the same order as the best resolution of the electron-microprobe analytical technique. Further analysis by techniques such as instrumental neutron activation, X-ray fluorescence, or inductively coupled plasma mass spectrometry may make it possible to resolve subtle differences between these tephra layers based on more precise determinations of minor and trace element concentrations, and permit more secure correlations.

The age of the Markagunt ash layer in the cores taken by Mulvey, et al. (1984), is constrained by radiocarbon dates of 14,400±850 ^{14}C yr B.P. (UCR-1661) and 9570±480 ^{14}C yr B.P. (Beta-5744) derived from bulk organic muds collected at depths of 6.80 m and 6.02 m, respectively, bracketing the ash layer at 6.12 m. The bog was also cored to a depth of 7.23 m by Anderson, et al. (1999). They obtained dates of 13,020±690 ^{14}C yr B.P. (Beta-56945) and 9200±100 ^{14}C yr B.P. (Beta-59897) on bulk sediment samples collected from ranges of 7.04-7.21 m and 5.00-5.12 m, respectively, which bracket a tephra they recognized at 6.43 m.

We attempted to more closely delimit the age of the tephra by collecting and dating organically enriched silty clays from above and below the 2-mm-thick air-fall tephra layer. After carefully cleaning the exterior of the core, 5 mm samples of laminated lacustrine silty clays from immediately above and below the ash were collected and analyzed. We used a simplified version of the preparation technique devised by Brown, et al. (1989), to concentrate fossil pollen for AMS radiocarbon dating. Sediment samples were sieved, treated with hydrochloric and hydrofluoric acids, and then KOH was used to remove portions of the non-pollen organic materials. The final residues were not "pure" pollen concentrates, but were predominately composed of pollen grains. This procedure has been used in ongoing research at Great Salt Lake (Thompson and Oviatt 1999; unpublished data), where the "pollen" AMS dates from sediments surrounding the Mazama ash (~6800 ^{14}C yr B.P.) have been found to be as much as 700 years too old. However, "bulk" organics from the same horizons are as much as 1,700 years (or more) too old, so the sample preparation technique does improve the accuracy of the radiocarbon ages. Mensing and Southon (1999) used an alternative manual separation technique to produce essentially pure concentrations of fossil pollen for AMS dating. They evaluated the accuracy of the resultant AMS dates by dating sediments adjacent to the Mazama ash from lakes in the Sierra Nevada. Although many of their dates were equivalent to the known age of the Mazama ash, a few were as much as 300 years too old. We conclude that even the most pure fossil pollen concentrates may contain pollen or other organic materials that are hundreds of years older than the sediment within which they were found.

The ages of the two Lowder Creek Bog samples bracketing the tephra are very consistent. The 5 mm sample below the ash dates to 14,280±60 ^{14}C yr B.P. (WW-1776), while that above the ash dates to 14,260±60 ^{14}C yr B.P. (WW-1775). To examine the possibility these age estimates are younger than surrounding sediment, we analyzed a series of six additional radiocarbon samples from the 1.37 m of lacustrine clays at the base of the core. Altogether, twelve age estimates, including four analyzed by Mulvey, et al. (1984) and Anderson, et al. (1999), are useful in interpreting the age of the tephra (Table E.2). The six pollen dates are relatively consistent in terms of age and stratigraphic position, but appear somewhat older than age estimates based on other materials. For example, a fragment of wood and unidentified plant material from 34 and 37 cm above the tephra date to 10,910±40 (WW-2238) and 10,950±90 (WW-2351) ^{14}C yr B.P., respectively, while a pollen sample immediately below the wood and 32 cm above the ash dates to 11,835±90 (WW-2352) ^{14}C yr

B.P. Yet when calibrated to calendar years (Stuiver, et al., 1998), the ranges of the dates at two standard deviations are relatively close (13,140-12,650 and 15,220-13,480 cal yr B.P.), suggesting the possibility that differences among the dates may be relatively small.

The date of 14,400±850 ^{14}C yr B.P. obtained by Mulvey, et al. (1984), on "stony organic mud" at the base of the deposits is also younger than the ~17,400 ^{14}C yr B.P. age estimate we obtained. However, the standard deviation of their 14,400 ^{14}C yr B.P. date is relatively large and the sandy gravels we penetrated at the base of our cores were quite clean, suggesting the Mulvey, et al. (1984), date may have been derived from slightly higher in the depositional sequence. The oldest date obtained by Anderson, et al. (1999), is also difficult to interpret, since we are unsure how it relates to the basal sandy gravels, and since it too has a large standard deviation. It also represents an average age of 17 cm of deposits. We are therefore confident that the average age of ~14,270 ^{14}C yr B.P. for the two dates bracketing the ash is close to the true age of the ash fall event, but hold out the possibility it may be slightly younger. The Markagunt tephra does not occur in the depositional sequence at the nearby Red Valley Bog, where $^{13}C/^{12}C$ corrected basal dates are 11,795±90 (WW-2355) and 11,645±95 (WW-2354) ^{14}C yr B.P.

Combining the best correlations based on the chemical compositions of the volcanic glass shards with the best available, closest age data, strongly suggests that the Markagunt ash beds correlate with Wilson Creek ash bed #3 or, less likely, #4. The ages of these ash beds are interpolated to be 14,260 and 14,760 ^{14}C yr B.P., respectively, based on a sequence of radiocarbon dates in the Wilson Creek section on tufa and ostracode valves (Lajoie 1968; Benson, et al., 1990). A regression of stratigraphic position versus ^{14}C age on multiple dates in the section by Lajoie (unpublished data) provides the above age estimates. The volcanic ash from Swamp Lake (Table E.1, #6A), is interpolated to have fallen ~12,545 ^{14}C yr B.P. (Smith 1990). This age is based on bulk peat dates of 13,690±340 and 10,420±100 ^{14}C yr B.P. collected at depths of 7.06-7.16 m and 6.00-6.10 m from the same core. However, the Tsoyowata ash bed, dated to 7015±45 ^{14}C yr B.P. (Bacon 1983), occurs at a depth of 4.29 m in the same core, suggesting that changes in deposition rates may make interpolation difficult. The Markagunt ash is also close in terms of apparent age to Mono Craters tephras found in Fish Creek Valley along the California-Nevada border east of the White Mountains. A core from the Leidy Creek fan on the Nevada side of the valley contains tephras (Table E.1, #7A) below peat dated to 11,736±150 ^{14}C yr B.P., which are estimated to be about 13,000 ^{14}C yr B.P. in age (Reheis, et al., 1995, 1996). Other volcanic ash horizons dated to the early Holocene, such as that at Barrett Lake (Anderson 1990), may also be from the same eruption, but the disparity in estimated ages makes such correlations uncertain. We suspect there are as yet unresolved problems with many of the different ages obtained for what appears to be the same tephra layer at different sites, and that these variations are environment dependent. It appears that different lakes have different reservoir corrections, and that samples from peat bogs tend to have younger ages than samples from lakes. For the moment, we consider the age of the Markagunt ash bed to be ~14,000±500 ^{14}C yr B.P. and suggest that a number of closely limiting age determinations will be necessary before a more definitive chronology is available. It is also possible, but less likely, that all the tephra layers at these different sites really do represent different ash-fall events.

Table E.2 Radiocarbon age estimates of samples from Lowder Creek bog.

Depth (cm)*	Material	Age (BP)	Laboratory Number
219-231	Bulk organic	9,200 ± 100	Beta-56945**
137	Top of lacustrine clays		
125	Plant material	10,950 ± 90	WW-2351
122	Wood	10,910 ± 40	WW-2238
120	Pollen	11,835 ± 90	WW-2352
98	Bulk organic	9,570 ± 480	Beta-5744**
89	Pollen	14,260 ± 60	WW-1775
88	Tephra		
87	Pollen	14,280 ± 60	WW-1776
50	Pollen	14,620 ± 110	WW-2358
10-27 (?)	Bulk organic	13,020 ± 690	Beta-56945**
?	Bulk organic	14,400 ± 850	UCR-1661**
19	Pollen	16,930 ± 70	WW-2064
3	Pollen	17,400 ± 160	WW-2353

* Measurements are relative to the coarse gravels at the base of the lacustrine deposits.
** Approximate position measured relative to the tephra layer as described by Mulvey, et al. (1984), and Anderson, et al. (1999).

The distribution of all previously known Mono Craters tephras is limited to areas within 250 km of the crater chain on the western edge of the Great Basin (Figure E.1). Lowder Creek Bog is ~550 km east of Mono Craters on the Colorado Plateau near the eastern margin of the Great Basin, suggesting that the late Pleistocene eruptive event that produced the ash was considerably larger than any of the subsequent Holocene eruptions. Except for the locations noted above, tephra layers similar to the Markagunt ash have not yet been recovered from any other sites in California, Nevada, Utah, or Arizona. Some of these sites (e.g., Walker Lake, NV [Bradbury, et al., 1989], Ruby Marshes, NV [Thompson 1992], Potato Lake, AZ [Anderson 1993], Sevier Lake, UT [Thompson, et al., 1995], and Tulare Lake, CA [Davis 1999]) have apparent hiatuses in sediment accumulation for the period surrounding the deposition of the Markagunt ash. Other regional localities, such as pollen sites on the Kaibab Plateau (Weng and Jackson 1999), probably are slightly too young for the Markagunt ash. At other sites (e.g. Death Valley [Lowenstein, et al., 1999] and Searles Lake [Litwin, et al., 1999]) the chemistry of the lake waters may have precluded preservation of the ash (R.M. Forester, personal comm.). The Owens Lake, CA record also lacks the Markagunt ash (Smith and Bischoff 1997), perhaps due to the poor recovery of the rotary coring rig in the upper sediments.

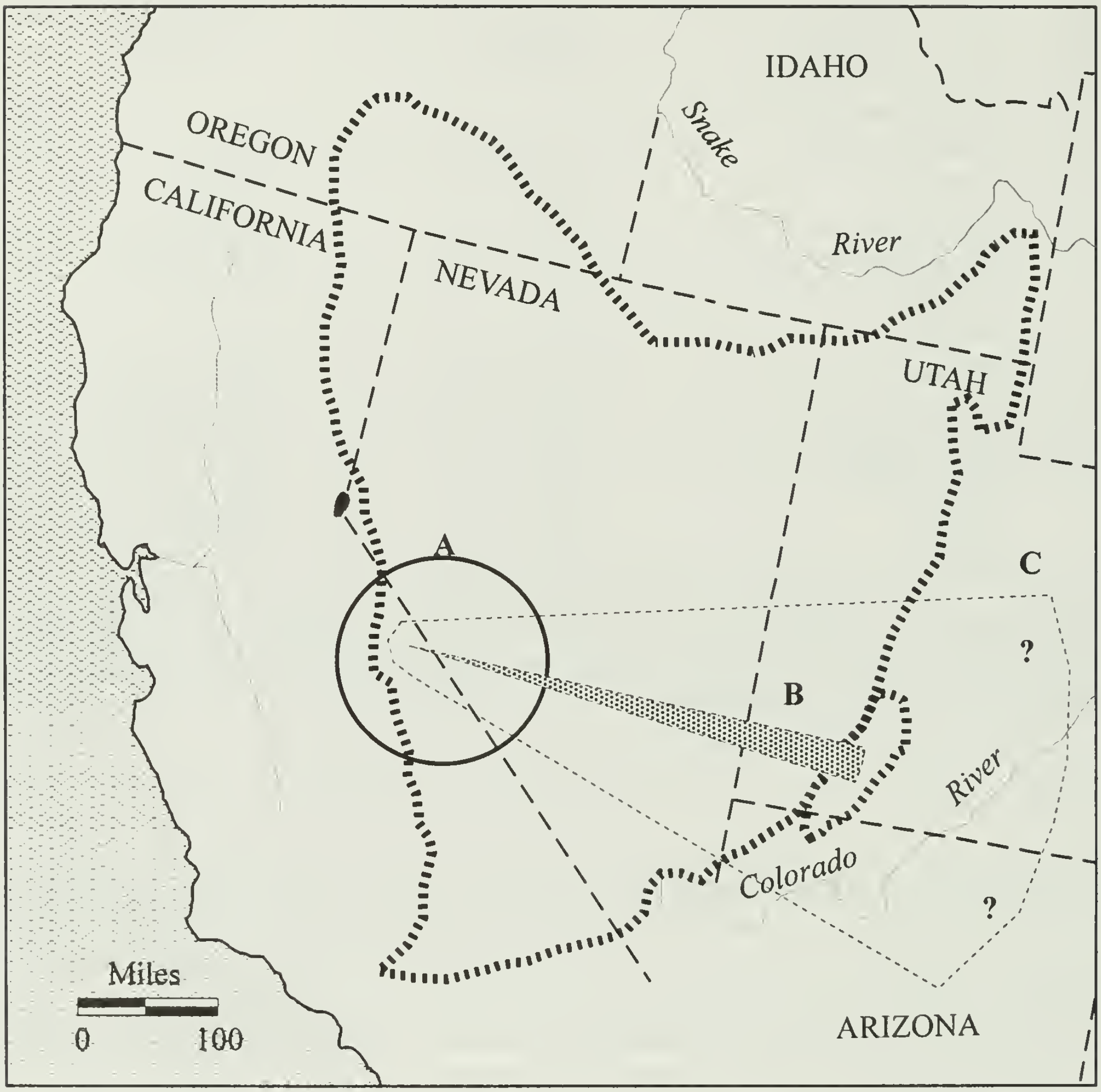

Figure E.1 Distribution of the Markagunt ash bed and other Mono Craters tephras: Circle (A) denotes the previously known limits of Mono Craters tephra; the small gray wedge (B) denotes the known distribution of the Markagunt ash bed; and the large dashed wedge (C) denotes the potential range of the ash bed.

The apparent absence of the Markagunt ash from the central and northern Lahontan basin, where the late Jonathan O. Davis conducted extensive stratigraphic and tephrachronological studies (e.g., Davis 1978), suggests that the ash was not deposited in this region (although other Mono Craters tephras have been identified [Benson, unpublished]). The Markagunt/Wilson Creek ash plume also apparently did not reach the Bonneville basin, where Currey and Oviatt (e.g., Currey 1990; Oviatt, et al., 1992) have conducted extensive stratigraphic studies, may indicate that the ash was not deposited in this basin. Sediment cores from the southern arm of Great Salt Lake also have not been found to contain the ash (Spencer, et al., 1984; Thompson and Oviatt 1999).

It is difficult to estimate the ash-fall area given the limited number of locations where the Markagunt ash bed has been recognized. Wind direction appears to have been from directly west to east during the period of deposition, since Lowder Creek Bog, at 37°40' north latitude, is almost due east of Mono Craters at 37°48'-56'. However, it is also possible that Lowder Creek was at the southern or northern margin of the ash plume. We think a plausible ash-fall area extends from the southern Bonneville Basin in central Utah to the Colorado River in northern Arizona (Figure E.1), and possibly as far north as Salt Lake City, Utah, and as far south as Flagstaff, Arizona. Given the 2 mm of clean air-fall ash in the Lowder Creek Bog sequence, at a location more than 500 km from the volcanic vent, the area covered by the Markagunt ash bed likely extends well to the east. How far east is uncertain, but the ash plume may have deposited tephra well onto the Colorado Plateau.

Identification and dating of a volcanic ash from Lowder Creek Bog suggest that the Markagunt ash bed may serve as a chronostratigraphic marker bed linking late Pleistocene deposits across much of the southern Great Basin and west-central Colorado Plateau. The tephra was probably derived from a Mono Craters source area during an eruptive event dating to about 14,000±500 ^{14}C yr B.P. At Lowder Creek Bog, the ash-fall event is closely dated to ~14,270 ^{14}C yr B.P. The Markagunt tephra may be the same as Wilson Creek ash #3. The combination of remarkably similar interpolated age (~14,260), and the best chemical match, in addition to the stratigraphic and age information from Benson, et al. (1990), and Lajoie (1968, and unpublished), strongly point to this conclusion. However, a more definitive chronology will require a larger suite of dates. Close inspection of fine-grained lacustrine deposits from Great Basin lakes dating to this period, particularly those to the east of Mono Craters in the southern Bonneville basin, will likely detect the presence of the Markagunt ash bed.

RED VALLEY BOG

Introduction

In August, 1997, we conducted initial explorations of the deposits at Red Valley Bog (UTM: 349420 easting, 4165160 northing, zone 12; ne 1/4, nw 1/4, se 14, section 2, R8W, T37S; Henrie Knolls, Utah 7.5" quadrangle). As noted, the bog was selected for investigation because it has been drained, making it possible to create an exposed profile and to sample the deposits directly to obtain large samples for both macrofossil and insect analyses. In addition, we hoped to define a fire history for the area, using charcoal stratigraphy in the profile. The bog is also at the current ecotone between the spruce/fir forest dominating the higher regions of the Markagunt Plateau, and the ponderosa pine-dominated ecosystems found on upper mid-slope areas, making the bog sensitive to up and down slope movement of these forest types. The bog is at an elevation of 2,822m (9,260ft) on the northeast facing slope of a 3,064m (10,054ft) high volcanic cone. The slope is dominated by mixed aspen and Douglas fir, with some subalpine fir and Engelmann spruce. With the exception of a grass- and forb-dominated meadow along the stream channel, which flows through Red Valley below the bog, the remainder of the area is currently dominated by almost pure stands of aspen. Isolated stumps of ponderosa pine remain on low south-facing ridge margins 100-200m northeast of the bog, but the highest stand of ponderosa pine occurs ~1.5km southeast of Red Valley at an elevation of 2,786-2,810m (9,140-9,220ft).

During these initial investigations, we excavated a 2 x 3m area in the center of the bog and mapped the coarse stratigraphy of the bog deposits. A 2.5 m deep exposure was excavated down and into what appeared to be basal colluvial gravels. We obtained dates of 11,420±70 (Beta-108555) and 11,470±60 (Beta-108554) B.P. on spruce branches collected from the top and bottom of a peat layer within these gravels, suggesting that the bog would provide an insect and macrofossil record that could supplement the Holocene pollen record for the Markagunt reported by Anderson, et al. (1999). A minimum of 14 fire horizons, represented by wood ash and/or charcoal were recognized in the Red Valley Bog sequence during these initial explorations.

In 1998, we returned and explored other areas of the bog, to locate the deepest and most complete exposures and to re-sample the sequence for pollen, for small macrofossils such as seeds and pine needles, and for insects. As it turned out, the deepest stratigraphic section at the bog is in the same area as our original test excavation unit, so we merely expanded this to a 3 x 3m work area. In so doing, we were able to reach bedrock and expose a second, lower peat deposit within the basal gravels. Two spruce branches taken from the base of this lowest peat (Stratum 2) date to 11,795±90 (WW-2355) and 11,645±95 (WW-2354) B.P. Twenty-five (25) depositional units were recognized (Figure E.2). These consist of strata whose upper and lower surfaces can be readily mapped and defined. Microstratigraphic units are evident within most of these larger depositional units, but these can neither be mapped accurately nor excavated separately with confidence. Large bulk samples were collected from the major stratigraphic units. In addition, the complete exposure was sampled at 2.5cm intervals (measured from the top of the sequence), with the samples mapped against the coarse stratigraphy. This strategy produced large bulk samples from each mappable stratigraphic unit, as well as smaller sub-samples within them. Additional dates on spruce and ponderosa pine needles recovered from Strata 20, 12, and 7 were obtained to investigate depositional continuity within the bog sequence (Table E.3). The date of ~5.3 ka on ponderosa pine needles from Stratum 7 suggests that a marked depositional hiatus exists between the initial peat deposits dating to 11-12 ka and those immediately above them. Additional samples from these lower strata are being analyzed to better define the length and duration of this hiatus. Very preliminary results from the insect analysis and from the identification of small plant macrofossils are now complete and can be reported here. Identification of larger macrofossils and pollen analysis are continuing. Because all of these investigations remain in progress, and because age estimates are not yet complete, none of the results presented here should be considered definitive.

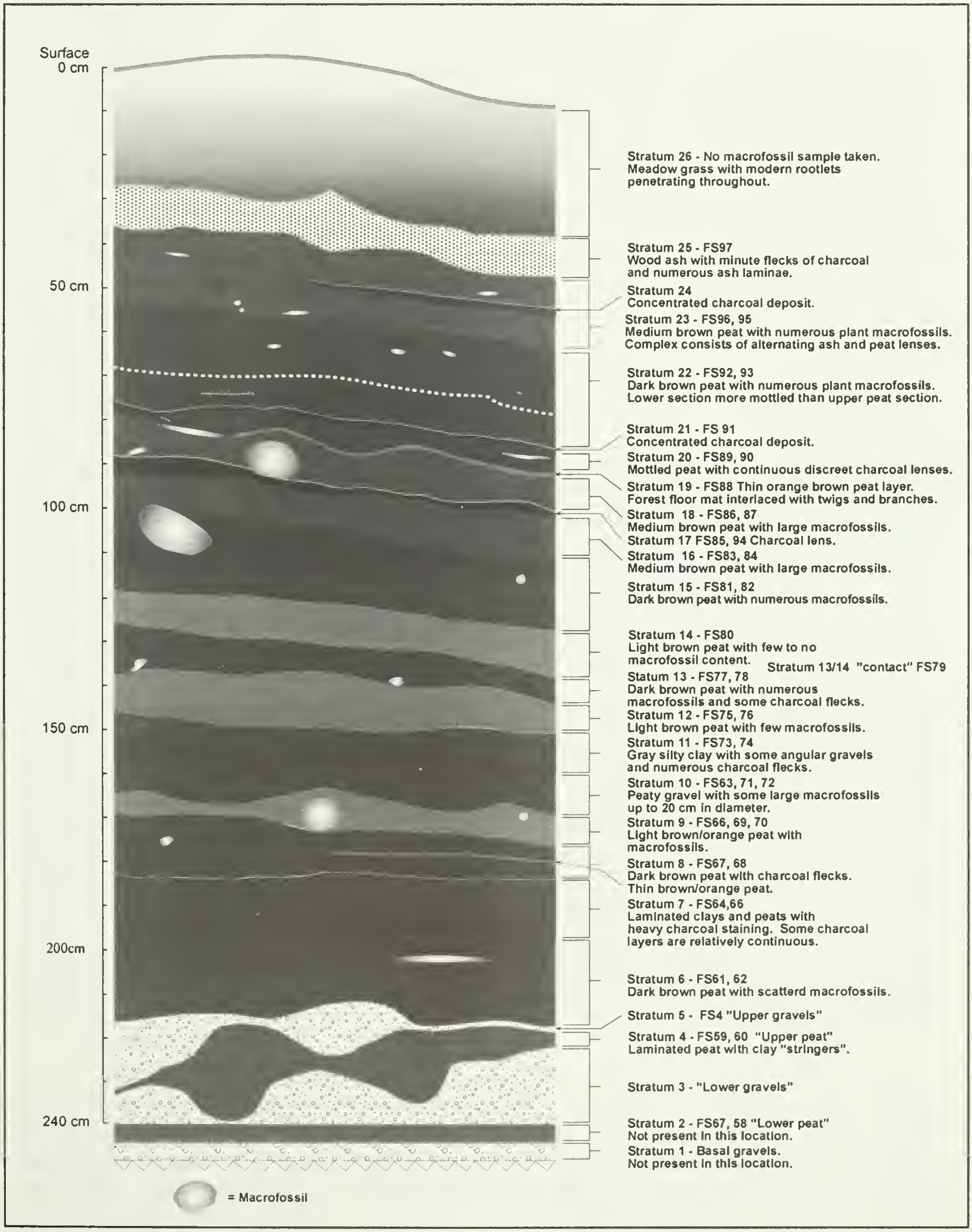

Figure E.2 Mapped profile from Red Valley Bog.

Table E.3 Radiocarbon age estimates of plant macrofossil samples from Red Valley Bog.

Depth	Material	Age (BP)	Laboratory Number
Stratum 21 (42-63cm)	Spruce needles / cone scales	2,630 ± 50	Beta-130149
Stratum 12 (138-146cm)	Spruce needles / cone scales	4,940 ± 60	Beta-130148
Stratum 7 (169-182cm)	Ponderosa pine needles	5,320 ± 60	Beta-130147
Stratum 4 (232cm)	Spruce branch	11,470 ± 60	Beta-108554
Stratum 4 (258cm)	Spruce branch	11,420 ± 70	Beta-108555
Stratum 2 (~ 275cm)*	Spruce branch	11,645 ± 95	WW-2354
Stratum 2 (~ 275cm)*	Spruce branch	11,795 ± 90	WW-2355

* Collected from separate profile; depth approximate

Plant Macrofossils

Plant macrofossils and macrocharcoal from 18 peat strata from Red Valley Bog were processed and analyzed. The plant macrofossils include fragments from both terrestrial and aquatic flora. Taxa include *Picea* (spruce); *Abies lasiocarpa* (subalpine fir); *Abies* spp. (fir); *Pinus ponderosa* (ponderosa pine); *Pseudotsuga* (Douglas fir); *Sambucus* spp. (elderberry); *Rubus* spp. (raspberry); *Populus* spp. (aspen); and *Carex spp.* (sedge). All of them are terrestrial except *Carex.* The most frequent macrofossils are conifer needle fragments. The results indicate elevational vegetation changes and climate change on the Markagunt Plateau, Utah, during the late last glacial and the Holocene.

Sediment samples of 50 to 400cm^3 were sieved through 2.0 mm, 710 μm and 355 μm soil sieves sequentially. Macrofossils and mega-charcoal fragments were sorted under a dissecting microscope at a magnification of X 6.5. Plant macrofossils were identified by comparison with reference collections using the dissecting microscope at a magnification of X 6.5 to X 40. Macrofossil data are expressed as number per 100 cm^3 sediment. Mega-charcoal fragments were picked out under the dissecting microscope and dried in an oven at about 100 degrees C. Weights were obtained using a Mettler H10W balance with the precision of 0. 1mg. The value is expressed as weight (mg) per liter sediment.

The macrofossil diagram can be described in three zones. Based on the dates from the profile, the three zones could be assigned to the late Glacial and early Holocene, the Mid-Holocene, and the late Holocene.

Late Glacial and early Holocene: Stratum 2 to Stratum 6 (depths 190 - 245cm). *Picea* needles and cone scales are abundant. *Abies lasiocarpa* needles are also present in this zone (Figure E.3). However, most of the *Picea and Abies* needles are not well preserved (especially for Stratum 2 and Stratum 4). Most are broken fragments. Complete needles are rare. A possible interpretation is that they were transported for some distance by water before deposition. This is consistent with the gravel and clay deposits. One piece of *Pinus* *ponderosa* and one piece of *Pseudotsuga* needle fragment are found in samples from Stratum 2 and stratum 6, respectively. Mega-charcoal value is moderately high in one of the samples (FS 59 from Stratum 4, ~1000mg/L), and is almost absent in the other two.

Early and Mid Holocene: Stratum 7 through Stratum 16a (depths 190 - 90 cm). This zone is most diverse in macrofossils. All taxa found in this site are seen in this zone. *Pinus ponderosa* and *Pseudotsuga* appear in this zone. *Carex* achenes (both lenticular and trigonuous), *Rubus* seeds, and a *Populus* bud scale are also found. Macrocharcoal values are high in most of the samples in this zone. Most are between 500 and 1000mg/L. In one of the samples (FS 73 from Stratum 11), this value is as high as 13,000mg/L, which is the highest we obtained in the whole profile (Figure E.3).

Late Holocene: Stratum 16b through Stratum 24 (90cm - 30cm). Only a few *Picea* needles, cone scales, and *Abies* needles were found in this zone. The diversity of macrofossils is the lowest among the three zones. There are three charcoal deposits in this zone. However, we do not have samples to measure charcoal values in these deposits. Macrocharcoal concentration from the measured deposits are very low (most -30mg/L) (Figure E.3).

The study site was surrounded by *Picea-Abies* forest during the late Glacial and early Holocene. The temperatures then compared to today are difficult to estimate. Plant macrofossil evidence does not indicate whether it was warmer or cooler then than it is today. The moisture was probably higher than today's because *Picea* needles and cones could be transported for some distance by flowing water, which may indicate more rainfall. This inference is consistent with the results from Kaibab Plateau, Arizona (Weng and Jackson 1999) and Lowder Creek Bog, Utah (Anderson, et al., 1999), where the late Glacial and early Holocene were thought to be wetter than today. The early to mid-Holocene was warm and probably dry. *Pinus ponderosa* and *Pseudotsuga* are growing lower than the study site today. During the late early Holocene and mid-Holocene, a warmer climate allowed them to colonize higher elevations, including the study site. The invading time for *Pseudotsuga* was around 7,000-8,000 B.P. *Pinus ponderosa* invaded a little later, around 5,000-6,000 B.P. These are apparently different from the cases in Bear Lake on the Kaibab Plateau, Arizona, where *Pinus ponderosa* invaded earlier than *Pseudotsuga.* We cannot give further interpretation due to lack of detailed information on the current site (e.g., denser pollen and macrofossil diagrams). The invading date was a little younger than that in Bear Lake on the Kaibab Plateau, Arizona, probably due to the higher elevation. *Picea and Abies* persisted at the site. Higher macrocharcoal values might be due to more fire events, which was probably the consequence of warmer and drier conditions in this area. The late Holocene climate was cooler. *Pinus ponderosa* and *Pseudotsuga* disappeared from the study site, as their upper elevational limits shifted down to lower elevations. The disappearing date for both was around 3,000 B.P.

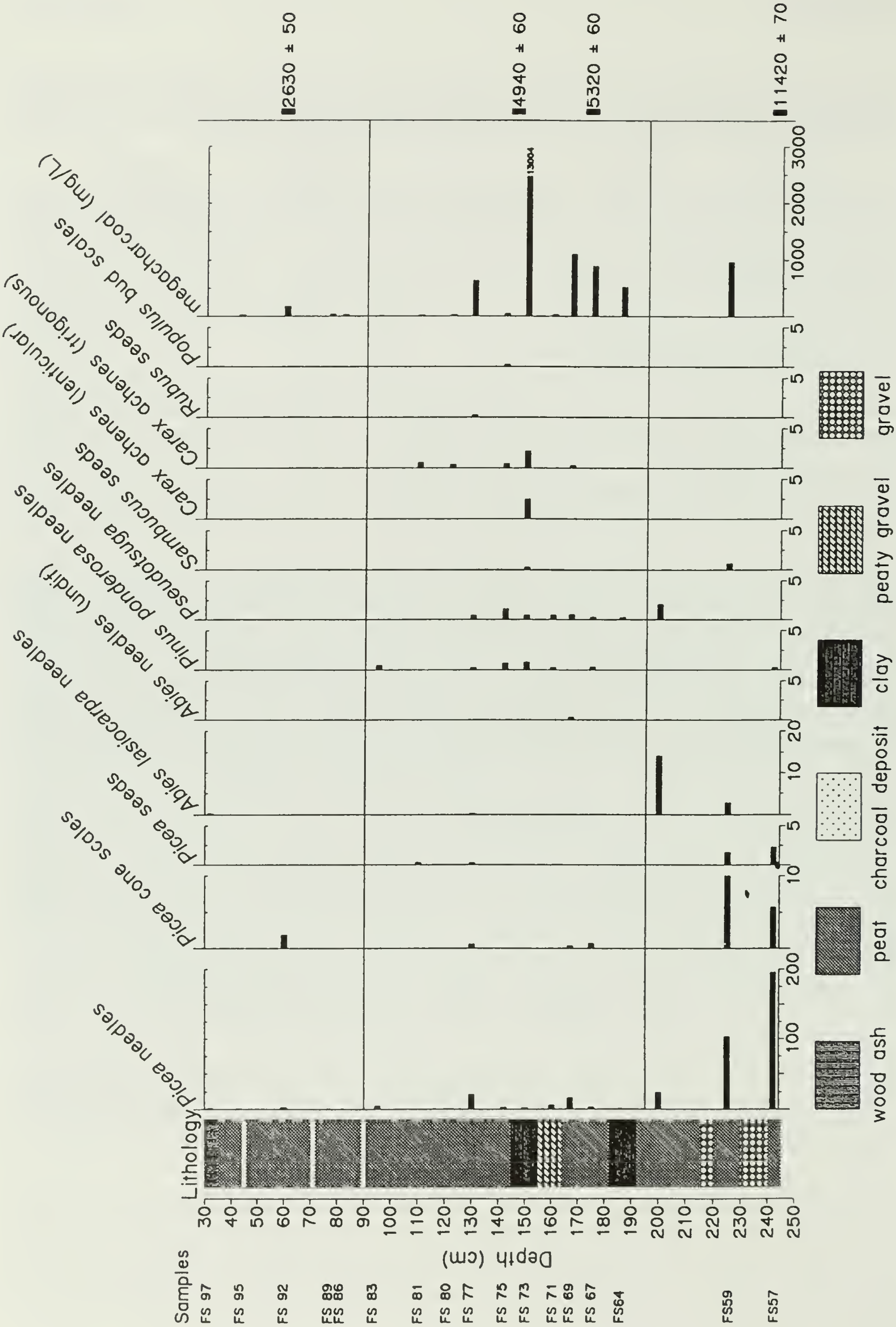

Figure E.3 Plant Macrofossils from Red Valley Bog.

Insect Fauna

The peat samples from Red Valley Bog yielded 33 insect and arachnid taxa, mainly beetles (Table E.4). The faunal assemblages are generally indicative of bog habitats, and many assemblages contain aquatic taxa indicative of open-water habitats. On the whole, the faunal diversity of the assemblages is low. However, preservation of insect chitin in the peat samples is extremely good, so the only tenable explanation for the low diversity is that the samples represent habitats near the middle of the ancient bog, rather than near the edges of the bog. Peats that accumulate near the margins of bogs generally show far greater diversity in beetles and other insects, simply because the upland habitats adjacent to the bog contribute specimens to the faunal assemblages. In contrast to this, the central parts of peat bogs offer only a low variety of insect habitats, and few species are adapted for living there. For instance, most montane beetle assemblages contain several species of ground beetles (family Carabidae). Ground beetles are almost absent from the Red Valley Bog samples thus far examined.

A number of insect taxa from the Red Valley Bog assemblages provide useful paleoecological information. We discuss these by ecological groups, as follows:

Forest Indicators: The presence of the bark beetle, *Phloeotribus lecontei,* in samples FS 89 Stratum 19A and FS 57 Stratum 2 indicates the close proximity of spruce trees to the bog. Likewise, the presence of the carpenter ant, *Camponotus herculeanus,* in FS 61 Stratum 4 and FS59 Stratum 4 indicates that there were trees very near the bog during those intervals. This species of ant builds its nest in rotting tree trunks. Again, if peat samples could be obtained from a site closer to the margin of the bog, additional bark beetle and other tree-associated taxa would probably be recovered.

Bog Environment: In sorting through the samples, sedge macrofossils dominated over moss (i.e., *Sphagnum)* remains. The beetle fossil specimens directly associated with bog habitats include the aquatic leaf beetles, *Plateumari;,* the minute moss beetles (family Limnebiidae); several of the rove beetles (family Staphylinidae); and the short-winged mold beetle (family Pselaphidae), *Reichenbachia. Plateumaris* beetles feed on emergent vegetation. The adults feed on the leaves and flowers above the water level, and the larvae feed on the plant parts in the water, puncturing the hollow stems of the plants with a sharp spine on their abdomens that allows them to use the plant as a snorkel for obtaining air. The minute moss beetles, *Hydraena* and *Ochthebius,* live in open-water habitats, frequently in bog pools. *Reichenbachia* live in moist meadows and bogs, feeding on molds that grow there. The rove beetles associated with bogs and other damp habitats include *Eucnecosum brunnescens, Olophrum boreale, 0. consimile, 0. rotundicolle,* and *Tachinus lanei. Eucnecosum brunnescens* is most often found in moist leaf litter, especially alder and willow litter. However, it also lives in sedge marshes. Its modern range is mainly in the boreal and arctic regions of Canada and Alaska, but it has also been collected in the Rocky Mountains of Colorado, near Leadville, at elevations between 10,000 and 11,000ft (3,050-3,350 m). *Olophrum boreale,* as the name implies, is a boreal-zone rove beetle. It ranges across Canada and Alaska, and south along the Rockies to Utah.

Table E.4 Insect and arachnid remains from Red Valley Bog.

Taxon	Sample																		
	St 24 FS 97	St 22 FS 95	St 21 FS 92	St 19a FS 89	St 18 FS 88	St16b FS 86	St16a FS 83	St 15 FS 81	St 14 FS 80	St 13 FS 77	St 11 FS 73	St 10 FS 75	St 10 FS 71	St 9 FS 69	St 8 FS 67	St 7 FS 64	St 4 FS 61	St 4 FS 59	St 2 FS 57
COLEOPTERA																			
Carabidae																			
Agonum sp.														1					
Selenophorus sp.																		1	
Dytiscidae																			
Hydroporus sp.																1			
Hydrophilidae																			
Helophorus oregonus McCrk.									2										
Cercyon sp.																		1	
Enochrus sp.	1																		
Hydrobius fuscipes L.						1													
Limnebiidae																			
Hydraena sp.										1							4		
Ochthebius sp.									1										
Gyrinidae																			
Gyrinus sp.																		1	
Staphylinidae																			
Eucnecosum brunnescens (Sahlb.)							1	3	3		1	8	1	3				2	2
Elonium sp.																		1	
Phlaeopterus sp.																			1
Olophrum boreale (Payk.)																	1		
Olophrum consimile (Gyll.)																		4	2
Olophrum sp.																			1
Quedius spp.								1	1								1	2	
Xantholininae sp.									1	1						1			
Stenus sp.										1									
Tachinus lanei Hatch												1					1	1	
Aleocharinae sp.									1			1					1	1	
Micropeplidae																			
Micropeplus cribratus LeC.																			1
Pselaphidae																			
Reichenbachia sp.										1		1		1					
Elateridae																			
Genus et sp. indet.																	1		
Chrysomelidae																			
Plateumaris spp.	1								1			2							

Table E.4 Insect and arachnid remains from Red Valley Bog.

Taxon	Sample																		
	St 24 FS 97	St 22 FS 95	St 21 FS 92	St 19a FS 89	St 18 FS 88	St16b FS 86	St16a FS 83	St 15 FS 81	St 14 FS 80	St 13 FS 77	St 11 FS 73	St 10 FS 75	St 10 FS 71	St 9 FS 69	St 8 FS 67	St 7 FS 64	St 4 FS 61	St 4 FS 59	St 2 FS 57
Scolytidae																			
Phloeotribus lecontei Schedl.				1															2
HYMENOPTERA																			
Formicidae																			
Camponotus herculeanus L.																	1	1	
Formica sp.																			1
Genus et sp. indet.																			1
HEMIPTERA																			
Cydnidae																			
Genus et sp, indet.									1										
DIPTERA																			
Chironomidae																			
Genus et sp. indet.			1							3									
TRICHOPTERA																			
Limnephilidae																			
Genus et sp. indet.									1										
LEPIDOPTERA																			
Microlepidoptera																			
Genus et sp. indet.												1							
ARACHNIDA																			
ACARI																			
Oribatei																			
Genus et. sp. indet.											1							1	

In Utah, modern specimens have been collected in the Wasatch National Forest at 8,500ft (2590m). It is often found in clumps of emergent vegetation at the margins of bogs. *0. consimile* also lives at the edges of bogs, lakes, and streams, in clumps of emergent vegetation. It is also found in deciduous leaf litter, such as willow and alder. It ranges today across Canada and Alaska, and south along the Rockies to Colorado and Utah. Modern specimens have been taken in Utah at sites ranging in elevation from 9,000-9,700ft (2,740-2,960m). These sites include Blue Lake and Geyser Pass in Grand County, and Whiskey Creek in Summit County. *0. rotundicolle* lives in the same habitats as *0. boreale* and 0. *consimile*. It is a boreal and arctic species. Modern specimens have not been collected in the Rocky Mountain region. *Tachinus lanei* also lives in damp leaf litter and emergent vegetation at the edges of bogs, ponds, and lakes. It is found today in the mountain ranges of the western states. In Utah, modern specimens have been collected in American Forks Canyon, City Creek Canyon, and near Ogden. Finally, the species *Micropeplus cribratus* (in a family closely allied with rove beetles) is often associated with marsh habitats. However, today it lives only in the eastern half of the United States, from New York south to Georgia, and west to Michigan, Illinois, and east Texas. Aquatic beetles found in the fossil assemblages include the predaceous diving beetle (family Dytiscidae), *Hydroporus;* the water-scavenger beetles (family Hydrophilidae), *Helophorus oregonus* and *Hydrobiusfuscipes;* and the whirligig beetle (family Gyrinidae), *Gyrinus. Hydroporus* and *Gyrinus* live in open water habitats, where they prey upon small invertebrates. *Helophorus and Hydrobius* are associated with shallow, vegetation-choked waters in bogs and at the margins of ponds and lakes. *Hydrobiusfuscipes* is almost cosmopolitan in the temperate and boreal regions of North America. *Helophorus oregonus* is found today in Utah, Arizona, California, and Oregon. It seems to prefer higher elevation habitats in California (the Sierra Nevada), Utah, and Arizona. In Utah, it has been collected from the Aquarius Plateau in Garfield County.

The fossil insect data allow some preliminary reconstructions of past environments, as follows. Late glacial environments: The oldest samples, FS 57 from Stratum 2 and FS 59 and 61 from Stratum 4, contain some of the best evidence for paleoenvironmental conditions at the site, because of the diversity of beetle species. These assemblages included the temperate-zone species, *Micropeplus cribratus;* the spruce bark beetle, *Phloeotribus lecontei;* and the boreal rove beetles *Eucnecosum brunnescens* and *Olophrum consimile.* Taken together, this indicates that mean summer temperatures at the site were probably warmer at the time of fossil deposition than now. These assemblages represent very warm late Wisconsin summer environments. Holocene environments: Unfortunately, the diversity of species drops off considerably in the Holocene peat samples, perhaps reflecting the full-scale development of the bog (i.e., the sampling locality came to represent the central bog region). The fossil assemblages ranging from Stratum 9 to Stratum 16b all contain the boreal rove beetle, *Eucnecosum brunneseens.* In a general sense, this suggests that early to mid-Holocene summer temperatures remained within a few degrees C of modem values at the site. The late Holocene samples had the fewest insect fossils, and no species useful for paleoclimate reconstruction.

Fire History

The fire history recorded in Red Valley Bog was defined through a combination of direct observation of the exposed profiles and the identification of charcoal fragments in the plant macrofossil samples. Altogether 17 fire "events" were identified (Table E.5), but what these represent is uncertain. In a number of cases, what we recorded as an "event" is a series of thin, continuous-to-discontinuous, charcoal layers within a single stratigraphic unit. It is possible that these represent separate fires, but more probably they are the result of multiple sheet wash episodes that deposited charcoal in the bog following a major fire. Such depositional sets are noted in Table E.5. Given the pervasiveness of charcoal throughout the depositional sequence, it is probable that some charcoal is present in all stratigraphic units as a result of bioturbation. For that reason, we did not identify fire events from the plant macrofossil samples, where macrocharcoal concentrations were low.

Sixteen (16) fire events are recorded between Stratum 7, dated ~5.3 ka, and the modern surface. While this suggests that a forest fire occurred in the vicinity of the bog about every 330 years, limited chronological controls make such an interpretation problematic. However, these events are distributed rather uniformly throughout the depositional sequence, suggesting that some cyclical pattern of forest growth, maturity, and fire may be present. This uniformity contrasts with plant macrofossil and insect data, indicating change in the composition of the forest around the bog. Whether or not these fire events are related to beetle infestation is not yet clear.

FUTURE WORK

The work reported here is incomplete. Pollen analyses of samples from both Lowder Creek and Red Valley bogs remain in progress. Additional radiocarbon analyses are under way at Red Valley Bog to more tightly control the age of the deposits and to define a possible depositional hiatus. Further sampling of deposits along the margins of Red Valley Bog are planned to obtain more comprehensive insect and macrofossil samples. We also hope to collect and analyze fossil woodrat middens from along the edges of the Markagunt Plateau to investigate how changes at the lower forest margins relate to those we are finding on the Plateau itself. This more comprehensive work may necessitate changes in the preliminary interpretations presented here.

Table E.5 Fire history at Red Valley Bog.

Stratum	Depth below surface (cm)	Evidence of Fire
25	10-13	ash and charcoal
24	18-22	ash and charcoal
22	33-35	ash and charcoal
22	37-40	ash and charcoal
19b	-77	charcoal
20	80-83	charcoal and charred macrofossils
19a	83-87	multiple charcoal laminae
17	96-98	charcoal and charred macrofossils
13	131-137	charcoal
11	150-158	multiple charcoal laminae and charred macrofossils
10	158-163	charcoal
9	163-173	charcoal
8	173-182	charcoal
7	182-193	multiple charcoal laminae; 2 major continuous layers may represent separate fires
4	223-227	charcoal

*U.S. GPO 2001-0-674-891

SELECTIONS from the DIVISION OF CULTURAL RESOURCES
Rocky Mountain Region, National Park Service

No. 1 **Cultural Resource Inventory and Testing in the Salt Creek Pocket and Devils Lane Areas, Needles District, Canyonlands National Park, Utah** by Betsy L. Tipps and Nancy J. Hewitt; 1989.

No. 2 **Gateways to Commerce: The U.S. Army Corps of Engineers' 9-Foot Channel Project on the Upper Mississippi River** by William Patrick O'Brien, Mary Yeater Rathbun, and Patrick O'Bannon; 1992.

No. 3 **The Archaeology of Beaver Creek Shelter (39CU779): A Preliminary Statement** by Lynn Marie Alex; 1991.

No. 4 **Archaeological Investigations at Two Sites in Dinosaur National Monument: 42UN1724 and 5MF2645** by James A. Truesdale; 1993.

No. 5 **The History of the Construction of the Road System in Yellowstone National Park, 1972-1966. Historic Resource Study Volume I** by Mary Shivers Culpin; 1994.

No. 6 **The Obsidian Cliff Plateau Prehistoric Lithic Source, Yellowstone National Park, Wyoming** by Leslie B. Davis, Stephen A. Aaberg, and James G. Schmitt; 1995.

No. 7 **Holocene Archaeology near Squaw Butte, Canyonlands National Park, Utah** by Betsy L. Tipps; 1995.

CULTURAL RESOURCES SELECTIONS
Intermountain Region, National Park Service

No. 8 **Cultural Landscape Report: Fruita Rural Historic District, Capitol Reef National Park** by Cathy A. Gilbert and Kathleen L. McKoy; 1997.

No. 9 **Ethnographic Overview and Assessment of Devils Tower National Monument** by Jeffry R. Hanson and Sally Chirinos; 1997.

No. 10 **A Classic Western Quarrel: A History of the Road Controversy at Colorado National Monument** by Lisa Schoch-Roberts; 1997.

No. 11 **Cultural Resource Investigations Near White Crack, Island-in-the Sky District, Canyonlands National Park, Utah** by Betsy L. Tipps, Andre D. La Fond, and Robert I Birnie; 1996.

No. 12 **Barrier to Crossroads: An Administrative History of Capitol Reef National Park** by Bradford Frye; 1998.

No. 13 **Archeology at the Fort Laramie Quartermaster Dump Area, 1994-1996,** edited by Danny N. Walker; 1998.

No. 14 **Cultural Landscape Report for Hubbell Trading Post National Historic Site, Ganado, Arizona** by Peggy Froeschauer-Nelson; 1998.

No. 15 **Cultures at a Crossroads: An Administrative History of Pipe Spring National Monument** by Kathleen L. McKoy; 1999.

No. 16 **Cultural Landscape Report, Golden Spike National Historic Site, Box Elder County, Utah** by Carla Homstad, Janene Caywood, and Peggy Nelson; 2000.

No. 17 **High-altitude Archeological Investigations at Cedar Breaks National Monument, Utah** by Timothy W. Canaday; 2001