

UNIVERSITY OF OKLAHOMA

GRADUATE COLLEGE

SOUTHERN PLAINS HUNTER-GATHERER ADAPTATIONS DURING THE
LATE ARCHAIC: A STUDY IN OPTIMAL FORAGING

A Dissertation

SUBMITTED TO THE GRADUATE FACULTY

in partial fulfillment of the requirements for the

degree of

Doctor of Philosophy

By

KENNETH CHARLES KRAFT

Norman, Oklahoma

2005

UMI Number: 3203314



UMI Microform 3203314

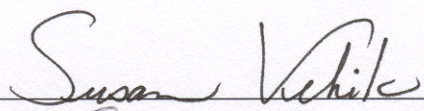
Copyright 2006 by ProQuest Information and Learning Company.
All rights reserved. This microform edition is protected against
unauthorized copying under Title 17, United States Code.

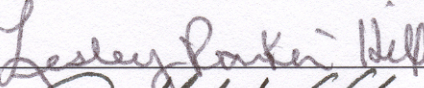
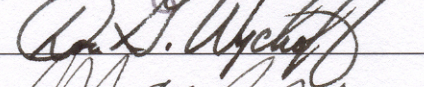
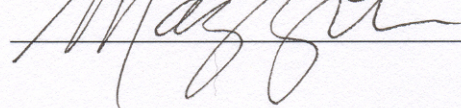
ProQuest Information and Learning Company
300 North Zeeb Road
P.O. Box 1346
Ann Arbor, MI 48106-1346

SOUTHERN PLAINS HUNTER-GATHERER ADAPTATIONS DURING THE LATE
ARCHAIC: A STUDY IN OPTIMAL FORAGING

A Dissertation APPROVED FOR THE
DEPARTMENT OF ANTHROPOLOGY

BY



ACKNOWLEDGEMENTS

Several individuals, organizations, and institutions contributed to this work. Foremost is my dissertation committee which includes members of the University of Oklahoma, Department of Anthropology and Department of Geography. They are Chair, Dr. Susan Vehik; Dr. Leland Bement; Dr. Lesley Rankin-Hill; Dr. Donald Wyckoff; and, Dr. May Yuan. Each of these committee members was chosen for their respective expertise and provided hours of instruction both inside and outside the classroom. Susan deserves special merit for bringing structure to my speculation and musing.

The University of Oklahoma Graduate School, Graduate Student Research program provided three grants to me in 1994, 1995, and 1997. These funds were used to perform exploratory coring at the L. E. Certain site, to analyze and photograph the stone artifacts from the site, and to observe and document bovine skeletal durability and preservation in the same setting as the L. E. Certain site. In 1996, the American Academy of Distinguished Students provided a grant for incidental expenses related to my research. I acknowledge Phi Kappa Phi national honor society for their support.

I thank Dr. Robert Brooks, Oklahoma Archaeological Survey, University of Oklahoma, for providing space to analyze the L. E. Certain site artifacts. The 1993 and 1995 University of Oklahoma fieldschool participants assisted with excavations at the L. E. Certain site under the supervision of Lee Bement and Kent Buehler. Lee Bement, Jason Bement, and Scott Brosowske assisted with coring at the L. E. Certain site in 1994. Also from the University of Oklahoma, I acknowledge the late Dr. Alan Witten, Department of Geology and Geophysics. In 1995 Dr. Witten collected and interpolated magnetometer data from the L. E. Certain site. Assisting Dr. Witten was Jesse Ballenger. Oklahoma Archaeological Survey, laboratory assistant Amber Van Der Walker assisted with cataloging the bones from the L. E. Certain site under the direction of Oklahoma Archaeological Survey, laboratory manager, Kent Buehler.

The Oklahoma Anthropological Society undertook excavations at the Beaver Dam site twice in 1988 and again in 1991. For their toil, they are thanked. Mr. Pete Thurmond, Thurmond Ranch, provided the infrastructure that made excavations at the Beaver Dam site possible. In addition, Thurmond Ranch funded the radiocarbon dating, as well as provided supplies for the analysis of the Beaver Dam artifacts. Pete and Susie offered room and board on several occasions accompanied by titillating conversation. For their graciousness I thank them.

Dr. Don Wyckoff, Associate Curator, Archaeology, Sam Noble Oklahoma Museum of Natural History, provided space to analyze the accessioned L. E. Certain site materials collected in the 1970s. Space was also provided to analyze the Beaver Dam artifacts on loan from Thurmond Ranch. Oklahoma Museum of Natural History

volunteer Deborah Weiss and Warren Lail assisted with cataloging the Beaver Dam collection.

And finally, I thank my mother Sally, sister Elizabeth, father Charles, and step-mother Barbara for their enduring support. Additionally, I thank my in-laws Kay and Joe Wheeler for their encouragement. I acknowledge, thank, and praise my wife Lisa who has provided moral support far beyond recognition. I dedicate this work to our son, Conrad.

TABLE OF CONTENTS

ACKNOWLEDGMENTS.....	Page iv
LIST OF ILLUSTRATIONS.....	xiii
LIST OF TABLES.....	xvii
ABSTRACT.....	xx
DEDICATION	xxi
Chapter	
1. INTRODUCTION	1
Introduction.....	1
Evolutionary Ecology and Optimal Foraging Theory.....	1
Cultural and Temporal Considerations	2
Introduction.....	2
Bison Populations on the Southern Plains.....	4
The Late Archaic.....	5
The Research.....	6
Organization of the Dissertation.....	6
2. THEORETICAL UNDERPINNINGS: A DEDUCTIVE APPROACH.....	8
Introduction	8
The Scientific Method.....	8
Hunter-Gatherer Generalizations.....	8
Evolutionary Ecology and Optimal Foraging.....	10
Introduction.....	10
Evolutionary Ecology.....	10
Optimal Foraging Theory and Anthropology.....	11
Key Components of Optimal Foraging Theory.....	13
Shortcomings of Optimal Foraging Theory.....	14
Optimal Foraging Theory: Late Archaic Hunter-Gatherer Applicability.....	16
Introduction.....	16
Central-Place Foraging Model.....	16
Foraging Group Size Theorem.....	18
Communal versus Nuclear Family Hunting and Gathering.....	18
Discussion: Expectations from the Data.....	21
Specific Considerations in Examining the L. E. Certain and Beaver	
Dam Data.....	21
The L. E. Certain Data and Implications.....	22
Faunal Remains.....	22
Floral Remains.....	23

	Lithic Remains	24
	The Beaver Dam Data and Implications	25
	Faunal Remains	25
	Floral Remains	26
	Lithic Remains	26
	Human Remains	27
	Conclusion	27
3. NATURAL SETTING		29
Introduction		29
Study Area		30
Location		31
Physical Setting and Physiographic Provinces		34
Introduction		34
Osage Plains—Origins		34
Osage Plains—Surface Character		35
Osage Plains—Biotic District		35
Geology, Topography, and Geography		36
Introduction		36
Geology		37
Salt Dissolution		41
Gravel Clasts and Their Origins		42
Topography		44
Geography		46
Hydrology		48
Introduction		48
Floods		48
Spring Water		50
Surface Water		51
Summary		52
Climate		52
Introduction		52
Drought		53
Precipitation		54
Seasonal Dynamics		55
Introduction		55
Winter		56
Spring		57
Summer		57
Autumn		58
Plant Communities and Associated Fauna		58
Introduction		58
Cross-timbers and Mixed Grass Prairie/Plains		59
Shin Oak Grassland and Sandsage Grassland		61

Summary.....	63
Paleoenvironmental Data.....	64
Introduction.....	64
Selected Paleoamerican Sites.....	65
Selected Archaic Sites.....	67
Sites Associated with the Post-Altithermal Recovery.....	68
Conclusion.....	69
 4. CULTURE HISTORY: LATE ARCHAIC-WOODLAND SITES AND SITE COMPONENTS.....	70
Introduction.....	70
General Overview.....	71
Paleoamerican (12,000-7500 BP).....	71
General Archaic.....	72
Early and Middle Archaic (7500-3000 BP).....	73
Late Archaic (3000-1650 BP).....	76
Plains Woodland (1650-1150 BP).....	77
Late Prehistoric (1150-400 BP).....	79
The Dempsey Divide.....	81
Difficulty with Distinguishing Late Archaic from Early Woodland Sites.....	81
Late Archaic-Woodland Base Camps, Human Interments, Game Kills, and Game Processing Sites in the Vicinity of the Dempsey Divide.....	83
Introduction.....	83
NE New Mexico, SE Colorado, SW Kansas, and Oklahoma Panhandle Base Camps.....	83
Base Camps.....	83
Western Oklahoma and the Texas Panhandle.....	95
Base Camps and Human Interments.....	95
Game Kills and Game Processing Sites.....	105
Conclusion.....	108
Dempsey Divide Sites.....	109
Base Camps.....	109
Burials.....	113
Game Kills and Processing Areas.....	115
Concluding Remarks.....	116
 5. L. E. CERTAIN (34BK46): A REPEATED-USE LATE ARCHAIC BISON KILL SITE ON THE SCARPED PLAINS.....	119
Introduction.....	119
Site Discovery and the Early Collections.....	120
History of Investigation.....	125
Introduction.....	125

The 1970s	125
The 1980s and 1990s	126
Excavation Techniques and other Considerations	127
Area A	132
Introduction	132
Results of Excavations–Area A	134
Chipped Stone Assemblage–Area A	138
Absolute Dating–Area A	140
Area B	141
Introduction	141
Results of Excavation–Area B	142
Absolute Dating–Area B	144
Area C	145
Introduction	145
Results of Excavations–Area C	145
Absolute Dating–Area C	150
Area D	155
Introduction	155
Results of Excavations–Area D	155
Absolute Dating–Area D	166
Area E	166
Introduction	166
Results of Excavations–Area E	167
Other Activity Areas at the L. E. Certain Site	174
Introduction	174
Area F	174
Area G	175
Area H	176
Area I	177
Conclusion	178

6. FURTHER INTERPRETATION OF THE CERTAIN SITE'S TRENCH C

DATA: FAUNA AND LITHICS	179
Interpretive Analyses	179
Introduction	179
Limitations of Data: Taphonomy	179
Death Assemblage: Minimum Number of Individuals	180
Introduction	180
Technique	181
Trench C Findings	183
Crania	184
Mandibles	188
Death Assemblage: Age	188
Introduction	188

Dental Technique.....	190
Trench C Findings.....	193
Other Techniques.....	198
Crania.....	198
Post-Crania.....	199
Summary.....	200
Death Assemblage: Sex.....	202
Introduction.....	202
Cranial and Mandibular Techniques.....	206
Trench C Findings.....	207
Post-Cranial Technique.....	208
Trench C Findings.....	209
Metatarsals.....	211
Metacarpals.....	211
Summary.....	213
Butchering Strategies and Group Coordination: Trench C	
Findings.....	214
Butchering Strategies.....	214
Group Coordination.....	214
Meat Production and Utilization.....	219
Introduction.....	219
Trench C Findings.....	220
Stone Assemblage.....	220
Projectile Points.....	221
Point Descriptions.....	221
Utilized Flakes/Flake Tools.....	228
Tool Descriptions.....	229
Biface Resharpener Flakes.....	230
Summary and Conclusion.....	233
 7. THE LATE ARCHAIC COMPONENT OF THE BEAVER DAM SITE	
(34RM208).....	235
Introduction.....	235
Site History and Discovery.....	236
Previous Archaeological Investigations and Findings.....	237
The Late Archaic Component.....	239
Feature and Artifact Analyses–Area A.....	242
Feature 1.....	244
Feature 21.....	246
Feature 22.....	249
Feature 10.....	251
Late Archaic Burial.....	256
Conclusion.....	263

8. THEORETICAL INTERPRETATION OF THE DATA	266
Introduction	266
History, Science, and Archaeology	266
Optimal Foraging Theory	266
Central-Place Foraging and Foraging Group Size	
Constructs	268
Data Specifically Supporting Central-Place and Group Size Foraging	269
Introduction	269
Test Implications	270
Beaver Dam Site	272
Test #1a: Beaver Dam Site Placement	272
The Expectations	272
The Evidence	272
Test #1b: Beaver Dam Faunal Remains	273
The Expectations	273
The Evidence	274
Features 1 and 10	274
Feature 21	274
Feature 22	275
Summary of Faunal Data	275
Test #1c: Beaver Dam Floral Remains	276
The Expectations	276
The Evidence	276
Isotopic Data	276
Macrobotanical Data	277
Cambium Data	280
Summary of Floral Data	281
Test #1d: Beaver Dam Lithic Remains	282
The Expectations	282
The Evidence	283
Feature 1	284
Feature 10	285
Feature 21	286
Feature 22	287
Summary of Lithic Data	287
Test #1e: Beaver Dam Human Remains	291
The Expectations	290
The Evidence	291
Test #1: Implications	292
L. E. Certain Site	295
Test #2a: L. E. Certain Site Placement	295
The Expectations	295
The Evidence	296
Test #2b: L. E. Certain Faunal Remains	297

The Expectations	297
The Evidence	298
L. E. Certain, Area A–Kill	298
L. E. Certain, Area C–Kills	299
L. E. Certain, Area C–Support Facility	302
L. E. Certain, Area B–Support Facilities	302
L. E. Certain, Area D–Support Facility	303
L. E. Certain, Area E–Support Facility	304
Test #2c: L. E. Certain Floral Remains	305
The Expectations	305
The Evidence	306
Test #2d: L. E. Certain Lithic Remains	306
The Expectations	306
The Evidence	307
L. E. Certain, Area A	307
L. E. Certain, Area C	308
Test #2: Implications	310
Assessment of the Model	316
9. SUMMARY AND CONCLUSIONS	318
Introduction	318
Setting the Stage	318
Evaluating the Model	322
Extending the Model	322
Conclusion	323
REFERENCES CITED	326
Appendixes	
A. Select Spring to Fall Bison Kills with Mandible Data	428
B. Select Fall to Winter Bison Kills with Mandible Data	432
C. Trench C Mandibles	437

LIST OF ILLUSTRATIONS

Figure	Page
1.1 Aerial Photograph of the Southern Great Plains with Select Hydrologic Units Delineated.....	3
1.2 View of the Upper End of Bone Bed 1 in Trench C, L. E. Certain Site	5
3.1 The Study Area with Topographic Features and Hydrologic Units Denoted	31
3.2 Composite of USGS 15-Minute Series Topographic Maps: Cheyenne (north) and Sayre (south)	32
3.3 Composite of USGS 15-Minute Series Topographic Maps: Cheyenne (east) and Reydon (west)	33
3.4 Extent of Ogallala Outwash and Salt Dissolution.....	40
3.5 Major Hydrologic Units, Geographic Regions, and Topographic Features of Western Oklahoma.....	45
3.6 Precipitation Gradient for Western Oklahoma in Centimeters.....	55
3.7 Temperature Gradient for Western Oklahoma in Celsius (winter).....	56
4.1 General Study Area Showing Late Archaic and Woodland Sites Mentioned in the Text.....	85
5.1 View of Modern Canyon at the L. E. Certain Site in Winter of 1970	121
5.2 John Flick Standing next to Bone Eroding from Gully Wall in 1970.....	122
5.3 A 1992 Aerial Photograph of the L. E. Certain Site, View is North.....	123
5.4 Tractor Road Area in 1975—Note Bones in Circles.....	126
5.5 Model of Taphonomic Factors Affecting the Faunal Assemblage.....	128
5.6 Taphonomic Factors Affecting Bone in Bone Beds.....	129
5.7 A 1966 Aerial Photograph of the L. E. Certain Site with Prehistoric Cultural Activity Areas Depicted.....	132

5.8	Bement (leaning) and Buehler Coring at the L. E. Certain Site in 1992.....	133
5.9	Dart Point Embedded in Thoracic Vertebra.....	134
5.10	Bison Crania Attached to Vertebrae but Removed from the Remainder of the Carcass	136
5.11	Smashed Crania of Bison Encased in Spray Foam.....	137
5.12	Lithic Assemblage Exclusive of Projectiles from Trench A	139
5.13	A 1992 Aerial Photograph of the L. E. Certain Site, View North-Northwest.....	141
5.14	Area B, Feature 1 (Uppermost Hearth).....	143
5.15	Removal of Area C Overburden.....	146
5.16	Trench C West Wall Profile Showing Cultural Activity.....	147
5.17	Trench C North Wall Profile Showing Natural and Cultural Activity.....	149
5.18	Northeast Edge of Bone Bed 1 (N10/13-E16).....	151
5.19	Southeast Corner of Bone Bed 1 (N11/12-E14).....	152
5.20	North Central Part of Bone Bed 1 (N11/12-E14).....	153
5.21	North Central Part of Bone Bed 1 (N11/13-E14).....	154
5.22	Orientation of Soil Coring Adjacent to Area D.....	156
5.23	Trench D Articulated Right Leg Segment.....	158
5.24	Trench D Articulated Right Leg Segment.....	162
5.25	Right Bison Scapula from Trench D.....	163
5.26	Note the Distinct Characteristics of <u>Geomys bursarius</u> ' Dentition.....	164
5.27	Trench E Articulated Left Leg Segment.....	168
5.28	Plan View of Trench E.....	171

5.29	Canine Tooth Mark on the Head of Right Femur Recovered from Trench E	172
5.30	Trench E Bone with Differential Breakage Patterns.....	173
5.31	Weathered and Root-Etched Caudal Vertebrae from Trench E.....	174
5.32	Area F Bone in 1993 Eroding from Canyon Wall	175
5.33	Area F Bone Bed in 1995 after Being Partially Exposed.....	176
5.34	Pedestal from Area G after Bone Was Mapped and Recovered.....	177
5.35	Trench I (old tractor road) Being Excavated by Buehler in 1999.....	178
6.1	Bison Anatomy.....	184
6.2	Trench C Plan Map 1993 and 1995 Crania	187
6.3	Trench C Plan Map 1993 and 1995 Mandibles.....	189
6.4	Cusps (1-3) and Facets (I-IX') of LM3.....	191
6.5	Overall Life Stage and Age Structure of Trench C Death Assemblage.....	195
6.6	Sutures of the Bison Crania.....	199
6.7	Sutures near Closure on Crania.....	199
6.8	Seasonal Fluctuations of Nutritional Health of Bulls and Cows.....	205
6.9	Mandible Height Measurement below M3.....	206
6.10	Note the Rather Stable Nature of Mandibular Widths from Trench C	208
6.11	Sexual Dimorphism in Metatarsals.....	210
6.12	Variable Preservation of Metacarpals from Trench C.....	210
6.13	Note the Rather Stable Nature of Metatarsal Widths from Trench C.....	212
6.14	Note the Rather Stable Nature of Metacarpal Widths from Trench C.....	212

6.15	Excavation Underway on a Pile of Four Bison Skulls and Mandibles	215
6.16	Excavation Underway on a Pile of Pelvic Girdles and Associated Limb Pile	216
6.17	Bison Skull Obliterated by Brain Harvesting	217
6.18	Intact but Inverted Bison Skull Found in Trench C	217
6.19	Chop Marks on a Ramus of a Mature Bison	218
6.20	Trench C Plan Map of 1993 and 1995 Projectile Points and Tools	223
6.21	Projectile Points Recovered from Trench C Kills between 1993 and 1995	224
6.22	Impact Damage on Projectile Points	225
6.23	Point #99 Found <i>in situ</i> in the Hump Section of Bison in Trench C	226
6.24	Fragment of a Notch from a Projectile Point	228
6.25	Biface Resharpening Flakes Subsequently Used as a Flake Tool	229
6.26	Biface Resharpening Flakes, Byproduct of Edge Rejuvenation	230
7.1	Profile of Ancient and Modern Valley	239
7.2	Beaver Dam Plan Map	240
7.3	Area A	240
7.4	Profile of Excavation Trench at Area A	242
7.5	Cut Bank along Brokenleg Creek	243
7.6	Feature 1, Fire Hearth	244
7.7	Typical Kitchen Area Complete with Grinding Stone and Dump	245
7.8	Typical Hearth Surround with Dump Pile of Smaller Boiling Stones	246
7.9	Plan Map of Feature 21	247

7.10	Plan Map of Feature 22 Showing Layout of Stones and Charcoal	250
7.11	View of Feature 10 upon Contact	251
7.12	View of Feature 10 after Excavating 30 cm of Fill	252
7.13	Corner-Notched Dart Point Recovered from upper Part of Feature 10	253
7.14	Corner-Notched Dart Point Recovered from lower Part of Feature 10	254
7.15	Photograph of Beaver Dam Lunate Stone	256
7.16	Projectile Point Associated with Beaver Dam Lunate	257
7.17	Photograph of the Biface Knives Associated with the Beaver Dam Burial	258
7.18	Large Flake Blank of Siliceous Ogallala Formation Quartzite (Potter Chert)	259
7.19	Biface Failure Demonstrating End Shock during Biface Production	260
7.20	Biface Reject Exhibiting Large Mass (circled) of Resilient Material	260
7.21	Biface Reject	261
7.22	Viable Biface Knife Similar to that Shown in Figure 7.17	261
7.23	Close-up Photograph of the Lunate Stone from the Beaver Dam Burial	263
8.1	Optimal Foraging Theory (OFT) Flowchart	271

LIST OF TABLES

Table	Page
3.1 Generalized Geologic Time Scale.....	38
3.2 Localized Geologic Time Scale.....	44
4.1 Archaic Sites on the Thurmond Ranch.....	75
4.2 Late Archaic-Woodland Sites Mentioned in the Text.....	86
5.1 Preliminary Faunal Assemblage from the L. E. Certain Site: 1970.....	124
5.2 1992 Assemblage of Age-Distinctive Faunal Material from 1970 Collection Area.....	124
5.3 Excavated Materials from Trench D: 1995.....	157
5.4 Faunal Materials Recovered from Trench D: 1995.....	160
5.5 Trench D Faunal Materials–Taphonomy: 1995.....	161
5.6 Faunal Materials Recovered from Trench E: 1995.....	169
5.7 Trench E Faunal Materials–Taphonomy: 1995.....	170
6.1 Minimum Number of Individuals.....	184
6.2 Bison Crania (1993).....	185
6.3 Bison Crania (1995).....	186
6.4 Season of Death for Select Bison Kill Sites: Spring through Winter.....	194
6.5 Overall Life Stage and Age Structure of Trench C Death Assemblage.....	195
6.6 Metacarpal (Distal) Transverse Width.....	201
6.7 Metatarsal (Distal) Transverse Width.....	202
6.8 Metric Attributes of Trench C Kills Projectile Points.....	222

7.1	Late Archaic Radiocarbon Dates from the Beaver Dam Site	242
7.2	Feature 21 Cultural Debris: Faunal	247
7.3	Feature 21 Cultural Debris: Lithic	248
7.4	Feature 22 Cultural Debris	250
7.5	Feature 10 Cultural Debris	254
7.6	Feature 10 Cultural Debris: 1m Radius	255

ABSTRACT

In this study, optimal foraging theory is used to evaluate hunting and butchering practices as well as the residence patterns of Late Archaic hunter-gatherers from the southern Plains. Their behavior is represented in the archaeological record by sites, features, and artifacts. Prior to exploring the data, the tenants of optimal foraging theory and central-place foraging, are presented. The first aspect of central-place foraging is that a group will venture from a home base to acquire resources. The second aspect of the theory states that special task groups are used to acquire the said resources. Once located, the resources were returned to the base. In order to better explain the task group aspect of the equation, the group foraging size theorem is employed. The theorem states that the task group's success is contingent on the appropriate number of individuals being available coupled with the appropriate resource placement on the landscape. To check the validity of this argument, two test implications are formulated using the above theoretical constructs. Test #1 is used for Beaver Dam (reliance on a home base) whereas Test #2 is applied to L. E. Certain (employment of a resource encounter and exploitation site). Initially, I set forth the expectations. Then, utilizing the evidence found at the sites, the implications are discussed. Beaver Dam, the base camp, is discussed first since this is where forays into the surrounding biomes originate. This discussion is followed by an assessment of L. E. Certain, a special extractive camp. The data revealed that Late Archaic groups maximized net energy intake while reducing energy expenditure by using a base of operation, that base being situated in an area where multiple resources were gathered just a short distance from camp. When a resource was abundant and some distance from camp, the strategy was to harvest the resource using a specially qualified group. In this study, the groups were bison hunting taskforces. These hunters embarked on their mission with a set of highly specialized stone tools to kill and process the game. The bison meat was procured utilizing butchering techniques that produced large amounts of meat and other byproducts quickly. While some of the meat was eaten on-site, most was dried and returned to camp. That this response was successful is indicated by the fact that large-scale bison kills were conducted at the L. E. Certain site for over 500 years.

TO:

C.C.K., II

CHAPTER ONE

INTRODUCTION

Introduction

Archaeological data consist of the tangible results of cultural behavior. Unfortunately, the archaeological data are restricted as to both quantity and range of representation. Quite often cultural behavior is a direct result of interaction with the natural environment, so there is a need for archaeologists to interpret and synthesize empirical facts and place them in a cultural context. Evolutionary ecology is a means to this end. Evolutionary ecology holds that certain cultural practices are selected for *de facto* by ecological conditions which in turn concurs a selective advantage upon a group and consequently its survival.

Evolutionary Ecology and Optimal Foraging Theory

The cornerstones of evolutionary ecology are based in Darwinism which focuses on an organism's relationship with its environment. Without a doubt, human cultures are highly adapted to their local environment, and most cultural behavior is the extrasomatic response to the environment (Thomas et al. 1979:31-34; White 1959:8). Diet, in particular, is responsive to seasonal and annual fluctuations in resources. As a result, the manner in which hunter-gatherers organize themselves into groups depends in part on the environment in which they make their living. It should be kept in mind that the environment is not a deterministic factor in cultural adaptation but merely one of several factors with which cultural and biological adaptation must interact. Further, human culture should not be viewed as passively reacting to outside stimuli such as the environment, but rather an interactive process of behavior, biology, and environment in its broadest definition.

One of the most important aspects to archaeology is reconstructing past lifeways. Even more important is the search for the processes that underlie and explain human behavior. When examining the dynamics of human behavior, the vibrancy of the environment and its resources must be considered equally. The most basic way to go about this line of inquiry is to look at human interaction with the environment, namely the acquisition of food (Jochim 1981:64-113; 1983; Thomas et al. 1979:1-3). Optimal foraging theory, which is based in evolutionary ecology, holds that decisions by the group about food acquisition are formed according to least-cost estimates and the potential energy payoff thereof (Foley 1985; MacArthur and Pianka 1966; Pyke et al. 1977; Smith 1981; Smith and Winterhalder 1981; Thomas et al. 1979). Other issues involved in subsistence strategy, which fall under the rubric of optimal foraging theory, focus on specific resource attributes such as spatial and temporal distribution, reliability, search and pursuit times, risk minimization, and resource density. Decisions as to whether the group should move *en masse* to the food source, or if the group should make forays to a resource and return to a base camp, are paramount to this discussion (Binford 1980; Hayden 1981a, 1986, 1987; Kelly 1983, 1995).

Cultural and Temporal Considerations

Introduction

This study is concerned foremost with post-Altithermal (4450 BP) subsistence on the southern Plains of North America. Two archaeological sites, in particular, the L. E. Certain site and the Beaver Dam site, are utilized in this study to shed light on decision-making processes involved in food-resource acquisition (Figure 1.1). The Certain site is a bison trapping location and the Beaver Dam site is a residential camp, both utilized repeatedly over several centuries. The abandoned artifacts, features, and bones at the Certain site offer the best chance at illuminating the nature of food acquisition and group movement on the landscape during the post-Altithermal environmental recovery. The Beaver Dam campsite (34RM208), with its tool varieties, raw material use patterns, and

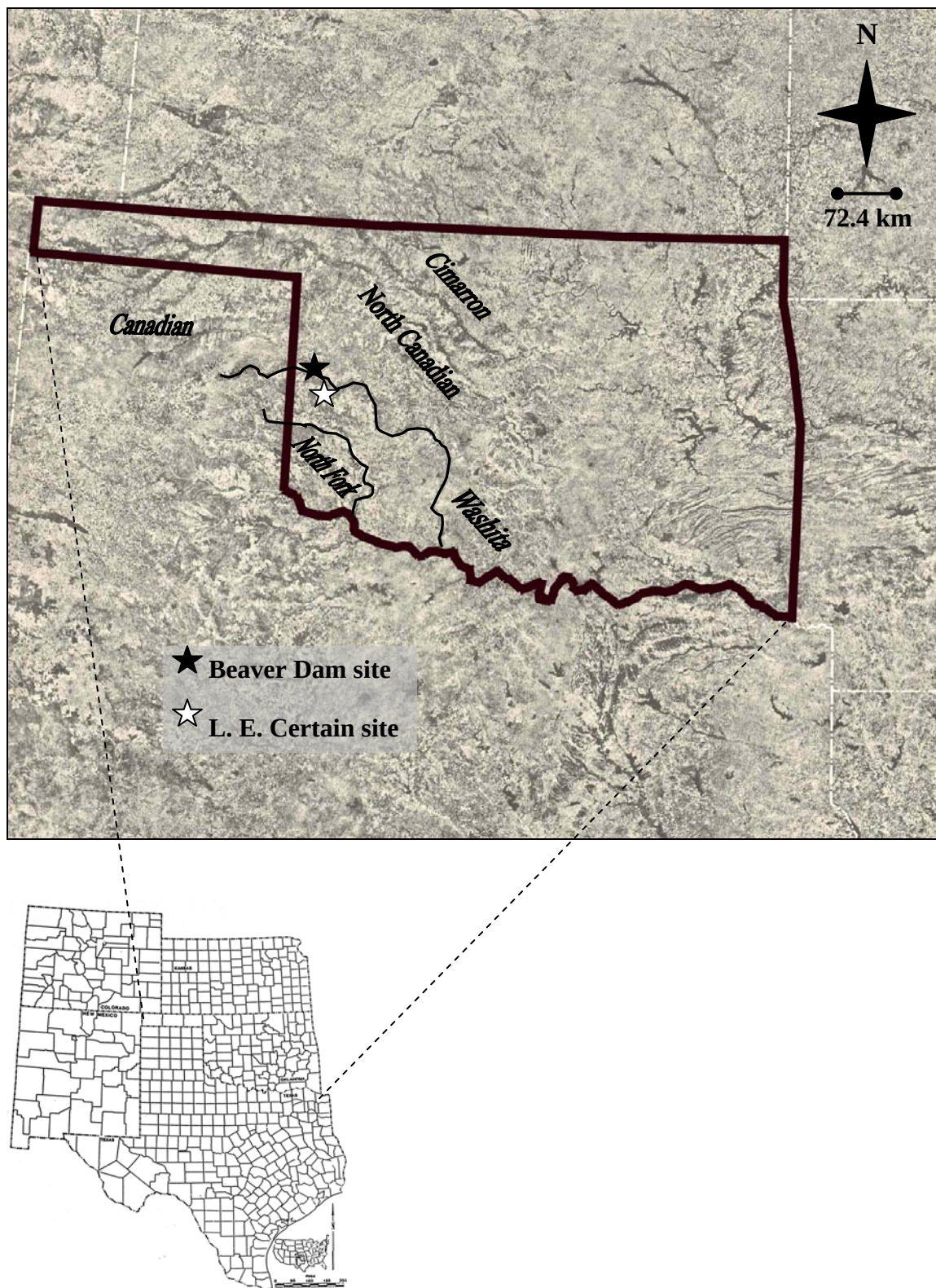


Figure 1.1. Aerial photograph of the southern Great Plains with select hydrologic units delineated. Also depicted are the L. E. Certain site and the Beaver Dam site.

features is attributed to the same people/time. As with the L. E. Certain site, the Beaver Dam site will be used to address residential mobility.

Bison Populations on the Southern Plains

The importance of bison as a food source for southern Plains inhabitants has waxed and waned through the millennia (Baugh 1986; Dillehay 1974; Flynn 1982; Lynott 1979). Pleistocene and Holocene climate changes periodically affected the availability of the animal on the southern Plains. The focus on bison for subsistence is likely correlated with environmental conditions conducive to supporting bison forage (Reher 1977a:22, 24, 29-32, 1977b). Regional paleoecological findings confirm that environmental conditions on the Plains fluctuated regularly, especially during the Holocene. Shifts from cool and moist (Anathermal), to warm and dry (Altithermal), and finally to conditions similar to today (Medithermal) have characterized the environment and climate with which post-Pleistocene Plains hunter-gatherers had to contend (Antevs 1955; Bryant and Holloway 1985a; Bryant and Shafer 1977; Holliday et al. 1985). Holocene epoch foraging groups exemplify the adaptive changes made necessary by warmer climatic conditions occurring after the end of the Pleistocene. Hunting and gathering groups remained fairly mobile and continued to focus on bison as their primary game animal during the Anathermal (9950-7450 BP). However, evidence for Altithermal (7450-4450 BP) bison is sparse in the archaeological and paleontological record. The fluctuation in environmental conditions may have resulted in fewer bison being available and most likely adversely affected human groups. Nevertheless, people continued to inhabit the southern Plains, but perhaps in smaller numbers, at least until the Medithermal (Thurmond and Wyckoff 1999; Wyckoff 1992a).

The Medithermal (4450-1950 BP) climatic construct coincides with the Late Archaic cultural unit recognized for the southern Plains. According to archaeological and environmental data, this time period experienced a dramatic shift to more mesic conditions coupled with escalation in cultural activity. Increased cultural activity is

represented by a proliferation in the number and types of sites relative to the previous centuries (Bement and Buehler 1994; Buehler 1997; Hughes 1991:20-26; Thurmond 1991a; Thurmond and Wyckoff 2000). Accompanying the apparent growth in human populations is a rise in bison numbers (Dillehay 1974; Lynott 1979). As a result, we see the return of large bison kills (Bement and Buehler 1994; Hughes 1977a) not seen since the Pleistocene (Bement 1999; Hill and Hofman 1997). These environment-induced changes in herd size, structure, spatial distribution, and foraging patterns most likely contributed to changes in human predation.

The Late Archaic

The Late Archaic cultural interval saw the rise of a particular type of bison procurement on the southern Plains, the arroyo trap (Figure 1.2). However, one bison jump has been identified (Bement and Buehler 1998). Arroyo traps were used for a relatively short period on the southern Plains following the Altithermal. Several radiocarbon dates from



Figure 1.2. View of the upper end of bone bed 1 in Trench C, L. E. Certain Site.

the L. E. Certain site support this (Bement and Buehler 1994, 1998). Three other dates are available from the Twilla bison kill site in the Texas panhandle, another arroyo trap. Additionally, four other dates from four nearby trap-type kills are also available (Hughes 1977a:130-131; Lintz et al. 1991:262-263; Wilkens 1997:35). These data sets define a 2100-2450 BP time span for the use of arroyo traps.

The Research

Little is understood about Late Archaic lifeways although a number of sites are attributed to this time period. Several site-types characterize the Late Archaic occupation of the southern Plains. Sites include base camps, temporary camps, kill sites, plant processing locations, quarry /lithic workshops, and human interments. These site types allude to the adaptive strategies used by the Late Archaic hunter-gatherers to make their living.

There have not been many interpretive analyses of subsistence from Late Archaic sites. For this study, optimal foraging theory is used to shed light on subsistence strategies and settlement patterns. Likewise, logistical collecting is used to understand butchering as a transport decision, thereby estimating the risk and energy required for large-scale communal bison hunts. The results of these analyses should hint at human relations to the land and its resources.

Organization of the Dissertation

There are nine chapters in this study including this chapter, the introduction. Chapter Two addresses questions presented in the introduction and the methods utilized to compile the information and evaluate the research questions. That chapter outlines the advantages of using evolutionary ecology, optimal foraging theory, and logistical organization to answer research questions posed in the chapter. Chapter Three describes the natural setting for the study area and presents information on the resources available

to prehistoric inhabitants. Chapter Four reviews previous Late Archaic (and early Woodland) research on the southern Plains which will bring the current study into a regional context. Chapter Five introduces all of the activity areas of the L. E. Certain site to set the stage for the in-depth analysis of the Trench C data found in Chapter Six. Chapter Seven presents the Late Archaic component at the Beaver Dam site. A model for Late Archaic use of the post-Altithermal environmental tapestry of the southern Plains is suggested and then evaluated in Chapter Eight. Results of this study are summarized and the validity of expanding the model beyond the southern Plains is discussed in Chapter Nine.

CHAPTER TWO

THEORETICAL UNDERPINNINGS: A DEDUCTIVE APPROACH

Introduction

The Scientific Method

Archaeology claims to be a science, or at the least to follow the scientific method (Salmon 1975:459, 464; Watson et al. 1971:23). The scientific method consists of three essential components that apply to archaeology. First is to establish a hypothesis; second is to determine the test implications of that hypothesis; and third, the archaeologist is to evaluate these implications by further examination. So, the first step is to frame a hypothesis which is a pronouncement designed to transcend the description of known facts. Before this takes place, one must begin with a careful assessment of the known facts. What matters most is how well the hypothesis accounts for unobserved phenomena. Once the hypothesis is formed, the scientific method requires the translation of the statement into a testable form. Translation of the statement usually requires deductive reasoning. Deductive arguments often take the form of “*if x, then y*”. In other words, *if* the hypothesis is true, *then* we should expect to observe the said outcome. Bridging the gap between *if* and *then* is the key. Deductive reasoning is used to provide a connection between expectations and the archaeological record. Knowing prior probabilities, as determined by others, bolsters deductive reasoning. The final operation of the scientific method is to test the implications with the available data. If the implications are not verified, additional data may need to be gathered. If this is unachievable, then the hypothesis must be further scrutinized (Kuhn et al. 1988:12-33; Scheffler 1963:25-31).

Hunter-Gatherer Generalizations

One of the major assumptions of anthropology, based in generalizations, is that hunter-gatherers use their environment efficiently and effectively (Bettinger 1987:123; Lee

1972:342-345, 361; Trigger 1995:334). This is accomplished by adhering to a lifestyle characterized by a low energy budget (Bousman 1993:62-64; Hawkes 1987; Hayden 1981a:544; Lee 1972:343, 361-364, 1979:158). In other words, a minimum of energy is used to extract sufficient resources for survival. A low energy budget is simply another way to state that hunter-gatherers strive toward minimizing energy output and maximizing energy intake, thus maintaining an energetically beneficial relationship with the environment (Thomas et al. 1979:21-22). Another generalization about hunter-gatherers, based in observation, is that a group's dietary staples vary along with the local environment (Damas 1972:12-15; Frison 1991:327-334; Rogers 1972:102-103). Thus, diet is responsive to seasonal and annual fluctuations in resources. Still another generalization made by anthropologists is that hunter-gatherers organize themselves into different sized groups depending in part on the environment they are exploiting (Conkey 1980:610; Frison 1970:47-48; Rogers 1972:120, 123).

Various models and theories based in optimality studies have been proposed and tested by cultural anthropologists based on the above presumptions (O'Connell and Hawkes 1981, 1984; Smith 1983; Wilmsen 1973; Winterhalder 1987). These presumptions have been formulated into hypotheses and tested. Food has been weighed, counted, and inventoried in an effort to arrive at these propositions. Likewise, group movements have been mapped, the timing of such movements calculated, and group interaction documented. Framed in optimality studies, archaeologists use the same models employed by cultural anthropologists. However, archaeologists are required to account for (apparent) optimal tendencies without the benefit of first-hand contact. Cultural debris left behind by hunter-gatherers can assist archaeologists in determining if people were using their environment efficiently, if resource use changed with seasonal fluctuations, and if group size varied at different times of the year. Evolutionary ecology and optimal foraging theory can help determine whether or not hunter-gatherers acted with energetic efficiency in their environment, by means of non-genetic behavioral adjustment (Thomas et al. 1979).

Evolutionary Ecology and Optimal Foraging

Introduction

At its core, evolutionary ecology is steeped in functionalism and Darwinism. In turn, both of these concepts are based in Newtonian cause and effect relations (Grossman 1977). First, the functionalist approach emphasizes the importance of studying a culture as an integrated system. Thus, each component of the social system contributes to the whole. Included in that are cultural responses to the vagaries of the environment. Those human behaviors and institutions developed to cope with the environment, and which prove successful, are perpetuated. Second, Darwinian evolution is the underlying theme of American archaeology. Cultural chronologies demonstrate this fact. For example, big-game hunters of the Paleoindian period often developed into hunter-gatherers, then to horticulturists, and finally farming villagers. Another hallmark of American archaeology is the importance placed on the relationship between cultural groups and the environment. Often, the variety of cultural responses exhibited by groups is brought on by variation in environmental conditions. Therefore, the basic relationship between humans and nature (environment) is ecological. Human ecology and settlement patterns are regulated not only by environments but also are determined by the behavioral products (technology) available to exploit the environment (Allan 1973:211-212; Thomas et al. 1979:31-32). In short, humans are part of the ecological community and remain part of nature. All cultures, prehistoric and recent, exist in an ecological setting. As a result, a culture is molded or influenced by the exigencies of the physical and social environment all the while making periodic adjustments to the social unit.

Evolutionary Ecology

Evolutionary ecology generally consists of a group of related theories addressing foraging strategies, spatial organization, group size and formation, and equilibrium with ecological communities. Evolutionary ecology holds that differential persistence of cultural practices is due to the fact that a given practice bestows a selective advantage upon the group. Because hunter-gatherers exhibit a fairly strong degree of interaction

with the environment, evolutionary ecology and its derivative, optimal foraging theory, may be of use in studying their subsistence and settlement systems.

Evolutionary ecology has its history in mathematical biology, economics, and population genetics (Emlen 1966; Hutchinson 1959, 1965:26-78, 1975; MacArthur 1960, 1961, 1965; MacArthur and Pianka 1966; Schoener 1971). The basic premise is that select phenotypes within a genus have differing capabilities of harvesting resources that are distributed about the environment (MacArthur and Pianka 1966). For example, a specific bird may have a certain physical trait, based in genetic composition, that helps it harvest particular flora or fauna. That physical advantage then allows the bird to exploit the flora or fauna better than any other bird in the ecosystem and to reproduce more successfully. Of course, this premise applies to biological studies rather than human group studies. However, evolutionary ecology is well suited for the analyses of behavioral variations that are characteristic of humans (Smith and Winterhalder 1981:6; Thomas et al. 1979:2-4, 21-22). The above example hints toward one of the more utilized aspects of evolutionary ecology and that is optimal foraging models. Such as it is, feeding is treated as a device in which performance is measured in net energy yield, feeding time, and fitness, all of which can be maximized by natural selection (Cox 1961; Emlen 1966; MacArthur and Pianka 1966; Rosenzweig 1966; Smith 1968). Natural selection, in the case of humans, is the ability to prosper in a given environment. That success, in turn, leads to successful procreation and allows stable maturation as a result of a reliable food source and available energy through nutrients (Pyke et al. 1977; Schoener 1971). The above premise was the foundation for applying evolutionary ecology to anthropological studies (Smith and Winterhalder 1981:1-10).

Optimal Foraging Theory and Anthropology

Anthropological advocates of optimal foraging models put forth that there is an inherent connection between human behavior and the constituent environment (Durham 1981; Foley 1985; Smith 1987; Smith and Winterhalder 1992; Stephens and Krebs 1986;

Winterhalder 1981a, 1981b, 1986, 1987; Yesner 1981). In other words, humans and human groups will follow a subsistence (and settlement) strategy that increases their chances of survival. The improvement comes through optimization; that is, judicious use of time and effort spent searching for food, time and energy required to process that food, and time and effort to consume, protect, or return the food to others in the group. This process is continual. The procedure and results can be defined as adaptation and, eventually, cultural practice or habit. A relevant example might be the perpetuation of a unique style of bison hunting that is passed on from generation to generation, which may require “tweaking” occasionally to contend with the circumstances of the environment. The environment need not be limited to flora, fauna, and climate, but could also entail intra- and inter-group social aspects including familial responsibilities, fictitious kin obligations, and totemic commitments.

In its most basic form, optimal foraging involves a cost and benefit analysis (Smith 1983:625-627). This hints at the history optimality models have in economic theory and western capitalism (Peregrine 1996). Assumptions in foraging models place behavior in terms of maximization of net rate return of energy and nutrients (protein and calories) per unit of foraging time (Smith 1983:626). The “net rate per unit” viewpoint is most likely to be manifest in situations where there is moderate scarcity of protein and calories, distance and seasonal constraints, and inherent danger incurred when hunting and gathering. For example, scarcity of bison meat may occur when herds move out of an area previously occupied. In turn, increased travel time to reach a herd may outweigh net rate per return. Then again, time constraints may influence the net rate per unit return when the quality of bison meat is unsatisfactory. For example, cows are in better nutritional shape at certain times of the year while the same is true for bulls during other seasons. The net rate return in protein and calories would be lowered even though meat was procured. Finally, the unavoidable dangers of hunting a large mammal such as bison go without saying. An injury sustained by a member of the group could decrease the net rate of energy returned to the group in the form of raw meat. The same might be true if

enemies were encountered while hunting and gathering. An injured member of a hunting party cannot help with the hunt or butchering activities, so less is procured. Additionally, the injured party member consumes a supply of meat that is already short because there is one less hunter. I contend that all these issues are taken into account by a group and thus are reflected in their subsistence and settlement choices.

Key Components of Optimal Foraging Theory

If optimization or efficiency criteria are applied to foraging models, key components must be specified. Schoener (1971) was the first to present these components in his discussion of animal feeding strategies. However, Smith (1983) best articulates the anthropological application of these components. In both applications, the first two steps to model building are to specify a *currency* and to recognize a *goal* or *goals*. Choosing a currency helps operationalize an optimality model so there is something to measure, and defining a goal helps establish the unit of analysis. Besides determining the character of optimality, currency is used to construct input-output analyses. This analysis is often expressed as a formula. Mathematical equations/formulae standardize the optimal foraging approach, thereby controlling variables and thus allowing for a cleaner observation of the results. In ecological studies, currency is usually associated with energy. In short, the input-output dichotomy can be expressed as the amount of energy needed to achieve a goal (e.g. physical effort to search, procure, prepare, and transport sustenance) and the amount of energy-return from the above pursuits through minimization of risk, time, or energy (Foley 1985; Schoener 1971). Energy return is paramount since this is the manner in which minerals and nutrients are put back into the organism as a means to compensate for caloric output. After a currency and a goal are selected, a set of *constraints* must be identified. Constraints are best represented in an illustrative manner, as was the case when selecting a goal and a currency (Smith 1983:625-627). In other words, constraints are also displayed via a formula. The formula helps reduce real-world complexity and thus permits one to identify *options*. Option identification is the final component to developing optimality models. A set of options is

the greatest strength to optimality models. These options can include risk avoidance, behavioral modification, buffering, risk sharing, resistance/opposition, conformity, or total reorganization (Thomas et al. 1979:22-28).

Returning to constraints, these can be of human (biological or cultural) or environmental (physical or social) origin. Limitations can take the form of resource availability or the amount of energy lost in capturing the resource. Searching in an uncertain environment might be an example of a constraint whereby resource size, resource density, resource distribution, and resource variability are unknown or unpredictable. The amount of energy lost or gained could include pursuit, handling, and consumption time and energy, as well as predator and competitor avoidance and defense. Modeling constraint is usually achieved by reconstructing past social, meteorological, and physical environments. On the other hand, modeling options is the point where phenotypic plasticity comes into play or where a range of adaptive responses must be specified. In archaeology this range of responses must be reconstructed rather than observed in order to draw viable conclusions. However, archaeologists are comfortable with using ethnologies and ethnographic analogies to draw conclusions. All in all, optimality models are useful to archaeologists since they provide a systematic basis to examine and understand human behavior as represented by artifacts and features.

Shortcomings of Optimal Foraging Theory

Now that the key components of optimal foraging theory have been noted, there are a few issues that require further comments. Smith (1983) noted that a general feature of optimal foraging theories is a presumption that a system or organism strives toward optimization. Some may argue that such an assumption is ethnocentric when applied to human groups. Post-processualists hold that theories dependent on notions of efficiency (optimality) in resource exploitation are statements about how society should work rather than how a system worked prehistorically (Duke and Wilson 1995). Expecting an organism or groups of organisms to enact ideal adaptive responses to all social, biological, and environmental

situations is also a problematic assumption (Thomas et al. 1979:25). Nevertheless, hunter-gatherer groups do tend to interact efficiently with their environment and reach cultural/social/biological equilibrium to a certain extent, lest all three become dysfunctional and ultimately the adaptive unit fails to exist (Thomas et al. 1979). The articles in Winterhalder and Smith (1981) highlight this. Moreover, optimization theory is based in animal studies and undeniably humans are animals. Likewise, humans are part of the ecological community.

In regard to choosing a *currency*, a unique circumstance arises when discussing prehistoric cultures. You will recall that in ecological studies currency usually takes the form of energy-use and energy-gain. This is easily accomplished when studying living groups, no matter the genus or species. However, there is no method available for calculating energy expenditure cost in prehistory (Foley 1985:238-240). This is hardly a drawback for modeling prehistoric foraging behavior because archaeologists are familiar with the application and interpretation of cultural parallels. Like cultural anthropologists, archaeologists make use of cultural artifacts to confirm or disprove modeled expectations. Expectations are based on *goal* achievement. As stated in the previous paragraph, the basic goal of any culture, past or present, is efficient resource utilization or equilibrium. This in turn leads to successful procreation and stable maturation. Therefore, prehistoric cultural residues can be used with relative success to ascertain the range of responses employed by bygone groups to cope with environmental challenges (Foley 1985:238-240).

Another major aspect of optimal foraging models is the use of equations for illustrative purposes. Critics of optimal foraging theory and optimality models contend that humans cannot be reduced to formulae or algebraic equations (Shanks and Tilley 1987:35-36). It is recognized that cultural groups are difficult to characterize with a set of variables or parameters such as are required for modeling *constraints* and *options*. Additionally, cultural groups may not always act as expected because of social obligations Thomas et

al. 1979:31-34). Therefore, certain modifications must be made for human institutions, which may affect optimal behavior. Nevertheless, by utilizing formulas such as those purported by Emlen (1966), Pyke et al. (1977), and Schoener (1971) some generalization about human behavior can be made. Of course archaeology is steeped in generalizations, and these generalizations are based on observations that specific attributes recur in particular situations, particular geographic localities, etc.

Recognizing the limits of optimal foraging modeling outlined above, Smith (1983:626) stresses that optimal foraging theory must be thought of as a general theory that should be used to develop models. He (Smith 1983:625-627) further warns that optimization assumptions should be viewed as useful starting points for model building rather than be applied heavy-handed across a wide spectrum of situations.

Optimal Foraging Theory: Late Archaic Hunter-Gatherer Applicability

Introduction

Specific models that have spun off the original optimal foraging construct include, the “diet breadth” or “prey-choice” model, the “patch-choice” or “patch-use” model, and related to the latter is the “marginal value” theorem. The “central-place foraging” model is another offshoot of optimal foraging theory as is “site catchment”. Finally, there is the “foraging group size” theorem. Central-place foraging and foraging group size theorem will be used to analyze the L. E. Certain and Beaver Dam sites.

Central-Place Foraging Model

Central-place foraging occurs when a group ventures out from a central location or village to acquire resources. According to Kaplan and Hill (1992:184) this can include both random encounter situations and target and search pursuits. Central-place theory is related to Binford’s (1980) collector and forager subsistence and settlement dichotomy. Binford (1980) makes a sharp distinction between collectors and foragers, unlike Kaplan

and Hill (1992) who use “forager” in a more general manner. According to Binford (1980), foragers are those groups that are highly mobile and gather food on an encounter basis, but within a foraging radius. To a certain extent, this radius is reminiscent of the central-place foraging model discussed by Kaplan and Hill (1992). Earlier in the anthropological literature this sort of existence was referred to as “tethered nomadism” (Taylor 1964). By contrast, Binford’s (1980:10-12) collectors are characterized by groups that are logistically organized and supply themselves with specific resources through specially organized task groups. Evidence on the landscape of these types of settlement and subsistence patterns comes in the form of specific types of archaeological sites (e.g. field camps, stations, and lookouts). Unfortunately, many of the sites that characterize the different subsistence and foraging patterns overlap, and return visits to a site by a group might mask earlier uses (Wiessner 1982).

Residential mobility and logistical mobility address issues of groups positioning themselves on the landscape in response to structural properties of the environment (Binford 1980:15-17). Therefore, groups adhere to, avoid, or switch between foraging (residential mobility) and collecting (logistical mobility). Often this transformation from “forager” to “collector” is based on seasonal fluctuations of resources involving a fine balance between maintaining and conserving the resource base while harvesting it at an optimal level (Guthrie 1990; Hayden 1981b:375). The seasonal aspect of this type of behavior leaves salient clues about hunter-gatherer economic pursuits in the local archaeological record (Binford 1980:7-19). Settlement behavior is best analyzed in its environmental context as a way to determine not only the pattern but also the settlement system (Flannery 1976). Both the placement of sites on the landscape and site spacing, as well as possible social and political elements, are purported to leave different patterns of interaction on the landscape and, ultimately, in the prehistoric archive (Jochim 1979; Wilmsen 1973).

Foraging Group Size Theorem

The foraging group size theorem is like many other optimality constructs in that it must account for the uneven distribution of resources. Horn's (1968) theorem was developed to predict the occasion when foraging as groups should be advantageous over foraging on an individual basis. When resources are unevenly distributed and unpredictable, foraging as groups is the optimal system (Foley 1985:227; Thomas et al. 1979:33). Because environmental factors are not static, the timing, magnitude, and manner in which resources are collected or used affects energy costs, yields, and reliability (Jochim 1979:83-85; Thomas et al. 1979:29-30). For example, a host of observations indicate that climate is overwhelmingly important in regard to optimal feeding periods for mammals. Some animals feed more often and on specific patches/prey in the warm season and alternately they feed less often and on other patches/prey in the cooler seasons of the year (Schoener 1971:392). Humans that stalk mammals with variable feeding patterns must have social institutions (non-genetic adaptation) in place to cope with the vagaries of the ecosystem (MacDonald and Hewlett 1999; Marshall 1993; Messer 1988; Mithen 1990; Testart 1987; Wallace 1971). All in all, we should expect a positive relationship between resource variability, predictability, reliability, and foraging group size (Smith 1981:42-45; Thomas et al. 1979:25-36).

Communal versus Nuclear Family Hunting and Gathering

One of evolutionary ecology's prospects is to isolate ecological factors, which affect individuals through the context of group membership, among other social institutions or non-genetic cultural behavior. In turn, groups form in response to concentrations of food and/or prey (Driver 1990:11-12; Schoener 1971:392-394). In reply to this postulate, it might be argued that a single hunter or nuclear family could also capture a clumped mobile resource such as bison. Nevertheless, animal studies prove that an aggregation of individuals increases the efficiency of the pursuing group (Schoener 1971:393-396). Without a doubt, this carries over to human groups. Not only is dispatching a herd of bison easier with multiple hunters, but cooperative efforts in the search for and pursuit of

herds better the group's chances at success, thus averting risk of failure or injury (Jochim 1979:85; Schoener 1971:392-394; Winterhalder 1981a:30-31). In effect, cooperative social agreements extend the response options of an organism or group of organisms (Thomas et al. 1979:31-33). Human group size, as it is argued, is altered accordingly so as to magnify the net energy yield per individual and minimize the time needed to locate and harvest edible resources (Driver 1990:25-28; Steele and Baker 1993; Winterhalder 1981a:30). In addition, a group of hunter-gatherers can increase the effective density of certain prey by flushing (Winterhalder 1981a:30). A prime example is the utilization of natural corrals to assemble bison for ambush. Using a pound or a jump for that matter is no doubt an optimizing strategy used by hunters of swift-footed, dangerous ungulates. An aggregate of hunters may also lessen the likelihood of injury and increase hunting efficiency when taking larger prey (Winterhalder 1981a:30).

Groups are also more effective at locating undepleted resource areas by preventing foraging overlap (Bamforth 1985; Cody 1971). Using such a strategy the group can avoid areas that have been searched and harvested as opposed to individual family units going about it alone without the benefit of communication between other household units (Winterhalder 1981a:30). In short, hunting and collecting decisions made by the group represent response modes designed to minimize risk and which prevents the group from entering a dysfunctional state (Durham 1981:225; Thomas et al. 1979:30). However, group size is tied to the efficient procurement of specific resources. Too many individuals would cause net harvest per individual and per unit of time to decline (Hofman 1994:345-346; Lee 1979:366-367; Smith 1981:43-44; Thomas et al. 1979:29-30). According to Smith (1981:43), large foraging parties have much greater encounter rates for each individual forager in certain situations and the optimal size of collecting and hunting groups vary according to the prey species, all in an effort to maximize efficiency. In the case of communal bison hunting, a balance must be met between the number of individuals necessary to flush, direct, and corral the animals and the amount of meat and supplies available for distribution to make the pursuit worth while (Hofman 1994:345-

347). Steward (1955:103-111) observed Great Basin groups splintering into family units for seed and root collecting while the group congregated for communal hunts of larger species. Observations of other groups find that variation of group size depends heavily on the type of prey pursued. With herds of ungulates, a large group of individuals is assembled while solitary animals or individual cow-calf pairs are best taken by a nuclear family in order to maximize energy unit replacement per individual (Damas 1972:23-24; Wilmsen 1973). In general, group size is tied to the efficient procurement of *specific* resources (Smith 1981:43).

Another advantage to group collecting and hunting is the ability to monitor large areas for prey (Winterhalder 1981a:30-31). For example, loose-knit extended family units situated on the landscape could meet in a central place and exchange information (Damas 1972:26). Such a strategy works best with heterogeneously and irregularly distributed resources, not exclusive to fauna but flora as well (Schoener 1971:395-396). Examples include mobile animals such as bison, flocks of birds, and alternately ripening fruits and nuts. Thus, information-sharing groups have an improved chance of locating ephemeral resource points with predictable packets of resources (Smith 1981:43; Thomas et al. 1979:33). Cooperative search procedures, by way of information sharing, increase the chances of hunting success, especially for resources that move about the landscape (Wilmsen 1973:2, 9, 24-25). Efficient harvesting of food is further increased by the natural behavior of certain species that congregate on patches of abundant food (Reher 1973:90, 102-104, 1977a, 1977b; Reher and Frison 1980a; Schoener 1971:393). Specific to the Late Holocene hunter-gatherers on the southern Plains is the gregarious buffalo. Outside of finding large accumulations of bones with a variety of point forms and material types, identifying information-sharing in the archaeological record is just as difficult as identifying evidence of food sharing. However, information sharing and food sharing are clearly represented in modern hunter-gatherers (Testart 1987).

Discussion: Expectations from the Data

Specific Considerations in Examining the L. E. Certain and Beaver Dam Data

This section examines some of the unique aspects of the L. E. Certain and Beaver Dam sites from the perspective of the foraging group size theorem, optimal foraging theory and its construct, the central-place foraging model. As a result, certain aspects of optimal behavior should be measurable with particular data classes such as site types, faunal and floral assemblages, and lithic remains. In effect, people would be adhering to a land-use pattern consistent with residential mobility, which is closely related to spatial distribution of the exploited resource (Kelly 1983:294-297).

So, what sort of sites should be found on the landscape if central-place foraging existed? I put forth that base camps and special-extraction localities would be used primarily. Binford's (1980:10-12) model of hunter-gatherer residence and mobility strategies specifies that field camps, stations, and lookouts leave distinct signatures on the landscape. Each of these site types is consistent with a central-place foraging type of lifestyle and the foraging group size theorem. Under this regime, the use of base camps is implied, as is the case with Kelly's (1983:296:300) hunter-gatherer land-use system. Like base camps, special extractive localities, where bulk resources are procured, are implied by Kelly's construct and the same is true of Binford's system. Kelly (1983:294) specifies that "the average distance moved between residential locations should be closely related to the spatial distribution of the exploited resources". Consequently, a camp's location must be changed as soon as commuting time becomes an excessive energy drain on the group (Cashdan 1992; Kelly 1983:295).

If we examine paleoclimatic data for the Late Archaic cultural interval, which coincides with the Medithermal, there is evidence of an environmental recovery underway (Thurmond and Wyckoff 2000, 2001). According to Dillehay (1974) and others (Baugh 1986; Flynn 1982; Lynott 1979), bison resurgence was taking place at the same time.

Therefore, special extractive locales produced by Late Archaic folks should contain evidence of bison use. Bison procurement localities coupled with processing stations should predominate, each with its distinctive faunal and lithic utilization patterns. The foraging group size theorem predicts that evidence of social activity, to cope with environmental shortcomings, should be apparent in the archaeological record. For example, evidence of special task groups at a harvest locality should be evident. Social activity can be inferred through recurrent and organized faunal utilization patterns. Conversely, base camps should have a greater diversity of activities if a group employed an optimal foraging routine. Compared to extractive localities, base camps are where preparations for special forays would be initiated. Besides being a locality where resources are transported for consumption, under the group size foraging theorem and optimal foraging theory, base camps are also where downtime was spent before and after clumped resources were harvested. Specific to Late Archaic southern Plains hunter-gatherers, there should be evidence at base camps for the bison faunal component which was removed from the bison procurement and processing stations. Related to the bison procurement and processing events, there should be evidence for the manufacture of tools necessary for bison exploitation. Base camps should have evidence for a diverse set of procurement and consumption activities. Evidence may come in the form of faunal, floral, and lithic remains. These activities should represent local resources in close proximity to the camp, which could be gathered on a daily or biweekly basis.

The L. E. Certain Data and Implications

Faunal Remains

If we accept that bison herd movement and behavior is patterned, as dictated by seasonal-social parameters (McDonald 1981; Roe 1970), then we can predict that kills under central-place foraging would reflect seasonal redundancy based on the bison reproductive cycle (i.e. rut and birthing). If bison were killed during these seasonal congregations, such would be evidenced by stages of mandibular development or epiphyseal fusion rates.

Assessing whether a central-place foraging lifestyle was being carried out during the Late Archaic might also come about from an analysis of butchering practices. So, if Late Archaic hunter-gatherers were venturing out from a base camp to pursue bison, and they meant to return to the camp with food, then butchering strategies at the kill site would reflect techniques amenable to transport. A meat stripping technique that leaves the bulky, low utility items such as bones at the kill would be the most efficient manner to haul staples back to camp. Not only would filleting take place, but decisions about which cuts to harvest would be apparent in the faunal remains. These butchering decisions would be reflected in discard patterns. Butchering decisions would also be based, to a certain extent, on differences in bull and cow physiology during certain times of the year. Such discrimination and selectivity are directly tied to transport decisions and net energy return. Selecting highly nutritious gourmet cuts of meat and organs would be favored in order to gain the greatest energy return for the least cost in regard to transport weight. However, cultural perception and viability of a bison or bison herd's condition can be in direct conflict with a positive cost-benefit ratio. Just as travel time requires energy, butchering a dispatched herd burns protein and calories (energy) in the human organism. As a result, the optimal behavior would be to establish butchering stations where task specific activities such as harvesting brains and tongues, or stripping limbs and pelvises of meat would be represented in the archaeological record. The task specific activity would also center on elements whose nutritional content varied by season and sex. Butchering an entire herd probably took several days whereby the hunters constructed other processing and support facilities such as campfires and drying racks. Evidence for these settings should be present in the archaeological record.

Floral Remains

At a game kill where a target species was sought, evidence for floral remains should be limited. Evidence for the use of non-animal products at a kill or processing locality, primarily as an additive to meat, is not unusual (Quigg 1997c; Quigg and Peck 1995). Paleoenvironmental data indicates that environmental conditions during the Late

Holocene were similar to those of today (Bryant and Schoenwetter 1987; Bryant and Shafer 1977; Thurmond and Wyckoff 2000). Thus, modern botanical data can be used to tentatively reconstruct the floral environment available to Late Archaic hunter-gatherers.

Lithic Remains

Further evidence reflecting the notion that Late Archaic hunter-gatherers employed a central-place foraging lifestyle and a logistical residence pattern may come from the lithic remains discarded at a kill site. This data class should indicate that their technology was transportable and curated with respect to exotic or semi-local material use. Biface cores of exotic or semi-local material would represent the transportability of their toolkit, as would discarded tools produced from the cores. Curation of the specialized tools might also be demonstrated by way of resharpening flakes discarded at the kill. Refurbishing the portable toolkit (e.g. projectile points and knives), rather than abandoning the tools on site, would support curating tendencies. The use of a specialized tool such as projectile points is also another line of evidence that task-specific tools were prepared for a pre-planned event.

The quality of the tool stone might be another avenue to support the notion that central-place foraging was taking place. Specialized tools such as projectile points and butchering knives would most likely be manufactured from highly siliceous tool stone that fractured predictably while expedient tools would be manufactured from local or substandard material (Andrefsky 1994). Materials might be judged as substandard based on fracture properties or original raw material (clast) size. Using high quality materials for formal tools and lower quality materials for expedient tools might be considered a conservative use of high quality material and thus reflect optimal behavior. On the other hand, when high quality materials are found in abundance, they might be used for both formal and informal tools. To some extent, the L. E. Certain site is in a lithic poor area compared to surrounding regions. Under optimizing conditions high quality materials will be used for formal tools and subject to conservation. These tools will only be present

at a kill when lost or exhausted. Minute retouch flakes should also represent use of the material. Manufacturing evidence of formalized tools at the kill site will not be in evidence. As alluded to above, informal tools will be of local, lower quality material. Such tools might be manufactured at the kill site and likely discarded there regardless of breakage or exhaustion.

The Beaver Dam Data and Implications

Faunal Remains

In terms of central-place foraging and logistical residence, having a base camp perched on an ecotonal boundary would be optimal behavior. This is where generalized collecting jaunts would originate. Not only could the Beaver Dam site hunter-gatherers hunt, fish, and collect from the stream valleys and uplands surrounding their base camp, they could also take advantage of the differing vegetation associated with geologic formations in the vicinity. Clearly such a setting would provide a variety of subsistence needs with little energy expenditure (Nicholas 1998). Establishing a base camp on such a boundary is obviously an advantageous form of residence, a prime location where a plethora of edible and non-edible provisions could be acquired. Travel time would be kept to a minimum, although a variety of resources could be exploited. The harvest or raw energy in the form of food would more than outweigh the energy expended to visit distant localities in each biome.

It has already been noted that if Late Archaic hunter-gatherers were adhering to a least effort regime in relation to food transport, then large mammals would be prepared in a manner that reduced the overall weight of the prey. As a result of this practice, bison bone would be abandoned at a kill site and only filleted meat bundles would be transported to a centralized camp. However, some bones for tools and bone grease/marrow extraction may have been transported back to camp. In addition to bison bone, it is expected that small- and medium-sized animals would supplement the ever-present bison used by the Late Archaic hunter-gatherers. Animal bones recovered from

occupational surfaces and features at Beaver Dam should then indicate that the inhabitants were securing food from surrounding biomes. Since relatively smaller animals are easier to transport, and capturing or snaring would take place close to camp, a higher ratio of non-bison bones might be represented.

Floral Remains

It could be expected that Late Archaic hunter-gatherers would also utilize a variety of plants for food, fuel, and tools at a centralized camp. Paleoenvironmental data indicates that environmental conditions during the Late Holocene were similar to those of today (Bryant and Schoenwetter 1987; Bryant and Shafer 1977; Thurmond and Wyckoff 2000). Thus, modern botanical data can be used to tentatively reconstruct the floral environment available to Late Archaic hunter-gatherers. Indirect evidence for processing floral remains would include grinding implements and nutting stones. Direct evidence might come from the plant remains themselves. Logistical foraging should produce a variety of floral resources from other nearby environmental zones also.

Lithic Remains

Another data class that should be represented at a base camp, and thus support a central-place foraging lifestyle, is the lithic assemblage. In effect, generalized and task-specific knapping events would be taking place at the camp. To a certain extent lithic technology would be suited for specialized tasks while still possessing some expedient characteristics. Projectile points, biface cores, and possibly skinning knives would be manufactured at a base camp leaving discrete piles of specialized production debris. Lithic evidence to support this logistical collecting profile would include point production debris and evidence of late stage biface thinning in discrete activity areas. A high ratio of debitage to biface tools and points would also support this supposition. Unfinished, broken bifaces might suggest that preparations for a special kill event might have transpired at the site. Further documentation or verification that Late Archaic hunter-gatherers were behaving as central-place foragers and following a logistical

residence and subsistence pattern can be deduced by using inference and reasoning. For example, the recovery of broken projectile points at a site, especially the point bases, would indicate that damaged tools were retrieved in hopes of making repairs. Such might occur at a base camp. Regarding tool stone, raw material used for formalized tools should be highly siliceous and fracture in a predictable manner (i.e. high quality). Conversely, both local and semi-local tool stone might be used to produce unspecialized or generalized tools. Theoretically, the local material would be used for expedient tools made on the spot or used for tools discarded after a single use (expendable).

Other lithic materials one might expect to recover at the Beaver Dam site include hearthstones. Multiple fire pits would show that the site was repeatedly occupied and used as a base for extended stays. Likewise, heat-altered and fire-cracked rock and boiling pebbles would also indicate that household activities occurred at the site. These activities are often reserved for meal preparation at base camps although not exclusive to them. These are some of the household activities and their byproducts that might be represented at a multipurpose base camp.

Human Remains

Besides the faunal, floral, and lithic remains recovered from a logistical camp, one might expect to find human remains at a base camp that central-place foragers occupied. The presence of a burial or burials would suggest that the site occupants were comfortable enough with the location to bury a group member. Such a practice would seem to indicate that the camp was considered home to these people. Burial furniture interred with an individual or individuals would also denote a sense of home. If burial offerings were fashioned from local material it can be assumed the cultural group was indigenous, or at least frequented the area on a regular basis.

Conclusion

When applied to archaeological studies, the focus of optimal foraging theory has been on

how non-genetic human behavior is manifest in the archaeological record (patterns). The same is true with the foraging group size theorem. In order to avoid some of the pitfalls inherent to evolutionary ecology and its tie to early twentieth century functionalism (Malinowski 1922; Radcliffe-Brown 1922; White 1949, 1959), this study will address and operationalize the energy capturing aspects of adaptation by focusing on energy production, consumption, and expenditure rather than making functional generalizations (Hofman 1994:345-349; Smith and Winterhalder 1981:3).

The difficulties inherent in attempting to determine the complex relationship between the incompletely understood physical environment and the even more enigmatic human factors are a challenge (Macinko 1978; Thomas et al. 1979). A constructive approach to employing optimal foraging theory to archaeological data is to recreate past environments, both physical and cultural. The human-environment relationship brings about a crucial social equation that must be addressed. Evolutionary ecology facilitates an investigation of some aspects of that relationship. To that end, Chapter Three will cover floral and faunal reconstructions for the southern Plains and geological and hydrologic analyses.

CHAPTER THREE

NATURAL SETTING

Introduction

This chapter describes the general study area, the southern Plains, and the natural setting. The natural setting of the project area will be initially discussed on a gross scale. The discussion will then proceed to a refined regional focus. Finally, the physical setting will be discussed on a local level. The underlying theme is to highlight the role that the physical environment plays in influencing the settlement patterns and economic pursuits of Late Archaic peoples on the southern Plains. The physical space of western Oklahoma and the eastern Texas panhandle can therefore be viewed as a stage upon which human activities of the past unfolded (Goodman 1977:9).

As noted by Fawcett (1987:13), bison kill sites are known to exist throughout the Great Plains and surrounding regions. Even though bison are found in various geographic regions, historic documents suggest they were most numerous in the American Plains (Hornaday 1887, 1904:99-103; McDonald 1981; Reynolds et al. 1982:974; Roe 1970; Sample 1987; Shaw and Lee 1997; Sheridan 1888:297; Vehik and Kraft 1995; Wedel 1978:26). The presence of prehistoric bison in North America, and in particular the Great Plains, is measured by various means. Most of these estimations are based on skeletal elements recovered from archaeological sites. By using this methodology, archaeologists can talk about “presence” and “absence” periods (Dillehay 1974; Flynn 1982; Hubener 1991). More refined, local versions of this presence-absence dichotomy are also proposed for Oklahoma (Baugh 1986), north Texas (Lynott 1979), and west-central Texas (Creel et al. 1990). Similar proposals have been made for the Historic period using eyewitness accounts of herds, and to a lesser extent, excavated protohistoric archaeological sites (Shaw and Lee 1997; Vehik and Kraft 1995).

Study Area

The area of primary interest is delineated by the following boundaries: the Washita River to the north, the North Fork of the Red River to the south, the 99th Parallel to the east, and the eastern edge of the Llano Estacado to the west (Figure 3.1). The above area is rather restricted and should only be regarded as a core area for discussion. Events and archaeological sites from a broader area will be incorporated, as necessary, into the discussion that follows. It is understood that the arbitrary boundary established above was probably unrecognized as an environmental-ecological unit by prehistoric inhabitants of the region. However, a few niches within the said boundary were used more extensively than surrounding zones (Thurmond 1991a:123, Figure 10). The upland divide between the Washita River and the North Fork of the Red River, referred to hereafter as the Dempsey Divide (Thurmond 1990a; Thurmond and Wyckoff 1999:233), was a favored prehistoric locale. Far from suggesting that the Dempsey Divide is a distinct archaeological region as Boyd (1997:9) does with his Caprock Canyonlands (which includes the L. E. Certain site), the divide was used in a specific manner and had an impact on local subsistence strategies and local subsistence patterns (Thurmond 1991a:122, 125, Figures 9, 13, 14). Nevertheless, use of arbitrary lines of demarcation to define a unit of study is not new. It simply serves a purpose in representing an approximate boundary between large, generalized physiographic features (see Fenneman 1931:1-4).

The natural setting surrounding the L. E. Certain site and the Beaver Dam site is presented in subsections. The primary focus is on the L. E. Certain site whereas specific data related to the Beaver Dam site are incorporated into the discussion later, when appropriate. Subsections utilized to organize this chapter include: location; physical setting and physiographic provinces; geology, topography and geography; hydrology and hydrography; climate; seasonal dynamics; plant communities and associated fauna; and, relevant paleoenvironmental data. The overall objective of this chapter is to identify the

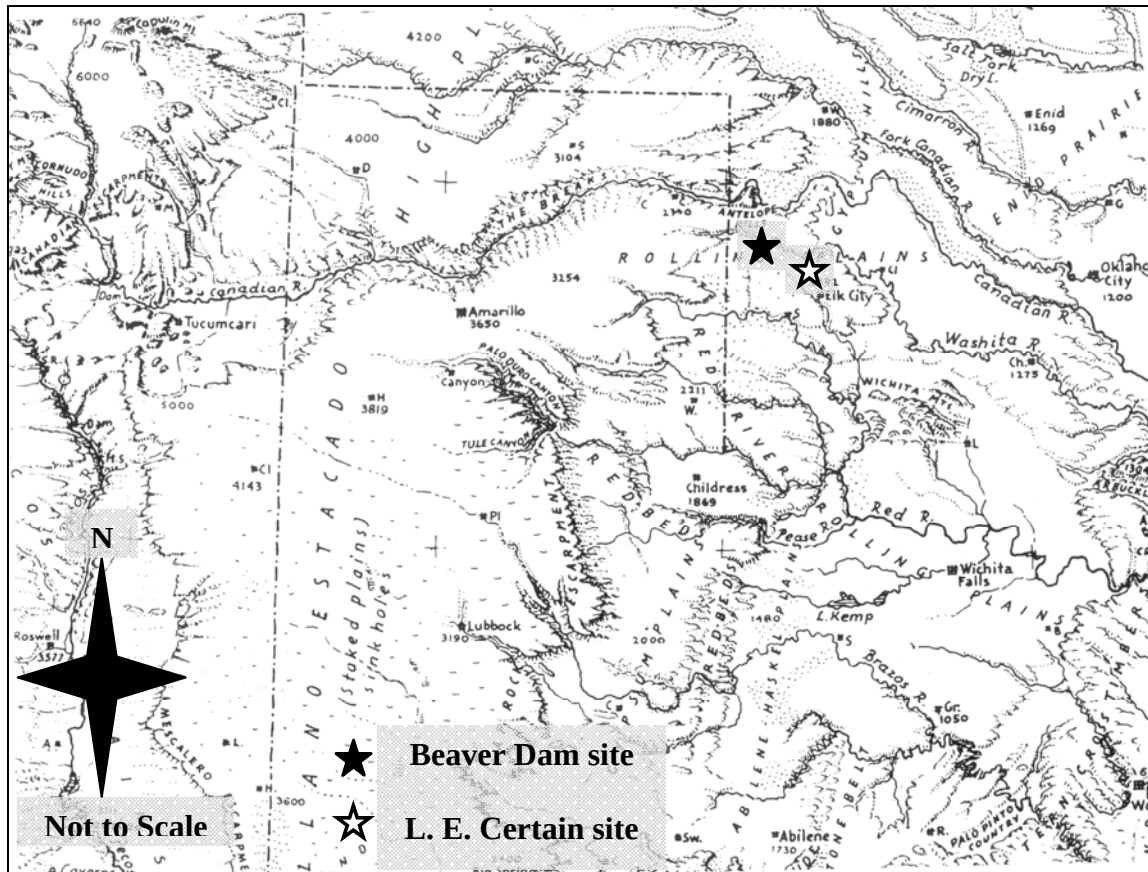


Figure 3.1. The study area with topographic features and hydrologic units denoted (adapted from Raisz 1957).

environmental conditions with which the people living in the region interacted. The natural setting obviously represents only one aspect of an adaptive system.

Location

The L. E. Certain site is on an unnamed tributary of Sandstone Creek that flows north to its confluence with Sandstone Creek proper, and on to the Washita River (Figure 3.2). The unnamed eastern branch of Sandstone Creek where the L. E. Certain site is located should not be confused with the East Fork of Sandstone Creek, which lies further east (United States Geological Survey 1989). Sandstone Creek is one of many capillary

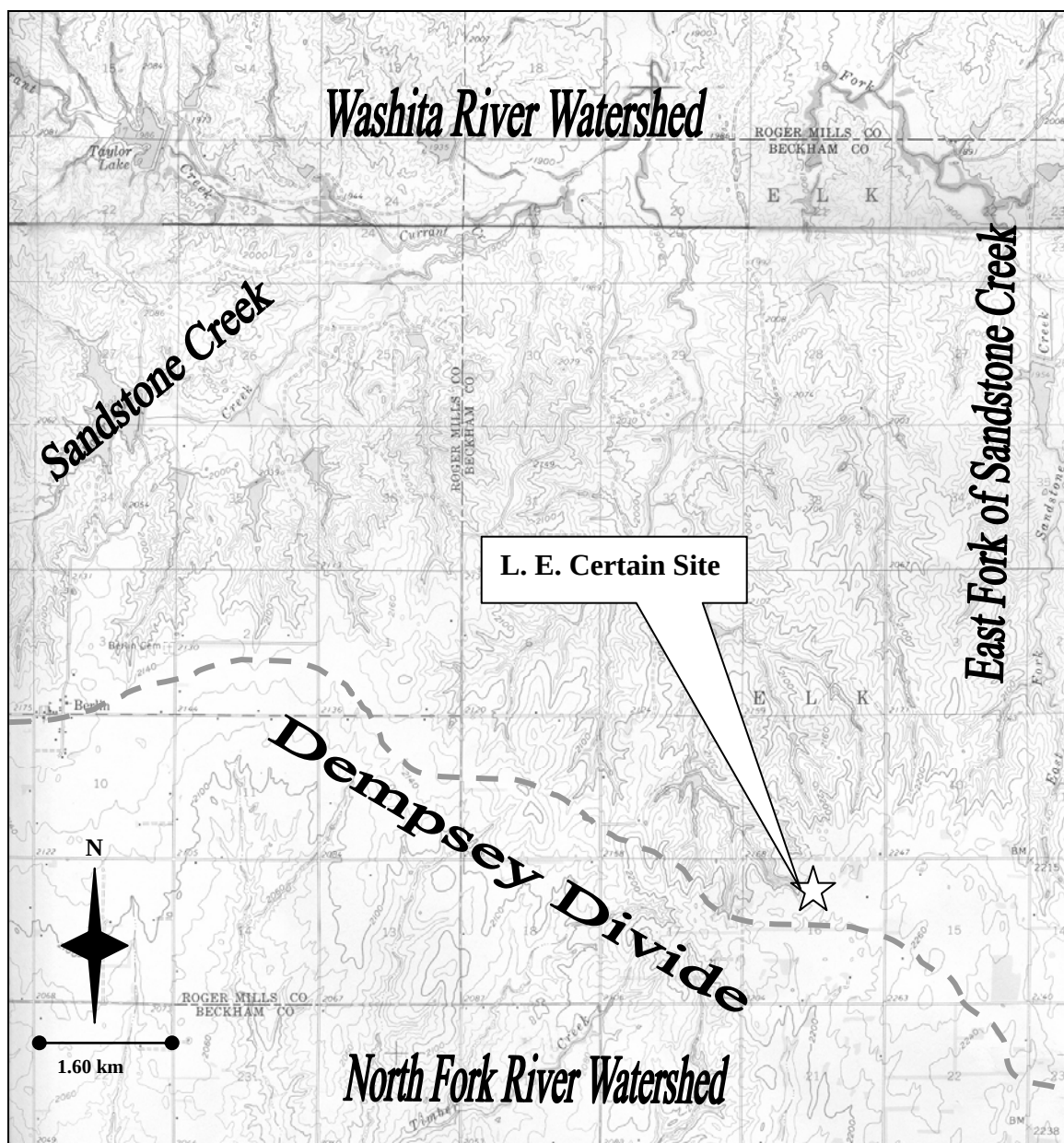


Figure 3.2. Composite of United States Geological Survey 15-minute series topographic maps: Cheyenne (north) and Sayre (south).

drainages in the dissected uplands that separate the Washita River drainage basin from the North Fork of the Red River basin to the south. The L. E. Certain site is 16.09 km from the Washita River and roughly the same distance from the North Fork of the Red River. The Beaver Dam site is a bit closer to the Washita River but still located on the

Dempsey Divide (Figure 3.3).

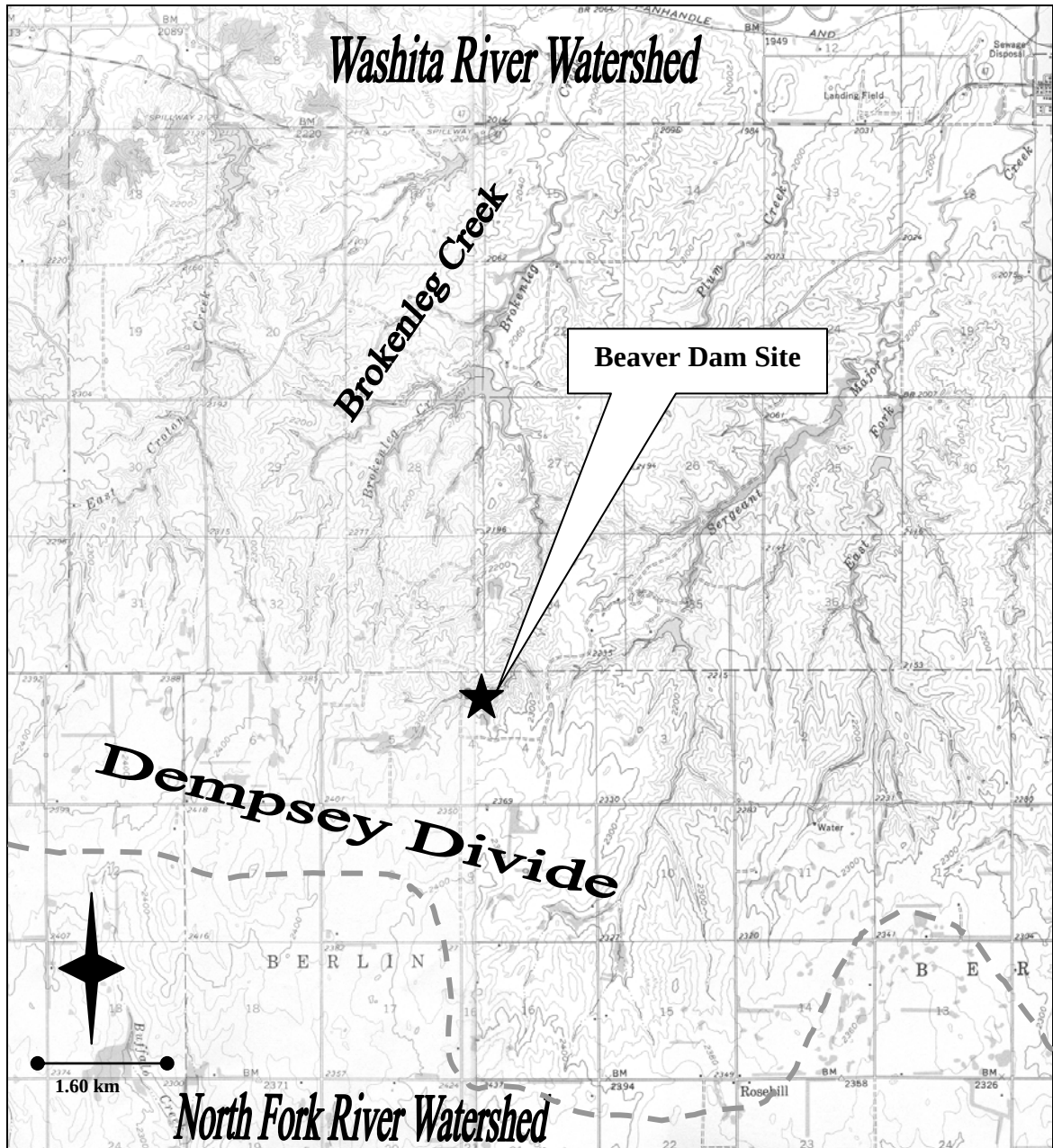


Figure 3.3. Composite of United States Geological Survey 15-minute series topographic maps: Cheyenne (east) and Reydon (west).

Physical Setting and Physiographic Provinces

Introduction

An important step in the assessment of prehistoric subsistence strategies and general resource utilization is the accurate reconstruction of resources at hand for exploitation in the vicinity (Roper 1979:120-123). Consequently, the modern resources (environmental, botanical, and faunal) in a given area can be utilized as a proxy indicator of the prehistoric setting (Madole et al. 1991:504), especially when detailed paleoenvironmental data are not available or obtainable. Besides revealing the nature of past environments, paleoenvironmental conditions dictate the character of modern physical settings and physiographic provinces to a certain extent (see Brand 1953:7-21; Dolliver 1984:32-35, 57-77; Fay 1959; Gustavson 1979, 1986; Gustavson and Finley 1985:42; Holliday 1997; McGookey et al. 1988:8; Shaak and Franz 1978).

In brief, numerous cut-and-fill episodes (see Antevs 1952) are present in the canyons of central and western Oklahoma (Ferring 1992, 1995; Hall 1982a, 1982b, 1990; Hall and Lintz 1984). These cut-and-fill episodes represent a cyclical pattern of mass wasting and sediment accumulation that occurred before, during, and after the occupations of the L. E. Certain and Beaver Dam sites (Green 2002:87-125; Wood and Johnson 1978:348-352). Even the studies from adjacent biomes (Antevs 1952; Ferring 1992, 1995; Hall 1982a, 1982b, 1990; Hall and Lintz 1984) can assist in illuminating the character of the past environments along the Dempsey Divide. Limited research on cut-and-fill episodes and prehistoric soil development in the study area has been conducted, and further research is currently underway (Green 2002; Thurmond and Wyckoff 2000).

Osage Plains—Origins

The modern physiographic provinces recognized in the study area, based on paleoenvironmental conditions, include the Osage Plains and the Central Lowlands (Atwood 1940; Fenneman 1923, 1931:1-27, 1938:605-620; Hunt 1974). The surface

structure in a particular region is in part the result of the underlying strata (Fenneman 1923:115-117). According to Dolliver (1984:75-77) and Madole et al. (1991:507), most of the pre-Quaternary strata and geologic structures of the Osage Plains are Paleozoic in age. Madole et al. (1991:507) state that:

“a pattern of arches and basins evolved during the Paleozoic, and the region was submerged by seas episodically throughout this time. Hence, subsurface rocks range in age from Cambrian to Mississippian, and the rocks at the surface are almost entirely Pennsylvanian and Permian: Permian in the western part of the region and Pennsylvanian in the eastern part.”

To most geographers, the Osage Plains of Kansas, Oklahoma, and Texas are simply the southward extension of the Central or Interior Lowlands (Fenneman 1923:116, 1938:605; Goodman 1977; Madole et al. 1991:503; Stephens and Holmes 1989:4). The Central Lowlands extend far to the east of Oklahoma and continue as far north as the Great Lakes in the Midwest.

Osage Plains—Surface Character

The Osage Plains physiographic province represents a surface produced by degradation (Fenneman 1923:116; Morris et al. 1986a). This low plain, interrupted by east-facing escarpments from 15.24 to 60.96 m high, lend credence to the presence of stronger strata in a great mass of relatively weak rocks (Fenneman 1923:116, 1938:605). In the Oklahoma section, the wide valleys produced by the east-flowing rivers cause the escarpments to be deeply scalloped (Fenneman 1938:606). Some of the dissected escarpments have become hilly belts with the intervening valleys possessing broad, smooth surfaces. Fenneman (1923:116) suggests that the zones in Oklahoma, exhibiting alternations between these two types of topography, be referred to as the Scarped Plains. The most prominent of these hilly tracts is designated as the Gypsum Hills (Fenneman 1923:116; Snider 1917:86-90).

Osage Plains—Biotic District

Besides being a recognized section of the Central Lowlands, the Osage Plains is also a

designated biotic district. The following information comes exclusively from Blair (1939) and Blair and Hubbell (1938:433-435). Keeping in mind that the Osage Plains represent a large, interstate zone, the principal plant association is a scrubby forest. The general aspect of the forest floor is one of sandy soil with a sparse cover of grasses, and herbaceous vegetation. Sandstone and limestone blocks of varying sizes choke the headwaters of most streams forming pools that remain in times of drought, many filled with aquatic mosses. North-facing sandstone bluffs have more mesic type vegetation while the well-shaded slopes have mosses, liverworts, and lichens. Many of these plants could have been utilized for medicines and cultural ceremonies (Svoboda 1967). The rolling areas on the shale-derived soils host grassland communities closely related to the Mixed Grass Plains. Finally, the relative amount of grassland and forest varies greatly in different parts of the Osage Biotic district, primarily from east to west. The eastern forests and obligatory species thin toward the western part of the state with the western limits of their range extending as slender tongues along the larger river valleys (Snider 1917:221). However, short grasses are limited in the east by sufficient soil moisture which supports a continuous growth of mid and tall grasses, effectively keeping the short grass understory in dense shade (Weaver and Alberston 1956:18). Blair (1950:110-111) has classified this same area as the Kansas biotic province. The plant associations remain the same however.

Geology, Topography, and Geography

Introduction

In the words of geologist Jonathan Davis, “Archaeology is Geology or it is nothing” (quoted in Elston 1994:84). Davis came by this knowledge honestly; he was the great grandson of William Morris Davis (father of geomorphology) and the son and nephew, respectively, of legendary Texas archaeologist, E. Mott Davis, and notable Arkansas archaeologist, Hester A. Davis. What did Davis mean by this statement? In short, he firmly believed that archaeological interpretation would be flawed if archaeologists failed

to understand the processes in which the archaeological record is enveloped (Elston 1994). Likewise, knowledge of those resources available for exploitation by prehistoric peoples can assist archaeologists in deciphering landscape-use strategies.

The geology of the general study area is presented in this section with personal and local observations inserted periodically. The underlying theme here is to draw attention to the types of land-based resources that were available to the people who lived in the area. In a sense, the geologic resources of the study area helped these people master their environment. Proof of this is in the cultural byproducts manufactured from these abundant resources. Following the discussion of available geologic resources, the focus will turn to the topography of the study area, which is often reflected as geomorphic provinces. Each of these zones was exploited in different manners. Geographic regions are then discussed within the context of these recognized/delineated geomorphic provinces to further set the stage for future discussions.

Geology

This geology review is relatively detailed. However, many of the resources available to the prehistoric occupants owe their origin to the unique characteristics of the underlying strata. Geologically, the Anadarko Basin is the most dominant structural feature in western Oklahoma and the Texas panhandle (Carr and Bergman 1992, Sheet 2; Johnson 1979); therefore, its life history will be discussed extensively. The basin is principally within the drainage basins of the Cimarron, Canadian, and Washita river valleys (Freie 1930:7). It stretches across two modern physiographic provinces, the Great Plains to the west and the Central Lowlands to the east (Beck and Haase 1989:2; Fenneman 1923, Plate 1; Weaver and Albertson 1956:3-15). The outline and location of this large syncline is known mostly through the mapping of Permian formation surface-exposures and field logs (well logs) from drilling deep wells. The western edge of the Anadarko Basin is marked by an unnamed anticline followed by the plunge of the Dalhart Basin (Gustavson et al. 1980:3, Figure 2; Nicholson 1960:51-64). The northern reach of the Anadarko

Basin is bound by the Kansas Shelf (Gustavson et al. 1980:3, Figure 2; Nicholson 1960:51-64). In western Oklahoma the trough-feature is bounded on the south by the Wichita-Duncan-Ardmore uplift evidenced on the surface by the Wichita Mountains (Howell 1922:23), and by the buried Amarillo Mountains in the Texas panhandle (Nicholson 1960:51-64). Both uplifts are thought to date between the early Mississippian (Table 3.1) or late Pennsylvanian periods (Gould and Lewis 1926:25-29; Moore 1921:33).

Table 3.1. Generalized Geologic Time Scale.

Era	Period	Epoch*
Cenozoic	Quaternary	Holocene Pleistocene
	Tertiary	Pliocene Miocene Oligocene Eocene Paleocene
Mesozoic	Cretaceous Jurassic Triassic	
Paleozoic	Permian Pennsylvanian Mississippian Devonian Silurian Ordovician Cambrian	
Precambrian	Proterozoic Archean	

Note: Data from Palmer (1983).

* Not all categories are represented in the study area.

During the Permian, sedimentation occurred in the Anadarko Basin until it was gradually filled with clastic materials brought in by paleorivers. This filling, along with the southwestward withdrawal of a vast inland sea, brought about the intercalation of marine and non-marine sediments (Freie 1930). We see these sediments today as bedrock exposed on the surface, in erosional cuts, and in incised river valleys. These bedrock

materials and topographic features served prehistoric people with raw material for various tools. These include milling and grinding stones, anvil stones, hearth surrounds, abraders, and mudstone for dye. Permian features also provided shelter in the form of canyons, caves, and overhangs. Following the Permian, the former basin stood above water, especially during the Mesozoic (Table 3.1). However, the retreat of water was slow. For example, during the Triassic conditions shifted between humid and arid (Green 1954). It is at this time that the oldest and lowest of the Triassic deposits, the Dockum group, was laid. It is within the lowest part of the Dockum that the Tecovas Formation was deposited. Within the Tecovas Formation occurs Tecovas jasper, a material occasionally employed by prehistoric peoples, including the Late Archaic period. Tecovas jasper, often referred to Tecovas chert, formed in hypersaline water bodies during periods of evapotranspiration (McGowen et al. 1979:34). The Tecovas Formation and its knappable units are spotty and localized with the easternmost exposure generally following the receding edge of the Caprock Escarpment (Mallouf 1989:313). Following the Triassic and during Cretaceous times, a great sea invasion completely covered the area once again (Freie 1930:78). During the late Cretaceous and early Tertiary, regional uplift and eastward tilting occurred throughout most of the Great Plains changing the character of the region once again (Gable and Hatton 1982).

The Tertiary and subsequent Quaternary deposits in the area are the most extensive of any in North America (Gustavson et al. 1991:477). In the southern Plains, uplift first resulted in extensive erosion that locally stripped away Cretaceous and older rocks during the early Tertiary (Gustavson et al. 1991:477). This observation is echoed by Dolliver (1984:27), who believes that climate was only a subordinate factor (Seni 1980) in initiating what he terms, the Ogallala erosion cycle. Dolliver (1984:27) cites research by Savin (1977:333, 339) and Vail et al. (1977:87) which demonstrates a lack of evidence for a climatic shift during the late Miocene to early Pliocene epochs. McGookey et al. (1988:4) believe the uplift started in the late Tertiary (early Miocene) as a result of Cenozoic orogeny (mountain development). According to Schultz (1977), by middle

Miocene times deposition of the Ogallala Formation had begun on the irregular topography created by uplift-induced erosion (Figure 3.4). The most recent synopsis of the Ogallala Formation on the southern Plains is provided by Reeves and Reeves (1996). Knappable stone from the Ogallala Formation were heavily exploited by southern Plains

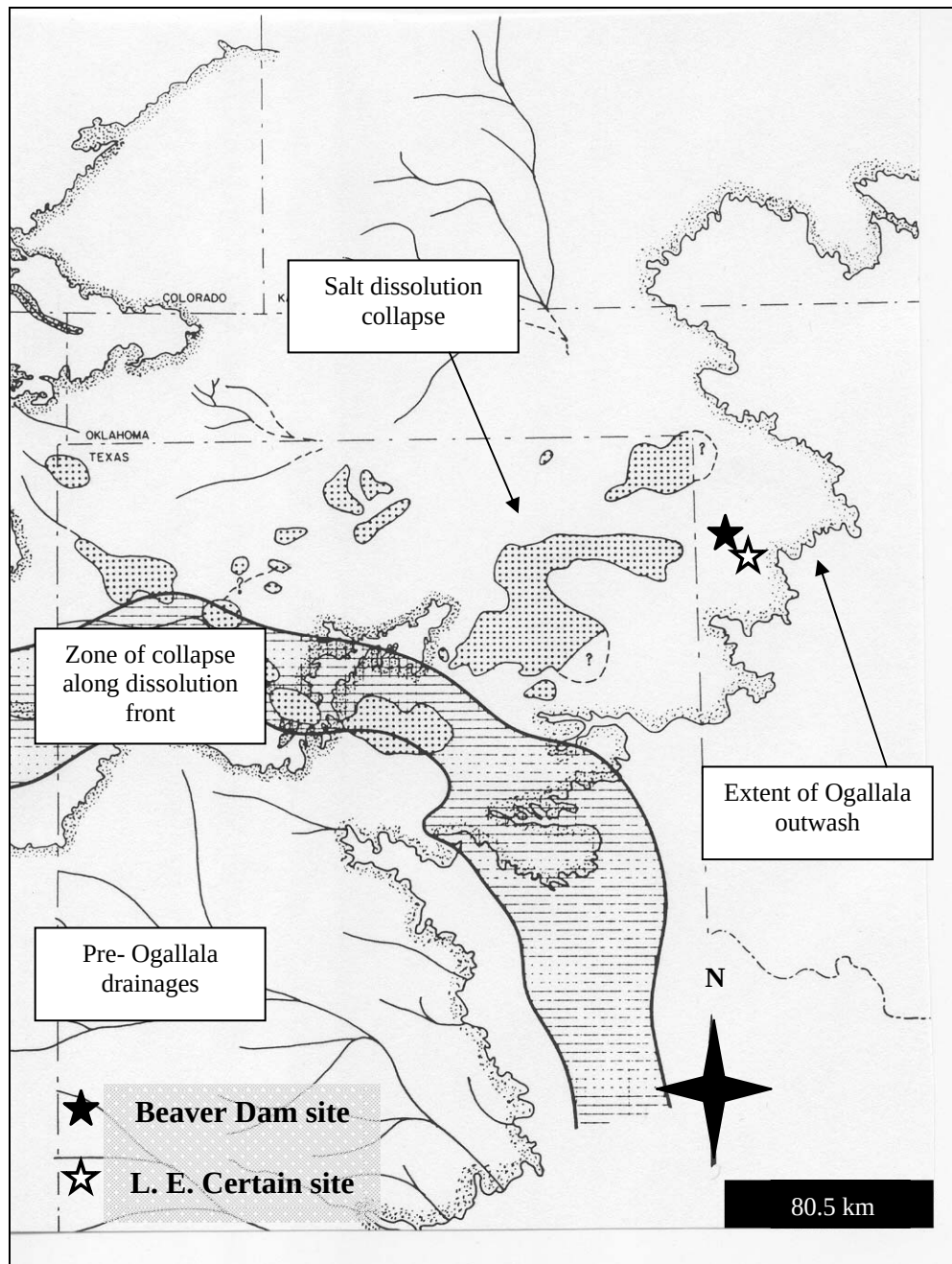


Figure 3.4. Extent of Ogallala outwash and salt dissolution (adapted from Dolliver 1984).

Archaic cultures and occasionally used by subsequent groups (Ballenger 1999:58-61; Hammatt 1976:270; Hofman 1973, 1978:315).

Whether initiated during the early or middle Miocene, the Ogallala Formation of the late Tertiary age unconformably overlies Permian, Triassic, Jurassic, and Cretaceous strata in the Texas panhandle and the adjacent study area (Dolliver 1984:32-35; McGookey et al. 1988:4). Fluvial deposits were confined to the valleys and did not overtop the topographic divides created during the Tertiary. Evidence of such comes from the eolian deposits that overlie the divides (Gustavson et al. 1991:477). The accumulated eolian deposits also indicate that Ogallala streams on the Plains were cutoff from fluvial discharge and sediments by the late Miocene (Dolliver 1984:32-35; Gustavson and Holliday 1985). The occurrence of calcic paleosols throughout the Ogallala section and the presence of windblown deposits suggest that deposition occurred in an arid to sub-humid environment (McGookey et al. 1988:5), contrary to that postulated by Seni (1980).

Salt Dissolution

During the late Tertiary (Pliocene) and early Quaternary (Pleistocene), southwest flowing streams, ancestral to the Pecos and Canadian rivers induced subsidence by dissolving underlying salt beds laid down during the Permian (Dolliver 1984:32-35; Gustavson 1979, 1986; Gustavson and Finley 1985:42; McGookey et al. 1988:8). This dissolution induced widespread subsidence of specific points on the landscape (Figure 3.4). This produced non-tectonic vertical displacement through the collapse of overburden sediments (Gustavson et al. 1991; Simpkins et al. 1981:23). Other drainage systems in the study area (Washita and North Fork) have developed over strata, which had much of the Permian salt previously removed (Gustavson and Finley 1985). Nevertheless, the above relatively recent streams still have a high salinity index (Richter and Kreidler 1986; United States Army Corps of Engineers 1993).

In theory, the prehistoric occupants of the area could use the salt-bearing layers that are present in the region. The deposits are exposed on the surface by erosion or in erosional cuts along stream valleys. Normally, salt bearing layers can be anywhere from 9.14 to 1,524.0 m below the surface in western Oklahoma (Morris 1977:104, 1982:175) although exposed in erosional cuts. Salt springs also occur in the study area—Beckham County, Oklahoma (Morris 1982:175, Oklahoma Water Resources Board 1980:5-6). The prehistoric and protohistoric use of salt and salt deposits elsewhere has been adequately documented especially for preserving meat and seasoning meals (Brown 1981; Early 1993; Morris 1982). Salt deposits on the exposed surface would attract various animals including bison. In the Salt Plains region of Oklahoma, northeast of the project area, the Osage were observed scraping salt off the ground. Early explorers noted that they scraped it off the prairie with a turkey's wing and then into a wooden bowl (Foreman 1932:477).

Reddish-brown mudstone overlies many of the Permian age salt beds and is hypothesized to be salt-dissolution residue (McGookey et al. 1988:8). This mudstone was also potentially exploitable, like the associated salt. Mudstone has high iron oxide content and might have been useable as a pigment on the body or accessories. Red ochre was used at the Folsom-age Cooper site to the north (Bement et al. 1997) and was employed by Late Prehistoric potters to the east (Brown 1996:327-339, 401-404; Suhm and Jelks 1962:1, 17, 101, 113, 141).

Gravel Clasts and Their Origin

The gravel that makes up the bulk of the Tertiary-Ogallala deposits in the study area served as raw material for a variety of tasks. Use of so-called Ogallala gravel (miscellaneous quartzites, silicified wood, and other materials) for manufacturing projectile points and other tools are well-documented (Ballenger 1999:40-88; Buehler 1997:142-143; Thurmond 1991a:130-137, 1991b). Potter chert is the term generally applied to very siliceous or fine-grained quartzite. The material is geologically related to the Ogallala Formation gravel originating from the Rocky Mountains (Patton 1923:78-

80). The name of the local variant is derived from the Texas county (Potter) in which it was originally identified. Local archaeologists are responsible for the distinction between the more siliceous materials and the typical large crystal quartzites. Presumably heat-treating was done to make the material easier to work (Collins and Fenwick 1973; Crabtree and Butler 1964; Hurst and Rebnegger 1999; Mandeville 1973; Purdy 1974). Raw materials contained in these deposits were also used as hammers, anvils, boiling stones for cooking, and as hearthstones (Leonhardy 1966a:30-32). It is quite possible that Ogallala clasts were recycled or reused (Camilli and Ebert 1992). The importance of employing Ogallala material by Archaic folk was noted early on by those working with the cultural taxonomy for the study area (Collins 1968; Leonhardy 1966a:30-32; Shaeffer 1966).

Within the Ogallala outwash gravel, a variety of other materials from different geologic ages occur (Dolliver 1984:35). Redeposited materials include Cretaceous age Kiowa Formation materials and remnants of the Permian age Quartermaster Formation (Table 3.2) (Fay and Hart 1978:5, 37). The Kiowa Formation consists of shale which is characterized by inclusion of Cretaceous fossils (Texigryphaea). It was utilized as a tempering agent in the earliest pottery found in the region (Moore 1988a) and used by earlier groups to produce utilitarian items (Thurmond 1991b). Other materials such as Dakota Group quartzite, generally found far to the west (Black Mesa vicinity) are also present in the immediate study area (Carr and Bergman 1992, Sheet 1; Fay and Hart 1978:43-44, Plate 1). Dakota quartzite is found on hilltops east of the study area (Custer County) as gravel intermingled with Ogallala clasts and as *in situ* remnants on high points (Carr and Bergman 1992, Sheet 1; Fay and Hart 1978:43-44, Plate 1). Dakota cobbles and pebbles are also present in the minor creeks and streams in Beckham and Roger Mills counties. The stone is most often utilized for expedient tools. Alibates cobbles and pebbles from the Quartermaster Formation are also found amongst Ogallala outwash gravel. Alibates is also found on hilltops as well as on Pleistocene terraces and in various river and stream beds (Bureau of Economic Geology 1969; Kraft 1998). These are the

same highly desirable materials exposed in the Texas panhandle and along the course of the Canadian River (Kraft 1997a; Wyckoff 1989, 1993a). For an in-depth review of the Tertiary-Ogallala in the study area, see Reeves and Reeves (1996).

Table 3.2. Localized Geologic Time Scale.

Era	Period	Nomenclature
Cenozoic	Quaternary	Dune Sands Alluvium Terrace Deposits
	Tertiary Cretaceous	Ogallala Formation Kiowa Formation Dakota Group
Paleozoic	Permian	Elk City Sandstone Doxey Shale Cloud Chief Formation

Note: Data from Carr and Bergman (1992).

Topography

A geomorphic province is a large region of similar landforms (topography) resulting from erosion of rocks and/or deposition of sediments that are uniform in nature and structure. Geomorphology and the establishment of geomorphic provinces involve the study of topographic forms. Topographic forms exert far-reaching and fundamental influences upon the patterns of human activity (Strahler 1955:109-112). Direct topographic effects and indirect geographical influences must be considered when discussing topographic forms (geomorphology). A quick example illustrates this point. For instance, a high mountain range influences climate in adjacent areas in addition to serving as a barrier between groups of people. In short, landforms and climate interact to produce environments that influence human settlement patterns (Goodman 1977). To facilitate the study of landscape features, geomorphic provinces have been established whereby landforms are placed into classes or groups. The recognized geomorphic provinces of western Oklahoma are the High Plains, the Western Red Bed Plains and the Western Sandstone Hills, also known as the Gypsum Hills (Figure 3.5) (Curtis and Ham 1979).

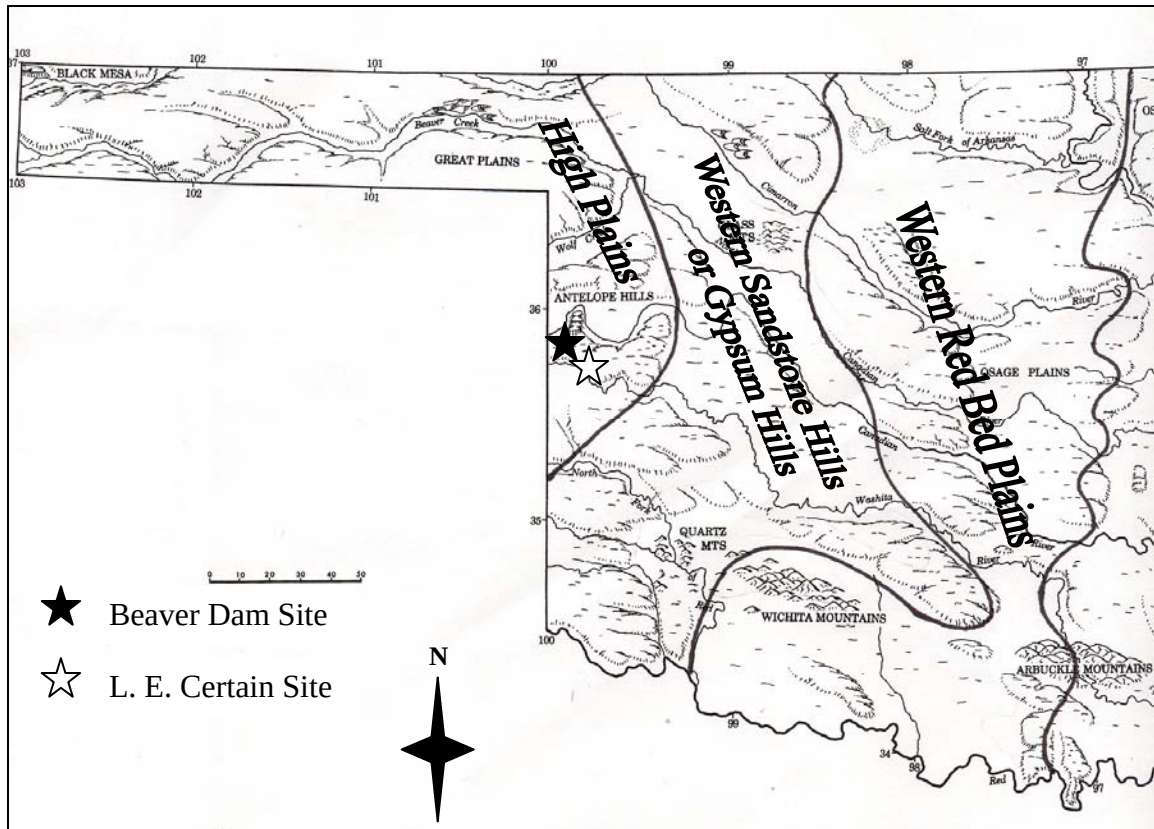


Figure 3.5. Major hydrologic units, geographic regions, and topographic features of western Oklahoma (adapted from Morris et al. 1986a).

On the surface, Permian deposits in the study area are characterized by gently rolling hills and broad flat plains referred to as the Western Red Bed Plains while to the west steep walled canyons cut the plains to form the Western Sandstone Hills (Curtis and Ham 1979; Snider 1917:80-81). Both these areas are also considered a single unit and referred to as the Western Red Prairies by some (Goodman 1977:23). To the immediate west of the study area is the High Plains province (Curtis and Ham 1979; Snider 1917:90-92). This geomorphic province contains Tertiary and Pleistocene alluvial sands. This relatively flat upland surface is described as being featureless. However, the province is deeply dissected along rivers and major streams (Curtis and Ham 1979; Fenneman 1931:1-30).

One of the major drainages in the study area, the Washita River, cuts through the center of the Western Red Bed Plains (Figure 3.5). This river alternates from a narrow creek-like channel to broad, flat floodplains. To the north of the Washita River, the North Canadian River and the Canadian River are lined with sand dunes. The North Fork of the Red River to the south is also lined with sand dunes (Madole et al. 1991:522-524). These features are generally referred to as the Western Sand Dune Belts (Curtis and Ham 1979; Snider 1917:218-219). These hummocky fields of grass-covered sand dunes mainly occur on the north sides of the aforementioned rivers and owe their origin to wind blown Quaternary alluvium (Curtis and Ham 1979). Prevailing winds from the south helped form this topographic feature (Snider 1917:40-42). Also along the margins of the greater study area are segments of interbedded gypsum and shale deposits. These gently rolling hills interspersed with steep bluffs and badlands settings have developed among the Permian deposits in the region and support their own unique flora and fauna (Curtis and Ham 1979).

Geography

The Great Plains constitute an area of more than 2,072,000 km² and stretch the length of the North American continent from the Canadian arctic to Texas (Weaver and Albertson 1956:3-15). The Great Plains once was vast grassland dominated by short grasses in the west and tall grasses in the east (Baker and Waln 1985:191-196; McKelvey 1955:227-237; Malin 1967:82-91). Despite the uniformity of terrain and general vegetation implied by the label Great Plains, there is remarkable diversity in land-surface forms (Atwood 1940:237-277; Fenneman 1931:1-91; Raisz 1957; Trimble 1990; Weaver and Albertson 1956; Wedel 1978:25). The eastern margin of the southern Plains is one such unique zone within the Great Plains geographic district (Snider 1917:43-92). The eastern portion of the Texas panhandle and western Oklahoma are included in this sector. The physical environments of Oklahoma (and the Texas panhandle) have had a strong influence on prehistoric settlement patterns. The landscape set the backdrop for human activity for thousands of years (Ballenger 1999; Baugh 1984a; Boyd 1997; Campbell 1976; Drass

1997; Drass and Dycus 1994; Drass and Turner 1989; Gunnerson 1987; Lintz 1986; Moore 1988b).

The geographic regions identified for the study area mirror the recognized geomorphic provinces presented in the previous section. Starting in the west, the Southern High Plains (Llano Estacado) is the southern portion of the High Plains section of the Great Plains (Hunt 1974; Raisz 1957). The Southern High Plains region is the largest, almost featureless, plain of its kind in the United States. Although the Llano Estacado visually appears to be level, it does slope southeast at a rate of 2.133 m/1.60 km (National Oceanic and Atmospheric Administration 1974). Beside the above, the only relief that exists on the Southern High Plains is that of dunes and playa lakes (Malin 1967:85; National Oceanic and Atmospheric Administration 1974). Captain Marcy's 1849 visit to the immediate study area left him with the impression that it was as boundless as the sea. He further lamented that "neither an animate nor inanimate object was in sight to break the monotony of the high tableland". His impression was that "no man, savage or civilized", could permanently inhabit the region (Malin 1967:85).

The High Plains geographic province is usually limited to the Texas and Oklahoma panhandles. However, Morris et al. (1986a) include the upper reaches of the Washita and the North Fork of the Red rivers and portions of northwest Oklahoma in their geographic overview of the area. Continuing eastward, the Gypsum Hills or Scarped Plains geographic region is characterized by a broken line of hills capped with layers of white gypsum. Between the undulating rises are large areas of fertile land (Morris et al. 1986a; Snider 1917:43-92). The Red Bed Plains are further east beyond the Gypsum Hills. The Red Bed Plains geographic province is characterized as being a relatively level region with moderately incised stream and river valleys. The variation in landforms that is present throughout this zone is caused by wind and water erosion (Morris et al. 1986a; Snider 1917:43-92).

Hydrology

Introduction

Rivers are a dynamic and important part of the physical environment. They represent a potential threat to human populations through floods and erosion (Knighton 1984:1-3). Often hydrologic units are essential to human and animal survival and the rivers of the southern Plains figured prominently in the prehistoric and historic settlement of the study area (Irwin 1977; Oklahoma Water Resources Board 1984:1). Thousands of years ago, humans hunted and collected along the watercourses and upland playa lakes, fished and drank from the same, and followed the rivers and creeks' winding channels between biotic zones. Moreover, the upland divides between the drainages played just as an important role as the waterways. The interfluvial ridges served as ready thoroughfares for prehistoric inhabitants of the area (Thurmond and Wyckoff 2000). As it is impossible to separate the story of prehistoric cultures from the waters in the study area, so it is in contemporary Oklahoma (Irwin 1977:25).

Floods

Droughts and floods continue to interrupt Oklahoma's well being, as they did prehistorically (Harper 1960; Oklahoma Water Resources Board 1984:1). Water causes about two-thirds of the erosion on modern agricultural lands with sediment from affected areas clogging rivers and increasing the hazard and severity of future flooding (United States Department of Agriculture 1994:3-4). In the past, episodic heavy downpours have caused considerable damage along the Washita River and its north-flowing tributaries. Generally, rainfall is most erosive after droughts. Thus, when intense rains arrive and the soil is bare, resistance to erosion is the lowest (Fenneman 1931:23; United States Department of Agriculture 1994:9). Surely prehistoric inhabitants of the area had to contend with such floods and sediment displacement.

In 1934, close to 33.02 cm of precipitation fell in a few hours in the Sergeant Major

Creek watershed (Figure 3.3) all but wiping downstream communities off the map (Bailey 2000; Oklahoma Water Resources Board 1984). Officially termed the “Hammon Flood,” approximately 100 people were left homeless, 10 were missing, and one died (Bailey 2000; Oklahoma Water Resources Board 1984). Other sources purport that 17 lost their lives (Caldwell 2001; Steele 1966:434; United States Department of Agriculture 1964:2). Record floods also occurred in 1995 along the Elm Fork, a southern tributary of the North Fork of the Red River in southwest Oklahoma (United States Geological Survey 1996). The mean annual discharge of Elm Fork is usually $1.18 \text{ m}^3/\text{sec}$; the United States Geological Survey measured $1,699.0 \text{ m}^3/\text{sec}$ south of the study area in June 1995 (United States Geological Survey 1996). According to locals, heavy downpours and flooding in this part of western Oklahoma and the Texas panhandle result in an average of four water-related disasters per year, less than the average nine per year before flood prevention measures were initiated by the United States Department of Agriculture (Anonymous 2000:2; Steele 1966).

Without a doubt, water flow is one of the most potent forces operating on Earth’s surface both in terms of total energy exerted and total amount of debris transported (Knighton 1984:1-3). In performing their erosional and transportational functions, the network of rivers and streams in the study area have developed and transformed themselves and the surrounding environments repeatedly (Knox 1983). Confirmation of such is found throughout the southern Plains, occasionally at archaeological sites. It is generally accepted that the lack of intact Archaic deposits is the result of loss and destruction through erosion. It is also very likely that the sites from this time are deeply buried in colluvium and thus undiscovered. These two facts have been noted for years (Hughes 1976, 1991:10-24). Analogous situations are noted elsewhere in the Plains and Plains-prairie margin (Bettis 1991; Mandel 1991). The L. E. Certain site (34BK46) and the Beaver Dam site (34RM208) are two examples. Both sites are on a high, linear interfluvial divide between the Washita River and the North Fork of the Red River (Thurmond 1991a:108). Both sites are in broad upland valleys that were hydrologically

active at the times the sites were occupied. Only recently have the archaeological sites been discovered as a result of modern hydrologic and fluvial processes (Bement and Buehler 1994:173-175; Kraft and Thurmond n. d.). Bison traps similar to L. E. Certain site were also found under comparable circumstances (Bement 1999:11-14; Hughes 1977a; 1989; Madle 1972:171; Wheat 1972:3; Wilkens 1997).

Spring Water

The L. E. Certain site sits at the edge of an isolated outcrop of Elk City Sandstone. This type of sandstone generally thins toward the edges. Associated with the isolate is a localized aquifer yielding up to 473.17 liters/min, which is more than areas outside the outcrop. Granted, prehistoric peoples were not pumping water from aquifers as is done today, it does however suggest that a reliable water source would be available via spring discharge (Carr and Bergman 1992, Sheet 2). Also unique to the immediate study area is a feature hydrologists refer to as a non-contributing zone. These localities are points within a watershed where there is no outlet for surface water. Hence it is a non-contributing zone. Surface water from these sectors soaks into the earth and effectively becomes spring discharge. Approximately 95.91 ha in the upper reach of Sandstone Creek Watershed is just such an area. This non-contributing zone is in the land section (Section 16, T11N, R22W) containing the L. E. Certain site (United States Department of Agriculture 1958). Moreover, the gully in which the L. E. Certain bison kills are contained has an active spring which surely existed prehistorically given the local hydrology and topography outlined above.

Observations regarding the availability of spring water have been made on the Thurmond Ranch where the Beaver Dam site is situated (Thurmond n. d.). In a matter of years, inactive springs have become active once again. Reliable springs are moving headward, up the canyons, suggesting that the local discharge could change rather quickly. Archaeological sites thought to be some distance from a water source are now revealed to be situated atop newly activated springs (Thurmond et al. 1998). Nearly every stream

valley transecting the Tertiary/Permian outcrop boundary in the study area is spring fed, the groundwater emanating from the base of the Ogallala Aquifer (Thurmond 1991a:106; Thurmond and Wyckoff 1998). Overall, the Ogallala Aquifer is limited to 10 western Oklahoma counties, which include the two in the study area—Beckham and Roger Mills counties (Oklahoma Water Resources Board 1980).

Surface Water

Two major interstate rivers drain Oklahoma; the Red River and the Washita River. The Red River and its tributaries drain 64,692.72 km², or about 33% of the state (Oklahoma Water Resources Board 1980:5). The Washita River extends a total of 1, 007.44 km, 933.41 km in Oklahoma (Oklahoma Water Resources Board 1984:32-33). The Washita River and the North Fork of the Red River are two of the Red's major tributaries. The Washita River and the North Fork of the Red River have their origin on the High Plains of the Texas panhandle (Atwood 1940:237-277; Raisz 1957).

The North Fork of the Red River originates in Carson County, Texas, and flows eastward for a river distance of 115.84 km when it enters Beckham County, Oklahoma (Oklahoma Water Resources Board 1967:34, 1984:32-33). The North Fork of the Red River crosses Beckham County from northwest to southeast, and its broad sandy terraces cover a large portion of the county (Ford et al. 1980:2). Numerous canyons cut steep rocky uplands and gullies to the south of the study area while the study area itself consist of gently sloping uplands (Oklahoma Water Resources Board 1984:1-2). The watershed begins in an area that is nearly absent of topography except for a number of playa lakes which dot the landscape. The river drops off the caprock at a rate of about 10.05 m/km and then stabilizes at a uniform rate of 2.13 m/km once in Oklahoma (Oklahoma Water Resources Board 1967:34). The principal tributaries of the North Fork of the Red River are McClellan Creek, Sweetwater Creek, Timber Creek, Elm Fork of the Red River, Elk Creek, and Otter Creek (Oklahoma Water Resources Board 1967:34).

The Washita River begins in southern Roberts County, Texas, and enters Oklahoma in Roger Mills County. The Washita River flows through the central part of Roger Mills County and drains about 75% of the county while tributaries of the North Fork of the Red River drain the southern part (Burgess et al. 1959:1-2). From the south, the principal tributaries of the Washita River are Croton Creek, Brokenleg Creek, Plum Creek, Sergeant Major Creek, Dry Creek, Beaver Dam Creek, Sandstone Creek, and Kiowa Creek.

Summary

In summary, the character and behavior of a fluvial system, at any particular location, reflects the integrated effect of a set of upstream controls. The upstream controls, notably climate, geology, and basin physiography (landforms and elevations), together determine the hydrologic regime of a watershed (Irwin 1977:25; Knighton 1984:1-3). Climate (e.g. seasonal precipitation) is of primary significance in that it provides the energy that shapes the fluvial system. In turn, seasonal precipitation affects the amount and distribution of groundcover, some edible, that is crucial to preventing runoff and channel degradation.

Climate

Introduction

Climate is often cited as playing a pivotal role in affecting change in prehistoric cultural patterns, especially on the Plains (Goodman 1977:9-12; Van Royen 1937; Vehik 1982; Wedel 1940). Oklahoma's climate is influenced by the State's geographic location on the leeward side of the Rocky Mountains (National Oceanic and Atmospheric Administration 1977). Generally speaking, the Oklahoma landscape is dominated by rolling plains, 181,090.21 km² to be exact, which in part contributes to its climate (United States Geological Survey n. d.). It can be said that Oklahoma is climatically a borderland (Goodman 1977:9). Overall, it is temperate. The climate varies due to the blending of horizontal and vertical climatic zones, each exerting influence over the flora, fauna, and

humans that inhabit the area (Irwin 1977:25; Oklahoma Water Resources Board 1984).

Climate generally refers to the average temperature and average precipitation of a locality. Climate also includes atmospheric elements such as sunshine, cloud cover, visual range, wind, and humidity, as well as special items such as thunderstorms, fog, and frost (Sutherland 1977:40). All these phenomena are generally referred to as weather. The juxtaposition and alterations of three major air masses bring about weather changes in the study area. Included is a southern warm, moist air mass from the Gulf of Mexico, a relatively cooler, oceanic air mass from the west, and a cold, dry air mass from the arctic (Strahler and Strahler 1994:155-195; United States Geological Survey n. d.). The movements of these air masses tend to stimulate rapid changes in temperature, humidity, cloudiness, precipitation, and wind in Oklahoma.

Drought

The troposphere is the lowest atmospheric level, which extends upwards approximately 11.26 km from the Earth's surface (Strahler and Strahler 1994:56-57). Everyday weather, such as clouds or storms, occurs mainly in this level, as does all human activity (Bear et al. 1986:121-122; Strahler and Strahler 1994:56-57). An important feature of the troposphere is that it contains significant amounts of water vapor (Skinner and Porter 1992:16). When water vapor content is high, it falls to the ground as rain, sleet, or snow depending on the season. One of the more important climatological events in Oklahoma, prehistorically and historically, is the infrequency of precipitation (i.e. the variability of rainfall and its distribution) (Oklahoma Water Resources Board 1969; Sutherland 1977:49). A drought is defined as two or three successive years of abnormally low precipitation in a season that normally has ample precipitation (Strahler and Strahler 1994:170). The United States Environmental Protection Agency (2000) defines a drought as a natural phenomenon caused by changes in weather patterns that result in less-than normal rainfall.

The concept of *normal* or *average* precipitation is actually misleading and some believe it should be expelled from the weather-related lexicon (Sutherland 1977). Evidence shows that outstanding droughts in Oklahoma tend to occur somewhere in the neighborhood of every 20 years (Sutherland 1977:52). On the other hand, hydrologic droughts, characterized by continuously less than average streamflow, have extended nearly statewide four times since the 1920s: 1929-41, 1951-57, 1961-72, and 1975-82 (United States Geological Survey n. d.). These drought conditions occurred periodically in the past as well (Harper 1960; Van Royen 1937). Thurmond and Wyckoff (2000) document evidence for similar relatively short-lived late-Holocene events. Of course, the Altithermal of mid-Holocene times consisted of less than average precipitation, and less than average stream flow, throughout the Southwest and southern Plains (Meltzer 1991, 1995:359-360).

Precipitation

The distribution of precipitation in the study area generally has two peaks during the year. The largest peak is in the late spring, and the secondary peak is in early fall (Eddy 1982). Contributing to the vacillation in precipitation is the geographic location of the study area. Situated on the eastern edge of the Southern Great Plains, Beckham and Roger Mills counties have a favorable continental climate, typified by somewhat moderate winters and prolonged sweltering summers (Oklahoma Water Resources Board 1969:25.).

The year-by-year variation in precipitation of the study area has been averaged from all available records for the period 1893-1967 (Oklahoma Water Resources Board 1969). The period average is 68.5 cm, while yearly averages range from 33.02 cm in 1910 to 106.68 cm in 1923. Individual gauging stations show their driest years have ranged from 24.13 cm at Cloud Chief (Washita County) in 1910 to 43.18 cm at Anadarko (Caddo County) in 1963 (Figure 3.6). The wettest years between 1893 and 1967 show totals ranging from 96.52 cm at Fort Cobb (Caddo County) in 1959 to 121.92 cm at Clinton

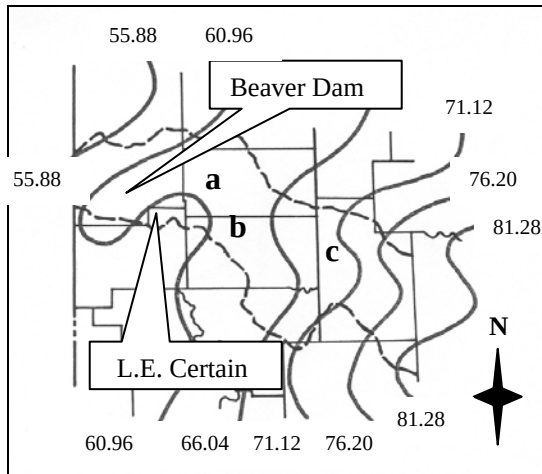


Figure 3.6. Precipitation gradient for western Oklahoma in centimeters: (a) Washita County; (b) Caddo County; (c) Custer County. Dashed lines demark the Washita River basin. Not to Scale.

(Custer County) in 1941. Gauging stations in the westernmost part of the study area average between 40.64 and 78.74 cm of moisture in eight out of 10 years, while, the eastern stations average between 50.8 and 111.76 cm (Oklahoma Water Resources Board 1969). In the general study area, the greatest difference in annual precipitation was documented in 1945 when totals ranged from 39.37 cm at Elk City (Beckham County) to 106.68 cm at Anadarko, a difference of

nearly 68.58 cm (Oklahoma Water Resources Board 1969). Given the variability in rainfall amounts listed above, local researchers determined there was a trend toward an increase in average annual rainfall over the past century (Thurmond and Thurmond 2000). Only continued research in this arena will determine if these statements hold true.

Seasonal Dynamics

Introduction

In most places, air temperatures follow natural cycles. First, there is a daily rhythm of rise and fall in air temperatures caused by the rhythm of incoming solar energy (i.e. day and night) (Miller and Hartman 1981:38-48). Second is a seasonal rhythm. This variation is caused by the tilt of the Earth's axis, which exposes the northern and southern hemispheres to differential solar intensity as the year progresses (Gabler et al. 1977:22-23; Guyette 1974:22-23; McIntyre 1973:6-7; Strahler and Strahler 1994:51). Seasonal climatic features in Oklahoma are well defined, but the gradual changes between seasons are often marked by brief periods of stormy weather (Oklahoma Water Resources Board

1969:25). The collision of air masses that occurs over Oklahoma whip up violent tornadoes and electrical storms, which scatter hail or sand in their wake (Morgan and Morgan 1984:1-18). So prevalent were the effects of weather on day-to-day life for early settlers, many resorted to pithy frontier humor. When a pilgrim would ask “does the wind always blow this way,” the response would be “no it sometimes blows the other direction” (Dale 1965:9).

Winter

Winters are ordinarily less severe and shorter than the bitter winters delivered on Kansas, Nebraska, and the Dakotas (Oklahoma Water Resources Board 1969:25-27, 1984:30-31). In winter, the study area lies in the southern range of the arctic jetstream and the northern range of the equatorial jetstream; the result is extremely variable temperature and precipitation (Cooter n. d.; Sutherland 1977). Cognizant of Sutherland’s (1977) laments about *averages*, the mean January temperature in Beckham and Roger Mills counties from 1941 to 1970 was between 1.6 and 38 C° (Figure 3.7) (Beck and Haase 1989:4; Burgess et al. 1959:1; Ford et al. 1980:1; Morris et al. 1986b; Oklahoma Water Resources Board 1967:31, 1969:27-28; Sutherland 1977:44, Figure 8). The average daily

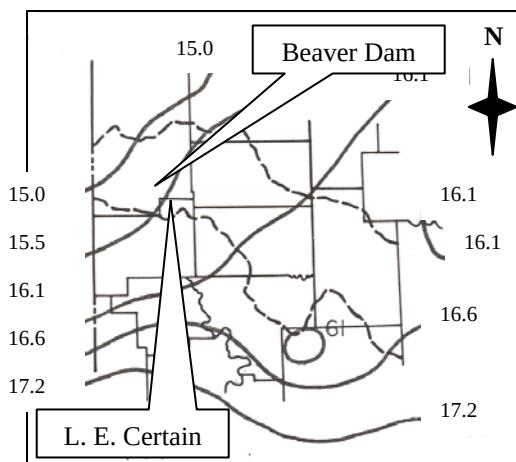


Figure 3.7. Temperature gradient for western Oklahoma in Celsius (winter). Dashed lines demark the Washita River basin. Not to Scale.

minimum between 1951 and 1976 was -2.7 C° and the lowest temperature on record, -21.1 C°, was recorded in 1959 (Ford et al. 1980:1). A combination of rain, ice, and snow account for winter precipitation in the region (National Oceanic and Atmospheric Administration 1977). Although heavier amounts of snow fall in the west than elsewhere (opposite of rainfall patterns), the winter season receives the least precipitation (Burgess et al. 1959:3; Ford et al. 1980:110;

Oklahoma Water Resources Board 1969:25-27, 1984:30-31). Nevertheless, winter precipitation provides much needed soil-moisture recharge (Oklahoma Water Resources Board 1969:25-27). Discharge from springs along the Dempsey Divide increases during the winter because of less intake by dormant plants (Thurmond, personal communication 1997).

Spring

The warming trend of spring is a time of renewed plant growth after a dry cold winter. In the study area, the mightiest winds materialize in the spring often bringing dust storms. Winds often damage sandy soils that are not protected by ground cover while strong winds and high temperatures dry surface soil and cause plants to lose valuable moisture (Burgess et al. 1959:1-2). In Beckham County and portions of western Oklahoma, the mean surface wind speed from March to June is between 22.52 and 25.74 km/h with winds prevailing from the south (Oklahoma Water Resources Board 1967:32-33; Snider 1917:40-41). Spring is the wettest season, almost tripling the amount of precipitation that occurs in the winter. Hail and hail-damage are often associated with these spring storms (Oklahoma Water Resources Board 1969:25). The majority of tornadoes occur in the spring, however, the thunderstorms that accompany the twisters provide ever-important moisture to the subsoil in preparation for the drier months of summer (Oklahoma Water Resources Board 1969:25).

Summer

The long sizzling summers in the study area, which commonly have temperatures of more than 37.7° C, are often punctuated by droughts of varying duration (Burgess et al. 1959:2; Oklahoma Water Resources Board 1984:30-31). In the study area, the mean temperature in July from 1941 to 1970 was between 26.6 and 28.3° C (Beck and Haase 1989:5; Burgess et al. 1959:1; Ford et al. 1980:1; Morris et al. 1986b; Oklahoma Water Resources Board 1967:31, 1969:27-28; Sutherland 1977:45, Figure 10). The average daily maximum temperature between 1951 and 1976 was 33.8° C (Ford et al. 1980:1).

The highest recorded temperature in the study area between 1914 and 1955 was 46.1° C and the highest recorded temperature between 1956 and 1976 was 43.8° C (Burgess et al. 1959:2; Ford et al. 1980:1). Convective storms move across the state from southwest to northeast, providing summer rainfall. On average, thunderstorms occur about 50 days each year (Ford et al. 1980:1). The eastward trending storms form into massive complexes, which can be 16.09 km wide and 46.22 km long on average (Eddy 1982). Moisture from the Gulf of Mexico and a Northern Atlantic high-pressure system called a Bermuda High prevail during the summer accounting for Oklahoma's summer rain and humidity (Bomar 1983:265).

Autumn

Autumn in Oklahoma is the second wettest season after spring (United States Geological Survey n. d.; Oklahoma Water Resources Board 1969:25-27, 1984:30-31). The cooling trend of autumn, combined with a return of precipitation, assist in establishing and maintaining those plants that thrive on the short but pleasant sunny days and brisk nights (Oklahoma Water Resources Board 1969:25-27; Sutherland 1977). It is this time of year that some fruits and most nuts ripen including acorns, hickory nuts, pecans, and walnuts (Hall 2000:107-109; McCoy 1980, 1981, 1987:141, 179; Peterson and Boyd 1998; Petrides 1972:135, 158; Svoboda 1967). For ungulates, cool season grasses provide an excellent diet for about three months although the nutritive value (e.g. digestible energy and protein) of native range declines rapidly soon thereafter (Bruner 1931:102; Harlan 1960:16-17; Peden 1976; Waller et al. 1972). Nevertheless, cool season grasses provide for a lengthened green-grazing period (United States Department of Agriculture 1997:44), especially for bison.

Plant Communities and Associated Fauna

Introduction

Temperature and precipitation are usually related to the natural vegetation of a region—

forest or grassland, shrubland or tundra (Snider 1917:215-246; Strahler and Strahler 1994:155). The natural vegetative cover is often a distinctive feature of a climatic region and typically influences the human use of the area (Strahler and Strahler 1994:155). The vast interior grassland known as the Great Plains has had a significant effect in shaping the ways in which prehistoric groups dealt with the expansive, but diverse, Plains environment (Wedel 1978:25). Natural vegetation of the Plains is overwhelmingly grasses and so-called weeds (Blair 1939, 1950:109-112; Blair and Hubbell 1938:437-438, 440; Dayton 1960; Stubbendieck et al. 1995; Weaver and Albertson 1956). This vegetative regime was originally associated with vast herds of bison, lesser numbers of antelope and small game, with deer and elk living on the periphery (Beck and Haase 1989:10-12; Boone and Crockett Club 1893:155-211; Caire et al. 1989; Hornaday 1904:99-103; United States Department of Agriculture 1977:3; Wedel 1978:26).

Cross-timbers and Mixed Grass Prairie/Plains

Besides being linked to temperature and precipitation, plant communities are usually associated with the recognized geographic and geomorphic areas of a region, and thus geology (Kelting and Penfound 1953). Generalized natural vegetation in the Red Bed Plains geographic district and the Central Red Bed Plains geomorphic provinces consists of assorted grasses and the savanna-woodland oriented Cross-timbers (Blair 1939, 1950:109-112; Morris et al. 1986c). The Mixed Grass ecotone divides the Short Grass Plains of the west from the Tall Grass Prairie/Plains of the east (Blair 1939, 1950:109-112; Duck and Fletcher 1945; Morris et al. 1986c). According to Bruner (1931:110), the Tall Grass association is a “subclimax (community) since it occurs in an area with a potential forest climate.” Tall Grass zones hosts various species of tall sod-forming grasses, as well as legumes, and composites (Bruner 1931:110).

In general, the Cross-timbers’ trees compete with the tall grasses for land occupancy in the Western Sandstone Hills area (Morris et al. 1986c). Appropriately, mixed grasses consist of short grasses and tall grasses such as buffalo grass, blue grama, sideoats grama,

and little bluestem. The Cross-timbers, the largest natural vegetation area in Oklahoma, consist of post oak and blackjack oak (Blair 1939, 1950:109-112; Foreman 1947:1-22; Morris et al. 1986c). Like the Mixed Grass ecotone, this cultural and natural landmark divides the bluestem prairies and rolling woodlands of the east from the Short Grass-covered, level plains of the west (Morgan and Morgan 1984:15). The Cross-timbers region is poised between the humid east and the semi-arid west. Moist conditions encourage growth of oaks while arid conditions promote erosion of the underlying sandy soil (Goodman 1977:22-23). In fact, the boundary between the prairie/plains and Cross-timbers, as well as the location of the Mixed Grass Plains, were thought to have migrated from west to east and back with long-term climatic trends (Albertson and Weaver 1945; Blair 1939; Blair and Hubbell 1938:451; Bruner 1931:112; Weaver and Albertson 1956). To some extent, the stream valleys that transect both zones served as thoroughfares for the westward extension of eastern forest species of animals and plants (Blair 1939; Blair and Hubbell 1938:439; Snider 1917:221). Conversely, Blair and Hubbell (1938:438) assert that the east-west trending sand dunes of the Mixed Grass Prairie served as highways for the eastward extension of many western species of animals and plants.

The water content of the Mixed Grass Plains' soils is variable due to declining precipitation moving west to east. To the west, long intervals of dry periods are more frequent and parching winds increases xerophytism (Blair 1939, 1950:110; Bruner 1931:112). The mixed grass ecotone includes tall grasses that have established a foothold during times of high precipitation (Bruner 1931:112; Weaver and Albertson 1956:75-116). Besides pasture vegetation, the Mixed Grass Plains accommodate thickets of Chickasaw plum, stinking sumac, cottonwood, stands of mesquite, oaks, junipers, American elm, black walnut, sugar maple, hackberry, box elder, a number of mosses, ferns, and flowering herbs (Blair 1939; Blair and Hubbell 1938:438-439; Gregg 1954:359-361; McCoy 1980, 1981; Petrides 1972; Wright and Bretz 1949:65-72).

Despite being a tangled and stunted forest of oaks, the Cross-timbers subregion supports

a broad diversity of plant life and a profusion of springs (Anonymous n. d.; Gregg 1954:359-361; Morgan and Morgan 1984:17) as it probably did in the past. The Cross-timbers at one time occupied 2,023,500 ha in over 31 counties of Texas and Oklahoma (Mattoon and Webster 1943). The main strip of forest was once about 120.67 km wide at the Oklahoma-Texas border but progressively became narrower as it stretched north to the Cimarron River in Oklahoma (Foreman 1947:5-6). In portions of the Cross-timbers, pecan, and plums are common, as are trees with non-edible by-products, such as ash and cottonwood (Foreman 1947:8-9; Gregg 1954:359-361; Hall 2000:104-106). In addition to the fruits and nuts above, bison, bears, deer, and turkeys are reported to have been in abundance in the Cross-timbers (Armstrong et al. 1986; Foreman 1947:43-44; Stangl et al. 1992; United States Department of Agriculture 1977:3). Undoubtedly, those who occupied the region would have utilized all these species for food, shelter, fuel, and other life-sustaining activities.

Shin Oak Grassland and Sandsage Grassland

Within the High Plains geographic and geomorphic zones are the Shin Oak Grassland and the Sandy Sageland or Sandsage Grassland plant communities (Snider 1917:217-219). The shin oak grassland is separate from the post oak and blackjack oak dominated Cross-timbers to the east. The shin oak ecotone, often times called Sand Shinnery, hosts several species of trees, shrubs, and grasses. However, Sand Shinnery is defined by shin oak. According to Peterson and Boyd (1998:1), “sand shinnery communities comprise the nation’s largest stand of oak and occupy 2,023,500 to 2,832,900 ha of the southern Great Plains.” The stand, which stretches from the High Plains of northern Texas and the Gypsum Hills of western Oklahoma south into the Chihuahuan Desert, is made up of ancient plants (Beckett 1976:154; Hafsten 1961; Peterson and Boyd 1998:1-6). Given this, the shin oak ecotone was surely around when the L. E. Certain and Beaver Dam sites were occupied. Furthermore, the Late Archaic cultural repertoire, toolkit, and site features should reflect the usage of the flora and fauna that accompanies the Sand Shinnery community. Archaeological sites containing toolkits reflecting acorn harvesting

are found in shin oak stands on the western margin of the southern Plains in the Mescalero Dunes (Montgomery 1991). One would expect the same on the eastern margin of the southern Plains in the immediate study area (Bement and Buehler 2000a). It is suggested that field processing of these nuts is minimal. Furthermore, it is argued that acorns (nuts) are readily transportable in a finished or unfinished state thus making them highly desirable (Bettinger and Malhi 1997). Likewise, the progenitor of the nuts is a non-moving resource making exploitation highly predictable and reliable.

Sand plum, prairie baccharis, wolfberry, skunkbrush, and Oklahoma plum occupy shinnery stands, while eastern red cedar and post oak occur on the eastern fringe in Oklahoma (Duck and Fletcher 1945; Engle et al. n. d.; Peterson and Boyd 1998:2; Wolfshol 2000:54-55). Sagebrush, snakeweed, mesquite, hackberry, and soapberry (chinaberry) are also widespread within the Shin Oak Grassland. Tall grasses such as sand bluestem, big bluestem, switchgrass, and giant dropseed take hold where the sand is deep; water content is high in these areas since precipitation percolates deeper into the soil (Peterson and Boyd 1998:2). Forbs in the stunted oak grassland include annual buckwheat, annual sunflower, western ragweed, prairie coneflower, false dandelion, and many, many others (Peterson and Boyd 1998:2; Thurmond et al. 2002). Fauna of the Sand Shinnery community includes mule deer, white-tailed deer, pronghorn antelope (now uncommon), wild turkey, peccary, jackrabbits, cottontails, rodents, desert shrews, and eastern moles (Armstrong et al. 1986; Oklahoma Department of Wildlife Conservation n. d. a; Peterson and Boyd 1998:15-17; Snider 1917:183-213, 223; Stangl et al. 1992; United States Department of Agriculture 1977:3). Remains of these animals have been found at archaeological sites in the shin oak biome on the western edge of the Llano Estacado (Montgomery 1991; Smith 1985).

Other edible wildlife species in the Sandsage Grassland include lesser prairie chickens, quail, turkey, mourning dove, and approximately 20 species of perching birds (Baumgartner and Baumgartner 1992; Duck and Fletcher 1945; Peterson and Boyd

1998:17-20; Robbins et al. 1966; Sutton 1977; United States Department of Agriculture 1976, 1978). In the past, gray wolves, cougars, black bears, and grizzly bears ranged into the shin oak ecotone and may have been encountered by occupants of the L. E. Certain and Beaver Dam sites (Armstrong et al. 1986; Caire et al. 1989; Peterson and Boyd 1998:20; Stangl et al. 1992). Currently, coyotes, bobcats, badgers, striped skunks, swift fox, many species of hawks, and owls dominate the top of the food chain in the shinnery (Armstrong et al. 1986; Baumgartner and Baumgartner 1992; Oklahoma Department of Wildlife Conservation n. d. b; Peterson and Boyd 1998:20; Stangl et al. 1992; Sutton 1977). Reptiles in the ecological niche include terrestrial and aquatic turtles, 25 species of snakes, a few skinks, and a variety of lizards (Blair 1939, 1950:111-112; Jackson 1983; Peterson and Boyd 1998:20-21; Sievert and Sievert 1993). Assuredly bison, elk, and antelope utilized the shin oak community in the past thus making them prime targets of Late Holocene hunter-gatherers. Archaeological evidence indicates that bison and elk prehistorically occupied the same ecotone (Beckett 1976:154; Hafsten 1961; Smith 1985:6).

The less extensive Sandsage Grassland community has a plethora of weedy annuals and woody species such as hackberry, plum, and sumac, as well as skunkbush, little bluestem, big bluestem, sandhill bluestem, Indiangrass, buffalograss, blue grama, and sideoats gramma. Certainly, this small isolated plant community along the Elm Fork and the North Fork of the Red River attracted bison and other browsing and grazing animals (Duck and Fletcher 1945; McCoy 1981; Stangl et al. 1992). Like the Shin Oak community, the Sandsage Grassland plays host to quail, prairie chicken, dove, assorted waterfowl, and cottontail (Central Flyway Waterfowl Council 1986; Snider 1917:192-193; Sutton 1977; United States Department of Agriculture 1976, 1978, 1979). These flora and fauna represented resources attractive to prehistoric peoples.

Summary

In review, the Shin Oak Grassland and Sandsage Grassland are wedged between the

Short Grass Plains biotic district and the Mixed Grass Plains biotic district of western Oklahoma (Blair 1939; Blair and Hubbell 1938:437-441; Morris et al. 1986c; Peterson and Boyd 1998:2, Figure 1; Socolofsky and Self 1988:5). Likewise, these communities and districts overlay portions of the Gypsum Hills geographic region and Western Red Bed Plains geomorphic province as well as portions of the High Plains (Blair 1939; Blair and Hubbell 1938:437-441; Curtis and Ham 1979; Morris et al. 1986a). Generally, the fine textured soils of the High Plains are fertile but water content is only sufficient for short grasses due to limited and unevenly distributed precipitation (Bruner 1931:105-112). Additionally, the soils of the Gypsum Hills and Red Bed Plains are fine textured and the increased frequency of precipitation gives these soils a favorable water balance (Burgess et al. 1963; Ford et al. 1980; Madole et al. 1991:503-509; Morris et al. 1986b; Socolofsky and Self 1988:4). In turn, this allows drought resistant short grasses to maintain a foothold when precipitation is lacking and tall grasses to flourish when atmospheric moisture is plentiful (Blair 1939, 1950:109-112; Blair and Hubbell 1938:437-441; Bruner 1931:105-112; Curtis and Ham 1979; Morris et al. 1986a, 1986b). Further information on the flora in these areas can be gleaned from Johnson and Milby (1989). Plant species specific to the 4,047 ha Thurmond Ranch, where the Beaver Dam site is located, is also available (Thurmond et al. 2002).

Paleoenvironmental Data

Introduction

The late Pleistocene-early Holocene environment of western Oklahoma can assist in deciphering the physical changes that the region went through over time. From this, insight into the environmental trends that occurred during the Late Archaic time period can be suggested. The best way to reconstruct past environments is through the examination of fossil pollen, soil cores, and the fluvial record. There are no detailed pollen records published for the immediate study area; however, pollen records from the adjacent Llano Estacado (although controversial) indicate the presence of a generalized

grassland regime on the Llano Estacado and prairie biome in western Oklahoma (Bryant and Holloway 1985a; Bryant and Schoenwetter 1987; Holloway and Bryant 1985). Hydrological studies from the Llano Estacado offer additional data regarding past environmental conditions. Studies of pluvial lake basins (playa lakes) indicate an increase in precipitation during the Late Pleistocene, compared to modern trends (Reeves 1966). Moreover, alluvial deposits in the area demonstrate that Paleoamericans congregated around the marshy environments, springs, and lush river meanders that were so prevalent at the time (Stafford 1981).

The most extensive fossil pollen record from the Southern High Plains is from the Texas-New Mexico border in the Texas panhandle. Just 250 km west of the study area, White Lake formerly occupied a 32 km² basin (Hall and Valastro 1995:238). Pollen extracted from clay deposits at the lake indicated that grassland type vegetative cover existed. However, the pollen assemblage recovered does not correspond exactly to any modern grassland environments. As a result, Hall and Valastro (1995:244) suggest that there might be no modern analog. The paleoecology of late Pleistocene mammalian faunas matches the pollen records, thus lending credence to this reconstruction (Hall and Valastro 1995; Semken 1983:200-207).

Selected Paleoamerican Sites

By looking at a few Paleoamerican sites surrounding the study area, a better picture of the former environmental conditions can be gained. These sites have multidisciplinary studies, or have been investigated by archaeologists trained in such fields. Prior to the Clovis occupation of the immediate area, streams were subject to deep incision. However, these streams slowly filled-in leaving most Paleoamerican sites deeply buried or recently exposed on the surface of old, high terraces (Holliday 1997:149-164). The first two sites utilized to gauge environmental conditions in the region are from the Clovis period (Miami and Domebo) and are mammoth kill localities. The next two sites are Folsom and Plainview-aged bison kill sites (Lake Theo and Perry Ranch). The Miami

site is about 96.54 km northwest of the Beaver Dam site and roughly 12.63 km from the L. E. Certain site, while the Domebo site is approximately 12.63 km southeast of the L. E. Certain site and around 128.72 km from the Beaver Dam site. Both the Lake Theo and Perry Ranch sites are about 112.63 to 120.67 km southwest of the L. E. Certain and Beaver Dam sites.

The Miami site is within a playa lake on the extreme northeast end of the Southern High Plains (Llano Estacado) and the Domebo site is in a spring-fed stream at the bottom of a deep, narrow ravine southeast of the Llano Estacado (Holliday 1997:115; Leonhardy 1966b:1). The Miami site consists of five mammoths that were dispatched around 11,400-10,800 BP (Holliday 1997:117). Sediment studies indicate that there was a slow accumulation of wind-blown dust in the well-vegetated moist basin (Hall and Valastro 1995:237-244; Holliday 1997:116). The Domebo site is on a low order tributary of the Washita River in the Gypsum Hills of western Oklahoma. At the time of the mammoth kill (circa 11,000 BP), the Domebo site was a deep gully. The canyon was carved into the underlying sandstone and evidence suggests that alluvium was beginning to accumulate (Albritton 1966). The single mammoth was contained within the fill-sand overlain by marshy soil (Albritton 1966). The multidisciplinary study indicated that there was greater effective precipitation at the time of the kill with the local canyon environment exhibiting a humid woodland setting surrounded by an upland grassland community (Holliday 1997:162).

Lake Theo (9400-8000 BP) is a Folsom period site associated with the remains of extinct bison with a possible Plainview site above (Harrison and Smith 1975). Lake Theo is on the eastern margin of the Llano Estacado along a terrace of Holmes Creek, a Red River capillary stream. Based on recovered snail faunas, seasons were less variable and rainfall was distributed more evenly throughout the year during Folsom times (Neck 1987). Woodland vegetation was apparently dense at Lake Theo, but this may have been a phenomenon related to a locally high water table (Holliday 1997:159-160). Perry Ranch

is a small Plainview bison kill in the Gypsum Hills of southwest Oklahoma. The remains of two extinct bison were recovered from the site (Holliday 1997:161-162). The kill (circa 7030 BP) took place in an arroyo, indicating that an episode of canyon cutting was underway or had previously occurred (Holliday 1997:161-162).

Briefly, the Waugh and the Cooper bison kills are Folsom period sites which took place in canyons cut into the underlying bedrock much like that at the L. E. Certain and Beaver Dam sites (Bement 1999:3-40; Hill and Hofman 1997; Hofman et al. 1992). Both sites are approximately 104.58 and 120.67 km north of the L. E. Certain and Beaver Dam sites, respectively.

Selected Archaic Sites

The transition between the Pleistocene and Holocene epochs differed regionally; however, most agree that there was a vegetation change that occurred about 10,000 BP (Bryant and Holloway 1985b). Likewise it is evident that by this date the Holocene character of vegetation was firmly established (Holloway and Bryant 1985). Not until about 7500 BP did things start to change dramatically (Antevs 1955; Ferring 1995; Meltzer 1995:349-350; Nance 1972). The proposed long-term drought, dubbed the Altithermal, apparently ended some 2500-3000 years later (Ferring 1995).

Initially the Altithermal was thought to be widespread, however the Middle Holocene environments of the Plains are shown to be notably inconsistent, spatially and temporally (Holliday 1987; Johnson 1987a; Knox 1983; Mandel 1995; Ruhe 1983; Semken 1983; Wedel 1986:78). For example, the Ogallala aquifer continued to emit freshwater on the central Plains when many outlets on the southern Plains failed (Meltzer 1995:351). Likewise, Wedel (1986:79-80) argues that the Republican River valley remained a grassy bottomland thanks to springs and thus was able to support a limited human population. Although water was available on the central Plains, the Mustang Springs site (6800-6600 BP) alludes to a different situation on the southern edge of the Llano Estacado. The site

contains nearly 60 water wells excavated at the location of a dry, spring-fed pond (Meltzer 1991). Other wells from the same period are known at Blackwater Draw Locality #1 (Meltzer 1991, 1995:359-360).

The generally dry climate of the Altithermal persisted until about 3000 years ago. Evidence of such is obvious especially in the central Osage Plains at Carnegie and Delaware canyons (Hall 1988, 1990). After the Altithermal, effective precipitation appears to increase. This conclusion is based upon an observed increase in hickory in the Cross-timbers and a greater abundance of moist-habitat land snails in the vicinity (Hall 1988:206).

Sites Associated with the Post-Altithermal Recovery

Occupation of the Beaver Dam site and the L. E. Certain site began around 2500 to 2000 years ago or about 500 years after the end of the Altithermal. Radiocarbon dates from others sites attributed to this timeframe include 34RM334 (Thurmond 1989), 34RM507 (Rebnegger and Green, n.d.; Thurmond, personal communication 1997), the Shinnery Ridge site (Thurmond 1991a), 34WA157 (Wallis 2000), and the Swift Horse site (Briscoe 1989; Thurmond et al. 2000). The environmental information gleaned from these sites document a recovery from Altithermal environmental conditions. In addition to these archaeological sites, several paleocanyons on the Dempsey Divide have been analyzed and radiocarbon dated (Thurmond and Wyckoff 2000). In essence, these sites document the character of the post-Altithermal recovery when the L. E. Certain and Beaver Dam sites were occupied. Other nearby archaeological sites, providing data on post-Altithermal environmental conditions are the Sanders site (Quigg 1997a, 1997b, 1998), the Twilla site (Hughes 1977a, 1989; Lintz et al. 1991), 34GR12 (Leonhardy 1966a), Lubbock Lake (Johnson and Holiday 1986), and Chalk Hollow (Wedel 1975), just to mention a few.

Conclusion

The natural setting of the study area, the Dempsey Divide, has been reviewed. In this area a plethora of animate and inanimate resources were available to the Late Archaic groups that made this place home.

The underlying theme of this chapter has been the post-Altithermal recovery of the physical environment signaled by the amelioration in the southern Plains climate. The change in climate in turn led to the establishment of distinctive seasons, each with a patterned precipitation regime. This precipitation influenced spring discharge and manipulated the two major watersheds flanking the Dempsey Divide. The Dempsey Divide is home to several micro-niches as a result of unique surface geology and topography. These niches provided distinctive flora and fauna in concentrated areas, making harvest and collection ideal. Fauna associated with the Dempsey Divide included mammals, reptiles, amphibians, avian species, fishes, and mollusks. Based on archaeological remains, there seems to have been a marked increase in the presence of bison over all other fauna. Beside the fauna, a variety of flora such as nut and fruit trees and several wetland roots, shoots, and invertebrates were available. Other useable items such as salt, chert, quartzites, sandstones, mudstone, and shale were also available to the prehistoric hunter-gatherers.

Overall, the natural setting of the study area served as a stage for human non-genetic adaptation. As a result, social institutions were established to collect the available resources, especially when confined to a specific area or irregularly dispersed. Both environmental conditions and cultural interaction allowed the Late Archaic groups of the Dempsey Divide to thrive.

CHAPTER FOUR

CULTURE HISTORY: LATE ARCHAIC AND EARLY WOODLAND SITES AND SITE COMPONENTS

Introduction

This chapter reviews previous work with the Late Archaic and early Woodland cultural stages on the southern Plains and vicinity. While it is tempting to synthesize the cultural occupations immediately before and after the Late Archaic (i.e. Middle Archaic and Woodland), it will not be done here. Research to that effect is underway (Kraft and Thurmond n.d.). However, viewing the Late Archaic as a discrete unit, studied independent of what occurred before and transpired after, is not conducive to scholarly research nor is it realistic (Hofman 1996:79-83). Therefore, an abridged review of all the cultural periods represented in the area will be offered. To a certain extent, this review will address the continuity in human use of the Great Plains biome and its preeminent herbivore, the American bison. Although there is unequivocal evidence of bison use at some sites (e.g. bison kills, bison processing localities, and trash pits), often the exploitation of bison at a site is inferred or implied in archaeological reports due to insufficient reporting of faunal assemblages (Dillehay 1974:181, 187). Rather than proceed through the litany of sites containing bison remains, or review research that adequately addresses this matter, the reader is directed to Fawcett (1985, 1987).

Following the abridged review of all cultural periods on the southern Plains, Late Archaic and early Woodland base camps, burials, and bison kills from the study area, are discussed in detail. Following the review of the aforementioned site types, the Dempsey Divide is treated as a single unit whereby behavior at local base camps and treatment of the dead are discussed. Next, the bison kill sites and processing areas are presented. The review of bison kill sites will aid with identifying trends in the utilization of landscape features to procure bison. The list of radiocarbon dates will demonstrate the contemporaneity of the sites. The same is true for base camps whether classified as Late

Archaic or Woodland by the original authors. Finally, the chapter is summarized and each section tied together to set the stage for a detailed discussion of the L. E. Certain and Beaver Dam sites in chapters Five, Six, and Seven.

General Overview

Paleoamerican (12,000-7500 BP)

Although a subject of interest for decades, analysis of the Paleoamerican period on the southern Plains has grown exponentially over the past 10 years or so (Amick 1995; Amick et al. 1989; Bamforth 1985; Bement 1994, 1995, 1997a; Haynes et al. 1992; Hill and Hofman 1997; Hofman 1991, 1992, 1994; Hofman et al. 1990, 1991, 1992; Todd 1991). Recently, our understanding of particular Paleoamerican rituals in the region also has been added to and revised (Amick 1999; Bement 1999:146-183; Roper 1987).

Despite being a bit dated, Hofman (1989:25-45) hits some of the high points in Paleoamerican research for the southern Plains. As a result of the research cited at the beginning of this paragraph, our perception about Paleoamerican-age radiocarbon dates, the peopling of the Americas, and the ongoing pre-Clovis discussion has changed as well (Bryan 1986; Dillehay 1984; Dillehay and Collins 1988; Eighmy and LaBelle 1996; Pendergast 2000; Stuiver 1993; Stuiver and Pearson 1992; Turner 1992; Wyckoff and Carter 1994; Wyckoff et al. 1990, 1991). Regarding late-Pleistocene weaponry, Dixon (1999:1-10) argues that the Paleoamerican hunting apparatus, with its detachable (lanceolate) point, is similar to that of a harpoon. He further argues that such an apparatus may be derived from marine mammal-hunting technology (Dixon 1999:1-10). This is perhaps a clue to the origin of the pre-Clovis peoples who populated the Western Hemisphere.

It is commonly accepted that sites yielding lanceolate projectile points in clear association with extinct fauna can be attributed to Paleoamericans (Wormington 1957). The presumed focus on large game by these hunters is now accepted as being flawed

(Fagan 1987; MacNeish 1973). This correlation may have more to do with the nature of the Pleistocene animals' bone size and mass (i.e. highly visible), rather than subsistence practices or availability of other resources. Assuredly, these people utilized plant materials and animals other than Ice Age megafauna. A variety of vegetable foods and smaller game would not have been ignored (Bryan 1991; Fagan 1987; Meltzer 1993; Meltzer and Smith 1986). Likewise, the wide variety of tools for specialized uses recovered from habitation sites necessitates the recognition of a far wider spectrum of activities than endless hunts for big game (Jennings 1989:81-109; Johnson 1977, 1991; MacNeish 1973).

Site-types for the Paleoamerican period are organized into three rudimentary categories. These include campsites, kill localities, and processing stations. Other site-types contain evidence of meat and lithic caches, as well as burials and special activity sites (e.g. hunting stands). In general, these people probably lived in rockshelters and temporary structures on a transitory schedule (Frison and Bradley 1980; Frison and Stanford 1982; Irwin 1971). In essence, these groups were probably highly mobile, possibly on a limited basis in some regions (Brosowske 1997; Hofman 1991; Kelly and Todd 1988; Kraft and Lail 1998; LeTourneau 1992; Shott 1986, 1989). Besides the ephemeral use of sites, the mobility patterns of Pleistocene groups is also reflected in the variety of knappable materials used to construct cutting, scraping, and piercing tools (Bement 1999:150-158; Holliday 1997:12-14, 244-252). Knowledge of the natural distribution of lithic materials and the ability to source them accurately is paramount to this conclusion. Burials of such groups are occasionally found, often exhibiting the usage of red ochre (Frison 1991:353, 367; Roper 1987). This practice along with other hints of social life (i.e. communal bison kills) further supports the supposition that ritual was a key part of the Paleoamerican milieu of activities (Frison 1991:41).

General Archaic

The Early, Middle, and especially, Late Archaic responses to the post-Pleistocene

environment are generally marked by an increase in the occurrence of grinding implements at archaeological sites, as well as rock-lined hearths and burned-rock middens/fire-cracked rock concentrations (Bagot and Hughes 1979; Etchieson et al. 1977; Hammatt 1976; Hughes 1991; Hughes and Hood 1976; Kraft and Thurmond n. d.; Leonhardy 1966a:12-30). On the Dempsey Divide, the most notable increase in tools is those utilized for processing non-edible vegetative matter (Saunders 1974; Tainter 1979). Activities such as cutting, pounding, and shredding are proposed. Gouges occur quite frequently in assemblages throughout the Archaic, and beyond (Boyd 1997:315; Etchieson et al. 1977:16-17, 1978:348-349, 1979:353-355; Hofman 1973; Hughes 1976; Ray 1941, 1961; White 1981). Not only can these tools be employed in processing plant material, they can also be used for working wood and hide which are clearly specialized activities (Hester et al. 1973; Hofman 1977; Turner and Hester 1985:205).

Early and Middle Archaic (7500-3000 BP)

Syntheses of the Early and Middle Archaic in the study area have relied on an inadequate database given the extent of time covered by the construct. It is generally accepted that the lack of intact Early and Middle Archaic deposits is the result of loss and destruction through erosion. It is also very likely that the sites from this time are deeply buried in colluvium and thus undiscovered (Hughes 1976, 1991:10-24). Analogous situations are noted elsewhere in the Plains and Prairie-Plains margin (Bettis 1991; Mandel 1991). On the other hand, the absence of Early and Middle Archaic sites in the archaeological record may be a result of the criteria archaeologists use to distinguish sites, namely projectile points, other stone tools, and the raw materials employed. The assumed characteristics utilized to define Early and Middle Archaic occupations may have misleading implications, an apparent absence of sites (Lewis 1986). The key indicator for this period is projectile point styles, however, these artifacts should only occur at a limited range of site types (i.e. kills and camps). In effect, other Early and Middle Archaic sites may be materially indistinguishable from sites belonging to other time periods (Lewis 1986). This issue will be revisited later in discussing Late Archaic and

early Woodland sites in the study area.

The Early and early-Middle Archaic is considered a transition period whereby Paleoamerican hunting traditions evolved into the classic Archaic legacy of a generalized or diversified economy (Willey and Philips 1958:107). Outside the study area and to a certain extent within the study area, Archaic economies are thought to have been based on territorial foraging and seasonally scheduled forays. Even so, some researchers have recognized an incongruity between the eastern Plains Archaic and the western Plains Archaic stages (Johnson and Wood 1980:38; Zimmerman 1985:59-60). These differences are generally the result of different lifestyles, which in turn are influenced by variability in climate, availability of resources, and the habits of neighboring groups. The general conclusion about the western Plains Archaic lifestyle is a rather dismal one. Most references to the Plains Archaic reflect the notion that these people survived on meager edible resources barely clinging to life, save the occasional buffalo (Wedel 1986:72). In the forests to the east, resources were more abundant, and thus Archaic life was presumed to be less dismal.

The southern Plains were not totally abandoned during the Altithermal (Middle Archaic). Although well-stratified and intact Archaic sites are lacking, the southern Plains Early and Middle Archaic are represented. Excavations at sites such as Gore Pit (Hammatt 1976), Lubbock Lake (Johnson 1987b) and Summers (Leonhardy 1966a:12-30), do offer some clues to life in the study area. Further evidence of human occupation is demonstrated by Calf Creek peoples venturing into the area, perhaps during a mid-Altithermal recovery (Thurmond and Wyckoff 1999). It is plausible that Ogallala Formation springs exposed along valley walls kept the Washita River valley habitable. The spring-fed tributaries of the stream therefore acted as an oasis strip capable of supporting limited forays to the area. Published research currently points to the possibility of four Calf Creek (Horizon) bands occupying the general study area during the Middle Archaic (Wyckoff 1993b:205-206; Wyckoff and Shockey 1994, 1995). The

basis for this argument focuses on the recurrent employment of four well-known lithic materials utilized to manufacture the distinctive Calf Creek (Andice and Bell) projectile point/knife (Wyckoff 1993b:196-200; Wyckoff and Neal 1994:347). Unfortunately, analogous, well-stratified radiometric-dated sites are rare in Oklahoma compared to adjacent regions (Grange 1980; Neal and Duncan 1996; Schmits 1978).

Controlled surface-collected sites in western Oklahoma attributed to the general Archaic, exclusive of the Calf Creek Horizon, include CD177 (Hofman 1973), Croton Creek (Tainter 1979), Clay (Saunders 1974), Edwards I, Assemblage A (Baugh 1982), Johnson-Cline (Lintz 1978), Muncy (White 1987), Nall (Baker et al. 1957), Pumpkin Creek (Wyckoff and Taylor 1971) and Roberts (Saunders 1974), to mention a few. Surface-collected sites identified on the 4,047 ha Thurmond Ranch are listed in Table 4.1. Numerous other “Archaic” sites are documented in the region. Systematic surveys of

Table 4.1. Archaic Sites on the Thurmond Ranch.

34RM332D, 34RM334C, 34RM336B, 34RM446, 34RM450, 34RM461, 34RM470A, 34RM507, 34RM508, 34RM510, 34RM513, 34RM532, 34RM601, and 34RM208

Note: Data from Thurmond 1997a.

large tracts of land and smaller parcels over the past 20 years or so lend credence to this summation (Ballenger 1999:36, 92-94, Table 3.2; Brosowske and Bement 1998:20-34; Drass and Turner 1989:50, Table 5; Edington 1997:146, 157-160; Litwinionek et al. 1997:307, Table 1; Moore 1984:175-178, 1988b:18-31; Morgan 1996, 1999; Thurmond 1991a; Thurmond and Moore 1985). Earlier surveys of large tracts of land also recorded several Archaic sites (Baker and Campbell 1960; Burton and Burton 1971; Green 1967; Hughes 1977b; Hughes 1959; Hughes and Willey 1978; Katz and Katz 1976; Kingsbury and Nowak 1980; Northcutt 1979; Pearson 1974; Saunders et al. 1972; Wendorf and Miller 1959; Willey and Hughes 1975; Wyckoff 1963). Additional information on Archaic sites can be gleaned from Hughes and Willey (1978:27-28) for the Texas

Panhandle, and Hofman and Hays (1989) for the entire southern Plains.

Late Archaic (3000-1650 BP)

The Late Archaic occupation of the region is marked by larger and more frequently occupied base camps which are surrounded by numerous smaller activity camps. Such a trend supports the notion that these groups were acting as logistical collectors (Binford 1980). With the onset of mesic conditions during the Late Archaic cultural sub-stage, there is a supposed increase in human occupancy of the Plains, perhaps because of a rebound in bison populations. In turn, the increase in human inhabitants is thought to have precipitated a reduction in group mobility and the establishment of territories. There appears to be an increase in population based on the density of Late Archaic camps and the excess of material recovered from these camps. Also, by using a wider variety of food sources, Late Archaic groups would be able to maintain higher population densities.

Circumstantial evidence for increased population growth, and thus inter-group contact and stress, is the apparent rise (compared to Paleoamericans) in interments exhibiting evidence of brutality or violent death. In southwest and southeast Texas, communal cemeteries lend credence to the establishment and manifestation of territorial boundaries (Hall 1981; Taylor and Highley 1995). On the eastern margin of the southern Plains, the occurrence of lunate stones in burials and elsewhere may, circumstantially, reflect this social process (Thurmond 1991b:248).

Proposed settlement patterns for the Late Archaic involve the use of uplands in autumn, spring, and summer with a change in residence patterns during the winter (Hofman 1989:56; Hughes 1991:20-26; Wedel 1975:273). Logically, Late Archaic groups wintered in canyons of the Llano Estacado and its eastern margin (Thurmond 1997, personal communication). Conclusions to this effect, that is utilizing the incised drainages (canyons) of the Dempsey Divide, are presented elsewhere (Moore 1984:190-199, 1988b:33-63; Thurmond 1991a:128-140). Similar predictive models and observations are

made for the Lower Plains and canyonlands directly below the Caprock Escarpment (Boyd 1997:265-266). The same observation is made in the foothill-plains of southeastern Colorado (Campbell 1976:68). The non-winter camps are manifest as scattered upland sites but high-integrity deposits are often masked as previously noted. Likewise, faunal and botanical remains, which would assist in verifying this settlement pattern, are often lost to taphonomic processes (i.e. sample degradation).

Plains Woodland (1650-1150 BP)

The Woodland period corresponds to a time when patterns of subsistence were changing on the southern Plains, however slowly. The subsistence shift is hypothesized based on the recovery of new artifacts never seen before in the region. A change in food-storage technology (pottery) and weaponry (bow and arrow) are the keys to this hypothesis (Vehik 1984:175-177). This adoption of Woodland technology was probably slow and uneven across the southern Plains. Thus, settlement and subsistence patterns were not drastically altered for some time based on artifact assemblages and radiocarbon dated components (Campbell 1976:50; Kraft and Thurmond n. d.). The reason for the technological change is argued to be the result of a shift in climate or an influx of people (or their ideas) from an adjacent region (see Boyd 1995a, 1995b; Hartley 1974; Johnson and Johnson 1998:209-211). Cave and canyon sites on the eastern edge of the southern Plains, such as Delaware Canyon and Duncan-Wilson bluff shelter, demonstrate a Woodland-oriented technology existed alongside a typical Late Archaic toolkit. Sites in the heart of the study area also bolster this argument. Base camps such as Lake Creek, Deadman's Shelter, and Swift Horse are prime examples. Further to the west, in the foothills and mesas of southeast Colorado and northeast New Mexico, Late Archaic toolkits at Metate Cave, Trinchera Cave, and McEndree Ranch also demonstrate the introduction of Woodland-oriented technologies.

It is well-established that Woodland peoples took advantage of caves and rockshelters (Campbell 1976; Lawton 1968). These were most likely occupied during late-autumn and

winter, as in the Late Archaic. Faunal and botanical evidence to support this seasonal pattern is not available, however. River valleys, canyons, and other protected areas were surely used in the colder months. To the far west there is evidence for the use of semi-subterranean structures (Shields 1980:4-5). However, there is no evidence for semi-permanent villages or hamlets. Features such as storage pits or trash middens are rare at base camps; however the use of rock-lined hearths is obvious in caves and at open sites. Upland sites were most likely used in the warmer months by Woodland populations, mirroring the pattern adopted by Late Archaic groups. These ephemeral camps and special processing areas are difficult to distinguish from the Late Archaic sites except for the presence of scaled-down Late Archaic-style projectile points (Thurmond 1997, personal communication). All in all, a logistical collecting lifeway was perpetuated.

Faunal remains from Woodland camps indicate that a wide variety of animals were used, quite similar to that during the Late Archaic. Bison continue to be part of the diet along with smaller mammals and some aquatic species, mostly invertebrates (Campbell 1976; Honea 1964; Saunders 1983; Steen 1955; Winter 1988). Direct evidence of vegetable materials in the diet is lacking, however circumstantial evidence in the form of grinding stones indicate that floral remains were processed. The same is true of flaked items and other miscellaneous tools, however very few use-wear studies have been conducted. No horticultural tools have been recovered in the study area. Deer hunting appears to be more prevalent in the Woodland period rather than bison hunting based on the ratio of bone recovered from each. Whether availability of game as opposed to cultural preference on the part of the hunters was responsible for this pattern has not been demonstrated. Dillehay (1974:187) has suggested that climatic change was the primary cause for the absence of bison during the Woodland occupancy of the southern Plains. Splintered bison bone, usually associated with grease processing, and burned bison bone do show that bison were used to a certain extent (Briscoe 1987a, 1987b; Saunders 1983; Shields 1980; Wedel 1975).

As alluded, Woodland material culture includes pottery, dart points, arrow points and a variety of flake tools used to process plants and animals. Raw material to produce these items is all local in origin or within a range that could easily be reached during seasonal movements. Ogallala and Dakota quartzites were employed as was Alibates dolomite. Miscellaneous river cherts and jaspers were also exploited. Temper used in those few pieces of recovered pottery includes locally available fossil-impregnated shale and crushed quartzite or scoria. The pottery is utilitarian and homogenous with no specialized decoration other than impressions left by cord-wrapped paddles. The shape of the vessels are in question but were most likely jars with conical bases.

In summary, the Woodland era on the southern Plains was a more generalized expression of the lifestyle than that to the east. Plains Woodland populations basically adhered to a Late Archaic seasonal pattern which used specific landscape features. Flora and fauna collections from sites, when recovered, indicate a broad spectrum food-collecting habit. Food stuffs mostly included large and small mammals and aquatic resources, as well as a continued use of plant materials, all of which were returned to a central base camp. Despite the fact that caves, overhangs, and shelters were used, no clothes, sleeping mats, or nets and baskets made from cordage have been recovered. Personal adornment items also are rare as are other personal items such as smoking pipes. Little in the way of ritual has been detected.

Late Prehistoric (1150-400 BP)

The most obvious expression of the Late Prehistoric on the southern Plains is the Plains Village tradition. It is argued that Woodland groups are ancestral to Plains Villagers (Hofman 1978; Lintz 1974). Groups in the Texas and Oklahoma panhandles lived in partial masonry structures with contiguous rooms. Bison hunting was supplemented with horticulture and collecting. These semi-permanent residences primarily overlooked the upper Canadian River and its tributaries as well as tributaries of the Cimarron River (Lintz 1986:177-216). Those groups living along the floodplains of the Washita and

Canadian rivers occupied circular to square wattle and daub structures with thatched roofs for most of the year (Drass 1997). Bison were hunted and horticulture and collecting was practiced between the summer and winter hunting seasons (Drass 1997:53-165).

Storage pits or cisterns were used by both groups, although those living on the Washita and Canadian river floodplains have been studied in more detail (Campbell 1969:21-22; Drass 1992). Quite often these storage pits are filled with habitation debris, presumably once they no longer served their purpose (Drass 1992). Faunal and floral remains include corn, beans, squash, as well as many other seed bearing plants (Brooks 1988; Drass and Flynn 1990). Horticultural tools were used and made mostly from bison and deer bone. Many varieties of small triangular points were used to hunt prey and formalized knives and flake tools were employed to butcher prey. Ceramics include both smoothed, cord-marked, and decorated varieties with temper varying both regionally and temporally (Drass 1997:78-92). Another ceramic item occasionally found are elbow-shaped smoking pipes. Local, semi-local, and exotic knapping materials were utilized for both formal and informal tools (Drass 1997:92-100; Duncan 2002:166-202).

In summary, Plains Villagers lived in permanent houses. Food plots of corn, beans, squash, and possibly tobacco were harvested (Drass 1993). Preparation and harvest was conducted with bone hand tools. Depending on the production and ripening schedule of wild plants, gathering and collecting took place throughout the year. Bison and other animals were hunted. Storage pits were utilized to stockpile food and later used to dispose of household rubbish. Ceramic vessels have some decoration but remained relatively utilitarian (Drass 1997:78-92; Duncan 2002:224-233). Variations in style and tempering agents reflect regional and perhaps familial differences. Burials rarely include grave goods although there is evidence of violence and disease (Brooks 1994; Lopez 1970; Owsley 1989:131-136, 1994a).

The Dempsey Divide

Difficulty with Distinguishing Late Archaic from Early Woodland Sites

The recurrent theme of finding Woodland-associated artifacts, such as arrow points and pottery, in the company of Late Archaic dart points, deserves a brief explanation. This situation occurs in caves and open sites on the Chauquaqua Plateau (Campbell 1969:187-199), South Park Plateau/Raton Mesa (Simpson 1976:200-205; Wood 1974:54-55), and elsewhere. In Oklahoma and Texas similar occurrences take place at the Sanders site (Quigg 1997a:173-177), Delaware Canyon (Ferring 1982:231-234), and with the later occupations at the Beaver Dam site (Thurmond 1988b:3) among others (Couzzourt 1985, 1987). In these settings cord-marked pottery predominates. Other pottery forms, namely thin, smooth brownwares, also co-occur with large corner-notched dart points at Chalk Hollow (Lintz 1995; Wedel 1975, 1983:219-220) and Deadman's Shelter (Willey 1978; Willey and Hughes 1978:a187) in the Texas panhandle. Several explanations can account for this situation, however only three scenarios will be addressed.

For example, deflated, exposed, surface sites pose unique problems to archaeologists working with the Late Archaic and Woodland. The high visibility of these sites makes them likely candidates for periodic scavenging by past and recent passersby (Johnson and Holliday 1986:25; Thurmond 1990a:10, 49). In effect, diagnostic indicators such as temporally distinct projectile points and pottery are removed from the surface (see Brown 1999:79).

Another example is best demonstrated at the Lubbock Lake site. In all, some nine features represent the Late Archaic occupation at the site. These range from a caliche covered baking oven, piles of crania, smashed and articulated vertebral bodies, and miscellaneous other lithic and bone clusters. However, some of the features may be attributable to the later Ceramic [Woodland] Period (Johnson and Holliday 1986:25). Sediment slowly accumulated throughout the Late Archaic and Woodland occupations making for poor separation and delineation of artifact collections from either occupation.

This is especially true when radiometric dating is not feasible or samples are contaminated. These two examples might draw into question the integrity of deposits which may represent mixed assemblages. However, assemblages that appear to be mixed may actually not be.

The third example recognizes that cultural change is not simultaneous and that new technologies may not have been adopted wholesale by southern Plains hunter-gatherers, or at an even rate, across the study area. At any given time there always exist side-by-side old-fashioned forms that are in the process of dying out beyond their peak in popularity and new forms becoming popular over time (Ford 1972). Reasons for such a heterogeneous adoption of new technologies or maintaining traditional technologies may include cultural conservatism, lack of immediate necessity, social isolation, environmental exigency, or personal preference. Moreover, the concomitance of dart points with arrow points and pottery may simply signal a partial adoption of new technologies in a manner equivalent to seasonal tasks, each with its specialized toolkits (Hofman 1996:81; Thurmond 1991a:121).

Given the current problem with separating Late Archaic sites from early Woodland sites, no matter the cause, those sites dating between 3000 BP and 1150 BP will be generally designated as Late Archaic-Woodland sites herein. When site and component dates clearly represent the extremes of the designated timeframe, they are designated as either Late Archaic or early Woodland. The entire Woodland period is not incorporated into this construct since there appears to be another transitional period between Woodland and Late Prehistoric which is not fully understood at the present. Nevertheless, based on radiocarbon dates, the majority of Late Archaic and early Woodland sites on the southern Plains cluster between 2150 BP to 1250 BP.

Late Archaic-Woodland Base Camps, Human Interments, Game Kills, and Game Processing Sites in the Vicinity of the Dempsey Divide

Introduction

This section is organized with two issues in mind. The first is the need to present the background data in a format that recognizes modern political boundaries, simply as an organizational tool. However, modern political boundaries rarely correspond with prehistoric cultural boundaries. Given that, prehistoric sites situated in northeastern New Mexico, southeastern Colorado, southwestern Kansas, and the Oklahoma Panhandle are presented in one section while sites in western Oklahoma and the Texas panhandle are presented in another. Secondly, within each of these groupings the sites are presented so that they correspond to the river valleys and other topographic features which were certainly recognized by prehistoric groups. Seasonal forays to these landscape features, based on the different and varied resources hosted by each, were without a doubt the impetus for occupying these unique biomes. The chapter then moves on to a discussion of the Dempsey Divide and the sites found along this topographic feature. These include base camps and burials as well as bison kill sites and faunal and floral processing areas.

NE New Mexico, SE Colorado, SW Kansas, and Oklahoma Panhandle

Base Camps

In extreme northeast New Mexico and southeast Colorado are the headwaters of the Cimarron River (Raisz 1957), referred to locally as the Dry Cimarron Valley. Winter (1988) presents an unparalleled overview of previous research in the valley. As a whole, the study offers an excellent valley-wide cultural overview from Late Archaic to early-Historic times (Winter 1988:73). The Late Archaic for the Dry Cimarron vicinity is thought to have started around 3950 BP and persisted until 1700-1500 BP (Winter 1988:75). Winter (1988:73-76) surmises that the Late Archaic culture(s) utilizing the Dry Cimarron Valley were probably part of the Plains Archaic tradition. As far as adaptation goes, the “Archaic” foraging lifeway persisted through the Basketmaker era and up to

650 BP (Mobley 1978, 1979).

Four radiocarbon dates in northeast New Mexico and far southeast Colorado date the Late Archaic occupation of the Dry Cimarron Valley. The first of the dated samples was retrieved from an open site. The open site (LA8120), near Folsom, New Mexico was centered on several bedrock mortars (Figure 4.1; Table 4.1). In addition, a fire-cracked rock concentration, a formal hearth, and a few ash stains were also unearthed (Honea 1964:3-4). Materials from the above were submitted for radiometric analysis with the results dating the hearth to 2650 ± 130 BP (GX 146) (Anonymous 1965). Flakes, a variety of stone tools, and bison and deer bones were also recovered at the site. The three other dates from the region were secured from three separate rockshelters. The shelters were excavated between 1974 and 1979, by Colorado College, in Colorado Springs, Colorado. All are along North Carrizo draw, a tributary to the Cimarron River. The Big Hole Spring site (5BA320) located within the grassy plains of the Cimarron River, was dated to 1870 ± 70 BP (unavailable). The carbon sample was retrieved from a hearth in the lowermost occupational unit of the rockshelter (Black 2005, personal communication).

Another hearth from a different cave (5LA1053) was radiocarbon dated to 2040 ± 70 BP (DIC 324) (Kingsbury and Nowak 1980:119, Table 6). An Ellis point and a Garza “arrow point” were recovered near the hearth but the association of the arrow point and maybe even the dart (Ellis) is questionable. An additional rockshelter excavated by Colorado College in northeast New Mexico surrendered grinding paraphernalia (hand-stone and slab), miscellaneous debitage, two cores, and a hammerstone. The site, 5LA1055, revealed a hearth that had one of the earliest dates in the vicinity. Results from radiocarbon testing placed use of the hearth to 3140 ± 60 BP (DIC 323) (Kingsbury and Nowak 1980:25-27). Like the previous two rockshelters (5BA320, 5LA1053), 5LA1055 is located along North Carrizo draw. Native vegetation in the region is predominantly blue grama and buffalograss while small pockets of wheatgrass and sandsage occur

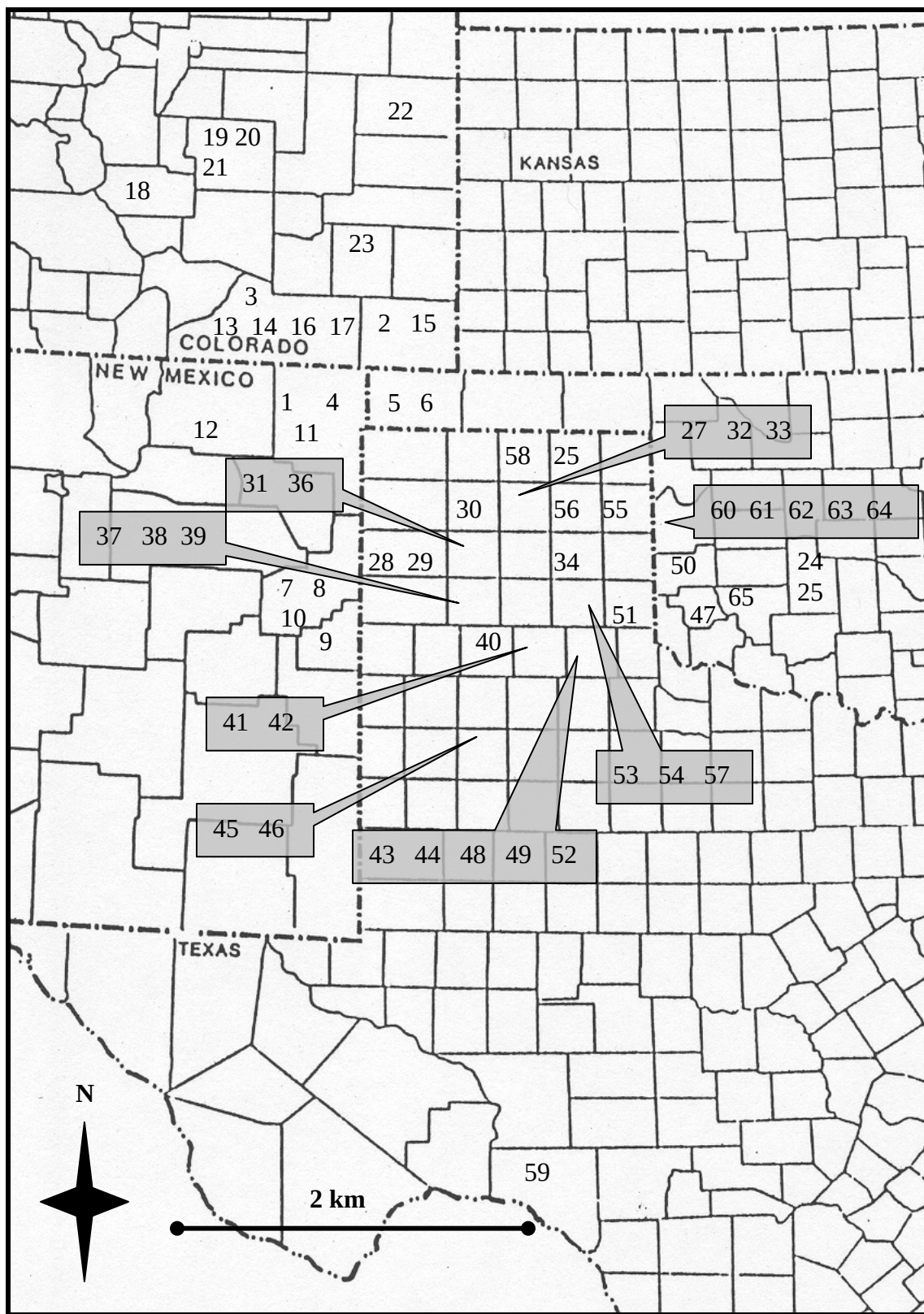


Figure 4.1. General study area showing Late Archaic–Woodland sites mentioned in the text.

Table 4.2. Late Archaic-Woodland Sites Mentioned in Text.

1	LA8120	34	Fatheree
2	5BA320	35	Courson B
3	5LA1053	36	Plum Creek
4	LA1055	37	Little Sunday
5	Cimarron County	38	Chalk Hollow
6	Carrizozo Creek Bridge	39	Canyon City Cave
7	Rock Ranch	40	Deadman's Shelter
8	San Jon	41	County Line
9	Blackwater Draw	42	Blue Clay
10	LA5573	43	Bitter Creek
11	Pigeon Cliffs	44	Polecat
12	Ancho Canyon	45	Wolfforth
13	Medina Rockshelter	46	Lubbock Lake
14	Metate Cave	47	Summers
15	McEndree Ranch	48	Bell
16	Running Pit House	49	Collier
17	Trinchera Cave	50	L. E. Certain
18	5FN12	51	Strong
19	5EP320	52	Twillla
20	5EP576	53	Buzzard's Roost
21	5EP935	54	Finch
22	Fort Carson Piñon	55	Hoover
23	Martin Dam	56	McIntyre
24	Duncan-Wilson	57	R. O. Ranch
25	Delaware Canyon	58	Sanders
27	Lake Creek	59	Bonfire Shelter
28	Tascosa Creek	60	Swift Horse
29	Maintenance Barn	61	Beaver Dam
30	41MO5	62	34RM334
31	41PT29	63	34RM507
32	Middle Cheyenne	64	Carpenter-Sullivan
33	Borger Bridge	65	34WA157

sporadically (Noel et al. 1994:3). This vegetative regime offers circumstantial clues as to the fauna that the Late Archaic folk in the area encountered. Surely an ample bison herd would have been sustainable in the region.

While unexcavated, a few additional sites in the foothills-Plains margin warrant review. For example, three sites in Black Mesa State Park in Cimarron County, Oklahoma, have possible Late Archaic affiliations (Saunders 1978). Archaeological sites 34CI104, 34CI106, and 34CI111 contain dart point fragments; however, no complete specimens were recovered. Other artifacts recovered from the terrace sites, which overlook Carrizo Creek, include debitage, utilized flakes, scrapers, graters, cores, grinding implements, and faunal remains (unidentified bone and fresh-water mussel). A second survey of the Black Mesa area documented an additional site (34CI274) possibly dating to the Late Archaic (Haury 1982:22-23). The presence of broken points, debitage, and miscellaneous tools indicate that these sites served as base camps where retooling took place and where food stuffs were transported following logistical forays. Based on the topographic setting of the sites, they were most likely summer camps.

Site 34CI199 (Carrizozo Creek Bridge) contained approximately 17 features or artifact clusters (Saunders 1983). Materials encountered include a midden, faunal remains (bison and fresh-water mussel), and a possible storage pit. The co-occurrence of darts and arrows can be found in contexts considered Late Archaic in surrounding biomes especially on the Chaquagua Plateau, in northeast New Mexico, and the Texas panhandle (Saunders 1983:79-84). The Carrizozo Creek Bridge occupation dates between 1150 and 850 BP (Tx 4415, Tx 4416, and Tx 4417).

Although unexcavated (and unregistered), the Rock Ranch site in northeast New Mexico contained evidence of several hearths and large accumulations of fire-cracked rock (Baker and Campbell 1960). The severely deflated site yielded a corner-notched dart made from Alibates silicified dolomite associated with *in situ* burned bones. This site,

just off the Llano Estacado, was obviously visited by Late Archaic hunter-gatherers with knowledge of the Canadian River flint quarries of the Texas panhandle. However, there are some “look-alikes” in northeast New Mexico (Hillsman 1992). The fire-cracked rock was most likely used to prepare vegetable and meat products collected from the vicinity.

The Smithsonian Institution undertook “prospecting” at the San Jon site (LA6437) in 1941 under the direction of Frank Roberts (1942). Most of the excavations at the eastern New Mexico location centered on a filled-in lakebed on the northern edge of the Llano Estacado. The archaeological site is on a tributary of the Canadian River referred to locally as Sand Canyon. Near the surface (~ 5-10 cmbs) of the site two Late Archaic dart points were recovered (Roberts 1942:11). The projectiles (Roberts 1942: Plate 4) resemble the standard broad-based corner-notch darts associated with Late Archaic sites in Oklahoma and Texas. The points were excavated from ash- and charcoal-stained deposits amongst sandy alluvium. Regretfully, radiocarbon dating was not available at the time of excavation, and understandably no samples were collected or curated. The recovery of complete points indicates that the watering hole was used as a hunting spot. Moreover, the extensive ashy layer suggests the location is where local foods were prepared and consumed.

Also in eastern New Mexico is Blackwater Draw Locality #1 (LA6195). Late Archaic projectiles were recovered at Locality #1 along with other artifacts. The Archaic strata encountered at the site provide indirect evidence of Altithermal and post-Altithermal use in the form of several wide, corner- and side-notched dart points. These include forms compatible with Darl, Pandale, Travis, and Williams points (Prewitt 1981; Turner and Hester 1985:50). The Archaic materials and features were contained in a reworked sand lens making dating impossible if not unreliable. Again, the points represent a hunting and collecting spot where extended stays took place. But without clear stratigraphy and other materials attributable to the Archaic occupation at the site, little can be said regarding their specific use for the site.

Another eastern New Mexico location, in which no radiometric dates are available but Late Archaic style points were recovered, is site LA5573. The site consists of a deeply stratified rockshelter with an abundance of charred organic matter among other items. Site LA5573 was discovered in preparation for the construction of Ute Creek Dam and Reservoir (Hammack 1965). Excavations at the multicomponent site recovered several classic Late Archaic point styles, namely Edgewood-, Ellis-, and Williams-like darts (Hammack 1965:46). Given that the site is a rockshelter, the location was most likely used during cold episodes. This assumption is based on Late Archaic-Woodland settlement patterns noted elsewhere in the region.

The Pigeon Cliffs site (LA31674) at the headwaters of the Canadian River in northeast New Mexico is another location where abundant charred organic matter was encountered. But, no dates are available. The charcoal was identified during “salvage excavations” in 1954 at the proposed location of Clayton Dam and Reservoir (Steen 1955). In the middle occupational layer of the cave, presumably belonging to Late Archaic or Plains Woodland folks, several bison bones, both burned and unburned, were recovered along with an Alibates silicified dolomite chipped-stone tool (Steen 1955:178). The use of bison and the well-known Alibates material suggests a connection to the Late Archaic-Woodland hunting lifestyle so prevalent on the Plains.

The Ancho Canyon Project in the South Park Plateau/Raton Mesa region of New Mexico has provided several radiocarbon dates, many coinciding with traditional southern Plains Late Archaic dates. Natural vegetation in the immediate area is juniper, sagebush, and piñon along with a transitional ponderosa pine life zone (Beck and Haase 1985:4). This biome would offer resources not found on the Plains proper. Three multicomponent sites (KS48, KS53, and KS61) yielded Late Archaic components spanning the timeframe 2310 to 1780 BP (Dorshow 1994). Excavations at the open campsites uncovered debitage, dart points, grinding implements, bell-shaped pits, and a fire pit. Dates at KS48, from three separate fire pits, document occupations between 2220 $\pm$ 60 BP, 1870 $\pm$ 70 BP, and

1860 $\pm$ 70 BP. Two other fire pits were tested at KS61, each coming from separate strata. The feature from stratum 1 had a date of 1780 $\pm$ 70 BP (Beta 71337). The second feature dated to 2160 $\pm$ 60 BP (Beta 71338). The lower level at rockshelter KS53 in Ancho Canyon was dated to 2940-2460 BP (Beta 71330 and 71332) while two additional sites (SW292 and SW301) had hearths documenting usage at 2240 $\pm$ 60 BP and 1780 $\pm$ 100 BP, respectively (laboratory data unavailable in original source). The dated hearths at these sites had Late Archaic darts (Ellis-like) in clear association with the cultural features (Dorshow 1994). Again, the use of caves in the region circumstantially suggests a typical Late Archaic-Woodland usage.

Adjacent to the South Park Plateau/Raton Mesa region is the Chaquaqua Plateau which is at the edge of the High Plains (Noel et al. 1994:3). Two sites in particular, both caves, were excavated by Campbell (1976:27, 43) on the plateau. One provided the earliest date for the region. In all, Campbell (1976:46) identified 10 sites with Late Archaic point types and dating between 1970 and 1880 BP. The first cave, Medina Rockshelter (5LA22) contained a hearth, associated with Late Archaic dart points, dating to 1970 $\pm$ 100 BP (GAK 672) (Campbell 1976:27-31, 42-48). The four dart forms include Ellis, Williams, Yarbrough, and Young (Campbell 1976:30). Each of these denotes a Late Archaic presence on the adjacent southern Plains. Native grasses and a variety of trees are available on the 0.80 km wide floodplain just below the shelter while the valley escarpment hosts piñon pine and juniper. Campbell (1976:30-31) estimates that the rockshelter was occasionally used during winter as a seasonal encampment by a small hunting and gathering group.

Metate Cave (5LA211) is the second rockshelter tested by Campbell (1976:32, 43). Result from radiometric testing determined that the site represents the earliest Plains Woodland site on the Chauquaqua Plateau. Besides the radiocarbon date (1680 $\pm$ 95 BP, GX 0718), this Plains Woodland assessment is based on the recovery of a single cord-marked pottery sherd. Although classified as “Woodland-aged,” the occurrence of a dart

point recalls the Archaic period. The frequency of animal remains at the site and the topographic setting led Campbell (1976:32) to conclude that the cave served as a temporary residence for a dart-wielding forager group. The site was probably occupied on a seasonal basis most likely during the winter.

The most frequently cited Late Archaic site in southeast Colorado is McEndree Ranch (5BA30). According to radiometric assay, the riverside location was occupied repeatedly for a 200 year period (Shields 1980:4-5). The site is in Baca County, Colorado, and was first identified in 1978 along a stretch of Two Butte Creek. At the time of discovery, a 140 m section of cutbank was exposed. The collection of archaeological materials and a subterranean structure led Shields (1980) to interpret the location as a Late Archaic “village”, although no other structures were detected. Two of the five hearths identified at the deeply buried site were measured for carbon content. The result of the assays 2350 ± 65 BP (DIC 1258) and 2170 ± 55 BP (DIC 1254) fit well into the Late Archaic sequence of the region as outlined by Campbell (1976, 1978). Consequently these dates coincide with Late Archaic dates on the adjacent southern Plains.

Besides identifying rock-lined and unlined hearths, and a dwelling at the McEndree Ranch site, evidence of a bone-grease extraction pit was uncovered (Shields 1980:4-5). The bone was primarily that of bison (Shields 1980:8) indicating that bison were present in the region. Pollen and fiber analysis of cultural materials recovered from the camp identify the presence of pine, juniper, yucca, flax, and willow (Scott 1982). Many of the same plants that are present on the plains of Colorado today were also present at the time of occupation (Scott 1982:23). Alibates silicified dolomite flaking debris was recovered from the occupational surface at the High Plains grassland site. Other stone materials include local quartzite, which was being heat-treated. Thermally altering quartzitic materials is anecdotally argued, by local archaeologists, to be a classic southern Plains Late Archaic trait. The manufacture and utilization of cordage, matting, and basketry at the site is suggested by way of the amounts of yucca recovered from the subterranean

structure (Scott 1982:23). The same types of materials were recovered from the Kenton Caves in the Oklahoma panhandle (Lintz and Zabawa 1984; Renaud 1929a, 1929b, 1929c, 1930a, 1930b), which might have been visited by Late Archaic-Woodland folks. The manufacture of fibrous materials is also noted in western Oklahoma directly (Saunders 1974; Tainter 1979) and indirectly (Hester et al. 1973; Hofman 1977; Turner and Hester 1985:205). Despite the fact that so much information was gathered from the McEndree Ranch site, no diagnostic projectile points were recovered (Cassells 1983:86). Nevertheless, the radiocarbon dates suffice for placing the site in context for the discussion herein and the artifacts and features imply that local materials were collected and returned to the structure for processing and/or consumption.

A little further north toward Trinidad, Colorado, Dick (1974) excavated Running Pit House (5LA1479). The site is along a northern tributary of the Purgatorie River and had a semi-subterranean structure as well. The structure had four sections, with two portions being intentionally filled. A bench was inferred by way of the structure's outline and post configuration. Numerous artifacts were recovered including drills, scrapers, graters, knives, grinding utensils, worked graphite, bone, and shell. No ceramic artifacts were recovered but the projectiles do resemble those employed by Basketmaker groups to the southwest from about 1850-1450 BP (Dick 1974). Since the site was excavated in 1954, no radiocarbon dates are available to aid in a more accurate placement of the site in the regional chronology. Nevertheless, the projectile points are consistent with the Late Archaic-Woodland on the southern Plains and the activities and structure suggest the site served as a base camp.

Also near Trinidad and on the Chaquagua Plateau is the multicomponent Trinchera Cave (5LA1057). Trinchera Cave is in the Trinchera National Register District, a 161.88 ha area consisting of several caves along Trinchera Creek. The shelter was "tested" over the years by people associated with Trinidad State Junior College. Hal Chase led all the excavations in early 1950s (Black 2002, personal communication). A Trinidad

Archaeological Society dig was also conducted in the 1960s (Black 2002, personal communication). Simpson later excavated the site (1976:2-3). The rockshelter is approximately 7.01 m above Trinchera Creek (Simpson 1976:2; Wood 1974:53). There are several springs near the cave that flow year-round and the southeasterly exposure makes the rockshelter conducive to habitation all year. In the winter, the sun warms the surrounding Dakota sandstone and in the summer with the sun's orientation, the shelter remains cool (Simpson 1976:2).

The lowest level of the stratified deposits at Trinchera Cave contained large corner-notched points similar to the well-known Ellis projectile type found in western Oklahoma and the Texas panhandle. Ellis-style points are noted elsewhere in southeast Colorado and northeast New Mexico (Campbell 1976:30; Dorshow 1994; Hammack 1965:46; Irwin-Williams and Irwin 1966:206-207; Kingsbury and Nowak 1980). Other cultural materials recovered from the cave include drills, scrapers, grinding apparati, bone awls, bone beads, and shell pendants and discs (Wood 1974). Animal remains include a variety of fauna such as deer, antelope, bison, squirrel, cottontail, jackrabbit, hawk, and sandhill crane. Freshwater mussels were also exploited. This is consistent with findings in the upper reaches of the Cimarron River and its tributaries at other sites in New Mexico, Colorado, and Oklahoma panhandle such as LA35463, LA48889, 5LA1053, and 34CI199 (Campbell 1976; Saunders 1983; Winter 1988).

No radiocarbon dates were secured from the Trinchera Cave although samples were collected (Wood 1974). Attempts were made to date the non-ceramic levels (III-IV) through the obsidian hydration method, but the results are not believed to be reliable (Simpson 1976:204). The Late Archaic inhabitants of Trinchera Cave are interpreted as being oriented both toward the Plains and the Southwest as would be expected in such a location. This applies to the floral and faunal populations as well (Wood 1974:53). The area is considered to be geographically peripheral in a cultural sense, somewhat of a contact zone (Simpson 1976:204-205; Wood 1974:55). This is represented not only in the

non-ceramic levels (Late Archaic) but in all cultural levels in the cave (Wood 1974). North of Trinidad, Colorado, near Colorado Springs, Colorado is site 5FN12. The site consists of a hearth discovered in an arroyo wall of Salt Canyon (Buckles 1974:62-65). The charred organic matter recovered from the hearth was dated to 2900 $\pm$ 90 BP (II 17908). The circular pit contained burned sandstone fragments, a polyhedral core fragment, and two flakes (Buckles 1980). Also in the Colorado Springs area are three sites that yielded corner-notched dart points similar to those found at Trinchera Cave (Wood 1974) and other caves excavated by Campbell (1976:46) and attributable to the Late Archaic on the southern Plains. The caves are 5EP320, 5EP576, and 5EP935. Other sites further north that possess radiocarbon dates contemporaneous with the Late Archaic of the southern Plains and the western margin include Draper Cave (5CR1) in central Colorado, Van Biber Creek, Magic Mountain, LoDaisKa, and Willowbrook Cave in the Denver vicinity, and many others in the Fort Carson, Piñon Canyon, and Martin Dam and Reservoir areas (Anderson 1989; Eddy et al. 1982:92-105, 125-127, 1984; Hagar 1976; Irwin and Irwin 1959; Irwin-Williams and Irwin 1966; Nelson 1969).

In summary, a few well-stratified or single component sites have been systematically excavated and reported by professionals, students, and avocationalists northwest of the Dempsey Divide. However, the basic groundwork of cultural history has yet to be established for southeastern Colorado, northeastern New Mexico, southwestern Kansas, and the Oklahoma panhandle. Cassells (1983:92) stresses that delineating the Late Archaic in southeast Colorado is probably the most challenging task for archaeologists working in the region, but Campbell (1976) has laid the groundwork. Wiseman (1997, personal communication) echoes Cassells' comment for northeast New Mexico however with a bit more optimism. As for southwestern Kansas, almost no information is available for the Late Archaic (Brown and Simmons 1987; Kay 1998). A cumulative bibliography of reports received by the Kansas State Historic Preservation Office reveals that all work in the southwest corner of the state has consisted of small contract projects. These reports have done little to aid in establishing a chronological framework for the Late Archaic-

Woodland in that part of the state (Stein 1983).

Despite these shortcomings, it has been established that there was extensive utilization of rockshelters, promontories, and river valleys. In the mountainous areas along the western edge of the southern Plains, uplands, including mountain foothills, were exploited in warm seasons while protected areas at lower elevations (i.e. canyon settings) were inhabited in the winter. The caves and overhangs were apparently reoccupied seasonally, most likely during the winter (Eighmy 1984:16). Evidence of subterranean structures being utilized is also present, although the season of use is still unknown. Plant collecting, as represented by grinding stones, played an important role in subsistence practices on the (western) Plains periphery and bison were often exploited along with other fauna including freshwater mussels. Winter (1988:75-76) sees the recurrent exploitation of mussels by Plains Archaic/Woodland-oriented people as a westward push of groups into the area during an environmental optimum. The modern streams in the vicinity do not host colonies of mussels or even permanent water for that matter. Whether the long-term use of this species reflects more rainfall has not been determined (Winter 1988:75). However, the Piney Creek alluvium of southeast Colorado suggests that perhaps rainfall did increase around 1850 BP. This conclusion is based on the widespread occurrence of the Piney Creek alluvium across portions of Colorado, coupled with cross-referenced radiocarbon dates from sites above, below, and within the alluvium (Buckles 1980). Additional information on eastern Colorado deposition and site associations can be gleaned from Madole (1995).

Western Oklahoma and the Texas Panhandle

Base Camps and Human Interments

Starting in the east (central Oklahoma) and moving west, Duncan-Wilson Bluff Shelter (34CD11) offers the best look at a prehistoric shelter occupation in central Oklahoma. This multicomponent site does have its shortcomings due to the manner in which it was excavated and the complex stratigraphy. Rather than follow the natural stratigraphy of the

shelter, the cultural deposits were excavated in arbitrary 1.52 m (5 foot) squares and 15.24 cm (6 inch) levels (Lawton 1968:6). Lawton (1968:10), the amateur archaeologist that excavated the bluff shelter, states that the site was first occupied around the BC/AD interface and sporadically used until Territorial days. Radiocarbon dates from level 20, the lowest level radiocarbon dated, place occupation of this segment of the cave around 1520±170 BP (SM 773). Excavations of the arbitrary 15.24 cm levels continued to level 26 leading Lawton (1968) to postulate that human usage began about 1760 BP. Scrapers, knives, nutting stones, grinding stones and “Clear Fork” gouges were recovered from the bottom reaches of the rockshelter. The dominant projectile points from levels 16 through 21 were Marcos, Ellis, and other corner-notched dart forms. Another dart form generally associated with Late Archaic and Woodland groups to the east, and found at 34CD11, include the Gary-type (contracting stem). Gary-like forms are rarely found in western Oklahoma save the few documented along the Red River (Baugh 1982; Leonhardy 1966a; Oklahoma Archeological Survey, site files; Thurmond 1997, personal communication). Cultural deposits in the lower portions of the shelter did not contain pottery. Lower levels of the shelter obviously served as a Late Archaic-Woodland base camp where a variety of chores took place.

Of the other excavated sites that can be attributed to the broadly defined category of Late Archaic-Woodland adopted herein includes Delaware Canyon sites 34CD257 and 34CD258 (Ferring 1977, 1982, 1984, 1986, 1995). Levels 15 and 20 produced large corner-notched projectiles (Ferring 1977:33, 1982:28, Figure 1.2, 1984:57-63). Both Gary-type points (contracting stem) and broad-based, corner-notched darts were recovered from 34CD257 and 34CD258. Grinding implements, bone tools, and chipped stone tools from a variety of materials were also recovered in Delaware Canyon (Ferring 1984:57-63).

The excellent preservation and careful excavation at Delaware Canyon (Ferring 1982:22-28) also provided some interesting elements of material culture not often available at

other Late Holocene base camps. Personal items recovered included hematite plectils, a bone bead, and several drilled dog's teeth. Use of asphalt adhesive was also detected (Ferring 1984:57-65, 1986:63-64). Skeletal remains of three individuals were recovered from the canyon, none exhibiting evidence of ritual in the form of grave offerings or inclusions (Ferring 1984:66). Two people, presumably a mother and daughter, were interred together chest to back at 34CD258. Four (dart) points were found associated with their bodies clearly demonstrating violent death (Ferring 1984:66-67).

Over 150,000 animal bones were recovered with many of the animals originating from stream and pond settings and the upland and canyon forest environments (Ferring 1995:24-25). According to Ferring (1984:63, 1986:61-62), the immense diversity of animals represented indicates that the occupants exploited almost every single environmental niche surrounding the sites. Deer were by far the predominant animal exploited by the Delaware Canyon groups. From the faunal collection it is obvious that surrounding flora and fauna were procured and returned to camp. This subsistence and settlement pattern clearly represents a logistical collecting lifeway.

The sequence of radiocarbon dates at Delaware Canyon is extensive (Ferring 1986:59, Figure 5). The earliest date from the site (2750 ± 73 BP) (laboratory data unavailable in original source) comes from the base of the canyon's paleosol (Ferring 1986:63, Table 1). The double interment was excavated from the middle of the paleosol and extended below the base of the paleosol (Ferring 1984:66, 1986:54). However, from the data provided by Ferring (1977, 1982, 1984, 1986, 1995) it is difficult to determine, in radiocarbon years, when the burial event actually took place. The best estimate would be shortly after paleosol development circa $2575 \text{ BP} \pm 65$ (SMU 584).

Along the Canadian River, in the Texas panhandle, are many other sites relevant to the discussion at hand. The most notable of these sites is the Lake Creek site (A48). The Lake Creek site is interpreted as a Plains Woodland manifestation in the heart of the

southern Plains (Hughes 1962). The Lake Creek site is on a south flowing tributary of the Canadian River in the central Texas Panhandle. The site is in the sheltered part of a canyon with the cultural debris occurring on a bench near a spring (Hughes 1962:82-83). A large surface collection of artifacts (N=103) was procured from the site. Some 51 specimens were also collected from an exploratory trench. Both thick cord-marked sherds and thin brownware sherds were recovered amongst arrow points and dart points. Other stone items include fire-cracked rock, grinding stones, miscellaneous scrapers, gravers, a chopper or hammer, cores, and a blade (Hughes 1962:72-79).

Bison, deer, jackrabbit, and turtle are represented in the faunal assemblage. Bison bones make up the majority of the faunal collection with foot bones predominating. Bison feet are not known for their nutritional value. However, the presence of these bones may hint toward the use of a bison hide, with attached hooves, as a carrying apparatus. The hooves would serve as readily available handles for logistical collectors to carry filleted meat back to a camp. Although 51 of the chipped-stone specimens were found above, below, or within “dark, sooty sand”, radiocarbon dates were not collected from the sooty layer (Hughes 1962:68-69). Hughes (1962:82-84) contends that the site represents several camping events by local people that also had contact with “Puebloan” groups or possibly eastern or central Plains groups.

Other sites or components in the Texas panhandle possibly belonging to the Lake Creek focus/complex include mixed components from the Tascosa Creek (A2060) and Maintenance Barn (A1543) sites (Couzzourt 1982, 1985, 1988, 1992). Components not directly attributed to “Lake Creek groups” are thought to be present at 41MO5 and 41PT29 in the Sanford Reservoir area (now Lake Meredith), and at the Middle Cheyenne site (A2082) and the Borger Bridge site (A34) (Couzzourt 1982:70; Green 1967:71-81, 102-114). Although attributed to Lake Creek groups, no cord-marked pottery was recovered either from 41PT29 or 41MO5. However the dart points are, according to Green (1967:183), similar to those recovered at the Lake Creek site. Three other sites

with possible Lake Creek or Late Archaic connections are the Fatheree (41GY32), Courson B (41OC27), and the Plum Creek (LAMR176) sites (Etchieson 1982:11; Hughes and Hughes-Jones 1987:57; Hughes et al. 1977:5; Hughes et al. 1978:165-168; Newman 1976).

Still in the Texas panhandle, the Little Sunday site (A160) is on the northwest rim of Little Sunday Canyon, a tributary of Palo Duro Canyon, which turns into the Prairie Dog Town Fork of the Red River. The site is comprised of a relatively small surface collection of artifacts representing a single component (Hughes 1955, 1991:20). Apparently material extended well below the surface (Hughes 1955:57). The erosional gullies that made the subsurface deposits visible were also responsible for destroying most of the site. In addition to identifying a possible hearth, approximately 160 artifacts were collected from the exposed occupational level. However, most of the artifacts came from the surrounding washes. The collection includes end scrapers, side scrapers, other miscellaneous scrapers, gravers, gouges, and 67 bifaces (Hughes 1955:59-64). Twenty-three projectile points were recovered, all corner notched (e.g. Ellis, Lange, Palmillas, and Refugio) (Hughes 1955:67, Plate 10). Knives, choppers, drills, and grinding paraphernalia were also recovered or documented (Hughes 1955:69-71). Boyd (1997:235) notes that the surface-collected materials from the Little Sunday site and the excavated materials from the Summers site (discussed later) are similar and representative of the Late Archaic bison hunters in the region. Based on the collection of bifaces, points, and plant/hide/wood-working tools, the site surely served as a base camp which was probably used on a seasonal basis.

The excavated Chalk Hollow site (41RD51) is a multicomponent canyon location with evidence of two major occupations (Wedel 1975:271-273). Between the upper and lower middens is a culturally sterile zone (Wedel 1975:272). Some years after his excavation and work at Chalk Hollow, Wedel (1983:220) hypothesized that the occupation-free zone (circa 2350-1550 BP) at the site may reflect drought conditions in the area. Lintz (1995)

has shown that the “later midden”, as Wedel (1975) characterizes it, actually contained three discrete Late Archaic occupations. Through his review of artifact and radiocarbon date distributions, Lintz (1995) determined that approximately 18 of the 22 dart points recovered from the deposits could positively be attributed to the Late Archaic occupation of the canyon site. Point varieties, all of which are broad-based, corner-and side-notched in manufacture, include Castroville, Ensor, Marcos, Palmillas, Williams, and four unclassified specimens (Wedel 1975:272, 277, Figure 4). Other stone tools include scrapers, choppers, biface knives, and chipped-stone debitage. Lithic materials include Alibates dolomite, Tecovas jasper, Edwards chert, Ogallala quartzite, and chalcedony were present (Wedel 1975:272, 1983:220, 227). Fire-cracked rock, slab-lined hearths, caliche-ringed hearths, milling stones and basins, as well as bone awls and bone gaming pieces (dice) were also recovered.

The dated features in the lower level of Chalk Hollow reveal three distinct occupation periods or extended (generational) camping events. The antiquity of the deposits undeniably places the occupations at the site in the Late Archaic recognized by most southern Plains archaeologists. The earliest occupation was dated to 3820-3566 BP (SI 1293), the second camping event(s) was between 3042-2552 BP (SI 1707), and the final stay-over was dated to 2421-2210 BP (SI 1294). The first occupation is represented by two assays, the second visit or visits is marked by 11 to 13 radiometric measurements, and the third and final Late Archaic occupation is based on three radiocarbon dated samples (Lintz 1995). The site would have been well watered based on the presence of two molluscan species, both of which require fresh water (Wedel 1975:273). Current conditions do not reflect the presence of permanent or pooled water (Wedel 1975:270).

In addition to the seep springs at Chalk Hollow, approximately 40 playa lakes dot the surrounding landscape. The lakes were surely an additional attraction to the sheltered locale (Wedel 1975:270). The playas would also attract animal types that are represented in the Chalk Hollow faunal assemblage. Included in the inventory are bison, pronghorn

antelope, and coyote or wolf. Wedel (1975:223, 1983:227) also speculates that waterfowl, turkey, native small game, fruits, nuts, tubers, and grass seeds were also exploited by the Chalk Hollow occupants. The primary pursuit of those occupying Chalk Hollow seems to have been bison. Lintz (1995) observes that the findings at the Summers site (Leonhardy 1966a) and Chalk Hollow establishes the early existence of bison hunter campsites associated with large corner-notched dart points. Lintz (1995) goes on to note that bison kill sites dating into the early centuries AD also contain similar points to those associated with bison killing events with greater antiquity. Without a doubt, Chalk Hollow served as a base camp where logistical forays were initiated and where the target prey was transported for consumption or use.

Canyon City Country Club Cave (A251) is a few miles upstream from Chalk Hollow. The site serves as further testament to the use of caves by Late Archaic and early Woodland groups on the southern Plains. A report by Hughes regarding the findings at the cave is yet to be published. As with Chalk Hollow, two cultural levels were identified. Also like Chalk Hollow, the deposits appear to be severely mixed with the vast majority of the cultural materials representing occupation after the Late Archaic. One zone was almost devoid of artifacts (Level 5) and was radiocarbon dated at 2846 ± 72 BP (WIS 430) and 2116 ± 72 BP (WIS 420) (Boyd 1997:247, Table 62). Wedel (1983:220) assigns dates of 2830 and 2375 BP to this level, citing personal communication with Hughes. Elsewhere Hughes (1991:21) restates the dates cited by Wedel in 1983. Besides there being a near absence of artifacts and no diagnostics (Hughes 1991:21), the faunal and geological evidence suggest possible drought conditions from roughly 2750-2350 BP, somewhat corroborating the artifactual evidence, or lack thereof (Wedel 1983:220). Level 4 contained dart points such as the Ellis and Lange types (Hughes 1991:21) and was radiocarbon dated to 1666 ± 68 BP (WIS 404) and 1266 ± 72 (WIS 414) (Boyd 1997:247, Table 62). Brownware pottery, Deadman's arrow points and Scallorn arrow points were also found in Level 4.

Deadman's Shelter (41SW23) is another refuge utilized by multiple groups throughout prehistory. Willey and Hughes (1978a) investigated the site as part of the pre-planning process for construction of Mackenzie Reservoir, east of Chalk Hollow. A burial was found in the shelter adding another dimension to the site not often found on the southern Plains (Willey 1978). In Deadman's Shelter, the lowermost stratum (D) contains traditional Late Archaic points including Edgewood, Elam, Ellis, Kent, and Lange types (Hughes 1991:21; Willey and Hughes 1978a:185-190). Cores, knives, scrapers, drills, graters, denticulates, spokeshaves, and choppers were recovered as well as grinding equipment. Rock-lined hearths were unearthed as well as numerous charred animal bones and a shell pendant. Faunal remains are primarily deer (Schultz and Rawn 1978). Stratum D at Deadman's Shelter was radiocarbon dated to 1740 $\pm$ 40 (SI 1899) and 1830 $\pm$ 60 BP (SI 1900) (Willey and Hughes 1978a:185). Two additional sites identified during the Mackenzie Reservoir project were the County Line site (41BI33) (Willey and Hughes 1978b) and the Blue Clay site (41BI42) (Willey et al. 1978). No pottery was recovered from the County Line site, but arrow points and dart points were found together. In fact, Willey and Hughes (1978c:279) concede that the arrows appear to be scaled-down versions of classic Late Archaic points. The same is noted by Thurmond (1997, personal communication). The Blue Clay site also has both brownwares, arrow points, and darts co-occurring at the site.

There are many other sites such as these, but their description or write-ups often occur in obscure regional reports or the sites are not reported at all. Two sites on a tributary of the Red River in the lower Texas panhandle illustrate this point. Hughes and Hood (1976) discovered the Bitter Creek site (41HL62) and the Polecat site (41HL63) during a survey of Lakeview watershed in Hall County, Texas. The sites have not been radiocarbon dated but materials collected from the surface indicate an Archaic if not Late Archaic presence. Other cultural debris considered to be typical of the Archaic way of life were also recovered or observed. These include fire-cracked rock, milling stone fragments, bifaces, scrapers, choppers, gouges, and Late Archaic style points (Edgewood) or point fragments

(Hughes and Hood 1976:54, 67, 83-85).

The Wolfforth site (SPAS LU-10), near the panhandle town of Wolfforth, Texas, is another site that is reported in a local journal with limited distribution. The Lubbock County site is a playa lake that was repeatedly occupied over the past 3000 years or so (Brown 1999a). Many sites with this pedigree dot the region and are only known to artifact collectors. Of interest here are some 22 Late Archaic projectile points, all recovered by a single avocationalist. Others have collected from the site for years as well (Brown 1999:61, 79). Late Archaic points include Bulverde, Elam, Ellis, Palmillas, and Williams (Brown 1999a:63, Figure 3.4). Rather than being a special-activity camp as seems to be the case with the Bitter Creek and Polecat sites, the Wolfforth playa appears to reflect a more substantial occupational event. In fact, based on the number of points and point fragments recovered, it can reasonably be argued that the upland lake was revisited several times, either to retool (make new points and discard damaged points) or harvest prey that ventured to the watering hole for the same reasons that humans did.

Continuing into the lower Texas panhandle, Lubbock Lake (41LU1) is one of those rare spots on the landscape where 12,000+ years of human occupancy can be documented. Likewise, Lubbock Lake is one of the few sites on the southern Plains with a well-stratified Archaic sequence (Johnson and Holliday 1986), although not without its problems as mentioned at the beginning of this section. The Archaic period at Lubbock Lake contains datable cultural strata with discrete activity-specific features which include camping debris, a roasting oven, and bone beds. The largest bone bed is actually the partial remains of about eight to ten bison. From the array of bones present at the watering spot, the animals were probably killed on site during the late-Middle Archaic or early-Late Archaic (strata 3 and 4) (Johnson and Holliday 1986:27-29). Animals were then quartered and transported to the base camp for final preparation and consumption. Herd composition consisted of three bulls, four cows, and one sub-adult. Gender determinations were based solely on comparative element size. One interesting aspect

about the skeletal collection from strata 3 and 4 is the condition of the teeth. Dentition from most of the animals displays unusual heavy use and irregular wear (Johnson and Holliday 1986:43-44). The researchers conclude, “the dental abnormalities denote poor range conditions due to excess grit on the vegetation” (Johnson and Holliday 1986:43).

Besides being excavated, the Summers site (34GR12) has been radiocarbon dated. The site is on a ridge overlooking the Salt Fork of the Red River in southwest Oklahoma. Five features were uncovered in Area 2 of 34GR12 (Leonhardy 1966a:17). Cultural materials extended from the plowzone down 50 cm below the surface. The bulk of the occupational debris was contained in a lens some 20 cm thick. A charcoal sample was collected for radiocarbon dating from Feature 1, a “rock-filled cooking pit” containing bison bones (Leonhardy 1966a:18-20). The shallow oval depression was 100 x 75 cm wide and about 15 cm deep (Leonhardy 1966a:20). The hearth, with its array of bison bones, was dated to 2770 ± 150 BP (GAK 694) (Leonhardy 1966a:29-30). The four other features discovered at the site represent possible activity areas or remnants of previous occupations at the creekside locale. Feature 2 was assigned to a small cluster of stones and a scraper, approximately 2 m to the northeast of Feature 1 and roughly on the same level. Feature 3 represents a small hearth which includes a circle of stones and charcoal stained earth. Feature 4, like Feature 3, probably represents a small hearth. However, the ash concentration was not completely exposed. Although not completely excavated either, Feature 5 was assigned to a concentration of bison bones. Elements of the lower leg as well as ribs and vertebrae were uncovered in a relatively small pile. From the brief inspection, no pit or hearth outline could be detected. Projectile points (N=9) recovered from the excavations include the typical corner-notched forms of Ensor, Lange, and Marshall points (Leonhardy 1966a:21-23). Knives, thin bifaces, gravers, scrapers, scraper-planes, utilized flakes, choppers, grinding stones, and “pounding” stones were also recovered with the temporally diagnostic points (Leonhardy 1966a:14-28). The partial skeleton(s) of bison and vegetable and faunal procurement tools indicate that resources from the vicinity were collected and then returned to the site for use. The

discovery of cooking features, and possibly undetected others, further suggests that the site was used repeatedly for similar purposes.

Game Kills and Game Processing Sites

In the literature there appears to be a preponderance of bison bone beds (N=13), representative of kill events which are affiliated with the Late Archaic-Woodland hunter-gatherer's tenure on the southern Plains (Bement and Buehler 1994; Buehler 1997; Hughes 1977a, 1989; Tunnel and Hughes 1955). Bell, Collier, L. E. Certain, Strong, Twilla, Buzzard's Roost, Finch, Hoover, McIntyre, and R. O. Ranch all appear to represent a specific type of bison killing strategy—the arroyo trap. Arroyo traps seem to be the preferred method of corralling and killing herds of bison during the Late Archaic-Woodland. However, geologic and taphonomic evidence of one jump event and the possibility for one other jump on the southern Plains shows that trapping was not used solely (Bement and Buehler 1998; Hughes 1977a:60). Yet, the fact remains that of the 13 kill locations, or 17 individual kill events, the arroyo trap was the preferred method. Single animals were surely killed also (Briscoe 1989; Leonhardy 1966a; Thurmond 1991a:121) either by intent, happenstance, or a flaw in a communally organized herd-hunt. The Bell, Collier, L. E. Certain, McIntyre, Strong, and Twilla bison kills have been dated. The Twilla and Collier sites have undergone additional testing since they were originally brought to the attention of the archaeological community. Lintz et al. (1991:262) found that three of the dates from the Twilla and Collier sites overlap the period from 2040 to 1830 BP. Undoubtedly some bone and most of the meat from these kills were transported to base camps to prepare and share with others.

Like Delaware Canyon, the Sanders site (41HF128) is another well-excavated, well-documented archaeological site (Quigg 1997a). With sites such as Sanders, a short-term bison processing camp, we can also get a rare look at how idle time was spent at a processing facility. Gaming pieces, site maintenance (rubbish clearing and dumping), and cooking practices are all represented (Quigg 1997a). The identification of selective

harvesting of bones for grease and marrow extraction, and tool use and maintenance adds crucial factors to the study of the social organization of groups responsible for primary kills elsewhere on the southern Plains. As far as the season of use, the Sanders site represents an early spring communal bison kill although the actual kill location was never identified. The single occupation site covers approximately 2,275 m² on a relatively level floodplain (Quigg 1997a:39-40).

In all, 16 secondary refuse features were uncovered at the Sanders site, yet only a small segment of the site was excavated and an unknown portion of the site was destroyed by erosion. Also unearthed at Sanders were burned bone concentrations, collections of burned rock, and discrete lithic debris groupings (Quigg 1997a:42-47; Tomka and Quigg 1997). Horizontal distribution of the features and other bones reveal patterns of systematic discard whereby materials were collected and deposited away from the primary activity area (Tomka and Quigg 1997:50-51).

A few expedient bone tools were used at the site, most notably ulna hammers. Multipurpose tools (scraping and cutting), a few choppers, several cores, and flaking debris were also recovered, with conspicuous absences of grinding implements and gouges. A cord-marked sherd was also recovered among the Late Archaic materials. Thirteen dart points and dart fragments were recovered during excavations (Quigg 1997a:39, 196). Three of the 13 points were considered by Quigg (1997a:196) to still be functional and thus were probably lost. Approximately 14 deliberately carved rib fragments, inlaid with red ochre, are thought to represent recreational activity or social interaction at the site (Quigg 1997a:198-199). The items, probably manufactured during idle time at the location, were tentatively referred to as “bone dice” (Lintz 1998, personal communication). Patterns on the specimens included tiny notches, V-shapes, cruciforms (Xs), and zigzags (Quigg 1997a:198). Similar specimens are found at sites to the west dating between 1905 and 1620 BP, or the Basketmaker II era (Cordell 1984:55-58; Wormington 1957:47) and at sites in southeast Texas (Hall 1981:5-14). The specimens

from Texas are interpreted as being hairpins based on their location in the burials from which they were recovered (Hall 1981:87-90, 222-240) but might also have served a dual purpose as lice-crushers (Hall 1988:169-170).

Five diverse organic samples from Sanders were submitted for dating, two were from bone (gelatin dates) and three were from charred organic material (wood). The bone dates were characteristically too recent (Hofman 1995: 431-432) but within the range of the Late Archaic-Woodland use of the southern Plains (Quigg 1997a:41). As unreliable as the gelatin dates are, the charcoal dates were more in line with the excavator's expectations (Quigg 1997a:41-42). Of the bone gelatin dates obtained, one yielded a reading of 2115 ± 85 BP (GX 16405) while the other was 1770 ± 90 BP (GX 16406) (Quigg 1997a:40-41). Quigg (1997a:41) states that "the 345 year difference between the two bone gelatin dates is surprisingly large and cannot readily be explained". The three radiocarbon dates from charcoal presumably date the wood used in the campfires with the fast-growing hackberry-wood sample (1690 ± 70 BP, Beta 93287) being the best date for pinpointing the cultural occupation (Quigg 1997a:42).

Two bone collagen dates from the previously mentioned Twilla bison kill (41HL1) in the Texas panhandle (Hughes 1977a:131; Lintz et al. 1991, Table 1) and from Bonfire Shelter (41VV218) in west Texas (Dibble and Lorrain 1968:51) fit in with the 2770 BP date from the southwest Oklahoma Summers site, if compensation is made for the known shortcomings of collagen-derived dates. Given the 300 to 350 year shortfall with bone dates documented by Hofman (1995:430-431), the 2335 ± 100 BP (Beta 1927) and 2110 ± 85 BP (Beta 1929) dates from Twilla are within acceptable limits to be coeval with Summers. The same is true for the 2516 ± 210 BP (Tx 46) and 2526 ± 100 BP (Tx 131) dates for Bone Bed 3 at Bonfire Shelter. A sample from 41HL64, the Collier site (Hughes 1977a:131; Lintz et al. 1991, Table 1), in the Texas panhandle is also consistent with the above observations (2136 ± 117 BP, RL 571).

Conclusion

In conclusion, the description of sites above demonstrates that Late Archaic-Woodland groups adhered to a broad-based hunter-gatherer lifestyle. This is evidenced by the stone tools which they utilized. These include grinding stones, flake tools, biface and uniface tools, and corner-notched spear points, which decreased in size through time. Eventually the bow and arrow entered the area as is evidenced by the periodic recovery of arrow points. Both spear and arrow technologies existed side-by-side following a period when darts were used exclusively. Pottery was gradually incorporated into their technological base just as the bow and arrow was. It appears the pottery was locally manufactured based on the variety of local tempers used in the varied geographic settings. Presumably pottery gave these people the ability to store and prepare foodstuffs better than previous generations.

Based on faunal remains recovered from many of the sites, bison were exploited from the mountain foothills to the Prairie-Plains margin and from the Llano Estacado to its eroded borders on the north, west, and east. There is strong evidence for organized hunts which often took entire herds of animals. Small mammals were also taken advantage of as were fresh-water aquatic resources. Grinding tools continued to be employed with an increased use through time. The Late Archaic-Woodland groups apparently moved around on a seasonal basis using natural shelters in the fall and winter but might have constructed shelters at other times. Spring and summer camps were probably situated on uplands and around permanent water sources. Further, it appears that logistical forays were made from these base camps during all seasons. Special resources were procured from nearby and returned to camp for further processing and consumption. The size of the groups are not known but probably consisted of extended families. This conclusion is based on modern hunter-gatherer studies as well as observations made by early explorers. Based on human skeletal evidence the dead were buried, but rarely with grave offerings. In addition, there is some suggestion that violence occasionally occurred among neighboring groups.

Dempsey Divide Sites

In general, Late Archaic and early Woodland site types on the Dempsey Divide include, base camps, communal kill sites, special activity/extractive camps, reconnaissance or temporary camps, and burials. Of these, base camps, game kill sites, and burials will be discussed in more detail, since all have been radiocarbon dated or have unquestionable Late Archaic-Woodland associations.

Base Camps

The Swift Horse site (34RM501), like many Late Archaic-Woodland sites in western Oklahoma, northeastern New Mexico, and southeastern Colorado, is on an upland ridge overlooking a creek. The site was tested in 1986 (Briscoe 1987a, 1987b, 1989). The faunal assemblage at the site was 70% bison with deer, antelope, rabbit, bird, turtle, snake, and fish completing the inventory. The site is generally equated with the early-Plains Woodland Lake Creek focus/complex of the region (Briscoe 1989). Both radiocarbon dates and pottery sherds are the basis for the above classification. However, three classic Late Archaic darts were recovered (Briscoe and Burkhalter 1986:12, Figure 4). Four additional dart point fragments were also found along with a questionable arrow point fragment.

During excavations three cord-marked sherds were recovered from the site, two from the surface and one from feature-fill (Briscoe 1987a:25, 41-42, 1989:109, Table 1; Briscoe and Burkhalter 1986:10, Table 1). This author spied one additional cord-marked sherd on the surface in 1997. The excavated sherd from the feature-fill was recovered from level 6; this level was radiocarbon dated to 1650±70 BP (Beta 18432). Thurmond et al. (2000:12) place the occupation closer to 1538 BP. However, extensive bioturbation had occurred in the feature as a result of the ever-present Plains pocket gopher (*Geomys bursarius*) (Thurmond et al. 2000). Erlandson (1984) has demonstrated that downward displacement or redistribution of artifacts by pocket gophers (faunalturbation) occurs at a rate averaging over 5% per century. The effect of such disturbance is the homogenization of

cultural deposits and the blurring of discrete features (Erlandson 1984:789). The bioturbation identified at the site may also account for the fact that the dated samples are not progressively older with depth (Thurmond et al. 2000). I am inclined to accept the dated sample from the base of the feature with an intercept date of 1820 ± 100 BP (Beta 18433) as a more accurate date for early site use (Thurmond et al. 2000:12).

The Beaver Dam site (34RM208) occurs along a spring-fed creek draining the north face of the Dempsey Divide (Thurmond 1988a). Modern erosion in the upper reaches of Brokenleg Creek exposed cultural deposits starting at the present surface and carrying down to approximately 1.7 m below the surface (Thurmond 1991a:120). The cultural materials were sealed within dark brown, sandy alluvial and colluvial deposits, which filled a paleocanyon (Thurmond 1988a:2, 1991a:120). The site, with its three areas (A-C), was repeatedly utilized for some 2000 years. A paleosol or buried soil horizon, which general denotes stable wet conditions, was documented and dated. This soil development event has been traced to other canyons and dated elsewhere on the Dempsey Divide (Thurmond and Wyckoff 2000, 2001).

Area A of the site was first thought to represent only two cultural horizons, Late Archaic and Plains Woodland (Thurmond 1988a, 1988b, 1991:120). However, a detailed analysis of the findings has revealed a third cultural occupation at Area A. Between the lower levels containing dart points and the upper levels having arrow points and cord-marked pottery is a “transitional” phase. The transitional tenure at the site includes evidence of scaled-down versions of classic, Late Archaic dart points, namely Ellis, Ensor and Marcos varieties. Numerous hearths were identified and excavated from this transitional occupational zone at Beaver Dam allowing for detailed radiometric analyses. Ten dates were collected from this segment of the site and range from 1560-1350 BP (Kraft and Thurmond, n. d.; Thurmond and Wyckoff 2000).

The stratigraphy at the Beaver Dam site shows the natural slope of the valley setting at

the time it was inhabited by Late Archaic hunter-gatherers (Thurmond 1988b:4). In the filled paleovalley, Area B of the Beaver Dam site is somewhat lower in elevation than Area A. The recovery of artifacts within the valley-fill and near the cut bank of this portion of the site indicates that it was contemporaneous with the lower occupations at Area A. No features were identified from excavations of Area B. Modern erosion and heavy equipment has removed most of the deposits at Area B. Surface collections from the eroding cut-bank have supplied numerous dart points as well as copious pieces of fire-cracked rock (Thurmond 1997, personal communication). Area C, which contained a burial, is discussed later in this chapter.

Although unexcavated, 34RM334 has provided several dates (Thurmond 1989:3, 1990b). The first date (1789 $\pm$ 81 BP) (NZA 712) comes from an intact hearth found along Dry Creek on the north face of the Dempsey Divide. Besides a hearth, the site contained side-notched dart points, a number of biface failures, debitage, utilized and modified flakes, burned rock, and bison bones (Thurmond 1989:3, 1991a:121). A small charcoal sample was submitted for accelerator mass spectrometer (AMS) dating, with the results placing hearth-use at 1789 $\pm$ 81 BP (Thurmond 1989:3, 1991b:252, Table 3). A bulk sediment sample from another hearth was also submitted for analysis (Thurmond 1991b). The black, charcoal-stained fill dated to 1500 $\pm$ 80 BP (Beta 37430). An additional four AMS dates from rock-lined hearths at the site average between 1675-1379 BP (Beta 37430, NZA 1246, NZA 1247, and NZA 1248) (Thurmond 1991a:121).

Another radiocarbon-dated site along Dry Creek is 34RM507. The site is possibly a remnant portion of 34RM334 and another site in the immediate vicinity (34RM470). Thurmond (1989:3) states that “the three appear to have been isolated from one another by historic era incision of the west branch of Dry Creek”. Copious flaking debris and fire-cracked rock predominate. In 1997, an Ensor dart point from the surface was observed by this author. Feature 1, identified only as a pit, was submitted as a bulk sample for radiocarbon dating. The sample was collected from melanized gully-fill (soil

development) observed in a cut-bank profile. The 1630 $\pm$ 40 BP (Beta 135654) date of the pit would mark the inception of landscape stability in the paleocanyon setting where 34RM334, 34RM470, and 34RM507 were situated (Thurmond 1999, personal communication). The date from Feature 1 is contemporaneous with the samples acquired from the adjacent 34RM334. A second hearth (Feature 2) uncovered during geologic profiling at 34RM507 was dated to 2010-1820 BP (Beta 136173) but was likely used about 1909 BP (Thurmond 1999, personal communication). Three large Ogallala quartzite bifaces and a large Ogallala flake were associated with Feature 2 (Rebnegger 2001, personal communication). Consequently, the date from Feature 2 at 34RM507 is consistent with the lower component of Beaver Dam (1850-1815 BP).

Finally, site 34WA157 was excavated by Wallis (2000) on the south side of the Dempsey Divide in the North Fork Red River watershed. Two features were excavated. Both features were circular with Feature #2 being shallower. Wallis (2000:3) thinks the features might be storage pits although some charred organic material was scattered in the fill. Feature #1 had 15 retouch flakes (mostly quartzite), remnants of deer limbs and a mandible, bones from smaller species, and charred organic material (1330 $\pm$ 110, Beta 26970). Feature #2 had quartzite retouch flakes also, a bone awl manufactured from a deer metapodial, other species smaller than deer, and the tip or barb of a biface (Wallis 2000:3-5). Charcoal extracted from feature fill produced an 1820 $\pm$ 250 (Beta 26971) radiocarbon date (Wallis 2000:3). This site and others in the North Fork of the Red River watershed hold potential for being as big as the Beaver Dam site and offer excavation opportunities. Site files at the Oklahoma Archaeological Survey document surface collection from avocationalists in the watershed that contain the same toolkits and point forms documented on the 4,047 ha Thurmond Ranch and adjacent stream valleys (Moore 1984, 1988b). Still other collections have been documented by Bement (2005, personal communication), Briscoe (2000, personal communication) and Thurmond (1997, personal communication) in the North Fork of the Red River watershed.

Burials

Burials dating to the Late Archaic-Woodland transition on the Dempsey Divide can be divided into four broad groups, those containing lunate stone grave inclusions and those without such cultural elements, and those burials exhibiting evidence of violence and those not showing obvious evidence of violence. These interment types lend clues to some of the social interactions or interplay associated with Late Archaic-Woodland bison hunting culture in the Dempsey Divide area.

Some Dempsey Divide burials exhibit evidence for violence. The Carpenter-Sullivan burial (34RM668) represents the best example of Late Archaic-Woodland conflict in the region (Gettys 1991a, 1991b; Owsley 1994b). The Carpenter-Sullivan burial consists of three sets of human remains “stuffed” into a relatively small burial pit (Gettys 1991a:1, 1991b). All three persons were in a flexed position, two atop a single individual in the bottom of the feature. The first individual interred (bottom) lay on its back while the top two were on their right sides (Gettys 1991a:1, 1991b). The skull of one of those interred was found on the opposite side of the pit, with the atlas (C1) and axis (C2) attached. Thus, the victim was decapitated (Gettys 1991a, 1991b). Subsequent osteological examination located a depression in the skull of the subject with radiating fractures, suggesting perimortem blunt force trauma had occurred (Owsley 1994b). The right rib from the same person displayed a beveled cut on the superior margin nearly one cm deep. Perimortem trauma is inferred since a dart point was recovered in the general area of the fractured rib (Owsley 1994b). Based on the osteological evidence, the Late Archaic dart would have passed through the right lung and exited on the superior border of the seventh rib. The victim was determined to be a 25-29 year old male (Owsley 1994b).

The second individual removed from the pit had a projectile point lodged in one of its lower vertebra (Gettys 1991a:1, 1991b). Other points were found in the chest and pelvic area of the same person (Gettys 1991b). Owsley (1994b) also found the L2 of this victim to be damaged. The left superior articular facet of the vertebra was severed and the neural

arch was separated from the vertebral body. However, the projectile did not penetrate the centrum or the spinal canal (Owsley 1994b). This casualty was determined to be a 45 to 49 year old male. The third fatality was identified as a 14 to 16 year old male. Four Late Archaic darts were found with the third skeleton. Photographs show two points near the pelvis, one near the left clavicle, and one in the lower chest or thoracic region (Oklahoma Archeological Survey, photographic archives). Besides the points found in the chest cavity, several cuts were identified on two zones of the body. Cuts were found on the right clavicle, the acromium process (shoulder blade), and the right metacarpal. This last incision probably represents a defensive wound (Owsley 1994b).

Bones from the three-man burial were submitted for radiocarbon dating soon after the site was excavated. A 1510 ± 100 BP (Beta 56529) date and a 1430 ± 90 BP (Beta 57058) date were both acquired (Anonymous 1993). Taking into consideration the problem in collagen dating (Hofman 1995:430-431), the burial roughly dates to the first few decades or centuries AD.

A flexed burial was recovered from the Late Archaic component of Area C at the Beaver Dam site (Thurmond 1988b:6-7). The burial included two chipped-stone bifaces and a corner-notched dart point all made from local material. A lunate stone made of locally available fossiliferous shale was also recovered (Thurmond 1991b:). The shale is from the Cretaceous-age Kiowa Formation of western Oklahoma (Carr and Bergman 1992; Fay and Hart 1978). The two chipped stone knives found with the burial were manufactured from locally available Ogallala quartzite. The ovoid bifaces, left as grave offerings, perhaps reflect the direction Late Archaic-Woodland lithic technology was geared; that is, a biface-core technological regime. Such cores or bifacial tools would serve overland travel well.

Some 11 lunate stones, or specially designed atlatl weights (Parsons et al. 1979), are documented within the southern Plains area. These stones stand apart from other forms of

atlatl weights (Bell 1980:47; Turner and Hester 1985:241-242) given the transverse notching along their plano-convex dorsal edge. These polished semicircular stones are limited to the Caprock Escarpment on the east side of the Llano Estacado. The Beaver Dam specimen is the only stone found beyond the Caprock (Thurmond 1991b). Nevertheless, these dorsally notched stones are associated with corner- and side-notched dart points (Thurmond 1991b:246) such as those recovered from the aforementioned bison kills (Buehler 1997:142, Figure 4; Hughes 1977a:13, Figure 5-7) and radiocarbon-dated Late Archaic-Woodland campsites (Thurmond 1991a:135). All the lunate stones, exclusive of the Dempsey Divide example, were manufactured from exotic materials (Parsons et al. 1979; Redding and Parker 1991; Thurmond 1991b:248). Even more interesting is the fact that the source of these materials is to the west and southwest (e.g. diorite, rhyolite, metamorphic stone, igneous stone, and others).

Of the 11 lunate stones recovered from the southern Plains, six had clear association with human interments including the Beaver Dam specimen (Cockrum 1963; Holden 1999; Parsons et al. 1979; Ray 1999; Redding and Parker 1991; Thurmond 1991b). One can assume that the maker, and group, deemed the items important enough to be interred. In fact, most artifacts during the Archaic are quite utilitarian, and because a considerable amount of care and time was taken to make these objects, it can be inferred that they were highly regarded by the sociocultural group and reflect a shared group identity (Thurmond 1991b:248). Apparently the interment style was not rigidly defined. The method of interment in which the lunate stones were recovered is variable. Inhumation contexts include the flexed position, multiple flexed individuals, cremated, slab-lined pits, and cairn-covered (Cockrum 1963; Holden 1999; Parsons et al. 1979; Ray 1999; Redding and Parker 1991; Thurmond 1991b:248). Sometimes these burials were associated with habitation sites, but most were strictly single-event mortuary sites.

Game Kills and Processing Areas

As previously mentioned, the L. E. Certain site is one of nine bison kill sites on the

southern Plains. Of these, only the Certain site has been dated with charred organic matter (Bement and Buehler 1994). All others kill sites have been dated through bone collagen. Moreover, the L. E. Certain site consists of seven separate bison kill episodes. In fact, one of the kill localities has two and possibly three separate kill events. Additionally, there are three processing areas at the site, another factor distinguishing the L. E. Certain kills from the other sites. Consequently, some measure of processing took place on the killing floor prior to removal elsewhere. Hundreds of bison were killed at the site through the years and numerous projectile points have been recovered along with resharpening flakes and pounding tools. Hearths with and without bone in them were also recovered (Bement 1992; Bement and Buehler 1994). All of the human activity at the site took place in canyon settings, both steep-sloped and not, which were eventually filled with sediment. Modern erosion has only recently exposed the prehistoric activity areas. The results from the L. E. Certain excavations are discussed in great detail in chapters Five and Six.

Concluding Remarks

The Late Archaic-Woodland on the Dempsey Divide and the southern Plains for that matter is *de facto* all lithic material culture not associated with diagnostic point forms (e. g. Saunders 1974; Tainter 1979). Oklahoma and Texas archaeological site forms substantiate this assertion. It is a daunting task to organize and make sense of such a broadly imposed category. Early attempts to do so in western Oklahoma include the Summers Complex and Lawton Aspect of the Altus Focus with their requisite fire-cracked rock, corner- and side-notched darts, gouges, and grinding implements (Hammatt 1976; Leonhardy 1966a:12-30; Shaeffer 1966). Most of these items were predominantly hewn from the ubiquitous Ogallala Formation quartzites in the region. Quarry/workshops are by far the most frequent sites. While quarry/workshops could belong to any cultural period, these special activity localities are often considered the remnants of Late Archaic-Woodland cultures. The absence of diagnostic points at most Ogallala Formation quarry

sites should be a clear indication that assigning these and other specialized activity localities to a particular cultural period or stage is spurious. However, diagnostic dart points and point fragments are periodically recovered from Ogallala Formation lag deposits, demonstrating that these cultures did frequent these locations (Thurmond 1997, personal communication).

Late Archaic-Woodland peoples apparently followed seasonal rounds in restricted areas and revisited the same sites on a seasonal basis. Besides the quarry sites mentioned above, base camps, communal game kill sites, and animal processing sites can also be attributed to the Late Archaic-Woodland by way of radiometric dating. The use of local stone materials by the groups occupying the different parts of the southern Plains (e. g. mountain foothills, Llano Estacado, Raton Mesa, and Ancho Valley) is the rule rather than the exception. Fauna and flora collections from most sites demonstrate that Late Archaic-Woodland populations practiced a broad-based collecting regime. Small mammals, avian species, and invertebrates were harvested depending on the unique biomes used by the different groups, especially at different times of the year. Large game kills that required the organization of multiple families are also evident in the archaeological record, as is evidence for taking individual animals.

Sheltered areas were utilized primarily during the winter whereas other settings were used when temperate weather predominated. On the Dempsey Divide, interfluvial divides and canyons were used on a bimodal basis. Temporary shelters were probably constructed when necessary, and there is some evidence that semi-permanent structures were built, and reused, in the western part of the study area. Stone tools recovered from these sites represent a technology that changed, however slightly, through time. Use of the atlatl gradually gave way to the bow and arrow with both being employed for an undetermined period of time. Utilitarian cord-marked pottery came to be used and evidence suggests that the vessels were manufactured locally. Surely animal skins and cordage continued to be used along with the new technology. However, the only evidence

of this comes in the form of stone tools used to prepare such items.

Overall, the Late Archaic-Woodland population of the southern Plains established themselves at base camps for extended periods of time from which they ventured out to collect resources. These resources, be they animate or inanimate, were returned to the camp after minor processing at the source. Special activity groups, most likely based in age, sex, kinship, previous experience, and skill differences were dispatched to procure the special resources needed to sustain the group. Such jaunts would require the establishment of temporary camps which were abandoned after they served their purpose. Besides moving when resources became scarce, the group's relocation corresponded with seasonal changes which coincided with natural congregations of animals or the ripening of roots, shoots, and fruits.

CHAPTER FIVE

L. E. CERTAIN (34BK46): A REPEATED-USE LATE ARCHAIC BISON KILL SITE ON THE SCARPED PLAINS

Introduction

Most prehistoric organizers of communal bison hunts were hunter-gatherers (Driver 1990; Fawcett 1987:23-24). Horticulturists also participated in cooperative bison hunting, as well (Bolton 1987:101; Bowers 1950:177-178; Perttula 1992:3, 14; Weltfish 1965:137-150, 159-165, 171-207). Of particular interest here are those hunter-gatherers roaming the Scarped Plains and Llano Estacado some 3500 to 1500 years ago. The L. E. Certain bison kills and a select few other bison kill sites in the study area represent Late Archaic procurement strategies and techniques for dispatching and dismembering small groups of bison, if not entire herds.

Data gathered from investigation at the L. E. Certain site between 1969 and 1999 are presented below. This includes work conducted on areas A through I. The primary focus of this dissertation will be the analyses of cultural and faunal materials excavated from trenches C, D, and E during the 1993 and 1995 field seasons. The results from excavations of trenches A and B were presented previously (Bement 1992, 1997b; Bement and Buehler 1994). Portions of the data from the 1995 fieldschool have also been presented previously, although not to the extent of that to follow (Kraft and Bement 1995). Given the above, the data from trenches C, D, and E will receive more detailed analysis, however excavations at Trench C are ongoing and thus the data are incomplete. Nevertheless, the Trench C data are discussed even further in Chapter Six in regard to herd composition (e.g. age structure, season of death, and gender makeup) and butchering strategies (e.g. bone condition and disbursement, and lithic debris). Finally, areas F through I are introduced and briefly discussed for context.

Site Discovery and the Early Collections

In the fall of 1969, the Certain site was brought to the attention of avocational archaeologist John Flick (Hammon, Oklahoma) by the then-landowner L. E. Certain (Wyckoff 1992b). Flick was an active member of the Oklahoma Anthropological Society (OAS), a long-established group of avocationalists in Oklahoma (Albert 1984:56-57). Mr. Certain was familiar with Flick's interest in prehistoric Amerindian sites since both were active local farmers. Mr. Certain relayed to Flick that a deep gully on his property contained bone that was buried by some 2-3 m of soil (Figure 5.1). The gully developed below one of the springs that formed the headwaters of Sandstone Creek. The entire Sandstone Creek basin was experiencing heavy erosion at the time of site discovery despite the efforts of the Soil Conservation Service (SCS) (Steele 1966). A grade stabilization structure was built by the SCS approximately 1 km downstream to alleviate headward erosion, but to no avail (United States Department of Agriculture 1958). Intensive farming that accompanied homesteading in the region and unchecked cattle grazing had caused irreparable damage to the landscape. Fortunately for archaeologists, the regional erosion initiated over 70 years ago has led to the discovery of several now-filled paleocanyons containing evidence of sizeable prehistoric game kills.

In early February 1970, John Flick invited then-State Archeologist Don Wyckoff to inspect the bones discovered on Mr. Certain's property. At the time of the inspection, the modern gully was roughly 10 m deep. A 10 to 25 cm layer of bone was observed in two areas in the upper reach of the canyon (east end). The bone bed was approximately 3 m below the surface (Wyckoff 1992b). Continued inspection of the modern gully revealed bone fragments, some of which were burned. This bone deposit was about 60 m west of the two original bone layers identified by Flick and Certain. The new accumulation of bone was 4-5 m below the surface (Figure 5.2). It was from here that a few bones were collected for species identification. The bones were soon determined to be modern bison (Wyckoff 1997, personal communication). Other bones, assumed to be part of this bone accumulation, were found in an adjacent two-track road leading to the bottom of the



Figure 5.1. View of modern canyon at the L. E. Certain Site in winter of 1970. Mr. Certain on the left and John Flick on the right. Photograph taken by Don Wyckoff from the other side of the canyon. Note bones in canyon wall in circled area. Also note bone actively falling to canyon floor. White areas below the bone are root casts and calcium carbonate build-up on the exposed Permian bedrock.

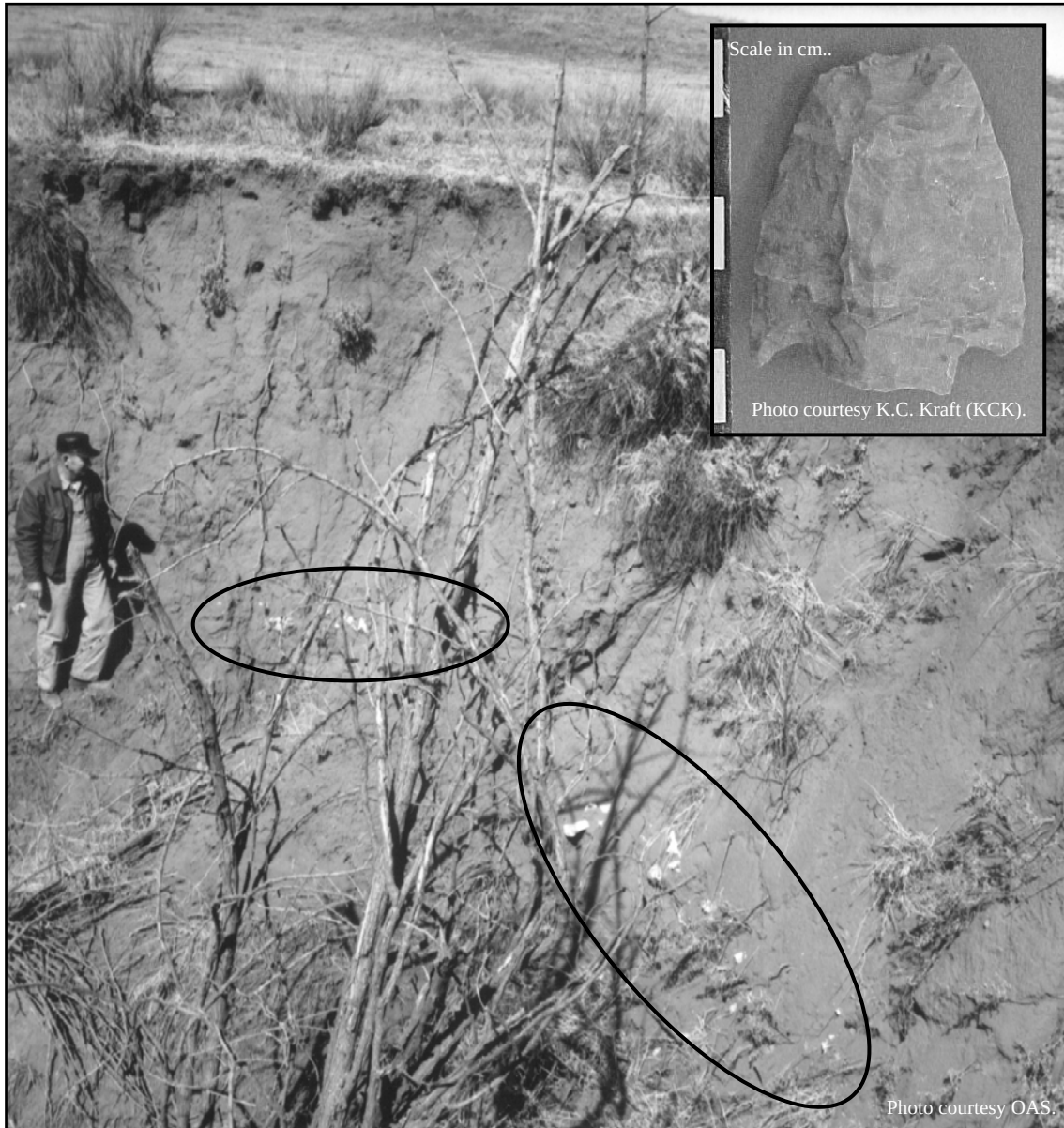


Figure 5.2. John Flick standing next to bone eroding from Certain's gully wall in 1970. Inset: Point from eroded area, scale.

canyon (Figure 5.3). While cleaning off this third exposure, John Flick recovered an articular end of a right radius and a broken, corner-notched spear point (Figure 5.2, inset) hewn from Ogallala Formation quartzite (Wyckoff 1992b). Beside the bone and point recovered, the distal end of a tertiary flake, removed from an Ogallala quartzite biface, was also recovered. Burned bone was collected. The majority of the burned bone

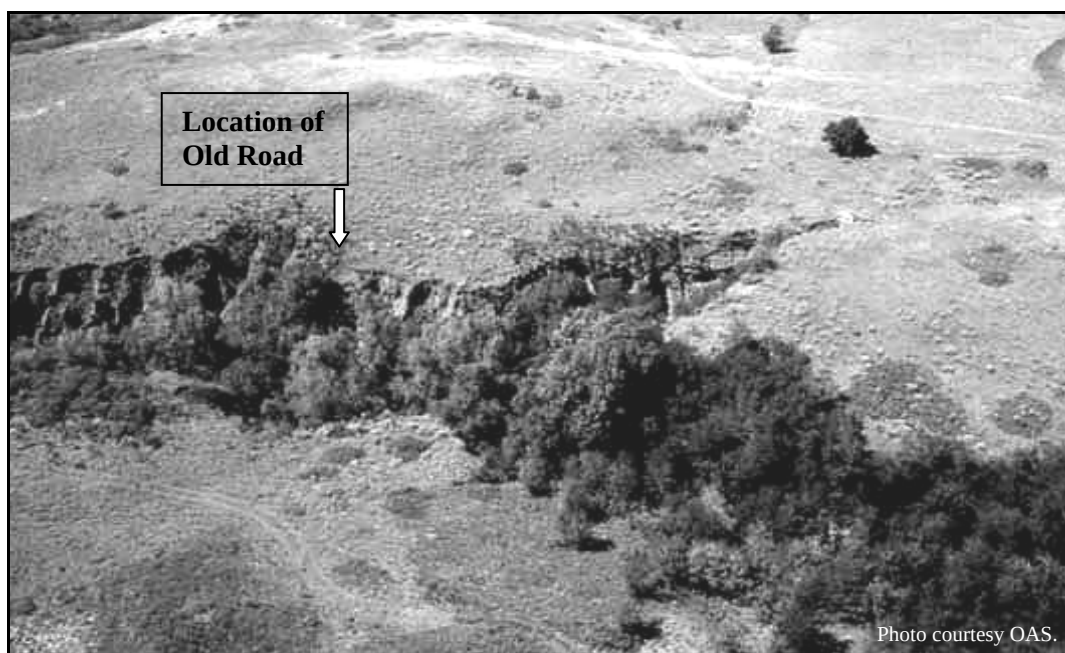


Figure 5.3. A 1992 aerial photograph of the L. E. Certain site, view is north. Bone bed depicted in Figure 5.2 is near the old tractor road, now Area I.

came from the same exposure that the point was collected (i.e. third exposure). The burned bone was later interpreted as coming from the scattered remnants of a hearth (Bement and Buehler 1994:175).

In 1970, these materials were accessioned into the archaeology collection at the Stovall Museum (Oklahoma Museum of Natural History). Close to 150 specimens consisting of bison teeth, miscellaneous bison bones, and several unmodified gravels comprise the early collection (Table 5.1). Additional materials collected from the eroding cliff face in 1992, mostly teeth, are presented in Table 5.2. Materials collected by Bement in 1992 from the tractor road complement conclusions reached after analysis of the 1970 collection. However, based on age determination, one additional animal (0.3 years) is represented in the 1992 collection. Analysis of both collections was conducted by the author in 1994. All bone specimens correspond to Behernsmeyer's (1978) Stage 3 weathering category.

Analysis of the 1970 collection (Table 5.1) suggests the presence of two animals, one sub-adult and one mature animal. The sub-adult or premature animal (1.6 years) is represented by limited wear on specific parts of the teeth. An essentially mature animal (4.6 years) is represented based on the degree of epiphysis-diaphysis fusion and a worn M3. The recovery of a deciduous fourth premolar (dP4), with extensive wear, is the basis for identifying a third bison. The dP4 is present at birth. However, extensive wear on this tooth would place the animal at three to four months since forage accompanies a milk diet a few months after birth. Age estimates for the other two animals represented in the 1970 collection do not match exactly with that determined from the 1992 collection (Tables 5.1 and 5.2). Yet, they are within acceptable range given the paucity of age-specific bone data available for assessment. In essence, the two animals represented in the 1970 collection are most likely the same two animals represented in the 1992 collection. If not, a minimum number of animals would be five.

Table 5.1. Preliminary Faunal Assemblage from the L. E. Certain Site: 1970.

Count	Element	Age	Side	Damage/Comments
1	Radius w/o ulna	4.6 to 5 years of age	Right	Bleached; Animal #1
1	Scapula	Unknown	Right	Glenoid fossa only
3	Rib heads-unfused	Sub-adult	Right?	Fragments; Animal #2
Multiple	Rib shafts	Sub-adult and Adult	Unknown	Fragments
1	Astragalus	Adult	Left	a.k.a. (tibia tarsal)
Multiple	Burned bone fragments	Unknown	Unknown	N/A
1	Third molar (M3)	4.6 years of age	Left	Animal #1
1	First molar	1.6 years of age	Right	Animal #2
1	First molar	1.6 years of age	Left	Animal #2

Table 5.2. 1992 Assemblage of Age-Distinctive Faunal Materials from 1970 Collection Area.

Count	Element	Age	Side	Damage	Comments
1	Deciduous P4	0.3+	Left	Dislodged	Extensively worn; Animal #3
1	M2-Maxillary	1.5-2.5	Right	Dislodged	Moderate wear; Animal #2
1	M2-Maxillary	1.5-2.5	Left	Dislodged	Moderate wear; Animal #2
1	M3-Maxillary	1.5-2.5	Left	Dislodged	Moderate wear; Animal #2
1	Mandible	5.6	Left	N/A	Width blw M3, 70.4 mm, cow; Animal #2
1	Frontal lobe	Unkn.	N/A	Weathered	Encased in plaster; includes left horn core

History of Investigation

Introduction

Since the winter of 1970, Oklahoma Archeological Survey (Survey) staff has monitored the exposed bones at the L. E. Certain site. A chronology of events leading to the 1993 and 1995 University of Oklahoma fieldschools at the site is presented here. These data come from conversations with those who have worked at the site or are otherwise associated with the events that have transpired there. Data from the 1993 and 1995 fieldschools are from observations made by the author or from published sources. Additional research at the site since 1995 and up to the present will also be briefly reviewed although not a major part of this dissertation. These data are the result of observations made by the author during subsequent visits to the site or from published data. Because of this there are inconsistencies in the amount of research that has been conducted with the different datasets.

The 1970s

In February of 1970, that portion of the Certain property containing the bison bones was assigned archaeological site number 34BK46 by Don Wyckoff. In 1973, University of Oklahoma student Nick Evans revisited the L. E. Certain site under the direction of Wyckoff (1970). Additional bones were collected at that time; no other stone artifacts were recovered. In 1970, Dr. Wyckoff was tasked by Dr. Robert E. Bell to find a suitable site to direct a University of Oklahoma fieldschool for the upcoming summer (Wyckoff 1997, personal communication). Wyckoff revisited the L. E. Certain site with John Flick and another OAS member, Mr. Parham, to assess the current situation of the bone exposures (Figure 5.4). It was determined that conducting a fieldschool at the Certain site was not feasible given the unstable condition of the canyon wall, and the amount of effort necessary to reach the cultural deposits. Besides the safety issue and overburden problem, large-scale excavations would only exacerbate the broadening erosion problem on the property (Wyckoff 1997, personal communication).

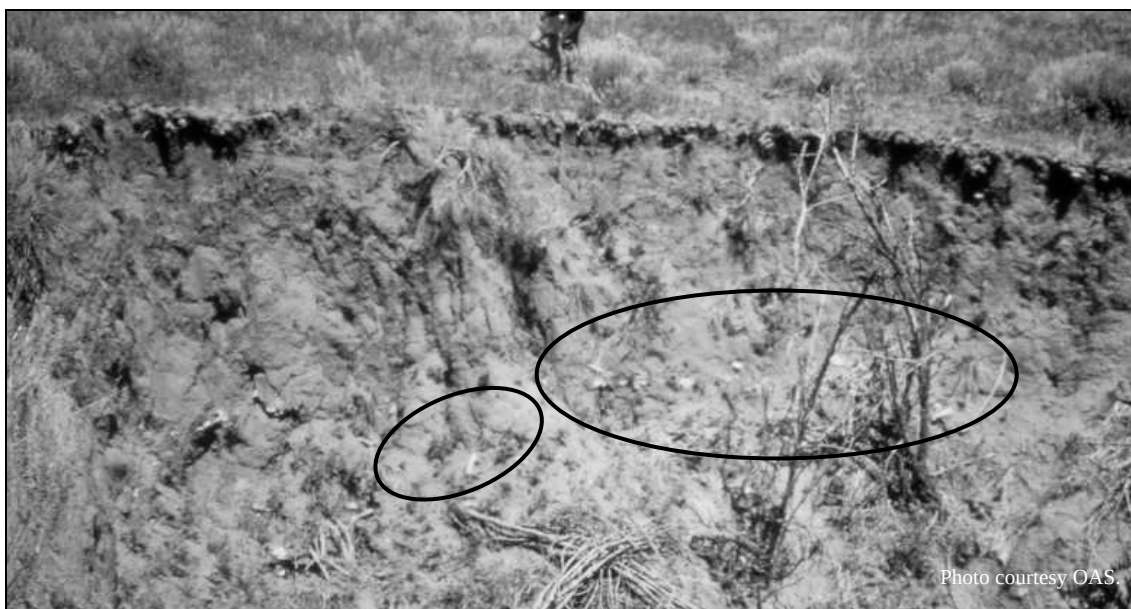


Figure 5.4. Tractor road area in 1975—note bones in circles.

The 1980s and 1990s

The L. E. Certain site was not visited again until the mid-1980s. Jack Hofman examined the site in 1986; however, it is not clear if any additional bone samples were gathered. Apparently no artifacts were collected either. During the spring of 1992, Lee Bement examined the site. A fragmented bison skull and its respective mandible, a fractured hyoid, and several dorsal spines from four to six thoracic vertebrae were recovered. The majority of the vertebrae were articulated (Bement and Buehler 1994:175) suggesting that the animal was relatively intact rather than strewn about by humans, carnivores, or other taphonomic agents (e.g. erosion, fluvial transport, or gravity) (Efremov 1940). Later in 1992, limited subsurface testing was conducted at the L. E. Certain site by Survey staff, OAS members, and University of Oklahoma students (Bement 1992; Bement and Buehler 1994:175). The summer excavations involved opening two exploratory backhoe trenches. A systematic and discretionary coring regime was also undertaken at the site (Bement 1992:2; Bement and Buehler 1994:175; Buehler 1997:137-138).

Excavation Techniques and other Considerations

Excavation techniques utilized on the firm, compact soil, were quite unique as all excavators of bone beds have come to realize. Special care had to be taken to achieve the desired results, that being the need to minimize damage to the bone during extraction. No trowels, knives, dental picks, or other metallic tools were employed. In doing so, any consequential marks on the bones were avoided. Marks on the bone in some cases might be misinterpreted as prehistoric cultural modification. The nature of examining bone is difficult enough given the taphonomic factors that have the possibility of affecting it (Figure 5.5), even when humans are removed from the equation (Behrensmeyer et al. 1986; Lyman 1984a, 1984b; Walker and Long 1977).

In place of the normal tools of excavation, quartered and halved bamboo shafts were utilized to expose the bone as were other miscellaneous wooden apparatuses. Matrix was cleared away from the bones using the bamboo splints with the surrounding materials being swept into plastic dustpans or modified plastic containers such as soft drink “bottles” or bleach jugs. Being well aware of the drawbacks of various screening methodologies (Shaffer 1992), the matrix from around the bone was passed through 8 mm mesh. Utilizing such a fine sieve also assisted in recovering tiny flakes that were not originally detected *in situ*.

Initially, a grid was established within the excavation trench utilizing 2 m squares oriented north. Magnetic north is 28° to the west. The larger squares were further divided into quarters (1 m squares) with the southwest corner being used for provenience. The traditional north and west base lines were employed as the designating system (e.g. N10-E14). Further provenience was recorded for unique items such as stone tools, by measuring in from the western and northern edges of the larger excavation unit, thereby piece-plotting these items within the 1 m squares. Before bones were extracted from the



Figure 5.5. Model of Taphonomic Factors Affecting the Faunal Assemblage (adapted from Bonnichsen and Will 1990:8)

units, a dozen or so analytical attributes were recorded in addition to the bones being mapped in place. On a standardized catalog sheet, the square designation and elevation of the surface upon which the bone rested was documented, and the strike and dip were recorded. Respectively, strike and dip are the orientation of the bone or articulated segment in relation to magnetic north and the angle at which it lay on the depositional surface. Such information might help interpret cultural or natural factors affecting the orientation of the bone (Figure 5.5). The condition of the elements was also noted. For example, comments were made if the bone was broken, complete, or modified by animals (Figures 5.6a-b). With crania, notation was made if the skull was inverted, in anatomically correct position with the rest of the carcass, or if the atlas (C 1) and axis (C 2) were present. Field notes were made regarding the placement of the bones such as whether they were piled or stacked. It was also documented in the notes if the catalog number was assigned to an articulated limb, axial skeleton, or single element. The surface



Figure 5.6a. Taphonomic factor affecting bone in bone beds: spiral fracture on tibia—cultural.



Figure 5.6b. Taphonomic factors affecting bone in bone beds: gopher hole gnawed into horn core—non cultural.

character of the specimens was recorded as defined by Behrensmeyer (1978) and Todd (1987a:117-128). If there was clear, vertical separation between bone concentrations, the upper layer was designated as Bone Bed 1 and the lower as Bone Bed 2. Finally, any associated artifacts were documented with the constituent bone and the surrounding matrix associated with the bones. The two most common associations were colluvial fill or bedrock-contact. Further documentation included both black and white and color photographs, color slides, instant developing film photographs, and videotape recording. As a matter of protocol, a scale and a designation to north was included in every shot (Fladmark 1978:63-82; Howell and Blanc 1992:65-93). This was accomplished either employing a “north arrow” or a trowel pointing to grid north.

In addition to the above, specific bones were treated with a consolidant before being removed. The barrier material or overcoat helped to stabilize the bone yet it was still reversible, resistant to water, thin enough to flow and thick enough to form a film. In addition, the material was fast-drying, had good adhesion, and was resistant to flaking. The commercially available product utilized to achieve all these goals was polyvinyl acetate resin. Special care was taken to assure that the bones had sufficiently dried, allowing what little soil moisture that was caught in the bones to escape, to avoid mold from developing internally. If the bone was coated while wet, it would turn a blue-green color. Those elements collected for collagen testing were not treated to prevent contamination. These bones were noted as such on the catalog sheets.

After applying resin to the bone prior to removal, spray foam insulation was utilized to encase particular bones, or articulated segments left behind by the prehistoric hunters. The spray foam, which was utilized in place of plaster, adhered to the bone and expanded to form a soft yet rigid protective shell (Bement 1985). The foam hardened relatively quickly providing a smooth outer surface for marking the cocoon with a catalog number (Bement, personal communication 1993). Before the foam was applied, a channel was cut around, and slightly under, the bone. The foam was used to outline the bone and then a back and forth application method was used to tie the foam together. Once the material set-up, the remaining pedestal was cut away and the bone and foam were quickly flipped. Great care was taken to cradle the foam and bone mass while inverting the foam shell. If necessary, foam could be applied to the open face for further protection. As a result, the encased specimen was protected in a fracture-proof shell that weighs far less than plaster (Bement 1985; Buehler and Bement 1995).

Area A

Introduction

The first backhoe pit at the L. E. Certain site was placed atop one of the areas originally identified by Flick and Certain in 1969. Additional excavations took place in 1992 and 1993. This area was labeled Trench A (Area A) in 1992 (Figures 5.1 and 5.7).

Throughout the text the terms *trench* and *area* are used interchangeably to designate activity localities. Trenches were not always the method of initial excavation but since the first three units (A-C) were started by backhoe trenches, the adjective has remained a part of the L. E. Certain site lexicon. Hand excavations within the 8 x 4 m trench exposed the carcasses of 12 bison (Bement and Buehler 1994:175). Later excavations determined

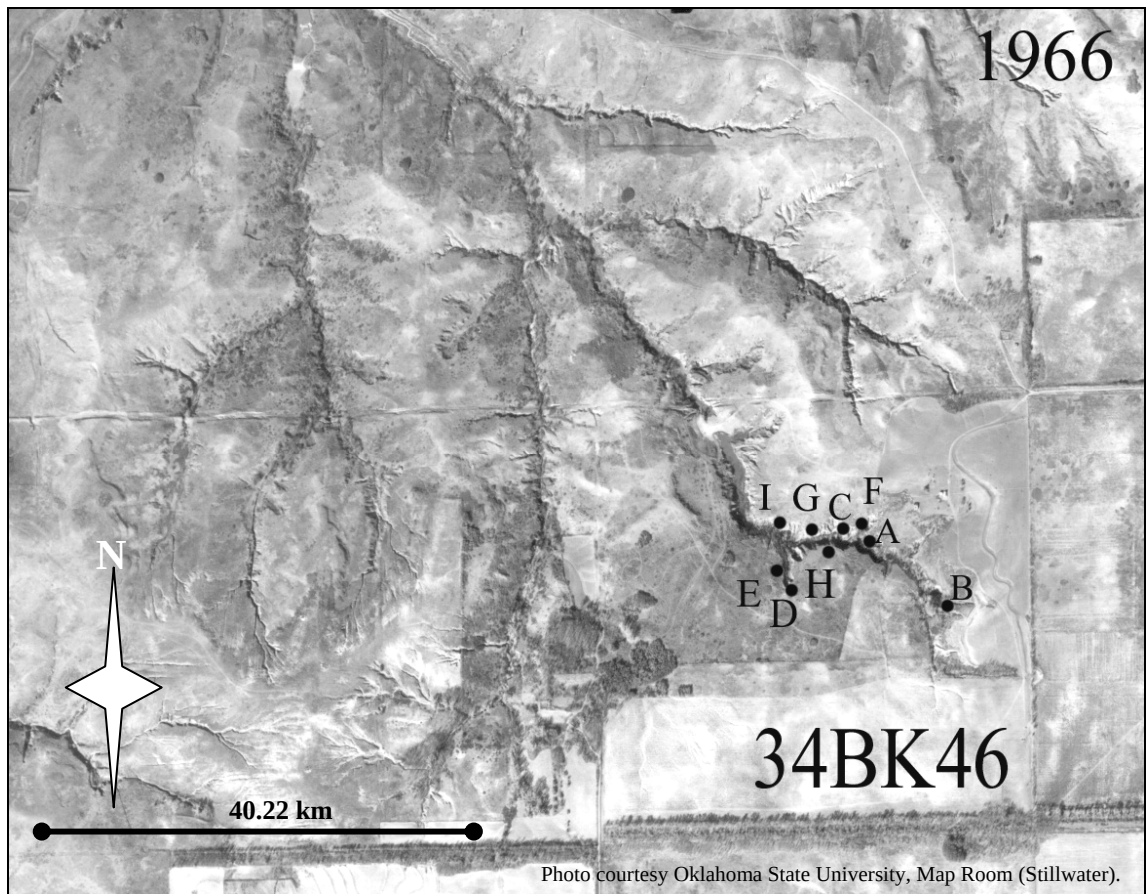


Figure 5.7. A 1966 aerial photograph of the L. E. Certain Site with prehistoric cultural activity areas depicted.

that the remains of at least 20 and perhaps 23 bison were contained within a now-filled prehistoric gully (Buehler 1997:137-138). The paleogully was approximately 7 m long and 10 m wide based on exploratory coring with a mechanized truck-mounted auger (Figure 5.8). The tail end (south) of the fossil gully was lost to lateral erosion of the modern canyon and thus, the original dimensions of the trap and the number of animals killed will never be known (Bement and Buehler 1994:175). The steep-sided fossil gully served as a natural trap and the bone bed represents the killing floor. The semi-articulated bones of the buffalo indicate a single-event kill, which took place at the head of the once open arroyo (Buehler 1997:138). Other evidence of human interaction with the bison in Trench A includes the recovery of a dart point lodged in the vertebral column of one animal (Figure 5.9). This find, along with butchering evidence described below, leaves no doubt that the death event at Area A was precipitated by prehistoric hunters.



Figure 5.8. Bement (leaning) and Buehler coring at the L. E. Certain site in 1992.



Figure 5.9. Dart point embedded in a thoracic vertebra. The base of the point is damaged from impact and/or shaft-retrieval. Not to scale.

Results of Excavations—Area A

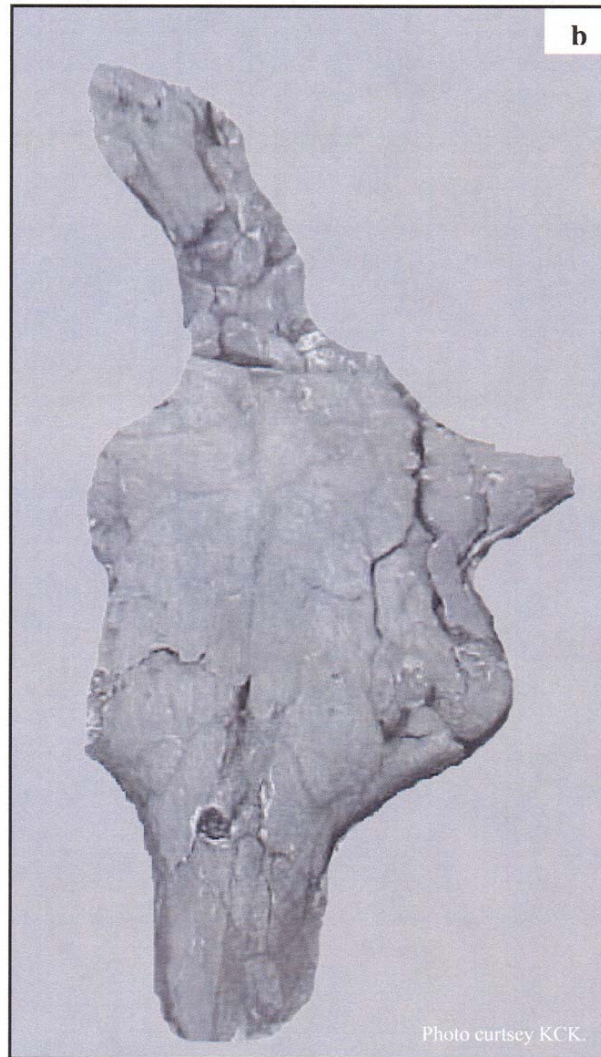
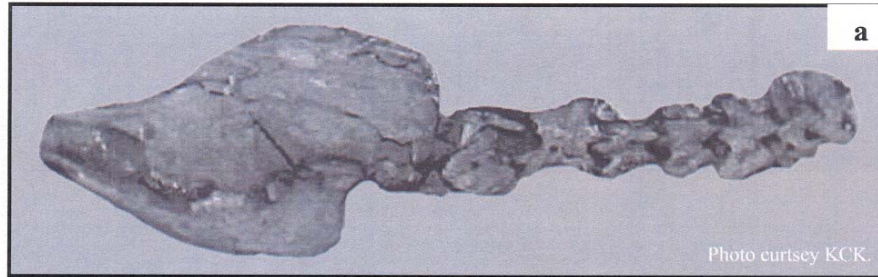
Before the kill that occurred in Area A, the canyon had eroded to the underlying sandstone (stable surface) and minimal secondary filling had just begun. Hence, the kill and butchering took place about 20 cm above bedrock (Buehler 1997:138). The position of the axial segments shows that the animals were laid on their side or back (supine). One animal was prone, with hind legs stretched out and extended to the rear (Bement and Buehler 1994:175-176; Buehler 1997:138). Several of the animals were split lengthwise with upper rib segments and limbs removed to an off-site location (Buehler 1997:138). The quartered segments from the primary kill at Area A were found elsewhere at the site (Bement and Buehler 1994:178; Kraft and Bement 1995). This locality is interpreted as a

secondary processing area where an impromptu kitchen was established. The secondary processing area will be discussed later.

One-third of the animals at Area A had intact vertebral columns with the others having been disarticulated at the eighth, ninth, and tenth thoracic vertebra (Buehler 1997:138). The remainder of the butchered carcasses was generally left intact minus the anterior portion of the animals (Bement and Buehler 1994:175-177; Buehler 1997:138). Little overlap of the skeletons was detected during excavations at Area A. In general, the animals were oriented parallel or perpendicular to the long-axis of the gully trap (Bement and Buehler 1994:175). Such placement and technique represents some form of organization and procedure by those processing the dispatched animals (Buehler 1997:138).

Other butchering strategies observed at Area A include removal of the hides, retrieval of the brain, and extraction of the tongue. The discrepancy in the number of caudal vertebrae to the number of axial units identified at Area A suggests that the hides were removed from some if not the majority of the animals (Bement and Buehler 1994:177-178; Buehler 1997:138). However, the size and mass of the tail bones make them likely candidates for displacement by taphonomic agents (Efremov 1940; Hill 1976:335-336, 1979a, 1979b:272).

In Trench A, the crania were left attached to the vertebral columns of each animal in about half the cases (Figures 5.10a-b) (Bement and Buehler 1994:176; Buehler 1997:138). The skulls were, however, usually shattered, presumably for removal of the brains (Figures 5.11a-b) (Bement and Buehler 1994:177-178; Buehler 1997:138; Kehoe and Kehoe 1960:422). Hyoid bones were broken for the most part. Anatomically, the hyoid bone is in close proximity to the fleshy tongue. Removal of the tongue for consumption is thought to fracture if not severely damage the fragile hyoid bone (Hesse and Wapnish 1985:86-87).



Figures 5.10a-b. Bison crania attached to vertebrae but detached from the remainder of the carcass: (a) specimen with fractured vault; (b) specimen with intact vault and right horn core (pre-maxilla was damaged by a datum pin prior to excavations).



Figure 5.11a. Smashed crania of bison encased in spray foam, crania found face-down in the bone bed.

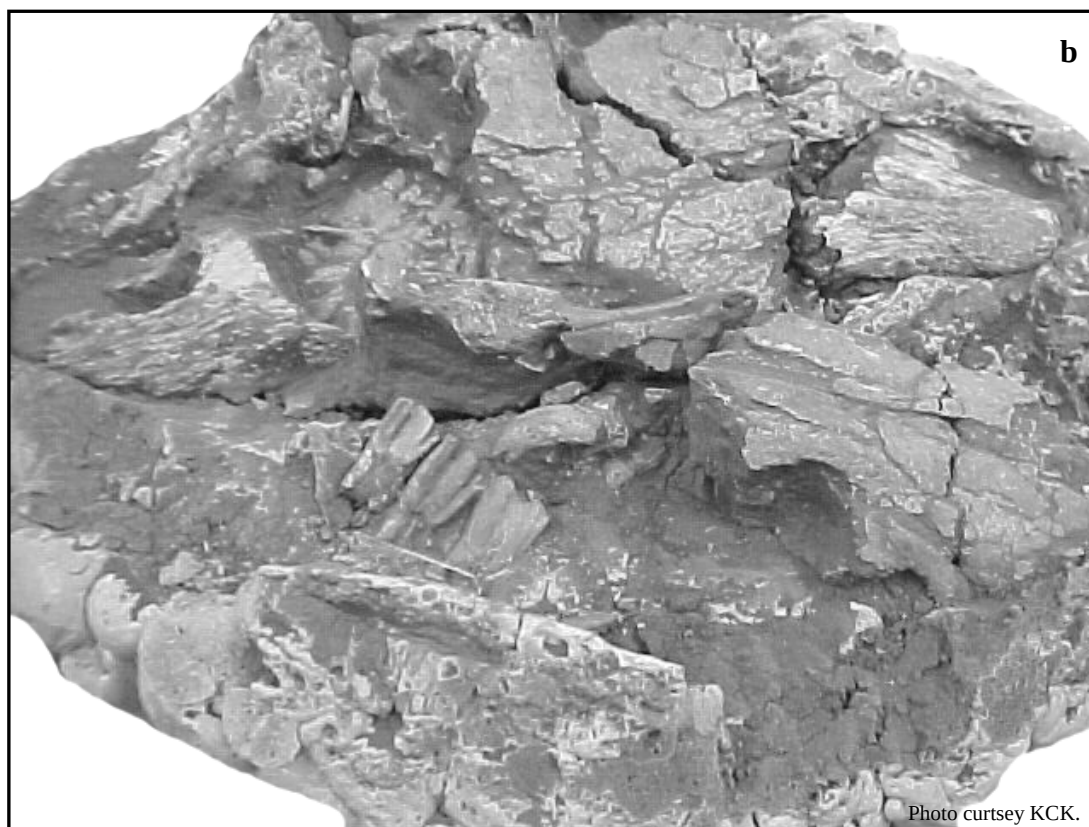


Figure 5.11b. Smashed crania of bison encased in spray foam, destroyed skulls often are only identified by teeth within a mass of bones.

Chipped Stone Assemblage—Area A

No formalized projectile points, knives, or scrapers were recovered from excavations in Trench A in 1992 (Bement 1992:2). However, subsequent excavations in 1993 recovered three dart points from Area A (Bement and Buehler 1994:181). All three points were of very siliceous Ogallala Formation materials, generally referred to as Potter chert.

In all, 16 flakes were recovered from the Area A bone bed (Figure 5.12). Seven biface/knives are represented based on tool stone color, texture, and ultraviolet florescence. The mean length of the flakes was 11.09 mm and the mean width was 12.70 mm (Kraft 1994a, 1995). Eleven of the flakes recovered from Trench A were Alibates

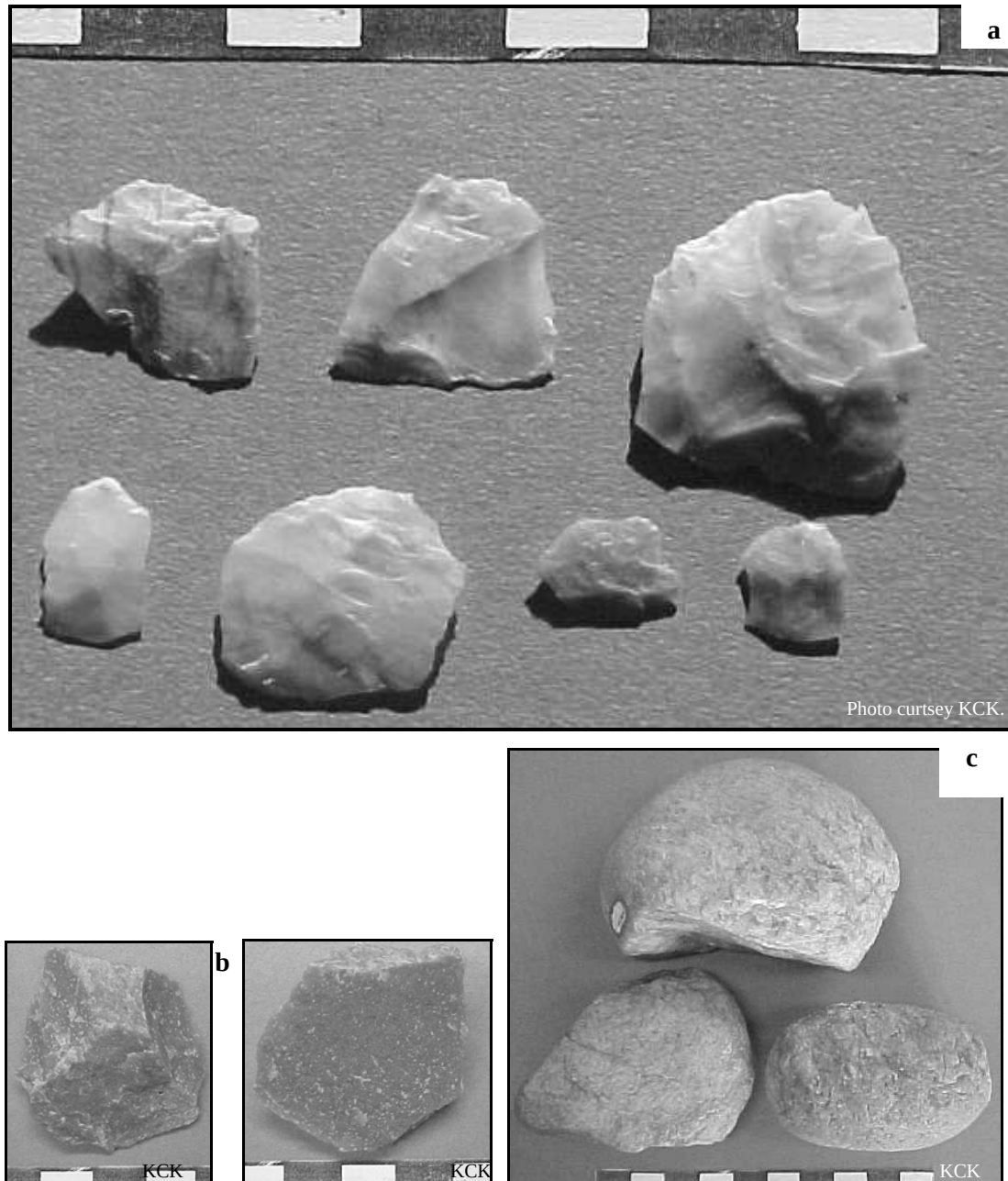


Figure 5.12. Lithic assemblage, excluding projectiles, from Trench A: (a) select Alibates biface resharpening flakes, all were found within the bone bed (striking platforms of flakes [biface cutting edge] are to the top and oriented on a level plane); (b) large quartzite tertiary flake with polish on distal end (cutting edge) found in bone bed; (c) battered cobbles found in the bone bed. Scale in cm.

silicified dolomite (69%) and five were Ogallala Formation quartzites (31%). Closer examination of the recovered flakes reveals that they were not removed from projectile points. Rather, they were flaked off a different type of bifacial tool. The ridge orientation on the platforms of the flakes clearly indicates that they were detached from bifacial knives (Kraft 1995). Biface maintenance flakes are generally uniform in shape, that is they exhibit slight concave ventral surfaces and display tapering terminations. Moreover, the flakes are relatively equal in length and width. Bordes (1961:6) indicates, “flakes from the completion of biface edges are generally small, (and) sometimes uniform.” Semenov (1976:55-62) describes biface resharpening flakes in a similar manner.

Interestingly, no knives were recovered from the killing floor, thus there is a missing tool type at Trench A. Therefore, it can be suggested that the knives were highly desirable and curated. At bison kill sites from other regions (and time periods), biface knives are usually part of the bison hunting toolkit (Agenbroad 1989:80-81; Bradley 1991; Brooks and Flynn 1988:473-475; Frison 1973:60-61; Hemmings 1987:437-439; Huckell 1989:172-173; Quigg 1997a:66-72; Speth and Parry 1980:170-171). However, the projectile points themselves might have served this purpose, but probably did not (Greiser and Sheets 1979:292-296).

Absolute Dating—Area A

Dating the use of Area A was achieved by way of bone collagen assay. Three dates in all are available for Trench A or the Trench A vicinity (Bement and Buehler 1994:181, Table 1). In 1988, a bone eroding from the modern cut bank was submitted for radiocarbon analysis. The uncorrected result was 1400 ± 70 BP and the ^{13}C adjusted age was 1655 ± 70 BP (Beta 28121). Another bone sample from Area A was pretreated using XAD resin to remove residual impurities. The purification process removes soil contaminants, thus providing a more accurate bone date. The XAD purified total collagen bone sample produced an age of 1730 ± 70 BP (NSRL 267) (Hofman 1995:431). Overall, a rough calendar date of AD 220 to 350 is not unreasonable (Boyd 1997:240, Table 61;

Hofman 1995:432; Thurmond 1991a:115, Table 4). A bone recovered from test excavations in 1992 yielded an uncorrected age of 1440 ± 70 BP (Bement and Buehler 1994:181, Table 1). The sample (Beta 55386) was ^{13}C adjusted to 1680 ± 70 BP by Beta Analytic, Incorporated. An estimated calibration, based on an average of three ^{13}C bone collagen (-12.2) dates from the site, places the death of the animal around AD 270 more or less (Boyd 1997:240, Table 61). Thus it can be assumed, with relative confidence, that the Area A bison kill occurred within the first few centuries AD.

Area B

Introduction

Area B of the L. E. Certain site is at the east end of the modern canyon (Figure 5.13). The location is approximately 150 m upstream from Area A (Bement 1992:2). In 1992, bone was observed eroding from the head of a side gully that emptied into the larger, modern

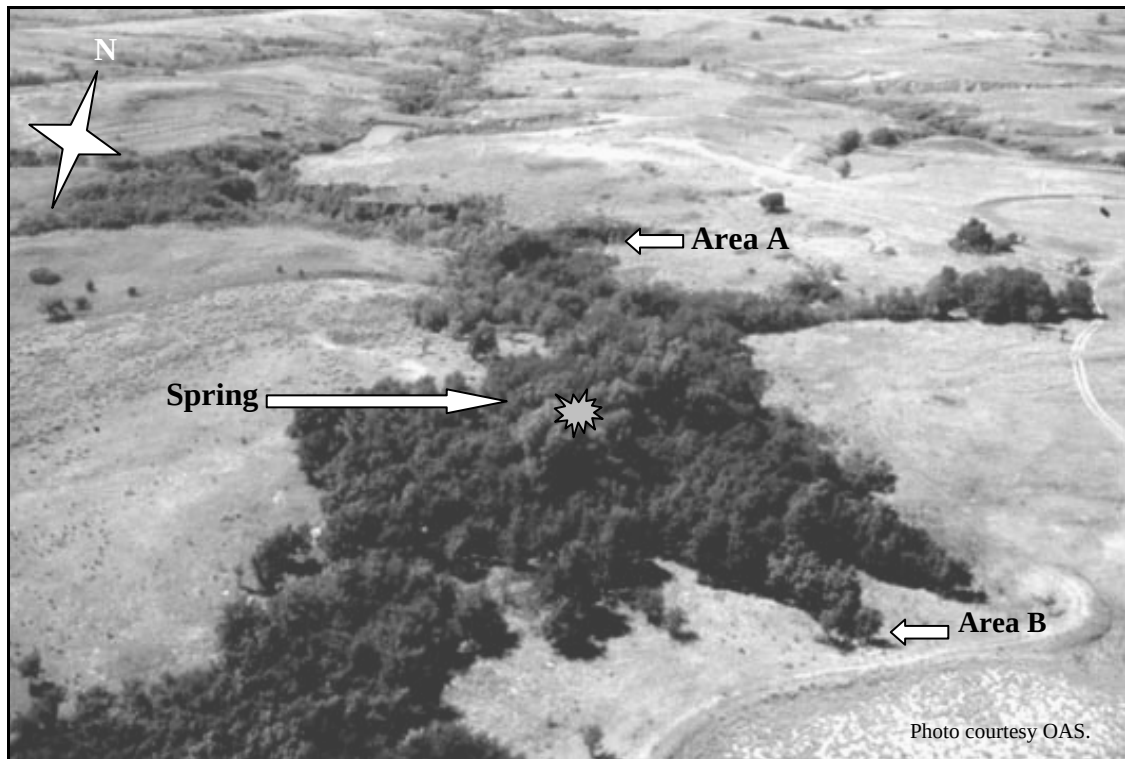


Figure 5.13. A 1992 aerial photograph of the L. E. Certain site, view north-northwest. Area B is to the bottom right.

canyon. Coring in the general vicinity indicated that this portion of the site was a gently sloping bench at the time the kill and camping events took place (Bement and Buehler 1994:175; Green 2002:92-95). Such a location would be ideal for a short-term food preparation locality.

Results of Excavations—Area B

Coring of the upland setting of Area B with a truck-mounted auger was conducted in 1992 (Bement 1993, personal communication). From the coring, it was known that the bedrock in this portion of the site sloped to the north-northwest. Also in 1992, a small backhoe pit was excavated above a smattering of bones eroding from the canyon wall. The small 2 x 3 m trench was excavated down about 2 m with another 1.5 m being excavated by hand (Bement 1992:2). Hand excavations uncovered a collection of bison bone contained within a shallow oblong pit (Bement and Buehler 1994:175; Buehler 1997:137). The bone accumulation represents a single event much like that documented in Trench A (Bement 1992:2; Bement and Buehler 1994:175). The small feature (Figure 5.14) was roughly 80 cm wide and 130 cm long (Bement 1992:2) and contained long bones from the front quarters of two animals (Bement and Buehler 1994:175). Apparently the above elements, and others, were stripped of meat with the bone being discarded into the pit (Buehler 1997:137).

In preparation of the 1993 fieldschool, five exploratory backhoe trenches were excavated near Area B. Two backhoe trenches were excavated to the left of the modern gully head, two on the right of the modern gully head, and one trench was placed immediately above the modern gully head. These exploratory trenches complemented and verified the coring results. No artifacts, features, or bones were retrieved during the digging.

A detailed taphonomic analysis of the bones has yet to be conducted, but some information can be gleaned from published materials (Bement 1992:2; Buehler

1997:137), discussions (Bement 1993, personal communication), and Oklahoma Archaeological Survey archived photographs. The minimum number of individuals or MNI (Chaplin 1971:69-71; Lie 1980) is based on the recovery of two right humeri and two left scapulas. In all, a total of 36 bones or bone fragments were recovered. Portions of a hind leg were recovered as well as three teeth, several ribs, and one thoracic vertebra (Buehler 1997:137). None of the disarticulated limb bones had cut marks or were burned, although the pit did contain calcined bone and burned sandstone fragments (Buehler 1997:137). Bone grease extraction or processing may have taken place given the number of bone fragments recovered, however only one bone showed a definitive green-bone fracture (right proximal humerus). The feature was most likely used as a roasting or

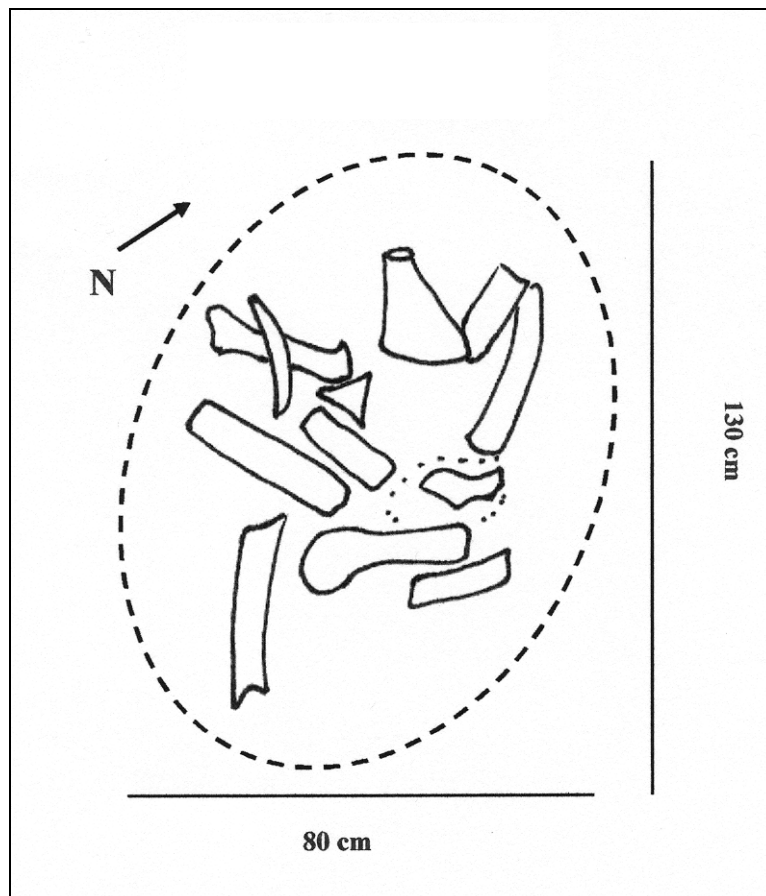


Figure 5.14. Area B, Feature 1 (uppermost hearth).

cooking pit (Bement 1992:2) rather than used in the grease extraction procedure. The feature does not lend itself to being involved in bone grease processing based on the recovered material (Leechman 1951; Logan 1998; Peterson et al. 1993; Quigg 1997c; Vehik 1977). The feature was first used for roasting or cooking, and then later served as a trash receptacle (Bement 1992:2). No charcoal was recovered from the “hearth” and, as previously noted, none of the long bones were burned. Finally, no chipped stone debris, or chipped-stone tools were recovered from the feature.

Over the years, Area B was monitored for additional signs of human activity. This persistence paid dividends in 1995 when a hearth, some 90 cm below the bone accumulation, was observed eroding from the gully wall. The hearth was exposed following a rather rainy autumn and winter. During this time, the modern side-gully expanded laterally and revealed the feature. Very little of the hearth remained intact and the dimensions were not determined.

Absolute Dating—Area B

A left bison tibia (~390 g) from Area B was submitted for radiometric dating in 1992. The assay of bone collagen (Beta 55429) resulted in an uncorrected radiocarbon age of 1370 ± 90 BP and a ^{13}C adjusted age of 1560 ± 90 BP (Bement and Buehler 1994:181, Table 1). Using an average of the three $^{13}\text{C}/^{12}\text{C}$ values from Certain’s bone collagen dates (reported by Bement and Buehler 1994), Boyd (1997:240, Table 61) estimates that Area B might date to AD 390 ± 90 . Adjusting for the inherent flaws in bone dates (Hofman 1995:432), a more accurate date is AD 40 or thereabouts. Based on this, Area B was utilized before the Area A kill transpired.

Fill from the lower hearth was collected for Accelerator Mass Spectrometer (AMS) dating. The small charcoal sample removed from the matrix-fill yielded a date of 2100 ± 40 BP, uncorrected (Beta 104860). The most basic calendar correction for this date is 160 ± 40 BC which is acceptable given the adjusted bone date 1 m above (~AD 40).

Based on the number of kill and processing events noted along the modern canyon, Bement and Buehler (1994:181) speculated that the site was repeatedly utilized over the years. The two dates from Area B and the three dates from Area A appear to verify this supposition. It is entirely possible that the first Area B hearth was covered with sediment soon after its use and then the area was occupied once again some 200 years later. It appears that the slight bench where Area B is located was developing between BC 160 and AD 40 (Green 2002:92-95).

Area C

Introduction

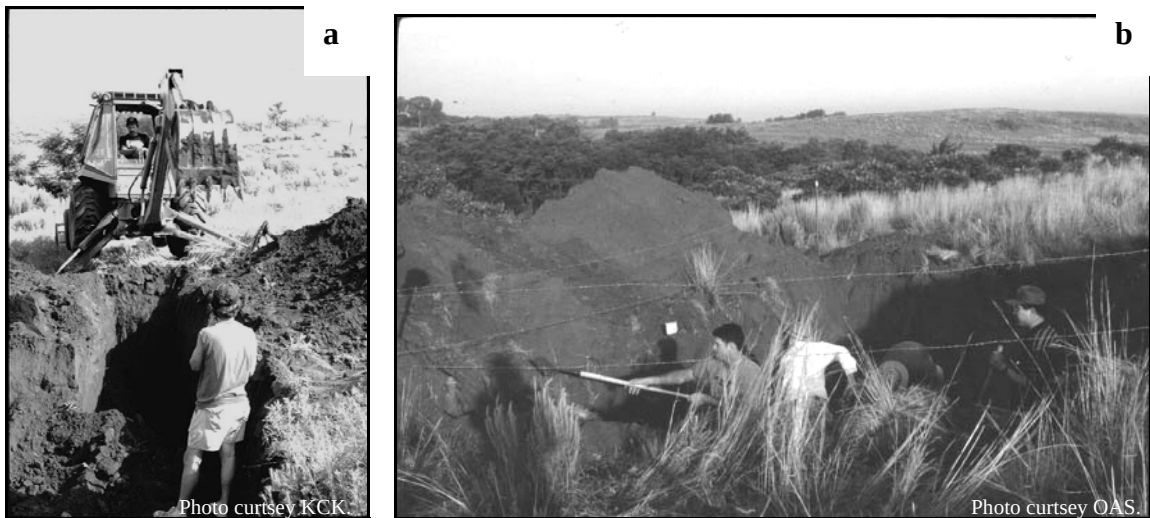
Only a portion of the data gathered from excavation at Trench C is presented here. Excavations at Trench C are ongoing; thus, these data are only preliminary. Unreferenced statements are from first-hand observations.

Area C represents the remains of another kill event similar to that uncovered in Trench A. However, excavation over the years revealed that the paleogully in Area C was utilized repeatedly. Two and possibly three bone beds are contained within this very large arroyo (Buehler 1997:138). Three stratigraphically discrete cultural levels have so far been identified (Bement and Buehler 1994:178). Supporting evidence includes separation by matrix, differential bone weathering where the deposits grade together, and a stratigraphically isolated radiocarbon date. The date comes from one of two hearths approximately 50 cm above the first bone bed.

Results of Excavations—Area C

In 1992, a systematic coring regime, paralleling the modern canyon, identified a large paleogully that contained bison bone. Based on additional coring, the ancient arroyo was determined to be 25 x 30 m long and wide, respectively (Bement and Buehler 1994:178).

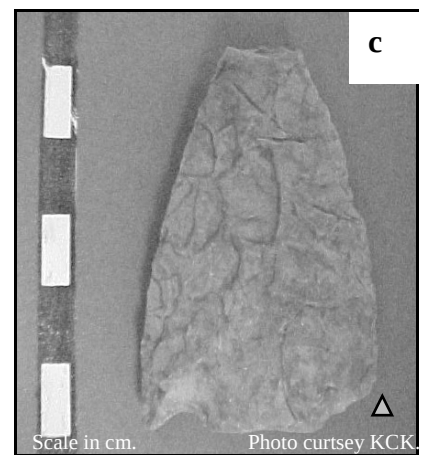
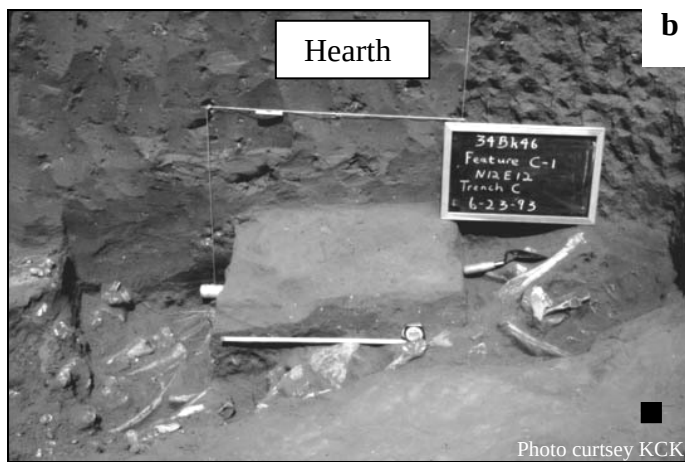
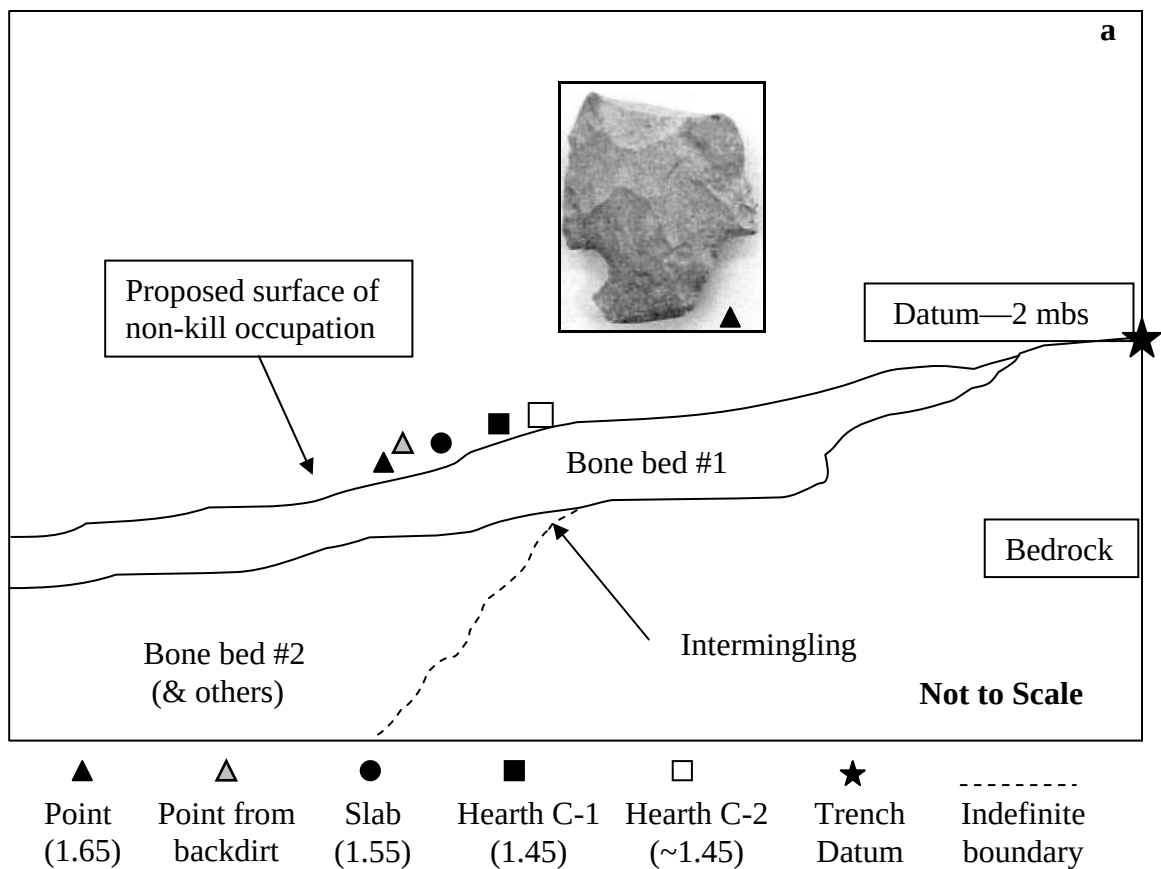
Mechanical excavation in early June 1993 opened an 8 x 6 m trench where one of the soil cores penetrated a dense bone layer (Figures 5.15a-b). Thus, the excavation unit only covered one quarter of the fossil arroyo. Area C is the same location where Certain, Flick and Wyckoff observed bone eroding from the gully face in 1969 and 1970. Based on subsurface exploration the bone deposit was determined to be approximately 3 m below modern ground surface.



Figures 5.15a-b. Removal of Area C overburden: (a) mechanical excavation to bone bed identified in soil probes and canyon exposure; (b) final removal of sterile fill prior to hand excavation with bamboo skewers.

Hand excavations at Area C began in earnest in the summer of 1993 with a University of Oklahoma fieldschool. Trench C unearthed the north and east limits of a bison trap. Simply put, Trench C was positioned in the northeast corner of the fossil arroyo (Figure 5.15).

While excavating the western edge of the trench, a corner-notched dart point with damage to the tip and base was recovered about 2.65 m below the modern surface (Figure 5.16). The broken projectile point suggests the shaft was retrieved and the point discarded in preparation to retooling (Bement 2002:136-137; Keeley 1982). The artifact was found roughly at the same depth as a hearth and a sandstone slab. The hearth and sandstone slab

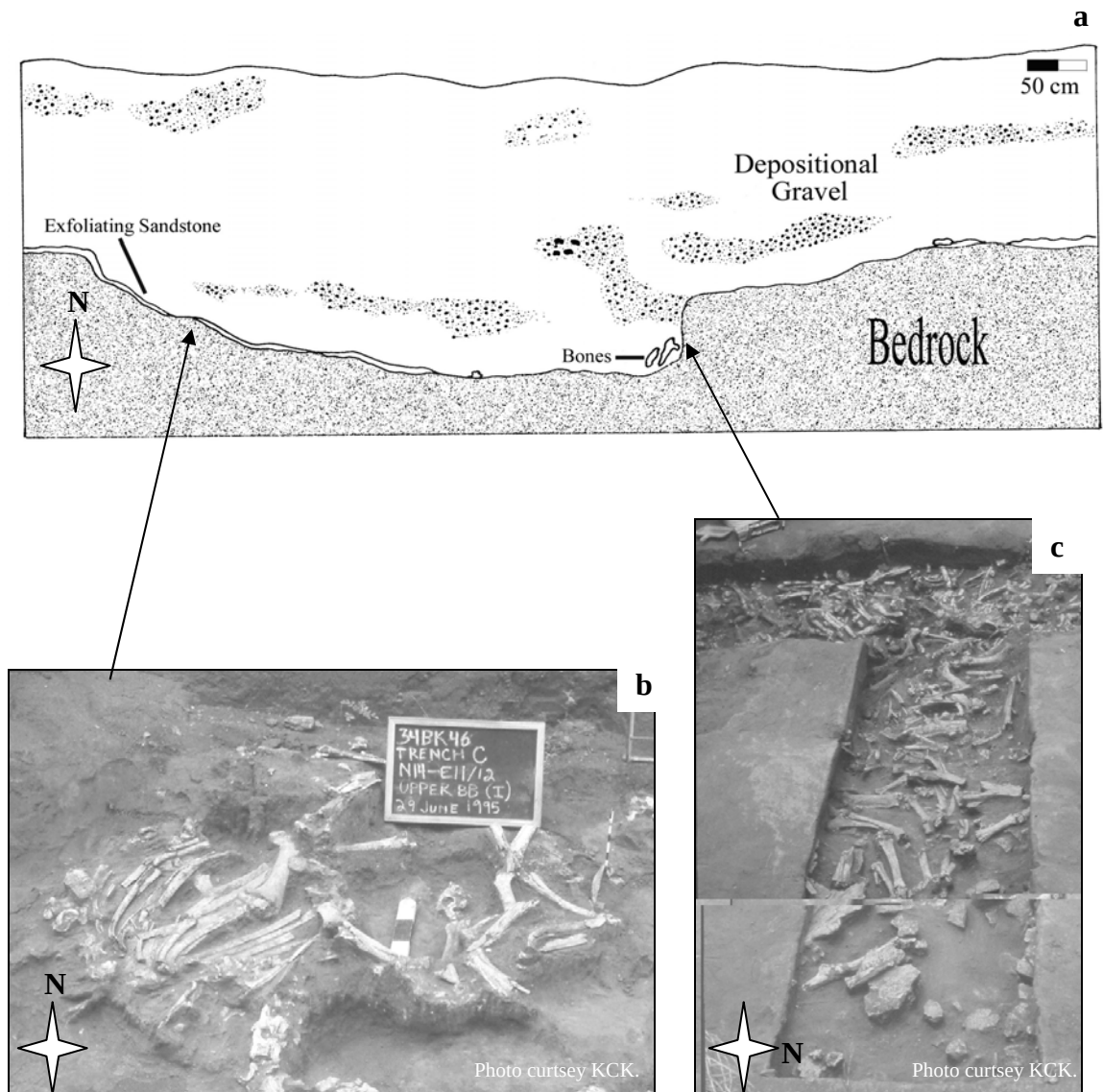


Figures 5.16a-c. Trench C west wall profile showing cultural activity: (a) idealized cross-section showing location and depth provenience of cultural occupations, all measurements in cm below datum (cmbd); (b) photograph of Feature C-1, scale set at 10 cm; (c) projectile point found in backdirt pile.

were designated as Feature C-1. The feature was not a prepared hearth (stone-lined); rather, it was a shallow pit roughly 25 cm in diameter and 15 cm deep (Bement and Buehler 1994:178). This form of fire pit is similar to the one unearthed at Area B. Although not found within the pit, a sandstone slab was found about 25 cm below and 50 cm to the south of the hearth. Sandstone slabs are readily available for use in such a feature. The hearth and slab were contemporaneous and did not represent two separate occupations. Based on the deposition of the bone below these items, and subsurface coring, it can be established that the partially filled gully had a slope of 15° to the south, more or less. In effect, the camping event took place on a slight grade. No bones were found associated with the hearth or slab.

A second hearth (small fire pit) found in Trench C was designated Feature C-2. The hearth was just above the bone bed, and unassociated with the kill event just below. The outline of the hearth was indiscernible given the amount of rodent activity noted previously. All that remained was a charcoal-stained patch of earth with much of the blackened matrix distributed in rodent runs (Bement and Buehler 1994:179). Unlike Feature C-1, prehistoric excavation of Feature C-2 penetrated the underlying bone bed. It thus can be established with relative confidence that the hearths in Trench C were in place and utilized after the upper kill and after the kill had been covered by colluvium. Finally, a point fragment assumed to be associated with the hearths was found in unscreened fill removed just above the bone bed. Because screening began at the layers containing the hearths, in all likelihood the point came from this portion of the site.

As for the bone bed, initial excavations revealed that the bones contained in Trench C were not arranged in an orderly fashion as observed in Trench A (Bement and Buehler 1994:179). The majority of the bones first uncovered were scattered about the trap, presumably representing extensive dismemberment. Fluvial and/or aeolian transport also played a role in covering the bones and probably displaced some of the smaller bones. This assertion is based upon the gravel stringers seen in profile (Figures 5.17a-c). Chunks



Figures 5.17a-c. Trench C north wall profile showing natural and cultural activity: (a) profile illustrating depositional sequence represented by gravel and sharp rise and constriction at the nick point or head of the paleocanyon; (b) photograph of an articulated bison skeleton in the upper reach of the canyon (facing north, scale in 5 cm increments); (c) scattered bison elements along the eastern edge and head of the ancient gully (facing west). Note exfoliated sandstone (bedrock) in profile and both photographs. Some fragments may have been culturally placed but most were deposited as a result of erosion.

of sandstone detached from the water-carved canyon were also found within the bone bed which also indicates fluvial action (Figures 5.18-5.21). Other evidence for non-human involvement in the scattering of the bison bones, such as carnivore gnawing or damage, is minimal. While natural factors have affected the composition of the bone beds (Behrensmeyer 1975:480-481, 564; Brain 1981:11-29; Buenger 2001; Hill 1976, 1979a, 1979b; Hill and Behrensmeyer 1984; Todd et al. 1997:146-147; Voorhies 1969:1-2), there is clear evidence that humans played a role also. For example, among the dense jumble of bison bones were axial skeletons as well as entire or partial limb segments (Figure 5.19). Limb segments included both full articulations from terminal phalanx to scapula and from terminal phalanx to proximal femur. There was the occasional semi-articulated carcass (Figure 5.18). Thus every conceivable stage or type of butchering was observed. Moreover, piles of like bones such as pelvises and mandibles were unearthed in the uppermost layer of bones (Figures 5.18-5.19). Additional evidence of extensive dismemberment such as cut marks, at the articular ends of single elements, is missing. The lack of cut marks, though, can be explained by the amount of root-etching exhibited on the surface of the bones (Buckman and Brandy 1969:14-17). Nevertheless, discrete pockets of human activity were clearly obvious.

Absolute Dating—Area C

Of the two hearths discovered, only Feature C-1 retained enough integrity for sampling. After flotation, the charred organic material from Feature C-1 was submitted for radiometric dating. Less than 8 gms of usable material were collected. Charred organic materials from this feature yielded a ^{13}C adjusted radiocarbon date of 1740 ± 60 BP (Beta 66019) (Bement and Buehler 1994:181, Table 1), or AD 210+60.

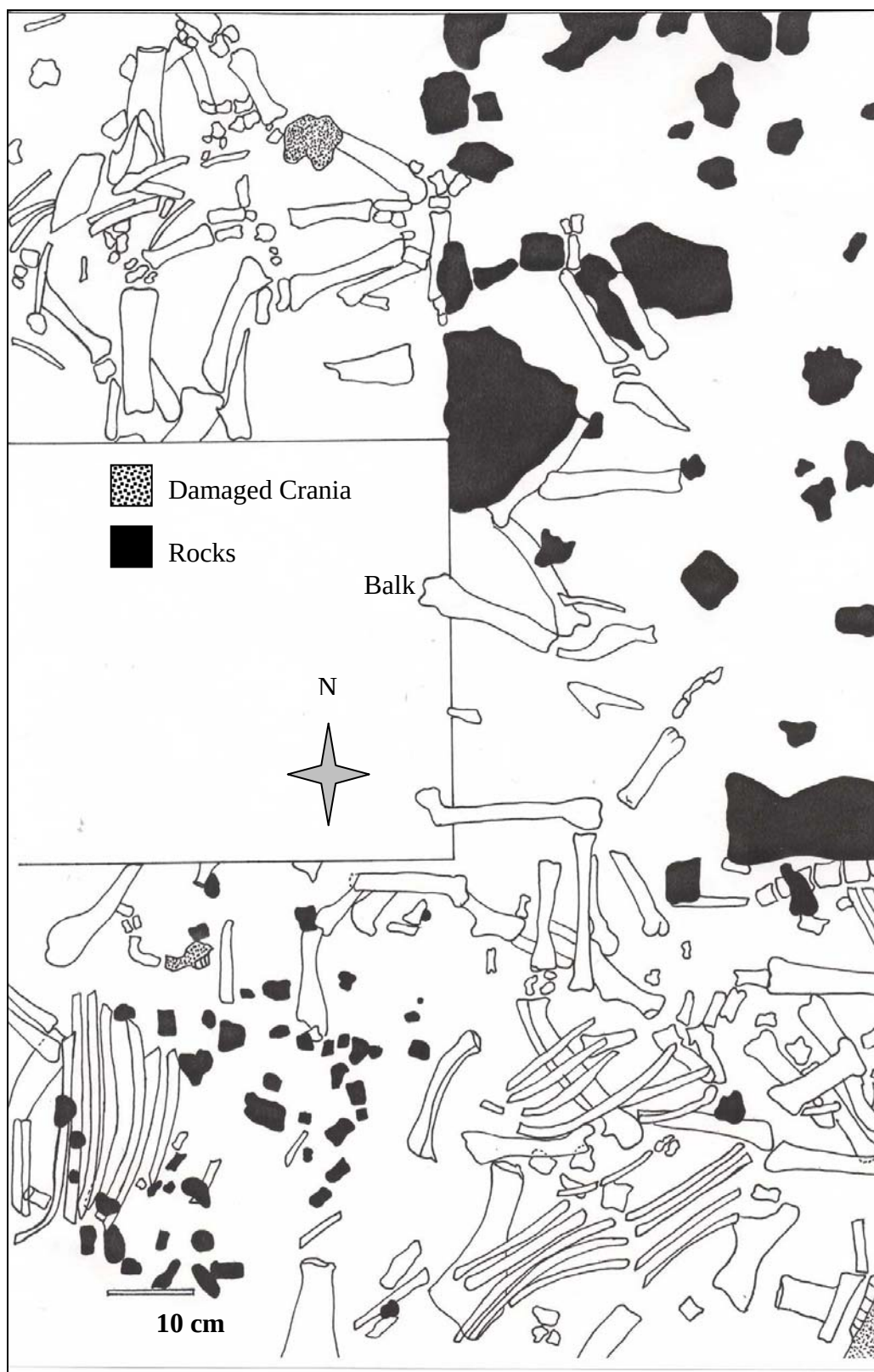


Figure 5.18. Northeast edge of Bone Bed 1 (N10/13-E16). Note crania fragments and large amount of rocks.

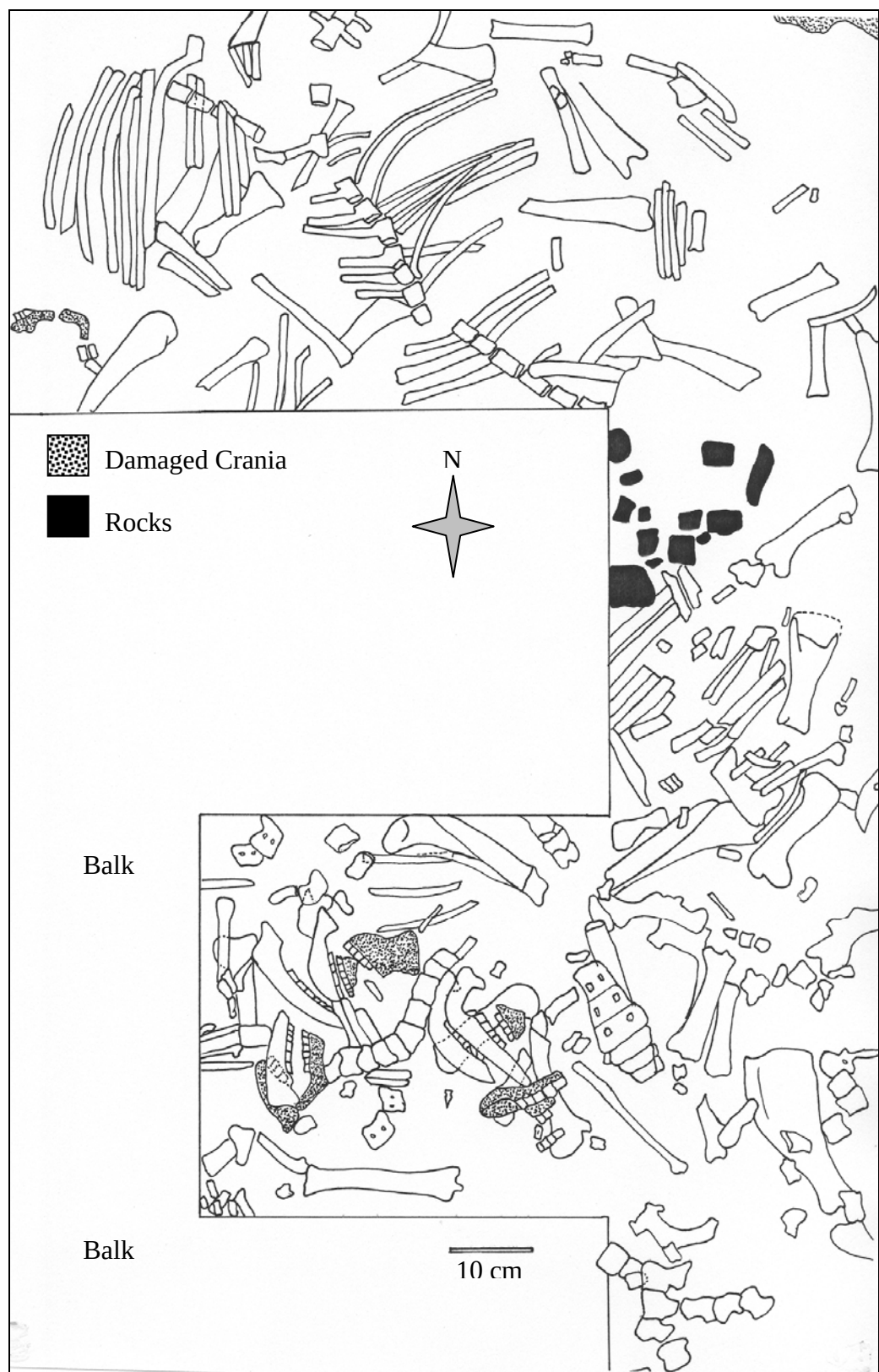


Figure 5.19. Southeast corner of Bone Bed 1 (N11/12-E14). Note axials, semi-articulated limbs, and mandibles.

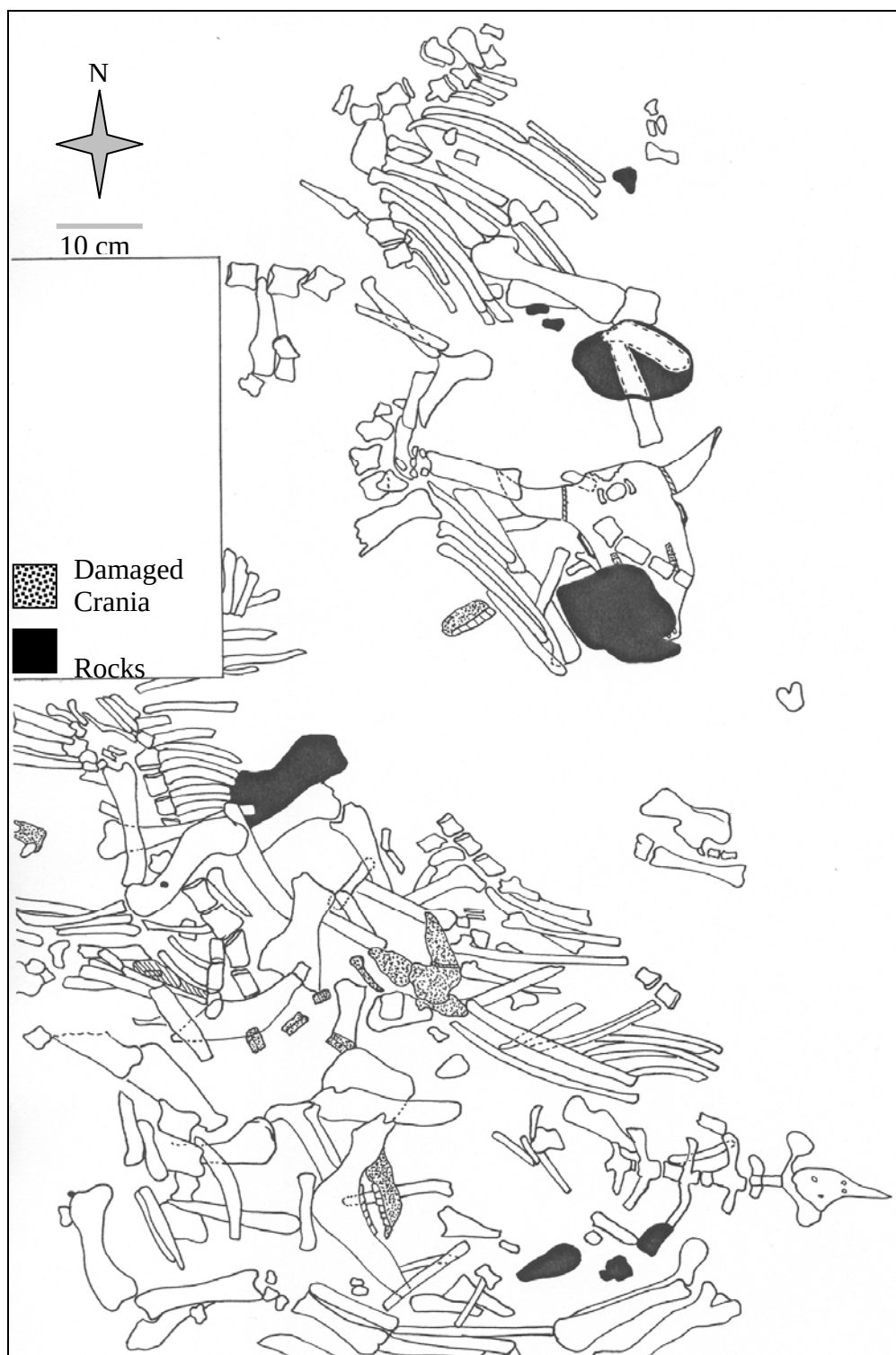


Figure 5.20. North central part of Bone Bed 1 (N11/12-E14). Note axials, complete & partial crania, and rocks.

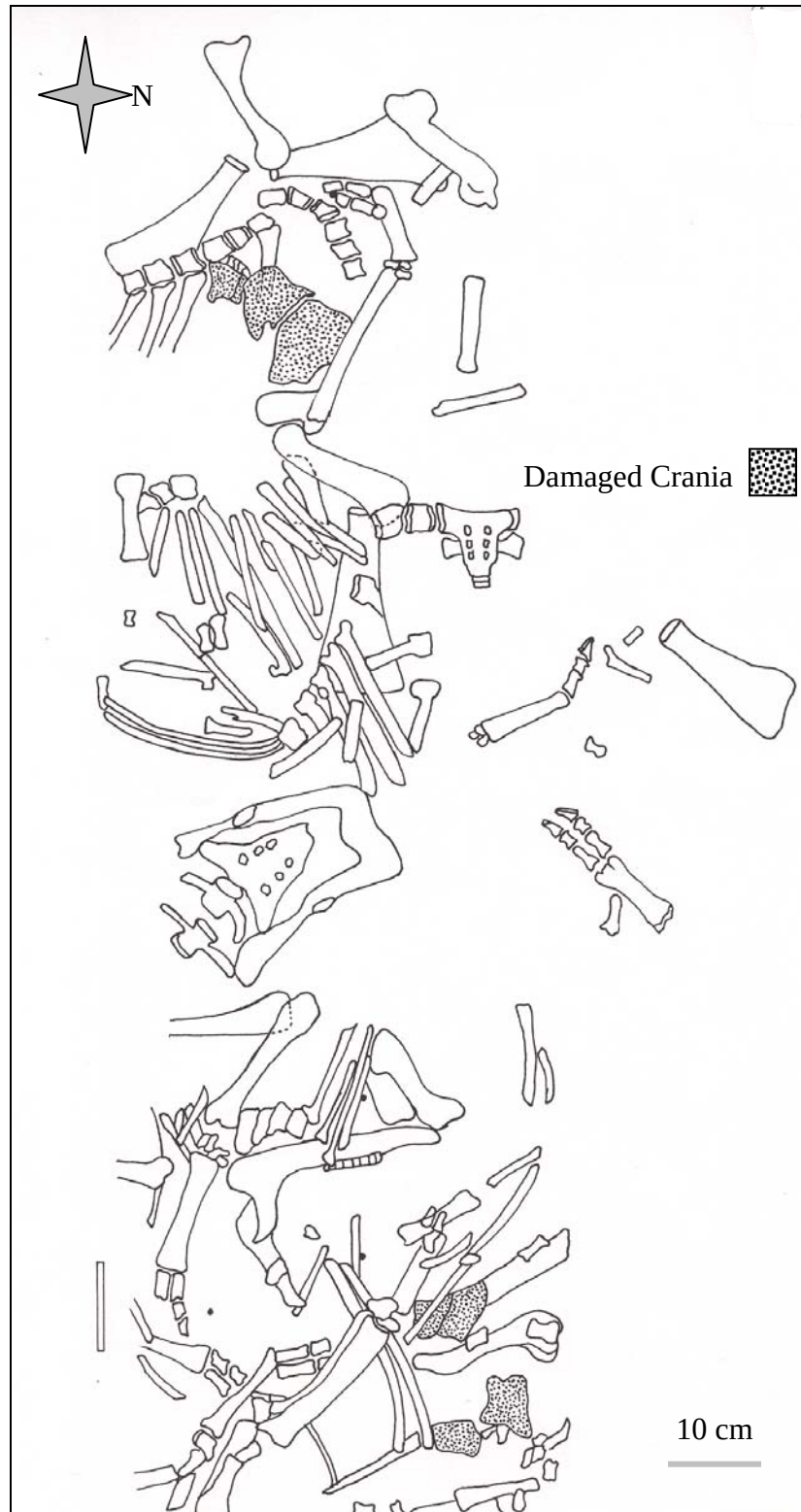


Figure 5.211. North central part of Bone Bed 1 (N11/13-E14). Note vertebral column, partial crania, pelvis, sacrum, and leg segments.

Area D

Introduction

Area D is interpreted as a secondary processing area or support facility such as that uncovered in Area B. Bone was observed protruding from an erosional cut on the south side of the modern canyon opposite trenches A and C (Figure 5.7). In 1994 the face of the gully head was cleaned for a profile (Kraft 1994b). The matrix was sifted through 7 mm mesh. No artifacts were recovered and the exposed bone was left in place. That same year, the author secured funding to perform exploratory coring on the south side of the modern canyon (Kraft 1994b) (Figure 5.22). The coring program would complement that performed by Survey staff in 1992 (Bement and Buehler 1994:176, Figure 3). Using a truck mounted soil auger, cores were taken at 10 m intervals perpendicular to the side canyon dubbed Area D. Coring revealed that the bone was contained in a now-filled, gently sloping, paleo gully. According to the soil probes, the bedrock rose sharply on the east and west which formed the ancient canyon walls. Subsequent research at Area D confirms this interpretation (Green 2002:101-104).

Results of Excavations—Area D

During the 1995 University of Oklahoma field school, Area D was excavated while work continued at Trench C on the north side of the modern canyon (Kraft and Bement 1995). The excavation strategy was to remove the matrix from above the eroding bone, thus exposing the layout of the bones seen in profile. Dimensions of the excavation unit were 1 x 2 m, east-west and north-south respectively. A temporary datum was set in the northwest corner of the 1 x 2, approximately 2 m below surface. The unit was excavated in arbitrary 10-cm levels for vertical control. All excavated material was screened in the field through 7 mm mesh (Table 5.3). No stone artifacts were recovered from the excavation unit or from the canyon wall or floor. Several burned bones encased in sediment were recovered as a unit. The bone accumulations were cleaned and screened in the laboratory through a #4 sieve. The burned bone is mostly rib fragments, with sizes ranging from 15 to 60 mm. There are some burned long-bone splinters and unburned

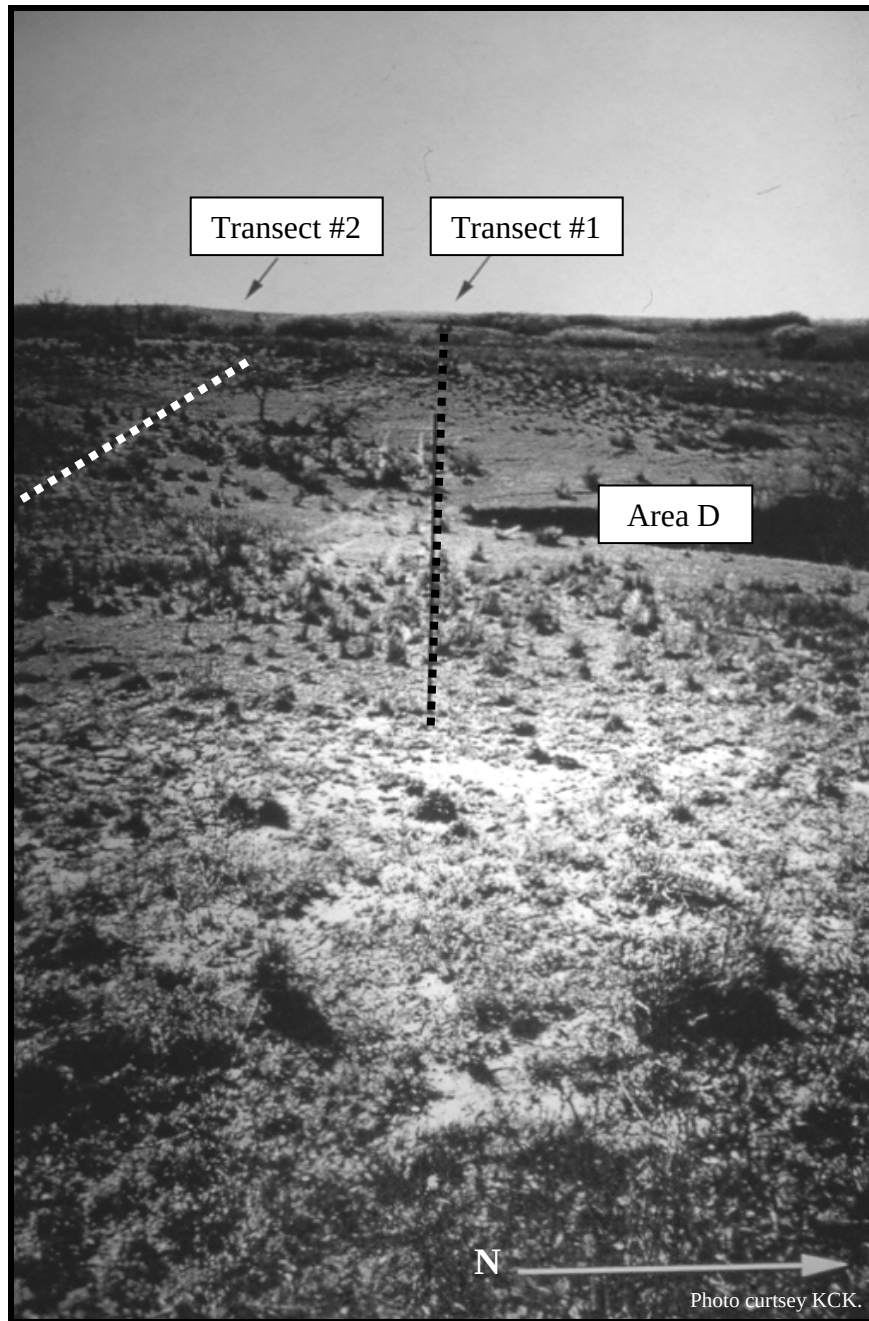


Figure 5.22. Orientation of soil coring adjacent to Area D. Trench D was subsequently excavated at the edge of the recently formed gully. Bison bones were seen in the gully wall at a depth of ~2 m.

long-bone splinters as well. The miscellaneous burned bone fragments weighed approximately 135 g total. Weight of the material was calculated rather than a count since

weight better represents the mass of burned bone recovered. The burned bone could have come from bone grease production, but according to Vehik (1977:172), bones would not be burned during the grease rendering process. The only way bone fragments could be burned would be if they were subsequently discarded in the fire pit used to heat the water-bone mixture.

Apart from these bones, a few other items were also present. Three relatively large clasts were recovered during excavation. These stones measured 20 x 17 mm, 35 x 25 mm, and 13 x 6 mm in dimension. This offers a clue to the great hydraulic force, which passed over the bone before being completely sealed. The stones are too small to have served as butchering tools. Three hackberry seeds were also recovered from the sieved sediment. Additionally, one of the burned bone clumps removed in the field and processed in the laboratory contained the left ulna from a Plains pocket gopher (*Geomys bursarius*). The most notable aspect of the Trench D excavations was the recovery of an articulated forelimb, the distal portion of a hind limb, and a handful of thoracic vertebrae (Figure 5.23). The remains recovered from Trench D are believed to be that of a young bull based

Table 5.3. Excavated Materials from Trench D: 1995.

Level	Amount	Material
1	3.5 g	Burned bone fragments: ribs and humerus
2	7.0 g 0.2 g	Burned bone fragments: ribs and humerus Calcium carbonate (N=4)
3	29.5 g 0.2 g 1 count	Burned bone fragments: ribs and humerus Calcium carbonate (N=4) Quartzite flake: medial (8.4 x 1.1 mm)
4	104.5 g 22 count >0.1 g	Rib head-burned Gravel (cobbles/pebbles)* Calcium carbonate (N=1)
5	182.0 g 3 count 0.8 g	Rib head-burned Hackberry seeds Calcium carbonate (N=6)

* Largest clast measures 35.6 x 20.4 x 22.5 mm.

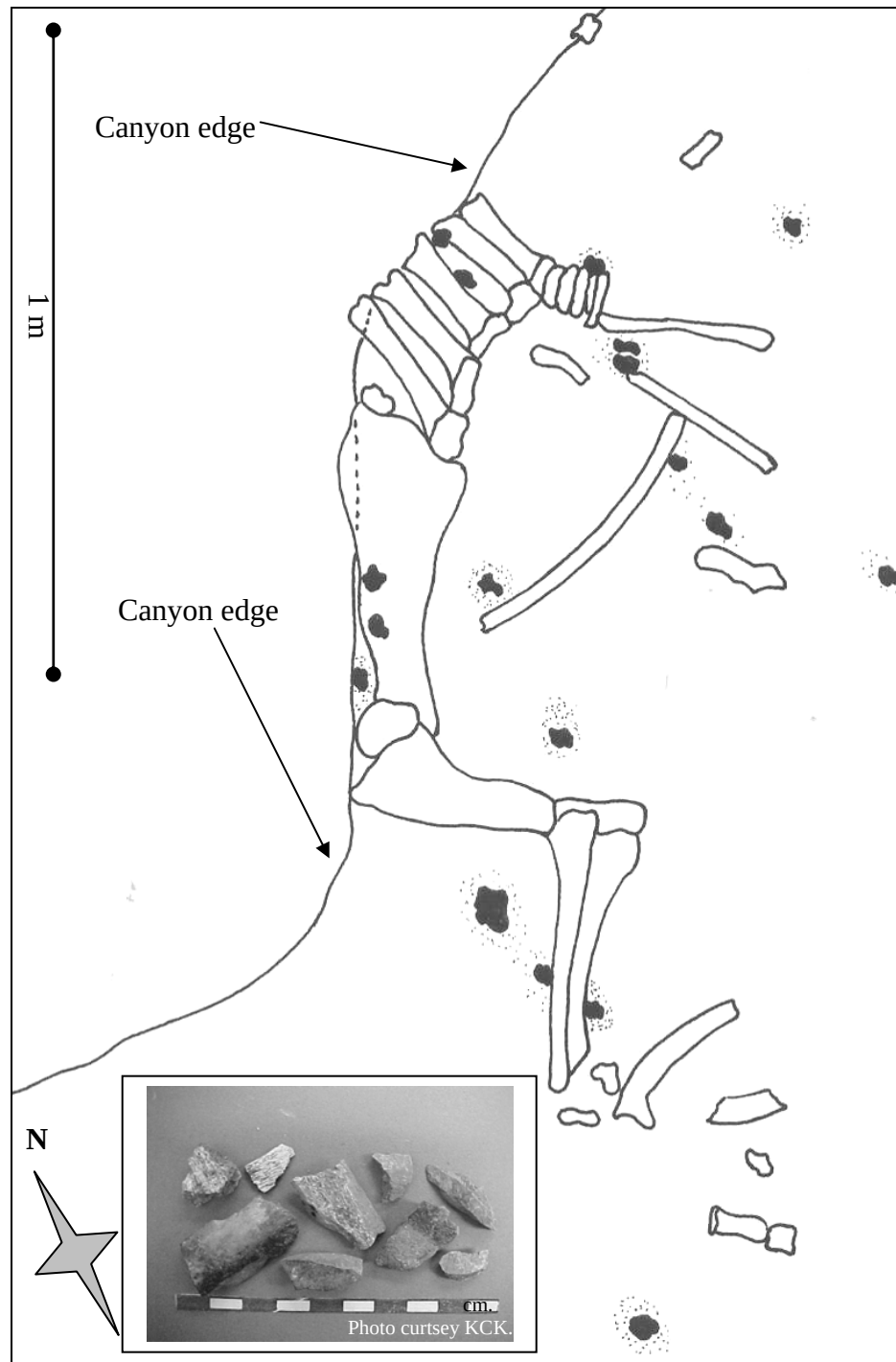


Figure 5.23. Trench D articulated right leg segment. Black areas are burned bone clusters probably from fluvial displacement of hearth material. No pit was detected during excavations. Inset is burned bone clusters processed in the laboratory under controlled conditions.

on comparative specimens. All bone surfaces were examined with the aid of a hand-lens (Table 5.4). Suspicious surface features were further scrutinized under a microscope. Surface characteristics were noted based on biological, chemical, cultural, and other agents (Table 5.5). Weathering stages are based on Behrensmeyer (1978) and Todd (1987a:117-128).

The articulated limb segment recovered from Trench D includes the scapula, humerus, and radius-ulna, in addition to five carpals (Figure 5.24). Five articulated thoracic vertebrae were also recovered as a result of excavations. The vast majority of the bones recovered were ribs. Besides the leg and hump section transported to Area D, it appears that a rack of ribs were included. Based on analysis of all the recovered faunal elements, every bone came from the right side of at least one animal. However it is possible that a few ribs from the left side of the animal made their way to Area D. A description of the bones recovered from Trench D follows.

The right scapula recovered from the excavations appears to have rodent gnawing, however, the marks also resemble biface cut marks (Figures 5.25a-b). Stone tool cut marks are generally short, parallel series of cuts with an open cross section (Binford 1981:105; Walker and Long 1977:607, 609-611). Savage (1995:260) observed similar markings further down on the scapulae but the marks were attributed to butchering. No such marks were observed on the bone in question, however. The extreme root etching makes a definitive assessment difficult (Buckman and Brandy 1969:14-17). Under the microscope, the opposing surface of the altered bone has faint tooth marks suggesting the indentations are representative of an animal actor rather than humans, most likely Plains pocket gopher (*Geomys bursarius*) (Figures 5.26). Evidence of burrowing animals has been noted previously.

Table 5.4. Faunal Materials Recovered from Trench D: 1995.

Cat. #	Count	Element	Side	Comments/Damage
1272	1 of 9	Scapula	Right	Rodent gnawed
1272	2 of 9	Humerus	Right	Spiral fractured-distal
1272	3 of 9	Radius	Right	Root etched
1272	4 of 9	Ulna	Right	Rodent gnawed; root etched
1272	5 of 9	Accessory carpal	Right	Root etched
1272	6 of 9	Ulnar carpal	Right	Root etched
1272	7 of 9	Intermediate carpal	Right	Rodent gnawed; root etched
1272	8 of 9	4th carpal	Right	Rodent gnawed; root etched
1272	9 of 9	5th metacarpal	Right	Rodent gnawed; root etched
1273	5	Thoracic vertebrae	—	Postmortem breakage; etched
1274	1	Rib fragment	Unknown	Burned; body fragment
1275	1	Thoracic vertebra (isolated)	—	Root etched
1276	1	Rib fragment	Left?	Root etched; body fragment
1277	1	Rib fragment (head)	Unknown	Burned; proximal fragment (head)
1278	1	Rib fragment	Unknown	Burned; postmortem breakage
1279	5	Rib fragments incl. head	Right	Root etched; spiral fractd.; rodent gnawed
1280	3	Rib fragments	Unknown	Burned; fragmented
1281	6	Rib fragments	Unknown	Burned, fragmented
1282	1	Rib fragment	Unknown	Splintered
1283	1	Humerus fragment	Right ?	Burned; fragmented
1284	1	Rib	Right	Root etched, spiral fractured
1285	3	Rib fragments	Unknown	2 burned, 1 unburned
1286	1	Rib fragment	Unknown	Burned
1287	1	Calcaneus	Right	Splintered; exfoliated (Stage 3)
1288	1	Humerus fragment	Right?	Burned; fragmented
1289	1	Rib fragment (head)	Right	Burned; splintered; "dry" break
1290	1	Unidentified	—	Burned; fragmented
1291	1	Rib fragment	Unknown	Burned; fragmented
1292	1	Rib fragment	Unknown	Burned
1293	1	Proximal-lateral sesamoid	Right	Minor cracking
1294	1	Rib fragment (head)	Right	Rodent gnawed; root etched
1295	1	2nd & 3rd carpal (fused)	Right	Root etched
1296	1	1st phalanx	Right	Root etched
1297	1	2nd phalanx	Right	Root etched
1298	1	Rib fragment	Unknown	Burned; fragmented
1299	1	Rib fragment	Unknown	Burned; fragmented

Table 5.5. Trench D Faunal Materials---Taphonomy: 1995.

Catalog #	Element	Weathering Stage* & Other Comments
1272	Scapula	Stage 2 (rodent gnawed)
1272	Humerus	Stage 3 (spiral fractured); culturally modified
1272	Radius	Stage 3 (root etched); linear fracture
1272	Ulna	Stage 3 (slight cracking) faunal and chemical alteration; bleached
1272	Accessory carpal	Stage 2 (slight cracking; no flaking)
1272	Ulnar carpal	Stage 2 (slight cracking; no flaking)
1272	Intermediate carpal	Stage 2 (slight cracking; no flaking)
1272	4th carpal	Stage 2 (slight cracking; no flaking)
1272	5th metacarpal	Stage 2 (slight cracking; no flaking)
1273	Thoracic vertebrae	Stage 3 (cracking; bleached) postmortem breakage
1274	Rib fragment	Stage 4 (fragmented); burned
1275	Thoracic vertebra (isolated)	Stage 2 (slight linear cracking); no cultural modification
1276	Rib fragment	Stage 4 (fragmented); culturally modified
1277	Rib fragment (head)	Stage 4 (fragmented); culturally modified?
1278	Rib fragment	Stage 4 (fragmented); culturally modified?
1279	Rib fragments incl. head	Stage 4 (fragmented); culturally modified?
1280	Rib fragments	Stage 4 (fragmented); culturally modified?
1281	Rib fragments	Stage 4 (fragmented); culturally modified?
1282	Rib fragment	Stage 5 (disintegrating); culturally modified?
1283	Humerus fragment	Stage 4 (disintegrating); culturally modified
1284	Rib	Stage 3 (spiral fractured); culturally modified
1285	Rib fragments	Stage 4 (fragmented); burned
1286	Rib fragment	Stage 4 (fragmented, splintered); burned
1287	Calcaneum	Stage 3 (splintered, exfoliated); bleached
1288	Humerus fragment	Stage 3 (fragmented); burned
1289	Rib fragment (head)	Stage 2 (splintered; transverse break); burned; postmortem damage
1290	Unidentified	Stage 4 (fragmented); burned
1291	Rib fragment	Stage 4 (fragmented); burned
1292	Rib fragment	Stage 4 (fragmented; splintered); burned
1293	Proximal-lateral sesamoid	Stage 1 (minor cracking); bleached
1294	Rib fragment (head)	Stage 4 (fragmented); burned; root etched
1295	2nd & 3rd carpal (fused)	Stage 3 (splintered; exfoliated); bleached; no cultural modification
1296	Rib fragment	Stage 3 (splintered; exfoliated); bleached; no cultural modification
1297	Rib fragment	Stage 3 (splintered; exfoliated); bleached; no cultural modification

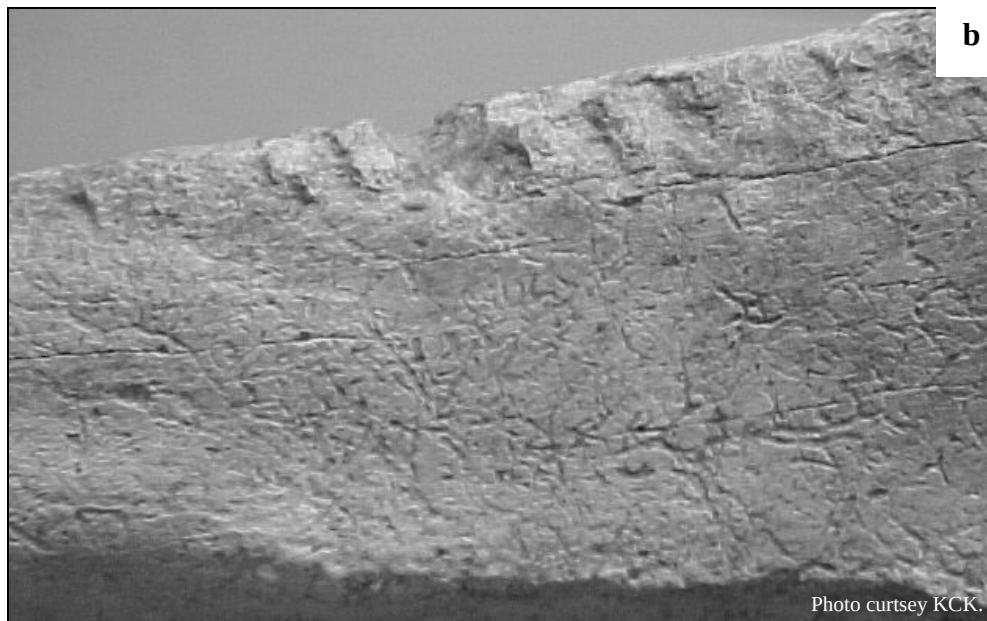
Note: Data from Behrensmeyer (1978) and Todd (1987a:117-128).



Figure 5.24. Trench D articulated right leg segment. View east.

The recovered humerus displays a spiral fracture indicative of a break before or soon after death (Hughes 1986). The break occurs on the distal end. The shaft of the element was pulverized and all that remains are burned fragments. Perhaps this is a sign of marrow extraction and processing. The fragments could not be refit. In other words, certain segments of the shaft are missing. Two other humerus fragments were recovered from Trench D. The specimens are presumed to be segments of the fractured humerus from the articulated forelimb described above. The reason for the humerus fragment being positioned away from the other bones is unclear.

The radius, articulated to the humerus and scapula, contains a linear crack along the shaft, which radiates from anterior to posterior. The ulna is detached from the radius; it is unclear if the separation occurred postmortem or perimortem. Rodent gnawing and root etching are present. Root etching indicates that subsurface burial was not immediate and the element lay upon the surface. Based on personal observations, the etching suggests



Figures 5.25a-b. Right bison scapula from Trench D: (a) rodent gnawing; (b) close-up view of gnawing. Not to scale.



Figure 5.26. Note the distinct characteristics of Geomys bursarius' dentition. Specimens courtesy of Oklahoma Archeological Survey.

that the bone was partially exposed for at least two growing seasons and possibly more. Five carpals were associated with the articulated limb segment also. The specific bones are the accessory, ulnar, intermediate, fourth, and fifth carpals. All carpal bones are in relatively good shape.

The next set of articulated elements uncovered in Area D was five thoracic vertebrae. According to Binford (1981:110-113) thoracic vertebrae are likely to have multiple transverse cuts on the upper flanks of the neural spine and just below the rib heads as a result of butchering. Such damage is attributed to filleting the tenderloin. Root etching on the Trench D specimens made it difficult to identify any cut marks. The vertebrae are presumably associated with the various ribs, also recovered from the processing area. Extensive post mortem damage has occurred to these specimens also. Articular ends are friable which may be the result of perimortem processing. On the other hand, the decomposition is probably due to the animal not being fully mature, and thus the vertebral bodies not being completely developed. This developmental characteristic provides a relative age indicator. From this, the animal is roughly estimated to be five years of age. Another thoracic vertebra was recovered from Trench D. This isolate was displaced from the five articulated thoracic vertebrae by some 30 cm.

Several rib fragments were also recovered from Trench D. The specimens are in various stages of decomposition. Many of the fragments are burned and some still had fusion lines visible. Most of the ribs display root etching, spiral fracturing and rodent gnawing. In one instance a section of rib was found atop the vertebrae articulation. When this rib is oriented in anatomical position, with sharp edge posterior, the shaft portion of the element becomes wider. This suggests that the rib is from the left side of the body unlike the majority of the ribs and the limb segments which are from the right side of an animal.

Besides the front, right limb of a single bison, and possibly the ribs from both sides of an animal, a portion of a hind limb was recovered. A single calcaneum was associated with the above bones. This element is large compared to known bison cows in the comparative collection. Thus, a logical conclusion would be that the specimen represents a large, mature cow or a bull. However, the lack of complete fusion between the epiphysis and diaphysis indicates that the animal is not entirely mature and therefore cannot represent a mature cow. Also of importance, the splintering and exfoliating of the exterior surface suggests that the bone lay exposed to the elements for a relatively long period of time. These observations coincide with Behrensmeyer's (1978) Stage 3 weathering. Stage 3 weathering is indicative of extensive exposure to the elements which often lead to chemical digenesis.

Finally, a proximal-lateral sesamoid was recovered from Trench D. It is probably affiliated with the articulated forelimb described in detail above. Much like the scapula and calcaneum discussed earlier, this carpal is relatively large in relation to the comparative specimen (cow) of the same age. Based on this, the carpal probably came from a bull as well. Additionally a first phalanx and second phalanx were also recovered at Trench D. The size of these two elements leads to the conclusion that the lower portion of a bull's limb was deposited at the processing locality.

Absolute Dating—Area D

One bone sample was submitted for radiocarbon dating from Area D. The uncorrected date for the collagen sample was 1540 ± 70 BP (Beta 110540). The ^{13}C adjustment places the date at 1810 ± 70 BP. The aforementioned conventional age of 1810 ± 70 BP has a $^{13}\text{C}/^{12}\text{C}$ ratio of -8.1 . By adjusting the date for the XAD calculations published by Hofman (1995:431), the Trench D date would roughly calculate to 2010 ± 70 BP. A rough calendar date of 60 BC is not totally unreasonable although speculative.

Area E

Introduction

Area E is yet another secondary processing area (support facility) comparable to areas B and D. This locality was first identified from bone protruding from the canyon wall. The locality was briefly examined in early 1995 and excavated during the 1995 field season (Kraft and Bement 1995). As was the case at Trench D, the excavation strategy was to remove the matrix from above the eroding bone. As a result, the layout of the bones seen in profile could be seen in plan view. Upon coming into contact with the bones, a structural crack was noted in the ground surface. The crack was filled with a different color soil making the feature even more discernable. In time the mass of soil, with bones, would sheer off and slide down the canyon wall. Similar slump blocks are noted all along the modern canyon.

Dimensions of the excavation unit were 1.5×2.25 m, north-south and east-west respectively. A temporary datum was set in the northwest corner of the unit, approximately 2.25 m below surface. The unit was excavated in arbitrary 10 cm levels for vertical control. All excavated material was screened in the field through 7 mm mesh. Only three caudal vertebrae and a proximal sesamoid were recovered from the screen. The tail bones came from Level 2 (10-20 cmbd) and the sesamoid from Level 3 (20-30 cmbd). No other bones were recovered from the excavated levels. No stone artifacts were

recovered from the excavation unit, from the canyon wall, or canyon floor. Additionally, no absolute dating was performed.

Results of Excavations—Area E

Trench E represents the articulated left hind limb of a bison (Figure 5.27). The rear leg segment was apparently carried to Area E intact. Included were the left femur, tibia, patella, metatarsal, calcaneus, astragalus, and three cannon bones. A right femur, a right patella, the right proximal, medial, and distal phalanges, two right tarsals, four ribs, and a left radius were also recovered (Table 5.6). Based on the bone assemblage, at the least, two or possibly three animals are represented by the recovered bones. Based on comparative samples, the size and length of the long-bones, metatarsal, calcaneum, and astragalus of the Trench E specimens represent a cow. All bone surfaces were examined with the aid of a hand-lens. Suspicious features were further scrutinized under a microscope. Surface characteristics were noted based on biological, chemical, cultural, and other agents (Table 5.7). Comments on weathering conform to Behrensmeyer (1978) and Todd (1987a:117-128).

An unidentified element, triangular in cross-section, possibly represents a radius or tibia from a bison. It was displaced from the major bone accumulation by 70 cm. The anatomical side of the bone was also indeterminate. It is very likely that the bone is a right tibia since a right femur was recovered as was a right patella, right medial tarsal, and a right third phalanx (Figure 5.28). The right metatarsal is missing. Evidence of carnivore activity at Area E can be seen on the head of one of the femurs (Figure 5.29). The presence of carnivores at bison bone beds has been noted elsewhere (Bement 1999:59-61, 87-88, 106-107, 133; Kraft 1993:4-7; Todd 1987b:150-153; Todd et al. 1997). Another damaged bone is a left tibia. The bone is fragmented, but does not appear

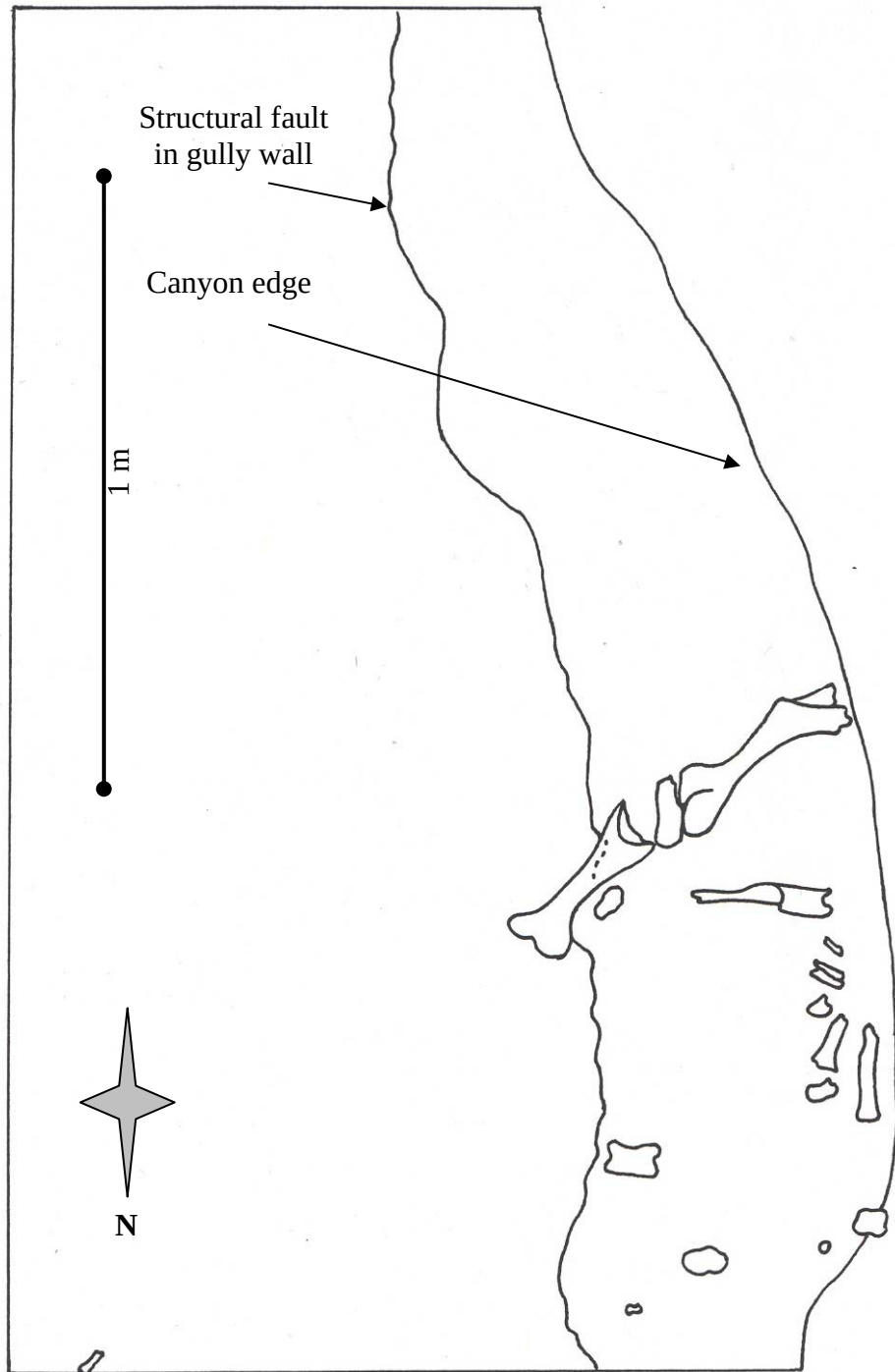


Figure 5.27. Trench E articulated left leg segment. Also includes elements from a right leg. No pit was detected during excavations.

Table 5.6. Faunal Materials Recovered from Trench E: 1995.

Catalog #	Count	Element	Age	Side	Comments
1400	1	Tibia or Radius	Unknown	Indeterminate	Fragment (74.7 x 15.5mm); triangular cross-section
1401 (a)	1	Sesamoid-proximal	Unknown	Left	Proximal-medial
1401 (b)	1	Sesamoid-proximal	Unknown	Left	Proximal-lateral
1402	1	3rd phalanx	Unknown	Right	Chemical damage---disintegrating
1403	1	Sesamoid-distal	Unknown	Left	Chemical damage---disintegrating
1404	1	Patella	Unknown	Right	Chemical damage---disintegrating
1405	1	Astragalus	Unknown	Left	No cultural or subsurface mods.; fused (approx. >2-3 ya)
1406	1	2nd phalanx	Subadult	Left	No cultural or subsurface modifications
1407	1	Calcaneum	Subadult	Left	Not completely fused (<5 ya)
1408	1	1st phalanx	Subadult	Left	No cultural or subsurface mods.; fused (approx. >2-3 ya)
1409	1	Metatarsal	Adult	Left	Smaller than male comparative specimen (female?)
1410	1	Rib fragment	Unknown	Indeterminate	Extensive root etching; (62mm L); midsection-age indeterminate.
1411	1	Medial tarsal (2 & 3)	Unknown	Right	Chemical damage---disintegrating; anterior fragment
1412	1	Patella	Unknown	Left	Chemical damage---disintegrating
1413	1	Tibia fragment	Adult	Left	Distal fragment
1414	1	Rib fragment	Unknown	Indeterminate	Extensive root etching; (92.1mm L); midsection-age indeterminate
1415	1	Femur	Adult	Left	Chemical damage-all articular surfaces & trochanteric ridge
1416	1	Femur	Adult	Right	Chemical damage-all articular surfaces; reconstructed
1417	3	Caudal vertebrae	N/A	—	Level 3 (20-30 cm below datum)-screened
1418	1	Sesamoid-proximal	Unknown	Right	Level 4 (30-40 cm below datum)-screened
1419	1	Radius	Subadult	Left	In canyon below excavation; not completely fused (<5 ya)

Note: Datum set at 2.3 meters below surface.

Table 5.7. Trench E Faunal Materials---Taphonomy: 1995.

Catalog #	Element	Weathering Stage* & Other Comments
1400	Tibia or Radius	Stage 3 (homogeneous weathering; fibrous texture); bleached & rounded
1401 (a)	Sesamoid-proximal, medial	Stage 2 (cracking & flaking); bleached & rounded
1401 (b)	Sesamoid-proximal, lateral	Stage 2 (cracking & flaking); bleached & rounded
1402	3rd phalanx	Stage 5 (disintegrating); weathered
1403	Sesamoid-distal	Stage 2 (cracking & flaking); bleached & rounded
1404	Patella	Stage 5 (disintegrating; fragile & easily broken)
1405	Astragalus	Stage 2 (cracking & flaking); no cultural modifications
1406	2nd phalanx	Stage 2 (cracking & flaking)
1407	Calcaneum	Stage 2 (cracking & flaking); no cultural modifications
1408	1st phalanx	Stage 2 (cracking & flaking)
1409	Metatarsal	Stage 2 (cracking & flaking); no cultural modifications
1410	Rib fragment	Stage 3 (weathered; fibrous texture); extensive root etching
1411	Medial tarsal ("fused 2 & 3")	Stage 5 (disintegrating); fragmented
1412	Patella	Stage 5 (disintegrate; fragile & easily broken)
1413	Tibia fragment	Stage 2 (cracking & flaking); green break & root etching
1414	Rib fragment	Stage 3 (weathered; fibrous texture); extensive root etching
1415	Femur	Stage 4 (weathering on articular surfaces & trochanteric ridge); root etching
1416	Femur	Stage 4 (weathering on all articular surfaces); root etching
1417	Caudal vertebrae	Stage 5 (disintegrating; fragile & easily broken); bleached & rounded
1418	Proximal sesamoid	Stage 2 (cracking & flaking); bleached & rounded
1419	Radius	Stage 2 (cracking & flaking---recent exposure); postmortem breakage

*Behrensmeyer 1978; Todd (1987a:117-128).



Figure 5.28. Plan view of Trench E. Note articulated leg segment of a five-year-old bison cow. North is the bottom of the photograph.



Figure 5.29. Canine tooth mark on the head of right femur recovered from Trench E.

to have been used as a tool (Figure 5.30a). The proximal end of the bone was not recovered. No other long bones are broken besides the tibia and a radius described below.

Another bone displaying damage is a left radius. The broken specimen exhibits differential weathering patterns (Figure 5.30b). Both pieces of the bone were altered by surface exposure prehistorically, but one-half has recently been exposed again as indicated by freshly exfoliated areas and sun bleaching. Some refitting of the fragmented bone is possible, but it is still missing several pieces. Fusion lines still visible between the diaphysis and one epiphysis suggest that the animal was approximately five years of age or less at the time of death. Besides the left radius mentioned above, one left calcaneus was recovered which was not completely fused. Lack of complete fusion places the animal in

the five-year-old range.

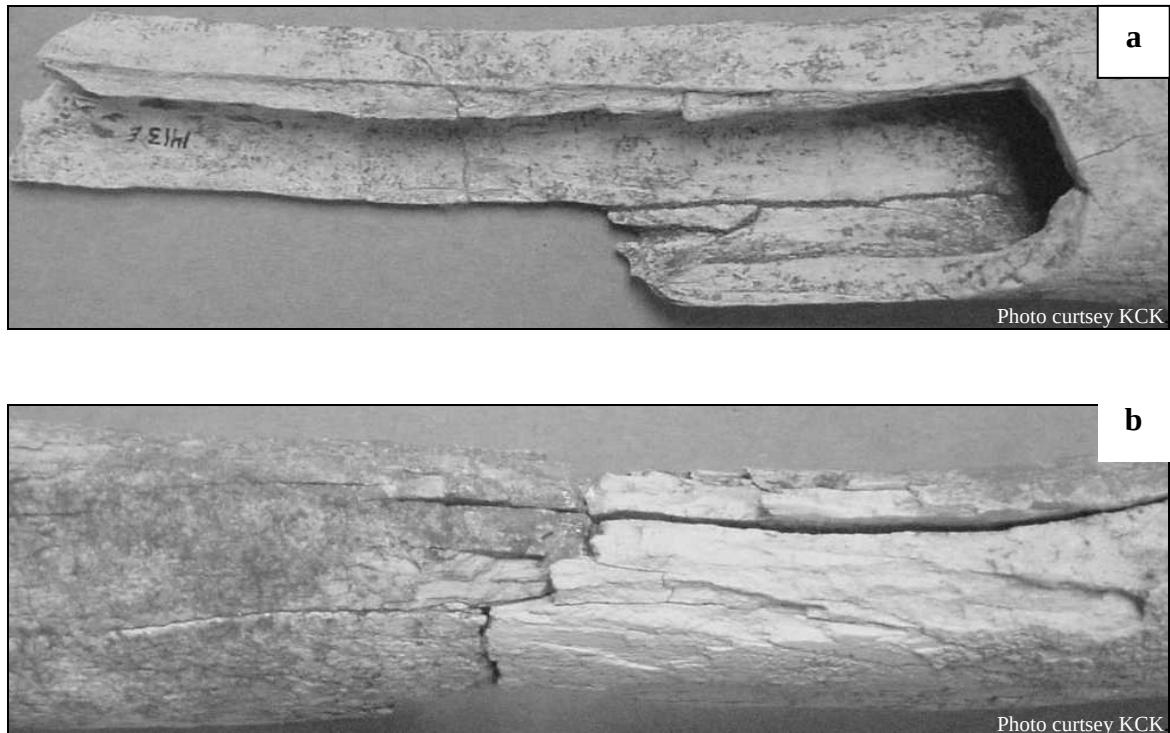


Figure 5.30. Trench E bones with differential breakage patterns: (a) tibia with green bone fracture as well as environmental weathering; (b) radius with differential weathering as a result of partial exposure. Not to scale.

The recovery of a left articulated rear limb from a bison alludes to the presence of one animal. Other bones recovered from Trench E suggest that additional animals are represented in the faunal collection. Besides the articulated left limb, a right femur was recovered. Both femurs exhibit cortical damage on the articular surfaces. Other bones from the right side of a bison include one proximal sesamoid, a third phalanx, a patella, and one medial tarsal. Besides there being two animals represented at the processing locality, the recovered caudal vertebrae indicate that the hide from one of the animals was carted to the location (Figure 5.31).



Figure 5.31. Weathered and root-etched caudal vertebrae from Trench E.

Other Activity Areas at the L. E. Certain Site

Introduction

Four other activity areas have been identified at the L. E. Certain site (areas F through I). However, data on these areas are limited and as a result are not a major part of this dissertation. These areas are simply presented for context. Comments are based on firsthand observations and published information. Areas F through I are all primary kill localities. The kills vary by method of entrapment and season of the year. Preliminary radiocarbon dating also suggests that these kills are separated in time, sometimes by several hundred years (Bement and Buehler 1998).

Area F

Area F is a primary kill on the north side of the modern canyon. Trench F is a few meters east of Trench C (Figure 5.7). Excavations began in 1995 and have continued through the years. Bones were first observed eroding from the wall of the modern canyon in 1993

(Figure 5.32). Once the exposed bone was uncovered, another arroyo style kill was revealed (Figure 5.33). Examination of the recovered mandibles suggests the event took place in the spring. Additionally, a fetal bison was recovered furthering the conclusion that Trench F represents a spring kill event (Bement 2002, personal communication).

Area G

Area G is yet another kill locality on the north side of the modern canyon (Figure 5.7). Bone was observed in the modern canyon wall some years before minimal excavations were undertaken. Under the auspice of an Oklahoma Historic Society, State Historic Preservation Office grant, awarded to the Survey, small scale excavations were conducted as was a comprehensive pedestrian survey downstream from the L. E. Certain site (Bement and Buehler 2000a:1). Additionally, a few bone exposures were investigated.

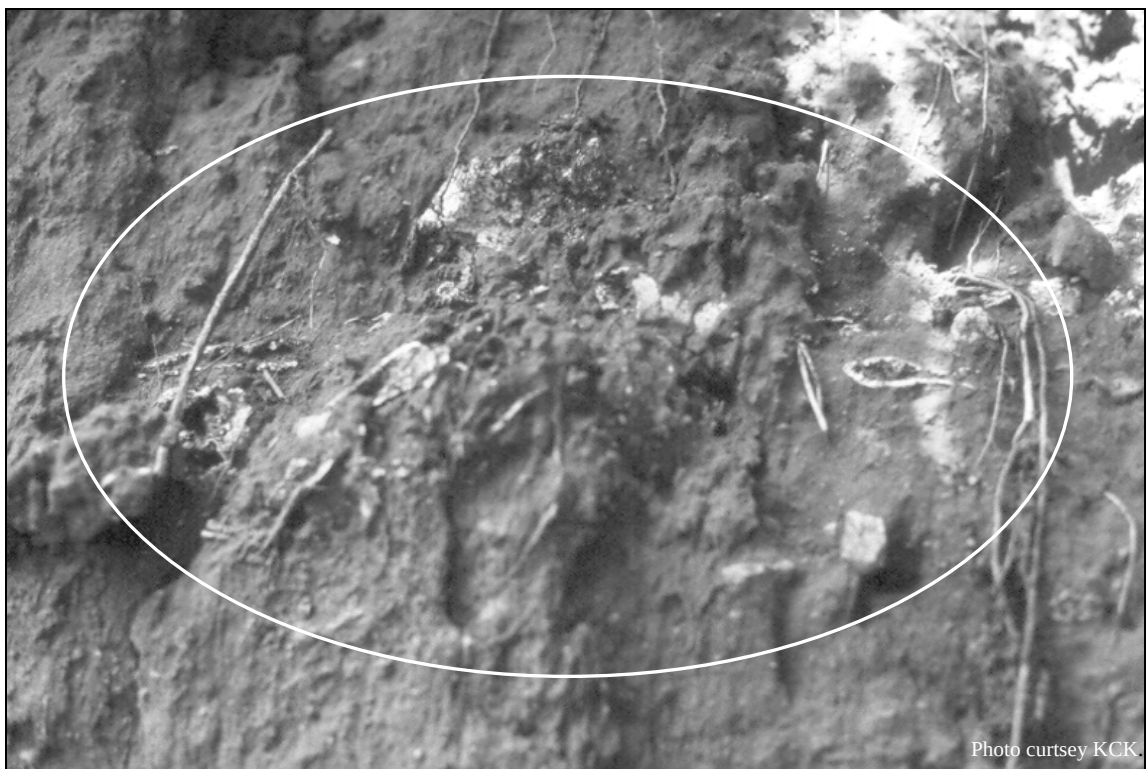


Figure 5.32. Area F bone (circle) in 1993 eroding from canyon wall.



Figure 5.33. Area F bone bed in 1995 after being partially exposed. Canyon edge is at the top of the photograph.

Area G was one of these localities. A level line was established in the immediate vicinity and the exposed bone was recovered (Figure 5.34). Data collected from this locality has yet to be published.

Area H

On the south side of the modern canyon another bone accumulation was discovered (Figure 5.7). Unlike processing areas D and E, also on the south side of the canyon, Area



Figure 5.34. Pedestal from Area G after bone was mapped and recovered.

H is the location of a bison kill. All other kills were on the north side of the modern gully. Investigation of Area H progressed through the years beginning in 1995. In 1996 continued research by Bement and Buehler (1998) and Green (2002:115-119) revealed that the locality is where a bison jump occurred. This is the first jump recorded at the L. E. Certain site. Geology and sedimentation in the canyon confirm that Area H represents a different type of hunting strategy. Additionally, the jump is 400 years older than the arroyo kills (Bement and Buehler 1998). Following a 1997 Cameron University (Lawton, Oklahoma) field school, the bone accumulation at the jump locality was mapped in part by the author (Bement 1997b:2). Apparently the sandstone cliff was buried at the time the arroyo kills were conducted (Bement 1997, personal communication). According to Bement (1997b:2) the cliff would have only been available before the dead end canyons formed.

Area I

Area I is the location of the old tractor road once used by Mr. Certain to traverse the

modern canyon. Bone was first discovered in this area between 1969 and 1970. This area has produced several bones through the years as well as a broken projectile point (refer back to Figures 5.2 and 5.3). Much of the bone recovered was burned. These materials and their condition are presented in Tables 5.1 and 5.2. Based on this information at least three animals are represented. Bement and Buehler (2000a:1) conducted additional work at the location of the old tractor road while preparing the National Register nomination for the L. E. Certain site (Figure 5.35).



Figure 5.35. Trench I (old tractor road) being excavated by Buehler in 1999.

Conclusion

Data gathered from areas A through I at the L. E. Certain site, between 1969 and 1999, were discussed. These areas represent either primary kill localities or secondary processing areas. In 1993 and 1995 University of Oklahoma field schools excavated trenches C through E. These excavations were the primary focus of this chapter although Trench C is discussed further in the next chapter. Finally, radiocarbon dates from various cultural deposits at the L. E. Certain site were discussed. These dates reveal that the site was repeatedly used over a 500 year period, roughly between BC 160 to AD 350.

CHAPTER SIX

FURTHER INTERPRETATION OF THE CERTAIN SITE'S TRENCH C DATA: FAUNA AND LITHICS

Interpretative Analyses

Introduction

Because the deposits at the Area C paleogully are so extensive and only a portion of the locality has been excavated, the following data are far from being complete. Although incomplete, the analysis and the preliminary conclusions outlined below will allow some generalizations. As a result, the relevancy of using evolutionary ecology and optimal foraging theory to pose and answer questions about Late Archaic resources usage will be evident. Finally, a quick note on terminology is necessary. To assist with syntax and flow, I utilize the terms *element* and *specimen* interchangeably, when discussing fauna, rather than follow Shottwell (1955, 1958) who draws a distinction between the two. Terminology utilized to discuss the lithics follows Keeley (1980), Knudson (1983), and Newcomer and Keeley (1979). All data herein is original.

Limitations of Data: Taphonomy

Many taphonomic factors can act upon an archaeological site both before and after burial. As a result, interpretation of features such as bone clusters, hearths and meat-drying racks, and artifacts such as lithic materials and faunal remains, can be skewed. There is no doubt that the law of entropy applies to all archaeological assemblages. In short, the total amount of information that can be gathered from archaeological assemblages declines through time (Sullivan 1978). For example, an archaeological faunal sample is subjected to a series of processes before it is discovered and analyzed. These include a *biotic process* (encounter species), a *thanatic process* (depositional context), a *perthotaxic process* (weathering, gnawing, trampling, and other agents), a *taphic process* (mechanical and chemical actions), and finally an *anataxic process* (attrition). Beyond

the transformation from biosphere to lithosphere, there is the *suilegenic process* (interpretational biases), and finally a *trephic process* (curatorial or storage factors) (Hesse and Wapnish 1985:18-30). Cowgill (1970) and Meadow (1980) break the taphonomic course into populations which are self-explanatory. These include the *target population*, the *physical consequences population*, and the *physical find population*. Equivalents to the above processes and populations are the *life assemblage* which is the living community of animals and the *death assemblage* which is that portion of the living community that might collect in a natural or cultural feature. Additional stages in this taphonomic sequence include the *deposited assemblage* and the *fossil assemblage* (Klein and Cruz-Urbe 1984:1-10). All of the organizational and explanatory schemes mentioned above have one thing in common; each identifies the complexity of taphonomic pathways and thus the limitations of faunal analysis. These processes, populations, and assemblages will be referred to, interchangeably, throughout the text. Sections to follow use these pathways to address butchering patterns and human manipulation of the bison carcasses such as removal of elements and bone stacking. Differential preservation of particular bones and fluvial transport of other bones is also discussed. Additionally, the effect of carnivores, scavengers, and rodents are addressed.

Death Assemblage: Minimum Number of Individuals

Introduction

An estimate of the number of individual bison represented at the L. E. Certain site provides a basis for interpreting possible hunting and processing strategies. For example, the number of animals present in a region can influence bison procurement strategies, including timing of the kills and extent of butchering (Frison 1967:30-32, 1970; Reher 1977a, 1977b; Reher and Frison 1980a). These estimates are based on results from individual kill events. Given this, an estimate of the number of animals recovered so far from Trench C will assist in interpreting the specific activities that took place at the site and the reason specific butchering and transport decisions were made. Such data can also highlight additional cultural adaptations of the Late Archaic bison hunters on the southern

Plains.

When discussing the minimum number of individuals (MNI) in an assemblage, age and gender of the animals cannot be divorced from the equation. As a result, general references to age and gender must be made when presenting MNI data. On the other hand, age and gender data can be discussed without reference to the MNI. Thus, age and gender are presented in separate sections.

Technique

In the most basic sense, the number of animals present in a mortality group can be calculated by select bone frequencies. The relative frequency of skeletal elements is the most basic class of information that can be extracted from a faunal collection (Binford 1978:69; Brain 1981:19, 20; Chaplin 1971:69-70). For archaeologists the next step in this line of inquiry is usually related to human subsistence as well as the relative abundance of different species in the surrounding environment (Grayson 1984:20).

White (1953) was one of the first to utilize bone frequency information in interpreting faunal remains and drawing connections to human behavior. Others who employed an early version of what was later to become known as the Minimum Number of Individuals (MNI) were Howard (1930), Merriam and Stock (1932), and Stock (1929). Like White, the aforementioned researchers had backgrounds in paleontology. The fundamental idea of the MNI calculation is simple since the basic reference unit is a single faunal element. Likewise all faunal assemblages with similar species composition are therefore directly comparable (Chaplin 1971:70). The first step in assessing a death assemblage is to determine the count and frequency for select bones within a sample. For example, a bison has two femora; one left and one right. In turn, this count reveals the potential number of animals killed, harvested, or removed from a kill site depending on the research question. Chaplin (1971:69) states that the minimum numbers method, as he calls his bone count formula, involves no hypotheses and is purely factual. The minimum number of animals

that the bones could have come from is an indisputable fact. Thus, by recording the basic facts, one provides a sound basis for extrapolation or interpolation (Chaplin 1971:70). Despite the MNI method being pioneered by others (Howard 1930; Merriam and Stock 1932; Stock 1929), Binford (1978:69) articulated the technique best. Specifics of the methodology follow.

An MNI is calculated by determining the Minimum Number of Elements (MNE) or the Number of Identified Specimens (NISP). Once the NISP or MNE is calculated, it is divided by the number of elements referable to the same unit in the animal being studied. Appropriately, bison will be used to illustrate this technique. For example, if one left and one right femur are recovered from a site or feature, a preliminary estimate of one animal is represented since bison have one left and one right femur. The MNE or NISP calculation also provides a MAU, or Minimum Number of Animal Units. In short, a MNI calculation begins with a MAU count. The procedure can be extended to estimate the number of animals that contributed parts to an assemblage, manipulated by humans or not. This practice has been widely used by paleontologists (Voorhies 1969). The MNI can be further refined or modified by distinguishing between right and left elements when applicable and by distinguishing between male and female and adult and juvenile animals (Bedford 1974; Binford 1978:69-75; Chaplin 1971:70; Morlan 1991; Nichol and Creak 1979; Peterson and Hughes 1980; Speth 1983:85-117; White 1953:397). By separating old and young, and left and right elements, the severe disadvantage of straight specimen counts (MNE, NISP) can be eliminated (Breitburg 1991). For example, if a faunal collection consists of eight right and nine left femora, the bones must have come from at least nine animals. Moreover, if a collection consists of 11 right, distal femora and 14 right, proximal femora, at least 14 animals are represented. However, the latter is not a statistically accurate measurement of the possible number of individuals represented in an assemblage. Without matching all the femora to the other with respect to age, size, and sex, a maximum number of 25 animals (11 + 14) could be represented (Chaplin 1971:70). As a result, a *modified* MNI is often referenced.

One aspect only briefly discussed in regard to MNIs is the impact humans can have on a recovered faunal assemblage. For example, White (1955:176) concluded that humans act differently toward specific animal parts. Such as it is, the gender of the animal or age can be tied to butchering decisions (Point 1967:120; Speth 1983:85-117). By determining which bones remain or were removed from a site, a basic measure of a species and its importance to a group can be determined (Chaplin 1971:70). Optimal foraging logic follows that those parts of the prey which yielded low food return, relative to transport weight, were rarely removed from the kill site (Daly 1969). Therefore, crania, scapulae, pelvises, and metapodials were often abandoned and not removed from the primary kill locus. As a result, elements with low overall utility for sustenance or tool production offer the best estimate for a MNI of the original kill population (Speth 1983:78). However, Lyman (1991) does question some of the arguments made by archaeologists about differential transport characterizations. It should also be kept in mind that some low utility bones are prime candidates for being removed from a kill site by humans as riders (Binford 1978:74; Daly 1969:149). Given all this, the MNI estimates for several elements from the L. E. Certain site are presented below.

Trench C Findings

The results from the MNI counts calculated for Trench C (NISP 1901) are presented in descending order in Table 6.1. Readily identifiable bones excavated from Trench C in 1993 and 1995 that were used in determining a MNI, include astragali, calcanei, tibiae, femora, humeri, radii, ulnae, and scapulae (Figure 6.1 and Table 6.1). Crania were also used to calculate a MNI for Trench C, since this element is rarely removed from the kill site; however, in rare instances crania were removed for ritual purposes (Bement et al. 1997). Still the best estimate for the number of animals represented so far at Trench C is derived from the recovered mandibles. This is the most accurate estimate since mandible data allows for greater distinction of age and gender groups than other faunal elements (Frison and Reher 1970; Klein and Cruz-Urbe 1983; Reher 1973, 1974; Reher and Frison 1980b). Thus, only the mandible and crania data are detailed.

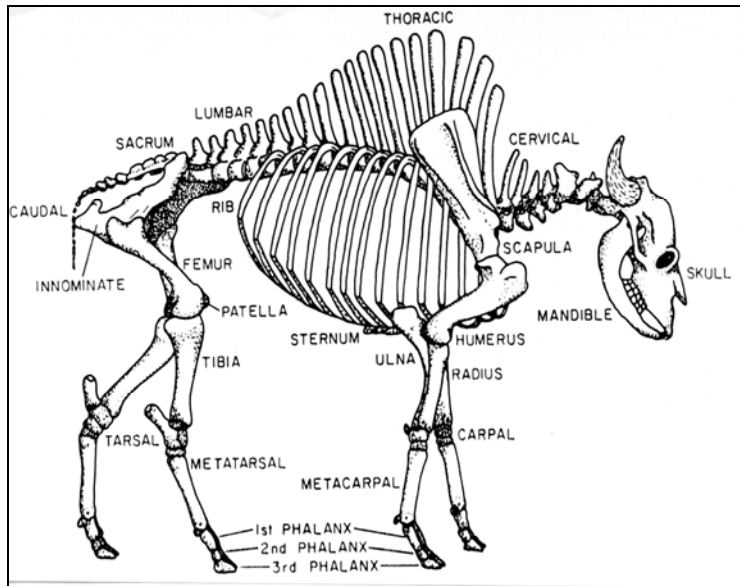


Table 6.1. Minimum Number of Individuals.

Element	Count
Ulnae	20
Calcanei	21
Femora	22
Scapulae	22
Astragali	26
Tibiae	27
Humeri	28
Metatarsals	30
Crania	34
Metacarpals	34
Radii	34
Mandibles	43

Figure 6.1. Bison Anatomy (adapted from Gilbert 1990).

Crania

As mentioned above, the advantage to using crania to determine a preliminary MNI is that skulls are usually not transported elsewhere for processing and consumption (Speth 1983:78). However, White (1952:337) does note that skulls of smaller mammals, such as antelope, are returned to base camps. Nevertheless, since bison crania are usually abandoned at kill sites (Kehoe and Kehoe 1960), they serve well for calculating a cursory MNI count. The recovered crania from Trench C are listed in separate tables based on the 1993 (Table 6.2) and 1995 (Table 6.3) excavations for presentation purposes.

Based upon the number of complete and incomplete crania uncovered in Trench C, 34 individuals are represented (Figure 6.2). Unfortunately, the number of crania excavated and examined does not represent a direct correlation to the number of animals killed since

Table 6.2. Bison Crania (1993).

Cat. #	Field Observation	Condition	Context	Associated Elements	Laboratory Analysis	Age*
1007	Foamed; skull & hyoid	Smashed	Right	Mandible 1007; "ear" 1025	Three, right teeth; atlas---cultural mod.	Mature
1050	Skull fragment	Fragmentary	negligible	Maxillary tooth & ribs	External auditory meatus only	Unknown
1075	Skull fragment	Fragmentary	Negligible	Caudal, pelvis & premolar	Horn core fragment only	Mature
1096	Ear bone	Fragmentary	Negligible	Tibia-astragalus & verts.	External auditory meatus only	Unknown
1156	Skull	Inverted	Negligible	Skull 1181, radius & ribs	Scapula, skull & vertebrae articulation	Unknown
1161	Foamed; skull fragment	Smashed	Right	Mandible 1161, tibia & ribs	Frontal, palatine, premaxilla & three teeth	Mature
1166	Foamed; skull & vertebrae	Smashed	Right	Skull 1166, radius-ulna	Right dental arcade, cervical 1-3 & hyoid	Mature
1167	Foamed; skull & bones	Smashed	Right	Pelvis, verts. & phalanges	Frontal, palatine, premaxilla, R & L arcade	Mature
1178	None	Fragmentary	Right	Mandible 1178	Four well-worn maxillary teeth	Mature
1181	Foamed; skull	Smashed	Right	Skull 1156, pelvis & ribs	Right arcade, palatine, hyoid---cultural mod.	Mature
1184	Maxillary teeth	Fragmentary	Inverted	Mandible 1194 & metacarpal	Four maxillary teeth & bone	Mature
1187	Skull	Fragmentary	Left	Axial 1221 & humerus	Left, maxillary dental arcade only	Mature
1212	Foamed; skull	Fragmentary	Left	Radius-ulna & metacarpal	Left, maxillary dental arcade & premaxilla	Mature
1222	Foamed; skull	Fragmentary	Left	Mandible 1222 & vertebrae	Left, maxillary dental arcade & premaxilla	Mature

*Guthrie 1966a, 1966b; Shackelton et al. 1975; Skinner and Kaise 1947.

Table 6.3. Bison Crania (1995).

Cat. #	Field Observation	Condition	Context	Associated Elements	Laboratory Analysis	Age*
1260	Foamed; horn cores	Smashed	Inverted	Unassociated maxilla at occiput	Severely damaged---cultural modified	Unknown
1476	Foamed; skull frag; horn core	Fragmentary	Inverted	Tibia, humerus	Frontal, parietal & horn core only	Unknown
1550	Skull fragment---bagged	Fragmentary	Negligible	Tibia, radius-ulna, carpals	Temporal & basal-sphenoid only	Unknown
1988	Skull fragment	Fragmentary	Negligible	Tibia, rib, hyoid	Nasal & nasal concha fragment	Unknown
2006	Skull fragment	Fragmentary	Negligible	Vert. column, scapula, metacarpals	Hammerstone (Lithic F)	Unknown
2025	Skull fragment	Fragmentary	Negligible	Tibia, sesamoid, phalanx, tooth	Nasal & nasal concha fragments	Unknown
2051	Atlas & skull fragment---bagged	Smashed	Negligible	Left maxillary premolar---unworn	Atlas & occiput---culturally modified	Juvenile
2092	Foamed; skull frag.	Fragmentary	Left	Mandible 2092	Right, maxillary dental arcade; little bone	Mature
2121	Skull fragment	Fragmentary	Right	Mandible 2121	Left, maxillary dental arcade only	Mature
2148	Foamed; skull	Intact	Inverted	Mandible 2036, radius shaft, rock	Complete crania with horn cores	Mature
2152	Foamed; skull	Compressed	Right	Mandible 2152	Left & right maxillary dental arcades	Juvenile
2190	Skull fragment & hyoid	Intact	Left	Axial 1815---pelvis, vert., scapula	Nasal cavity crushed by overburden	Mature
2198	Five maxillary teeth	Fragmentary	Negligible	Mandible 2150	Tooth row damaged in excavation	Mature
2223	Skull fragment & hyoid---bagged	Fragmentary	Inverted	Two (2) third molars---facets 1-3	Crania frags., maxillary teeth & horn core	Mature
2232	Foamed; skull & teeth	Smashed	Left	Mandible 2232	Left & right maxillary dental arcades	Mature
2253	Maxillary tooth row---bagged	Fragmentary	Negligible	Vertebrae, atlas	Four maxillary teeth, side unknown	Mature
2320	Skull	Smashed	Negligible	Femur	Crania fragments & auditory meatus	Unknown
2365	Skull fragment---bagged	Fragmentary	Negligible	Metatarsal, metacarpal, vertebrae	Bag of fragments	Unknown
2393	Mandible & maxilla	Fragmentary	Left	Mandible 2393	Left maxillary arcade, six teeth; palatine	Unknown
2554	Skull, atlas & axis (Feature 3)	Intact	Inverted	Cervical vertebrae 1-4	Hole in right premaxilla---unit id stake	Mature

*Guthrie 1966a, 1996b; Shackelton et al. 1975; Skinner and Kaise 1947.

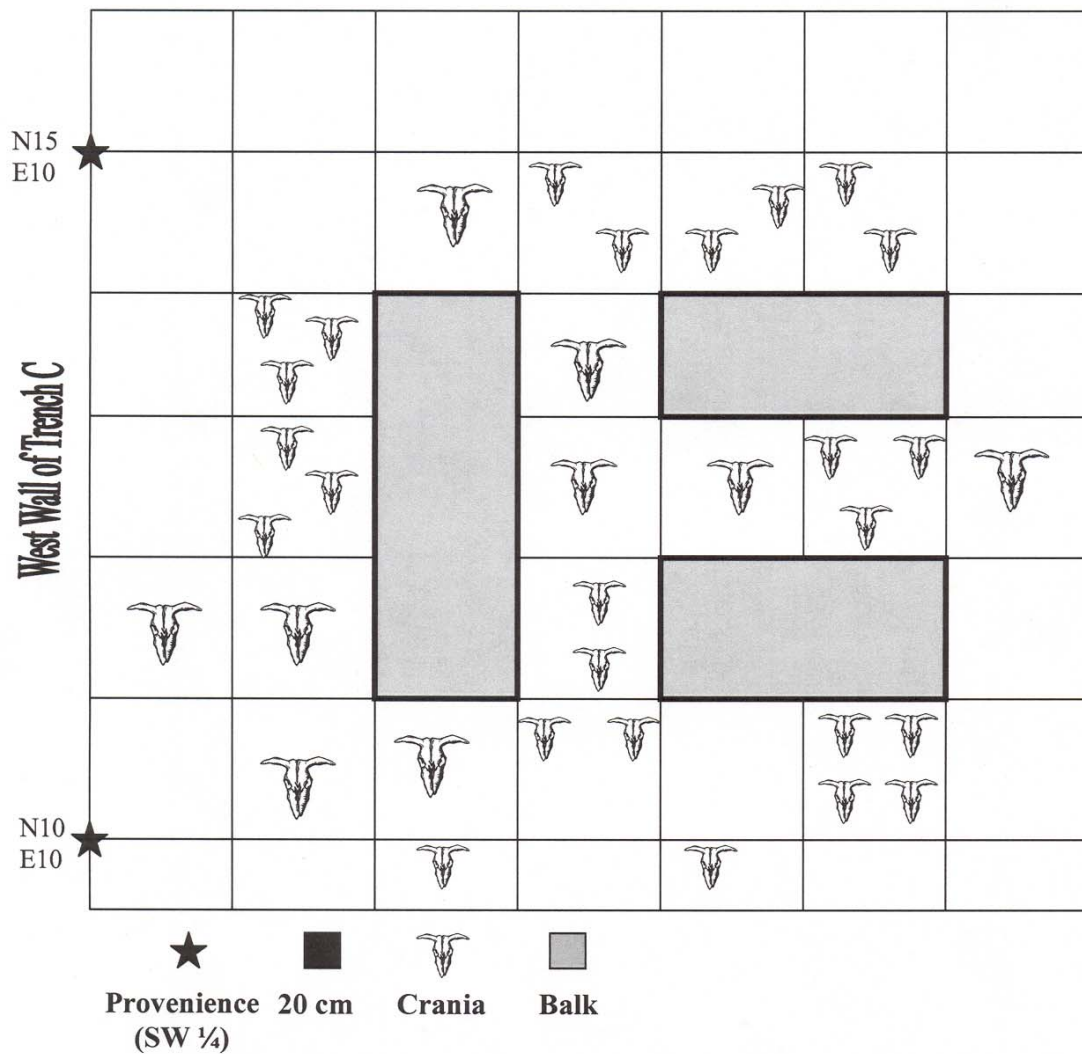


Figure 6.2. Trench C Plan Map 1993 and 1995 Crania.

many of the specimens are fragmentary or obliterated (refer back to Figures 5.11a-b). As a result, some of the isolated dental arcades, horn cores, and external auditory meatus (EAM) that belong to the same animal might have been counted as multiple individuals. Nevertheless, the crania data are corroborated by the metacarpals and radii data (Table 6.1).

Mandibles

As pointed out by Todd (1987a:137-138), bison mandibles and isolated mandibular teeth are often employed by archaeologists to determine MNI counts at kill sites. Lower dentition serves this purpose well since they are often the most frequently recovered element at kill sites. Their occurrence is a result of the meager marrow returns from them and propensity for preservation (Frison 1991:299).

A total of 44 specimens including loose teeth and complete and fragmentary mandibles were analyzed. This count includes 12 paired specimens which were only counted once. This initial MNI of 44 was then adjusted since another set of paired mandibles were assigned separate catalog numbers in the field and analyzed independently as a precaution (#1036A and #1036B). Therefore, of the 44 specimens examined only 43 animals are actually represented. Thus, a *modified* MNI or Grand Minimum Total (GMT) of 43 animals was determined from mandibles (Chaplin 1971:71). The locations of the mandibles in the bone bed are depicted in Figure 6.3.

Death Assemblage: Age

Introduction

One way to determine the relative age of bison is by degree of epiphyseal fusion. This applies to the larger long bones as well as crania. However, dental eruption and attritional wear of the dental arcade are considered the best data for determining age (Bedford 1974; Frison and Reher 1970; Fuller 1959; Gilbert 1990:32, 105-106; Guthrie 1966a, 1966b; Peterson and Hughes 1980; Reher 1973; Shackelton et al. 1975; Skinner and Kaisen

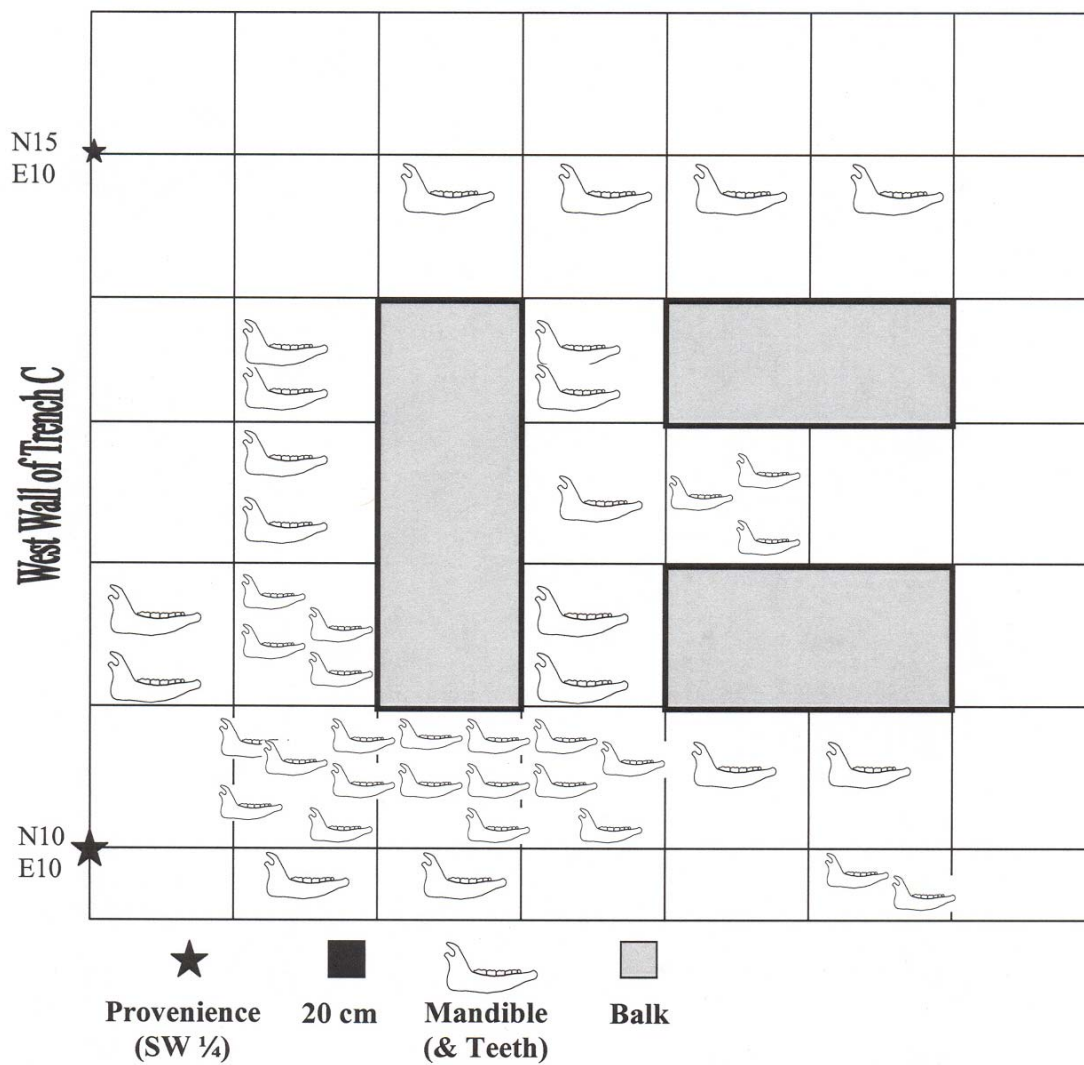


Figure 6.3. Trench C Plan Map 1993 and 1995 Mandibles.

1947; Todd 1987a:128-133, 1987b; Todd and Hofman 1987). Therefore, the mandible data and the cranial data relative to teeth are presented first. Finally, a brief discussion on carpal measurements and their use in determining age will conclude the discussion.

Dental Technique

Age from the mandibles of Trench C was determined by tooth eruption and attritional wear, and to a lesser extent comparison with known-age specimens. Another dental method for determining age in bison, and many other animals, is through cementum annuli although this method is labor intensive, time restrictive, and fiscally prohibitive (Hancock and Low 1956; Keiss 1969; Laws 1952; Low and Cowan 1963; Scheffer 1950). However, assessing cementum annuli from cross-sectioned teeth is more reliable than eruption and attrition (Keiss 1969). The mandibles recovered from the L. E. Certain site were aged based on the published works of Clark and Wilson (1981), Frison (1973), Frison and Reher (1970), Frison et al. (1976), Klein and Cruz-Urbe (1983); Kurtén (1953, 1963), Reher (1973, 1974), Reher and Frison (1980b), Speer (1979), Todd and Hofman (1987), Todd et al. (1996), Voorhies (1969), and Wilson (1981) (Appendixes A and B.). Measurements follow those methods established by Frison and Reher (1970), and Reher (1974).

The logic behind using mandibles for age and season of death determinations is based in wildlife studies and animal physiology. For example, since breeding for bison is seasonally limited, birthing season is also limited (Bee et al. 1981:229-230; Berger and Cunningham 1994:119-124; Dreiling 2001; Grinnell 1970:271-272; Lott 1979:421; McHugh 1958:30-34; Park 1969:68-70; Reynolds et al. 1982:980-983). It is generally accepted that cows are estrus synchronized, and as a result, calving starts around the end of April and might run through early June. The majority of calves are born in a one-month window after a 9-9.5 month gestation period. Since birthing season is limited, animal ages occur in discrete clusters. As a result, the discrete age groups show up in a death assemblage if the sample is from a single herd or a single catastrophic event.

Therefore, a fall kill will have some young individuals about six months old, give or take a few weeks, one year and six months, and so on through the entire life cycle. Thus, age and season of death are inherently tied together in regard to analyzing archaeological faunas.

Besides eruption timing, attrition rates are important in determining season of death and age. Frison et al. (1976:38) developed cusp terminology and described wear facets for bison based on Churcher (1972:63) and Crompton and Hiiemäe (1969). However, a modified version of Churcher's (1972:63) and Crompton and Hiiemäe's (1969) technique was developed since their method left some wear surfaces unnumbered. The Frison et al. (1976:38) cusp and facet numbering scheme is provide in Figure 6.4.

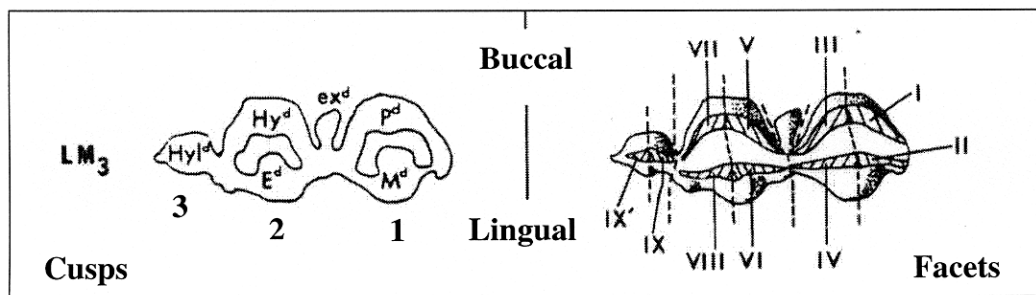


Figure 6.4. Cusps (1-3) and facets (I-IX') of LM3. Hyl^d is the hypoconulid and M^d is the metaconid. Both are used to measure relative attrition rates. Adapted from Reher and Frison (1980b).

According to Fuller (1959:344), the sequence of dental eruption and replacement in bison follows a predictable pattern between birth and age four. Fuller's (1959) initial work has been fine-tuned for archaeologists, mostly by Frison and Reher. Frison gained his experience through years of examining prehistoric bison kill sites and from personal experience with modern bison herds (Frison 1973, 1984; Frison and Reher 1970; Frison et al. 1976; Reher 1973, 1974; Reher and Frison 1980a). The highlights of the dental eruption sequence established by Frison and Reher (Frison and Reher 1970; Reher and Frison 1980b) are relevant to this discussion, as are attrition rates.

Before proceeding any further, a note on terminology is necessary. The dental arcade of bison includes incisors, canines, premolars, and molars. Since bison are herbivores, they do not possess true canines. Depending on the researcher, the “canine” teeth are often listed as a fourth incisor (I4) (Fuller 1959; Park 1969:21). Of primary importance here are the premolars and molars of which there are three each. From the most anterior, inferior point of the mandible on the median sagittal plane (gnathion) back, the teeth are numbered sequentially within their respective groups. Such as it is, there are three premolars on the left and right (P2-4) and three molars on the right and left (M1-3). The first premolar (P1) is non-existent.

Following Frison and Reher (1970:46-50), at 0.5 years all incisors and premolars are in place and M1 has erupted. M2 erupts at 1.1 to 1.2 years and starts wear at 1.5 years (Reher and Frison 1980b:64-70). At 2.2 to 2.5 years, M1 and M2 are moderately to well worn, and M3 is above the crypt but the hypoconulids (facets IX and IX') are never above the alveolus (Frison and Reher 1970:46-50; Todd et al. 1990). At 3.5 years P2 and P3 are moderately to well worn and P4 varies from slight wear to none (Frison and Reher 1970:46-50). At 4.7 years more or less, bison have a fully mature mouth (Reher and Frison 1980b:65). By 5.0 years of age all teeth have erupted and are in regular wear. Beyond five years, age is determined by the rate of attrition on the various cusps and facets illustrated in Figure 6.4. Attrition can be roughly associated between sites but it is best to establish the attrition rate amongst cohorts in a single death assemblage. Attrition can then be organized and calculated for all age classes.

The mandibular molar analyses at the L. E. Certain site were accomplished as follows. For age and season of death assessments, the specimens were first organized into loose groups utilizing the published studies presented in Appendixes A and B. The groupings were then compared to a collection of known-age bison mandibles housed at the Oklahoma Archeological Survey. The comparative collection comes from mixed-age animals culled from the herd each fall at the Wichita Mountain Wildlife Refuge

(WMWR), Oklahoma. Finally, the Trench C specimens were evaluated using the mandibles from Trench A, which are known to be representative of a late autumn to early winter death assemblage (Bement and Buehler 1994:178, 180). Those Trench C mandibles that did not correlate with the Trench A and the WMWR animals were then compared once again to the published reports (Appendix B and Table 6.4). The non-conforming specimens were evaluated using the data from kills known to occur outside of late fall to early winter (Appendix A and Table 6.4). Next, the rate of attrition or wear on the teeth was measured at various reference points on each tooth and then compared to age cohorts. The final assessment of the Trench C mandibles involved organizing the entire assemblage in an age regressive sequence starting with the youngest and progressing to the eldest. Eruption, wear, and metric attributes were organized for the cohorts. In some instances adjustments were made within and outside the identified age groups for animals displaying idiosyncratic wear patterns as a result of missing teeth, abscesses, and genetic mutation.

Trench C Findings

As mentioned previously, the mandibles recovered from Trench C so far represent an adjusted MNI of 43 animals. The paired, complete, and fragmentary mandibles and isolated mandibular teeth were used to determine season of death before age determination could be acquired. Excavations since the 1995 fieldschool have produced a few more specimens deeper in the bone bed that are not presented here.

The raw data for the Trench C mandibles are presented in Appendix C. Characteristics noted on the specimens include the side (right/left), age, sex (based on mandible width), and general comments about the condition of the mandibles. Additional observations were made which assisted in determining the age and sex of each individual. It should be kept in mind that only part of Trench C has been excavated and thus the sample does not represent a herd *per se* and probably represents multiple kill events over a relatively short period of time. The mandible data can be presented in several ways depending on

Table 6.4. Season of Death for Select Bison Kill Sites: Spring through Winter (Appendixes A and B).

Site	Season	Dental Ages
Vore	Spring to early summer	0.1 - 0.2
Mill Iron	Spring to early summer	0 - 0.1
Indian Creek	Spring to early summer	not available
Garnsey	Spring to early summer	0.1
Olsen-Chubbock	Late spring to early summer	not available
Scottsbluff	Late spring to early summer	0.1 - 0.2
Sheaman	Late spring to early summer	0.1 - 0.25
Clary Ranch	Late summer	0.1 - 0.3
Cooper-upper/middle/lower	Late summer to early fall	0.3
Lipscomb	Late summer to early fall	0.2 - 0.5
Plainview	Late summer to early fall	0.3
Folsom	Early fall	0.4 - 0.5
Glenrock	Early fall	0.5
Hudson-Meng	Early fall	0.5
Lake Theo	Early fall	0.4 - 0.5
Wardell	Early fall	0.4
Casper	Fall to early winter	0.6
Ayers-Frazier	Fall to early winter	0.6
Upper Twin Mountain	Fall to early winter	0.4 - 0.7
Finley	Late fall to early winter	0.6
Hanson	Late fall to early winter	not available
Hawken	Early winter	0.7
Agate Basin-Hell Gap	Winter	0.6 - 0.7
Carter/Kerr-McGee	Winter	0.6 - 0.7
Lubbock Lake-Plainview	Winter	not available
Agate Basin-Agate Basin	Early winter to late winter	0.6 - 0.9
Agate Basin-Folsom	Late winter to early spring	0.9
Bonfire Shelter-Bone bed 3	Late winter to early spring	not available

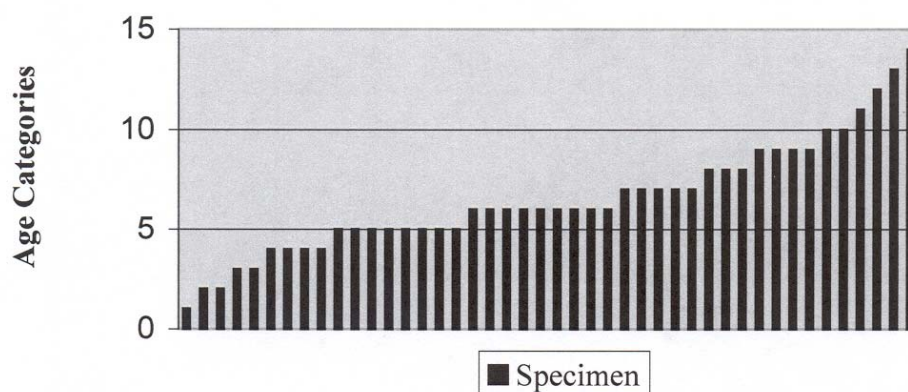
the problems being addressed. As a means to discussing the age composition of the recovered specimens, the mandible data are first presented based on the overall life stage of the animals (Table 6.5). The first thing to note within the three categories is that two seasons are represented. Referring back to the discussion of estrus, mating, birthing

Table 6.5. Overall Life Stage & Age Structure of Trench C Death Assemblage.

<i>New Born to Juvenile</i>			<i>Mature</i>			<i>Late Adult to Geriatric</i>	
Cat. #	Age		Cat. #	Age		Cat. #	Age
1065	0.6-1.0	←	1222	5.6		1179	8.0-8.6
1105	1.1	←	2516	5.6		1172	8.2-8.6
1257	1.6		2092	5.6		1194	8.6-9.6
2152	2.4-2.6		1166	5.6 (<6.6)		2333	8.6-9.0
1187	2.6-2.8		1167	5.6 (<6.6)		2509	9.2-9.6
1131	3.0-3.5		1100	5.6 (<6.6)		2557	9.0-12.0
1174	3.1-3.3	←	1175	5.6 (<6.6)		1178	(10.6+) 12
1007	3.6-3.9 (4.0)		2154	5.6 (<6.6)		1181	11.6+
1027	3.6-4.0		2177	5.6 (<6.6)		*2150	12+
1036 A	4.0-4.4		2121	6.0+		*2626	13+
1036 B	4.0-4.4		1034	<6.6		*see the associated photographs for examples of maximum attrition; note the root stubs in specimen #1 & the cupping on all three molars in specimen #2	
2342	4.0-4.6		2335	6.6			
2232	~4.6		2828	6.6			
1212	4.6+		2190	6.6-7.0+			
13	4.9-6.0	←	1161	7.0-7.6			
78	~4.6		1052	7.2-7.6			
84	~4.6		2226	7.6-8.6+			



Mandibles



sequence, and season of death, animals killed in late autumn to early winter will have an age range in $N+0.6$ intervals (e.g. age 0.6, 1.6, 2.6, etc.). It should also be pointed out that determining age beyond five years, when all teeth have erupted, is tenuous (Reher and Frison 1980b:65). Furthermore, attrition rates can vary depending on environmental circumstances, namely the state of forage and the amount of grit in the diet (Gilbert 1973:44). Geologic research at the Garnsey site reveals that environmental conditions were deteriorating in southeast New Mexico at the time the bison kill took place and thus attrition rates were rather advanced (Wilson 1980:125; Speth 1983:133-137). Johnson and Holliday (1986:43-44) noted a similar situation at Lubbock Lake. Obviously the high attrition rate and amount of grit in the diet are positively correlated. As for the L. E. Certain site, metaconid and hypoconulid heights are variable with few trends being manifest. Therefore, ages calculated to a specific month are relative and based on overall appearance of the samples rather than on metric attributes. However, some mandibles are clearly out of synchronization with a autumn/winter kill.

A majority of the mandibles analyzed from Trench C conform to a late fall-early winter kill, just as in Trench A, yet the contradictory specimens deserve further explanation. Looking at Table 6.5 and Appendix C reveals that four specimens (#13, #1065, #1105, and #1174) display characteristics inconsistent with the overall trend. Although the four mandibles do possess some overlap in interpreted ages ($N+0.6$ - $N+0.9$), there is some slight variation. However this can be accounted for given the grossness of scale necessary to gather the most basic data, much less specific age-sensitive data, from the specimens.

Ideally, analysis of the complete dental arcade is necessary to observe overall dentition characteristics for accurate age estimation. It is even more important when discussing age-sets separated by months and not years. On the other hand, relatively reliable information can be gathered to determine age at death. For example, specimen #13 is represented by one right LM3. Because the hypoconulid enamel ring on LM3 has joined that of the other cusps of the molar, but not to the extent of that observed on known late

autumn-early winter kills (Trench A and Appendix B), a late winter-early spring death (4.9-6.0 years) estimate is not unreasonable. Similar but not exact observations were made at Garnsey, Mill Iron, Vore, and to a lesser extent Scottsbluff (Table 6.4 and Appendix A). As for the other three specimens (#1065, #1105, and #1174), mandible #1065 is represented by a severely damaged right mandible containing M1-M3 of the dental arcade. This specimen displays wear on facets I-VIII of M1 and slight polish on facet I of M2 and absolutely no wear on M3 (see Figure 6.4). This eruption and wear pattern is consistent with a bison approximately 1.1 years old. Thus, the calf died in spring. Again, these wear patterns are consistent with observations made at Garnsey, Mill Iron, Vore, and Scottsbluff (Appendix A). Specimen #1105 is characterized as a single LM3 exhibiting wear on facets I–II. As seen with specimen #13, relatively reliable information can be gathered from a single tooth. Based on work conducted at Garnsey, Mill Iron, Vore and Scottsbluff (Appendix A) the tooth came from a calf that died in spring at 1.1 years of age. Finally, specimen #1174 is represented by paired mandibles, both displaying extensive damage but providing both left and right M1-M3s for analysis. The M3s exhibit wear on facets I and III. These wear patterns are consistent with spring through early summer deaths for a three year old bison based on observations from Garnsey, Mill Iron, Vore, and Scottsbluff (Appendix A). There is ample evidence to determine that mandibles #1174 came from a 3.1 to 3.3 year old bison. The slight variation observed with these four specimens (approximately 21-30 days) is acceptable since some animals can be born outside of the general birthing period (Garretson 1927:42; McHugh 1958:30; Meagher 1973; Soper 1941). Thus, two separate kill events are represented in Trench C. Keep in mind that Trench C is placed over the northwest portion of the paleogully that was used to trap and kill the animals. A relatively short period of time between the two is estimated. The duration between the two events is based on the incomplete burial of skeletal remains at the head of the paleocanyon which grades from no coverage into a maximum of 15 cm of sterile homogenous fill. The location of these mandibles in the bone bed and the relevance of having two kill events represented in Trench C will be discussed in Chapter Eight.

Other Techniques

Besides using mandible data to assess the age of a given population, crania and metapodials can be employed. Vertebrae, calcanei, carpals, tarsals and innominates can be used also (Bedford 1974; Duffield 1973; Haspel and Frison 1987; Koch 1934; Morlan 1991; Peterson and Hughes 1980; Shackleton et al. 1975:880-881; Speth and Parry 1980:317, Table B10a; Todd 1986). The Trench C cranial data and post-cranial data are presented in separate sections. Both sections begin with a discussion on the techniques used to determine age. In the post-cranial section the metapodial data from Trench C are highlighted since these elements were best preserved and rather numerous.

Crania

With crania, the amount of fusion that anterior sutures have undergone is a good indicator of relative age, as is orbital rigidity (Skinner and Kaisen 1947:146-148) (Figure 6.6). However, suture and orbit assessments are not very accurate. Animals can only be divided into four relative age groups (Guthrie 1966b:725; Shackleton et al. 1975:880-881; Skinner and Kaisen 1947:146-148). Basically these groups are immature, adolescent, mature, and geriatric (Tables 6.2 and 6.3).

Although some crania were well preserved (Figure 6.7), the level of preservation exhibited on most of the recovered crania was not conducive to utilizing the above methods with great confidence. Besides preservation, the level of processing that the crania underwent made precise assessments of age using sutures and orbits difficult (refer back to Figures 5.11a-b and 5.18-5.21). Moreover, the extreme dismemberment of the carcasses made cross-checking crania observation with other age-sensitive elements tenuous. However, it was possible to match 30% (N=10) of the crania sample to mandibles. To maintain reliability of the data analysis, blind tests were performed to assure that cranial age assessments were not tainted. The juvenile and mature animals were accurately identified according to cross-referenced mandibles. On the other hand, a skull (#2198) was misidentified as mature when it was actually a geriatric animal based

on the associated mandible (#2150) (Tables 6.3 and 6.5).

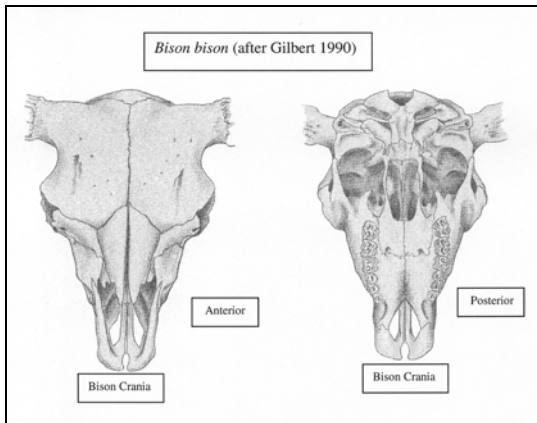


Figure 6.6. Sutures of the bison crania.

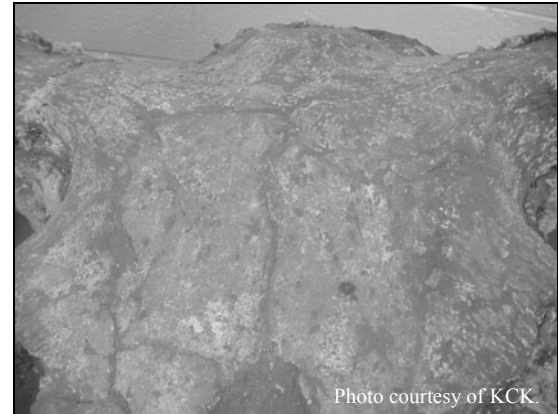


Figure 6.7. Sutures near closure on crania.

Post-Crania

Almost all bones can be used to determine relative age. Of all bones, metapodials and cannon bones are most useful in determining age based on metric traits, relative size and weight, as well as epiphyseal fusion. Sellards (1955) and Lorrain (1968:127-130) used astragali volumes with some success, while research conducted by Duffield (1973) and Koch (1934) used epiphyseal closure rates to determine age. Although Duffield's (1973) and Koch's (1934) reference subject was European bison, their work has been widely used on American bison as a measure of relative age.

According to Koch's (1934) and Duffield's (1973) metapodial data, by the end of the fourth year the fusion rate of long bones picks up considerably. It is at this time that the distal caps of the metapodials begin to connect. Yet, the diaphysis and epiphysis are integrated but full closure has not occurred. As with the fourth year, the fifth year of bison development proceeds rather quickly. By this time the animal is generally considered to be skeletally mature. Thus, metapodials are one of the last bones to fully develop. Although considered to be skeletally mature at five, wildlife ecologists place

overall physiological maturity at seven or eight years (McHugh 1958:38; Park 1969:32). Taking into consideration all metapodials (unadjusted MNI), there are 48 metacarpals and 26 metatarsals (Tables 6.6 and 6.7). Of the 48 metacarpals, a little less than 10% (N=5) were below the age of five and a little over 5% (N=5) of the metatarsals were less than five years of age. This does not corroborate the mandible data. According to the mandible data, 17 of 43 animals (39.5%) are at or less than five years of age. By comparing the mandible and metapodial samples, one general conclusion can be drawn; relatively few juvenile metapodials are represented in the death assemblage. The scarcity of metapodials attributable to juvenile animals is most likely related to selective removal of lower limbs

Summary

Eruption and attrition of mandibular dental arcades were used to determine age-at-death for the Trench C faunal assemblage. Fusion rates of cranial and post-cranial elements were also used to determine age, but with less accuracy. The mandibular data from Trench C reveals that the majority of the specimens conform to a late autumn-early winter kill. However, there are a few specimens that do not conform to the general results. The dissimilar specimens could be the results of irregular wear configurations or out of sequence birthing cycles, but most likely reflects a second kill event. The cranial and post-cranial elements inspected were the skull and metapodials, both of which provide relative age calculations. The anterior cranium sutures were scrutinized on each specimen to assess the degree of closure. Based on the level of fusion, all but one of the specimens was accurately identified when cross-referenced with associated age-sensitive elements. The metapodial results were not as conclusive as the dental and cranial findings. Reasons for the disconnect include grossness of age categories or source of the comparative collection (Bison bonasus), but most likely reflects selective human harvesting (Duffield 1973:132).

Table 6.6. Metacarpal (Distal) Transverse Width.

Bone#	Side	(mm)	Comments
1322	Left	62	Complete / fully fused
1673	Right	62	Complete; appears fully fused
2394	Right	62	Appears fully fused
1319	Left	63	Complete and fully fused.
1433	Left	63	Complete
1542	Left	63	Posterior 1/2 of distal epiphysis gone
1554	Right	63	Complete
1693	Left	63	Complete
2042	Right	63	Lateral 1/3 of proximal epiphysis missing; appears fully fused
1109	Left	65	Fusion line evident; juvenile
1196	Left	65	Weathered; Stage 4 (splintered)
1085	Right	65	Complete; root etched
2126	Right	65	Weathering & exfoliation on distal end
1164	Right	66	Complete
1571	Right	66	Measurements may be off due to weathering
1716	Left	66	Complete
2105	Right	66	Complete; fully fused
2214	Right	66	Appears fully fused; complete
1902	Right	67	Complete; appears fully fused
2001	Right	67	Complete
2106	Left	67	Complete; fully fused
1204	Right	67.5	Weathered; Stage 4 (splintered)
1202	Right	68	Fusion line evident; juvenile
1575	Right	68	Fusion line evident
1909	Left	68	Complete
2392	Left	68	Complete; fully fused; weathered; Stage 4 (splintered)
2511	Right	68	Appears fully fused
1197	Left	69	Fusion line evident; juvenile
2404	Right	69	Complete; weathered; Stage 4 (splintered); associated with carpals
2510	Left	69	Appears fully fused
1191	Right	69.5	Complete and fully fused
1199	Left	69.5	Damaged; measurement might be affected
1484	Right	70	Distal epiphysis unfused but reconstructed; young & robust.
1665	Right	70	Appears fully fused
1560	Right	71	Measurements may be off due to weathering
1573	Left	72	Measurements may be off due to weathering
2243	Right	73	Appears fully fused; complete
2316	Left	73	Complete; appears fully fused
1630	Left	74	Complete; fully fused
2432	Left	74	Complete
1101	Left	75	Complete
1182	Right	75	Weathered; Stage 4 (splintered)
1434	Right	75	Proximal end weathered away
2380	Right	75	Weathered on proximal & distal ends; complete; fully fused
1189	Left	76	Damaged; measurement might be affected
2472	Right	76	Complete; weathered; Stage 4 (splintered)
2286	Right	80	Appears fully fused; complete
1374	Left	81	Measurements may be off due to weathering

Table 6.7. Metatarsal (Distal) Transverse Width.

Bone #	Side	mm	Comments
1457	Left	53	Proximal epiphysis incomplete; distal epiphysis unfused
1556	Left	55	Distal epiphysis unfused; articulated to other canons
1551	Right	55.5	Complete; fusion line visible on distal end
1001	Right	57	Damaged; measurement might be affected; juvenile
2383	Right	58	Appears fully fused
1545b	Left	59	Badly weathered; measurement might be affected
1787	Left	59	Posterior 1/2 of proximal epiphysis absent; posterior weathered
1545a	Right	60	Badly weathered; measurement might be affected
1997	Right	60	Badly weathered; measurement might be affected
2477	Right	60	Proximal epiphysis weathered away; distal fusion line very evident
2305	Left	60.5	Complete
1785	Right	61	Complete
1781	Left	62	Complete; fully fused
1695	Right	63	Mostly complete
1517	Right	64	Complete specimen
1518	Left	64	Proximal epiphysis incomplete; fusion line visible on distal end
1985	Left	64	Weathered & exfoliated on both ends with longitudinal fractures
2376	Left	65	Complete; appears fully fused
2464	Right	65.5	Reconstructed; appears fully fused
1080	Right	66	Robust; heavy
2127	Left	67	Badly weathered; measurement might be affected
1590	Right	68	Badly weathered; measurement might be affected
2360	Right	68	Proximal damage; badly weathered; measurement might be off
1387	Right	70	Robust; reconstructed; measurement might be affected
2178	Right	70	Reconstructed; posterior portion of proximal epiphysis absent
2184	Left	70	Complete
1833	Right	73	Dorsal 1/2 of proximal end absent
2185	Right	75	Reconstructed; root etching-anterior, lateral & medial distal absent

on the part of the prehistoric hunters (Binford 1978:19-23; Speth 1983:102-104, 113-117; White 1952, 1955). Future excavations at Trench C may clarify this assertion.

Death Assemblage: Sex

Introduction

Just as there is differential treatment of specific parts of a bison, human selection of prey is gender specific. This is especially true at particular times of the year. Although cows and bulls experience differential health, research shows that both sexes suffer nutritional deprivation in winter (DelGuidice et al. 1994). According to McHugh (1972:243), deep

snow has a compromising effect on the nutritional status of bison by increasing energetic costs of locomotion and foraging. A prime example of this is the trail of blood sometime left behind while winter-feeding. Their “nasal snowplowing”, often down to four feet, is obviously rigorous work. However, this was probably a rare occurrence on the southern Plains. Another example includes semi-captive bison which are known to supplant one another from naturally occurring food sources during winter feeding (Meagher 1973:161; Van Camp 1973). Surely this occurred in the open range of the past. In short, the increased energetic costs and competition for forage contribute to nutritional deficiencies, which in turn lead to depletion of body protein (Torbit et al. 1985). This nutritional deprivation translates into an inferior quality of meat and marrow for human predators.

As previously mentioned, seasonal stresses experienced by bison are gender specific, especially at particular times of the year. As a result, nursery herds are preferred by some societies, while other times bachelor herds are sought (Ewers 1949:357; Roe 1970:860; Speth 1983:90-113; Weltfish 1965:369-378). The condition of cows can also vary from year to year. For example, research with bison herds in Oklahoma and Montana shows that non-lactating females are generally in better condition than lactating females (Halloran 1968; Rutberg 1986; Trivers and Willard 1973). It is generally accepted that pregnancy places considerable stress on cows. The fetus draws nutrients and minerals from the mother thereby depleting the supply available to her. Further damage can be done when yearling calves continue nursing into the second year, thus prolonging physiological stress to the mother (Halloran 1968:23-26). In fact, continued lactation can cause an *in utero* calf to have lower body weight than normal (Fuller 1961). Conversely, research shows that loss of a yearling calf can enhance the vigor of a fetus by improving the energy balance of the cow (Reynolds et al. 1982:980-983).

Staying with the observation that lactating cows lose nutritional strength before, during, and after the birthing season, Figure 6.8 displays the seasonal fluctuation of nutritional health in the form of a graph. According to McNaughton (1990), ungulates have evolved

parturition periods governed by the nutritional requirements of reproductive females and young animals. These requirements are also intimately related to seasonal precipitation patterns and spatial distribution of sufficient nutritional forage. In studying African buffalo, Sinclair (1977:261) and McNaughton (1990:614-615) determined that elevated levels of minerals are required at substantially higher concentrations by females in late stages of pregnancy and during lactation. These minerals are also necessities for the young.

Just as cows are nutritionally deficient in the spring, bulls are nutritionally bankrupt after the rut (Figure 6.8) (Berger and Cunningham 1994:162-169). This prolonged period of jockeying for receptive cows lasts from early July to late September on the southern Plains, but starts earlier elsewhere (Bee et al. 1981:229-230; Halloran 1968:26; Halloran and Glass 1959; McHugh 1958:23; Meagher 1973). In effect, bulls must decide to feed or attempt to cover as many cows as possible (Lott 1972). There is also some evidence that nutritional stress is related to forage quality (Peden 1972:84-93; Peden et al. 1974; Weaver and Albertson 1956:12-14, 160-161, 370). Coupled with the lack of adequate nutritional intake, whether due to quality or preoccupation, bulls must contend with a linear hierarchy of dominance and subordination during breeding season (Lott 1979; McHugh 1958:23-30). Quite often causalities occur as a result of this hierarchy especially when nutritional intake is low (Baggley 1933:39; McHugh 1958:28-29).

The relative condition of both cows and bulls were apparently recognizable to aboriginal hunters, most likely through experience and perhaps through observations of seasonal behavior. Differential treatment of select body parts during specific seasons is the basis of this argument. This practice is represented in the archaeological record and historical literature, and substantiated by wildlife management studies (Brooks 1978; Brooks et al. 1977; Ewers 1949:357-358; Point 1967:119-129; Speth 1983:90-113). By determining the gender composition of a death assemblage, meaningful statements can be made about

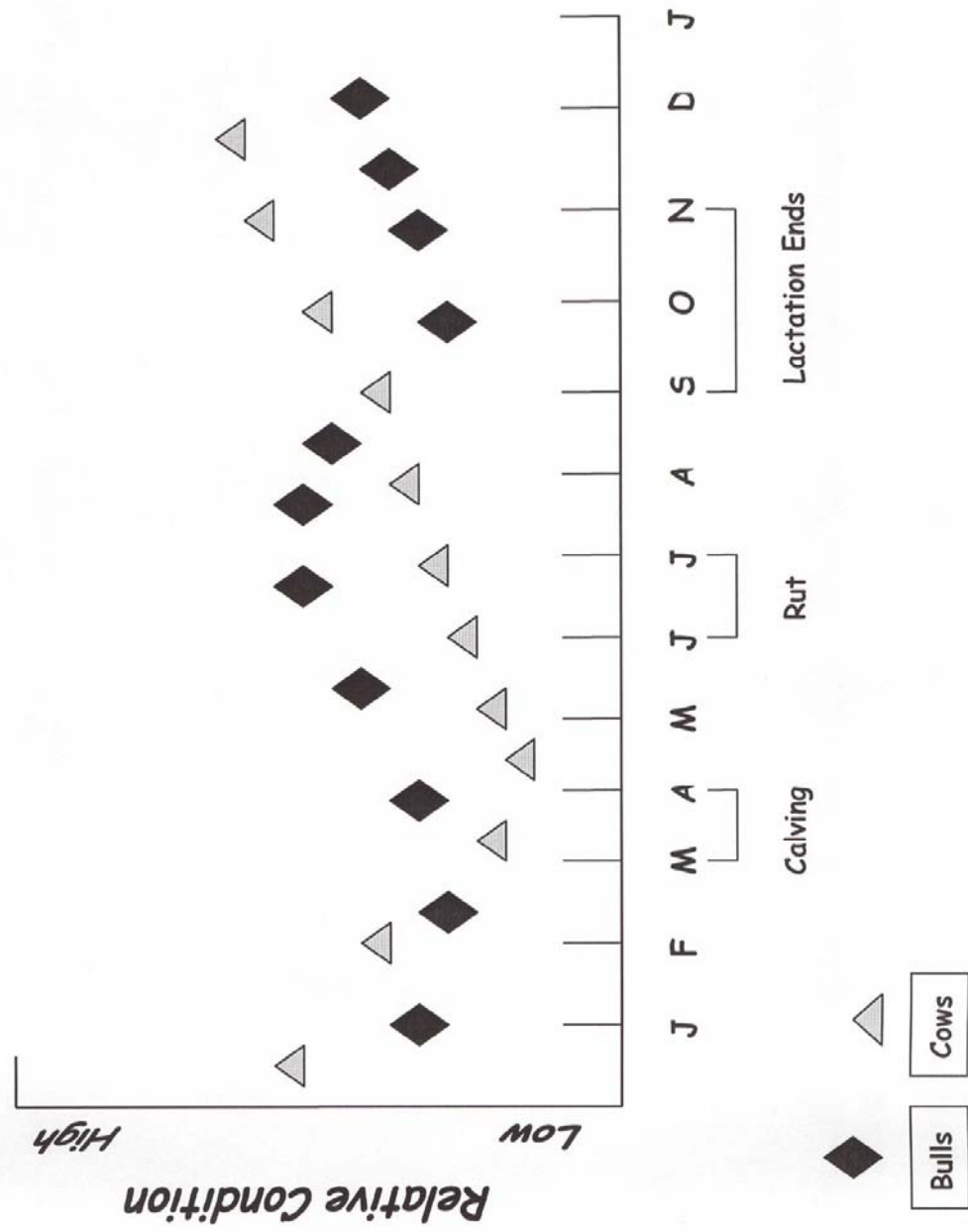


Figure 6.8. Seasonal fluctuations of nutritional health of bison bulls and cows.

prehistoric animal use. In turn, conclusions can be drawn about prehistoric economic systems and their relations to animal procurement activities.

Cranial and Mandibular Techniques

Besides being utilized to determine the age of bison at death and the season killed, mandibles can be used to determine the sexual composition of a death assemblage. Frison and Reher (1970) pioneered this technique and Reher (1974:116-117) advanced it using northern Plains death assemblages. Others have adopted the procedure as a matter of protocol on the southern Plains (Bement and Buehler 1994:178; Hofman and Todd 1997:109-112). The technique uses the metric height of the horizontal ramus (mandible) below M3 (Figure 6.9). The measurement is taken with calipers on the internal or lingual side of the mandible. The placement of the measurement is different from that utilized by Von Den Driesch (1976:56-57). The separation of the sexes is based on the principle that bulls have larger, more robust mandibles than cows (Frison 1991:298-300). In most cases a bimodal distribution of the measurements occurs (Reher 1974) but this is not true for the mandibles from Trench C (Figure 6.10). The reason for this is addressed later.

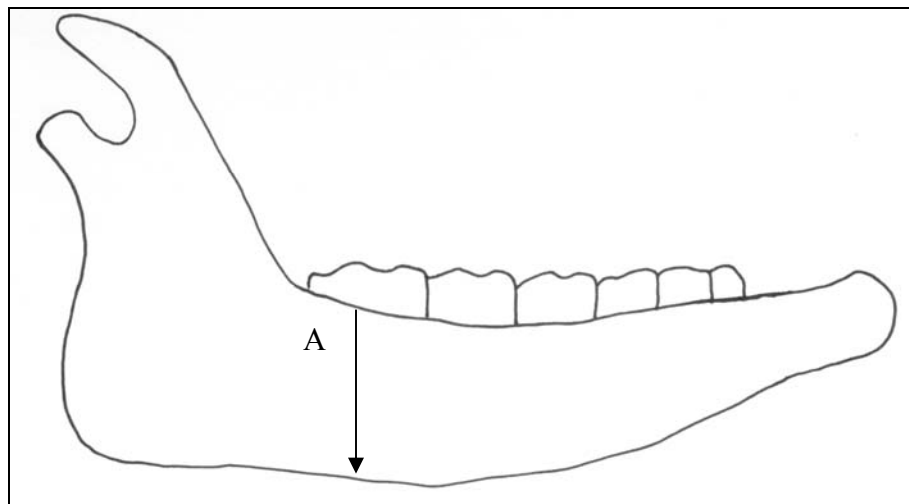


Figure 6.9. Mandibular height measurement below M3. Dimension A depicts the correct placement for acquiring the mandible height (sometimes listed as width) measurement below M3. View is lingual or interior side of the jaw.

Besides mandibles, determination of sex or a sex ratio for a death assemblage can also be achieved using crania (Guthrie 1966a, 1966b; Shackelton et al. 1975; Skinner and Kaisen 1947:146-148). However as previously noted, the unfavorable condition of the skulls at the L. E. Certain site makes gender recognition difficult. Nevertheless, those crania that were intact enough to examine did not contradict the mandible data that is presented below.

Trench C Findings

Of the 44 (*adjusted* MNI 43) mandibles recovered from Trench C, only 27 were qualified for attaining accurate height measurements. A plot of the mandible widths displays a progressive distribution between 68 and 81 mm (Figure 6.10). Only four of the mandible widths plot outside this range. One of the two smaller mandibles (Appendix C) belongs to an 8.6-9.6 year old (#1194) while the other specimen (#2232) belongs to a 4.6-year-old animal. The latter specimen is damaged so the measurement might be skewed. Nevertheless, the damage cannot account for a 10-mm discrepancy. Given this, these mandibles are interpreted as belonging to cows that are abnormally small or nutritionally deprived. As for the two mandibles on the high end of the plot, both had width measurements of 86 mm. Again, one of these mandibles (#2177) is damaged but not to the extent that it would change the recorded measurement by 10 mm, thereby placing it in with the majority of the other mandibles. Mandible #2177 belongs to a 5.5-year-old. The other large mandible (#1181) belongs to an old animal aged at 11.6+ years. The former is theorized to be a juvenile bull while the latter is interpreted as being a geriatric bull. It is not unheard of to have two such animals still attached to a cow-calf herd or on the periphery of a nursery group (McHugh 1958:14-16; Reynolds et al. 1982:986-987).

Bement and Buehler (1994:178) use a cut-off value of 72 mm to differentiate between cows and bulls based on work done by Reher (1974). Using an arbitrary break instead of a cluster will clearly not work with the Trench C mandibles. However, if the 72 mm cut-off is utilized, the herd composition becomes much different. Of the original 27

mandibles that are of adequate quality to measure, 15 would be cows and 14 would be bulls. The range in measurements for the cows spans 61-71 mm while the bulls vary between 72-86 mm. As it appears, there is a broad range of measurement values that encompass both bulls and cows. The other possibility is that the mandibles recovered from Trench C overwhelmingly belong to cows. With the currently available sample, distribution of the metric data from the mandibles, and the extent of excavation at Trench C, a definite conclusion regarding the sexual composition of the death assemblage cannot be reached at this juncture based solely on mandible width. However, based on season of death data gathered from the mandibles and hormone-induced social behavior, the death assemblage likely represents a cow-calf herd with an occasional adolescent or geriatric bull represented as well.

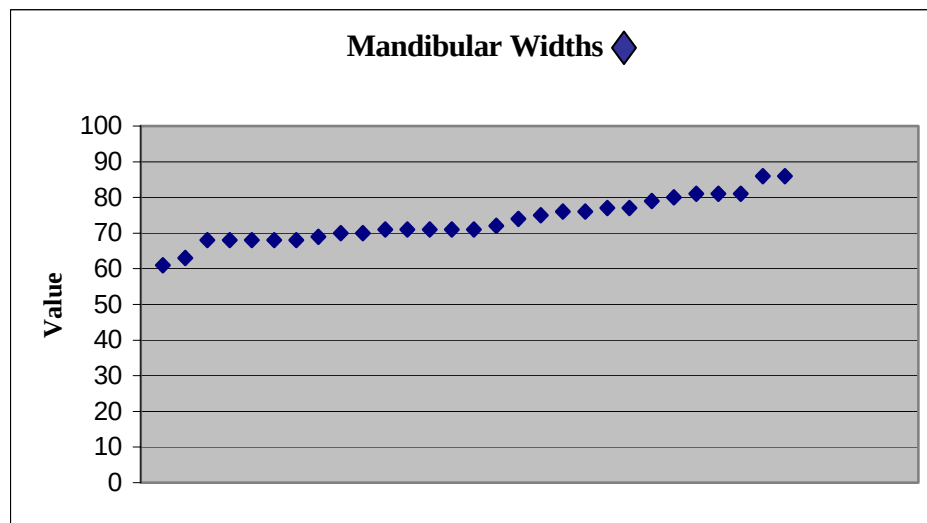


Figure 6.10. Note the rather stable nature of mandibular widths from Trench C rather than the bimodal distribution seen at other sites.

Post-Cranial Technique

Not until Bedford's (1974) noteworthy study of cannon bones from the Casper site was there a precise description for taking metapodial measurements. Although Von Den Dreisch (1976) and fellow osteoarchaeologists in München developed a standard for taking bone measurements in the 1950s, their work was not published in English until 20

years later. The Von Den Dreisch (1976:92-93) method is basically the same as that suggested by Bedford (1974). One other exception to Bedford's research was the work performed by Lorrain (1968) at Bonfire Shelter in Texas. However, Lorrain's (1968) report only provided a diagram with measurement locations rather than explicit instructions.

The measurement of premier importance to this discussion is the transverse width of the distal metapodial. Bedford (1974:202), who prefers an osteometric bone board to calipers, describes the measurement in detail. The element should be oriented so that the midline of the bone is perpendicular to the center slide and the distal end is flat on the bone board. Peterson and Hughes (1980:174) promote a similar measurement for the transverse distal width of both metacarpals and metatarsals.

From transverse width of the distal metapodial measurement, the sex of the constituent animal can be determined with relative success. The distinction between cows and bulls is based on the principle of sexual dimorphism as in the case with mandibles. Most mammals display sexual dimorphism, and informants and wildlife biologists have verified this fact in bison (Halloran 1960; Reynolds et al. 1982:979-980; Roe 1970:405; Wheat 1972:52; White 1953). In short, there is a great disparity in body weight between the larger bulls and the more gracile cows, and thus a differential loading on the long bones. The need for stronger support is reflected in bone length, width, and overall size. All three of these characteristics are evident in Figure 6.11.

Trench C Findings

Like the mandibles and crania, not all metacarpals and metatarsals were of sufficient character or quality to perform gender tests. The preservation of the bones varied from excellent, to slightly weathered, to friable (Figure 6.12). Variables recorded from the Trench C metapodials, include transverse width at the distal end, maximum length, extent



Figure 6.11. Sexual dimorphism in metatarsals.



Figure 6.12. Variable preservation of metacarpals from Trench C. From left to right, very little weathering and no cracking, to slight weathering with root etching, to extensive exterior weathering, cracking, and breakage.

of fusion, degree of weathering, anatomical side, and the overall character of the bone. The latter observations included parts missing, location of breaks, and cultural or natural modifications. Non-quantifiable variables noted include density, robusticity, and pathologies. All these characteristics can be used to qualify the results acquired from the transverse width (e.g. skewed measurement due to damage). Following Bedford (1974:239-240), only transverse width at the distal end was used to determine gender. A simplified version of the raw data was presented in Tables 6.6 and 6.7.

Of the 68 identified metacarpal specimens, 48 could be measured while only 28 of the 56 metatarsals could be analyzed metrically. Ideally the widths of each should form clusters representing bulls and cows when juveniles are removed from the sample. A quick glance at the sorted transverse width measurements for Trench C reveals that there is a gradual progression in width values with no true clustering (Tables 6.6 and 6.7; Figures 6.13 and

6.14). This trend may have a lot to do with the composition of the death assemblage, or it may be a result of the statistical methodology. For instance, Peterson and Hughes (1980:174) caution that using a single variable to separate bulls from cows is not very reliable. They (Peterson and Hughes 1980:174) promote the use of multiple variables to achieve a definitive cluster of cow and bull measurements. However, Bedford (1974:239-240) used the transverse width measurement with success on the Casper, Olsen-Chubbock, Finley, Hawken, Ruby, and Vore metapodial data.

Metatarsals

In regard to metatarsals, there is an ever so slight break in the measured widths on the upper and lower ends for the sample (Table 6.7, Figure 6.13). The 3-mm departure from the progressive increase displayed throughout the rest of the data may indicate atypical cows or juveniles on the low end and bulls on the upper end. It may also suggest differential nutritional intake based on forage quality. However, closer examination reveals that the three specimens on the low end are from juveniles. On the other hand, two of the five juvenile specimens plot out in the middle of the range (#2477 and #1518). As for the apparently wider specimens at the high end of the sample range, both specimens are damaged which may have altered their original dimensions. That is, the laboratory reconstruction of the friable elements and an expected loss of some bone material may have caused the specimens to measure smaller than they originally were.

Metacarpals

Turning attention to the metacarpals (Table 6.6, Figure 6.14), the only break in the data occurs on the upper end between 76 and 80 mm. Two specimens are of interest. One is interpreted as representing a bull (#2286), while the other is attributed to a skewed measurement caused by damage (#1374) (Figure 6.12, far right). The remainder of the measurements increases incrementally.

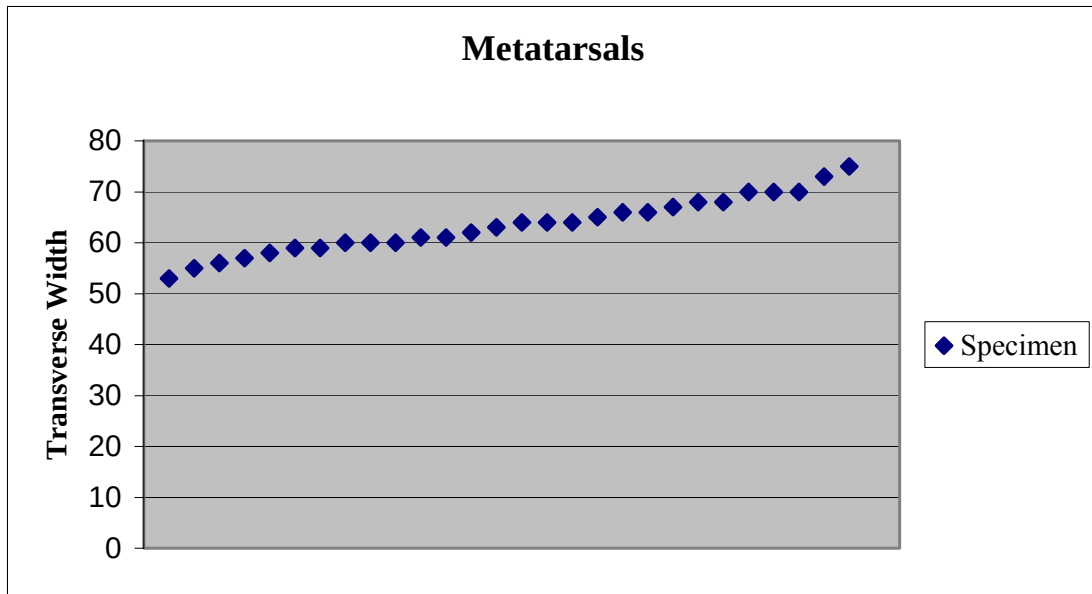


Figure 6.13. Note the rather stable nature of metatarsal widths from Trench C rather than the bimodal distribution seen at other sites.

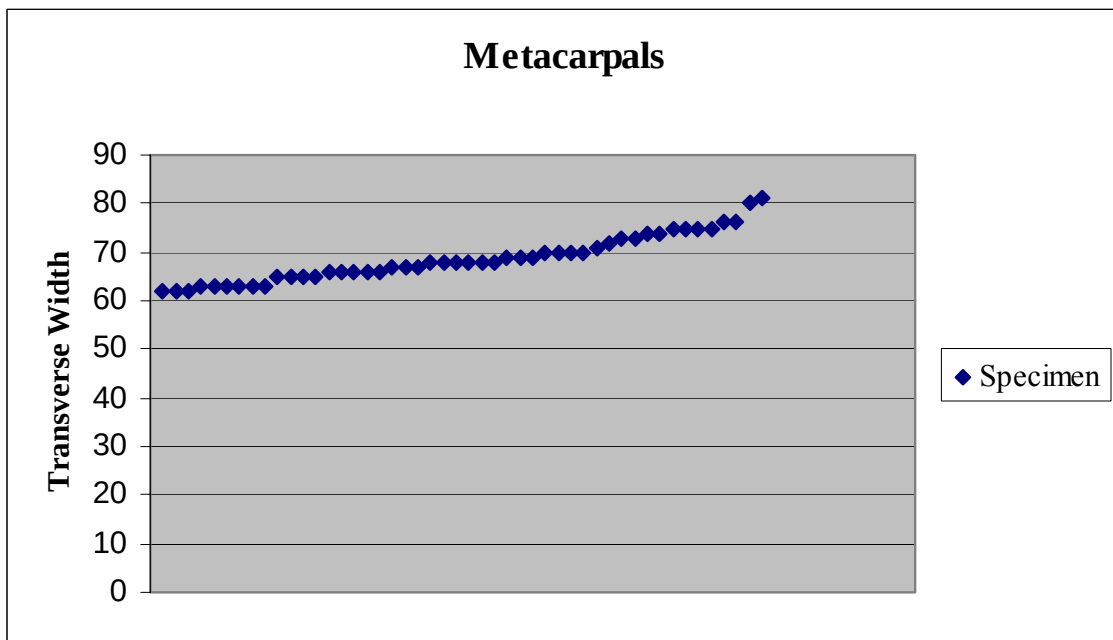


Figure 6.14. Note the rather stable nature of metacarpal widths from Trench C rather than the bimodal distribution seen at other sites.

Taking the juvenile metacarpal specimens into consideration does not change the

outcome. The juvenile specimens (#1109, #1202, #1575, #1197, and #1484) are distributed throughout the plot, unlike the metatarsal data set. One thing that the metatarsal and metacarpal values do have in common is that there is no definitive clustering to distinguish between cows and bulls. One conclusion regarding the sexual composition of the Trench C bison sample is that there is an overlap between large cows and small bulls on the southern Plains. Another conclusion is that the sample represents a single cow-calf herd with great variability. Yet another conclusion involves the possible presence of two different kill events contained in Trench C. Taking the season of death data gathered from the mandibles into consideration and hormone-induced social behavior of bison at particular times of the year, the death assemblage more likely represents two cow-calf herds.

Summary

Gender of the Trench C death assemblage was determined using metric attributes from mandibular, cranial, and post-cranial elements. The premise behind the gender classification formula is sexual dimorphism. By determining the sexual composition of a prey population, educated comments can be made regarding prehistoric economies. In other words, hunters' selection of prey by gender, when both sexes are available for harvest, reveals that deliberate choices were made as to which animals would be taken. The basis for this argument lies in ethnographic literature and animal physiology. Combined, the two demonstrate that cows and bulls experience nutritional, seasonal deprivation, which protohistoric and historic hunters were well aware. An inferior animal translates into poor quality byproducts. Additionally, bison form gender specific groups at different times of the year which in turn affected human predation and butchering strategies. All in all, at the current level of excavation and bone analysis it appears that Trench C represents at least two cow-calf kills. The larger kill occurred in late autumn or early winter while a smaller kill of approximately four animals occurred in early spring.

Butchering Strategies and Group Coordination: Trench C Findings

Butchering Strategies

In regard to butchering strategies, Binford (1978:15-23, 475) established a Meat Utility Index (MUI) while studying Nunamiut hunting practices. His ethnographic research is regularly applied to archaeological data. Binford's MUI was created to determine the cultural and nutritional importance of prey animals' body parts to a group. For example if an archaeological assemblage demonstrates that a specific body part was extensively butchered and others were intentionally avoided, it could be argued that the butchered part had a higher utility or value to the group. This is generally referred to as a gourmet butchering strategy (Binford 1978:15-23). When extensive dismemberment of carcasses takes place, and thus every conceivable part of the animal was being utilized, Binford (1978:15-23) referred to this behavior as a bulk butchering strategy. In effect, the quantity of meat was of primary importance rather than specific cuts of meat. Based on the composition and character of the Trench C bone bed, the latter of these strategies was employed at Trench C, however closer examination of the bone bed reveals a gourmet strategy was being employed within the larger mass of bones. That is, the position of the abandoned bones in Trench C reflects thorough dismemberment of the carcasses and possible use of most meat portions (Figures 5.18-5.21) as opposed to that represented at Trench A where carcass processing was less than complete (Bement and Buehler 1994:175-180; Buehler 1997:141).

Group Coordination

Besides the bulk butchering strategy outlined above, another trend was noted in Trench C. Piles of similar bones were found throughout the bone bed. This practice was noted at another southern Plains bison kill site (Speth 1983:90). Bone piles at L. E. Certain included limb segments, skulls, and mandibles. Besides the cluster of skulls and mandibles (Figure 6.15), piles of pelves with associated limbs were found in the bone bed as well (Figure 6.16).

The presence of bone piles and the sheer number of animals represented at the kill alludes to coordinated group behavior as well as a gourmet butchering strategy to a certain extent. In effect, once the animals were corralled and killed, select groups were probably responsible for processing specific parts of the carcass. Each group would strip the meat-bearing bones in preparation for transport. The de-boning process eliminated unnecessary transport weight. Not only were numerous meat-bearing bones processed, the skulls were harvested for the tongue and brains. By doing this, the useable elements from the skulls were removed while the bulky mass was left behind (Binford 1978:72-74). Evidence for this practice is presented below.



Figure 6.15. Excavation underway on a pile of four bison skulls and mandibles. Thorough dismemberment occurred but gourmet strategies were also evidenced.

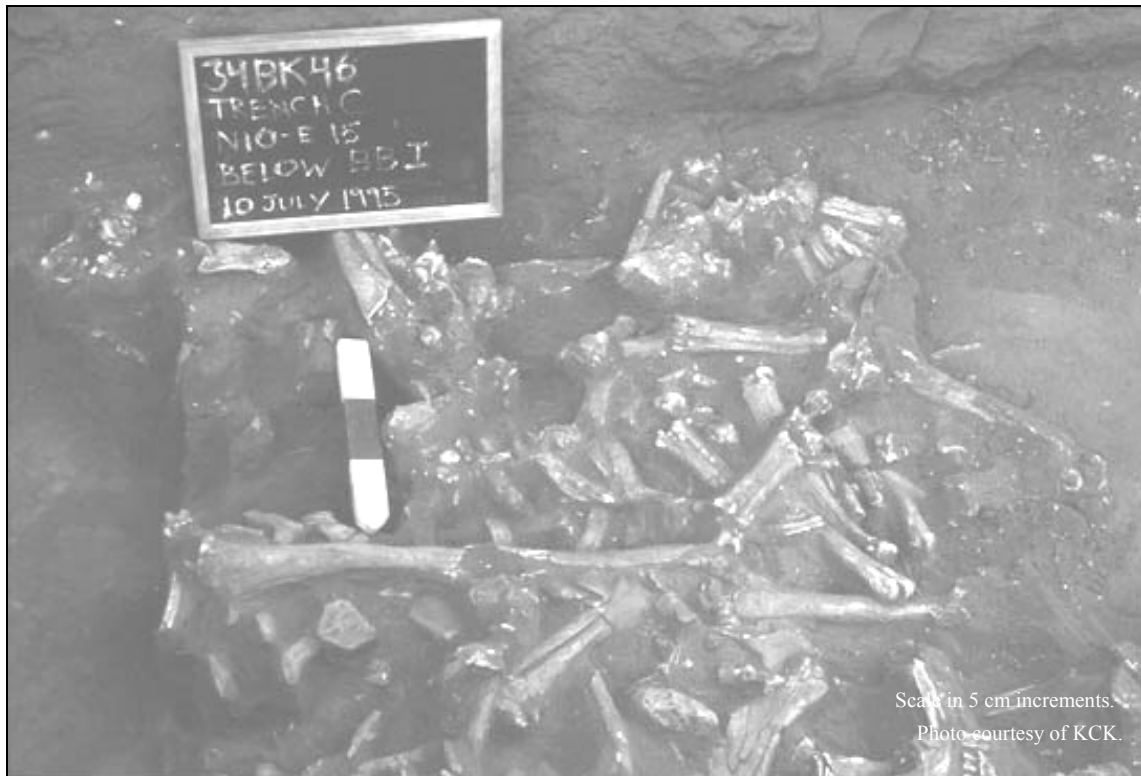


Figure 6.16. Excavation underway on pile of pelvic girdles and associated limb pile.

As previously mentioned almost all the skulls from Trench C were badly damaged. In most cases, maxillae were very fragmentary and consisted of not much more than the tooth rows (Figures 6.17). This was a result of brain harvesting strategies (Agenbroad 1989:45; Kehoe and Kehoe 1960). Grinnell (1962:268) documents that the Cheyenne left piles of (skull caps and) horns behind after butchering a herd of bison. This historically documented practice is further proof that brains were harvested at the L. E. Certain site. Not only were brains collected but tongues were harvested also. Kehoe and Kehoe (1960:423) noted that hunters placed mandibles in small piles at stations where tongues were harvested. In reference to the Blackfeet, Coeur d' Alene, and Flathead, Point's (1967:120, 125) informants relayed that there could never be an overabundance of tongues even when hundreds of animals were killed. Although most skulls were badly damaged, on occasion skulls were found intact, but inverted (Figure 6.18). This



Figure 6.17. Bison skull obliterated by brain harvesting. Note the fractured hyoid *in situ*; hyoids are generally damaged during tongue removal.

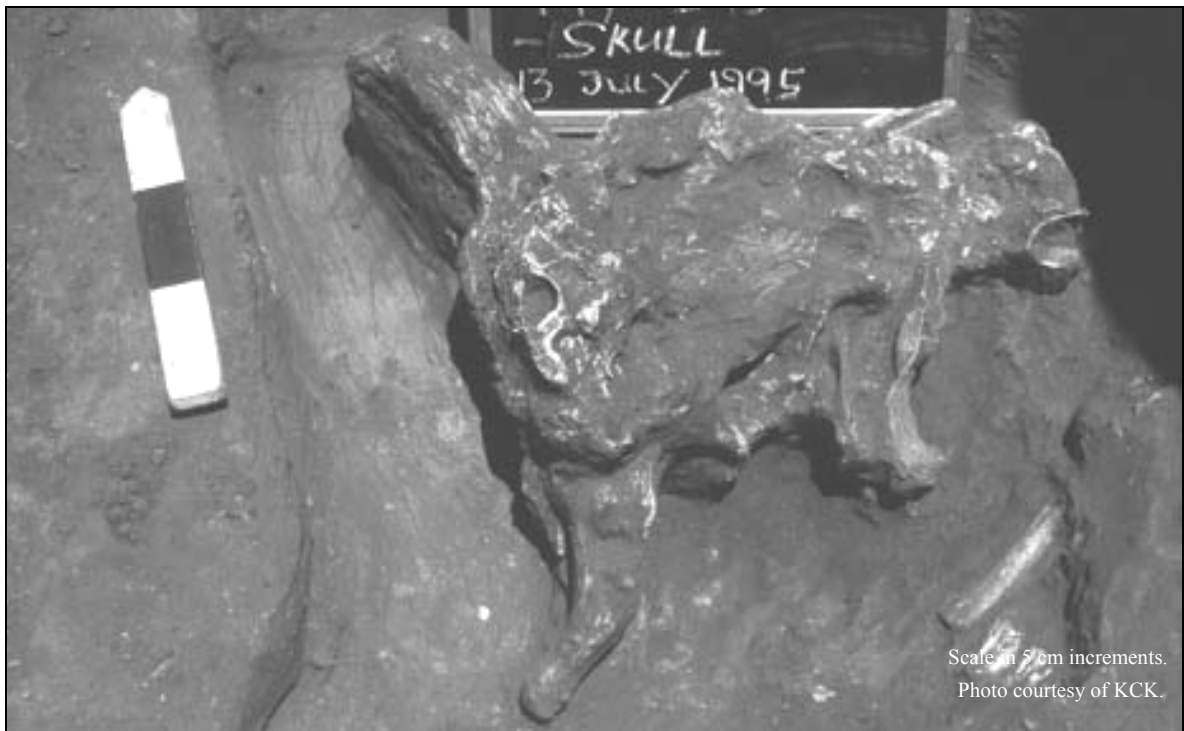


Figure 6.18. Intact, but inverted, bison skull found in Trench C. Complete skulls are rarely discovered.

positioning infers that tongue removal was taking place since this would facilitate the removal of the mandibles and thus access to the tongue. Additional evidence that tongues were harvested at the L. E. Certain site is the breaking of the mandibles at the ascending ramus. This was done when the anterior portion of the ramus could not easily be freed from the temporo-mandibular joint on the skull (Agenbroad 1989:44; White 1952:337) (Figures 6.19a, b).

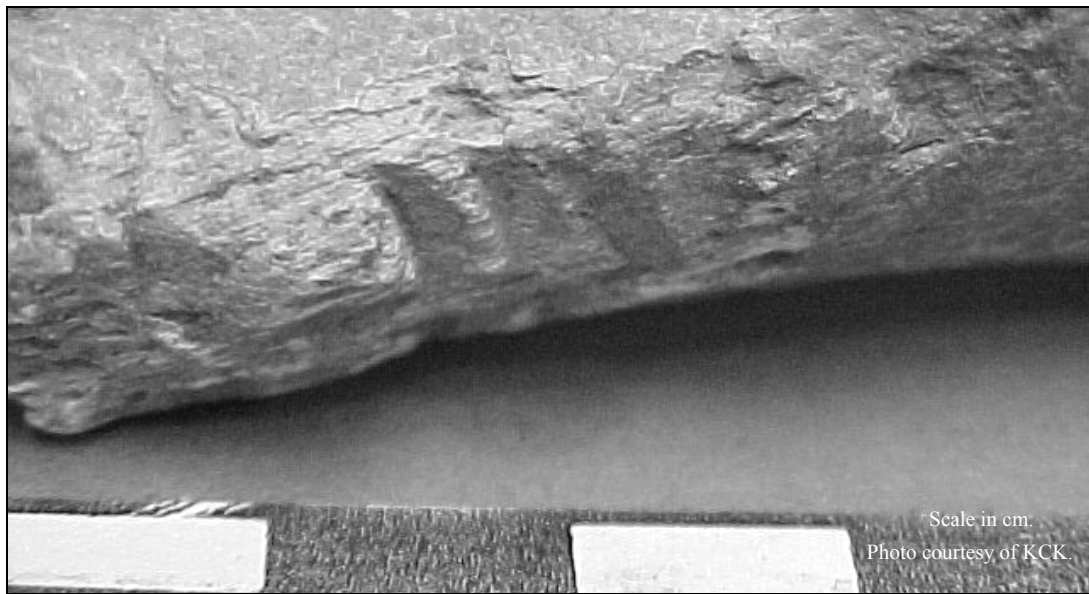


Figure 6.19b. Chop marks on the ramus of a mature bison.

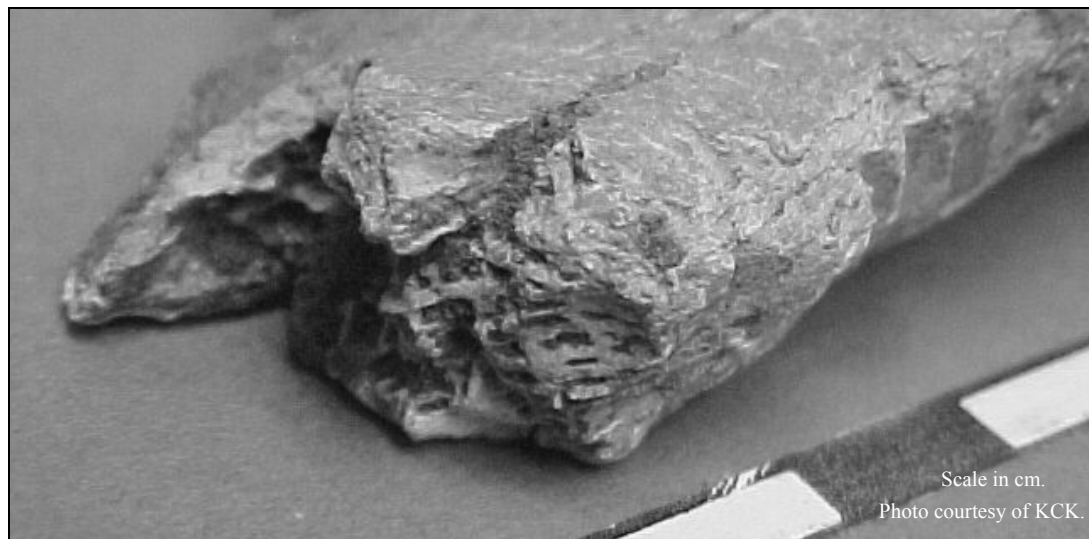


Figure 6.19b. Irregular edge of fractured mandible, posterior to the chop marks illustrated in Figure 6.18a.

Meat Production and Utilization

Introduction

White (1953) was the first to attempt to compute the amount of meat that was furnished by a given animal. His computations were based on observations made during excavations at villages in the Plains and Midwest. White (1953) attempted to outline a procedure to arrive at a reasonable estimation of the relative abundance that certain animals added to prehistoric diets. After determining the number of animals that were represented in the death assemblage, the amount of usable meat from that one element or animal was calculated using data from meat packers and animal husbandry experts. In trying to calculate the percentage that each animal furnished, White (1953:397) made the general observation that about four deer would equal one buffalo. Daly (1969) and others did the same. The crux of the method is determining live weight versus the useable meat weight.

A better representation of the amount of edible products provided by a modern bison was presented by Wheat (1972) in his study of the Olsen-Chubbuck bison kill site. Wheat (1972:114) used data collected by early explorers in the Northwest as opposed to using other less concise estimates (Ewers 1949; Grinnell 1962, 1970; Halloran 1960; Point 1967). Wheat (1972) did not calculate weights for each body part as employed by Binford (1978:15-23) with his General Utility Index (GUI) and Modified General Utility Index (MGUI). Rather, Wheat (1972:114-124) calculated the available meat based on gender and age. According to Wheat (1972), bulls could provide 259 kg (550 lb) of useable meat, cows could potentially provide 181 kg (400 lb) of useable meat, two-year-old heifers could supply 91 kg (200 lb), and a yearling had about 50 kg (110 lb) of useable meat (Wheat 1972:114). In regard to available bone marrow per animal, Wheat's (1972:114-124) calculations placed harvestable bone marrow from an adult at around 3.3 kg (7.5 lb). Agenbroad (1989:45-52) used the same calculations with the Hudson-Meng bone bed as well. Because of their success, the same figures will be used to assess the Trench C data.

Trench C Findings

Because some might question the sex of many of the animals from Trench C, the weights for bulls and cows presented above were averaged. Therefore the calculations to follow are based on an approximate weight of 220 kg of meat per animal. Furthermore, since the bison in Trench C were so extensively dismembered the assumption is made that all useable meat was removed. Because of that, full body weights will be used for the meat production calculations presented below.

Of the 43 animals recovered from Trench C, 40 animals are considered to be mature based on mandible data. Therefore approximately 8,800 kg of flesh could be derived from them. The three other animals are juveniles. All three could be considered yearlings. Using the yearling figure, a total of 150 kg of useable meat would be provided by juveniles. Therefore, about 8,950 kg of bison meat was potentially harvested from the 43 animals excavated from Trench C. Since one quarter of the Area C paleogully has been excavated (Bement and Buehler 1994:178), a rough calculation of the total meat available for Trench C can be ventured. Therefore, approximately 35,800 kg of useable meat in total (8,950 kg x 4) would have been available to the Late Archaic hunters responsible for the kill. Finally, since very few of the bones from Certain were cracked in a manner typical of large scale marrow harvesting, a marrow calculation using Wheat's (1972) and Agenbroad's (1989) figures will not be ventured.

Stone Assemblage

The 315 lithic artifacts from Area C can be separated into four major categories: projectile points and point fragments, retouch or resharpening flakes, flake tools, and hammerstone. All will be discussed in detail except for the Ogallala Formation quartzite hammerstone. This tool does not need further description other than to note that it was associated with a smashed cranium.

Three hundred and one flakes were recovered from Trench C during the 1993 and 1995

field seasons. In 1993, 16 flakes were recovered from the bone bed and another 29 flakes were recovered from the screen. The *in situ* flakes were piece-plotted and elevations were taken. In 1995, 101 flakes were piece plotted and assigned elevations while an additional 155 were provenienced according to excavation unit. In addition to the flakes, 10 projectile points or point fragments were recovered from Trench C, five in 1993 and five in 1995. All points were found *in situ* and were manufactured from quartzite or chert. The projectiles were overwhelmingly (90%) quartzite. Two flake tools were also piece-plotted and assigned elevations. The tools are equally split between quartzite and chert (Kraft 1995; Kraft and Bement 1998).

Projectile Points

At the L. E. Certain site, all but one of the points was broken (Kraft 1995; Kraft and Bement 1998). Although not damaged, the complete point had been resharpened. All the other points were extensively reworked, some more than others. In one case, a point took on an asymmetrical form from resharpening. Based on the shape and flaking patterns of the remaining points, it is evident that previously damaged specimens had been salvaged and rejuvenated. The reworking of broken points suggests that the projectiles were intentionally rescued. The points that were excavated from the bone bed were either broken at the tip or broken at the base. Since none of the point fragments refit, the missing bases must have remained lashed to the spear or fore-shaft. If bases did stay affixed to fore-shafts, then the recovery of a point base in the bone bed indicates that one of the hunters removed a point base from a fore-shaft and discarded it in the bone bed. Thus, at least one instance of preparation for replacement was made on the spot.

Point Descriptions

Of the 10 projectile points or point fragments recovered (Table 6.8), only two were found in the same square, the remainder was scattered about the excavation unit (Figure 6.20). Additionally, one point was found associated with a pile of burned bones and a broken

Table 6.8. Metric Attributes of Trench C Kills Projectile Points.

Catalog	Length	Max. Width	Min. Width	Max.Thickness	Min.Thickness	Base Width
#94	77 mm	33.2mm	11.1 mm	8.6 mm	4.8 mm	20.1 mm
#95	56.8	32	14.7	6.7	N/A	N/A
#98	8.8	24.6	N/A	5.3	N/A	18
#99	52.3	32.9	13	6.7	4.1	21.7
#101	N/A	N/A	N/A	5.2	N/A	14
A	37.7	30.5	10.3	5.9	4	19.6
B	51.8	31.3	15.3	5.7	4.6	19.8
C	33.5	24.9	7.9	7.2	5	17.1
I	2.7	N/A	20.9	9.3	4.4	N/A
K	34.1	33.7	N/A	6.8	6.3	19.7

femur, while another was found next to a thoracic vertebra, at a downward angle, although not embedded in the bone.

All the points fit loosely into established types, based on form. These points are all relatively large, shallowly corner- or side-notched specimens, with thick necks and strong bases (Table 6.8). Recognized point types are Ensor, Marcos, Marshall, Palmillas, Shumla, Trinity, Williams, and others. Idiosyncratic production gestures of the knapper always produce slight variations in form (Collins 1975, 1993; Cross 1983; Schlanger 1995). Since multiple hunters were likely necessary to accomplish this kill, it must be taken into consideration that multiple idiosyncratic flaking techniques would be displayed. A description of the Trench C points follows.

Point #94 is an undamaged specimen (Figure 6.21). This point is complete, rather long, and made of Potter chert or Ogallala quartzite. The point has a slight red hue to it suggesting it was heat-altered. Presumably heat-treating was done in order to make the material easier to work (Bleed 1980; Collins and Fenwick 1973; Crabtree and Butler 1964; Mandeville 1973; Purdy 1974). The point is relatively thin with finely chipped edges. One large step flake that originates from an edge is evident and measures 6.9 x 12.3 mm. Often such terminations are a result of inconsistencies in the material or a lack of adequate force to detach the flake uniformly. The base of the

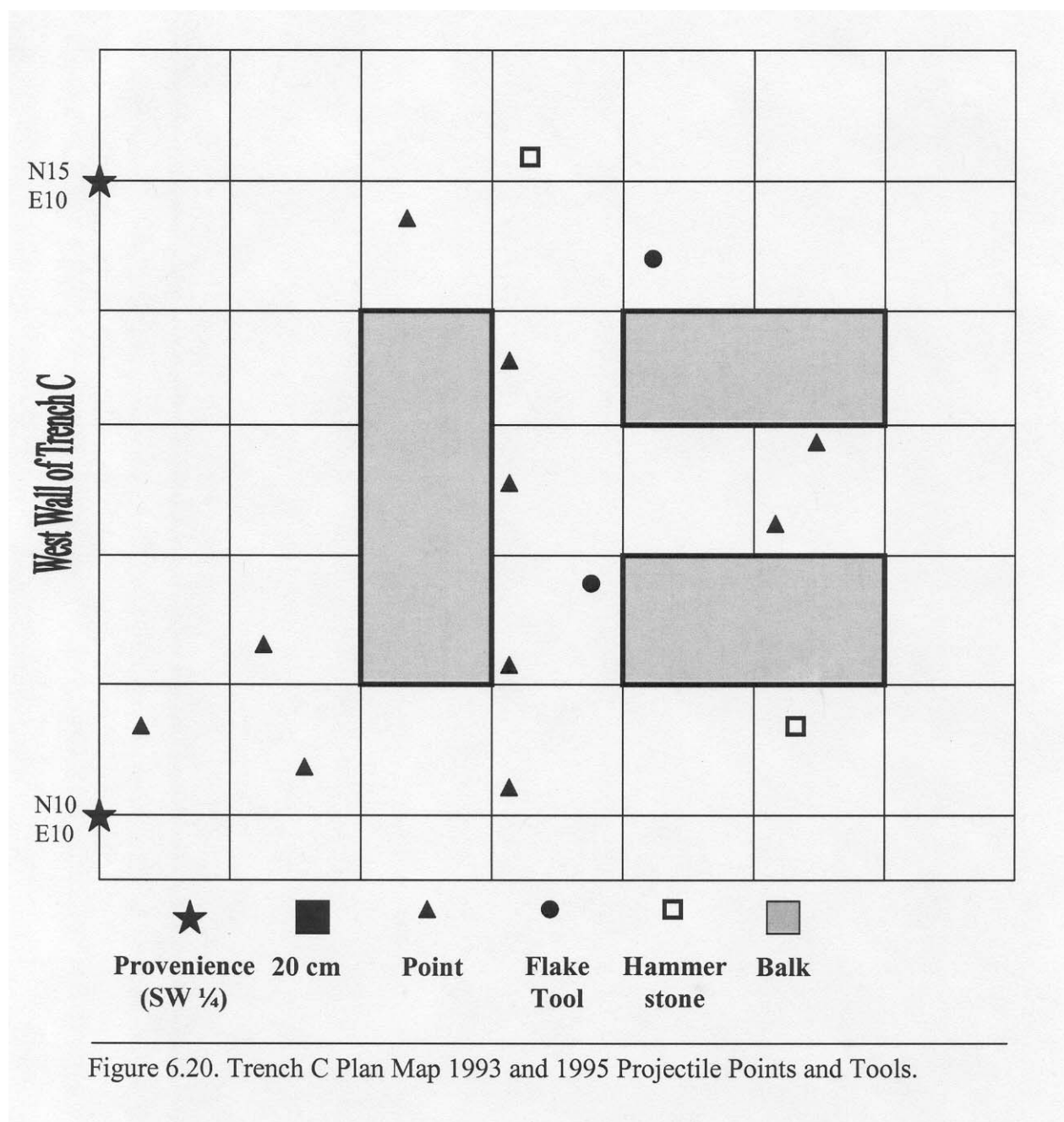


Figure 6.20. Trench C Plan Map 1993 and 1995 Projectile Points and Tools.

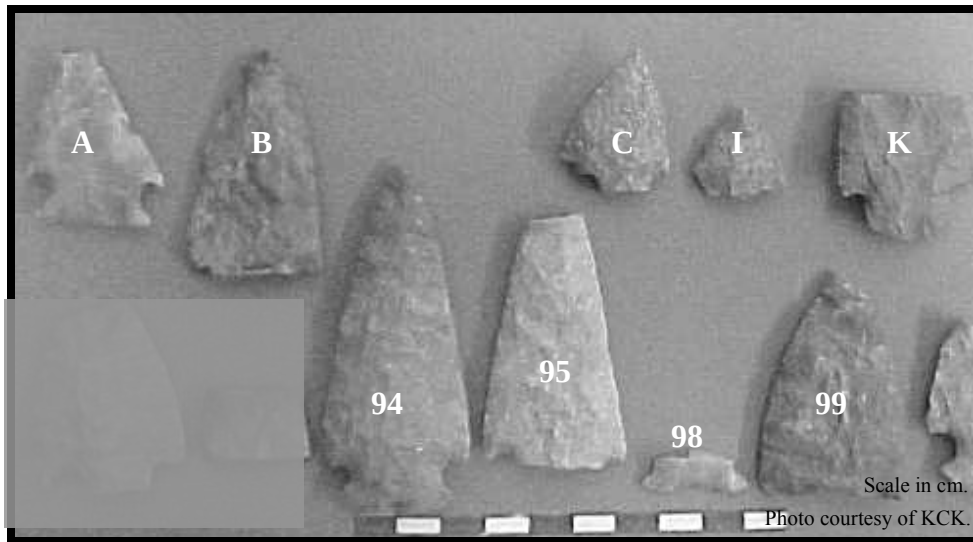


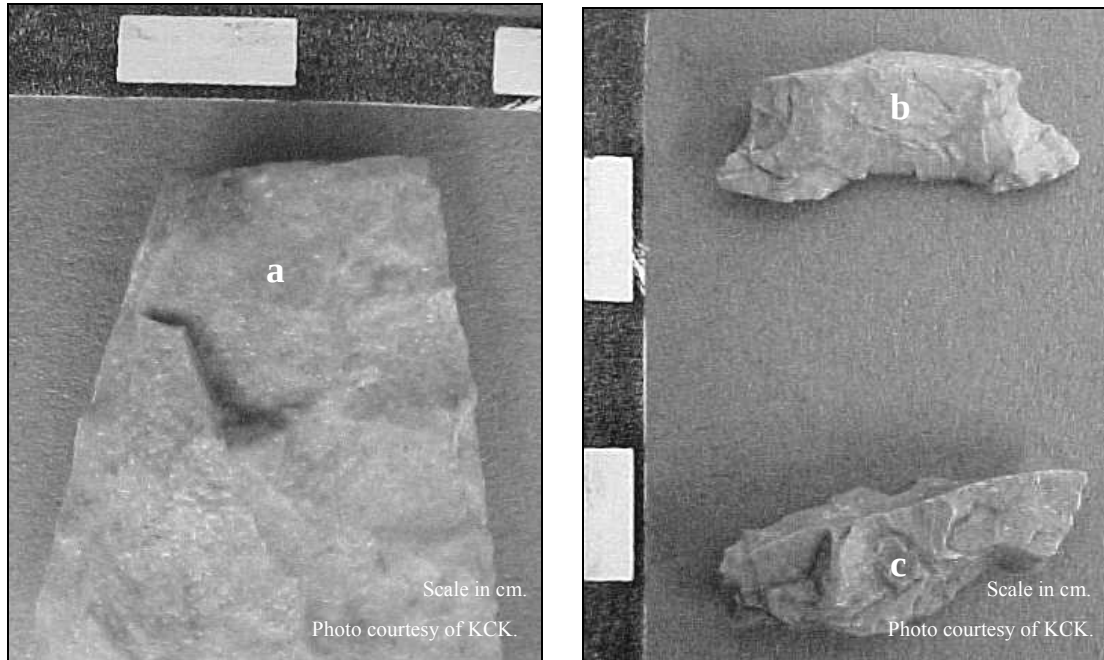
Figure 6.21. Projectile points recovered from Trench C kills between 1993 and 1995. Others have since been recovered from Trench C (*Scale in cm*). Top row, left to right: A, B, C, I, K; bottom row, l to r: 94, 95, 98, 99. Point 101 is not pictured.

point is dulled to facilitate hafting. The wide but shallow notches emanate from the corners but the shoulders of the notches are rounded and merge into the blade edges.

Projectile #95 is another well-made point constructed from a grainy piece of tan-gray Ogallala quartzite (Figure 6.21). The *outrépassé* flaking technique was utilized to shape the point. Thinning flakes at the top of the point travel the width of the specimen to the opposite edge. The tip and the base of the point are broken from impact shock. The tip has a large longitudinal impact flake (Figure 6.22a). The base is broken at the notches and the shoulders are sharp, not rounded. The sharp notches begin at the corner and are rather narrow. Presumably these sorts of notches widen and round off after several edge resharpening events. The point is slightly asymmetrical.

Specimen #98 is a point base fragment made of gray-tan Potter chert (Figure 6.22b). It does not refit to any of the other points collected from Trench C or any other points recovered from the L. E. Certain site. The base is concave and about 1.6 mm deep. No

other points from the site possesses a concave base. The concavity may be a result of reworking an impact-damaged base. The point from which the base came was side notched.



Figures 6.22 a-c. Impact damage on projectile points: (a) impact damage on point #95 typical of colliding with a rigid object; (b) point base #98, and (c) point base #101.

Point #99 is manufactured from dark gray to mottled tan Potter chert (Figure 6.20). The point has a broken base and reworked edges. The base was snapped off at the notches which originate from the corners of the specimen. Like the two previous points, damage was caused by impact. Further evidence for the cause of breakage comes from the point's provenience. Specimen #99 was found adjacent to a thoracic vertebra (Figure 6.23). It should be noted that Potter chert, is very resilient and does not fracture easily. The point appears to exhibit a few high points in the center but these are a result of step terminations that occurred while trying to detach thinning flakes.



Figure 6.23. Point #99 found *in situ* in the hump section of a bison in Trench C. Note the base is snapped off at the notches

Point fragment #101 is the neck of a heat-altered grayish-tan piece of Potter chert (Figure 6.21). The small fragment resulted from a longitudinal/diagonal break. The break initiated at the notch on one side and extended through the base of the tang on the other side of the point. Based on what is left, the point was originally corner notched. The obverse side of the surviving notch was reworked while the reverse does not display any reworking. Based on the thickness (5.2 mm) between the notches (neck) this is one of the narrower specimens which may have caused its failure. The point fragment does not refit to any of the other point fragments recovered from the site.

Projectile A is an asymmetrical piece with a broken tip (Figure 6.21). However, the side

notches are symmetrical and of equal size, and the base is straight. This is the only specimen not made from quartzite. The point is manufactured from a somewhat translucent piece of gray chert. Application of ultraviolet light reveals parallel bands indicative of Alibates silicified dolomite. The point base is very thin, perhaps to facilitate hafting. Flakes with step terminations mark the point's edges.

Specimen B is yet another point that has the base snapped off as a result of impact (Figure 6.21). The point broke at a diagonal angle from the top of one corner notch to the bottom of the opposing notch. The projectile, made of gray-brown Ogallala quartzite, is slightly asymmetrical from resharpening. The edge is damaged near the top on one side. There are several step terminations across the mid line of the point. Presumably *outrépassé* or feather terminations were attempted but the tenacity of the material or the skill of the knapper prevented the flakes from traveling across the face of the point. As a result of the step flakes, the point faces are rather irregular.

Dart point C is a corner-notched projectile made of tan Potter chert (Figure 6.21). The base of the point is missing. The specimen has been extensively reworked to the extent that it is reduced in length. The tip is still very sharp perhaps indicating that it was damaged while being resharpened.

Specimen I is a tip fragment (Figure 6.21). It is possible that the fragment came from an unnotched biface or knife. For discussion purposes, it is considered to be from a point. The point tip is manufactured from a piece of grayish-tan Potter chert. The break is lipped and resembles a hinge termination. The edges are extensively reworked and the tip is still rather sharp. The fragment does not refit with any other projectiles found elsewhere at the L. E. Certain site.

Dart point K is made from a flake of brownish-tan Ogallala quartzite (Figure 6.21). The profile of the point still retains a slight curve from the original flake used to make the

piece. The platform of the flake forms the base of the point. The tip is missing but the rounding of the shoulders from repeated notch-work makes it approach the side-notched category. Several plunging parallel flakes were employed to further thin the point.

Finally, a small fragment of a point was recovered and originally identified as a flake in the field. In essence, this could be considered an eleventh point. The bifacially flaked piece represents a fragment of a notch from a projectile point (Figure 6.22). As with the other point fragments described above, this specimen does not refit with any other points recovered so far.



Figure 6.22. Fragment of a notch from a projectile point.

Utilized Flakes/Flake Tools

Two utilized flakes were recovered from the bone beds. These tools exhibit use-generated flake scars, abrasions, and polish. One was discovered away from any conceivable activity area while the other was associated with a bone pile. The flake tools display the same trends exhibited in the projectile points and biface resharpening flakes. That is, they are made from both Alibates silicified dolomite and Ogallala Formation quartzite, or Potter chert. Additionally, the flake tools were removed from bifaces. The bifaces were much larger than the projectile points recovered from the site. This assertion is based on the fact that the striking platform is not multi-faceted. In other words, the edge of the biface from which the flake was removed, was not finely chipped. Rather, the biface edge possessed large flake scars.

Based on the recovery of these two utilized flakes, the knapping and use sequence that they went through can be reconstructed (Muto 1971:115). Although such reconstructions have been challenged (Read and Russell 1996:663-665), evidence from the points and the

biface resharpening flakes support the suggested sequence of events. It was already mentioned that the platforms from the two flake tools indicate that they were not removed from a projectile point. Additionally, the flake scars on the dorsal surface of the flake tools only had two or three flakes detached prior to the tool flake being removed. From this, an idea of the shape, outline, and flaking pattern of the original piece can be deduced. A large flake of similar size from a projectile point would possess multiple flake scars on the dorsal surface. Multiple flake scars result from thinning and honing point edges.

Tool Descriptions

Lithic G is an Alibates flake tool (Figure 6.23). The cream colored piece had faint red bands which stood out rather prominently when excited by ultraviolet wavelengths. Lithic G was associated with an articulated vertebral column. Cut marks were difficult to detect

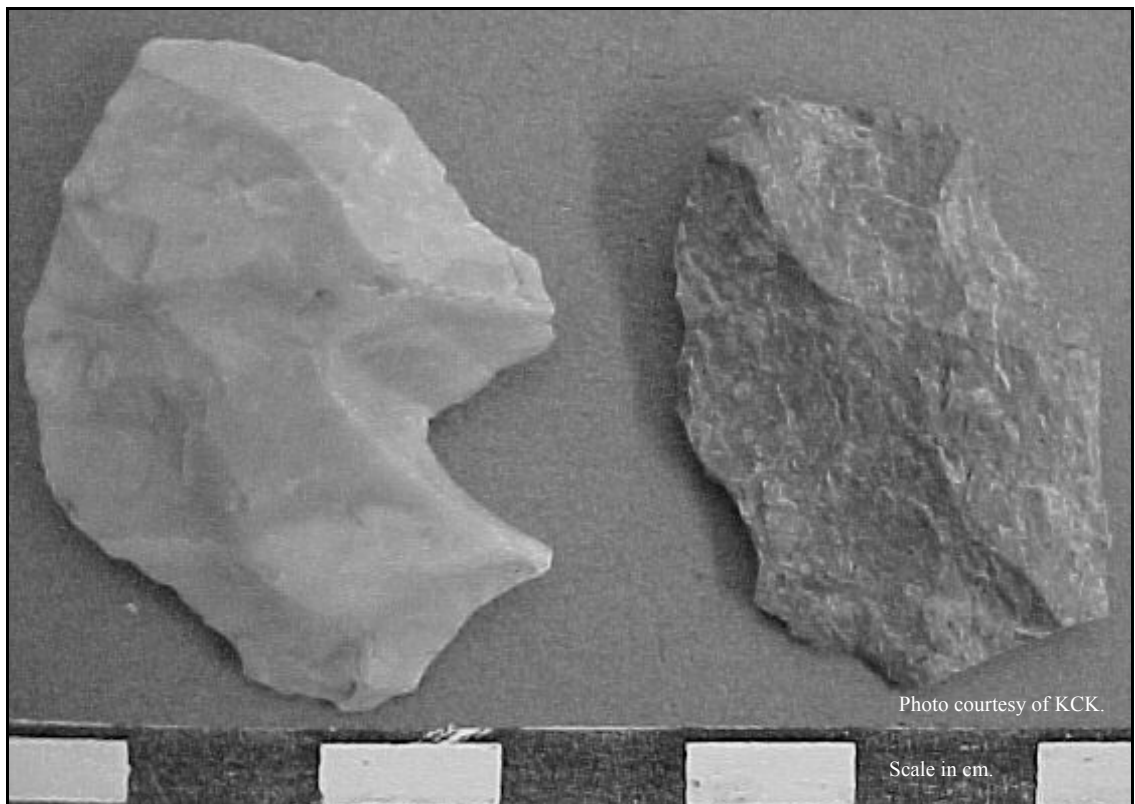


Figure 6.23. Biface resharpening flakes subsequently used as a flake tool (utilized flake).

on the vertebrae given the extensive root etching on the bones. Given this, it is not known if the flake was used on the associated bison carcass or not.

Lithic J was an Ogallala quartzite flake tool (Figure 6.23). Damage and use-wear on the flake was not as readily evident because of the coarse grain of the tool stone.

Biface Resharpening Flakes

The majority of the lithic material collected from Trench C was classified as biface-resharpening flakes (Figure 6.24). Biface resharpening flakes are distinguished from projectile point resharpening flakes by their absence of multiple platforms. This is a trend consistently noted at bison kill sites (Fawcett 1985). In all, 301 specimens were collected. Although Figure 6.25 demonstrates the variety of forms recovered from Trench C, the majority of the specimens fit the resharpening category as defined by Bordes (1961:6), Semenov (1976:55-62), and others (Brosowske and Bement 1997; Huckell 1978:170-175). The mean platform length was 17 mm and the mean platform width was 0.5 mm.



Figure 6.24. Biface resharpening flakes, byproducts of edge rejuvenation. Note the prominent lipping on the upper, center specimen.

The mean width of the flakes recovered from Trench C was 6.7 mm. The mean length of the flakes was 7 mm and the mean thickness of the recovered flakes was 1.4 mm. These data clearly illustrate that these flakes possess long, skinny platforms and mostly were as long as they were wide which is consistent with similar artifacts characterized as resharpening flakes (Bordes 1961:6; Semenov 1976:55-62).

These flakes are set apart from the utilized flakes in that they were not exploited after they were removed from the objective piece. The resharpening flakes served one purpose, they were removed as a means to rejuvenate the edge of a biface knife. The retouch flakes remained close to where they were removed, as they had no other utilitarian value. Such as it is, flakes were widely scattered suggesting retouch occurred within the context of ongoing butchering. The same was true at the Horner bone bed (Hemmings 1987). There is no clustering of debitage indicative of knapping stations such as at the Hudson-Meng bone bed in which there were clearly defined work areas (Huckell 1989:153-164). There were also clearly defined work areas at the Sanders bison processing site (Quigg 1997a:42-47). All the biface retouch flakes were most likely produced by the soft hammer technique or pressure flaking, opposed to hard hammer, based on body and platform dimensions (Crabtree 1967; Hayden and Hutchings 1989; Patterson and Sollberger 1978; Speth 1974). Of course, the striking platform of the flakes includes a small part of one side of the biface tool. However, there are always problems involved in distinguishing between wear produced deliberately, wear produced by removal technique, and true use-wear. Often biface edges are roughened to facilitate the removal of flakes. In other instances crushing is produced when detaching a flake. And then again, there is wear produced from actual use as a cutting and skinning device. A large majority of the Trench C specimens had crushed platforms.

In general, very large flakes are not produced from pressure flaking, or during resharpening (Patterson 1982). However in some cases research has shown that there is no essential difference in the size distribution of debitage from pressure and percussion

flaking (Magne 1989). The resharpening flakes from Trench C are relatively small, thin and often expanding (but not always), longitudinal in cross-section, and curved, as a result of the biface being ovoid. In general, soft hammer flakes have diffuse bulbs of percussion and generally lack prominent ripples or bulbar scars. Platforms are also generally ovoid or lenticular on soft hammer flakes (Pelcin 1997). The trait most characteristic of soft hammer flakes is lipping on the interior side of the platform (Crabtree 1972; Newcomer 1971; Ohnuma and Bergman 1981). Most of the Trench C flake platforms possessed prominent overhangs and possessed oblong to spherical platforms (Figure 6.24).

As it appears at the present the Late Archaic hunters came to the site with quartzite projectile points attached to a shaft with binding designed to penetrate on impact (Frison 1991:315). It also appears that the hunters arrived with hafted Alibates and quartzite biface knives designed for skinning and butchering. All retouch flakes were at the same stage of dullness when they were removed indicating that a particular level of wear was reached before resharpening took place. Frison (1968) observed a similar situation at the Piney Creek site. When the biface knives became dull, a few large flakes were taken off to rejuvenate the working edge. In some cases, the removed piece was not wasted; it was used as a cutting apparatus as well. It does not appear that a flake tool was produced until after it had first served its purpose as part of a biface knife.

Finally, it might be argued that the points themselves served as butchering tools (Ahler 1971:118). Frison (1991:314-315) argues that although there is abundant evidence of projectile points being used in manners other than piercing, points would not be the appropriate tool for processing a communal bison kill. In effect, the binding employed to attach a piercing tool does not have sufficient structural strength to withstand the pressures of cutting and slicing. Reinforcing the binding to perform both tasks lessens the ability of the tool to performing its piercing duties.

Microscopically, it is difficult to determine if the L. E. Certain site point edges served as butchering tools (Kraft 1995). However, recognizing use-wear on quartzite artifacts and quartzite test specimens is possible with a relative level of confidence (Greiser and Sheets 1979:292-296). The experimental mechanical tests performed by this researcher with comparable materials were inconclusive. Moreover, none of the resharpening flakes recovered from the bone beds are of the same dimensions as the flakes removed from the projectile points based on flake-scar size (Kraft 1995). Furthermore, none of the breaks on the projectile points are a result of use in a cutting or sawing manner. Rather the points were all broken as a result of impact.

Summary and Conclusion

The results from the Trench C faunal and lithic analysis were used to address bison hunting and processing strategies, as well as organizing strategies practiced by the Late Archaic hunter-gatherers who visited the L. E. Certain site. This was achieved by examining the patterned distribution and organization of skeletal elements as well as the use of specific stone tools found in the bison bone bed. The number of bison contained in the excavated area was first determined by using the frequency of various skeletal elements. This is the most basic unit of analysis in interpreting large-scale game kills. The number of animals present served as a basis for making interpretations about human group activity, namely communal hunting and butchering. The age of the animals and season of death was determined next using mandible data. Based on the season of death, it was determined that at least one large bison kill took place in late-autumn or early-winter and another smaller kill in early spring. The larger kill probably represents provisioning for winter by a collection of groups acting in concert (Frison 1967:36, 1973; Keyser 1979:140-144). This buffering technique fits well within the requirements of the Annual Model (Frison 1967:32, 1970:5, 1973:6-7). The smaller kill from early spring probably represents spring hunting by a small family unit in an area known to harbor bison in autumn. Herd activity in the spring usually consists of a loose unit of assorted

cow-calf pairs. At this time, neither strays more than 50 m from the other. Based on seasonal and maternal behavior, two cow-calf pairs could be easily dispatched especially around a water source. Archaeologically, similar herd subsets are noted at Lubbock Lake (Johnson and Holliday 1986:25-26), and observations of modern bison herds confirm this behavior (Bement, personal communication 2005 McHugh 1972:150-157; Schult and Haugen 1979:15). Finally, there is the possibility that the four spring animals represent special processing of a larger kill located nearby. Trench F with its fetal bison is a prime candidate.

The degree of skeletal disarticulation in Trench C reflected discrete activity areas. This complemented the notion that the hunt was the result of organized group behavior. Non-natural bone clusters identified human activity areas. Butchering decisions, represented by the distribution and composition of bone clusters, reflect intent to reduce transport weight. The stone tool assemblage recovered from the bone bed was rather uniform. The only tools used were those needed to dispatch and butcher a large number of bison. Several points were recovered reflecting various stages of damage which occurred during the hunt. All but one point showed previous episodes of breakage. Thus, the points had been recycled and repaired for an impending hunt. Since the biface retouch flakes did not come from these points, the points had likely undergone maintenance at another location. Implements devoted to processing meat, such as biface knives, were not recovered. However, evidence of their presence was reflected in the hundreds of biface resharpening flakes found in the bone bed. Since other knapping debris was not recovered, it is surmised that the hunters came prepared for the kill and processing event.

CHAPTER SEVEN

THE LATE ARCHAIC COMPONENT OF THE BEAVER DAM SITE (34RM208)

Introduction

To date, the Beaver Dam site (34RM208) is the largest, most extensively excavated, Late Archaic site on the southern Plains. However, that is not saying much since intact, quality sites from this time frame are few and far between. Most information from archaeological sites of this time is limited to surface collections. It is generally accepted that the lack of intact deposits is the result of loss and destruction through erosion and deposition, as discussed earlier. The lack of intact quality sites may also have something to do with the settlement patterns of the Late Archaic folks of the southern Plains. In short, people most likely camped in canyons during the winter to avoid harsh weather. Here they could enjoy morning and daytime sunlight beaming on the arroyo or canyon walls all the while being protected from Arctic winds. Campers would also enjoy increased spring discharge courtesy of the dormant flora. Conversely, these folks may have camped on high ridge tops in the summer to take advantage of the cool bug-free winds and the vistas that these locations offer. As a result of these settlement patterns, the upland ridge sites are subject to deflation whereby subsequent visits to the same locations by other groups become mixed context settings, a puzzle that is still being sorted-out today. Likewise, these upland settings are prime targets for surface collecting by past and present passersby. As a result, such sites are labeled as “unidentified prehistoric” components/sites by archaeologists or mixed context components/sites. As for the lowland canyon sites, subsequent cutting-filling-flushing cycles, so common on the southern Plains and its eastern margin, bury and redeposit materials used and discarded by these groups. Despite these shortcomings, the Beaver Dam site can provide insights into Late Archaic-Woodland adaptive strategies, namely subsistence approaches and settlement patterns. Through optimization (beneficial adjustment to the environment), subsistence and

settlement regimes increase a group's chance for survival. The prudent use of time and effort is reflected at base camps in the use of local faunal, floral, and lithic resources reflecting diverse sets of procurement and consumption activities. Additionally, there should be evidence for the manufacture of tools necessary for procuring the ubiquitous bison. The choice of site locations, namely residency along ecotonal and geologic boundaries allows multiple biomes to be exploited without great traveling distances.

Site History and Discovery

Archaeological site 34RM208 was discovered following an intense rain event and dam break in the 1960s (Thurmond 1988a). Since the original breach, the ranch road and dam traversing Brokenleg Creek on the Thurmond Ranch have been destroyed twice by beaver activity indirectly or directly (Thurmond, personal communication 1997). This is where the site gained its name. Each time the road was washed out, it was rebuilt. This process of destruction-and-rebuilding is due in large part to two factors, however closely related. The devastation is the result of an increase in precipitation, and the ferocity and duration with which it falls and runs off due to local relief (Thurmond 1993, 1996). As much as duration and increase in precipitation affect the natural and man-made environment, the sheer difference in amount of precipitation from year to year is a major factor in reshaping the physical environment. Current research suggests that local environmental shifts noted by Thurmond and Wyckoff (2000) are manifestations of a larger climatic trend, the result of fluctuations in solar output (Leventer et al. 1996; Stuiver and Brauinas 1989, 1993).

The localized shift in rainfall patterns is nothing new to this part of the southern Plains as indicated by an ever-growing body of unpublished data (Thurmond and Wyckoff 2000). Weather pattern shifts have been combated by modern technology, namely upstream dams. Tributaries feeding the Washita River from the south have experienced various stages of cutting and filling as the result of overall climatic patterns, vegetative cover, animal and human manipulation, and more recently historic farming practices (Burgess et

al. 1959:1-4). The same can be said for other feeder tributaries in western Oklahoma (Ferring 1982, 1995; Hall 1982a, 1982b, 1990). Five major drainages and surrounding upland settings have been examined in detail and from these settings more than 100 radiocarbon dates from bulk samples have been collected (Thurmond and Wyckoff 1998, 2000, 2001). The profiles and soil cores examined as part of the longitudinal research project indicate that enormous changes took place prehistorically in regard to local stream morphology (Kraft and Lail 1999; Thurmond and Wyckoff 2000).

In more recent times, the United States government, the State of Oklahoma, and local landowners organized as a conservation district, have tried to manipulate the behavior of the Washita River (Steele 1966). The Sandstone Creek Flood Prevention Project is a testament to that (United States Department of Agriculture 1964). Touted as the World's first complete upstream flood prevention project, hundreds of dams and over 724 km of terraces have been built since 1950 to prevent erosion and ultimately make the land one giant sponge (Steele 1966:432-433). In reality, flooding and siltation of the Washita River is much more of a historic problem than the well-known Dust Bowl's carnage. Stipulations placed on homesteading, particularly the 4 ha mandatory minimum of broken soil for every 64.7 ha, set the stage for accelerated erosion and subsequent flood damage long before the drought of the 1930s. The already marginal nature of the local environment is also influenced by geographic location, namely being on the leeward side of the Rocky Mountains. According to the cut and fill episodes observed in many central and western Oklahoma canyons, the cyclical patterning of mass wasting and accumulation of sediment was occurring before, during and after the occupation of the Beaver Dam site (Ferring 1982, 1995; Hall 1982a, 1990; Hall and Lintz 1984; Thurmond and Wyckoff 1999, 2000).

Previous Archaeological Investigations and Findings

J. Peter Thurmond recorded the Beaver Dam site in January 1983. Prior to 1983, Ranch Boss, Charles Batchelor, made occasional visits to the Brokenleg Creek location and

collected artifacts from the creek bank. Eleven separate collections of surface materials were procured from disturbed contexts at the site between 1983 and mid 1987 (Thurmond 1988c:1). A total of 584 lithic artifacts, faunal elements, and sherds are represented in the 11 collections. The predominate lithic material is Ogallala quartzite (75%) and the main animal represented is Bison bison (81.15%). From the projectile point forms recovered, Thurmond (1988a:2) surmised that at least two components were represented with the stratigraphy in the cut bank tentatively supporting this conclusion. In a proposal for emergency salvage excavations at the site, Thurmond (1988c:1) aptly describes the site's geographic setting and recent history. His observations are as follows:

“The site is contained within an alluvial/colluvial deposit of dark brown sandy valley fill in the upper reaches of Brokenleg Creek, a spring-fed tributary of the Washita River. The creek appears to have aggraded at varying rates from an unknown date (probably early Holocene) until Late Prehistoric times, accumulating deposits some 10-12 meters in depth. A final deposition of 10-15 cm of colluvium during the early historic period was followed by a rapid incision of the creek through these deposits, centered on the south side of its narrow valley in the immediate site area, forming a deep canyon.”

Based on the surface collection of ceramics, stone and bone tools, debitage and projectile points, the site is tentatively attributed to the Late Archaic and Plains Woodland occupation of the area (Thurmond 1988c). Preliminary analyses of the materials recovered from the site have been published on six separate occasions. Four *Oklahoma Anthropological Society Newsletter* articles have recounted the findings from research at the Thurmond Ranch. A ranch-wide survey by another archaeologist and Thurmond (Thurmond and Moore 1985) was the first of the four articles while another three articles focused on three field schools conducted at the site (Thurmond 1988a, b, d). Finally, an article addressing a great number of sites from the ranch concludes the research to date on the Beaver Dam Site. The aforementioned article also places the Beaver Dam site in a regional context (Thurmond 1991a). A partial burial from the site has also been published (Thurmond 1991b).

The Late Archaic Component

As previously mentioned, the Beaver Dam site was in use at a time alluvial deposits of Brokenleg Creek were aggrading. The aggradation process continued until the valley was covered with several meters of sediment. Subsequently, the cycle changed to one of degradation, and most of the alluvial and colluvial deposits in the creek were removed (Figure 7.1). Many of the capillary drains feeding Brokenleg Creek were spared this fate and cultural debris locked in these ancient tributaries are only now being exposed. After

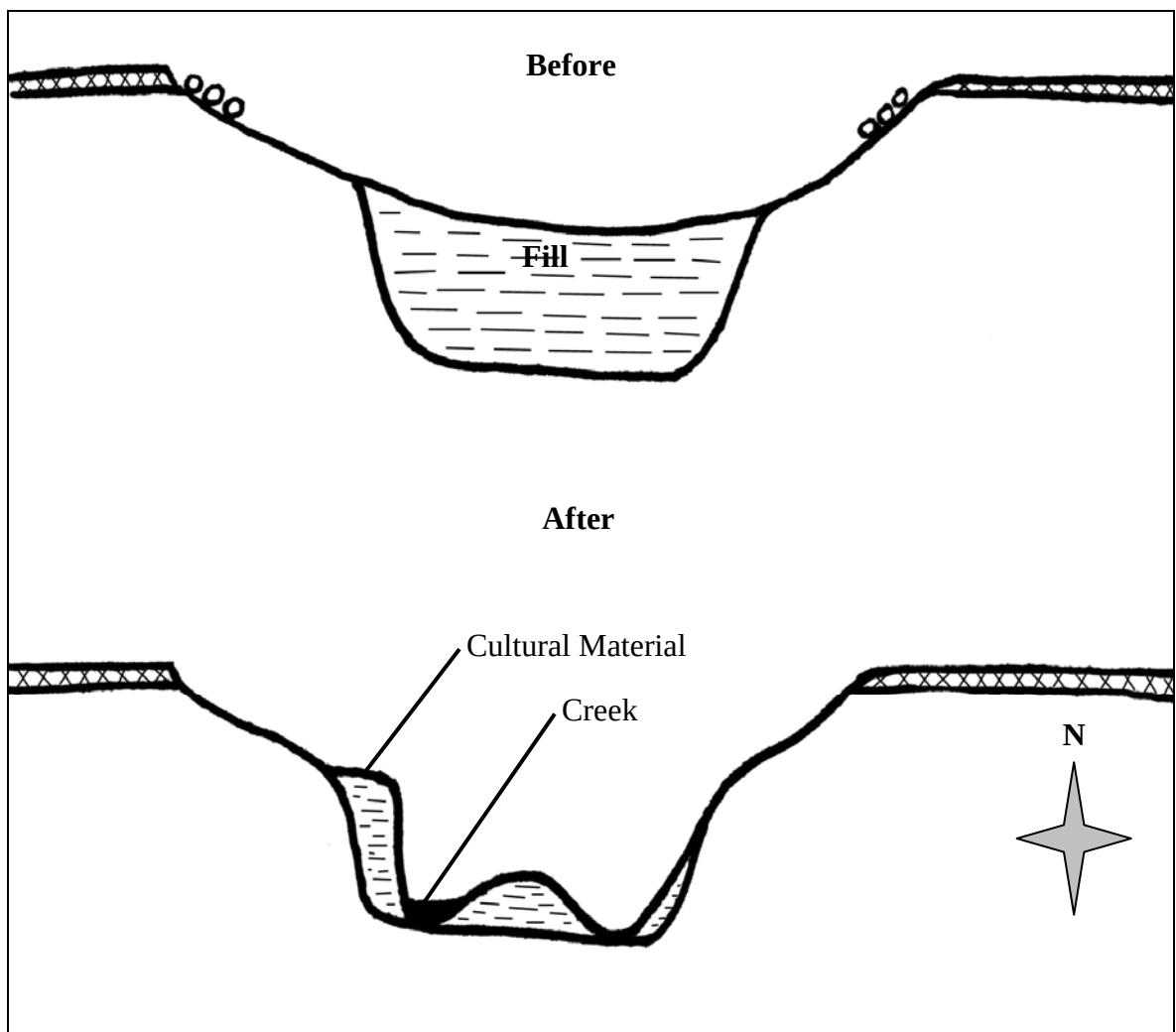


Figure 7.1. Profile of ancient and modern valley. Above: Profile of ancient valley filling in with sediment. Filling occurred through the millennia, all the while being occupied by prehistoric inhabitants of the region. Below: Profile of valley and fill following most recent erosional cycle. Adapted from field notes of J. Peter Thurmond (JPT.).

7.3a-b). The excavation unit was 2 m wide (N4 and N5) and 24 m long (W9 through W32). The Area A occupational surface at Beaver Dam changed through time as the adjacent creek evolved. As a result, the west end of the site, and the west end of the excavation unit, is vertically higher than the occupational surface on the east end (Figure 7.4). The dated paleosol, which the Late Archaic occupation is within, verifies this conclusion. Given this, the earliest date from the site (1910 ± 50 BP, Beta 116185) was only about 70 cm below the modern surface (Table 7.1). Likewise, analysis of two soil profiles by a soil scientist (Brian Carter, Oklahoma State University, Stillwater) reveals that deposition on the west end of Area A was strictly alluvial. Conversely, the east end of Area A had colluvial fill near the bottom. In short, it would take a lot longer to fill a canyon with alluvium than with colluvium when weather patterns are stable. As a result, sediment build-up on the west end of the site was considerably slower than that on the

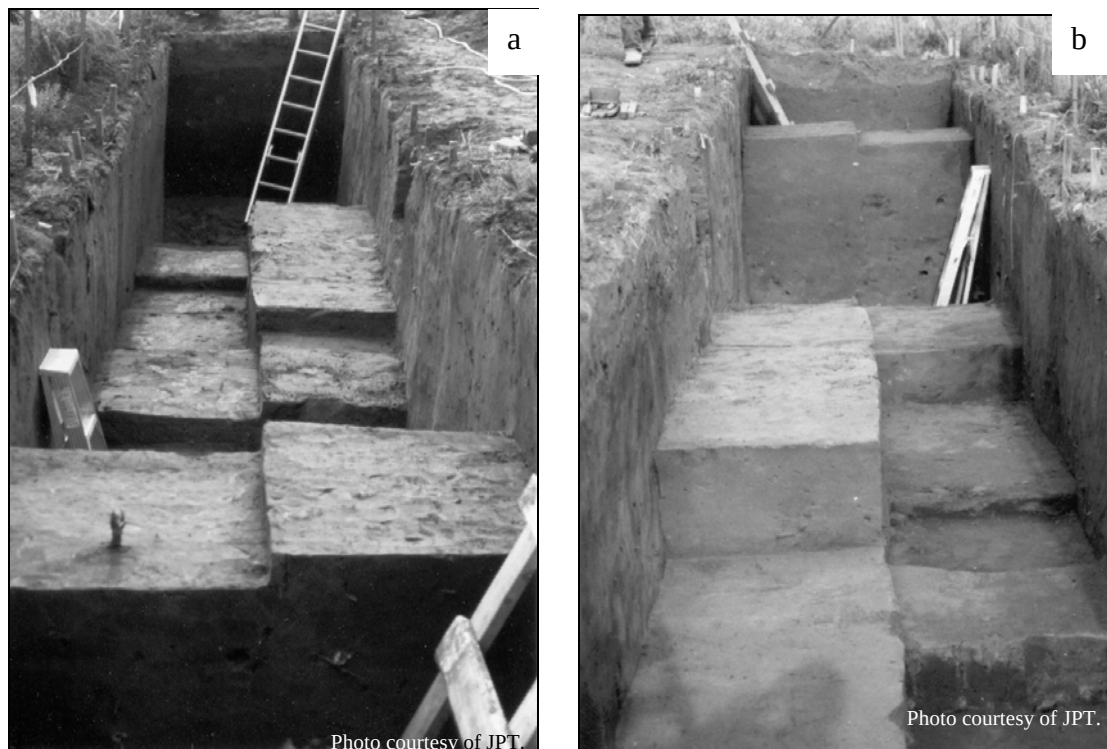


Figure 7.3a. Area A: (a) view west down the excavation trench from center of unit; (b) view east down the excavation trench from center of unit.

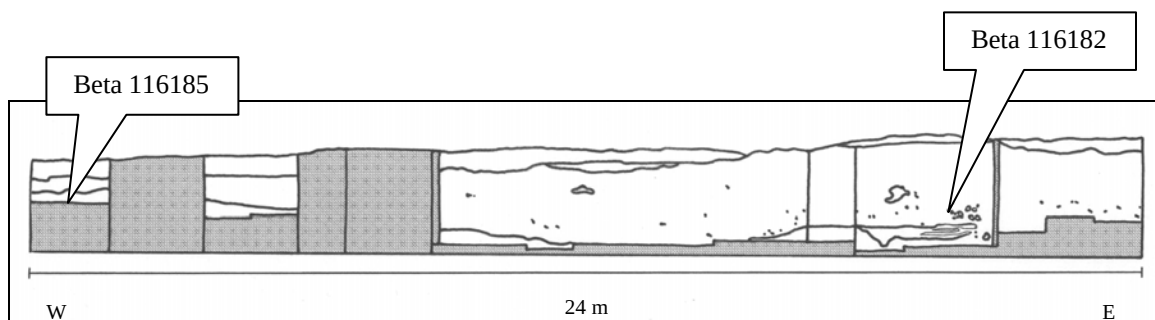


Figure 7.4. Profile of excavation trench at Area A. Shading depicts unexcavated areas.

east end. The second oldest radiocarbon date from Area A comes from the east end of the excavation unit. An 1870 ± 50 BP (Beta 116182) date was secured from charred material collected 2.2 m below the modern surface (mbms). Excavations at Beaver Dam did not go beyond 2.4 mbms, but cultural material was still being exposed. Based on these dates, it is clear that Beaver Dam and L. E. Certain are contemporaneous. Moreover, the sites are easily one day's walk from each other at 23 km. According to calculations utilized to trace Oñate's 1601 trek across the southern Plains, Vehik (1986:24-26) determined that the Spaniard and his entourage averaged approximately 16 km per day.

Table 7.1. Late Archaic Radiocarbon Dates from the Beaver Dam Site.

Laboratory & #	Measured ^{14}C	$^{13}\text{C}/^{12}\text{C}$ Ratio	Conventional ^{14}C	Calibration (95%)	Intercept	Material
Beta-116185	1880 ± 50 BP	-23.4	1910 ± 50 BP	AD 5 to 235	AD 100	Charred
Beta-116182	1850 ± 50 BP	-23.7	1870 ± 50 BP	AD 55 to 250	AD 135	Charred

Given all the above, this author argues that Beaver Dam provides a glimpse at Late Archaic camp life for southern Plains bison hunters. Tools and debitage recovered from Beaver Dam will allude to other activities in which Late Archaic bison hunters were involved. The cultural material from the campsite will also provide clues to the type of residence pattern followed by these inhabitants.

Feature and Artifact Analyses—Area A

In all, 24 features were recorded at the Beaver Dam site. All of these features were fire hearths with related habitation debris. Three and possibly more of these features can be

attributed to the Late Archaic component with a relative level of certainty. The Late Archaic component at Beaver Dam can be determined in three manners. The first, obviously, is absolute dating (as described above), the second is relative dating (paleosol), and the third is by projectile point form. The latter is a bit dubious to say the least, as a result of the depositional history noted earlier.

Neither of the two ^{14}C dates (Table 7.1) from Beaver Dam came from actual features. However two undated features adjacent to the AD 135 dated level can be attributed to the Late Archaic occupation based on point forms and radiocarbon dates above and below the features (Figure 7.5a). Granted, deposition in the stream valley location was irregular



Figures 7.5a-b. Cut bank along Brokenleg Creek: (a) View north at exposed cultural materials; (b) salvaged feature. Scale in 5 cm increments.

at times. Nevertheless, features 21 and 22 are only 1 m, horizontally, from the AD 135 date and 10 cm higher in the profile. In addition to features 21 and 22, Feature 1 is a little lower than the level from which the AD 135 date was secured. Feature 1 was salvaged from the cut bank prior to the start of excavations (Figures 7.5a-b).

Feature 1

Feature 1 was recovered from 1.90 cmbs or 98.17 cm below datum. The feature is best described as a fire hearth constructed of shale and quartzite cobbles (Figure 7.5b and Figure 7.6). Shale frequently occurs in the Ogallala Formation gravel that blankets the region. About half of the rocks were obviously heat altered while the remainder was not. All are interpreted as being hearth stones and not boiling stones, although this is a

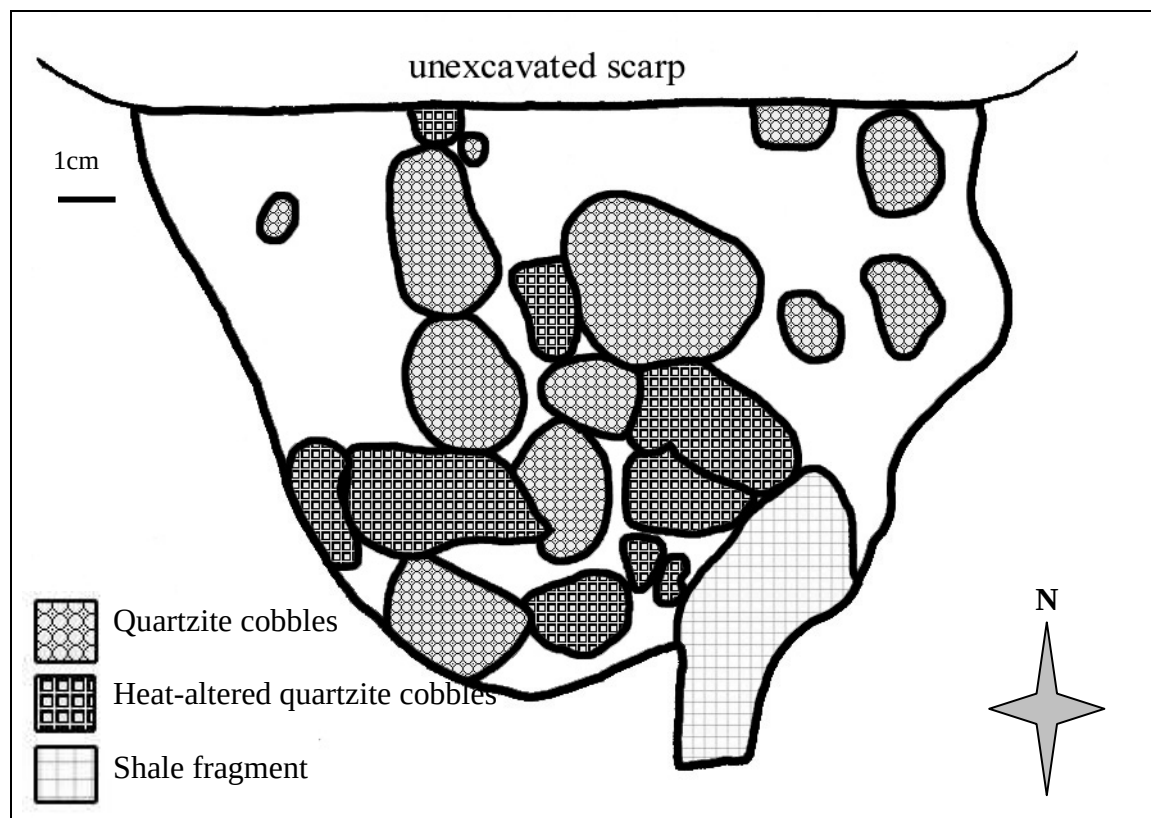


Figure 7.6. Feature 1, Fire Hearth. Note the variety of local stone materials employed.

tentative conclusion. Features with boiling stones frequently show greater use of quartzitic materials (Figures 7.7 and 7.8). Cultural materials associated with Feature 1 include one milling stone, one battered cobble, and 14 pieces of fire-cracked rock. Flaked artifacts include one possible core of an unidentified brown chert, two Ogallala quartzite decortication flakes, one Tecovas jasper decortication flake, one Ogallala quartzite biface thinning flake, one utilized flake of Alibates, and one utilized flake of Tecovas. No diagnostic artifacts were recovered from the feature area. A charcoal sample was also collected from the feature area, although not submitted for ^{14}C dating. The hearth measured 24 x 20 cm (N-S x E-W) once it was cleaned out, cross-sectioned, and pedestaled. It is quite possible portions of the hearth were lost to erosion.



Figure 7.7. Typical kitchen area complete with grinding stone and dump. Scale in 5 cm increments.



Figure 7.8. Typical hearth surround with dump pile of smaller boiling stones (circled).

Feature 21

Feature 21 is a rather large kitchen area stretching horizontally about two meters (Figure 7.9). Multiple materials were collected including lithic, faunal, and ceramic (Tables 7.2 and 7.3). A handful of unique items were mapped in place. Likewise, several stacked stones associated with a patch of charcoal-stained soil were afforded special attention during excavations. Species identified in the faunal collection include both deer and bison (Table 7.2). The deer is represented by a left premolar (P3). The premolar belongs to a deer less than three years of age based on comparative specimens. The premolar indicates that a deer was probably killed nearby and transported back to camp. Rarely are entire carcasses returned to a camp unless the kill took place in the immediate vicinity or the

animal is relatively small (Bunn 1993; Bunn et al. 1991). Several of the unidentified bones might also be from the deer. Numerous bison bones were recovered including an unidentified long bone with a spiral fracture. The spiral fracture represents good evidence that bone grease or marrow processing was undertaken at the kitchen hearth.

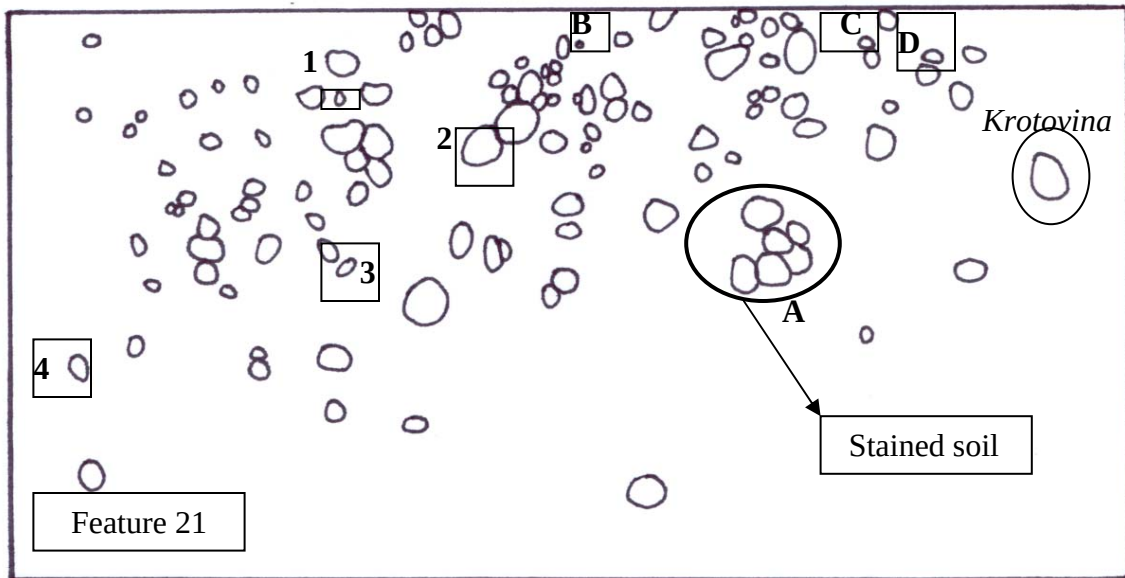


Figure 7.9. Plan map of Feature 21. Items 1-4 and A-D are listed in Tables 7.2 and 7.3.

Table 7.2. Feature 21 Cultural Debris: Faunal.

Count	Description	Material
44	Bone fragments (8.7 g)	Unidentified species
4	Burned bone (1.5 g) (<i>Mapped item B</i>)	Unidentified species
21	Bone fragments (7.2 g)	Bison
1	Long bone-spiral fractured (<i>Mapped item C</i>)	Bison
1	Left, 3rd maxillary premolar (<i>Mapped item D</i>)	Deer

The people responsible for creating Feature 21 used multiple lithic materials which are available from the local gravel (Table 7.3). All stages of lithic reduction are present with primary flakes slightly outnumbering interior flakes. However, none of the flakes were of sufficient size for biface production. Besides knapping debris, two scrapers were recovered in the midst of the feature. One was a flake tool or expedient scraper. It is

Table 7.3. Feature 21 Cultural Debris: Lithic.

Count	Description	Material
3	Chips	Quartzite=3
4	Blocky debris	Quartzite=1 Jasper=1 Chert=1 Siltstone=1
5	Primary flakes	Yellow-brown jasper=1 Blue-tan chert=1 Potter chert=1 Quartzite=2
2	Secondary flakes	Quartzite=1 Potter chert=1
3	Tertiary flakes	Potter chert=2 Opaque quartzite=1
6	Fire-cracked rock	Quartzite=5 Conglomerate=1
10	Heat-altered stones (<i>Mapped item A</i>)	Quartzite
1	Expedient tool (uniface scraper)	Unidentified chert
1	Biface tool (scraper)	Unidentified chert
1	Primary flake (<i>Mapped item #1</i>)	Ogallala quartzite
1	Secondary flake (<i>Mapped item #2</i>)	Ogallala quartzite
1	Primary flake-retouched (<i>Mapped item #3</i>)	Unidentified chert
1	Burned rock (<i>Mapped item #4</i>)	Sandstone
13	Boiling stones	Quartzite
1	Abrader	Sandstone

a larger interior flake with retouch along one edge. Additionally, a biface scraper was recovered. However, the scraper was associated with a rodent burrow and might be displaced from elsewhere.

Besides the knapping material, fire-cracked rocks, boiling stones, and a single-grooved sandstone abrader were found among the other items. Ogallala Formation quartzite comprises the fire-cracked rock and boiling stone categories while the abrader was manufactured from Permian sandstone. Like most abraders recovered in Oklahoma, the

artifact was broken but still of convenient size to hold (Bell 1980:33-35; Turner and Hester 1985:239). The sandstone abrader has a longitudinal groove on one face. Abraders are used to shape wood or bone tools and are also used to prepare striking platforms during the knapping process. Abraders used for sharpening bone awls and other pointed tools are characterized by V-shaped grooves while those used in flint knapping possess shallow grooves on the surface (Bell 1980:35; Turner and Hester 1985:239). Abraders are rarely modified before use, and are usually discarded after short-term service (Bell 1980:35; Turner and Hester 1985:239). Finally, a (fossil) shell-tempered cord-marked sherd (Moore 1988a) was recovered from the feature. The item measured 8.9 x 9.3 mm and was about 7 mm thick. Similar sherds have been recovered from the site but mostly higher up in the cultural fill. Other cord-marked sherds were found in the talus along the actively eroding creek bank.

Feature 22

Feature 22 consists of an oval pit measuring approximately 50 cm² and about 5 cm deep at the center (Figure 7.10). Mapped items included one milling stone, a couple of fire-cracked rocks, and a few boiling pebbles (Table 7.4). Another item recovered from the oval shaped hearth was a bone awl fragment. The tool was broken in two places and all that remained was the midsection. Microscopic analysis revealed striae both vertical and horizontal to the long axis of the bone tool. The original faunal element that the awl was made from was undetermined. Based on other awls found at Beaver Dam and elsewhere on the southern Plains, a good guess as to the raw materials would be a deer metapodial. Another interesting piece recovered from the feature was also faunal in nature. One valve from a Potamilis purpurata mussel was recovered which displayed use-wear. The sex of the mussel was indeterminate. The distal or thin edge of the valve exhibited micro flaking presumably from being utilized in a scraping fashion.

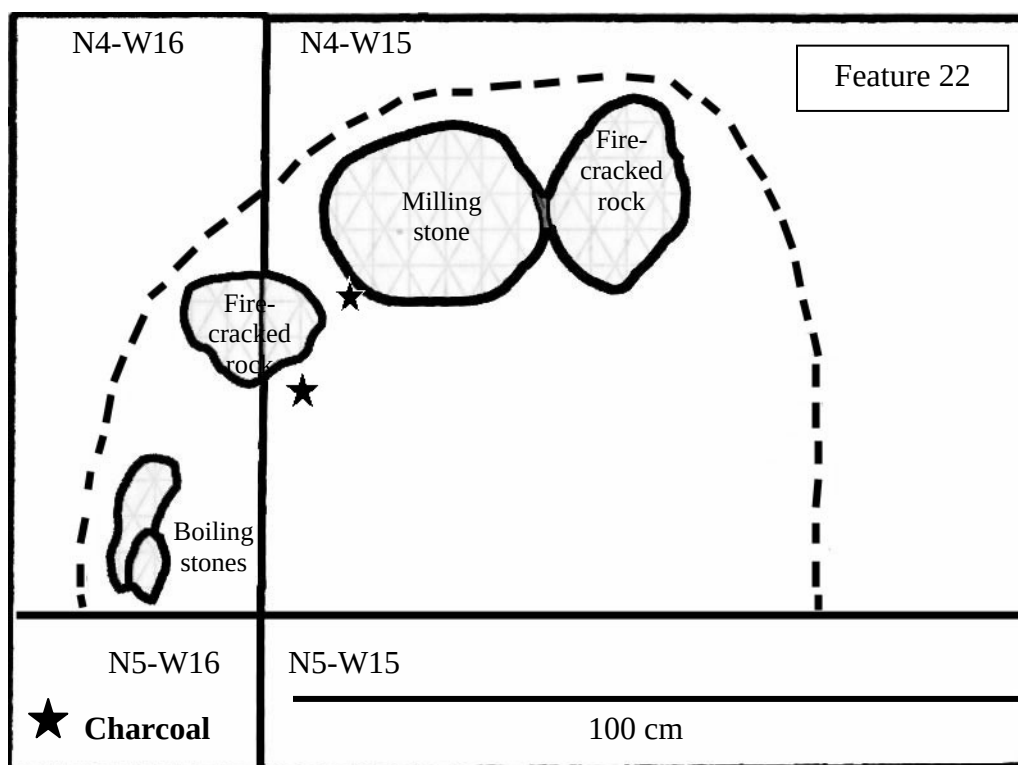


Figure 7.10. Plan map of Feature 22 showing layout of stones, charcoal, and stained soil (dashed segment).

Table 7.4. Feature 22 Cultural Debris.

Count	Description	Material
3	Primary flakes	Quartzite
2	Secondary flakes	Quartzite
3	Tertiary flakes	Potter chert=2 Alibates=1
2	Fire-cracked rock	Quartzite
4	Boiling stones	Quartzite
1	Milling stone	Sandstone
3	Unidentified fragments	Bone
1	Awl-medial fragment Vertical & horizontal striae	Bone
1	Scraper-reworked edge (<i>Potamilis purpurata</i>)	Shell

Feature 10

Feature 10 has a few problems in interpreting its cultural debris so it is being discussed last. It is argued that Feature 10 can be linked to the Late Archaic not so much on radiometric dating but more on projectile point forms. Feature 10 encompassed three separate excavation squares. One of the advantages of this is that it provides the opportunity to view the large feature in profile and in plan. Three radiocarbon dates were secured from Feature 10 and the immediate vicinity. The feature is rather deep extending down some 30 cm. When the feature was first uncovered, it appeared that it was badly disturbed by burrowing rodent activity (Figure 7.11). However once completely excavated, three distinct laminae were obvious in the profile (Figure 7.12). Two small rings of stained soil at the base of the feature (hearth remnants) further suggest that this



Figure 7.11. View of Feature 10 upon contact; note the dark stain in the corner of the unit. Smaller hole is from an exploratory soil probe. Scale in 5 cm increments.



Figure 7.12. View of Feature 10 after excavating 30 cm of fill. Note two small rings in the floor (with krotovina, dashed segment) and three lamina in the wall. Scale in 5 cm.

exact location was repeatedly used season after season or year after year. Some contamination probably does exist because of rodent burrowing which is typical in the region. Nevertheless the radiometric analyses are presented below.

A radiocarbon date for the upper part of the feature places the terminal use of the area around AD 551. The woody charcoal sample (NZA 1388) returned a conventional radiocarbon age of 1514 ± 79 BP. The 2 σ calibration (95% confidence) interval was AD 392 to AD 661. Associated with this level of the feature was a well-made corner-notched dart point constructed of dark red and green banded Alibates silicified dolomite (Figure 7.13).

Another dart point was found approximately 10 cm lower in the feature fill as well as a few other artifacts (Figure 7.14 and Table 7.5). Moving out from the formal feature to the surrounding excavation squares (~ 1 m radius), the activity associated with Feature 10 is further illuminated (Table 7.6). An abundance of fire-cracked rock was recovered from the surrounding squares, probably representing hearth maintenance. The second largest artifact class was unmodified flakes, most of which were secondary decortication flakes (58%). Tertiary flakes followed up (36%), with primary flakes representing the smallest

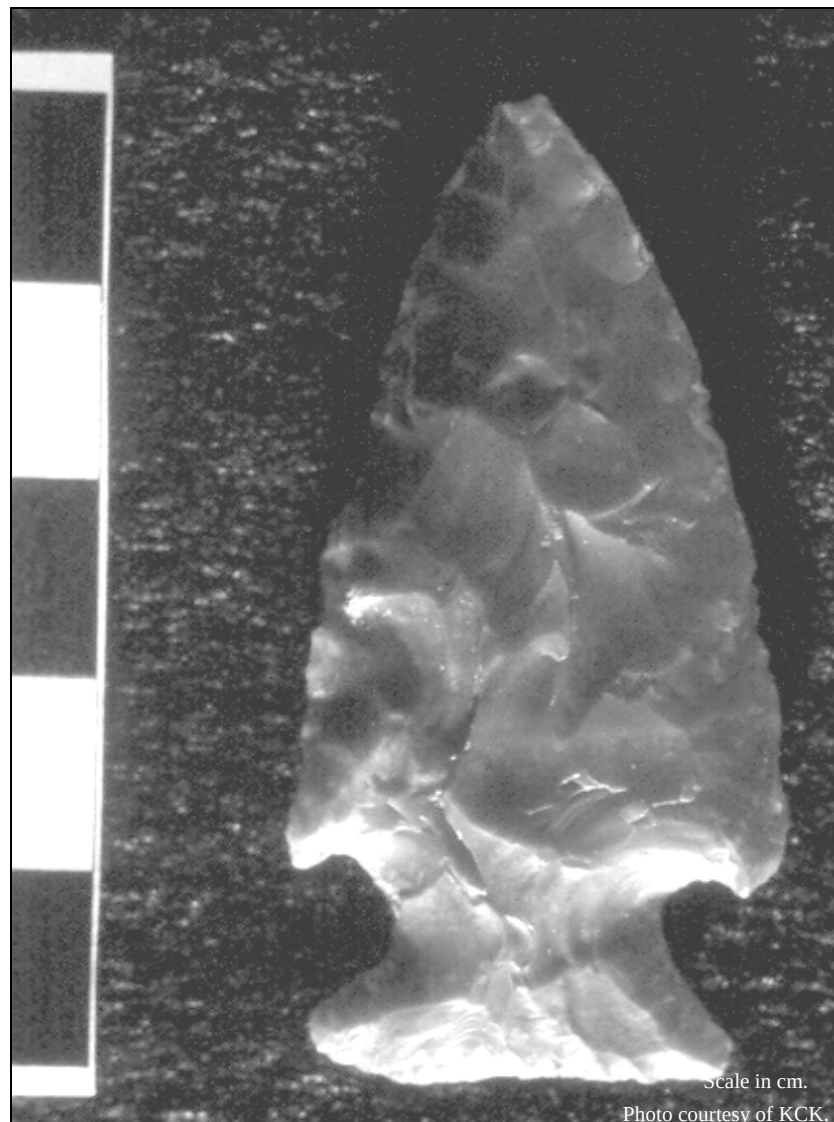


Figure 7.13. Corner-notched dart point recovered from upper part of Feature 10.

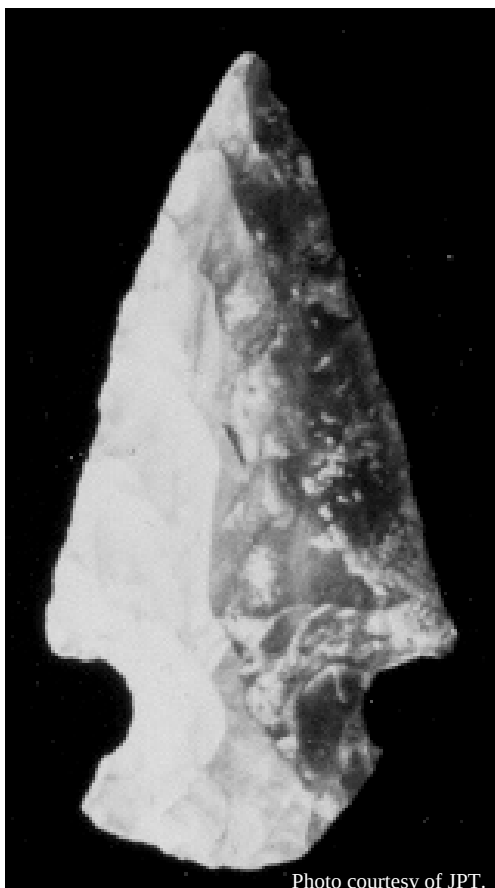


Figure 7.14. Corner-notched dart point recovered from lower part of Feature 10. Not to scale.

part of the class (6%). Numerous bone fragments were also associated with the feature, none of them coming from bison. Less a cobble section, the remainder of the artifacts is formal or informal tools. One unique artifact, a Plainview point later modified into a scraper, was also recorded in the vicinity of Feature 10 (Thurmond 1990a:10, 49). Finally, a bone bead from an unidentified species was recovered nearby the feature.

A bulk organic sediment sample from this lower portion of Feature 10 was submitted for dating. The resultant (conventional) radiometric date (Beta 116181) was 1620 ± 50 BP. The 2σ (95% probability) calibration averages out to AD 350-560 with a calibration curve intercept of AD 430.

Table 7.5. Feature 10 Cultural Debris.

Count	Description	Material
10	Unidentified fragments	Bone-small mammal (2.1 g)
1	Primary flake	Quartzite
5	Secondary flakes	Quartzite=2 Unidentified chert=3
3	Tertiary flakes	Quartzite=3
1	Modified flake	Quartzite
4	Fire-cracked rock	Quartzite
1	Cobble section	Quartzite

The charcoal sample from which the AD 135 date (Table 7.1) was collected about 10 cm below Feature 10. In effect, the Feature 10 area (around and below) was probably used for several hundred years with a calibrated upper date of AD 551 and a calibrated lower date of AD 135 with a hiatus between AD 135 and AD 430. Based on these dates, the feature's use is contemporaneous with the L. E. Certain occupation as demonstrated in Chapter Six.

Table 7.6. Feature 10 Cultural Debris: 1m Radius.

Count	Description	Material
193	Fire-cracked rock	Quartzite
162	Unmodified flakes	Chert, Dolomite, Jasper, Quartzite
61	Bone fragments	(non-bison)
3	Grinding stone fragments	Sandstone
2	Modified flakes	Chert
2	Utilized flakes	Chert
1	Cobble section	Quartzite
1	Drill fragment	Quartzite
1	End scraper (Plainview base)	Jasper/Dolomite
1	Bone bead	Unidentified species

One final insight into the history of Feature 10 comes from laboratory flotation of sediments collected from the center of the feature. Nearly 7 liters of stained soil was collected for analysis. The plant remains from the light fraction were analyzed by Dr. Richard Drass, Oklahoma Archeological Survey (Norman). Charred plant materials collected from the flotation residue include, "Cheno-Ams" or Chenopodiaceae-Amaranthus, mustard (Descurainia), spikerush (Eleocharis), an unidentified nut shell fragment, and several unidentified seeds. Barnyard grass (Echinochloa) was also recovered. As revealed by the analyzed charcoal fragments, Feature 10 contained fuel-wood remains from an elm (Ulmus Americana) or hackberry (Celtis occidentalis), a cottonwood tree (Populus deltoids var. monolifera), and possibly from an oak tree (Quercus sp.). This final bit of data helps verify that water was permanently available since cottonwood trees thrive in wet settings. Additionally, oak trees are a permanent

fixture on the upland dunes and hillocks today, suggesting a bit of continuity in flora and fauna. Moreover, hackberry seeds were recovered from a secondary processing area at L. E. Certain, demonstrating further continuity in tree species from the time the sites were occupied to the present.

Late Archaic Burial

A partial burial recovered from the Beaver Dam site adds yet another aspect to the type of life Late Archaic bison hunters lived. The burial was found eroding from the creek bank opposite of Area A. This part of the Beaver Dam site is designated as Area C. Only four human elements were collected. The bones include the right tibia, right humerus, and right and left scapulae. These specimens were found *in situ* within the creek bank while the remainder of the bones likely washed downstream and were not recovered by the collectors (Thurmond 1991b:241). Also found *in situ* were a lunate stone or atlatl weight and corner-notched dart point (Figures 7.15 and 7.16). The point is manufactured from a variegated piece of silicified wood. Such pieces can be found amongst the ubiquitous Ogallala Formation gravel deposits of the southern Plains. The point is corner-notched for the most part, but slight damage to one shoulder has rounded the notch to the extent



Photo courtesy of KCK.

Figure 7.15. Photograph of the Beaver Dam lunate stone (90L x 30H x 19T mm).



Photo courtesy of KCK.

Figure 7.16. Projectile point associated with the Beaver Dam lunate (56.3L x 27.6W x 10T mm). Specimen is manufactured from silicified wood, Ogallala Formation.

that it blends into the edge. The corner-notched dart point is similar in form to those recovered from Area A at the Beaver Dam site both from excavations and from the talus. The lunate stone is only one of ten known to occur on the eastern edge of the Llano Estacado as discussed earlier in this study. In addition to the above items, two ovoid biface knives were recovered just below the *in situ* bones (Figure 7.17).

The bifaces were manufactured from Ogallala Formation quartzite (Figure 7.17). The specimen on the left is a very dark gray (10YR 3/1) quartzite biface with a few step terminations. It measures 94.7L x 32.8W x 11.6T mm. The specimen on the right is a gray (7.5YR 6/1) Potter chert biface which measures 85.7L x 41.9W x 14.8T mm. By using soft hammer percussion, these biface-cores would yield numerous flakes that can be further modified into all the piercing, cutting, and scraping tools needed (see Wyckoff 1999:56). Such bifaces could also be used for hand-held rough cutting needs. Additionally, the bifaces could be transformed into any number of Late Archaic point

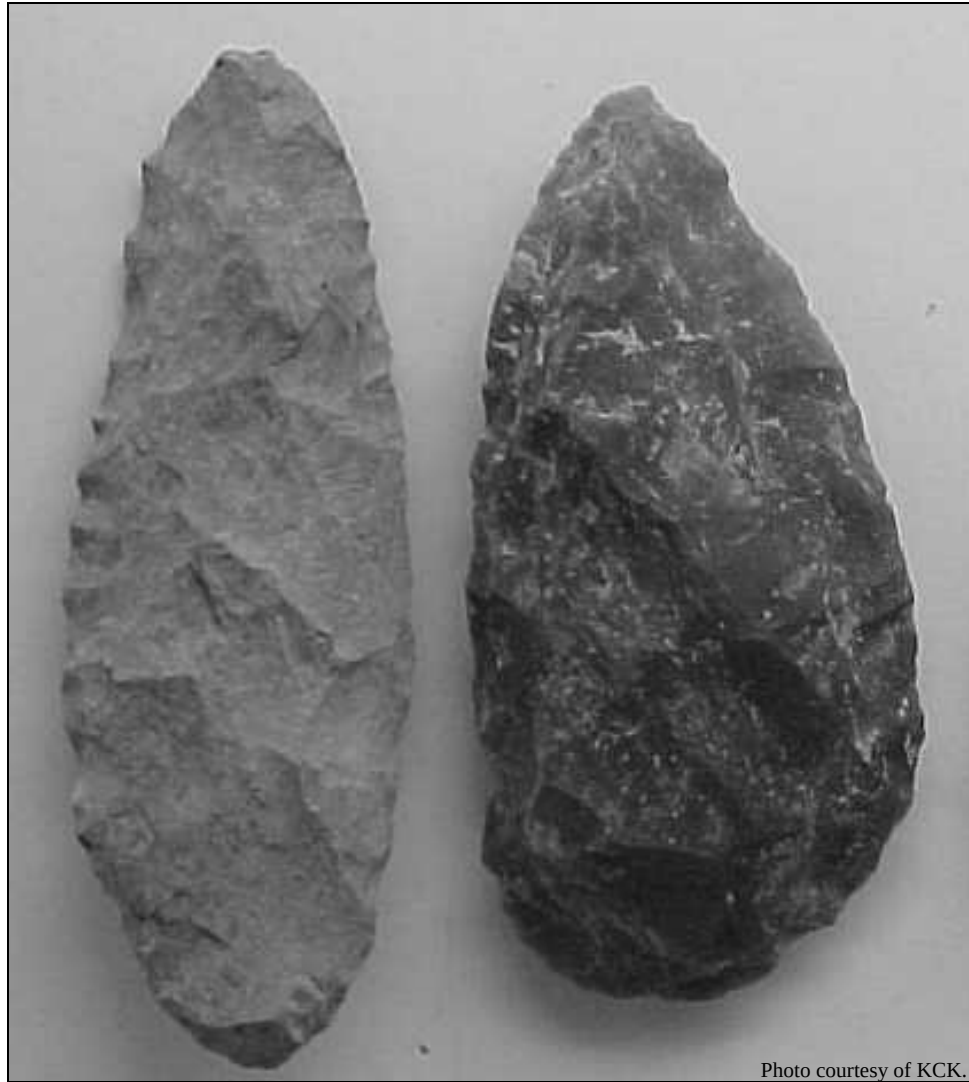


Photo courtesy of KCK.

Figure 7.17. Photograph of the biface knives associated with the Beaver Dam burial. The two knives complement the lunate stone and projectile points interred with the dead. All materials are of local origin. Not to scale.

varieties found at the Beaver Dam site and other documented Late Archaic sites and components in the vicinity. Discrete, isolated piles of biface production debris from making such knives were not associated with any of the features previously described. However, the stages of biface production and their specific flake characteristics are distributed throughout the entire Late Archaic component of the site. Keeping in mind

that excavated artifacts overwhelming represent rejected specimens, a sequence of biface production can be established. Supplemental data come from 34RM337, a quarry-workshop approximately 10 m up slope from the Beaver Dam site. In essence, the two sites could be considered mere features within a larger site associated with the Tertiary-Permian boundary that characterizes the area (Thurmond 1991a, Figures 4-5). The sequence of biface production begins with selection of a core with the (culturally) appropriate chemical and physical characteristics for removing large flake blanks (Figure 7.18). Quite often natural acute angles on the raw materials (clasts) are used in lieu of platform preparation. Once a satisfactory flake is produced, the blank can be fashioned into the beginnings of a biface. It is at this stage of the sequence that biface failures are

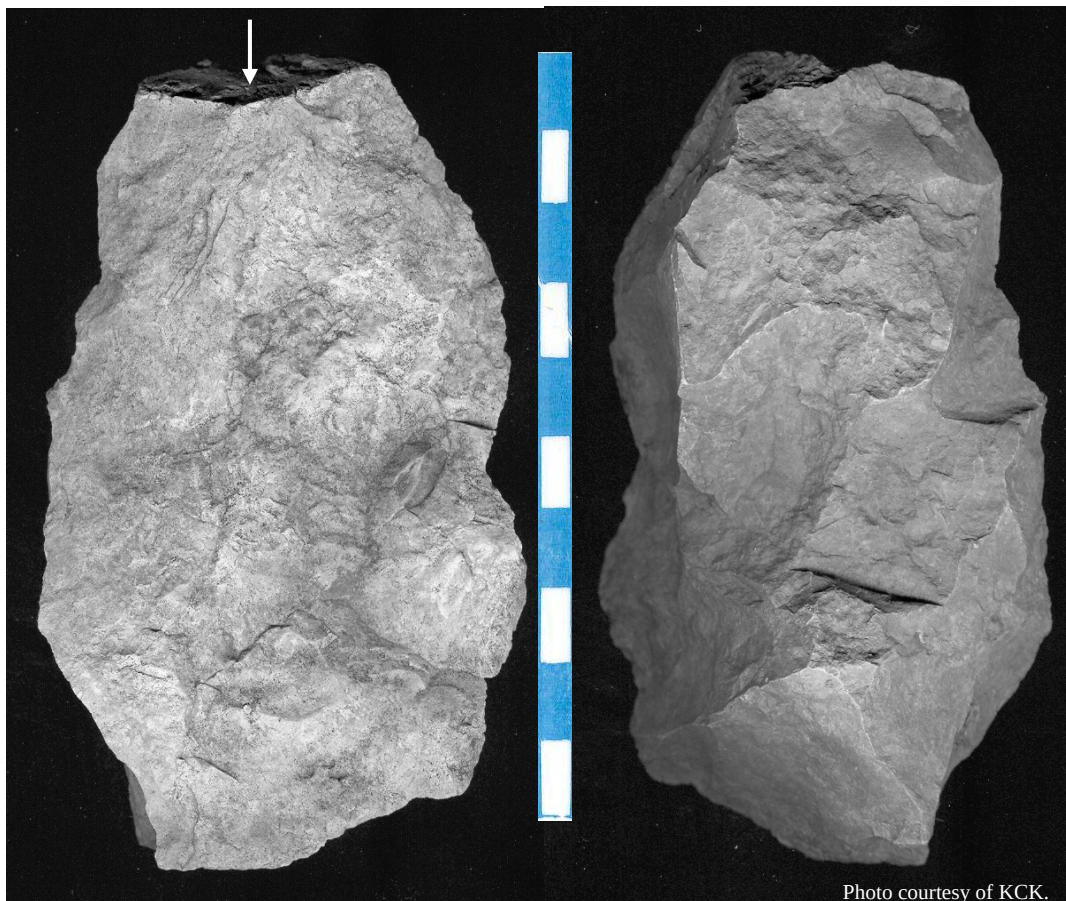


Photo courtesy of KCK.

Figure 7.18. Large flake blank of siliceous Ogallala Formation quartzite (Potter chert). This flake was obviously rejected because of the irregular fracturing. Note unprepared platform (arrow). Scale in cm.

produced (Figure 7.19) and substandard bifaces are rejected (Figure 7.20). The final product resembles those specimens interred with the Beaver Dam burial (Figure 7.17) as well as that shown in Figure 7.21. These are presumed to be the same type of bifaces (knives) used at the L. E. Certain site.

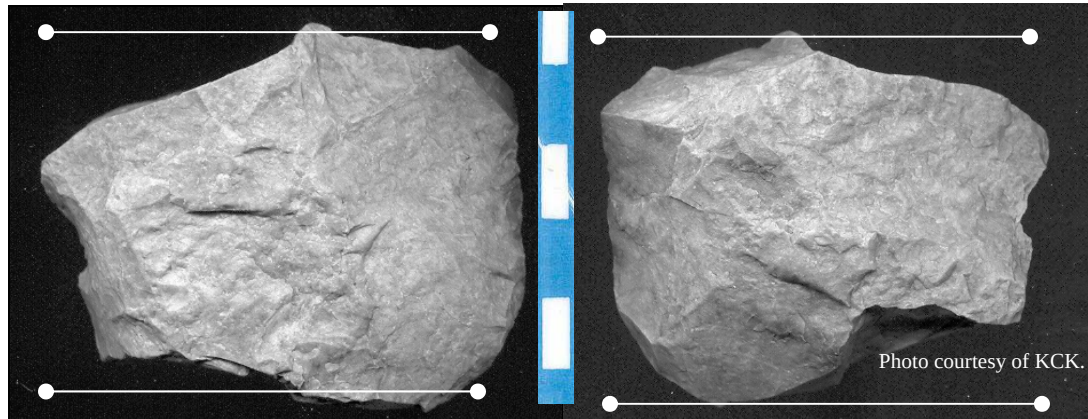


Figure 7.19. Biface failure demonstrating end shock during biface production. White lines denote transverse breaks. Scale in cm.

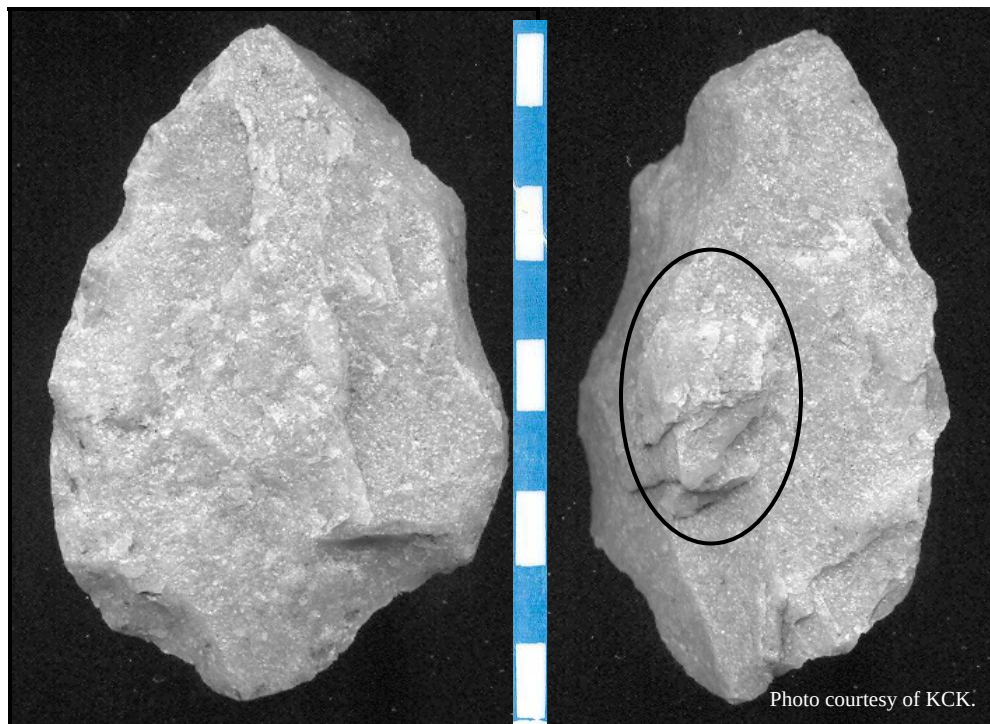


Figure 7.20. Biface reject exhibiting large mass (circle) of resilient material on one face and associated step terminations signaling unsuccessful attempts to remove the mass and further thin the biface. Scale in cm.

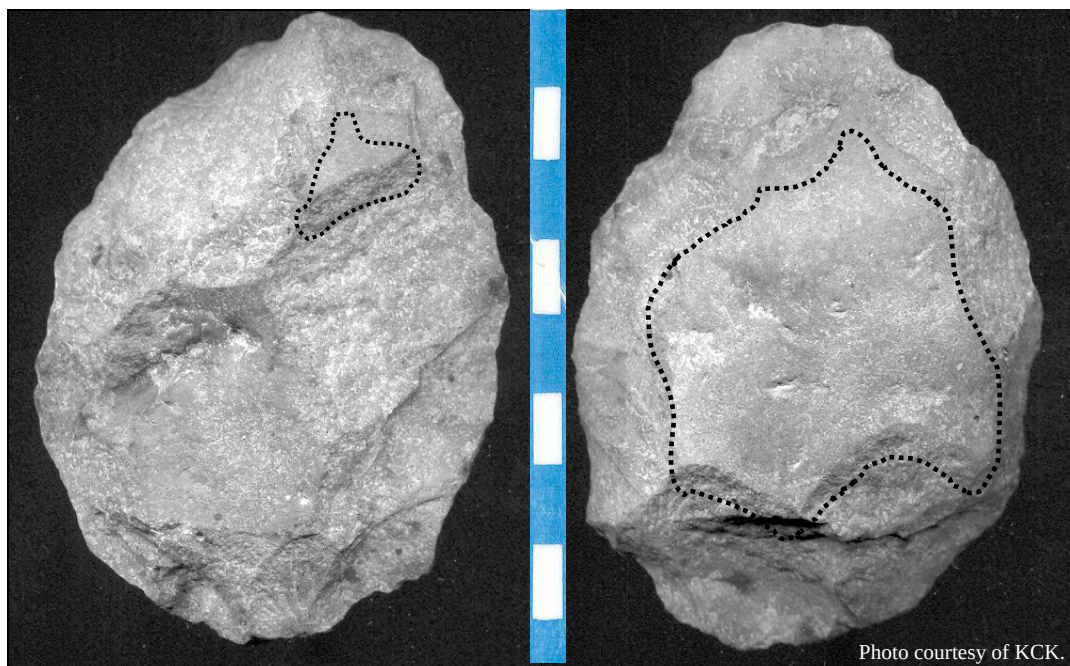


Figure 7.21. Biface reject. This specimen was fashioned from a cobble rather than a large flake. The biface was rejected when cortex sections (dashed polygons) could not be removed. Scale in cm.

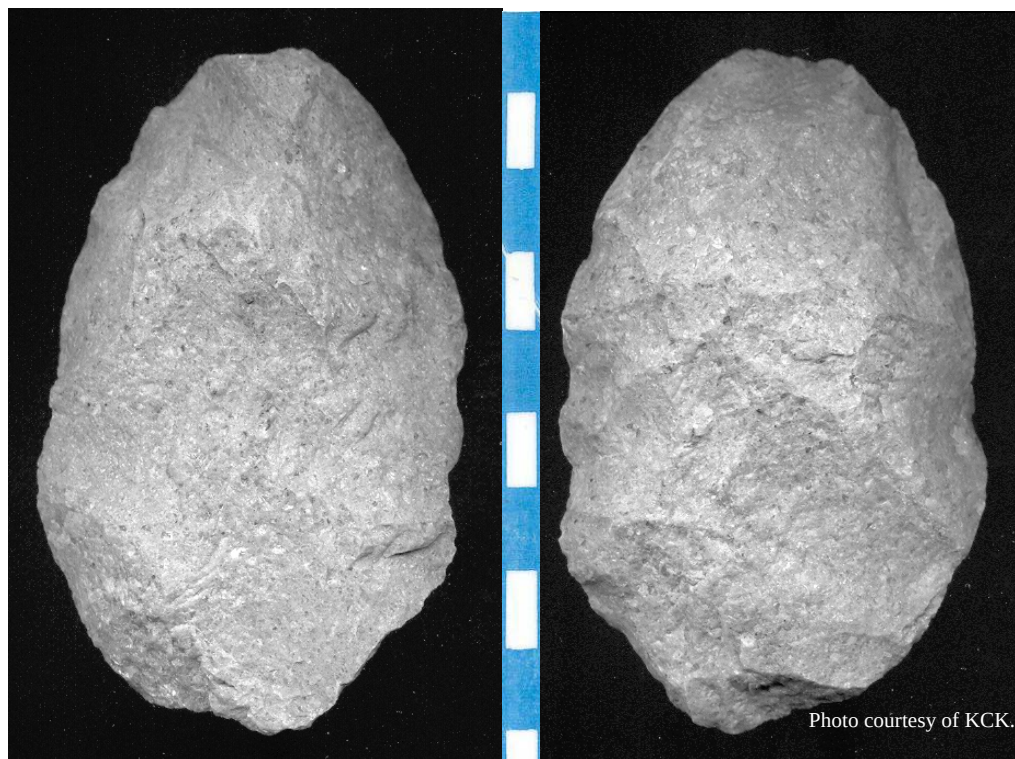


Figure 7.22. Viable biface knife similar to that shown in Figure 7.17 Scale in cm.

The human remains from the Beaver Dam burial were previously described by Thurmond (1991b:242-243). The general conclusion is that the bones represent an adult male, perhaps middle age, with a slight case of degenerative arthritis. The overall health of the Beaver Dam man cannot be determined in absence of the remainder of the body. What is known is based on the robust musculature of the arm and leg bones and the length of said bones. Robusticity is an important parameter in the reconstruction of the general physique of an individual. While the robusticity of an individual is not as quantifiable as stature, estimates of robusticity still serve as an important indicator of the general quality of the health of an individual (Anderson et al. 1977; Stini 1969, 1971, 1972; Van Gerven 1972). Thurmond (1991b:243) estimated the stature of the Beaver Dam hunter at 191-197 cm based on data provided by Trotter and Gleser (1951, 1957). The stature was based on the leg bone rather than the arm bone. Stature can be determined from arm bones with relative confidence, but estimates from long bones of the leg are more reliable (Krogman 1962:185). The Beaver Dam individual would have been between 6' 2" and 6'4" in height.

The lunate stone recovered from the Beaver Dam burial may be an atlatl weight (Dickson 1984; Howard 1974). This author tends to believe it did serve as a weight based primarily on use-wear the specimen displays. For discussion purposes, the flat portion of the artifact is considered the base or ventral face, and the curved portion the top or dorsal surface. Functional characteristics of the artifact include the curved, lateral edges of the piece and the notches carved on the dorsal surface, especially the central notch (Figures 7.15 and 7.23). The base of the artifact was relatively flat presumably to facilitate insertion into a large groove on an atlatl to prevent the weight from shifting during use (Bell 1980:47; Frison 1991:351-352). Based on relative heaviness of the stone, simply lashing the stone to a wood or bone surface would not adequately secure the artifact when being utilized in a hurling motion. The use-wear or groove below the central groove of the artifact is consistent with analogous specimens from surrounding areas (Bell 1980:47) (Figure 7.23). The other 21 notches on the dorsal surface of the artifact might have been

used to further secure the weight to a throwing apparatus. Although the Beaver Dam lunate stone is similar in form to others recovered on the eastern margin of the southern Plains, the number of notches varies from specimen to specimen (Cockrum 1963:28; Parsons et al. 1979:72).

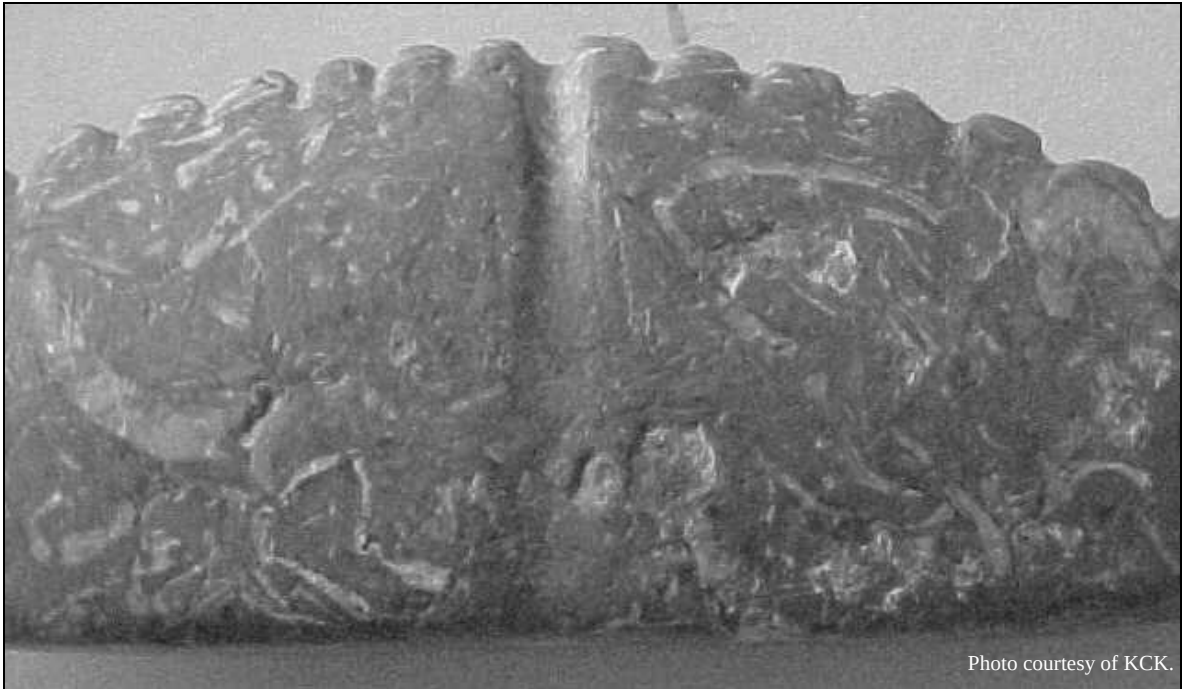


Figure 7.23. Close-up photograph of the lunate stone from the Beaver Dam burial. Note use-wear down the center of the artifact. Also note fossil oysters (*Texigryphaea*) in the Kiowa Formation shale used to make the artifact.

Conclusion

The best evidence for the Late Archaic component at the Beaver Dam site comes from the two radiocarbon results dating to the first century AD. One of the dates (AD 135) is associated with a typical Late Archaic form dart point. Two features (21 and 22) adjacent to the dated excavation level (AD 135) place their use roughly in the same time frame. One of the features (Feature 21) was associated with a dart point of Late Archaic-Woodland style, although reduced by resharpening. Finally, Feature 10 may be associated

with the Late Archaic component only, but most likely dates to the Late Archaic-Woodland. However, there are major problems with colluvial deposition atop the feature. Through excavations, it was determined that the feature was repeatedly used no less than five times, represented by three laminae and two pit outlines. Radiocarbon dates from both sediment and charred woody material span an almost two hundred year period (AD 551 and AD 430).

Cultural material from Beaver Dam suggests that the inhabitants were making generalized collecting, hunting, and fishing jaunts in the adjacent stream valleys and uplands. Freshwater mussels as well as small and medium-sized mammals were exploited based on faunal remains with bison bones conspicuously limited. Such would be expected if bison were thoroughly processed at the kill site and prepared for transport. Grinding implements tentatively indicate that floral remains were processed. However, the recovered floral remains from Feature 10 clearly indicate that local flora was consumed along with local fauna. The presence of multiple hearths with considerable amounts of fire-consumed debris (charcoal and ash), and associated concentrations of boiling stones and fire-cracked rocks, suggests that extended and repeated camping events transpired at the location. These groups probably consisted of heterosexual pairs and progeny with either matrilineal or patrilineal tendencies. Generalized and task-specific knapping also occurred at the site. Debitage indicates that local and semi-local tool stone was employed, with projectile points being made of highly siliceous materials. Select artifacts from the Late Archaic component represent their biface production sequence. These bifaces (blanks) were also precursors to manufacturing projectile points. Besides the abundance of faunal, floral, and lithic remains, along with fire/cooking pits, the human interment at the Beaver Dam site implies that Beaver Dam was a semi-permanent habitation spot where a group member could be laid-to-rest without being disturbed. Such is implied since the individual was intentionally buried and done so with grave goods. These grave goods are represented by local raw material, but they are pieces with

complex visual chemistry (variegated silicified wood and fossiliferous shale) and thus, aesthetically pleasing to the maker or group.

Establishing an unarguable connection between the Beaver Dam site and the L. E. Certain bison kills is difficult. Yet, radiocarbon dates, point forms, tool varieties, lithic material types, and proximity to each other do circumstantially imply a connection. For example, radiometric assays from both sites overlap, as do projectile forms. Expedient tools found in the bone beds are also found associated with Late Archaic features at the Beaver Dam site. Moreover, knapping debris from the L. E. Certain site reflects maintenance of bifacial knives such as those interred with the Beaver Dam burial. The usage of local materials by inhabitants of both sites also indicates that indigenous peoples, not outsiders, were using the sites. Local geologic material was also used to manufacture the lunate stone, projectile point, and bifaces associated with the Beaver Dam burial. Finally, the proximity of the sites to each other, within the vast southern Plains biome, indicates to some extent that the same groups occupied the sites. Likewise, the sites are little more than a one-day walk from each other. All in all, the Beaver Dam site provides a glimpse at Late Archaic camp life for southern Plains bison hunters.

CHAPTER EIGHT

THEORETICAL INTERPRETATION OF THE DATA

Introduction

History, Science, and Archaeology

Most historians would probably agree that history is a form of thought whereby questions about the past are asked and answers are sought; it is not simply a recount of the past (Kuhn 1996:1-9; Lovejoy 1964:3-23). Rather, history seeks to uncover seen or unseen phenomena in the historical record. In this sense, history can be likened to science (Collingwood 1994:1-13). While science is different from history, both history and science serve human self-knowledge. Taken together, history and science form the basis for archaeological inquiry. For example, archaeological theories pose questions about unseen human behavior as represented by artifacts. To this end, optimal foraging theory is one way to frame questions about past human behavior in an attempt to account for unseen phenomenon. Optimal foraging theory provides a scientific structure to evaluate hunting and butchering practices as well as residence patterns. Therefore, optimal foraging theory is utilized to pose questions about southern Plains Late Archaic hunter-gatherers of the Late Holocene.

Optimal Foraging Theory

Before exploring the data, it is important to clearly articulate how information will be analyzed in this study and how it correlates with the contention set forth in this analysis. In Chapter Two four main components to optimal foraging models were presented (Schoener 1971; Smith 1983). The first two components, currency and goals, are reviewed initially to set the stage for addressing the final two components, constraints and options.

First, a *currency* must be established as a unit of measure. Second, a *goal* must be established as a unit of analysis. In this discussion, the currency is energy and the goal is

equilibrium with an ecological community. In regard to food acquisition, energy takes the form of physical effort. Therefore, energy output must be recouped, at the least, to achieve the goal of ecological equilibrium. Equilibrium is interpreted as optimal behavior. In other words, optimality is defined as the most advantageous response to environmental challenges. I contend that the currency and the goals of the Late Archaic groups remained static. That is, energy recapture and optimal interaction with the environment are of prime importance.

The third component to optimal foraging modeling is to identify *constraints*. In discussing feeding behavior, energy output, and equilibrium achievement, potential constraints can be both environmentally induced and humanly enacted. Constraints are best described as factors that limit goal achievement which in this case is optimality. In the case of food acquisition, limitations to energy recapture and achievement of ecological equilibrium can include planning and resource preparation. Other limitations to acquiring food include pursuit time, resource acquisition, and resource density or distribution. Other constraints emerge once a target is acquired. These include handling, processing, consuming, protecting, and distributing the resource.

Responses to constraints can be positive or negative. That is, a challenge can be met and conquered, or a challenge can become a liability. Determining success is based in the available *options*, the fourth component to optimal foraging modeling. In short, options are choices that are available to achieve a goal. Options for maximizing net energy might include hunting and gathering as a group or harvesting a temporarily aggregated resource. I contend that as constraints changed, so did the options which were available to Late Archaic groups. So, while the goals and currency remain the same, the constraints and options change over time.

Overall, an optimal foraging model provides a systemic framework to examine and understand human behavior as represented by artifacts, features, and site types. These

representations connote the range of responses employed by humans to achieve efficient resource utilization. This chapter incorporates the data presented the three previous chapters into the theoretical models outlined in Chapter Two. These models, central-place foraging (logistical residence), and the foraging group size theorem, all fit under the rubric of optimal foraging theory.

Central-Place Foraging and Foraging Group Size Constructs

The principal tenant of central-place foraging is the use of a centralized habitational post from which resources are sought. Once a resource is captured, it is returned to the camp in part or whole as an optimizing mechanism (Binford 1980; Kaplan and Hill 1992; Saunders 1974:106-109). By adhering to this logistical settlement regime, resources from more than one biome can be exploited without excessive travel time and thus energy expenditure. Such camps may be relocated because of seasonal constraints, or when diminishing return situations prevail. Camps may also be moved to satisfy social obligations or as a means of resource or surplus defense (Thomas et al. 1979).

The foraging group size concept predicts instances when gathering food stuffs as a unit is advantageous as opposed to procuring resources on an individual basis (Foley 1985; Horn 1968). This also applies to small family groups coming together at times of resource abundance. Benefits associated with hunting by merged groups include flushing and decoying prey to a predetermined area, sharing reconnaissance information, and practicing a division of labor that maximizes group output (Driver 1990; Steele and Baker 1993). In short, both the central-place foraging and the foraging group size constructs operationalize energy-use aspects of human feeding behavior by focusing on energy expenditure, energy consumption, energy production, and energy recapture. Solutions to these challenges are thus reflected in technology and cultural institutions.

Data Specifically Supporting Central-Place and Group Size Foraging

Introduction

In this section, I examine the artifacts and features uncovered at two essentially contemporaneous sites, L. E. Certain and Beaver Dam. Analysis and interpretation of these artifacts and features demonstrate how particular subsistence and residence strategies were employed, as a means to maintain equilibrium with the southern Plains environment. To clearly articulate the hypothesis, I put forth the following: *if* Late Archaic hunter-gatherers were optimally foraging, *then* this would be reflected in their subsistence strategy, which would be consistent with specific types of sites, artifact categories, and site placement on the landscape.

Although not mutually exclusive, central-place foraging and group size foraging are intertwined as used in this situation. The central-place foraging model, as outlined in Chapter Two, provides a framework to evaluate decisions about what resources a group would exploit and the best means to return the harvest to dependents. As optimal foragers, these decisions are based on selecting foods that provide the most energy for the least effort. In an attempt to minimize the amount of energy exerted to obtain a resource, a centralized base camp would be established in close proximity to a variety of resources. In turn, special extractive camps, away from the home base, would be established and occupied by a select number of individuals. These task groups would collect and preliminarily process the materials before transporting them back to camp as a means of maximizing intake while minimizing output of the larger group.

If this hypothesis is correct, the southern Plains Late Archaic hunter-gatherers were venturing from the Beaver Dam site to secure faunal, floral, and lithic resources. These goods were returned to Beaver Dam for further processing and/or consumption. At times of abundance, co-existing optimal forager groups would assemble to exploit temporarily aggregated resources such as the bison trapped at the L. E. Certain site. The key to

proving that Late Archaic hunter-gatherers were following an optimal foraging regime is to assess and analyze the available data recovered from the sites.

For the Late Archaic hunter-gatherers on the southern Plains, clues about subsistence and residence patterns are found in the type and location of sites, the faunal remains, the floral residues recovered from these sites, as well as the stone tools and debitage recovered from these sites (Figure 8.1). Each of these datasets addressed above and outlined in Chapter Two are examined and evaluated in the following sections.

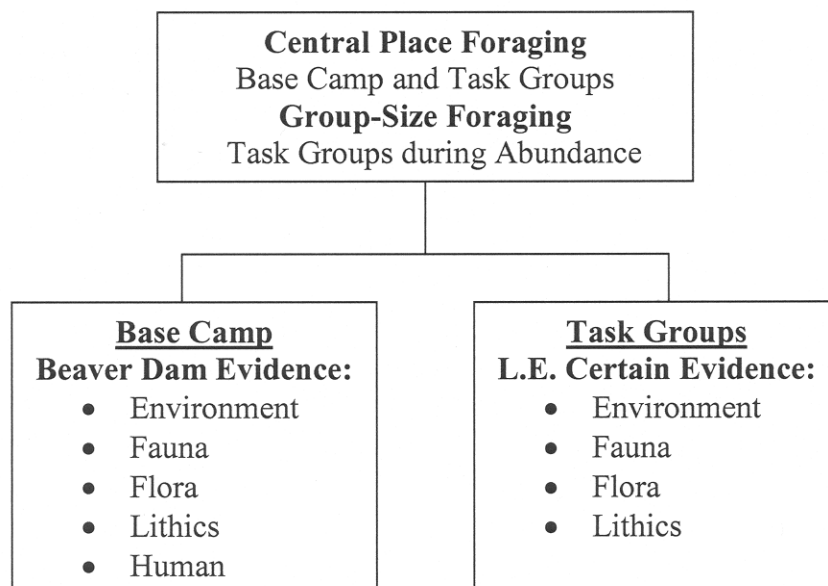


Figure 8.1. Optimal Foraging Theory (OFT) flowchart: presence or absence of OFT evidence at two contemporaneous sites.

Test Implications

In order to examine the outlined theoretical constructs in detail, two test implications were formulated. The test implications are further broken down into smaller categories to thoroughly examine the lifestyle of southern Plains hunter-gatherers. This format will be used to determine if these groups were acting as optimal foragers. The first aspect of central-place foraging is that a group will venture from a home base to acquire resources.

The second aspect of the theory states that special task groups are used to acquire the said resources which are then returned to the base. In order to better explain the task group aspect of the equation, the group foraging size theorem is employed. The theorem states that the task group's success is contingent on the appropriate number of individuals being available and the appropriate resource placement on the landscape. Test #1 is used for Beaver Dam (reliance on a home base) whereas Test #2 is applied to L. E. Certain (employment of a resource encounter and exploitation site). Initially, I set forth the expectations. Then, utilizing the evidence found at the sites, I will discuss their implications. Beaver Dam, the base camp, will be discussed first since this might be where forays into the surrounding biomes originated. This discussion is followed by an assessment of the L. E. Certain site, a special extractive camp.

Test #1: If southern Plains Late Archaic hunter-gatherers were optimally foraging, then they would utilize semi-permanent base camps as well as briefly occupy special extractive camps. The base camp would be (a) logistically located on an environmental boundary, (b) fauna would represent small- and medium-sized animals from close proximity to the camp, (c) flora would represent multiple species from close proximity to the camp, (d) lithics would represent production of formal and expedient tools from local and semi-local materials, and (e) presence of human remains would suggest refuge and sanctuary.

Test #2: If southern Plains Late Archaic hunter-gatherers were optimally foraging, then they would briefly occupy special extractive camps. The extractive camps would represent a focus on a target resource both animate and inanimate (Buehler 1997; Saunders 1974; Tainter 1979). According to the foraging group size theorem, seeking supplies as groups would be advantageous over foraging on an individual basis (Foley 1985; Horn 1968). The extractive camps would be (a) located at or associated with specific environmental settings, (b) fauna would represent a temporarily aggregated species, (c) flora would represent temporarily available species, and (d) lithics would

correspond to the requisite tools necessary to exploit the target resource.

Beaver Dam Site

Test #1a: Beaver Dam Site Placement

The Expectations

The main aspect in identifying a central-place foraging residence pattern is placement of the base camp. If a hunter-gatherer group were acting as central-place foragers, a base camp would be strategically situated on an environmental boundary with the intentions of capturing multiple resources with the least amount of effort. Ecologists refer to this as “edge effect” (Odum 1971:157-159). In the case of the Beaver Dam camp, one would expect to find resources from adjoining biomes or the transition zone (ecotone) between the two.

The Evidence

Evidence that the Beaver Dam site is perched on an environmental boundary is somewhat obvious simply by examining a variety of data sources, especially geologic, hydrologic, pedogenic, topographic, plant distribution, and precipitation maps (Burgess et al. 1959: Sheet 74; Fay and Hart 1978; Oklahoma Geological Survey 1917:37-44; Snider 1917:215-223; Thurmond n.d., 1991a, Figure 4, 1997b; Thurmond et al. 2002). Specific environmental settings in the vicinity of Beaver Dam include a stream valley-upland setting and an open range-woodland setting as noted in Chapter Seven. Each of these settings provides a variety of resources as presented in Chapter Three. For instance, Beaver Dam sits on the Tertiary-Permian boundary in western Oklahoma which provides ample spring water everywhere the contact zone of the two are exposed in valley walls (Gutentag et al. 1984:16-17; Thurmond n.d.). This boundary also provides some lithic resources which were used to produce piercing, cutting, and grinding implements (Collins 1968; Fay and Hart 1978:5, 37; Leonardy 1966a:30-32; Mallouf 1989:313; Schultz 1977; Shaeffer 1966; Patton 1923:78-80). Additionally, the surrounding stream and river valleys provide added lithic materials carried in from the west (Kraft 1997a;

Wyckoff 1993a). The differences in geologic formations, and specific soils that cap these formations also dictate the flora and fauna that inhabit each (Freeman et al. 2003; Thurmond 1991a; 1997b; Thurmond et al. 2002). For instance, the stream valley provide a woodland type setting of cottonwoods, walnut and other trees as do the sandy Tertiary-Ogallala hillocks on the uplands which host scrubby oak thickets (Blair 1939; Blair and Hubbell 1938:438-439; Gregg 1954:359-361; McCoy 1980, 1981; Peterson and Boyd 1998:2; Petrides 1972; Thurmond et al. 2002; Wright and Bretz 1949:65-72). Likewise, the settings surrounding the Beaver Dam site host a number of faunal resources. The spring-fed streams host freshwater mussels, small omnivorous foraging mammals, and avian species such as wading birds and waterfowl (Baumgartner and Baumgartner 1992; Central Flyway Waterfowl Council 1986; Duck and Fletcher 1945; Peterson and Boyd 1998:17-20; Robbins et al. 1966; Sutton 1977; United States Department of Agriculture 1976, 1978). Additionally, deer and turkey exploit the thicket-covered dunes and forest edge of larger stream valleys. Deer and turkey can also be found along the riparian edge of smaller streams to escape predators (Armstrong et al. 1986; Foreman 1947:43-44; Stangl et al. 1992; United States Department of Agriculture 1977:3, 1978). The stable uplands surrounding the stream valleys consist of open range while the eroding Permian settings consist of mixed grasses interrupted by various scrub bushes (Freeman et al. 2003; Peterson and Boyd 1998; Thurmond et al. 2002). Based on observations of modern bison (McHugh 1958: 36-37; Reynolds et al. 1982:984-985) the most likely animal to be found in these biomes is bison.

Test #1b: Beaver Dam Faunal Remains

The Expectations

If Late Archaic groups were practicing central-place foraging, fauna from more than one environmental setting should be represented at a logistical camp. These niches were detailed in Chapter Three. In Chapter Seven, four Beaver Dam site features attributed to the Late Archaic were described. These are features 1, 10, 21, and 22. Because not all of the features yielded faunal data for analysis, information from surrounding squares

provides supplementary data for this discussion.

The Evidence

Features 1 and 10

Unfortunately no faunal materials were collected from the kitchen area represented by Feature 1; more than likely this was a result of a large part of the feature being lost to erosion. Nevertheless, the adjacent excavated units contained bone fragments, although unidentified. It is obvious, however, that they are not bison. The faunal assemblage from Feature 10, like Feature 1, includes small mammals although no specific genus and species were readily identifiable. Circumstantially, this would suggest that the remains came from avian, amphibian, reptilian, or small mammalian species, because bison and deer bones are clearly larger and relatively easy to identify even when severely fractured and processed. This further implies that the fauna were not harvested from the open grassland but from one of the other biotic niches near the site. Manner of food preparation was indeterminate, but might include pulverizing the bones of small prey. However, the bone breakage might have taken place at any time afterwards (see Figure 5.5).

Feature 21

Feature 21, a kitchen area, had several artifacts mapped *in situ*, including three faunal elements. In addition to these prominent artifacts, several other faunal specimens were recovered from the screened fill. The *in situ* items included a left, maxillary, third premolar from an immature (< 3) male deer, a bison long bone fragment with a spiral fracture, and an unidentified bone splinter. Other bones recovered from the unit containing Feature 22 included both burned and unburned bone fragments from relatively small unidentified elements and unidentified species. Additionally, the desiccated remains of a bison molar were recovered. However, no other information could be gleaned from the specimen because of its poor preservation.

As was the case with the faunal collection from features 1 and 10, Feature 21 implicates human use of multiple settings. These included the sandy and scrubby uplands, the stream valleys, and the riparian edge of the latter. Not only do the faunal materials demonstrate use of the above settings, the bison remains imply the use of the open grasslands north of the site. Preparation of the harvested animals was variable. Treatment includes quartering carcasses and extraction of marrow as indicated by the spiral fractured long bone and bone splinter. Removal of the crania is based on the recovery of molar teeth from two different species. There is also possibly some sort of preparation that included the burning of bone. However, the bone burning might have taken place following preparation.

Feature 22

Feature 22 is another kitchen area. From Chapter Seven, Feature 22 was noted to contain two tools manufactured from bone. Included was a shell with an obviously worked edge, as well as a bone awl with various striations. The sex of mussel was undeterminable. Additionally, the genus and sex of the animal used to make the awl, and the actual element was indeterminate. However, based on awl production techniques and trends in surrounding areas and subsequent cultural periods, the raw material is assumed to be a deer metapodial. Other materials recovered from Feature 22 included two unidentified bone fragments from a large mammal, most likely bison, and one unidentified bone fragment from a smaller mammal. The latter may be associated with avian, amphibian, or reptilian species as noted with the other features. Manner of preparation was indeterminate. Nevertheless, activities associated with this feature appear to represent use of surrounding open grasslands based on the recovered bison remains, and exploitation of the riverine environments based on the presence of the utilized mussel shell and possible presence of avian, amphibian, or reptilian species that frequent permanent water.

Summary of Faunal Data

In summary, the animal remains from the Late Archaic features from the Beaver Dam

site include deer, bison, mussels, and a number of unidentified smaller animals. These were gathered from every niche near the camp including the grassy uplands, the tree-lined stream valleys, and the water they transport. No articulated faunal remains were recovered suggesting that all prey was thoroughly processed around a hearth.

Test #1c: Beaver Dam Floral Remains

The Expectations

Information on plants used at Late Archaic sites on the southern Plains is extremely limited, but a variety of wild plants were potentially available. Obviously, additional flotation samples are needed to document these plants. However, few extensive excavations have been conducted at Late Archaic sites and even fewer flotation samples collected. As discussed in chapters Three and Four, the paucity of data is the result of inadequate sites from which to collect such information. Fortunately, plant remains were collected and analyzed from one feature (Feature 10) at the Beaver Dam site. Because of this, the other features are not discussed individually as in the previous section. In lieu of discussing each feature, the Feature 10 floral data are discussed on isotopic, macrobotanical, and cambium levels, the results of which should represent flora from multiple biotic districts. Furthermore, the floral materials should represent items associated with different seasons.

The Evidence

Isotopic Data

According to Craig (1954), Murphy and Nier (1941), and Nier and Gulbransen (1939), stable carbon isotope ratios reflect photosynthetic pathways (C3/C4). Plant materials prehistorically collected by the Beaver Dam inhabitants confirm what modern maps reveal (as noted in Chapter Three): the site is perched along an environmental crossroads or ecotone. Isotopic evidence of such comes from the $^{13}\text{C}/^{12}\text{C}$ ratios from the two Late Archaic radiocarbon samples collected and processed. Before discussing the actual results, a general explanation about $^{13}\text{C}/^{12}\text{C}$ ratios is in order. For example, $^{13}\text{C}/^{12}\text{C}$ ratios

in the -26 to -29 o/oo range are usually associated with trees, brush, and sedges (C3) whereas the $^{13}\text{C}/^{12}\text{C}$ ratios in the -15 to -18 o/oo range are generally equated with grasslands (C4) (O'Leary 1988:328-332).

Having said that, the Beta 116182 sample (1850 $\pm$ 50 BP) from Beaver Dam had a $^{13}\text{C}/^{12}\text{C}$ ratio of -23.7 o/oo while the Beta 116185 (1880 $\pm$ 50 BP) sample had a $^{13}\text{C}/^{12}\text{C}$ ratio of -23.4 o/oo. These readings are consistent with the eight other radiocarbon dates from Beaver Dam, spanning the Late Archaic (~AD 100) to the late Woodland (~AD 1000) periods. Not only are the charred organic ratios consistently in the -23 o/oo range, but so are the bulk sediment samples. In effect, these ratios suggest that the Beaver Dam site setting consisted mainly of woody species. Such would be expected in a spring-fed upland canyon. That is, the $^{13}\text{C}/^{12}\text{C}$ ratios are neither high (-26 to -29 o/oo) nor low (-15 to -18 o/oo) (O'Leary 1988:328-332). Thus the conclusion is that the processed samples reflect a woody, shrub environment, yet one also containing a grassy element.

Macrobotanical Data

The next line of evidence to address Test #1c comes from flotation samples. These findings also suggest that inhabitants of the Beaver Dam site were exploiting an array of environmental zones. Materials identified in the Feature 10 sample represent a variety of plants, which could be utilized for food, fuel, fiber, spice, carbohydrate, and ritual and medicinal purposes as noted in the Plant Communities and Associated Fauna section of Chapter Three.

The archaeobotanical assemblage from the light fraction included charred materials such as Chenopodiaceae-Amaranthus, purslane (Portulaca), plus possible barnyard grass (Echinochloa), bulrush (Scirpus sp.), marshelder (Iva sp.), mustard (Cruciferae), spikerush (Eleocharis) seeds, several other unidentified seeds, and an unidentified nut shell fragment. Most of these plants are foodstuffs, but based on historical Amerindian uses many were possibly used for their ritual or medicinal properties (Dayton 1960;

Harrington 1972; Kindscher 1987, 1992). A few of the plants represented in the sample were totally edible but most were collected for their seeds (Gibbons and Tucker 1979; Kirk 1975; Knutsen 1975; Peterson 1977). Obviously, the heads of the seed-producing plants can be collected at a brief time during the year; but, these seeds could also have been consumed out of season if they were cached.

By far, the most numerous of the archaeobotanical residues observed were *Chenopodiaceae-Amaranthus* (N=84). The abundance of these small black shiny seeds, from a variety of species, indicates that they were an important food source. Small-seed harvesting was usually followed by parching and storage or consumption. After this, the seeds could be ground or eaten whole. Besides the seeds being edible, the greens could be consumed raw or boiled (Gibbons and Tucker 1979:83, 89; Kirk 1975:56, 63; Knutsen 1975:47; Peterson 1977:152, 154; Stubbendieck et al. 1995:252-255). *Chenopodiaceae-Amaranthus* (Cheno-Ams) are generally found in ruderal or disturbed areas such as unstable canyon slopes, or where climax plants were removed by human activity. Since these plant groups reproduce prodigiously, they can be collected frequently without harming the plants (Gibbons and Tucker 1979:83, 89). As a result, these plants were a resource easily obtainable near camp and tolerant to human manipulation.

Purslane (N=20) and unidentified small seeds (N=23) were the next most frequent botanical material recovered from Feature 10. Like Cheno-Ams, purslane can be eaten raw or boiled, but is best when young (Kirk 1975:46). The seeds are best when parched before storage or consumption as was the case with Cheno-Ams. Purslane seeds are crowded into tiny pods and they continue to ripen after being picked. This allows for a longer shelf-life (Knutsen 1975:64; Peterson 1977:72). As with the Cheno-Ams, purslane prefers sandy, ruderal areas, such as those found on the upland hillocks and dunes surrounding Beaver Dam (Gibbons and Tucker 1979:97; Knutsen 1975:64; Peterson 1977:72; Stubbendieck et al. 1995:492-493).

A handful of mustard seeds (N=9) also were identified in the flotation residue. This plant is usually found in prairie zones as well as in areas where climax plants have been removed (Freeman and Morse, n.d.). The Beaver Dam inhabitants had easy access to both types of environments as noted in the Plant Communities and Associated Fauna section of Chapter Three. While mustard seeds are consumed either as a spice or a ground meal, the young leaves can be boiled and eaten and the unopened buds can be served in a manner similar to broccoli (Kirk 1975:36, 38; Peterson 1977:64; Stubbendieck et al. 1995:206-207).

A charred acorn (Quercus sp.) hull fragment (N=1) was also recovered from Feature 10. The acorn was retrieved from that portion of the feature fill which was dry screened. As noted in the Shin Oak Grassland and Sandsage Grassland section of Chapter Three, Quercus prefers sandy soils exactly like those north and south of the Beaver Dam site. Thus, it is not surprising that the food was being exploited. However, the absence of acorn residue from the flotation sample is curious. Partial preparation of the nuts at a special extraction locality may account for this deficiency (Turner 1988:179-182). Additionally, the thin shells of acorns may not preserve well in comparison to other nut and seed crops and thus be underrepresented in the assemblage (Drass 1993:60).

Without a doubt, seed-foods and nut crops were an important part of the Late Archaic diet in the first few centuries AD. Seasonal collection of these foodstuffs was patterned after the plants' developmental cycles. For instance, in the spring the greens from Chenopodiums can be collected and cooked, as well as the buds from mustard and the roots and shoots of bulrush (Gibbons and Tucker 1979:83, 89; Knutsen 1975:44; Peterson 1977:64). In the summer, Chenopodium greens can be simmered, mustard seeds and buds can be prepared by roasting and boiling respectively, purslane seeds, stems and leaves can be consumed, and bulrush pollen can serve as an additive to thicken other recipes (Gibbons and Tucker 1979:83, 89; Kirk 1975:56, 63; Knutsen 1975:44, 64; Peterson 1977:64, 72). In autumn, Chenopodium greens can again be simmered and the seeds

parched, as can barnyard, bulrush, and purslane seeds (Gibbons and Tucker 1979:23, 83, 89, 97; Kirk 1975:187; Knutsen 1975:64). Purslane stems can also be eaten at this time of year as a tart and juicy snack or provide a meal if consumed in large quantities (Knutsen 1975, Plate 43). Nuts can be collected at this time of year as well (Gibbons and Tucker 1979:59; Peterson 1977:194, 198). And, during the coldest part of the year, winter, those nuts that did not fall after the first frost can be gathered and husked. Also, Cheno-Am greens can be cooked in early winter, when available (Gibbons and Tucker 1979:59, 83, 89). Obviously, winter is the time of year when cached foods would be critical to survival, primarily dried meat procured in previous seasons. In any event, empirical evidence for winter occupation of the site is lacking.

Cambium Data

Analysis of the charcoal fragments from Feature 10 reveals that the firewood gathered for domestic use was collected from multiple biomes. Species represented in the charred wood sample included elm (Ulmus americana) or hackberry (Celtis occidentalis), cottonwood (Populus deltoids var. monolifera), and oak (Quercus sp.). The difficulty in determining the difference between elm and hackberry is because both belong to the Elm family (Ulmaceae) and thus have similar cellular structure (Brockman 1968:138). The presence of elm or hackberry and cottonwood verify that water was permanently available in the vicinity since they prefer deep, well-drained soils (Brockman 1968:84; Little 2002:47, 93, 98; Wright and Bretz 1949:66-68). Given the setting of the Beaver Dam site, elm and hackberry could have been available onsite as noted in Chapter Three. On the other hand, cottonwoods truly thrive in the lowlands (Little 2002:47) located along the canyon system and are still present onsite. But cottonwood, elm, and hackberry will grow in sandier locations on uplands but do so more slowly (Wright and Bretz 1949:66-67). Such localities exist south of Beaver Dam. At present a variety of oaks are permanent fixtures on the upland dunes and hillocks and can grow in all varieties of sandy soils (Peterson and Boyd 1998:1-3; Pettit 1986:5). These environments occur near Beaver Dam as noted in the Shin Oak Grassland and Sandsage Grassland section of

Chapter Three. As far as fuel-wood collection goes, gathering cottonwood and hackberry limbs would be easy since their wood is moderately weak and subject to breakage while oak wood is more resilient and dense (Little 2002:47; Wright and Bretz 1949:66).

Summary of the Floral Data

From the isotopic, macrobotanical, and cambium data, it is plain to see that the Beaver Dam inhabitants were collecting an assortment of wild plants from different settings. As noted in Chapter Seven, the site is in the upper reaches of Brokenleg Creek, a spring-fed tributary of the Washita River. Specific environmental settings in the vicinity of the Beaver Dam site include a stream valley-upland setting and an open range-woodland setting. Each of these provides a variety of plant life. Starting with the larger flora, the sandy, upland Tertiary-Ogallala hillocks host various species of oak that were used for food and fuel. The stream valley hosts a woodland type setting of cottonwoods, hickory, walnut, willow, and other trees that also supply fuel and food. Based on the flotation residue, the spring-fed streams in the vicinity provide an assortment of microniches along their course. These streams interchange between fast-moving water bodies to pooled areas. Many of the seed plants collected by the Beaver Dam group such as barnyard, marshelder, and spikerush prefer mesic areas, especially near seeps. Cheno-Ams and purslane prefer sandy areas such as those recovered on the surrounding upland hillocks and dunes. They also prefer ruderal areas where climax plants were removed by human activity. Mustard plants do well where climax plants have been removed but can also be found in prairie zones such as those separating the many tributaries of the Washita River. According to the data collected from the Feature 10 flotation sample, these trees, seeds, and weeds were used for food, fuel, and possibly many other purposes around the camp. However, the modicum of winter plant food available was surely supplemented by cached plant foods and jerked meat.

Test #1d: Beaver Dam Lithic Remains

The Expectations

Another data class that should be represented at a base camp, and thus support a central-place foraging lifestyle, is the lithic assemblage. In effect, the focus of this discussion is on southern Plains hunter-gatherer lithic reduction strategies rather than projectile points. As noted in Chapter Two, task-specific and generalized knapping events with their characteristically distinct patterns of products and by products would be represented at a logistical camp. Other lithics associated with a base camp, such as hearth stones, cooking stones, and grinding stones, should also be evident. Moreover, an abundance of these artifacts would signal repeated occupancy and thus a lifestyle consistent with central-place foraging.

Preparation of specialized tools for target pursuits would be indicated by late stage reduction debris and biface thinning flakes of various sizes representing each stage of biface manufacture. Production debris from manufacturing specialized tools such as points and knives should be present if people meant to kill and process large game animals such as bison. However the size and composition of the group occupying Beaver Dam may limit the amount of biface and point production debris. Nevertheless, since bison trapping, killing, and processing took place away from the base camp (e.g., L. E. Certain), more often than not, the tools would also need to be transportable. If both are true, then there should be a high percentage of late stage reduction debitage to biface tools and points associated with a particular feature or a camp. Regarding tool stone, raw material used for formalized tools such as points and knives should be highly siliceous and fracture in a predictable manner (i.e. high quality). Raw material with predictable fracture properties reduces the chance of failure during manufacture and thus reduces time allocation to tool preparation.

On the other hand, generalized knapping will be manifest in a greater variety of flaking debris. This behavior should be reflected in the complete reduction of nodules. However,

early stage reduction of raw material will be limited since raw material is preliminarily trimmed and shaped at quarry locations (Holmes 1894:14, 1897:26). Generalized knapping behavior would also be evidenced by the use of expedient or instant tools. These tools are usually flakes that require little alteration or secondary shaping and could be manufactured from debris produced during any stage in the lithic reduction sequence. The same is true of minimally flaked cobbles which require little technological preparation before use. Both types of expedient tools would serve their purpose and would be discarded at the activity locus. If expedient technological strategies are used, then readily available raw materials are a necessary precondition. As noted in the Geology section of Chapter Three, the study area is blanketed with Ogallala Formation materials primarily consisting of coarse-grained and large-crystal quartzites. However Potter chert, a variety of unnamed cherts, and silicified wood are interspersed within the Ogallala quartzite deposits.

Other lithic materials expected at a semi-permanent base camp include hearthstones, fire-cracked rock, boiling pebbles, food-processing stones, and bone/stone/wood-working tools. These stones would be easy to collect and widely available. The ubiquitous Ogallala Formation clasts would be the primary material used in hearth construction. Multiple fire pits would show that a site was repeatedly occupied and used for extended stays (Wandsnider 1997:28). An abundance of fire-cracked rock, and boiling pebbles would also indicate that household activities occurred at the site time and time again, thus demonstrating use as a base camp. Finally, specialized tools used to prepare plant materials from the surrounding biomes should also be evident. Thus, a number of grinding implements and anvil stones should be represented in the archaeological record. Finally, grooved and scored stones would reflect maintenance and production of tools from various media.

The Evidence

In order to address all of these premises, the four features attributed to the Late Archaic at

Beaver Dam will again be utilized as support data. These are features 1, 10, 21, and 22. All of the features yielded some lithic material for analysis. As a supplement, artifacts from surrounding squares are employed to address the stated expectations. It must be kept in mind that a large portion of the site, not to mention the Late Archaic component, was lost to erosion and these four features probably only reflect a small portion of life at the Beaver Dam site.

Feature 1

As noted in Chapter Seven, two Ogallala quartzite and one Tecovas jasper cobble reduction flakes were recovered from Feature 1 as were one tested quartzite cobble, one chert core, one quartzite biface thinning flake, and two utilized flakes, one each of Alibates and Tecovas. Fire-cracked rock and a grinding slab round out the lithic assemblage. The fire-cracked rock was composed of Ogallala Formation quartzite and Permian shale. The slab was fashioned from a piece of Permian sandstone. The cobble reduction flakes and tested cobble demonstrate that the beginning stages of tool production were taking place. The discarded core reveals that a core technology was employed whereby cutting tools were removed as needed. The two flake tools bolster the argument that generalized knapping took place. Whether the flakes were manufactured for a specific task or were recycled from a discard pile of tool production debitage is not apparent. Finally, one thinning flake reveals that a biface was further worked or rejuvenated near the feature.

Given these data and based on the expectations presented above, Feature 1 reveals that generalized knapping was taking place at the base camp whereby locally available materials such as quartzite, sandstone, and shale, were employed for short-term use as hearth surrounds, grinding/smashing food products, or performing impromptu cutting. When acceptable knapping material (moderately siliceous) was acquired, it was reduced into multi-faced cores to produce flake tools. Thus, these bodies of evidence corroborate

part of the expectations. Biface production debris was limited, although expected in larger quantities

.

Feature 10

An assortment of debitage, a handful of tools, and a collection of fire-cracked rock were associated with this feature. As documented in Chapter Seven, the majority of debitage represents late stage cobble and biface reduction. For example, only 6% of the sample was primary flakes. Locally available Ogallala Formation materials such as coarse- and fine-grained quartzites, chert, and jasper are represented in the flaking debris. These trends correspond with the expectation set forth for a base camp.

Besides the debitage, additional chipped stone tools were found associated with Feature 10. These include five modified and utilized flakes. In essence, any pile of waste flakes represented potential tools although flake tool selection would have favored those with specific material, size, and edge attributes. The only trend noted was in regard to material type; four tools were chert and one was siliceous quartzite. It appears there was a preference to employ cryptocrystalline materials for expedient flake tools. Besides these five flakes, innumerable flakes were probably employed without modification and used so briefly that wear was not recognized as such. In addition to the debitage and flake tools, a scraper, a drill fragment, and two complete projectile points were associated with Feature 10. As noted in Chapter Seven, the corner-notched dart points were manufactured from highly siliceous materials: a fine-grained quartzite and Alibates silicified dolomite. The scraper was manufactured from either Alibates or Tecovas, and the drill was made from a siliceous piece of quartzite.

In addition to these flaked tools, three ground stone fragments were recovered from Feature 10. These were used as anvil stones or for grinding, rubbing, and abrading. All three stones were tabular and none required special manufacturing or preparation before use. None of the specimens refit, but all were manufactured from local sandstone.

Finally, the overwhelming majority of lithic materials associated with Feature 10 were fire-cracked rocks. The non-isotropic quartzites, which comprise the majority of the Ogallala Formation materials in the area, dominated the fire-cracked rock artifact class.

Based on the expectations noted above for generalized versus specialized knapping, the material culture does not exactly match the prediction but does favor specialized activities. As presented in Chapter Seven, late stage reduction debris overwhelms (94%) the chipped stone collection. Thus, it can be said with relative confidence that bifacial tool manufacturing was going on around Feature 10. However, there were no isolated biface production debris piles reminiscent of single knapping events. Both locally available materials and semi-local materials comprised the collection as expected. Given all this, it appears that some level of generalized as well as specialized activities was taking place near Feature 10, yet evidence for isolated, specialized knapping episodes are not represented.

Feature 21

Feature 21 is characterized as a rather expansive domestic area containing all stages of lithic reduction including chips and blocky debris. As demonstrated in Chapter Seven, the debitage inventory is rather limited and only local materials are represented. In all, 19 pieces of chipped debris were recovered with only six pieces representing secondary and tertiary classes. No biface maintenance debris was recovered such as that associated with production of specialized tools (e.g. points or biface knives). In addition to the debitage, a handful of expedient tools were recovered. The utilitarian tools include a unifacial scraper, a bifacial scraper, and a retouched flake. All were manufactured from siliceous materials and were locally available. From the above description of artifacts, generalized knapping and expedient tool use appear to be represented. Besides the generalized knapping debris and expedient tools, fire-cracked rocks, heat-altered rocks, and boiling stones were found. Again, local material was used to construct the feature. The same is

true of the sandstone abrader recovered from the feature.

Taking into consideration the stated expectations, it is clear that multiple (generalized) activities transpired in this area of the site. Locally available stones of knappable quality were reduced with the detritus being employed as impromptu tools. Given the ready availability of raw material, flake tools were used for cutting and scraping activities and then cast aside.

Feature 22

Feature 22 is an oval fire pit. The feature was cross-sectioned during excavation with only one-half of the fill being removed for analysis. The recovered lithic materials consisted of knapping debris, a milling stone, a collection of hearth stones, and a few boiling pebbles. Of the eight flakes recovered from the feature, three were primary decorticate flakes, two were secondary flakes, and another three were tertiary flakes. As noted in Chapter Seven, five of the eight flakes were quartzite. The remaining three, all tertiary flakes, were Potter chert and Alibates silicified dolomite. Both are fine-grained materials with variable availability in the immediate area. No point/knife maintenance debris was recovered, although expected. Besides the chipped stone artifacts recovered from the feature, three other artifact classes were represented. They are fire-cracked rocks, boiling stones, and grinding slabs. Locally available materials were used to manufacture these tools. The milling stone was made of Permian sandstone and the pebbles and fire-cracked rock came from the ubiquitous Ogallala Formation materials.

Summary of Lithic Data

Based on the expectations presented earlier in this section and the above data, the recovered debitage indicates that generalized knapping, expedient-tool use, and possibly early-stage tool production took place at the feature. Locally available materials such as fine-grained quartzite, coarse-grained quartzite, and sandstone were employed for short-term use. Activities represented include hearth construction, grinding or smashing

foodstuffs, and episodic cobble reduction.

The task in this section was to determine if the lithic data from the features would indicate task-specific or generalized knapping. Expectations were set and the data necessary to confirm or deny the expectations were established. Despite trying to fit each of the features into one or the other categories, the data revealed that the Beaver Dam inhabitants were performing both task-specific and generalized knapping around all the Late Archaic features. Given this, it became apparent that the degree to which specialized tools were being made could only be determined rather than a presence-absence situation. Early-stage reduction debris, indicative of generalized knapping, was recovered from all four features as was a modicum of late stage debris, thus reflecting some degree of specialized knapping. On the other hand, most of the material collected from Feature 10 represented tool production and tool maintenance activities. Expectations regarding the use of locally available materials for knapping as well as for other purposes (e.g. hearthstones, boiling pebbles, and food preparation) held firm. Without exception, the fine-grained quartzites and other high quality materials were used to produce bifaces or flake tools. Despite all this, it remains to be shown that any one of the features was solely associated with point and knife production, as required to kill and process large prey offsite.

Potential reasons for this shortcoming involve the integrity of the site and possibly the composition of the group that occupied the site. Even though the Beaver Dam site is the most extensively excavated Late Archaic camp site on the southern Plains, close to 75% of the site has been destroyed by periodic canyon flushing. This erosion pattern is characteristic of the area. In fact, areas A and C, which are contemporaneous, are separated by a 20 m modern gully (see Figures 7.1-7.2). In essence, the cultural sediments between these excavation areas were not available for analysis. Nevertheless, four cultural features were analyzed and interpreted.

The lack of lithic materials for analysis is a hindrance to interpreting the site and thus the validity of the proposed model. This shortcoming was addressed when interpreting Feature #10, the largest of the analyzed features. An attempt was made to incorporate more lithic data into the analysis by expanding the anticipated activity area around Feature #10 to a circumference of 1 m. In all, 454 lithic artifacts were recovered from the features and only 204 (44%) were knapping material. In turn, not even half of the lithic items from the four features were associated with specialized knapping. All in all, the lithic data denote a generalized knapping regime. This was expected, but the expectation was to also find copious biface and point production debris associated with each feature. Such would be expected if a group were preparing for bison hunting.

Before proceeding, it is worth reviewing the lithic data from a contemporaneous site in the immediate vicinity. Site 34RM507 is located to the east of the Beaver Dam site in the adjacent Higgins Creek valley (Rebnegger and Green, n.d.). Lithic artifacts recovered from there clearly display the different stages in biface production practiced by the Late Archaic occupants. These include large, complete primary and secondary flakes removed from even larger quartzite cobbles. These large Ogallala flakes are then thinned and shaped into oval and sometimes elongated biface knives (Rebnegger, personal communication 2001). Similar staged bifaces were found at the Beaver Dam site scattered about the Late Archaic component but not associated with any features. Evidence of biface production in the form of relatively large primary and secondary flakes in various forms of production has also been found actively eroding from the site. In fact, the presence of these distinctive artifacts was one of the first trends noted during Thurmond's surface collections at the Beaver Dam site (field notes, J. Peter Thurmond). Despite there being a lack of evidence for discrete biface production events, the knapping sequence employed by the Late Archaic hunter-gatherers at the Beaver Dam site can be discerned. These stages and their representative artifacts were reviewed in Chapter Seven.

If we accept that the four Late Archaic features are representative of the entire Late Archaic occupation at the Beaver Dam site, then the question as to the composition of the groups that called Beaver Dam home is raised. Based on the meager lithic remains and the propensity for Late Archaic groups to communally hunt bison, the Beaver Dam site was probably occupied by an extended family incorporating several affines and generations. The site served as a base of operations where daily if not weekly jaunts began and ended. It did not serve as a gathering point for other family groups prior to a large communal hunt. This might explain the lack of discrete piles of biface production debris indicative of a group of hunters preparing to pursue bison. Other family camps such as Beaver Dam should be found throughout the region. Candidates include the nearby sites 34RM507 (Rebnegger and Green, n.d.; Thurmond, personal communication 1999) and 34RM334 (Thurmond 1991a) and possibly even 34WA157 (Wallis 2000) on the other side of the Dempsey Divide.

The expectation that the Late Archaic features at the Beaver Dam site represent a family group rather than a gathering of Late Archaic folks is bolstered by the composition of the features. If the postulate of one feature represents one nuclear family, then the Late Archaic component at the Beaver Dam site represents an extended family group rather than a gathering of distantly related families or people with close social bonds. Nevertheless, it was at a predetermined time in autumn that member from these camps convened at the L. E. Certain site with points and knives ready to hunt buffalo as part of a social and communal event. By following this lifestyle, the hunter-gatherers maintained equilibrium with their environment as indicated by the perpetuation of the culture for nearly 500 years.

Test #1e: Beaver Dam Human Remains

The Expectations

If southern Plains Late Archaic hunter-gatherers were central-place foragers and utilizing semi-permanent camps as a base of operations, the camp might contain human remains.

The Evidence

As discussed in Chapter Seven, a Late Archaic burial was recovered from the Beaver Dam site. Associated with burial were an atlatl weight, ovate biface knives, and corner-notched dart point. The corner-notched point is manufactured from a variegated piece of silicified wood available from the ubiquitous Ogallala Formation gravel deposits at the location. Such gravel is eroding from gullies on the slope directly north of the site (Thurmond 1983). The dart point was produced using soft hammer and pressure techniques and is similar in form to those recovered from elsewhere at the Beaver Dam site, the L. E. Certain site, and other Late Archaic bison kills to the west (Buehler 1997; Hughes 1989). The atlatl weight is one of 10 known to occur on the eastern edge of the Llano Estacado. The Beaver Dam specimen is manufactured from locally available Kiowa Formation shale. The bifaces were manufactured from very siliceous Ogallala quartzite using soft hammer percussion.

From these data it is evident that the individual buried at the Beaver Dam site was familiar with the region. For example, items associated with the burial were made from resources available in the surrounding area. This, along with stylistic similarities of the associated objects to those found elsewhere in the region suggest this person was local and likely died during one of the Late Archaic site occupations.

Test #1: Implications

Test #1 dealt with the premier attribute of central-place foraging, use of a home base. This is the place from where group members departed and returned to once resources were acquired. Evidence that this was occurring would be reflected in the (a) environmental setting of the camp, (b) faunal remains, (c) floral residue, (d) lithics debitage, and (e) human interment and burial furniture deposited at the site.

The exploitation of multiple phylogenetic groups and topographic features is a clear indication that the Beaver Dam site was being used as a strategically located base camp.

As predicted in Chapter Two and codified in Test #1a, placement of the base along a well-defined ecotone was a cost-effective and secure response to the southern Plains environment. Nearby habitats include grassey uplands interspersed by sandy, oak-covered hillocks and tree-lined stream valleys and adjacent prairies. Not only did this residential strategy allow for dietary diversification with little effort, placement of the base camp along a well-defined topographic boundary made various raw materials for cutting, piercing, pounding, and cooking utensils readily available. In effect, the group and/or the individual was maximizing energy-return and minimizing energy-output with this residence and food-acquisition pattern.

Test #1b addressed the type of animals that might be expected at a base camp occupied by central-place foragers. Although most of the faunal remains recovered from the features were pulverized beyond positive species or element identification, most bones were obviously not from bison or deer although these animals are represented. Test #1a suggests that unidentified smaller species were harvested from habitats consistent with those described above (and in Chapter Three). These include grassy uplands; sandy, oak-covered hillocks; and tree-lined stream valleys and adjacent prairies. In addition to the small- and medium-sized prey collected from the identified biotic communities, freshwater mussels were also collected. The collection locale of the mussel was presumably from any one of the drainage systems described in the Location, and Hydrology sections of Chapter Three. Other aquatic species such as turtles and snakes were conspicuously absent. Nevertheless, it is evident from these data that the group and/or individuals were maximizing energy-return and minimizing energy-output with this hunting pattern, as predicted in Chapter Two.

Floral remains were collected and examined from Feature 10, one of the four features presented in this text. Test #1c incorporates the isotopic, macrobotanical, and cambium data collected from Feature 10. Isotopic data revealed that the Beaver Dam site area consisted of a woodland setting with a grassy prairie-plains element. You will recall from

Chapter Four that two different types of woodlands adjacent to the Beaver Dam site. Numerous species are associated with the local river valleys and the upland dunes of the prairie-plains foster scraggly thickets. The cambium data verifies the presence of a woodland element. As noted in Chapter Seven, fuel wood identified in the Feature 10 sample included elm or hackberry, cottonwood, and oak. Cottonwood trees thrive in wet settings and oak trees prefer upland dunes and hillocks. Not only were the tree branches of oak trees utilized but limited macrobotanical evidence suggests that acorns were collected, presumably for consumption.

The vast majority of the macrobotanical remains were collected from mesic areas of the identified environments. These plants demonstrate that human collection occurred during spring, summer, and autumn, and possibly even winter. However, the plant remains overwhelming represent summer and autumn. There was a modicum of spring-harvested plants, with a conspicuous absence of winter foods. The latter most likely reflects the paucity of available plant life, but does not signal that observations made by Hughes (1991:20-26), Moore (1984:190-199, 1988b:33-63), Thurmond (1991a:128-140), and Wedel (1975:273) are incorrect. Observations made to the north and south of the Dempsey Divide propose that Late Archaic groups sheltered in grottos, caves, fissures, and canyons also, even though there is limited botanical evidence to suggest such (Boyd 1997:265-266; Campbell 1976:68). However, the lack of empirical evidence does not connote that this harvest and settlement pattern was not employed. Keeping in mind Dale's (1965:9) recount of Oklahoma's preponderance for wind, and combine that wind with temperatures just above freezing for several months, a protected camp site like Beaver Dam would provide winter shelter. Personal observations confirm this postulate. Additional anecdotal support for winter use rests in the fact that the Beaver Dam site is located in a section of Brokenleg Creek canyon which is oriented northeast-by-southwest. This would provide ample morning and mid-day sunshine on the west side of the canyon which would also provide protection from unrelenting northern and western Arctic-charged air. Besides these observations, empirical evidence for winter utilization of

Dempsey Divide canyons by Late Archaic groups is not available. Evidence for winter use of canyons by Late Archaic groups might lie in collecting and analyzing palynological samples collected from sites with a relative level of depositional integrity. Whether used in the winter or not, the approach of harvesting seasonally abundant biota increased the group and/or the individual's quest to maximize energy-return and minimize energy-output as forecasted in Chapter Two.

Test #1d addressed the lithic data from the Beaver Dam site. The lithic materials recovered from the site reveals a pattern of using both local and semi-local stone materials. This behavior would be expected if central-place foragers occupied the base camp. By residing on a topographic and geologic boundary, a plethora of materials were available to produce both expedient and formal tools. Materials such as sandstone, shale, quartzite, silicified wood, jasper, and chert could be collected from the eroded and exposed geologic units; Alibates and Tecovas could be found along the major rivers originating in the High Plains. Miscellaneous jaspers and siltstones could also be acquired along the rivers. Siliceous quartzite, dolomite, and cherts were used to construct formal chipped stone tools as represented by the intact points and the debris resulting from maintaining formal tools. Tool maintenance is a response associated with limited amounts of isotropic material, as previously noted. Such behavior displays an investment of time for manufacture and upkeep. Isolated piles of point production debris, indicative of a single knapping event, were not identified even though evidence for the full-scale biface production was expected to co-occur with Late Archaic features. This was not the case. However, each stage of biface production was found throughout the Late Archaic component. In regard to other lithic artifacts, quartzite with large crystalline structure and available on site, was used to construct hearths. Likewise local sandstone and shale was used as grinding stones and anvils. This sort of tool production regime and raw material utilization minimized energy-output and maximized energy-return.

Test #1e dealt with the human remains and burial inclusions recovered from the Beaver

Dam camp site. It was argued in Chapter Two that a camp used by central-place foragers as a home base might contain human remains. This was the case with the Beaver Dam site. The act of burial, and all the symbolism it entails, implies that the camp was in fact a base of operations. Combining this with the fact that grave inclusions manufactured from locally available materials, it cannot be denied that the Beaver Dam site served as a logistical base camp, strategically located to exploit the surrounding environment and better the chance of survival.

In conclusion, most of the implications verify the validity of Test #1. It was established that the Late Archaic hunter-gatherers of the southern Plains were central-place foragers. Without a doubt, the Beaver Dam site served as a seasonally frequented, centrally located base camp where related group members departed from and returned to with the resources they needed to optimally operate on the southern Plains. On the other hand, there is little evidence to support the contention that the Beaver Dam site served as a gathering point for distantly related and similarly outfitted groups prior to a large communal bison hunt. Rather the site was a home base for a collection of closely related nuclear families. There is also little evidence to support the contention that the Beaver Dam site was occupied during the winter as proposed by others and expected by the author (Boyd 1997:265-266; Campbell 1976:68; Hughes 1991:20-26; Moore 1984:190-199, 1988b:33-63; Thurmond 1991a:128-140; Wedel 1975:273). However, evidence for winter use of the Beaver Dam site should be invisible if cached plant, nuts, and filleted meat were consumed. Finally, the camp also served as a repository for a deceased family member in addition to being a spot where local animals, plants, and stones were put to use by the Beaver Dam group.

L. E. Certain Site

Test #2a: L. E. Certain Site Placement

The Expectations

One of the major aspects of a central-place foraging residence pattern is the utilization of

special activity sites to procure target resources. As noted in the previous section, the base camp is the focus of the social system whereas special activity sites represent subsystems within the larger system (Saunders 1974:106-109). These special activity camps should be associated with specific environmental settings where the target resource could be found (Kraft 1996). As noted in Chapter Two, mixed-grass upland divides, steep-walled canyons, and fertile, sometimes tree-lined canyon bottoms characterize the eastern margin of the southern Plains. Seeps and springs along the canyon bottoms provide microniches that surely attracted bison and their prehistoric human predators (Thurmond et al. 2002:10-13). With ease, these hunters could maneuver bison into the broad canyon bottoms, if they were not already present, and chase them toward the head of a pre-selected canyon where they would find no escape. If this social adaptation to landform use and human cooperation were successful, one would expect to find evidence to that effect.

The Evidence

As noted in chapters Five and Six, the L. E. Certain site consists of numerous bison kills using a very specialized communal hunting technique, the arroyo trap. Besides its use by groups of people of varying size with various skill levels, the success of the hunt was predicated on the availability of bison and the presence of suitable canyons. For this sort of hunting manifestation to occur, an episode of canyon cutting had to be underway or to have previously taken place (Green 2002:87-125).

In 1992, systematic coring at the L. E. Certain site identified several large paleogullies that contained bison bones (Bement and Buehler 1994). Excavations of trenches A and C determined that the ancient arroyos possessed steep head cuts (nick points) and side walls. The heads of both gullies were packed with the butchered remains of bison. The bison were maneuvered into an arroyo bottom and toward an appropriate spot where hunters were stationed for the kill (Buehler 1997:139-140; Frison 1991:156, 166, 188, 195). Arroyo head cuts formed a natural barrier that impeded escape, as did steep side

walls. Once maneuvered upstream to the arroyo head, the animals were vulnerable and confused. Quite obviously this would require more than two hunters, active cooperation, and adherence to a preconceived plan (Driver 1990:12). Stratigraphic and spatial evidence at the site indicates that this form of social activity and animal manipulation was very successful and depended upon the efficient use of landscape and animals.

Test #2b: L. E. Certain Faunal Remains

The Expectations

Broad climatic trends are presumed to be responsible for the presence or absence of bison on the southern Plains (Dillehay 1977). On and around the Dempsey Divide, Thurmond and Wyckoff (2000, Table 2) have documented a patterned rainfall cycle (wet-to-dry). Intensive radiocarbon dating of buried soils that formed during the last two millennia indicates a vacillation between wet and dry periods every 400 years or so during the Late Holocene. Five pluvials have been defined on the basis of this soil study, but only the first two apply to the Late Archaic people's presence. The first pluvial or wet period began about BC 50 and lasted until AD 100. Another fluvial began in AD 400 and lasted until AD 600 (Thurmond and Wyckoff 2000, Table 2). On the northern Plains similar environmental recoveries are theorized to be correlated with an increase in bison populations (e.g. Vore Model) (Reher 1977a:22, 24, 29-32, 1977b).

Given these data and their combined implications, if the Late Archaic occupants of the southern Plains were striving for optimal interaction with their environment, then they were likely exploiting bison. As hypothesized in Chapter Two, if people were venturing out from a semi-permanent encampment to pursue bison, and they meant to return to the camp with food, then butchering strategies at the kill site would reflect techniques amenable to transport. These butchering strategies would vary slightly depending on the number of hunters available and the hunting group's composition and skill level. The strategy for preparing the meat packages may also lie in the group's immediate needs. While at the kill site, there should also be evidence of support facilities associated with

provisioning butchering teams. These support facilities would also reflect patterned group behavior based in the execution of a predetermined plan.

The Evidence

L. E. Certain, Area A—Kill

Area A excavations revealed a strategy of less than total dismemberment of at least 23 cows and juvenile bison killed in late autumn or early winter. In general, the animals were oriented parallel or perpendicular to the long-axis of the gully trap and only parts of the carcasses were exploited (Bement and Buehler 1994:175). Such placement and technique represents group organization by those processing the dispatched animals (Buehler 1997:138). Following a predetermined plan increased net energy capture by the group. As noted in Chapter Five, only the top portion of the animals was taken presumably as an optimizing strategy. This can be considered optimal behavior since no energy was expended to flip the animals over and further harvest the meat. In essence, a pattern of least resistance in butchering the animals was practiced. Other butchering strategies observed at Area A include removal of the hides, signaled by an absence of caudal vertebrae, and retrieval of the brain and extraction of the tongue, signaled by numerous shattered crania (Bement and Buehler 1994:177-178; Buehler 1997:137-138). Once the limbs, crania, and ribs were removed or accessed, the filleted appendages were discarded, the crania were abandoned, and rib cages sectioned, all in preparation for transport.

An estimate of the human group size and the human group composition responsible for the killing and butchering of the 23 animals in Trench A might provide clues why only parts of the animals were removed. For example, the number of hunters might have a direct correlation to the number of bison killed. Granted the postulate that one animal represents one hunter, then 23 hunters were responsible for the Trench A kill and butchering episode. Based on figures formulated by Wheat (1972:122) and discussed in Chapter Six, about 2,478 kg of bison meat was potentially harvested from the 23 animals.

Wheat (1972:122) also predicted that the average hunter and family (e.g. spouse and dependents) could eat 4.54 kg of meat daily. If 23 hunters would consume 104.4 kg of meat daily, and 2,478 kg was available for distribution, then each of the 23 nuclear families would be provisioned for approximately 24 days.

Now that the numbers of hunters/families potentially present and the amount of meat available for distribution is known, the method a butchering can be discussed. Two scenarios are proposed. The first scenario addresses the skill level of a nuclear family. By and large, the family unit was probably geared toward generalized tasks as part of a daily provisioning routine. Proof of these generalized skills is reflected in the treatment of the carcasses. In Trench A each carcass was treated as an individual unit of meat and probably handled by one family. This is in direct opposition to carcass treatment in Trench C where the bison were thoroughly disarticulated by teams of hunters/butchers. The second scenario, which builds upon the first, considers the immediate needs of the nuclear family. For example, the patterns observed at Trench A might reflect an episode of hide hunting rather than stockpiling meat. Once the herd was dispatched select cuts of meat were efficiently removed along with the requisite hides. These gourmet cuts, including filleted limbs, racks of ribs, brains, and tongues, were simply a bonus to acquiring hides. No matter the reason the animals were killed or why they were only partially butchered, it still remains that 23 bison from a cow-calf herd were decoyed, chased, maneuvered, dispatched, and prepared for transport in late autumn to early winter by a relatively small kinship group.

L. E. Certain, Area C—Kills

Despite less than complete excavation of the Area C bone beds and the loss of much of the bison kill to modern erosion, butchering techniques employed there are still quite evident. The harvesting strategy employed at Area C was total dismemberment of at least 43 bison. As noted in Chapter Six, 39 bison from a late autumn or early winter cow-calf herd were killed at Area C while another 4 mandibles, found in the upper end of the

canyon and thus the upper end of the bone bed, represent a spring kill of two cow-calf pairs. Nevertheless, based on the bones and stones surrounding the four spring specimens, the animals were butchered just as thoroughly as the autumn-winter killed animals. Such evidence demonstrates the flexibility of the Late Archaic social system. This system bestowed group members of this social organization with the ability to switch between family or band-style hunting of bison and periodic communal group hunting with economically similar familial units.

Returning to evidence that the larger autumn-winter kill was processed using butchering posts, several stations were identified in the bone bed even though the killing floor was only partially exposed. One station involved the harvesting of cranial elements. For example, one station was identified by a collection of skulls found in piles but rarely intact. Moreover, the hyoids were often fractured. Quartzite cobbles found amongst the bones were probably collected nearby and used to gain access to the brain case. In many instances, mandibles were detached from the crania both by knife and chopping. This demonstrates that the tongues and brains were intentionally extracted. Clearly this allowed for the harvest of the preferred cranial items without transporting the entire skull back to camp. Similarly, piles of pelves and articulated leg segments were found in heaps on the killing floor, thus representing another butchering station. As with the skulls, the useable materials were removed and the unused parts discarded. These strategies maximized the use of available labor by concentrating efforts on specific body parts, with concentrated energy stores or other appealing characteristics, in preparation for transport.

Given the above, it is argued that the hunters at Trench C established fixed positions in and around the canyon where select cuts of meat, organs, and hides were removed in a predetermined orderly fashion. Working as a team, toward a common goal, reduced the amount of time required to dismember and process a single carcass by a single hunter. Moreover, efficiency is indicated since select hunters repeatedly performed the same cutting motion rather than changing cutting strategies and motions with each anatomical

part. In effect, the animals were treated in an assembly-line manner.

To illustrate the point that Trench C represents a communal event, the amount of meat produced will be used to determine how many people could be served, rather than start with a human population estimate as done with Trench A. From there, estimating the group size and composition will provide clues to the total-disarticulation butchering strategy. It was established in Chapter Six that 43 bison are represented in the upper bone bed at Trench C. Four of these 39 animals represent a spring kill event; nevertheless a population of 43 bison is used for consistency in the analysis. It was also established in Chapter Six that only one-quarter of the bison kill has been exposed in Trench C. Given this, the Area C paleogully contains no less than 172 bison. It was further established in Chapter Six that approximately 35,800 kg of useable meat ($8,950 \text{ kg} \times 4$) would have been produced by the 172 animals.

Making 35,800 kg of meat divisible by 172 hunters with a daily ration of 781 kg ($4.54 \text{ kg} \times 172$) produces a meat surplus for approximately 45 days. Thus, the meat produced from Trench C could provision one family unit for six weeks. Such preplanning and execution of the strategy is obviously an efficient adaptation by a group of hunter-gatherers to the natural habits of a bison herd and their propensity to be easily driven. Once mobilized, the herd could be directed to a specific location with the particular topographical features to almost insure a successful kill.

Accepting that Trench C is a much larger kill than Trench A, and accepting that 172 hunters gathered at Trench C, then surely the human congregation must represent a special event. Of course there is always the chance that a well-positioned, well-timed attack by a nuclear family on an immense herd might account for the enormous numbers of animals killed in Area C. Putting this possibility aside, and acknowledging that most of the animals were killed in late autumn to early winter, the kill at Trench C probably

represents the gathering of multiple bands, at a predetermined time and location for the purpose of provisioning a group with meat for winter (e.g. Annual Model).

L. E. Certain, Area C—Support Facility

Shifting emphasis to the support facilities established at L. E. Certain, excavations of the uppermost cultural layer at Area C revealed the remains of one brief camping event. This support facility was established in the paleogully sometime after the underlying kills were covered with sediment. The Area C camp consisted of two hearths, one sandstone slab, and two broken projectile points. One hearth was associated with a sandstone slab which could be easily collected onsite. A charcoal-stained patch of earth represented the other hearth. Consequently, this hearth penetrated the underlying bone bed. In addition to the hearths and sandstone slab, two corner-notched dart point fragments were recovered from the encampment. Both points exhibited impact fractures on the tips and bases consistent with impacting hard objects. The broken projectile points and shafts were retrieved from the killing floor for future use. Once retrieved, the point fragments were removed and discarded as a precursor to making repairs (Bement 2002:136-137; Keeley 1982). Both acts reveal prudent use of downtime to prepare for future hunts.

L. E. Certain, Area B—Support Facilities

Area B contained the remains of two stratigraphically separated camping events perched on the slope of a now-filled paleogully. As with Area C, the Area B cultural materials reveal the use of the canyons for temporary camps just as they used them to trap and kill the bison.

The uppermost feature consisted of a shallow pit associated with the select remains of at least two bison, beyond adolescence and of indeterminate sex. Thirty-six bones or bone fragments were recovered. Identified elements include humeri, scapulae, teeth, ribs, and a vertebra. The humeri and scapulae indicate that a segment of articulated leg was transported to the camp for further processing. Breakage patterns indicate that after these

elements were stripped of meat the marrow was extracted. The presence of ribs reveals that a section of ribcage was carted to the site, probably with a vertebra as a rider. Poor bone preservation prevented the detection of any cut marks on the bones. The presence of the teeth cannot be accounted for at this time. None of the bones were burned except for a single calcined bone in the pit, thus indicating that some bone was incinerated. The pit also contained burned sandstone fragments, the significance of which is unknown. Nevertheless, it is obvious that the feature was used as a roasting or cooking pit for impromptu meals, and then later served as a trash receptacle (Bement 1992:2). Other than the burned sandstone fragments, no other lithic materials were recovered from the feature.

A second hearth from Area B, approximately 1 m below the first, was discovered eroding from the modern canyon wall. No other cultural materials were associated with the feature such as lithics or butchered fauna. Despite the paucity of data available for interpretation, it is probable that the location was used in a similar manner as the upper feature and thus supports the contention that the temporary camp served as a support facility for kills occurring elsewhere at the site.

L. E. Certain, Area D—Support Facility

The most notable aspect of the Area D excavations was the recovery of an articulated forelimb, five articulated thoracic vertebrae, the distal portion of a hind limb, and a “rack” of ribs. The articulated limb segment includes the scapula, humerus, radius-ulna, and the accessory, ulnar, intermediate, fourth, and fifth carpals. The humerus displays a spiral fracture on the distal end while the shaft of the element was pulverized. Two larger humerus fragments were recovered while multiple others exhibited exposure to fire. The ulna was detached from the radius at death evidenced by a linear crack along the shaft of the corresponding radius. As previously noted, a segment of vertebrae corresponding to the hump section of a bison was also recovered as was an additional vertebra displaced from the others by several centimeters. The articulated vertebrae were associated with the

complementary ribs. Most of the ribs were burned. In addition to the above, a calcaneus, a proximal-lateral sesamoid, and a first and second phalanx were recovered. Finally, the left ulna from a Plains pocket gopher was recovered and tentatively assumed to be an intrusive element.

Based on the data recovered from Area D, the locality clearly served as a support facility for a nearby kill. The right side of a young bull was transported to the locality, possibly using a hide satchel with rear foot and ankle serving as a handle. Once at Area D, secondary processing of the meat and bones transpired and the byproducts were cooked over a fire. The entire forequarter of the bull was stripped of available meat and the remaining bones were tossed aside as an articulated unit. However, not before the humerus was smashed and the marrow removed. The radius and ulna were likely separated to collect sinew. In addition, the tenderloin from the hump was filleted and the associated ribs roasted. The Area D residues suggest efficiency by employing the many canyons for temporary camps while preparing nearby kills for transport. Moreover, the act of harvesting all useable components of the appendage reveal that little went to waste.

L. E. Certain, Area E—Support Facility

Area E contained both articulated and disarticulated bison remains. Included were an articulated left hind limb, the unarticulated remains from a right and left fore and hind limb, a few ribs, and caudal vertebrae. The rear leg segment included the left femur, tibia, patella, metatarsal, sesamoid, calcaneus, astragalus, and three cannon bones. A right femur, a right patella, the right proximal and medial tarsals, and three distal phalanges were also recovered. A left radius, four ribs, and three caudal vertebrae were also found scattered amongst the articulated leg segment. A bison tibia fragment displaying a spiral fracture was also recovered.

Based on the data recovered from Area E, the spot clearly served as a support facility for a kill that occurred nearby. At the least, two animals are represented. Without a doubt, the

right and left sides of a five-year-old cow were transported to the locality using the hide as a carrying apparatus as indicated by the caudal vertebrae. Gender and age characteristics of other bones were indeterminate. Once at Area E, secondary processing of the meat transpired. There is no evidence of cooking, as represented by a hearth or burned bone. This cannot be explained at present other than a hearth may have been lost to erosion. The leg segments of the cow were stripped of meat and other useable products while the marrow was harvested from one long bone before the support facility was abandoned. The Area E cultural residue corroborates the suggestion that the group was predisposed to efficient behavior. Proof lies in the group's application of adjacent canyons for temporary camps while preparing their nearby kill for transport. Moreover, the act of harvesting all useable components of the animals divulges that no useable materials were squandered.

In closing, this section presents each activity area identified at the Certain site. Excavation of the kills revealed special preparation of the carcasses for transport. Meat was stripped from the bone and brains and tongues were removed from skulls. Two different patterns of butchering were employed by the hunters, total segmentation and partial dismemberment. Both methods served the collective interest of the group by maximizing the available workforce. Excavations elsewhere at the site revealed the presence of non-kill localities which served the hunters as temporary camping spots. Evidence of impromptu meals, signs of toolkit maintenance, and indications of onsite resource acquisition were uncovered.

Test #2c: L. E. Certain Floral Remains

The Expectations

At a game kill where a target species was sought, evidence for floral remains should be limited. Evidence for the use of non-animal products at a kill or processing locality, primarily as an additive to meat, is not unusual (Quigg 1997c; Quigg and Peck 1995). Unfortunately, poor preservation properties of the soil coupled with bioturbation and

erosion at the L. E. Certain site has limited the data available for analysis.

The Evidence

As noted in the previous sections and in Chapter Five, several hearths were used at the support facilities dubbed areas B, C, D, and possibly E. However, no carbonized wood large enough to identify species was recovered. Fortunately, three intact hackberry (*Celtis occidentalis*) pits were recovered from Area D despite the preservation problems previously noted (refer to Table 5.3). The pits themselves have a sweet date-like flavor and can be consumed whole or as a meal when pounded (Peterson 1977:194). The fruit or drupe, which surrounds a single pit, is sweet when ripe in early autumn (September-October) (Little 2002:93-94; McCoy 1980:66-67). Other than these, there is no direct evidence that the hunter-gatherers harvested or incorporated any plant materials into their diet while they occupied the kill localities or the support facilities.

Although direct evidence for the use of edible plants at the L. E. Certain site is patchy, charred walnut hulls dating to 1880 $\pm$ 40 BP (Beta 141245) were recovered from a hearth (34BK211) less than 1.5 km north of the L. E. Certain site in another arm of the same canyon (Bement and Buehler 2000b:13-14). To a degree, this site could be considered an extension of the L. E. Certain site since bison bones were recovered from the site. The uncorrected date from the charred walnut sample places utilization of the site at the same time the game kills were transpiring. Given this, it is very likely that walnut use complemented the use of hackberries by the hunters while at the kills, although the presence of specialized nutting stones suggests use by a separate logistical group.

Test #2d: L. E. Certain Lithic Remains

The Expectations

Tool production debris, tool maintenance detritus, and discarded and lost tools recovered from a game kill could easily be used to determine the technological organization of a given group, and thus bolster the contention that Late Archaic groups were central-place

foragers. The absence of certain tool classes, especially those required to process large game animals, would suggest that the subject tool was deliberately retrieved. The presence of maintenance debris only from such a tool would further support this contention. Conversely, the absence of tool production debris for another tool class used to kill animals would indicate that the tools were brought to the site ready to use. The raw materials employed for the production of certain tool classes might also be used to determine the technological organization of a group. To this end, the lithics from the L. E. Certain site are addressed.

The Evidence

No chipped stone materials were recovered from the support facilities of areas B, D, and E at the L. E. Certain site. However, lithics were recovered from the other kill and support localities.

L. E. Certain, Area A

Three dart points were recovered from Area A, with one being lodged in a thoracic vertebra (Bement and Buehler 1994:181). All three of the points were made of Potter chert, a tightly cemented quartzite. No signs of point production debris were located within the bone bed or at any of the identified support facilities. Thus, it can be concluded that the hunters prepared their weapons elsewhere and arrived at the kill with points at the ready. Besides the projectiles, 16 flakes were recovered from the Area A bone bed. Eleven of the flakes recovered from Trench A were Alibates silicified dolomite (69%) and five were Ogallala Formation quartzites (31%). The ridge orientation on the flake platforms, the relatively equal length and width of the specimens, the slight concavity of the ventral surfaces, and the tapering terminations clearly indicate the flakes are biface maintenance debris (Bordes 1961:6; Semenov 1976:55-62). Interestingly, no knives were recovered from the killing floor. Since biface knives are usually part of the bison hunting toolkits from all periods (Agenbroad 1989:80-81; Bradley 1991; Brooks and Flynn 1988:473-475; Frison 1973:60-61; Hemmings 1987:437-439; Huckell 1989:172-173;

Quigg 1997a:66-72; Speth and Parry 1980:170-171), the knives from Area A were likely desirable and curated. Clearly this indicates conservative, and thus efficient, use of the raw materials used to produce knives. Besides the resharpening flakes, one rather large and thick Ogallala quartzite tertiary flake was recovered within the bone bed. The flake exhibited polish on the distal and lateral edges as a result of being used to scrape a malleable yet tenacious product like a green hide. It is not known if this tool was produced onsite, but the use of a durable material like quartzite to work on a hide probably demonstrates a preference for one material over another for this task. Finally, three battering cobbles or hammerstones of Ogallala formation quartzite were recovered in the bone bed. In all likelihood the cobbles were used to fracture particular bones at the site, namely the crania. Using readily available materials from the kill site demonstrates an efficient use of time and energy. In effect, the hunters limited the number of tools transported to a site to achieve a predetermined goal.

L. E. Certain, Area C

No point production debris was recovered from Area C. In fact, no early stage reduction debris was recovered despite raw material being onsite, however limited in preferred quality. Over 300 biface resharpening flakes were recovered from the bone bed but no bifaces were recovered. From this, it can be concluded that the hunter-gatherers' technological organization included transportable tools that were curated. Transportability and curation is a strategy employed to insure that the appropriate tools are available when required and thus maintain efficient use of time and energy.

In all, 10 projectile points or point fragments were recovered from the Trench C kills. A possible eleventh point, represented by a very small portion of a notch, was recovered from the screen. The fragment measuring 10 x 11 mm may refit with one of the recovered point fragments, however this conclusion is tentative. Therefore the specimen is not included in the official point count. Eight of the 10 points bear evidence of heavy impact breakage. This and their provenience leave little doubt that they were used to kill the

animals. Nine of the points were quartzite and one was manufactured from an unidentified piece of translucent chert. Although not damaged, the two complete points had been resharpened, one rather extensively. The remaining eight points were extensively reworked, some more than others. Based on the shape and flaking patterns on some of the points, it is evident that previously damaged specimens were salvaged and rejuvenated. The reworking of broken points indicates that the makers intentionally rescued the projectiles. For the most part, the points were scattered about the excavation units and unassociated with any specific activity areas. However, one point was found with a pile of burned bones and a broken femur, while another was found next to a thoracic vertebra suggesting it was stuck in the fleshy hump.

The majority of the lithic material collected from Trench C was classified as biface resharpening flakes. This is a trend consistently noted at bison kill sites throughout the Plains (Fawcett 1985). In all, 301 specimens were collected. The resharpening flakes served one purpose: to rejuvenate the edges of dulled biface knives. The retouch flakes remained where they were removed and thus were widely scattered about the bone beds. Therefore, retouch occurred within the context of ongoing butchering. The flakes were produced by the soft hammer technique or pressure flaking, with the platforms (biface edges) on occasion being roughened to facilitate their removal. In other instances the billet crushed the platforms during fracture initialization while others displayed polish as a result of cutting activities. The flakes were equally divided between Alibates silicified dolomite and Potter chert (siliceous quartzite).

In addition to the biface retouch flakes and the points, two utilized flakes were also recovered from the bone bed, one was Ogallala Formation quartzite and the other Alibates silicified dolomite. These tools exhibit use-generated flake scars, abrasions, and polish on their distal and lateral edges. The quartzite tool was not associated with any conceivable activity area whereas the Alibates silicified dolomite tool was associated with an articulated vertebral column. The flake tools were removed from bifaces based on

the character of the striking platforms. In other words the edge of the objective piece from which the flake was removed was not finely chipped as with a point. Rather, the biface edge possessed large flake scars. Additionally, the flake scars on the dorsal surface of the flake tools only had two or three flakes removed prior to the tool being detached. The limited presence of flake tools is curious; however, they solved a specific problem at the time of butchering. Once the task was completed, the tool was discarded.

Based on the above data, it is evident that contemporaneous groups set out from camp with tools in-hand ready for a kill and butchering event. They brought with them specialized tools manufactured from high quality material. After the successful kill, the hunters proceeded to butcher the animals and prepare the carcasses for transport. When they were finished, the knives were retrieved as indicated by the absence of butchering tools in the bone bed. For those points lost or discarded at the kill, the amount of reworking on the points demonstrates that the projectiles were usually retrieved when salvageable. The retrieval of both knives and points, manufactured from high quality material, for later use reveals that the group employed a cost-effective strategy in material use within an area where very siliceous, finely cemented quartzites are far outnumbered by the poorly cemented, isotropic materials which they accompany. In other instances where Alibates silicified dolomite can be had by group(s) but probably only once within a seasonal round.

Test #2: Implications

Test #2 addresses hunter-gatherer utilization of special activity sites. These sites were used to procure target resources, both animate and inanimate, which were later returned to the base camp. If southern Plains Late Archaic hunter-gatherers were seeking equilibrium with their environment, as central-place foragers, then the special camps would be (a) located at or associated with specific environmental settings, (b) fauna would represent a temporarily aggregated species, (c) flora would represent temporarily available species, and (d) lithics would correspond to the requisite tools necessary to

exploit the target resource.

Test #2a states that the presence of briefly occupied special activity camps will be located at or associated with specific environmental settings. For example, lithic resources are acquired at quarry locations while floral materials are collected in patches, plots, and groves. In regard to the L. E. Certain site, the resource exploited was bison and the associated environmental setting was steep-walled canyons. The availability of bison during the Late Archaic has been established as has the patterned fluctuation in climate during the Late Holocene which formed the canyons (Buehler 1997:142-143; Thurmond and Wyckoff 2000). Although canyons are a premier aspect of this equation, one other landscape feature plays a vital role in this argument, uplands. The Dempsey Divide is clearly such a place. This vast upland between the Washita and North Fork of the Red rivers is exactly the luxuriant setting that could support grasslands and large herds of bison. Bison herds found grazing on the uplands or watering in the canyons at springs were driven into steep-walled gullies elsewhere in the drainage system. Once at the head of the canyon, they were killed with ease. Not only were the canyons used to trap and kill the animals but they were also used as provisioning stations or support facilities. It is here that select cuts of meat from the primary processing area were transported for impromptu meals. Rather than expending large amounts of energy to build a structure to corral and kill bison, these southern Plains Late Archaic hunters used the canyons as a cost-effective strategy to secure meat resources and even avoid personal injury (Frison 1971; Green 2002).

As stated in Test #2b, central-place foragers are expected to briefly occupy special activity camps associated with a temporarily aggregated resource. If true, then evidence to that effect would be found. The L. E. Certain site clearly demonstrates that this supposition is accurate. Just as the Late Archaic hunters used the canyons as a cost-effective strategy to acquiring resources, they also used the bison which roamed the grasslands. It goes without saying that bison are herd animals. The propensity for bison to

congregate made them a prime target for hunters operating to maximize efficiency. If not already congregating, bison could be driven into the canyons to bring small groups together. Either way, true success in capturing this aggregated resource was dependent on having the appropriate number of people to participate in the hunt. The group size foraging theorem addresses this issue. The theorem predicts that seeking supplies as groups would be advantageous over foraging on an individual basis. By acting in concert, the group bettered its chances of success (Foley 1985; Horn 1968). The sheer number and size of the bison kills documented at the L. E. Certain site indicates that bison were being amassed in the canyons of the Dempsey Divide before being dispatched.

The butchering strategies displayed at the kill site reflect a tendency to dismember the animals in a manner amenable to transport, but in different manners. Trench A displays evidence of filleting limbs, sectioning rib cages, removing the brain and tongue, and removing the hides. This is reminiscent a gourmet butchering strategy where select cuts were removed while other meat-producing elements were disregarded. Chapters Five and Six detailed the attributes of the Trench C butchering strategy. It was characterized by total disarticulation and stacking of processed skeletal elements. Trench C reveals that forelimbs and hind limbs were filleted also, however in Trench C the pelvic girdles were still attached to the hind limbs in some instances. Trench C also showed evidence of rib cage removal, brains and tongues harvesting, and most likely hide removal as observed in Trench A. Without a doubt, the L. E. Certain site served as a special activity locus where a temporarily aggregated resource was encountered and prepared for transport back to a base camp. However, the Trench A and Trench C kills occurred during the same season, had the same herd structure, and occurred in same geographic location. So, how can the treatment of the carcasses in Trench A reflect organized efficient use of energy (manpower) and time (man-hours) while total dismemberment in Trench C is also considered efficient use of energy and time? Furthermore, what factors cause one strategy to be used over another? The answer to both lies in group membership and group needs.

Based on observations made early in the discussion, Trench A probably represents a single bison hunting event carried out by approximately 20 related individuals with close kinship ties. The animals were handled as individual units, with special items being removed with little fanfare for other products. The meat and hides provided for this single event would supply the kin group with enough meat for a minimum of 24 days and several new hides. As noted earlier, Trench C displays the hallmarks of multiple groups participating in an event where a predetermined plan for capturing and butchering large groups of bison was executed. Most animals were totally disarticulated at butchering posts with the expertise of skilled laborers. The meat and hides provided from this single communal event would supply each participant and their dependents (N=172) with enough meat for a minimum of 45 days. In both cases, the butchering strategies at Trench A and Trench C reflect preparation of the meat and byproducts for transport elsewhere.

One final note on the seasonal strategies for hunting bison is necessary. It was already established that the bison kill at Trench A represented the work of an extended family's autumn-winter attack on a herd of bison. It was also established that the upper bone bed at Trench C represents a autumn-winter communal hunting episode where upwards to 172 hunters and their families gathered to ambush, butcher, and distribute kilotons of bison meat and byproducts. The final strategy of bison killing and butchering observed at the L. E. Certain site is based on the four animals found on the edges of the Area C paleogully. These animals were killed in early spring. Based on the above, a third hunting and transporting strategy was used by bison hunters. In spring, small flexible groups of bison could be ambushed, especially near water. Four extensively butchered spring bison would easily provision a handful of related family members for a few days if not a few weeks. This would provision the group until other edible items became available in sufficient quantities to support a collection of socially related groups for an extended period of time. Such might be expected if Late Archaic groups were dispersing during the lean parts of the year and gathering during times of floral and faunal abundance. This strategy was used as an alternate to the autumn-winter events where large herds of bison

were driven and killed for both large and small social gatherings. Small bison kills like the one observed on the edges of Trench C are also documented in the Archaic record at Lubbock Lake (Johnson and Holliday 1986). In any event, the flexibility of the social group is demonstrated at the three kills documented in trenches A and C. Based on the recovery of butchered bison remains from all three kills, it is apparent that all three killing and butchering strategies were successful, which validates the contention that Late Archaic groups were acting in concert with their environment in an efficient and successful manner.

Test #2c predicts that plants recovered from a special activity site would represent temporarily available species. As noted in Chapter Three, a variety of resources were available on the southern Plains for food or other provisions. However, the focus here is on the bison kills that comprise the L. E. Certain site and the only evidence that floral resources were used there lies in three hackberry pits recovered from one of the support facilities. Evidence for use of floral remains at a kill locality is not unprecedented (Quigg 1997c; Quigg and Peck 1995). Although the L. E. Certain site floral evidence can be considered suspect, it is worth noting that hackberry drupes ripen at the same time of the year the majority of the kills occurred at the L. E. Certain site, late-autumn. Thus, hackberry trees produce a product that is only available at particular times of the year. Furthermore, since one hackberry tree can produce numerous fruits, the resource is by definition a temporarily available, aggregated resource. Other than the hackberry pits, no direct evidence exists that the hunter-gatherers harvested or incorporated any plant materials into their meals while they occupied the kill localities or the support facilities. However if 34BK211, approximately 1.5 km downstream, might be considered an extension of the L. E. Certain site, then it is very likely that walnut use complemented the utilization of hackberries by the hunters while at the kills (Bement and Buehler 2000a, 2000b:20-21). Furthermore, walnuts ripen and detach from the tree during autumn-fall for the bison kills. However, 34BK211 was probably occupied at a time other than autumn, the same time the kills took place.

Test #2d states that the lithic resources from a special activity site used by central-place foragers should consist of tools essential to efficiently procure a target resource. The raw materials employed for the production of certain tool classes could also be used to determine the technological organization of a group. It has already been established that L. E. Certain is a bison kill and processing site. So, the lithic remains should be consistent with killing and processing bison. Lithic remains collected and examined from the L. E. Certain site included projectile points and point fragments, biface resharpening flakes, utilized flakes, hammerstones, and rock slab. Points and point fragments, debitage, utilized flakes, and hammerstones were collected from the kills while point fragments and the anvil stone/grinding slab were collected from one of the support facilities. These tools can be placed into two basic groups, specialized tools and generalized tools. Commonly, the specialized tools were brought to the site ready for use while the generalized tools were collected or made onsite as they were needed. The fact that the projectile points and point fragments recovered from the kill and support facilities were manufactured from high quality lithic materials supports the contention that specific raw materials were used for explicit tasks. The reworking of many of the points also indicates that the artifacts were used previously and recovered for later use. The resharpening flakes recovered from the kills indicate that knives of high quality stone were used on the killing floor, presumably for butchering the bison. The absence of knives themselves at the site supports the notion that they were recovered for later use, as was the case with the projectile points. Another tool associated with this special activity site was utilized flakes. These expedient tools were struck from a biface core or early-stage butchering knife, used for cutting and then discarded. The hammerstones found in the bone bed were obtained onsite and used to fracture specific bones, namely the crania. Finally, a sandstone anvil/grinding slab was recovered from the Area C support facility. Such materials were readily available at the site and surely were not part of their portable toolkit of points and knives. Using readily available stone materials for impromptu tasks demonstrates an efficient use of time and energy. Moreover, the transport of specialized tools manufactured from uncommon materials represents an investment of time and

energy before the kill took place. Additionally, the retrieval and reuse of the points and knives demonstrates that the hunters intended to protect their investment in tool production costs associated with Ogallala Formation quartzite-use for projectile point production.

Assessment of the Model

This chapter examined the L. E Certain and Beaver Dam sites from the perspective of the central-place foraging model, and to a lesser extent the foraging group size theorem, to determine if the Late Archaic hunter-gatherers of the southern Plains were indeed concerned with maintaining equilibrium with their environment. Central-place foraging occurs when a group ventures out from a central location or village to acquire resources. These specific resources are collected by specially organized task groups and prepared for transport. Evidence on the landscape of these types of settlement and subsistence patterns comes in the form of specific types of archaeological sites, their placement on the landscape, the fauna and flora collected from the sites, and the lithic technology which bettered a group's chances of survival. In addition to these, the presence of human remains and grave offerings would denote familiarity with the area.

So, do the data support the central-place foraging model? Two tests were created to determine if the L. E Certain and Beaver Dam data corroborated the expectations. Test #1 took up the home base aspect of the equation whereas Test #2 addressed the employment of special activity sites. The Beaver Dam information was applied to Test #1 and the L. E. Certain findings were applied to Test #2.

From this analyses it was determined that southern Plains Late Archaic hunter-gatherers were central-place foragers using the Beaver Dam site as a semi-permanent base camps logistically located on the landscape. The fauna from the site represented small- and medium-sized animals from multiple communities in close proximity to the camp and the

flora represented multiple species near the camp. The lithic remains from the base camp represented production of formal tools from local and semi-local materials with predictable fracture qualities while informal tools were manufactured from readily available material of mediocre quality. Finally, the presence of human remains and grave offerings reveal that the group was familiar with the area. Thus, the data does support the model. However, year-round occupation of the Beaver Dam site is not supported. There is no empirical evidence to support the contention that the Beaver Dam site was utilized during winter.

Regarding the use of special extractive camps, it was determined that the southern Plains Late Archaic hunter-gatherers were indeed briefly occupying such camps. The extractive camp was located in an environmental setting conducive to capturing bison. In this area the bison were temporarily aggregated, and certain floras were momentarily available. The lithics recovered from the kill represented specialized tools manufactured from local and semi-local materials, with predictable fracture mechanics which were used to kill bison. Moreover, butchering knives also manufactured from quality materials were used to dismember the carcass for transport, however none of the features at Beaver Dam were solely associated with point and knife production debitage as expected.

CHAPTER NINE

SUMMARY AND CONCLUSIONS

Introduction

The purpose of this study was to examine the settlement and subsistence strategies of a post-Altithermal hunter-gatherer group on the North American southern Plains.

The central hypothesis of this study was to determine if Late Archaic hunter-gatherers were optimally interacting with their physical environment. If so, they would be adhering to a residence and subsistence strategy consistent with central-place foraging theory. The first aspect of central-place foraging is that a group will venture from a strategically located home base to acquire resources. This home base would be established in an area where multiple resources could be acquired with the minimal amount of effort. The second aspect of the theory states that special task groups would be used to acquire a target resource which is returned to the base. In order to better explain the task group aspect of the equation, the group-size foraging theorem is employed. The theorem states that the task group's success is contingent on the availability of an appropriate number of individuals to share the workload and to insure the goal is achieved. Consequently, each of these site types leaves specific signatures on the landscape. In this study, I use two archaeological sites to determine if the Late Archaic hunter-gatherers were exploiting their environment in a cost-effective manner. The sites are Beaver Dam, an extensive residence camp and L. E. Certain, a repeated-use bison kill.

Setting the Stage

After outlining the direction of this dissertation in Chapter One, I reviewed optimal foraging theory and the advantages it provides for anthropological studies in Chapter Two. The key aspects of optimal-foraging theory were reviewed and their relevance to the problem statement was established. Next, expectations were set and the available

evidence was presented. In the case of the Beaver Dam site, if it served as a hub for central-place foragers then it would be strategically located on an environmental boundary to minimize travel time and physical exertion, fauna would represent small- and medium-sized animals from close proximity to the camp, flora would represent multiple species from close proximity to the camp, lithics would represent production of formal and expedient tools from local and semi-local materials, and the presence of human remains would suggest refuge and sanctuary. In the case of the L. E. Certain site, if it served as a special extraction camp then it would signal a focus on a target resource using the appropriate number of people. As a result, the extractive camp would be located at or associated with specific environmental settings, fauna would represent a temporarily aggregated species, flora would symbolize temporarily available species, and lithics would correspond to the requisite tools for exploiting the target resource and prepare it for transport.

The first step to addressing the problem was to present a comprehensive analysis of the environment, a stage upon which human activities of the past unfolded. This was done in Chapter Three. As it turns out, the L. E. Certain and Beaver Dam sites were occupied at a time when a post-Altithermal recovery was underway. The change in climate led to the establishment of distinctive seasons, each with a patterned precipitation regime. This precipitation influenced spring discharge and manipulated the two major watersheds in the area, the Washita River and North Fork of the Red River. Several micro-niches developed as a result of unique surface geology and topography in the study area. These niches provided distinctive flora and fauna in concentrated areas, making harvest and collection ideal. Fauna associated with the study area include mammals, reptiles, amphibians, avian species, fishes, and mollusks. Based on archaeological remains in the region, there seems to have been a marked increase in the presence of bison during this time. Beside the fauna, a variety of flora such as nut and fruit trees and several wetland roots, and shoots were available. Other useable items such as salt, chert, quartzites, sandstones, mudstone, and shale were also available to the prehistoric hunter-gatherers.

Chapter Four reviewed the cultural history of the Late Archaic and early Woodland cultural stage for the southern Plains and what defines each. With the onset of mesic conditions during the Late Archaic (and early Woodland), there is an increase in human occupancy of the Plains, due in part to a rebound in bison populations. There is also a striking increase in the use of a wider variety of food sources. The success of this broad spectrum foraging adaptation appears to have precipitated an increase in population based on the density of Late Archaic and early Woodland camps and the quantity of material recovered from the sites from this period. Proposed settlement patterns for the Late Archaic and early Woodland involve the use of uplands in autumn, spring, and summer with a change in residence patterns during the winter; the latter being the use of canyons.

Data gathered from investigation at the L. E. Certain site between 1969 and 1999 was the subject of Chapter Five. The primary focus of the chapter was on the analyses of cultural and faunal materials excavated from trenches C, D, and E during the 1993 and 1995 field seasons. The results from excavations of trenches A and B were published previously. These areas represent either primary kill localities or secondary processing areas. Radiocarbon dates from various cultural deposits at the L. E. Certain site were also discussed. These dates reveal that the site was repeatedly used over a 500 year period, roughly between BC 160 to AD 350.

In Chapter Six, Trench C was discussed in greater detail. The results from the Trench C faunal and lithic analysis were used to address bison hunting and processing strategies practiced by the Late Archaic hunter-gatherers. This was first achieved by conducting a detailed analysis of the bones to determine the number of animals present, the age and season of death of the herd, and the sexual composition of the herd. It was determined that at least two bison kills took place. The late-autumn or early-winter kill was a communal event where contemporaneous groups gathered to obtain provisions for winter. The remains of two cow-calf pairs killed in spring represent the second kill. This kill was probably conducted by a dispersed portion of a larger family group. Next, the specific

stone tools found in the bone bed were addressed. It was determined that the hunters used corner-notched dart points made of Potter chert, a tightly cemented and highly siliceous quartzite. The butchering knives were constructed of Alibates silicified dolomite and Potter chert. Finally, distribution and organization of skeletal elements in the bone bed were examined. This was done to decipher group organization, communal activity, nutritional requirements, and transport decisions.

In Chapter Seven the Late Archaic component at the Beaver Dam site was examined. Radiocarbon dates place use of the site from AD 135 to AD 430. Four features convincingly tied to the Late Archaic component were used as the primary unit of analysis. Cultural material from Beaver Dam suggests that the inhabitants were making generalized collecting, hunting, and fishing jaunts in the adjacent stream valleys and uplands. Freshwater mussels as well as small and medium-sized mammals were exploited based on faunal remains. Bison bone was conspicuously limited. Such would be expected if bison were thoroughly processed at the kill site and prepared for transport. Grinding implements, boiling stones, and fire-cracked rocks clearly indicate that floral remains were processed at the site and consumed along with fauna. The presence of multiple hearths with considerable amounts of incinerated debris (charcoal and ash) suggests that extended and repeated camping events transpired at the location. Generalized and task-specific knapping also occurred at the site. Debitage indicates that local and semi-local tool stone was employed, with projectile points being made of highly siliceous materials. Unfortunately, none of the features contained the complete sequence of biface production and reduction practiced by Late Archaic hunter-gatherers and seen at surrounding sites. Nevertheless, portions of their biface production and reduction sequence spread about the Late Archaic component. Besides the abundance of faunal, floral, lithic remains, and fire/cooking pits, the human interment at the site implies that Beaver Dam was a semi-permanent habitation spot where a group member could be laid-to-rest. Such is implied since the individual was intentionally buried and done so with burial furniture.

Evaluating the Model

In Chapter Eight the stated hypothesis was evaluated using optimal-foraging theory. The central hypothesis of this study was to determine if Late Archaic hunter-gatherers were beneficially adjusting with their surroundings through non-genetic behavioral adjustments. A model was developed to determine if the hypothesis was valid. The model relies on central-place foraging theory and the group-size foraging theorem. The data examined in chapters Five, Six, and Seven reveal that the Late Archaic hunter-gatherers of the southern Plains were acting as central-place foragers since they were adhering to a residence and subsistence strategy consistent with the use of a semi-permanent base camp from which special task groups set out to acquire special resources. In order to better explain the task group aspect of the equation, the group-size foraging theorem was employed. The theorem states that the task group's success is contingent on their ability to locate, manipulate, and harvest resources. In the case of bison hunting, cooperative participation and adherence to a preconceived plan was essential. The Beaver Dam habitation site was used to evaluate the model as was the L. E. Certain site, a communal bison kill.

Extending the Model

Can the model described herein be extended into adjacent geographic zones or cultural groups? In Chapter Two it was put forth that cultural behavior is largely a direct result of interaction with the natural environment. Evolutionary ecology holds that certain cultural practices are selected for *de facto* by ecological conditions which in turn concurs a selective advantage upon a group and consequently its survival. If this is true, then by definition the model could only be applied to a region that possesses the same criteria described as necessary for the Late Archaic to have been successful. For example, the subject base camp would need to be situated on an ecotonal boundary, an abundance of both small and large fauna associated with the aforementioned environment would be a

prerequisite, flora from the base camp would have to represent multiple species from close proximity to the camp, lithics would need to represent production of formal and expedient tools from local and semi-local materials, and human remains would need to be present. Moreover the presence of box canyons adjacent to bison-covered grass uplands would need to be available for use. However, if analogs are sought without such stringent criteria, the basic tenant of the model could be applied. That is, human interaction with the environment, especially the acquisition of food and base camp settings. Food-resource attributes such as spatial and temporal distribution, reliability, search and pursuit times, risk minimization, and resource density could be applied to sites and site components from adjacent regions. Criteria for residence patterns are easier to satisfy in adjacent regions. As noted in Chapter Four, sites such as Delaware Canyon, Swift Horse, 34RM507, Lake Creek, Lubbock Lake, Deadman's Shelter, or any of the sites or components in southeast Colorado and northeast New Mexico such as the Dry Cimarron River area or Chaquaqua Plateau would qualify. The availability of bison and canyons could occur in any of the surrounding areas.

Conclusion

I began the study by carefully analyzing the data in terms of anthropological models. Having established the theoretical framework, environmental setting, culture history, and description of materials collected from both sites, the theoretical results of the study were addressed. As it turns out, these inhabitants adopted a logistical residence pattern whereby they used a central base camp as the hub of social activity. This conclusion was arrived at by careful examination of the available data from the Beaver Dam and L. E. Certain sites. Optimal-foraging theory was determined to be the most viable model to explain the patterns recognized at these two sites.

Establishing an unarguable connection between the Beaver Dam site and the L. E. Certain bison kills was based on radiocarbon dates, point forms, tool varieties, lithic

material types, and proximity to each other. Radiometric assays from both sites overlap, as do projectile forms. Expedient tools found in the bone beds of the L. E. Certain site are also found associated with Late Archaic features at Beaver Dam. Moreover, knapping debris from the L. E. Certain site reflects maintenance of bifacial knives such as those interred with the Beaver Dam burial. The usage of local and semi-local materials by inhabitants of both sites also indicates that indigenous peoples were using the sites. Finally, the proximity of the sites to each other, within the vast southern Plains biome, indicates to some extent that the same groups occupied the sites. All in all, the Beaver Dam site provides a glimpse at Late Archaic camp life for southern Plains bison hunters, at least for part of the year. Direct evidence for winter use is lacking, however different datasets and data collection techniques, especially from palynological samples might address this shortcoming with the current Beaver Dam data.

During this examination characteristic patterns of landform, animal, plant, and lithic raw material usage were detected. At the strategically located base camp, the prey population consisted of small- and medium-sized animals, and a variety of seed plants were harvested, all from the vicinity of the camp. Moreover, local and semi-local raw materials were used to make both formal and expedient tools. At the specialized hunting camp, the group acted in concert, using a predetermined plan to chase, maneuver, corral, and kill a herd of bison. Patterns in the bone bed revealed that the animals were butchered in a patterned manner, amenable to transport back to the camp. However, results also indicated that there was more than one way to accomplish effective butchering; small family groups operating as a team killed and gourmet-butchered small groups of bison (~20) while multiple extended families gathered to decoy, drive, and thoroughly butcher large bison herds (~160) for distribution to the participants. As it appears, the number of people involved and the reason for provisioning prompted the use of one pattern over another.

By developing a problem statement and employing scientific inferences through the lens of theory, I contend that the cultural response to environmental constraints by the Late Archaic hunter-gatherers were overcome by adopting a central-place foraging lifestyle that was accentuated by use of task groups of appropriate size to harvest and process both temporarily and spatially aggregated resources. The scientific value of this study lies in the fact that when human groups are faced with ecological constraints, choices are made that ultimately lead to efficient interaction with the environment. The chosen options of the Late Archaic and early Woodland groups proved to be a successful survival strategy and demonstrated the flexibility of the Late Archaic social system. The revival and perpetuation of communal game hunting during the Late Archaic and early Woodland (50 BC-AD 500) signals that their chosen option was successful, until bison once again became infrequent on the southern Plains.

References Cited

Adair, M.

- 1996 Woodland Complexes in the Central Great Plains. In *Archaeology and Paleoecology of the Central Great Plains*, edited by J. Hofman, pp. 101-122. Arkansas Archaeological Survey, Research Series No. 48. Fayetteville, Arkansas.

Agenbroad, L.

- 1989 *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains*. Craxton Printers. Caldwell, Idaho. (Reprint)

Agogino, G., D. Boyd, V. Button, M. Etchieson, B. Ferguson, and S. Ireland

- 1985 *Salvage Excavations of Prehistoric Human Burials at Altus and Foss Reservoirs, Southwestern Oklahoma: 1980-1984*. United States Department of the Interior, Bureau of Reclamation, Southwest Region. Amarillo, Texas.

Ahler, S.

- 1971 *Projectile Point Form and Function at Rogers Shelter. Missouri*. Missouri Archaeological Society, Research Series No. 8. Columbia, Missouri.
- 1979 Functional Analysis of Nonobsidian Chipped Stone Artifacts: Terms, Variables, and Quantification. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 301-328. Academic Press. New York, New York.

Albert, L.

- 1984 Survey of Archaeological Activity in Oklahoma. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 45-63. Academic Press. New York, New York.

Albertson, F., G. Tomanek, and A. Riegel

- 1957 Ecology of Drought Cycles and Grazing Intensity on Grasslands of the Central Great Plains. *Ecological Monographs* 27:27-44.

Albertson, F. and J. Weaver

- 1945 Injury and Death or Recovery of Trees in Prairie Climate. *Ecological Monographs* 15:395-432.
- 1956 *Grasslands of the Great Plains: Their Nature and Use*. Johnsen Publishing Company. Lincoln, Nebraska.

Albritton, C.

- 1966 Stratigraphy of the Domebo Site. In *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains*, edited by F. Leonhardy, pp. 111-113. Museum of the Great

Plains, Contribution No. 1. Lawton, Oklahoma.

Allan, W.

- 1973 Ecology, Techniques, and Settlement Patterns. In *Man, Settlement, and Urbanism*, edited by P. Ucko, R. Tringham, and G. Dimbleby, pp. 211-226. Gerald Duckworth and Company. London, England.

Alvard, M. and D. Nolin

- 2002 Rousseau's Whale Hunt? *Current Anthropology* 43:533-559.

Amick, D.

- 1994 Technological Organization and the Structure of Inference in Lithic Analysis: An Examination of Folsom Hunting Behavior in the American Southwest. In *The Organization of North American Prehistoric Chipped Stone Tool Technologies*, edited by P. Carr, pp. 9-34. International Monographs in Prehistory No. 7. Ann Arbor, Michigan.

- 1995 Patterns of Technological Variation among Folsom and Midland Projectile Points in the American Southwest. *Plains Anthropologist* 40:23-38.

Amick, D. (editor)

- 1999 *Folsom Lithic Technology: Explorations in Structure and Variation*. International Monographs in Prehistory, Archaeological Series No. 12. Ann Arbor, Michigan.

Amick, D., J. Hofman, and R. Rose

- 1989 The Shifting Sands Folsom-Midland Site in Texas. *Current Research in the Pleistocene* 6:1-3.

Anderson, D., G. Thompson, and F. Popovich

- 1977 Tooth, Chin, and Body Size Correlations. *American Journal of Physical Anthropology* 46:7-12.

Anderson, J.

- 1989 Chronological Framework. In *A Chronological Framework of the Fort Carson Piñon Canyon Maneuver Site, Las Animas County, Colorado*, edited by C. Lintz, pp. 491-513. Center for Archaeological Research, Fort Carson Piñon Canyon Cultural Resource Project, Contribution No. 2. Denver, Colorado.

Andrefsky, W.

- 1994 Raw-Material Availability and the Organization of Technology. *American Antiquity* 59:21-34.

Anonymous

- n. d. *The Cross Timbers: Landmark, Barrier, and Ecotone in the Natural and Cultural History of Oklahoma* (pamphlet). Oklahoma Foundation for the Humanities and National Endowment for the Humanities. Oklahoma City, Oklahoma.
- 1993 Radiocarbon Dates for Rm-668. *Oklahoma Archeological Survey Newsletter* 12(3):3-4.
- 2000 *Flood of 1954*. Cheyenne Star, Special Edition. 14 April 2000.
- Antevs, E.
 1952 Arroyo-Cutting and Filling. *Geology* 60:375-385.
 1955 Geologic-Climate Dating in the West. *American Antiquity* 20:317-355.
- Armstrong, D., J. Choate, and J. Knox
 1986 *Distributional Patterns of Mammals in the Plains States*. The Museum of Texas Tech University, Occasional Papers No. 105. Lubbock, Texas.
- Arthur, G.
 1978 A Re-Analysis of the Early Historic Plains Indian Bison Drives. In *Bison Procurement and Utilization: A Symposium*, edited by L. Davis and M. Wilson, pp. 236-242. Memoir 14. Plains Anthropologist 23, Part 2.
- Atwood, W.
 1940 *The Physiographic Provinces of North America*. Ginn and Company. Boston, Massachusetts.
- Bach, D.
 1997 Interpreting the Cultural Significance of Charred and Uncharred Seeds Recovered from Prehistoric Hearths and Living Floors: Theory, Method, and Implications. Unpublished master's thesis, Department of Anthropology, University of Wyoming. Laramie, Wyoming.
- Baggley, G.
 1933 The Survival of the Fittest. *Yellowstone Nature Notes* 10:33-40.
- Bagot, J. and J. Hughes
 1979 *Archaeological Inventory of a Portion of the Caprock Canyons State Historical Park in Briscoe County, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- Bailey, P.
 2000 *The Hammon Flood of 1934*. Cheyenne Star, Special Edition. 14 April 2000.

Baker, R. and K. Waln

- 1985 Quaternary Pollen Records from the Great Plains and Central United States. In *Pollen Records of Late-Quaternary North American Sediments*, edited by V. Bryant and R. Holloway, pp. 191-204. American Association of Stratigraphic Palynologists Foundation. Dallas, Texas.

Baker, W. and T. Campbell

- 1960 Artifacts from Pre-Ceramic Sites in Northeastern and Southern New Mexico. *El Palacio* 67:78-86.

Baker, W., T. Campbell, and G. Evans

- 1957 The Nall Site: Evidence of Early Man in the Oklahoma Panhandle. *Oklahoma Anthropological Society Bulletin* 5:1-20.

Ballenger, J.

- 1999 *Goff Creek: Artifact Collection Strategy and Occupation Prehistory on the Southern High Plains, Texas County, Oklahoma*. Oklahoma Anthropological Society, Memoir No. 8.

Bamforth, D.

- 1985 The Technological Organization of Paleo-Indian Small-Group Bison Hunting on the Llano Estacado. *Plains Anthropologist* 30:243-258.
- 1986 Technological Efficiency and Stone Tool Curation. *American Antiquity* 51:48-50.
- 1997 Historical Documents and Bison Ecology on the Great Plains. *Plains Anthropologist* 32:1-16.

Bandy, P.

- 1977 A Review of Archaic Cultures of the Texas Panhandle. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 12:15-26.

Banifield, A.

- An Irruption in Elk in Riding Mountain Park, Manitoba. *Journal of Wildlife Management* 13:127-134.

Banks, L.

- 1984 Lithic Resources and Quarries. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 65-96. Academic Press. New York, New York.
- 1990 *From Mountain Peaks to Alligator Stomachs: A Review of Lithic Sources in the Trans-Mississippi West, the Southern Plains, and Adjacent Southwest*.

Oklahoma Anthropological Society, Memoir No. 4.

Barr, T.

- 1960 A Standardized Classification for Manos and Mullers in North America. University of Oklahoma, Department of Anthropology. *Papers in Anthropology* 1:20-28.
- 1966 An Archaeological Survey of the Upper Elk Creek Watershed—Washita, Beckham, and Kiowa Counties. Oklahoma River Basin Survey Project, General Survey Report No. 7. Norman, Oklahoma.

Bastian, T.

- 1964 State of Oklahoma Archaeological Site Form: 34CM160. Oklahoma Archeological Survey. Norman, Oklahoma.

Baugh, S.

- 1986 Late Prehistoric Bison Distributions in Oklahoma. In *Current Trends in Southern Plains Archaeology*, edited by T. Baugh, pp. 83-96. Memoir 21, Plains Anthropologist 31, Part 2.

Baugh, T.

- 1982 *Edwards I (34BK2): Southern Plains Adaptations in the Protohistoric Period*. Oklahoma Archeological Survey, Studies in Oklahoma's Past No. 8. Norman, Oklahoma.
- 1984a *Archaeology of the Mixed Grass Prairie, Phase 1: Quartermaster Creek*. Oklahoma Archeological Survey, Archeological Resource Survey Report No. 20. Norman, Oklahoma.
- 1984b Southern Plains Societies and Eastern Frontier Pueblo Exchange during the Protohistoric Period. *New Mexico Archaeological Society Papers* 9:154-167.

Baumgartner, F. and M. Baumgartner

- 1992 *Oklahoma Bird Life*. University of Oklahoma Press. Norman, Oklahoma.

Bear, F., W. Pritchard, and W. Akin

- 1986 *Earth: The Stuff of Life*. University of Oklahoma Press. Norman, Oklahoma.

Beardsley, R.

- 1956 Functional and Evolutionary Implications of Community Patterning. In *Seminars in Archaeology: 1955*. Society of American Archaeology, Memoir No. 11.

Beck, W. and Y. Haase

- 1985 *Historical Atlas of New Mexico*. University of Oklahoma Press. Norman, Oklahoma.
- 1989 *Historical Atlas of the American West*. University of Oklahoma Press. Norman, Oklahoma.
- Beckett, P.
 1976 *Mescalero Sands Archaeological Resource Inventory*. New Mexico State University Report No. 45. Bureau of Land Management. Las Cruces, New Mexico.
- Bedford, J.
 1974 Morphological Variation in Bison Metacarpals and Metatarsals. In *The Casper Site: A Hell Gap Bison Kill on the High Plains*, edited by G. Frison, pp. 199-240. Academic Press. New York, New York.
- Bee, J., G. Glass, R. Hoffmann, and R. Patterson
 1981 *Mammals in Kansas*. University of Kansas, Museum of Natural History, Public Education Series No. 7. Lawrence, Kansas.
- Behrensmeyer, A.
 1975 The Taphonomy and Paleoecology of Plio-Pleistocene Vertebrate Assemblages East of Lake Rudolf, Kenya. *Museum of Comparative Zoology Bulletin* 146:473-578.
 1978 Taphonomic and Ecological Information from Bone Weathering. *Paleobiology* 4:150-162.
- Behrensmeyer, A. and A. Hill (Editors)
 1988 *Fossils in the Making: Vertebrate Taphonomy and Paleoecology*. University of Chicago Press. Chicago, Illinois. (Midway Reprint)
- Behrensmeyer, A., K. Gordon, and G. Yanagi
 1986 Trampling as a Cause of Bone Surface Damage and Pseudo-Cutmarks. *Nature* 319:768-771.
- Bell, R.
 1980 *Oklahoma Indian Artifacts*. University of Oklahoma, Stovall Museum, Contributions No. 1. Norman, Oklahoma.
- Bement, L.
 1985 Spray Foam: A New Bone Encasement Technique. *Journal of Field Archaeology* 12:371-372.

- 1986 *Excavation of the Late Pleistocene Deposits of Bonfire Shelter, Val Verde County, Texas*. Texas Archaeological Survey, Archaeological Series No. 1. Austin, Texas.
- 1992 The Certain Bison Kill Site, Beckham County. *Oklahoma Archeological Survey Newsletter* 12(2):1-2.
- 1994 The Cooper Site: A Stratified Paleoindian Bison Kill in Northwest Oklahoma. *Current Research in the Pleistocene* 11:7-9.
- 1995 The Retooling Index, Seasonality, and the Folsom-Age Cooper Bison Kill. *Current Research in the Pleistocene* 12:61-62.
- 1997a The Cooper Site: A Stratified Folsom Bison Kill in Oklahoma. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 85-100. Memoir 29. Plains Anthropologist 42, Part 1.
- 1997b More Results from the Certain Site, A Late Archaic Bison Kill in Western Oklahoma. *Oklahoma Archeological Survey Newsletter* 17(2):1-2.
- 1997c Recipient of "Faculty Fellowship of the Big 12" Visits Survey. *Oklahoma Archeological Survey Newsletter* 17(2):2-3.
- 1999 *Bison Hunting at Cooper Site: Where Lightning Bolts Drew Thundering Herds*. University of Oklahoma Press. Norman, Oklahoma.
- 2002 Pickin' up the Pieces: Folsom Projectile Point Re-Sharpening Technology. In *Folsom Technology and Lifeways*, edited by J. Clark and M. Collins, pp. 135-140. Lithic Technology, Special Publication No. 4. Tulsa, Oklahoma.
- Bement, L. and K. Buehler
- 1994 Preliminary Results from the Certain Site: A Late Archaic Bison Kill in Western Oklahoma. *Plains Anthropologist* 39:173-183.
- 1998 Confirmation of a Southern Plains Bison Jump. Paper presented at the 56th Annual Plains Anthropological Conference. Bismarck, North Dakota.
- 2000a Bison, Nuts, and the Dempsey Divide. *Oklahoma Archeological Survey Newsletter* 20(1):1-3.
- 2000b *Archaeological Survey of Late Archaic Bison Kill Sites in Beckham County, Oklahoma*. Oklahoma Archeological Survey, Archaeological Resource Survey Report No. 41. Norman, Oklahoma.

- Bement, L., M. Hyman, M. Zolensky, and B. Carter
 1997 A Painted Skull from the Cooper Site: A Folsom Bison Kill in NW Oklahoma. *Current Research in the Pleistocene* 14:6-9.
- Bement, L. and S. Turpin
 1987 Technological Continuity and Functional Change: The Case of the Dorso End Scraper. *Plains Anthropologist* 32:191-196.
- Berger, J. and C. Cunningham
 1994 *Bison: Mating and Conservation in Small Populations*. Columbia University Press. New York, New York.
- Bettinger, R.
 1980 Explanatory/Predictive Models of Hunter-Gatherer Adaptation. In *Advances in Archaeological Method and Theory, Volume 3*, edited by M. Schiffer, pp. 189-255. Academic Press. New York, New York.
- 1987 Archaeological Approaches to Hunter-Gatherers. *Annual Review of Anthropology* 16:121-142.
- Bettinger, R. and R. Malhi
 1997 Central Place Models of Acorn and Mussel Processing. *Journal of Archaeological Science* 24:887-899.
- Bettis, E.
 1992 Soil Morphological Properties and Weathering Zone Characteristics as Age Indicators in Holocene Alluvium in the Upper Midwest. In *Soils in Archaeology: Landscape Evolution and Human Occupation*, edited by V. Holliday, pp. 119-144. Smithsonian Institution Press. Washington, District of Columbia.
- Bicchieri, M. (Editor)
 1972 *Hunters and Gatherers Today: A Socioeconomic Study of Eleven Such Cultures in the Twentieth Century*. Holt, Rinehart, and Winston. New York, New York.
- Binford, L.
 1968 Methodological Considerations of the Use of Ethnographic Data. In *Man the Hunter*, edited by R. Lee and I. DeVore, pp. 263-273. Aldine Press. Chicago, Illinois.
- 1978 *Nunamiut Ethnoarchaeology*. Academic Press. New York, New York.
- 1980 Willow Smoke and Dog's Tails: Hunter-Gatherer Settlement Systems and Archaeological Site Formation Processes. *American Antiquity* 45:4-20.

- 1981 *Bones: Ancient Men and Modern Myths*. Academic Press. New York, New York.
- 1983 *In Pursuit of the Past*. Thames and Hudson. London, England.
- 1984 *Faunal Remains from Klasies River Mouth*. Academic Press. New York, New York.
- Binford, L. and J. Bertram
 1977 Bone Frequencies—An Attritional Processes. In *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, edited by L. Binford, pp. 77-153. Academic Press. New York, New York.
- Black, J. and G. Sievert
 1989 *A Field Guide to Amphibians of Oklahoma*. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma.
- Blair, W.
 1939 Faunal Relationships and Geographic Distribution of Mammals in Oklahoma. *The American Midland Naturalist* 22:85-133.
- 1950 The Biotic Provinces of Texas. *The Texas Journal of Science* 2:97-117.
- Blair, W. and H. Hubbell
 1938 The Biotic Districts of Oklahoma. *The American Midland Naturalist* 20:425-455.
- Blakeslee, D.
 1981 Toward a Cultural Understanding of Human Microevolution on the Great Plains. In *Progress in Skeletal Biology of Plains Populations*, edited by R. Jantz and D. Ubelaker, pp. 93-106. Memoir 17. Plains Anthropologist 42 (159).
- Bleed, P.
 1980 An Objective Test of the Effects of Heat Treatment of Flakable Stone. *American Antiquity* 45:502-507.
- 1986 The Optimal Design of Hunting Weapons: Maintainability or Reliability. *American Antiquity* 51(4):737-747.
- Boas, F.
 1896 The Limitations of the Comparative Method in Anthropology. *Science* (Old Series) 4:901-908.

- Boldurian, A., G. Agogino, P. Shelley, and M. Slaughter
1987 Folsom Biface Manufacture, Retooling, and Site Function at the Mitchell Locality of Blackwater Draw. *Plains Anthropologist* 32:299-311.
- Bolton, H.
1987 *The Hasinai: Southern Caddoans as Seen by the Earliest Europeans*. University of Oklahoma Press. Norman, Oklahoma.
- Bomar, G.
1983 *Texas Weather*. University of Texas Press. Austin, Texas.
- Bonnichsen, R.
1973 Millie's Camp: An Experiment in Archaeology. *World Archaeology* 4:277-291.
- Bonnichsen, R. and R. Will
1990 Cultural Modification of Bone: The Experimental Approach in Faunal Analysis. In *Mammalian Osteology*, by M. Gilbert, pp. 7-14. Missouri Archaeological Society. Columbia, Missouri.
- Boone and Crockett Club
1893 *American Big-Game Hunting*. Forest and Stream Publishing Company. New York, New York.
- Bordes, F.
1961 *Typologie du Paleolithique Ancien et Moyen*. Université de Bordeaux, Publications de L'Institut de Préhistoire, Memoire No. 1. Bordeaux, France.

1971 Physical Evolution and Technological Evolution in Man: A Parallelism. *World Archaeology* 3:1-5.
- Bousman, B.
1993 Hunter-Gatherer Adaptations, Economic Risk, and Tool Design. *Lithic Technology* 18:59-86.
- Bovee, D. and D. Owsley
1994 Evidence of Warfare at the Heerwald Site. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D. Owsley and R. Jantz, pp. 355-362. Smithsonian Institution Press. Washington, District of Columbia.
- Bowers, A.
1950 *Mandan Social and Ceremonial Organization*. University of Chicago Press. Chicago, Illinois.

Boyd, D.

1995a Rethinking the Palo Duro Complex: Jornada Mogollon Influence in the Texas Southern Plains? *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 30:27-50.

1995b The Palo Duro Complex: Redefining the Early Ceramic Period in the Caprock Canyonlands. *Texas Archaeological Society Bulletin* 66:461-518.

1997 *Caprock Canyonlands Archeology: A Synthesis of the Late Prehistory and History of Lake Alan Henry and the Texas Panhandle-Plains, Volumes 1 and 2*. Prewitt and Associates, Reports of Investigations No. 110. Austin, Texas.

Boyd, D., J. Abbott, W. Bryan, C. Garvey, S. Tomka, and R. Fields

1990 *Phase II Investigations at Prehistoric and Rock Art Sites, Justiceburg Reservoir, Garza and Kent Counties, Texas*. Prewitt and Associates, Reports of Investigations No. 71. Austin, Texas.

Boyd, D., J. Peck, S. Tomka, and K. Kibler

1993 *Data Recovery at Justiceburg Reservoir (Lake Alan Henry), Garza and Kent Counties, Texas: Phase III, Season 2*. Prewitt and Associates, Reports of Investigations No. 88. Austin, Texas.

Boyd, D., J. Peck, S. Tomka, K. Kibler, and M. Freeman

1994 *Data Recovery at Lake Alan Henry (Justiceburg Reservoir), Garza and Kent Counties, Texas: Phase III, Season 3*. Prewitt and Associates, Reports of Investigations No. 93. Austin, Texas.

Bradley, B.

1991 Lithic Technology. In *Prehistoric Hunters of the High Plains*, edited by G Frison, pp. 369-395. Academic Press. New York, New York.

Brain, C.

1967 Bone Weathering and the Problem of Bone Pseudo-Tools. *Suid-Afrikaanse Tydskrif vir Wetenskap* 63:97-99.

1981 *The Hunters or the Hunted?* University of Chicago Press. Chicago, Illinois.

Brand, J.

1953 *Cretaceous of the Llano Estacado*. Bureau of Economic Geology, Report of Investigation No. 20. Austin, Texas.

Branson, C. and K. Johnson

1979 Generalized Geologic Map of Oklahoma. In *Geology and Earth Resources of*

Oklahoma, by K. Johnson, C. Branson, N. Curtis, W. Ham, W. Harrison, M. Marcher, and J. Roberts, p. 4. Oklahoma Geological Survey, Educational Publication No. 1. Norman, Oklahoma.

Breitburg, E.

- 1991 Verification and Reliability of NISP and MNI Methods of Quantifying Taxonomic Abundance: A View from Historic Site Zooarchaeology. In *Beamers, Bobwhites, and Blue-Points: Tributes to the Career of Paul W. Parmalee*, edited by J. Purdue, W. Kippel, and B. Styles, pp. 153-162. Illinois State Museum, Scientific Papers No. 23. Springfield, Missouri.

Briscoe, J.

- 1987a *Analysis of Cultural Materials from the Swift Horse Site, An Early Plains Woodland Site on the Black Kettle National Grasslands, Roger Mills County, Oklahoma*. United States Department of Agriculture, Forest Service, Cibola National Forest. Albuquerque, New Mexico.
- 1987b Radiocarbon Dates from the Swift Horse Site, 34RM501, Roger Mills County. *Oklahoma Anthropological Society Newsletter* 35(5):8-9.
- 1989 Chronology and Distribution of the Lake Creek Focus/Complex: Information from the Swift Horse Site. In *In Light of Past Experience: Papers in Honor of Jack T. Hughes*, edited by B. Roper, pp. 105-115. Panhandle Archeological Society, Publication No. 5. Clarendon, Texas.

Briscoe, J. and R. Burkhalter

- 1986 *Preliminary Report on Archaeological and Geomorphical Investigations at the Swift Horse Site, 34RM501, AR-03-03-06-098, Roger Mills County, Oklahoma*. Anadarko Basin Museum of Natural History, Natural History Research Report No. 1. Elk City, Oklahoma.

Broce, G.

- 1973 *History of Anthropology*. Burgess Publishing Company. Minneapolis, Minnesota.

Brockman, C.

- 1968 *Trees of North America: A Field Guide to the Major Native and Introduced Species North of Mexico*. Golden Press. New York, New York.

Brooks, P.

- 1978 Relationship between Body Condition and Age, Growth, Reproduction and Social Status in Impala, and Its Application to Management. *South African Journal of Wildlife Research* 8:151-157.

- Brooks, P., J. Hanks, and J. Ludbrook
1977 Bone Marrow as an Index of Condition in African Ungulates. *South African Journal of Wildlife Research* 7:61-66.
- Brooks, R.
1988 Plant Remains from an Early Plains Village Site (34ML3) in South-Central Oklahoma. *Oklahoma Anthropological Society Bulletin* 37:1-110.

1994 Warfare on the Southern Plains. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D. Owsley and R. Jantz, pp. 317-323. Smithsonian Institution Press. Washington, District of Columbia.
- Brooks, R. and P. Flynn
1988 34TX71: A Late Prehistoric Bison Processing Station in the Oklahoma Panhandle. *Plains Anthropologist* 33:467-487.
- Brosowske, S.
1997 Identifying Relative Levels of Mobility for Selected Southern Plains Hunter-Gatherers. Unpublished master's thesis, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.
- Brosowske, S. and L. Bement
1998 *Pedestrian Survey of Playa Lake Environments in Beaver and Texas Counties, Oklahoma*. Oklahoma Archeological Survey, Archeological Resource Survey Report No. 39. Norman, Oklahoma.
- Brown, A.
1997 *Alluvial Geoarchaeology: Floodplain Archaeology and Environmental Change*. Cambridge University Press. Cambridge, England.
- Brown, C.
1999 The Wolfforth Site (SPAS-LU-10), A Playa Site on the Southern Plains. *South Plains Archaeological Society Bulletin* 5:61-80.
- Brown, I.
1981 *The Role of Salt in Eastern North American Prehistory*. Louisiana Archaeological Survey and Antiquities Commission, Anthropological Study No. 3. Baton Rouge, Louisiana.
- Brown, J. A.
1996 *The Spiroan Ceremonial Center: The Archaeology of Arkansas Valley Caddoan Culture in Eastern Oklahoma, Volume 2*. University of Michigan, Museum of Anthropology, Memoir 29. Anna Arbor, Michigan.

- Brown, J.
1995 *Macroecology*. University of Chicago Press. Chicago, Illinois.
- Brown, K. and A. Simmons
1987 *Kansas Prehistoric Archaeological Preservation Plan*. Office of Archaeological Research, Museum of Anthropology, and Center for Public Affairs. Lawrence, Kansas.
- Bruner, W.
1931 The Vegetation of Oklahoma. *Ecological Monographs* 1:99-188.
- Bryan, A. (Editor)
1986 *New Evidence for the Pleistocene Peopling of the Americas*. Center for the Study of Early Man, Institute for Quaternary Studies. Orono, Maine.
- Bryan, A.
1991 The Fluted-Point Tradition in the Americas—One of Several Adaptations to Late Pleistocene American Environments. In *Clovis: Origins and Adaptations*, edited by R. Bonnicksen and K. Tunmire, pp. 15-33. Center for the Study of the First Americans. Corvallis, Oregon.
- Bryant, V. and R. Holloway
1985a A Late-Quaternary Paleoenvironmental Record of Texas: An Overview of the Pollen Evidence. In *Pollen Records of Late-Quaternary North American Sediments*, edited by V. Bryant and R. Holloway, pp. 39-70. American Association of Stratigraphic Palynologists Foundation. Dallas, Texas.
- Bryant, V. and R. Holloway (Editors)
1985b *Pollen Records of Late-Quaternary North American Sediments*. American Association of Stratigraphic Palynologists Foundation. Dallas, Texas.
- Bryant, V. and J. Schoenwetter
1987 Pollen Record from Lubbock Lake. In *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*, edited by E. Johnson, pp. 36-40. Texas A&M Press. College Station, Texas.
- Bryant, V. and H. Shafer
1977 The Late Quaternary Paleoenvironments of Texas: A Model for the Archaeologist. *Texas Archaeological Society Bulletin* 48:1-25.
- Buckles, W.
1974 *The 1973 Archaeological Survey of the Proposed Alignment of the Fountain Valley Conduit, Fryingpan-Arkansas Project, Bureau of Reclamation, in Fremont and El Paso Counties, Colorado*. University of Southern Colorado,

Department of Anthropology. Pueblo, Colorado.

- 1980 Radiocarbon Dates of Deposits of Piney Creek Alluvium in Southeastern Colorado. *Southwestern Lore* 46:18-22.

Buckman, H. and N. Brandy

- 1969 *The Nature and Properties of Soil*. Macmillan Company. London, England.

Buehler, K.

- 1997 Where's the Cliff?: Late Archaic Bison Kills in the Southern Plains. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 135-143. Memoir 29. Plains Anthropologist 42, Part 1.

Buehler, K. and L. Bement

- 1995 Application of Spray Foam Insulation as a Bone Encasement Technique. Paper presented at the 53rd Annual Plains Anthropological Conference. Laramie, Wyoming.

Buehler, K., L. Bement, and K. Kraft

- 1997 New Information from the Certain Bison Kill, Western Oklahoma. Paper presented at the 55th Annual Plains Anthropological Conference. Boulder, Colorado.

Buenger, B.

- 2001 Patterns of Appendicular Skeletal Disarticulation: A Taphonomic Investigation of the Hudson-Meng Bonebed. *Plains Anthropologist* 46:39-54.

Buikstra, J. and M. Swegle

- 1989 Bone Modification Due to Burning: Experimental Evidence. In *Bone Modification*, edited by R. Bonnicksen and M. Sorg, pp. 247-258. Center for the Study of the First Americans, Institute for Quaternary Studies. Orono, Maine.

Bunn, H.

- 1993 Bone Assemblages at Base Camps: A Further Consideration of Caracas Transport and Bone Destruction by the Hadza. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 156-168. Center for Archaeological Investigations, Occasional Paper No. 21. Carbondale, Illinois.

Bunn, H., E. Kroll, and L. Bartram

- 1991 Bone Distribution on a Modern East African Landscape and Its Archaeological Implications. In *Cultural Beginnings: Approaches to Understanding Early Hominid Life-Ways in the African Savanna*, edited by J. Clark, pp. 33-54.

Romisch-Germanisches Zentralmuseum. Mainz, Germany.

Bureau of Economic Geology

1969 *Geologic Atlas of Texas, Amarillo Sheet*. Austin, Texas.

Burgess, D., J. Nichols, and O. Henson

1959 *Soil Survey of Roger Mills County, Oklahoma*. United States Department of Agriculture, Soil Conservation Service. Stillwater, Oklahoma.

Burton, R. and S. Burton

1971 *An Archaeological Survey of the Lake Altus Shoreline, Greer, and Kiowa Counties*. Oklahoma River Basin Survey, General Survey Report No. 12. Norman, Oklahoma.

Butler, B.

1992 Human Skeletal Remains from the Delaware Canyon Sites. In *The Late Holocene Prehistory of Delaware Canyon, Oklahoma*, edited by C. Ferring, pp. 315-322. Institute of Applied Sciences, Contributions in Archaeology No. 1. Denton, Texas.

Butler, B., H. Gildersleeve, and J. Sommers

1971 The Wasden Bison Site: Sources of Morphological Variation. In *Aboriginal Man and the Environments of the Plateau of Northwest America*, edited by A. Stryd and R. Smith, pp. 126-152. University of Calgary Archaeological Association. Calgary, Alberta.

Button, V. and G. Agogino

1986 *Human Skeletal Material Exposed by Reservoir Induced Erosion at Lake Altus, Southwestern Oklahoma*. United States Department of the Interior, Bureau of Reclamation, Southwest Region. Amarillo, Texas.

1987 Human Skeletal Material Exposed by Reservoir Induced Erosion at Lake Altus, Southwestern Oklahoma. *Oklahoma Anthropological Society Bulletin* 36:15-37.

Caire, W.

1989 Physiognomic Regions of Oklahoma. In *Mammals of Oklahoma*, edited by W. Caire, J. Tyler, B. Glass, and M. Mares, pp.12-26. University of Oklahoma Press. Norman, Oklahoma.

Caire, W., J. Tyler, B. Glass, and M. Mares (Editors)

1989 *Mammals of Oklahoma*. University of Oklahoma Press. Norman, Oklahoma.

Caldwell, L.

2001 Good for Another 100 Years: The Rehabilitation of Sergeant Major Creek

Watershed. *Land and Water* 45(2):28. Fort Dodge, Iowa.

Camilli, E. and J. Ebert

- 1992 Artifact Reuse and Recycling in Continuous Surface Distributions and Implications for Interpreting Land Use Patterns. In *Space, Time, and Archaeological Landscapes*, edited by J. Rossignol and L. Wandsnider, pp. 113-136. Plenum Press. New York, New York.

Campbell, R.

- 1969 Prehistoric Panhandle Culture on the Chaquagua Plateau, Southeastern Colorado. Unpublished Ph. D. dissertation, Department of Anthropology, University of Colorado. Boulder, Colorado.
- 1976 *The Panhandle Aspect of the Chaquagua Plateau*. Texas Tech University, Graduate Studies No. 11. Texas Tech University Press. Lubbock, Texas.
- 1978 Southern High Plains and Upper Rio Grande Prehistory. *South Plains Archaeological Society Bulletin* 4:7-17.

Campbell, R. and S. Judd

- 1977 *Archaeological Reconnaissance of Portions of the Southern Plains Region*. Texas Tech University, Analysis of Archaeological Materials No. 4. Lubbock, Texas.

Campbell, W.

- 1921 Cheyenne Dog Soldiers. *Chronicles of Oklahoma* 1:90-97.

Carr, J. and D. Bergman

- 1992 *Reconnaissance of the Water Resources of the Clinton Quadrangle, West-Central Oklahoma, Sheet 1*. Oklahoma Geological Survey, Hydrologic Atlas No. 5. Norman, Oklahoma.

Cashdan, E.

- 1992 Spatial Organization and Habitat Use. In *Evolutionary Ecology and Human Behavior*, edited by E. Smith and B. Winterhalder, pp. 237-266. Aldine de Gruyter. New York, New York.

Cassells, E.

- 1983 *The Archaeology of Colorado*. Johnson Publishing Company. Boulder, Colorado.

Catlin, G.

- 1973 Letter 4. *Letters and Notes on the Manners, Customs, and Conditions of the North American Indians (1832-1839), Volume 1*. Dover Publications. New York,

New York.

Central Flyway Waterfowl Council

1986 *Waterfowl Identification in the Central Flyway*. Central Flyway Waterfowl Council. Jamestown, North Dakota.

Chaplin, R.

1971 *The Study of Animal Bones from Archaeological Sites*. Seminar Press. New York, New York.

Charnov, E.

1976 Optimal Foraging: Attack Strategy of a Manatid. *American Naturalist* 110:247-259.

Churcher, C.

Late Pleistocene Vertebrates from Archaeological Sites in the Plains of Kon Ombo Upper Egypt. Royal Ontario Museum of Life Sciences, Contribution No. 82. Ontario, Quebec.

Clark, G. and M. Wilson

1981 The Ayers-Frazier Bison Trap (24PE40). *Archaeology in Montana* 22:33-77.

Clark, J. and K. Kietzke

1967 *Paleoecology of the Lower Nodule Zone, Brule Formation, in the Big Badlands of South Dakota*. Fieldiana, Geology Memoir 5:111-129.

Clutton-Brock, T. and P. Harvey

1977 Primate Ecology and Social Organization. *Journal of Zoology* 183:1-39.

Cockrum, D.

1963 A Multiple Burial from the Caprock Area. *South Plains Archaeological Society Bulletin* 1:26-31.

Cody, M.

1971 Optimization in Ecology. *Science* 183:1156-1164.

Collingwood, R.

1994 *The Idea of History*. Oxford University Press. Oxford, England.

Collins, M.

1968 A Note on Broad Corner-Notched Projectile Points Used in Bison Hunting in Western Texas. *Bullroarer* 3:13-14.

1975 Lithic Technology as a Means of Processual Inference. In *Lithic Technology*:

- Making and Using Stone Tools*, edited by E. Swanson, pp. 14-34. The Hague, Netherlands.
- 1993 Comprehensive Lithic Studies: Context, Technology, Style, Attrition, Breakage, Use-Wear, and Organic Residues. *Lithic Technology* 18:87-94.
- Collins, M. and J. Fenwick
 1973 Heat Treating of Chert: Methods of Interpretation and Their Application. *Plains Anthropologist* 19:134-145.
- Conkey, M.
 1980 The Identification of Prehistoric Hunter-Gatherer Aggregation Sites: The Case of Altamira. *Current Anthropology* 21:609-630.
- Cook, J. and J. Dumont
 1987 The Development and Application of Microwear Analysis since 1964. In *The Human Uses of Flint and Chert*, edited by G. Sieveking and M. Newcomer, pp. 53-61. Cambridge University Press. Cambridge, England.
- Cooter, E.
 n. d. General Climatology. In *Oklahoma: Floods and Droughts*. United States Geological Survey, Water Supply Paper No. 2375. Oklahoma City, Oklahoma.
- Cordell, L.
 1984 *Prehistory of the Southwest*. Academic Press. New York, New York.
- Coues, E. (Editor)
 1965 *New Light on the Early History of the Greater Northwest: The Manuscript Journals of Alexander Henry and of David Thompson: 1799-1814*. Ross and Haines. Minneapolis, Minnesota. (Reprint)
- Coupland, R.
 1958 The Effects of Fluctuations in Weather upon the Grasslands of the Great Plains. *Botanical Review* 24:273-317.
- Couzzourt, J.
 1982 Archaeological Testing at Cal Farley's Boys Ranch, Oldham County, Texas. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 17:57-134.
- 1985 Preliminary Report: Testing at the Tascosa Creek Site, Oldham County, Texas. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 20:65-142.

- 1987 New Thermoluminescence Dates from the Panhandle. *Texas Archaeological Society Newsletter* 31(2):15-16.
- 1988 The Tascosa Creek Site: New Developments and Dates. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 23:44-79.
- 1992 Updates on Three Sites Previously Reported in SWFAS Transactions. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 28:17-25.
- Cowgill, G.
 1970 Some Sampling and Reliability Problems in Archaeology. In *Archeologie et Calculateurs*, edited by J. Gardin, pp. 161-175. Centre National de la Recherche Scientifique. Paris, France.
- Cox, G.
 1961 The Relation of Energy Requirements of Tropical Finches to Distribution and Migration. *Ecology* 42:253-266.
- Cox, S.
 1999 Group Size, Memory, and Interaction Rate in the Evolution of Cooperation. *Current Anthropology* 40:369-377.
- Crabtree, D.
 1967 Notes on Experiments in Flintknapping: Tools for Making Flaked Stone Artifacts. *Tebiwa* 10:60-73.
- 1972 *An Introduction to Flintworking*. Idaho State University Museum, Occasional Papers No. 28. Pocatello, Idaho.
- Crabtree, D. and B. Butler
 1964 Heat Treatment of Silica Materials. *Tebiwa* 7:1-6.
- Craig, H.
 1954 Carbon-13 in Plants and the Relationship between Carbon-13 and Carbon-14 Variations in Nature. *Geology* 62:115-149.
- Creel, D.
 1991 Bison Hides in Late Prehistoric Exchange in the Southern Plains. *American Antiquity* 56:40-49.
- Creel, D., R. Scott, and M. Collins
 1990 A Faunal Record from West Central Texas and Its Bearing on Late Holocene Bison Population Changes in the Southern Plains. *Plains Anthropologist*

35:55-69.

Crockett, J. and D. Engle

- 1999 Combustion Characteristics of Bison (*Bison bison*) Fecal Pats Ignited by Grassland Fires. *American Midland Naturalist* 141:12-18.

Crompton, A. and K. Hiiemäe

- 1969 How Mammalian Molar Teeth Work. *Discovery* 5:23-24.

Cross, J.

- 1983 Twigs, Branches, Trees, and Forests: Problems of Scale in Lithic Analysis. In *Archaeological Hammers and Theories*, edited by J. Moore and A. Keene, pp. 87-106. Academic Press. New York, New York.

Curio, E.

- 1976 *The Ethology of Predation*. Springer Verlag. Berlin, Germany.

Curtis, N. and W. Ham

- 1979 Geomorphic Provinces of Oklahoma. In *Geology and Earth Resources of Oklahoma*, by K. Johnson, C. Branson, N. Curtis, W. Ham, W. Harrison, M. Marcher, and J. Roberts, p. 3. Oklahoma Geological Survey, Educational Publication No. 1. Norman, Oklahoma.

Dale, E.

- 1965 *Cow Country*. University of Oklahoma Press. Norman, Oklahoma.

Daly, P.

- 1969 Approaches to Faunal Analysis in Archaeology. *American Antiquity* 34:146-153.

Damas, D.

- 1972 The Copper Eskimo. In *Hunters and Gatherers Today*, edited by M. Bicchieri, pp. 3-47. Holt, Reinhart, and Winston. New York, New York.

Davidson, S., C. Sticknet, and R. Weil

- 1978 *Financial Accounting: An Introduction to Concepts, Methods, and Uses*. Dryden Press. Hinsdale, Illinois.

Davis, T.

- 1869 The Buffalo Range. *Harper's New Monthly Magazine* 38:147-163.

Dawkins, R.

- 1982 *The Extended Phenotype: The Gene as the Unit of Selection*. Freeman and Company. San Francisco, California.

- Dayton, W.
 1960 *Notes on Western Range Forbs: Equisetaceae through Fumariaceae*. United States Department of Agriculture, Forest Service. Washington, District of Columbia.
- Deevey, E.
 1947 Life Tables for Natural Populations of Animals. *Quarterly Review of Biology* 22:283-314.
- Del Bene, T.
 1979 Once upon a Striation: Current Models of Striation and Polish Formation. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 167-177. Academic Press. New York, New York.
- Del Giudice, G., F. Singer, U. Seal, and G. Bowser
 1994 Physiological Responses of Yellowstone Bison to Winter Nutritional Deprivation. *Journal of Wildlife Management* 58:24-34.
- Dibble, D. and D. Lorrain
 1968 *Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas*. Texas Memorial Museum, Miscellaneous Papers No. 1. Austin, Texas.
- Dick, H.
 1974 The Running Pit House Site. In *Trinidad Reservoir Salvage Archaeology, 1972*, edited by S. Ireland, pp. 163-177. National Park Service, Midwest Archaeological Center. Lincoln, Nebraska.
- Dickson, D.
 1984 The Atlatl Assessed: A Review of Recent Anthropological Approaches to Prehistoric North American Weaponry. *Texas Archaeological Society Bulletin* 56:1-58.
- Dillehay, T.
 1974 Late Quaternary Bison Population Changes on the Southern Plains. *Plains Anthropologist* 19:180-196.
 1984 A Late Ice-age Settlement in Southern Chile. *Scientific America* 215:106-117.
- Dillehay, T. and M. Collins
 1988 Early Cultural Evidence from Monte Verde in Chile. *Nature* 332:150-152.
- Dixon, J.

- 1999 *Bones, Boats, and Bison: Archaeology and the First Colonization of Western North America*. University of New Mexico Press. Albuquerque, New Mexico.
- Dolliver, P.
 1984 *Cenozoic Evolution of the Canadian River Basin*. Baylor Geological Studies, Bulletin No. 42. Waco, Texas.
- Doran, G.
 1975 The Long Bones of the Texas Indians. Unpublished Master's thesis, Department of Anthropology, University of Texas. Austin, Texas.
- Dorshow, W.
 1994 Revisions of the Archaeological Record of Northeastern New Mexico: A Review of the Early Woodland Period on the Southern Park Plateau. Paper presented at the 67th Annual Pecos Conference. Mesa Verde, Colorado.
- Drass, R.
 1992 Salvage of a Pit from the Williams-Branch Site, 34GD122. *Oklahoma Anthropological Society Newsletter* 40:7-11.
 1993 Macrobotanical Remains from Two Early Plains Village Sites in Central Oklahoma. *Plains Anthropologist* 38:51-64.
 1997 *Cultural Change on the Eastern Margins of the Southern Plains*. Oklahoma Archeological Survey, Studies in Oklahoma's Past No. 19. Norman, Oklahoma.
- Drass, R. and D. Dycus
 1994 *Archeological Survey of the North Fork of the Red River*. Oklahoma Archeological Survey, Final Report on Project No. 40-92-80052.017. Report submitted to Oklahoma State Historic Preservation Office. Oklahoma City, Oklahoma.
- Drass, R. and P. Flynn
 1990 Temporal and Geographic Variations in Subsistence Practices for Plains Villagers in the Southern Plains. *Plains Anthropologist* 35:175-190.
- Drass, R. and C. Turner
 1989 *An Archeological Reconnaissance of the Wolf Creek Drainage Basin, Ellis County, Oklahoma*. Oklahoma Archeological Survey, Archeological Resource Survey Report No. 35. Norman, Oklahoma.
- Dreiling, L.
 2001 Bison Offer Good Value. *The High Plains Journal: The Farmer-Rancher Paper* 118(49):1, 3.

- Driver, H.
1961 *Indians of North America*. University of Chicago Press. Chicago, Illinois.
- Driver, J.
1990 Meat in Due Season: The Timing of Communal Hunts. In *Hunters of the Recent Past*, edited by L. Davis and B. Reeves, pp. 11-33. Unwin Hyman. Boston, Massachusetts.
- Duck, L. and J. Fletcher
1945 *A Survey of the Game and Furbearing Animals of Oklahoma*. Oklahoma Game and Fish Department, State Bulletin No. 3. Oklahoma City, Oklahoma.
- Duffield, L.
1973 Aging and Sexing the Post-Cranial Skeleton of Bison. *Plains Anthropologist* 18:132-139.
- Duke, P. and M. Wilson
1995 Introduction: Postprocessualism and Plains Archaeology. In *Beyond Subsistence: Plains Archaeology and the Postprocessual Critique*, edited by P. Duke and C. Wilson, pp. 1-16. University of Alabama Press. Tuscaloosa, Alabama.
- Dumont, J.
Mount Sandel Microwear: A Preliminary Report. In *The Human Uses of Flint and Chert*, edited by G. Sieveking and M. Newcomer, pp. 97-109. Cambridge University Press. Cambridge, England.
- Duncan, M.
1995 Calf Creek Foragers: Mobility on the Southern Plains during the Altithermal. *Oklahoma Anthropological Society Bulletin* 42:89-143.

2002 Adaptation during the Antelope Creek Phase: A Diet Breadth and Site Catchment Analysis of the Subsistence Strategy at the Two Sisters Site. Unpublished Ph. D. dissertation, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.
- Durham, W.
1981 Overview: Optimal Foraging Analysis in Human Ecology. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 218-231. University of Chicago Press. Chicago, Illinois.
- Durkheim, E. and M. Mauss

- 1963 *Primitive Classification*. University of Chicago Press. Chicago, Illinois.
- Early, A. (Editor)
 1993 *Caddoan Saltmakers in the Ouachita Valley: The Hardman Site*. Arkansas Archeological Survey, Research Series No. 43. Fayetteville, Arkansas.
- Edington, G.
 1997 Predictive Modeling in the Black Kettle National Grassland Roger Mills County, Oklahoma. Unpublished master's thesis, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.
- Eddy, A.
 1982 Operational Weather Modification: A Rainfall Climatology for Oklahoma. *Oklahoma Climatological Survey* 5:120. Norman, Oklahoma.
- Eddy, F., P. Friedman, R. Oberlin, T. Farmer, D. Dahms, J. Reining, and B. Leichtman
 1982 *The Cultural Resource Inventory of the John Martin Dam and Reservoir, Bent County, Colorado*. Science Applications, Incorporated. Golden, Colorado.
- Eddy, F., R. Oberlin, and T. Farmer
 1984 Spatial Analysis of Archaeological Data at the John Martin Dam and Reservoir, Southeast Colorado. *Plains Anthropologist* 29:25-40.
- Efremov, J.
 1940 Taphonomy: New Branch of Paleontology. *Pan-American Geologist* 74:81-93.
- Eighmy, J.
 1984 *Colorado Plains Prehistoric Context: For Management of Prehistoric Resources of the Colorado Plains*. Colorado Historical Society, Office of Archaeology and Historic Preservation. Denver, Colorado.
- Eighmy, J. and J. LaBelle
 1996 Radiocarbon Dating of Twenty-Seven Plains Complexes and Phases. *Plains Anthropologist* 41:53-69.
- Elston, R.
 1994 Obituary: Jonathan O. Davis. *American Antiquity* 59:82-87.
- Ember, C.
 1978 Myths about Hunter-Gatherers. *Ethnology* 17:439-448.
- Emlen, J.
 1966 The Role of Time and Energy in Food Preference. *American Naturalist* 100:611-617.

- Engle, D., T. Bidwell, and M. Moseley
 n. d. *Invasion of Oklahoma Rangelands and Forests by Eastern Redcedar and Ashe Juniper*. Oklahoma Cooperative Extension Service, Circular E-947. Oklahoma State University. Stillwater, Oklahoma.
- Ensor, H.
 1991 The Lubbock Creek Microlith Industry. *Southeastern Archaeology* 10:18-39.
- Epp, H.
 1985 Ecological Edges and Archaeological Site Location in Saskatchewan, Canada. *North American Archaeologist* 5:323-336.
- 1986 Prehistoric Settlement Response to the Harris Sand Hills, Saskatchewan, Canada. *Plains Anthropologist* 31:51-63.
- 1988 Way of the Migrant Herds: Dual Dispersion Strategy among Bison. *Plains Anthropologist* 33:309-320.
- Ericson, J.
 1984 Toward the Analysis of Lithic Production Systems. In *Prehistoric Quarries and Lithic Production*, edited by J. Ericson and B. Purdy, pp. 1-9. Cambridge University Press. Cambridge, England.
- Erlandson, J.
 1984 A Case Study in Faunal Turbation: Delineating the Effects of the Burrowing Pocket Gopher on the Distribution of Archaeological Materials. *American Antiquity* 49:785-790.
- Etchieson, G., R. Speer, and J. Hughes
 1977 *An Archaeological Survey of Certain Tracts in and near Caprock Canyons State Park in Eastern Briscoe County, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- 1978 *Archaeological Investigations in the Truscott Reservoir Area, King and Knox Counties, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- 1979 *Archaeological Investigations in the Crowell Reservoir Area, Cottle, Foard, King, and Knox Counties, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- 1982 Archaeological Investigations by the Youth Conservation Corps at Lake Meredith Recreation Area, Texas. *Regional Symposium for*

Southeastern New Mexico and Western Texas Transactions 17:7-14.

Evans, G.

1951 Prehistoric Wells in Eastern New Mexico. *American Antiquity* 17:1-8.

Ewers, J.

1949 The Last Bison Drives of the Blackfoot Indians. *Washington Academy of Sciences Journal* 39:355-360.

Fagan, B.

1987 *The Great Journey*. Thames and Hudson. London, England.

Fawcett, W.

1985 Variation in Chipped-Stone Tool Assemblages from Bison Kills and Associated Processing and Camp Sites. *Wyoming Archaeologist* 29:9-28.

1987 Communal Hunts, Human Aggregations, Social Variation, and Climatic Change: Bison Utilization by Prehistoric Inhabitants of the Great Plains. Unpublished Ph. D. dissertation, Department of Anthropology, University of Massachusetts. Amherst, Massachusetts.

Fay, R.

1959 Pleistocene Course of the South Canadian River in Central Western Oklahoma. *Oklahoma Geology Notes* 19:3-12.

Fay, R. and D. Hart

1978 Geological and Mineral Resources (Exclusive of Petroleum) of Custer County, Oklahoma. *Oklahoma Geological Survey Bulletin* No. 114. Norman, Oklahoma.

Feller, N. and A. Turner

1982 Number Estimation in Vertebrate Samples. *Journal of Archaeological Science* 9:49-62.

Fenneman, N.

1923 Physiographic Provinces and Sections in Western Oklahoma and Adjacent Parts of Texas. In *Contributions to the Geography of the United States, 1922*, pp. 115-139. United States Geological Survey Bulletin No. 730. Washington, District of Columbia.

1931 *Physiography of Western United States*. McGraw-Hill. New York, New York.

1938 *Physiography of Eastern United States*. McGraw-Hill. New York, New York.

Ferring, C.

- 1977 *A Report on Archaeological Investigations at the Delaware Canyon Sites: Cd-257 and Cd-258, Caddo County, Oklahoma*. Museum of the Great Plains. Lawton, Oklahoma.
- 1982 *The Late Holocene Prehistory of Delaware Canyon*. Institute of Applied Sciences. Denton, Texas.
- 1984 *The Delaware Canyon Project: An Investigation of Archaeology and Past Environments on the Southern Plains*. Institute of Applied Sciences. Denton, Texas.
- 1986 Late Holocene Cultural Ecology in the Southern Plains: Perspectives from Delaware Canyon, Oklahoma. In *Current Trends in Southern Plains Archaeology*, edited by T. Baugh, pp. 55-82. Memoir 21. Plains Anthropologist 31, Part 2.
- 1992 Alluvial Pedology and Geoarchaeological Research. In *Soils in Archaeology: Landscape Evolution and Human Occupation*, edited by V. Holliday, pp. 1-39. Smithsonian Institution Press. Washington, District of Columbia.
- 1995 Middle Holocene Environments, Geology, and Archaeology in the Southern Plains. In *Archaeological Geology of the Archaic Period in North America*, edited by E. Bettis, pp. 21-35. Geological Society of America, Special Paper No. 297. Boulder, Colorado.
- Finley, R. and T. Gustavson
- 1980 *Climatic Controls on Erosion in the Rolling Plains and along the Caprock Escarpment of the Texas Panhandle*. Bureau of Economic Geology, Geological Circular No. 80-11. Austin, Texas.
- Finnegan, M.
- 1981 Archaic Skeletal Remains from the Central Plains: Demography and Burial Practices. In *Progress in Skeletal Biology of Plains Populations*, edited by R. Jantz and D. Ubelaker, pp. 85-92. Memoir 17. Plains Anthropologist 42, Part 2.
- Fladmark, K.
- 1967 The Vertebrate Fauna and Hunting Patterns. In *The Prehistory of the Tehuacan Valley, Volume 1*, edited by D. Byers, pp. 132-178. University of Texas Press. Austin, Texas.
- 1978 *A Guide to Basic Archaeological Procedures*. Simon Fraser University, Department of Anthropology, Publication No. 4. Burnaby, British Columbia.

- Flannery, K.
1976 Evolution of Complex Settlement Systems. In *The Early Mesoamerican Village*, edited by K. Flannery, pp. 162-172. Academic Press. New York, New York.
- Flynn, P.
1982 Distribution of Prehistoric Bison Populations on the Southern Plains: A Test of Dillehay's Model. University of Oklahoma, Department of Anthropology. *Papers in Anthropology* 23:7-35.
- Foley, R.
1985 Optimality Theory in Anthropology. *Man* 20:222-242.
- Forbis, R
1960 The Old Women's Buffalo Jump. *National Museum of Canada Bulletin* 180:56-123. Part 1.
- Ford, J.
1972 *A Quantitative Method for Deriving Cultural Chronology*. University of Missouri-Columbia, Museum of Anthropology, Museum Brief No. 9. Columbia, Missouri.
- Ford, J., G. Scott, and J. Frie
1980 *Soil Survey of Beckham County, Oklahoma*. United States Department of Agriculture, Soil Conservation Service. Stillwater, Oklahoma.
- Forde, C.
1934 *Habitat, Economy, and Society*. Methuen Publishing. London, England.
- Foreman, C.
1947 *The Cross Timbers*. Star Printery. Muskogee, Oklahoma.
- Foreman, G.
1932 Salt Works in Early Oklahoma. *Chronicles of Oklahoma* 10:474-500.
- Foster, J., D. Harrison, and I. MacLaren
1994 *Buffalo*. Alberta Nature and Culture Series. The University of Alberta Press. Edmonton, Alberta.
- Fox, R.
1992 *Kinship and Marriage: An Anthropological Perspective*. Cambridge University Press. Cambridge, England.
- Freeman, C. and C. Morse
n. d. *Checklist of the Vascular Plants of the Thurmond Ranch, Roger Mills County*,

Oklahoma. R. L. McGregor Herbarium, Natural History Museum and Biodiversity Research Center, University of Kansas. Lawrence, Kansas.

Freeman, C., C. Morse, and J. Thurmond

- 2003 Vascular Flora of the Ogallala Ecotone on the Dempsey Divide, Roger Mills County, Oklahoma. *Sida* 20:1217-1245.

Freie, A.

- 1930 *Sedimentation in the Anadarko Basin*. Oklahoma Geological Survey Bulletin No. 48. Norman, Oklahoma.

Frison, G.

- 1967 The Piney Creek Sites, Wyoming. *University of Wyoming Publications* 33:1-92.
- 1968 A Functional Analysis of Certain Chipped Stone Tools. *American Antiquity* 33:149-155.
- 1970 *The Glenrock Buffalo Jump, 48CO304: Late Prehistoric Buffalo Procurement and Butchering*. Memoir 7. *Plains Anthropologist* 15, Part 2.
- 1971 The Buffalo Pound in Northwestern Plains Prehistory: Site 48CA302, Wyoming. *American Antiquity* 36:77-91.
- 1973 *The Wardell Buffalo Trap 48SU301: Communal Procurement in the Upper Green River Basin, Wyoming*. Museum of Anthropology, Anthropological Papers No. 48. Ann Arbor, Michigan.
- 1978 Animal Population Studies and Cultural Inference. In *Bison Procurement and Utilization: A Symposium*, edited by L. Davis and M. Wilson, pp. 44-52. Memoir 14. *Plains Anthropologist* 23, Part 2.
- 1980 Bison Dentition Studies. In *The Agate Basin Site: A Record of Paleoindian Occupation of the Northwestern High Plains*, by G. Frison and D. Stanford, pp. 240-261. Academic Press. New York, New York.
- 1984 The Carter/Kerr-McGee Paleoindian Site: Cultural Resource Management and Archaeological Research. *American Antiquity* 49:288-314.
- 1991 *Prehistoric Hunters of the High Plains*. Academic Press. New York, New York.
- Frison, G. and B. Bradley
- 1980 *Folsom Tools and Technology at the Hanson Site, Wyoming*. University of New Mexico Press. Albuquerque, New Mexico.

Frison, G. and C. Reher

- 1970 Appendix I. Age Determination of Buffalo by Teeth Eruption and Wear. In *The Glenrock Buffalo Jump, 48CO304*, edited by G. Frison, pp. 46-55. Memoir 7. Plains Anthropologist 15, Part 2.

Frison, G. and D. Stanford (Editors)

- 1982 *The Agate Basin Site: A Record of Paleoindian Occupation of the Northwestern High Plains*. Academic Press. New York, New York.

Frison, G., M. Wilson, and D. Wilson

- 1976 Fossil Bison and Artifacts from an Early Altithermal Period Arroyo Trap in Wyoming. *American Antiquity* 41:28-57.

Fuller, W.

- 1959 The Horns and Teeth as Indicators of Age in Bison. *Journal of Wildlife Management* 23:342-344.
- 1961 The Ecology and Management of the American Bison. *Terre et la Vie* 2:286-304.

Gable, D. and T. Hatton

- 1982 *Maps of Vertical Crustal Movements in the Conterminous United States over the Past 10 Million Years*. United States Geological Survey, Miscellaneous Investigations Map I-1315. Boulder, Colorado.

Gabler, R., R. Sager, S. Brazier, and J. Pourciau

- 1977 *Essentials of Physical Geography*. Holt, Rinehart, and Winston. New York, New York.

Galm, J.

- 1984 Arkansas Valley Caddoan Formative: The Wister and Fourche Maline Phases. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 199-219. Academic Press. New York, New York.

Garbarino, M.

- 1977 *Sociocultural Theory in Anthropology: A Short History*. Holt, Rinehart, and Winston. New York, New York.

Gardin, J.

- 1980 *Archaeological Constructs: An Aspect of Theoretical Archaeology*. Cambridge University Press. Cambridge, England.

Garretson, M.

- 1927 *A Short History of the American Bison*. American Bison Society. New York, New York.
- Genovés, S.
 1967 Proportionality of Long Bones and Their Relation to Stature among Mesoamericans. *American Journal of Physical Anthropology* 26:67-78.
- Gettys, F.
 1991a Salvage Excavation in Roger Mills County. *Oklahoma Archeological Survey Newsletter* 10(3):1-2.
 1991b State of Oklahoma Archaeological Site Form: 34RM668. Oklahoma Archeological Survey. Norman, Oklahoma.
- Gibbons, E. and G. Tucker
 1979 *Euell Gibbons' Handbook of Edible Wild Plants*. The Donning Company. Virginia Beach, Virginia.
- Gifford, D.
 1980 Ethnoarchaeological Contributions to the Taphonomy of Human Sites. In *Fossils in the Making: Vertebrate Taphonomy and Paleoecology*, edited by A. Behrensmeyer and A. Hill, pp. 93-106. University of Chicago Press. Chicago, Illinois.
- Gilbert, B.
 1973 *Mammalian-Osteoarchaeology: North America*. Missouri Archaeological Society. Columbia, Missouri.
 1990 *Mammalian Osteology*. Missouri Archaeological Society. Columbia, Missouri.
- Goodman, J.
 1977 Physical Environments of Oklahoma. In *Geography of Oklahoma*, edited by J. Morris, pp. 9-24. Oklahoma Historical Society. Oklahoma City, Oklahoma.
- Gould, C. and F. Lewis
 1926 *The Permian of Western Oklahoma and the Panhandle of Texas*. Oklahoma Geological Survey, Curricular No. 13. Norman, Oklahoma.
- Gramly, R.
 1984 Mount Jasper: A Direct-Access Lithic Source Area in the White Mountains of New Hampshire. In *Prehistoric Quarries and Lithic Production*, edited by J. Ericson and B. Purdy, pp. 1-9. Cambridge University Press. Cambridge, England.

Grange, R.

- 1980 *Archaeological Investigations in the Red Willow Reservoir, Nebraska*. Nebraska State Historical Society, Publications in Anthropology No. 9. Lincoln, Nebraska.

Grayson, D.

- 1984 *Quantitative Zooarchaeology: Topics in the Analysis of Archaeological Faunas*. Academic Press. New York, New York.

Green, D.

- 2002 Landscape Evolution and Prehistoric Bison Hunting Strategies on the Southern Plains. Unpublished master's thesis, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.

Green, F.

- 1954 The Triassic Deposits of Northwestern Texas. Unpublished Ph.D. dissertation, Department of Geology, Texas Technological College. Lubbock, Texas.
- 1962 Additional Notes on Prehistoric Wells at the Clovis Site. *American Antiquity* 28:230-234.
- 1967 *Archaeological Salvage in the Sanford Reservoir Area*. Texas Technological College. Lubbock, Texas.

Green, J.

- 1975 McKean and Lithic Technology: A Problem in Projectile Point Typology in the Great Basin of North America. In *Lithic Technology: Making and Using Stone Tools*, edited by E. Swanson, pp. 159-172. Mouton Publishers. The Hague, Netherlands.

Gregg, J.

- 1954 *Commerce of the Prairies*. University of Oklahoma Press. Norman, Oklahoma.

Greiser, S. And P. Sheets

- 1979 Raw Material as a Functional Variable in Use-Wear Studies. In *Lithic Use-Wear Analysis*, edited by Brian Hayden, pp. 289-299. Academic Press. New York, New York.

Grinnell, G.

- 1962 *The Cheyenne Indians: Their History and Ways of Life, Volume 1*. Cooper Square Publishers. New York, New York.
- 1970 The Last of the Buffalo. Arno Press. New York, New York. (Reprint)

Grossman, L.

- 1977 Man-Environment Relationships in Anthropology and Geography. *Association of American Geographers Annals* 67:126-144.

Gunnerson, D.

- 1956 The Southern Athabascans: Their Arrival in the Southwest. *El Palacio* 63:346-365.

Gunnerson, J.

- 1960 *An Introduction to Plains Apache Archaeology—The Dismal River Aspect*. Bureau of American Ethnology, Bulletin No. 173. Washington, District of Columbia.
- 1968 Plains Apache Archaeology: A Review. *Plains Anthropologist* 13(41):167-189.
- 1969 Apache Archaeology in Northeastern New Mexico. *American Antiquity* 34(1):23-29.
- 1987 *Archaeology of the High Plains*. United States Department of Interior, Bureau of Land Management, Cultural Resource Series No. 19. Denver, Colorado.

Gustavson, T.

- 1979 Salt Dissolution. In *Geology and Geohydrology of the Palo Duro Basin: A Report on the Progress of Nuclear Waste Isolation Feasibility Studies (1978)*, by S. Dutton, R. Finley, W. Galloway, T. Gustavson, C. Hanford, and M. Presley, pp. 87-95. Texas Bureau of Economic Geology, Geological Curricular No. 79-1. Austin, Texas.
- 1986 Geomorphic Development of the Canadian River Valley, Texas Panhandle: An Example of Regional Salt Dissolution and Subsidence. *Geologic Society of America Bulletin* 97:459-472.

Gustavson, T., R. Bumgardner, C. Caran, V. Holliday, H. Mehnert, M. O'Neill, and C. Reeves

- 1991 Quaternary Geology of the Southern Great Plains and an adjacent Segment of the Rolling Plains. In *Quaternary Nonglacial Geology: Conterminous United States*, edited by R. Morrison, pp. 477-501. Geological Society of America. Boulder, Colorado.

Gustavson, T. and R. Finley

- 1985 *Late Cenozoic Geomorphic Evolution of the Texas Panhandle and Northeastern New Mexico—Case Studies of Structural Controls on Regional Drainage Development*. Texas Bureau of Economic Geology, Report of Investigation No. 148. Austin, Texas.

Gustavson, T., R. Finley, and K. McGillis

- 1980 *Regional Dissolution of Permian Salt in the Anadarko, Dalhart, and Palo Duro Basins of the Texas Panhandle*. Texas Bureau of Economic Geology, Report of Investigations No. 106. Austin, Texas.

Gustavson, T. and V. Holiday

- 1985 *Depositional Architecture of the Quaternary Blackwater Draw and Tertiary Ogallala Formations, Texas Panhandle and Eastern New Mexico*. Texas Bureau of Economic Geology, Report No. 23. Austin, Texas.

Gutentag, E., F. Heimes, N. Krothe, R. Luckey, and J. Weeks

- 1984 *Geohydrology of the High Plains Aquifer in Parts of Colorado, Kansas, Nebraska, New Mexico, Oklahoma, South Dakota, Texas, and Wyoming*. United States Geological Survey, Professional Paper No. 1400-B. United States Government Printing Office. Washington, District of Columbia.

Guthrie, R.

- 1966a Bison Horn Cores—Character, Choice, and Systematics. *Journal of Paleontology* 40:738-740.
- 1966b Pelage of Fossil Bison—A New Osteological Index. *Journal of Mammalogy* 47:725-727.
- 1990 Late Pleistocene Faunal Revolution—A New Perspective on the Extinction Debate. In *Megafauna and Man: Discovery of America's Heartland*, edited by L. Agenbroad, J. Mead, and L. Nelson, pp. 42-53. The Mammoth Site of Hot Springs, South Dakota, Incorporated, Scientific Papers No. 1. Hot Springs, South Dakota.

Guyette, M.

- 1974 *The Story of the Globe*. Replogle Globes, Incorporated. Broadview, Illinois.

Hafsten, U.

- 1961 Pleistocene Development of Vegetation and Climate in the Southern High Plains as Evidenced by Pollen Analysis. In *Paleoecology of the Llano Estacado*, edited by F. Wendorf, pp. 59-91. Fort Burgwin Research Center Publication No. 1. Museum of New Mexico Press. Santa Fe, New Mexico.

Hagar, I.

- 1976 5CR1—Draper Cave Excavation and Report. *Southwestern Lore* 42:1-13.

Hall, G.

- 1981 *Allens Creek: A Study in the Cultural Prehistory of the Lower Brazos River*

Valley, Texas. Texas Archeological Survey, Research Report No. 61. Austin, Texas.

- 1988 Long-Bone Implements from Some Prehistoric Sites in Texas: Functional Interpretations Based on Ethnographic Analogy. *Texas Archaeological Society Bulletin* 59:157-176.
- 2000 Pecan Food Potential in Prehistoric North America. *Economic Botany* 54:103-112.

Hall, S.

- 1982a Late Holocene Paleoecology of the Southern Plains. *Quaternary Research* 17:391-407.
- 1982b Geology of Delaware Canyon. In *The Late Holocene Prehistory of Delaware Canyon*, edited by C. Ferring, pp. 47-63. Institute of Applied Sciences, Contributions in Archaeology No. 1. Denton, Texas.
- 1988 Environment and Archaeology of the Central Osage Plains. *Plains Anthropologist* 33:205-218.
- 1990 Channel Trenching and Climate Change in the Southern United States Great Plains. *Geology* 18:342-345.

Hall, S. and C. Lintz

- 1984 Buried Trees, Water Table Fluctuations, and 3000 Years of Changing Climate in West-Central Oklahoma. *Quaternary Research* 22:129-133.

Hall, S. and S. Valastro

- 1995 Grassland Vegetation in the Southern Great Plains during the Last Glacial Maximum. *Quaternary Research* 44:237-245.

Halloran, A.

- 1960 American Bison Weights and Measurements from the Wichita Mountains Wildlife Refuge. *Oklahoma Academy of Science Proceedings* 41:212-218.
- 1968 Bison (Bovidae) Productivity on the Wichita Mountains Wildlife Refuge, Oklahoma. *Southwestern Naturalist* 13:23-26.

Halloran, A. and B. Glass

- 1959 The Carnivores and Ungulates of the Wichita Mountain Wildlife Refuge, Oklahoma. *Journal of Mammalogy* 40:360-370.

Hamilton, W. and K. Watt

- 1970 Refuging. *Annual Review of Ecological and Systematics* 1:263-286.
- Hammack, L.
1965 *Archaeology of the Ute Dam and Reservoir*. Museum of New Mexico, Papers in Anthropology No. 14. Santa Fe, New Mexico.
- Hammatt, H.
1976 The Gore Pit Site: An Archaic Occupation in Southwestern Oklahoma and a Review of the Archaic Stage in the Southern Plains. *Plains Anthropologist* 21:245-277.
- Hamperl, H. and W. Laughlin
1959 Osteological Consequences of Scalping. *Human Biology* 31:80-89.
- Hancock, N. and J. Low
1956 *Aging of Rocky Mountain Elk (Cervus canadensis nelsoni) by Dentition*. Utah State Department of Fish and Game. Salt Lake City, Utah.
- Harlan, J.
1960 *Production Characteristic of Oklahoma Forages: Native Range*. Oklahoma State University, Oklahoma Experiment Station and United States Department of Agriculture, Agricultural Research Service, Crop Research Division. Bulletin B-547. Stillwater, Oklahoma.
- Harper, H.
1960 Drought Years in Central Oklahoma from 1710 to 1959 Calculated from Annual Rings from Post Oak Trees. *Oklahoma Academy of Science Proceedings* 41:23-29.
- Harrington, H.
1972 *Western Edible Wild Plants*. University of New Mexico Press. Albuquerque, New Mexico.
- Harrison, B. and K. Killen
1978 *Lake Theo: A Stratified, Early Man Bison Butchering and Camp Site, Briscoe County, Texas: Archaeological Investigations Phase II*. Panhandle-Plains Historical Museum. Canyon, Texas.
- Harrison, B. and H. Smith
1975 Excavations at the Lake Theo Site, PPHN-A917, Briscoe County, Texas. *Panhandle-Plains Historical Review* 48:70-106.
- Hartley, J.
1974 *The Von Elm Site: An Early Plains-Woodland Complex in North-Central*

Oklahoma. Oklahoma River Basin Survey, Archaeological Site Report No. 28. Norman, Oklahoma.

Haspel, H. and G. Frison

- 1987 The Finley Site Bison Bone. In *The Horner Site: The Type Site for the Cody Cultural Complex*, edited by G. Frison and L. Todd, pp. 475-491. Academic Press. New York, New York.

Hatch, M. and C. Slack

- 1966 Photosynthesis by Sugarcane Leaves: A New Carboxylation Reaction and the Pathway of Sugar Formation. *Biochemistry* 101:103-111.

Haury, C.

- 1982 *The Prehistory and Paleoenvironment of the Black Mesa Locality, Cimarron County, Oklahoma*. University of Tulsa, Laboratory of Archaeology. Tulsa, Oklahoma.

Haviland, W.

- 1975 *Cultural Anthropology*. Holt, Rinehart, and Winston. New York, New York.

Hawkes, K.

- 1987 How Much Food Do Foragers Need? In *Food and Evolution: Toward a Theory of Human Food Habits*, edited by M. Harris and E. Ross, pp. 341-356. Temple University Press. Philadelphia, Pennsylvania.

Hayden, B. (Editor)

- 1979 *Lithic Use-Wear Analysis*. Academic Press. New York, New York.

Hayden, B.

- 1981a Research and Development in the Stone Age: Technological Transitions among Hunter-Gatherers. *Current Anthropology* 22:519-548.

- 1981b Subsistence and Ecological Adaptations of Modern Hunter/Gatherers. In *Omnivorous Primates: Gathering and Hunting in Human Evolution*, edited by R. Harding and G. Teleki, pp. 344-421. Columbia University Press. New York, New York.

- 1986 Resource Models of Inter-Assemblage Variability. *Lithic Technology* 15:82-89.

- 1987 Reply to Contay. *Lithic Technology* 16:62.

Hayden, B. and W. Hutchings

- 1989 Whither the Billet Flake? In *Experiments in Lithic Technology*, edited by D.

Amick and R. Mauldins, pp. 235-258. British Archaeological Reports, International Series No. 528. Oxford, England.

Haynes, C.

1975 Pleistocene and Recent Stratigraphy. In *Late Pleistocene Environments of the Southern High Plains*, edited by F. Wendorf and J. Hester, pp. 57-96. Fort Burgwin Research Center, Publication No. 9. Taos, New Mexico.

1992 Contributions of Radiocarbon Dating to the Geochronology of the Peopling of the New World. In *Radiocarbon after Four Decades: An Interdisciplinary Perspective*, edited by R. Taylor, A. Long, and R. Kra, pp. 355-374. Springer-Verlag. New York, New York.

Haynes, C., R. Beukens, A. Jull, and O. Davis

1992 New Radiocarbon Dates for Some Old Folsom Sites: Accelerator Technology. In *Ice Age Hunters of the Rockies*, edited by D. Stanford and J. Day, pp. 83-100. Denver Museum of Natural History and University Press of Colorado. Niwot, Colorado.

Heffley, S.

1981 The Relationship between Northern Athapaskan Settlement Patterns and Resource Distribution: An Application of Horn's Model. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 126-147. University of Chicago Press. Chicago, Illinois.

Hemmings, E.

1987 The Horner Site Debitage. In *The Horner Site: The Type Site of the Cody Cultural Complex*, edited by G. Frison and L. Todd, pp. 435-442. Academic Press. New York, New York.

Henry, D., C. Haynes, and B. Bradley

1976 Quantitative Variations in Flaked Stone Debitage. *Plains Anthropologist* 21:57-61.

Hesse, B. and P. Wapnish

1985 *Animal Bone Archaeology: From Objectives to Analysis*. Taraxacum Incorporated, Manuals on Archaeology No. 5. Washington, District of Columbia.

Hester, J.

1972 *Blackwater Draw Locality No. 1, A Stratified, Early Man Site in Eastern New Mexico*. Fort Burgwin Research Center, Publication No. 8. Taos, New Mexico.

Hester, T., D. Gilbow, and A. Albee

- 1973 A Functional Analysis of "Clear Fork" Artifacts from the Rio Grande Plain, Texas. *American Antiquity* 38:90-96.

Hickerson, N.

- 1994 *The Jumanos: Hunters and Traders of the Southern Plains*. University of Texas Press. Austin, Texas.

Hill, A.

- 1976 On Carnivores and Weathering Damage to Bone. *Current Anthropology* 17:335-336.

- 1979a Butchery and Natural Disarticulation: An Investigatory Technique. *American Antiquity* 44:739-747.

- 1979b Disarticulation and Scattering of Mammal Skeletons. *Paleobiology* 5:261-274.

Hill, A. and A. Behrensmeyer

- 1984 Disarticulation Patterns of Some Modern East African Mammals. *Paleobiology* 10:366-376.

Hill, M. and J. Hofman

- 1997 The Waugh Site: A Folsom-Age Bison Bonebed in Northwestern Oklahoma. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 63-84. Memoir 29. Plains Anthropologist 42, Part 1.

Hillsman, M.

- 1992 Evaluation of Visible and Ultraviolet-Excited Attributes of Some Texas and Macroscopically Similar New Mexico Cherts. Unpublished master's thesis, Department of Anthropology, Eastern New Mexico University. Portales, New Mexico.

Hodder, I.

- 1982 *Symbols in Action: Ethnoarchaeological Studies of Material Culture*. Cambridge University Press. Cambridge, England.

- 1995 Fighting Back on the Plains. In *Beyond Subsistence: Plains Archaeology and the Postprocessual Critique*, edited by P. Duke and C. Wilson, pp. 236-239. University of Alabama Press. Tuscaloosa, Alabama.

Hofman, J.

- 1973 CD-177: A Small Archaic Camp in West-Central Oklahoma. *Oklahoma Anthropological Society Bulletin* 22:171-206.

- 1977 A Technological Analysis of Clear Fork Gouge Production. *Oklahoma Anthropological Society Bulletin* 22:171-206.
 - 1978 An Alternative View of Some Southern Plains Archaic Stage Characteristics. *Plains Anthropologist* 23:311-317.
 - 1981 The Refitting of Chipped-Stone Artifacts as an Analytical and Interpretive Tool. *Current Anthropology* 22:691-693.
 - 1989 Prehistoric Culture History—Hunters and Gatherers in the Southern Great Plains. In *From Clovis to Comanchero: Archeological Overview of the Southern Great Plains*, pp. 25-60, by J. Hofman, R. Brooks, J. Hays, D. Owsley, R. Jantz, M. Marks, and M. Manhein. Arkansas Archeological Survey, Research Series No. 35. Fayetteville, Arkansas.
 - 1991 Folsom Land Use: Projectile Point Variability as a Key to Mobility. In *Raw Material Economies among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 335-356. University of Kansas, Publications in Anthropology No. 19. Lawrence, Kansas.
 - 1992 Recognition and Interpretation of Folsom Technological Variability on the Southern Plains. In *Ice Age Hunters of the Rockies*, edited by D. Stanford and J. Day, pp. 193-224. Denver Museum of Natural History and University Press of Colorado. Niwot, Colorado.
 - 1994 Paleoindian Aggregations on the Great Plains. *Journal of Anthropological Archaeology* 13:341-370.
 - 1995 Dating Folsom Occupations on the Southern Plains: The Lipscomb and Waugh Sites. *Journal of Field Archaeology* 22:421-437.
 - 1996 Early Hunter-Gatherers of the Central Great Plains: Paleoindian and Mesoindian (Archaic) Cultures. In *Archaeology and Paleoecology of the Central Great Plains: A Volume in the Central and Northern Plains Archaeological Overview*, edited by J. Hofman, pp. 41-100. Arkansas Archaeological Survey, Research Series No. 48. Fayetteville, Arkansas.
- Hofman, J., D. Amick, and R. Rose
- 1990 Shifting Sands: A Folsom-Midland Assemblage from a Campsite in Western Texas. *Plains Anthropologist* 35:221-253.
- Hofman, J. and R. Brooks
- 1989 Prehistoric Complexes in the Southern Great Plains. In *From Clovis to*

Comanchero: Archeological Overview of the Southern Great Plains, pp. 61-70, by J. Hofman, R. Brooks, J. Hays, D. Owsley, R. Jantz, M. Marks, and M. Manhein. Arkansas Archeological Survey, Research Series No. 35. Fayetteville, Arkansas.

Hofman, J., B. Carter, and M. Hill

- 1992 Folsom Occupation at the Waugh Site in Northwestern Oklahoma. *Current Research in the Pleistocene* 9:22-25.

Hofman, J. and S. Hays

- 1989 A History of Archaeological Research on the Southern Great Plains. In *From Clovis to Comanchero: Archeological Overview of the Southern Great Plains*, pp. 15-24, by J. Hofman, R. Brooks, J. Hays, D. Owsley, R. Jantz, M. Marks, and M. Manhein. Arkansas Archeological Survey, Research Series No. 35. Fayetteville, Arkansas.

Hofman, J. and L. Todd

- 1990 The Lipscomb Bison Quarry: 50 Years of Research. *Regional Symposium for Southeastern New Mexico and Western Texas Transactions* 25:43-58.
- 1997 Reinvestigation of the Perry Ranch Plainview Bison Bonebed, Southwestern Oklahoma. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 101-117. Memoir 29. *Plains Anthropologist* 42, Part 1.

Hofman, J., L. Todd, and M. Collins

- 1991 Identification of Central Texas Edwards Chert at the Folsom and Lindenmier Sites. *Plains Anthropologist* 36:297-308.

Hofman, J., L. Todd, C. Schultz, and W. Hendey

- 1991 The Lipscomb Bison Quarry: Continuing Investigation at a Folsom Site on the Southern Plains. *Texas Archeological Society Bulletin* 60:149-189.

Holden, W.

- 1999 Some Recent Explorations and Excavations in Northwest Texas. *Texas Archaeological and Paleontological Society Bulletin* 1:23-25. (Texas Archaeological Society Reprint)

Holen, S.

- 1991 Bison Hunting Territories and Lithic Acquisition among the Pawnee: An Ethnohistoric and Archaeological Study. In *Raw Material Economies among Prehistoric Hunter-Gatherers*, edited by A. Montet-White and S. Holen, pp. 335-356. Westview Press. Boulder, Colorado.

Holliday, V.

1987 Cultural Chronology. In *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*, edited by E. Johnson, pp. 22-25. Texas A&M University Press. College Station, Texas.

1997 *Paleoindian Geoarchaeology of the Southern High Plains*. University of Texas Press. Austin, Texas.

Holliday, V., E. Johnson, H. Haas, and R. Stuckenrath

1985 Radiocarbon Ages from the Lubbock Lake Site: 1981-1984. *Plains Anthropologist* 30:277-291.

Holliday, V. and C. Welty

1981 Lithic Tool Resources of the Eastern Llano Estacado. *Bulleting of the Texas Archaeological Society* 52:201-214.

Hollimon, S. and D. Owsley

1994 Osteology of the Fay Tolton Site: Implications for Warfare during the Initial Middle Missouri Variant. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D. Owsley and R. Jantz, pp. 345-353. Smithsonian Institution Press. Washington, District of Columbia.

Holloway, R. and V. Bryant

1985 Introduction. In *Pollen Records of Late-Quaternary North American Sediments*, edited by V. Bryant and R. Holloway, pp. xi-xiii. American Association of Stratigraphic Palynologists Foundation. Dallas, Texas.

Holman, E.

1983 Time Scales and Taxonomic Survivorship. *Paleobiology* 9:20-25.

Holmes, W.

1894 An Ancient Quarry in Indian Territory. *Smithsonian Institution, Bureau of Ethnology Bulletin* 21:1-19. Washington, District of Columbia.

1897 Stone Implements of the Potomac-Chesapeake Tidewater Province. *Smithsonian Institution, Bureau of Ethnology, Annual Report 1893-1894*, pp. 3-149. Washington, District of Columbia.

Honea, K.

1964 *A Late Archaic Horizon Site near Folsom, New Mexico (LA8120)*. Museum of New Mexico, Laboratory of Anthropology and New Mexico State Highway Department. Santa Fe, New Mexico.

Hoover, K.

- 1984 *The Elements of Social Scientific Thinking*. Saint Martin's Press. New York, New York.
- Horn, H.
 1968 The Adaptive Significance of Colonial Nesting in the Brewer's Blackbird (*Euphagus cyanocephalus*). *Ecology* 49:682-694.
- Hornaday, W.
 1887 The Extermination of the American Bison with a Sketch of its Discovery and Life History. In *Report of the United States National Museum for 1887*, pp. 367-548. Washington, District of Columbia.
- 1904 The Order of Hoofed Animals. *The American Natural History*. Charles Scribner's Sons. New York, New York.
- Howard, C.
 1974 The Atlatl: Function and Performance. *American Antiquity* 39:102-104.
- Howard, H.
 1930 A Census of the Pleistocene Birds of Rancho la Brea from the Collections of the Los Angeles Museum. *Condor* 32:81-88.
- Howell, C. and W. Blanc
 1992 *A Practical Guide to Archaeological Photography*. The Institute of Archaeology, Archaeological Research Tools, Volume 6. Los Angeles, California.
- Howell, J.
 Some Structural Factors in the Accumulation of Oil in Southwestern Oklahoma. *Economic Geology* 17(1).
- Hubener, J.
 1991 Late Prehistoric Bison Populations in Central and Southern Texas. *Plains Anthropologist* 36:343-358.
- Hubener, J. and T. Boutton
 1991 Stable Carbon Isotope Analysis of Prehistoric Bison bison Diet. Paper presented at the 42nd Annual American Institute of Biological Sciences Meeting. San Antonio, Texas.
- Huckell, B.
 1989 Hudson-Meng Chipped Stone. In *The Hudson-Meng Site: An Alberta Bison Kill in the Nebraska High Plains*, by L. Agenbroad, pp. 153-191. Crayton Printers. Caldwell, Idaho. (Reprint)

Hudson, J.

- 1993 *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*. Center for Archaeological Investigations, Occasional Paper No. 21. Carbondale, Illinois.

Hughes, D.

- 1977a Analysis of Certain Prehistoric Bison Kills in the Texas Panhandle and Adjacent Areas. Unpublished master's thesis, Department of Anthropology, University of Arkansas. Fayetteville, Arkansas.
- 1977b Index to Archaeological Survey Reports and Manuscripts Resulting from Assessments of USDA, Soil Conservation Service Watershed Projects in Oklahoma. USDA, Natural Resources Conservation Service, Cultural Resources Section, State Office. Stillwater, Oklahoma.
- 1980 Archaic Nomenclature in Western Oklahoma. In *Archaic Prehistory on the Prairie-Plains Border*, edited by A. Johnson, pp. 121-144. University of Kansas, Publications in Anthropology No. 12. Lawrence, Kansas.
- 1984 The Foragers: Western Oklahoma. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 109-117. Academic Press. New York, New York.
- 1989 Terminal Archaic Bison Kills in the Texas Panhandle. In *In Light of Past Experience: Papers in Honor of Jack T. Hughes*, edited by B. Roper, pp. 183-204. Panhandle Archeological Society, Publication No. 5. Clarendon, Texas.
- 1994 *Analysis of Material from Archaeological Site 14MT183, Cimarron National Grasslands, United States Forest Service, Morton County, Kansas*. Wichita State University. Wichita, Kansas.

Hughes, D. and A. Hughes-Jones

- 1987 *The Courson Archaeological Projects, Final 1985 and Preliminary 1986*. Innovative Publishing, Incorporated. Perryton, Texas.

Hughes, J.

- Little Sunday: An Archaic Site in the Texas Panhandle. *Texas Archeological Society Bulletin* 26:55-74.
- 1959 *Archaeological Survey of Greenbelt Reservoir, Donley County, Texas*. National Park Service. Panhandle-Plains Historical Museum. Canyon, Texas.
- 1962 Lake Creek: A Woodland Site in the Texas Panhandle. *Texas Archeological Society Bulletin* 32:65-84.

- 1976 The Panhandle Archaic. In *The Texas Archaic: A Symposium*, edited by T. Hester, pp. 28-38. Center for Archaeological Research, Special Report No. 2. San Antonio, Texas.
- 1991 Prehistoric Cultural Developments of the Texas High Plains. *Texas Archaeological Society Bulletin* 60:1-55.
- Hughes, J. and J. Hood
 1976 *Archaeological Testing in the Lakeview Watershed, Hall County, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- Hughes, J., C. Hood, and B. Newman
 1978 *Archaeological Testing of the Red Deer Creek Watershed in Gray, Roberts, and Hemphill Counties, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- Hughes, J., C. Hood, B. Newman, and P. Hughes
 1977 *Final Report on an Archaeological Survey of the Red Deer Creek Watershed in Gray, Roberts, and Hemphill Counties, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- Hughes, J. and P. Willey
 1978 *Archaeology at Mackenzie Reservoir*. Texas Historical Commission, Survey Report No. 24. Austin, Texas.
- Hughes, S.
 1986 A Modern Analog to a Bison Jump. *Wyoming Archaeologist* 29:45-67.
- Hunt, C.
 1974 *Natural Regions of the United States and Canada*. W. H. Freeman and Company. San Francisco, California.
- Hurst, S. and K. Rebnegger
 1999 The Hidden Virtues of Ogallala Quartzite. Paper presented at the 57th Annual Plains Anthropological Conference. Sioux Falls, South Dakota.
- Hutchinson, G.
 1959 Homage to Santa Rosalia, or Why Are There So Many Animals? *American Naturalist* 93:145-159.
- 1965 *The Ecological Theater and the Evolutionary Play*. Yale University Press. New Haven, Connecticut.

- 1975 Variations on a Theme by Robert MacArthur. In *Ecology and the Evolution of Communities*, edited by M. Cody and J. Diamond, pp. 492-521. Harvard University Press. Cambridge, Massachusetts.
- Irwin, H.
1971 Developments in Early Man Studies in Western North America, 1960-1970. *Arctic Anthropology* 35:24-34.
- Irwin, H. and C. Irwin
1959 *Excavations at the LoDaisKa Site in the Denver, Colorado Area*. Denver Museum of Natural History, Proceedings No. 8. Denver, Colorado.
- Irwin, J.
1977 Water Resources. In *Geography of Oklahoma*, edited by J. Morris, pp. 25-39. Oklahoma Historical Society. Oklahoma City, Oklahoma.
- Irwin-Williams, C.
1968 The Reconstruction of Archaic Culture in the Southwestern United States. In *Archaic Prehistory in the Western United States*, edited by C. Irwin-Williams, pp. 19-23. Eastern New Mexico University, Contributions in Anthropology No. 1. Portales, New Mexico.
- Irwin-Williams, C. and H. Irwin
1966 *Excavations at Magic Mountain: A Diachronic Study of Plains-Southwest Relations*. Denver Museum of Natural History, Proceedings No. 12. Denver, Colorado.
- Jackson, J.
1983 *Snakes of the Southeastern United States*. University of Georgia, College of Agriculture, Publications Section No. MP-142. Athens, Georgia.
- Jennings, J.
1956 The American Southwest: A Problem in Cultural Isolation. *American Antiquity* 22:61-127.

1989 *Prehistory of North America*. McGraw-Hill. New York, New York.
- Jochim, M.
1979 Breaking Down the System: Recent Ecological Approaches in Archaeology. In *Advances in Archaeological Method and Theory*, Volume 2, edited by M. Schiffer, pp. 77-117. Academic Press. New York, New York.

1981 *Strategies for Survival: Cultural Behavior in an Ecological Context*. Academic Press. New York, New York.

- 1983 Optimization Models in Context. In *Archaeological Hammers and Theories*, edited by J. Moore and A. Keene, pp. 157-172. Academic Press. New York, New York.
- Johnson, A. and A. Johnson
- 1998 The Plains Woodland. In *Archaeology of the Great Plains*, edited by W. Wood, pp. 173-200. University Press of Kansas. Lawrence, Kansas.
- Johnson, A. and W. Wood
- 1980 Prehistoric Studies on the Plains. In *Anthropology on the Great Plains*, edited by W. Wood and M. Liberty, pp. 35-51. University of Nebraska Press. Lincoln, Nebraska.
- Johnson, E.
- 1977 Animal Food Resources of Paleoindians. In *Paleoindian Lifeways*, edited by E. Johnson, pp. 65-77. Texas Tech University, The Museum Journal No. 17. Lubbock, Texas.
- 1987a Paleoenvironmental Overview. In *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*, edited by E. Johnson, pp. 90-99. Texas A&M University Press. College Station, Texas.
- 1987b *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*. Texas A&M University Press. College Station, Texas.
- 1987c Cultural Activities and Interactions. In *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*, edited by E. Johnson, pp. 120-158. Texas A&M University Press. College Station, Texas.
- 1991 Late Pleistocene Cultural Occupation of the Southern Plains. In *Clovis: Origins and Adaptations*, edited by R. Bonnicksen and K. Turnmire, pp. 215-236. Center for the Study of the First Americans. Corvallis, Oregon.
- Johnson, E. and V. Holliday
- 1986 The Archaic Record at Lubbock Lake. In *Current Trends in Southern Plains Archaeology*, edited by T. Baugh, pp. 7-54. Memoir 21. Plains Anthropologist 31, Part 2.
- 1987a Summary. In *Lubbock Lake: Late Quaternary Studies on the Southern High Plains*, edited by E. Johnson, pp. 159-162. Texas A&M University Press. College Station, Texas.
- 1987b Lubbock Lake Artifact Assemblages. In *Lubbock Lake: Late Quaternary*

Studies on the Southern High Plains, edited by E. Johnson, pp. 100-119. Texas A&M University Press. College Station, Texas.

Johnson, F. and T. Milby

1989 *Oklahoma Botanical Literature*. University of Oklahoma Press. Norman, Oklahoma.

Johnson, K.

1979 Introduction to the Geology of Oklahoma. In *Geology and Earth Resources of Oklahoma*, by K. Johnson, C. Branson, N. Curtis, W. Ham, W. Harrison, M. Marcher, and J. Roberts, p. 1. Oklahoma Geological Survey, Educational Publication No. 1. Norman, Oklahoma.

Johnson, L.

1967 *Toward a Statistical Overview of the Archaic Cultures of Central and Southwestern Texas*. Texas Memorial Museum Bulletin No. 12. Austin, Texas.

Judson, S.

1953 *Geology of the San Jon Site, Eastern New Mexico*. Smithsonian Institution, Miscellaneous Collections 121(1). Washington, District of Columbia.

Kamminga, J.

1979 The Nature of Use-Polish and Abrasive Smoothing on Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 143-157. Academic Press. New York, New York.

Kaplan, H. and K. Hill

1992 The Evolutionary Ecology of Food Acquisition. In *Evolutionary Ecology and Human Behavior*, edited by E. Smith and B. Winterhalder, pp. 167-201. Aldine de Gruyter. New York, New York.

Katz, S. and P. Katz

1976 *Archaeological Investigation in Lower Tule Canyon, Briscoe County, Texas*. Texas Historical Commission, Archaeological Survey Report No. 16. Austin, Texas.

Kay, M.

1976 Wear Analysis and Unifacial Scraping Tool Morphology: Implications for Studying Individual Use. In *The Individual in Prehistory: Studies in Variability in Style in Prehistoric Technologies*, edited by J. Hill and J. Gunn, pp. 231-245. Academic Press. New York, New York.

1998 The Central and Southern Plains Archaic. In *Archaeology of the Great Plains*, edited by W. Wood, pp. 173-200. University Press of Kansas. Lawrence,

Kansas.

Keeley, L.

1980 *Experimental Determination of Stone Tool Uses: A Microwear Analysis*. University of Chicago Press. Chicago, Illinois.

1982 Hafting and Retooling: Effects on the Archaeological Record. *American Antiquity* 47:798-809.

Kehoe, A.

1992 *North American Indians: A Comprehensive Account*. Prentice-Hall. Englewood Cliffs, New Jersey.

Kehoe, T.

1967 *The Boarding School Bison Drive Site*. Memoir 4. Plains Anthropologist 12, Part 1.

1973 *The Gull Lake Site: A Prehistoric Bison Drive in Southwestern Saskatchewan*. Milwaukee Public Museum, Publications in Anthropology No. 1. Milwaukee, Wisconsin.

Kehoe, T. and A. Kehoe

1960 Observations on the Butchering Technique at a Prehistoric Bison Kill in Montana. *American Antiquity* 25:420-423.

Keiss, R.

1969 Comparison of Eruption-Wear Patterns and Cementum Annuli as Age Criteria in Elk. *Journal of Wildlife Management* 33:175-180.

Kelley, J. and M. Hanen

1988 *Archaeology and the Methodology of Science*. University of New Mexico Press. Albuquerque, New Mexico.

Kelly, R.

1983 Hunter-Gatherer Mobility Strategies. *Journal of Anthropological Research* 39:277-306.

1988 The Three Sides of a Biface. *American Antiquity* 53:717-731.

1995 *The Foraging Spectrum*. Smithsonian Institution Press. Washington, District of Columbia.

Kelly, R. and L. Todd

1988 Coming into the Country: Early Paleoindian Hunting and Mobility. *American*

Antiquity 53:231-244.

Kelting, R. and W. Penfound

- 1953 Literature on the Vegetation of Oklahoma. *Oklahoma Academy of Science Proceedings* 42:126-135.

Kent, S.

- 1981 The Dog: An Archaeologist's Best Friend or Worst Enemy. The Spatial Distribution of Faunal Remains. *Journal of Field Archaeology* 8:367-372.

Keyser, J.

- 1979 Late Prehistoric Period Bison Procurement on the Milk River in North-Central Montana. *Archaeology in Montana* 20(1):1-241.

Kimball, L., J. Kimball, and P. Allen

- 1995 Microwear Polishes as Viewed through the Atomic Force Microscope. *Lithic Technology* 20:6-28.

Kindscher, K.

- 1987 *Edible Wild Plants of the Prairie: An Ethnobotanical Guide*. University Press of Kansas. Lawrence, Kansas.

- 1992 *Medicinal Wild Plants of the Prairie: An Ethnobotanical Guide*. University Press of Kansas. Lawrence, Kansas.

Kingsbury, L. and M. Nowak

- 1980 *Archaeological Investigations on Carizo Ranches, Incorporated, 1974-1979*. Colorado College, Publications in Anthropology No. 2. Colorado Springs, Colorado.

Kirk, D.

- 1975 *Wild Edible Plants of the Western United States*. Naturegraph Publishers, Incorporated. Healdsburg, California.

Klein, R. and K. Cruz-Uribe

- 1983 The Computation of Ungulate Age (Mortality) Profiles from Dental Crown Heights. *Paleobiology* 9:70-78.

- 1984 *The Analysis of Animal Bones from Archaeological Sites*. University of Chicago Press. Chicago, Illinois.

Knighton, D.

- 1984 *Fluvial Forms and Processes*. E. Arnold Publishing. London, England.

- Knox, J.
 1983 Responses of River Systems to Holocene Climates. In *Late-Quaternary Environments of the United States*, edited by H. Wright, Jr., pp. 26-41. University of Minnesota Press. Minneapolis, Minnesota.
- Knudson, R.
 1983 *Organizational Variability in Late Paleo-Indian Assemblages*. Washington State University, Laboratory of Anthropology, Reports of Investigation. Pullman, Washington.
- Knutsen, K.
 1975 *Wild Plants You Can Eat: A Guide to Identification and Preparation*. Doubleday and Company, Incorporated. Garden City, New York.
- Koch, W.
 1934 The Age Order of Epiphyseal Union in the Skeleton of the European Bison (Bos bonasus L.) *The Anatomical Record* 61:371-376.
- Kortschak, H., C. Hartt, and G. Burr
 1965 Carbon Dioxide Fixation in Sugarcane Leaves. *Plant Physiology* 40:209-213.
- Kraft, K.
 1993 A Preliminary Analysis of the Cooper Bonebed (34HP45), Harper County, Oklahoma. Manuscript on file at the Oklahoma Archeological Survey. Norman, Oklahoma.
- 1994a Metric and Non-Metric Analyses of Trench C Materials. Paper presented at the 52nd Annual Plains Anthropological Conference. Lubbock, Texas.
- 1994b Certain Site: Soil Coring at a Late Archaic/Woodland Transition Bison Kill in Western Oklahoma. University of Oklahoma, Graduate Student Research Grant. Paper presented at *Graduate Student Research Day*. Norman, Oklahoma.
- 1995 Examining Lithic Technological Strategies at a Bison Kill in Western Oklahoma. University of Oklahoma, Graduate Student Research Grant. Paper presented at *Graduate Student Research Day*. Norman, Oklahoma.
- 1996 Predicting Bison Kill Site Locations on the Southern Plains Using Vector GIS. *Oklahoma Anthropological Society Newsletter* 44(3):6-8.
- 1997a The Distribution of Alibates Silicified Dolomite Clasts along the Canadian River. *Current Research in the Pleistocene* 14:106-109.

- 1997b Archaeological Site Formation Processes: Environmental Factors Affecting Modern Bones and an Analogy for Interpreting the Archaeological Record. University of Oklahoma, Graduate Student Research Grant. Paper presented at *Graduate Student Research Day*. Norman, Oklahoma.
- 1998 Multiple Bedrock Exposures of Alibates Silicified Dolomite along the Eastern Edge of the Caprock Escarpment. *Oklahoma Academy of Science Proceedings* 78:138.
- Kraft, K. and L. Bement
- 1995 Continued Research at the Late Archaic Certain Site, Western Oklahoma. Paper presented at the 53rd Annual Plains Anthropological Conference. Laramie, Wyoming.
- Kraft, K. and W. Lail
- 1998 Paleoindian Tool-Stone Utilization in Eastern Oklahoma: An Argument for Limited Mobility. *Current Research in the Pleistocene* 15:27-29.
- 1999 Geomorphological Changes in the Upper Reaches of Sergeant Major Creek, Oklahoma. *Current Research in the Pleistocene* 16:137-138.
- Kraft, K. and J. Thurmond
- n. d. *Oklahoma Anthropological Society Excavations at the Beaver Dam Site (34RM208) with Comments on Southern Plains Cultural Chronology from Calf Creek to Woodland*. Oklahoma Anthropological Society, Memoir No. 10.
- Krober, A.
- 1939 *Cultural and Natural Areas of Native North America*. University of California Publications in American Archaeology and Ethnology, Volume No. 38. University of California Press. Berkley, California.
- Krogman, W.
- 1962 *The Human Skeleton in Forensic Medicine*. Charles C. Thomas. Springfield, Illinois.
- Kuhn, T.
- 1996 *The Structure of Scientific Revolutions*. University of Chicago Press. Chicago, Illinois.
- Kuhn, D., E. Amsel, and M. O'Loughlin
- 1988 *The Development of Scientific Thinking Skills*. Academic Press. New York, New York.
- Kurtén, B.

- On the Variation and Population Dynamics of Fossil and Recent Mammal Populations. *Acta Zoologica Fennica* 76:1-122.
- 1963 Observations on Allometry in Mammalian Dentitions: Its Interpretation of Evolutionary Significance. *Acta Zoologica Fennica* 86:1-13.
- Kusimba, S.
 2005 What Is a Hunter-Gatherer? Variation in the Archaeological Record of Eastern and Southern Africa. *Journal of Archaeological Research* 13:337-366.
- Lail, W.
 1997 Gravel Bar Archaeology: Paleoindian Flaked Tools, Mastodon Remains, and other Intriguing Finds in Eastern Oklahoma. Paper presented at the 55th Annual Plains Anthropological Conference. Boulder, Colorado.
- 1999 Stone Tool Technology, Mobility, and Agricultural Dependence in Southeastern Arizona. Unpublished master's thesis, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.
- Larson, F.
 1940 The Role of the Bison in Maintaining the Short Grass Plains. *Ecology* 21:113-121.
- Larson, M. and M. Kornfeld
 1997 Chipped Stone Nodules: Theory, Method, and Examples. *Lithic Technology* 22:4-18.
- Lawrence, R.
 1977 Experimental Evidence for the Significance of Attributes Used in Edge-Damage Analysis. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 113-121. Academic Press. New York, New York.
- Laws, R.
 1952 A New Method of Age Determination for Mammals. *Nature* 169:972-973.
- Lawton, S.
 1968 The Duncan-Wilson Bluff Shelter: A Stratified Site of the Southern Plains. *Oklahoma Anthropological Society Bulletin* 16:1-94.
- Lee, R.
 1972 The !Kung Bushmen of Botswana. In *Hunters and Gatherers Today*, edited by M. Bicchieri, pp. 327-368. Holt, Rinehart, and Winston. New York, New York.

- 1979 *The !Kung Bushman of Botswana: Men, Women, and Work in a Foraging Society*. Cambridge University Press. Cambridge, England.
- Lees, W., D. Scott, and C. Haynes
 2001 History Underfoot: The Search for Physical Evidence of the 1868 Attack on Black Kettle's Village. *Chronicles of Oklahoma* 79:158-181.
- Leechman, D.
 1951 Bone Grease. *American Antiquity* 17:355-356.
- Leonhardy, F.
 1966a *Test Excavations in the Mangum Reservoir Area of Southwestern Oklahoma*. Museum of the Great Plains, Contributions No. 2. Lawton, Oklahoma.
 1966b *Domebo: A Paleo-Indian Mammoth Kill in the Prairie-Plains*. Museum of the Great Plains, Contributions No. 1. Lawton, Oklahoma.
- LeTourneau, P.
 1992 Folsom Use of Alibates and Edwards Chert: Raw Material Procurement and Technological Organization. *Current Research in the Pleistocene* 9:66-69.
- Leventer, A., W. Momack, S. Ishman, S. Brachfeld, C. McClennen, and P. Manley
 1996 Productivity Cycles of 200-300 Years in the Antarctic Peninsula Region: Understanding Linkages among the Sun, Atmosphere, Oceans, Sea Ice, and Biota. *Geological Society of America Bulletin* 108:1626-1644.
- Levi-Strauss, C.
 1982 *The Way of the Masks*. University of Washington Press. Seattle, Washington.
- Lewis, R.
 1986 Why Are Early Woodland Base Camps So Rare? In *Early Woodland Archaeology*, edited by K. Farnsworth and T. Emerson, pp. 596-597. Center for American Archaeology, Seminars in Archaeology No. 2. Kampsville, Illinois.
- Lie, R.
 1980 Minimum Number of Individuals from Osteological Samples. *Norwegian Archaeological Review* 14:24-30.
- Lintz, C.
 1974 An Analysis of the Custer Focus and Its Relationship to the Plains Village Horizon in Oklahoma. University of Oklahoma, Department of Anthropology. *Papers in Anthropology* 15:1-72.
 1976 Test Excavations at the Kenton Bison Kill Site (CI-81), Cimarron County,

- Oklahoma. *Oklahoma Anthropological Society Newsletter* 24(7):2-7.
- 1978 The Johnson-Cline Site (34-Tx-40): An Upland Dune Site in the Oklahoma Panhandle. *Oklahoma Anthropological Society Bulletin* 27:111-140.
- 1986 *Architecture and Community Variability within the Antelope Creek Phase of the Texas Panhandle*. Oklahoma Archeological Survey, Studies in Oklahoma's Past No. 14. Norman, Oklahoma.
- 1995 Radiocarbon Dates from the Chalk Hollow Site: A Stratified Archaic-Woodland Site in Randall County, Texas. Paper presented at the 53rd Annual Plains Anthropological Conference. Laramie, Wyoming.
- Lintz, C., J. Speth, D. Hughes, and J. Huebner
 1991 Additional Radiocarbon Dates from the Twilla Bison Kill Site, Hall County, Texas. *Texas Archeological Society Bulletin* 60:257-266.
- Lintz, C. and G. Zabawa
 1984 The Kenton Caves of Western Oklahoma. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 161-175. Academic Press. New York, New York.
- Little, E.
 2002 *Forest Trees of Oklahoma: How to Know Them*. State Department of Agriculture, Oklahoma Forestry Services, Revised Edition No. 17. Oklahoma City, Oklahoma.
- Litwinionek, L., E. Johnson, and M. Davis
 1997 Survey at the Southeastern Edge of the Llano Estacado. *Texas Archaeological Society Bulletin* 68:301-335.
- Logan, B.
 1998 The Fat of the Land: White Rock Phase Bison Hunting and Grease Production. *Plains Anthropologist* 43:349-366.
- Lopez, D.
 1970 The McLemore Cemetery Complex: An Analysis of Prehistoric Burial Customs. *Oklahoma Anthropological Society Bulletin* 19:137-150.
- Lorrain, D.
 1968 Analysis of the Bison Bones from Bonfire Shelter. In *Bonfire Shelter: A Stratified Bison Kill Site, Val Verde County, Texas*, by D. Dibble and D. Lorrain, pp. 78-134. Texas Memorial Museum, Miscellaneous Papers No. 1. Austin, Texas.

Lott, D.

1972 Bison Would Rather Breed than Fight. *Natural History* 81:40-45.

1979 Dominance Relations and Breeding Rate in Mature Male American Bison. *Zeitschrift für Tierpsychologie* 49:418-432.

Lovejoy, A.

1964 *The Great Chain of Being*. Harvard University Press. Cambridge, Massachusetts.

Low, W. and I. Cowan

1963 Age Determination of Deer by Annular Structure of Dental Cementum. *Journal of Wildlife Management* 27:466-471.

Lundelius, E.

1967 Late-Pleistocene and Holocene Faunal History of Central Texas. In *Pleistocene Extinctions: The Search for a Cause*, edited by P. Martin and H. Wright, pp. 287-336. Yale University Press. New Haven, Connecticut.

Lyman, R.

1984a Bone Density and Differential Survivorship of Fossil Classes. *Journal of Anthropological Archaeology* 3:259-299.

1984b Broken Bones, Bone Expediency Tools, and Bone Pseudotools: Lessons from the Blast Zone around Mount St. Helens, Washington. *American Antiquity* 49:315-333.

1991 Taphonomic Problems with Archaeological Analyses of Animal Carcass Utilization and Transport. In *Beamers, Bobwhites, and Blue-Points: Tributes to the Career of Paul W. Parmalee*, edited by J. Purdue, W. Kippel, and B. Styles, pp. 125-138. Illinois State Museum, Scientific Papers No. 23. Springfield, Missouri.

Lynott, M.

1979 Prehistoric Bison Populations of North-Central Texas. *Texas Archeological Society Bulletin* 50:89-101.

MacArthur, R.

1960 On the Relation between Reproductive Value and Optimal Predation. *Proceedings of the National Academy of Sciences* 46:143-145.

1961 Population Effects of Natural Selection. *American Naturalist* 95:195-199.

1965 Ecological Consequences of Natural Selection. In *Theoretical and Mathematical Biology*, edited by T. Waterman and H. Morowitz, pp 388-397. Blaisdell

Publishing. New York, New York.

MacArthur, R. and E. Pianka

- 1966 On Optimal Use of Patchy Environments. *American Naturalist* 100:603-609.

McCoy, D.

- 1980 *Roadside Wild Fruits of Oklahoma*. University of Oklahoma Press. Norman, Oklahoma.
- 1981 *Roadside Trees and Shrubs of Oklahoma*. University of Oklahoma Press. Norman, Oklahoma.
- 1987 *Oklahoma Wildflowers*. D. McCoy Publishing. Lindsay, Oklahoma.

MacDonald, D. and B. Hewlett

- 1999 Reproductive Interests and Forager Mobility. *Current Anthropology* 40:501-523.

McDonald, J.

- 1981 *North American Bison: Their Classification and Evolution*. University of California Press. Berkley, California.

McDowell, L. (Editor)

- 1984 *Nutrition of Grazing Ruminants in Warm Climates*. Academic Press. New York, New York.

McGookey, D., T. Gustavson, and A. Hoadley

- 1988 *Regional Structural Cross Sections, Mid-Permian to Quaternary Strata, Texas Panhandle and Eastern New Mexico: Distribution of Evaporites and Areas of Evaporite Dissolution and Collapse*. Texas Bureau of Economic Geology, Cross Sections. Austin, Texas.

McGowen, J., G. Granata, and S. Seni

- 1979 *Depositional Framework of the Lower Dockum Group (Triassic), Texas Panhandle*. Texas Bureau of Economic Geology, Report of Investigations No. 97. Austin, Texas.

McHugh, T.

- 1958 Social Behavior of the American Buffalo (Bison bison bison). *Zoologica* 43:1-40.
- 1972 *The Time of the Buffalo*. Alfred A. Knopf. New York, New York.

- McIntyre, M.
1973 *Physical Geography*. Ronald Press. New York, New York.
- McKee, E., S. Oriel, H. Berryhill, T. Cheney, E. Cressman, E. Crosby, G. Dixon, W. Hallgarth, K. Ketner, M. MacLachlan, E. Maughan, V. McKelvey, M. Mudge, D. Myers, and R. Sheldon
1967 *Paleotectonic Investigations (Maps) of the Permian System of the United States*. United States Geological Survey, Professional Papers No. 515. Denver, Colorado.
- McKelvey, S.
1955 *Botanical Exploration of the Trans-Mississippi West, 1790-1850*. Arnold Arboretum, Harvard University. Jamaica Plains, Massachusetts.
- McNaughton, S.
1990 Mineral Nutrition and Seasonal Movements of African Migratory Ungulates. *Nature* 345:613-615.
- MacNeish, R. (Editor)
1973 *Early Man in America: Readings from the Scientific American*. W. H. Freeman. San Francisco, California.
- Macinko, G.
1978 Conceptual Frameworks for the Study of Humans and Their Environment. In *Sourcebook on the Environment: A Guide to the Literature*, edited by K. Hammond, G. Macinko, and W. Fairchild, pp. 5-19. University of Chicago Press. Chicago, Illinois.
- Madle, H.
1972 Appendix I. Geology of the Olsen-Chubbuck Site. In *The Olsen-Chubbuck Site: A Paleo-Indian Bison Kill*, by J. Wheat, pp. 171-177. Memoir 26. American Antiquity 37, Part 2.
- Madole, R.
1995 Spatial and Temporal Patterns of Late Quaternary Eolian Deposition, Eastern Colorado, USA. *Quaternary Science Review* 14:155-177.
- Madole, R., C. Ferring, M. Guccione, S. Hall, W. Johnson, and C. Sorenson
1991 Quaternary Geology of the Osage Plains and Interior Highlands. In *The Geology of North America, Volume K-2*, edited by R. Morris, pp. 503-546. The Geological Society of America. Boulder, Colorado.
- Magne, M.
1989 Lithic Reduction Stages and Assemblage Formation Processes. In *Experiments*

in *Lithic Technology*, edited by D. Amick and R. Mauldin, pp. 15-47. British Archaeological Reports, International Series No. 528. Oxford, England.

Malin, J.

1967 *The Grassland of North America: Prolegomena to its History and Postscript*. Peter Smith Publishing. Gloucester, Massachusetts.

Malinowski, B.

1922 *Argonauts of the Western Pacific*. E. P. Dutton. New York, New York.

Malone, J.

1970 *Archaeological Reconnaissance in the Mackenzie Reservoir Area of Tule Canyon*. Texas Historical Survey Committee and Texas Water Development Board, Archaeological Survey Report No. 8. Austin, Texas.

Mallouf, R.

1976 *Archaeological Investigations at Proposed Big Pine Lake, 1974-1975, Lamar and Red River Counties, Texas*. Texas Historical Commission, Archaeological Survey Report No. 18. Austin, Texas.

1989 Quarry Hunting with Jack T. Hughes: Tecovas Jasper in the South Basin of the Canadian River, Oldham County, Texas. In *In Light of Past Experience: Papers in Honor of Jack T. Hughes*, edited by B. Roper, pp. 307-326. Panhandle Archaeological Society, Publication No. 5. Clarendon, Texas.

Mandel, R.

1992 Soils and Holocene Landscape Evolution in Central and Southwestern Kansas: Implications for Archaeological Research. In *Soils in Archaeology: Landscape Evolution and Human Occupation*, edited by V. Holliday, pp. 41-100. Smithsonian Institution Press. Washington, District of Columbia.

1995 Geomorphic Controls of the Archaic Record in the Central Plains of the United States. In *Archaeological Geology of the Archaic Period in North America*, edited by E. Bettis, pp. 37-66. Geological Society of America, Special Paper No. 297. Boulder, Colorado.

Mandeville, M.

1973 A Consideration of the Thermal Pretreatment of Chert. *Plains Anthropologist* 18:177-202.

Marshall, F.

1993 Food Sharing and the Faunal Record. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 228-246. Center for Archaeological

Investigations, Occasional Paper No. 21. Carbondale, Illinois.

Martin, P.

1963 *The Last 10,000 Years*. University of Arizona Press. Phoenix, Arizona.

Mattoon, W. and C. Webster

1943 *Forest Trees of Texas*. Texas Forestry Service, Bulletin No. 20. College Station, Texas.

Mauss, M.

1990 *The Gift: The Form and Reason for Exchange in Archaic Society*. Routledge. New York, New York. (Translated by W. D. Hall)

Meadow, R.

1980 Animal Bones: Problems for the Archaeologist Together with Some Possible Solutions. *Paléorient* 6:65-77.

Meagher, M.

1973 *The Bison of Yellowstone National Park*. United States Department of Interior, National Park Service, Monograph Series No. 1. Government Printing Office. Washington, District of Columbia.

Meech, L.

1968 *The Wolf: The Ecology and Behavior of an Endangered Species*. Natural History Press. Garden City, New Jersey.

Meltzer, D.

1991 Altithermal Archaeology and Paleoecology at Mustang Springs on the Southern High Plains of Texas. *American Antiquity* 56:236-267.

1993 Is there a Clovis Adaptation? In *From Kostenki to Clovis: Upper Paleolithic Paleo-Indian Adaptations*, edited by O. Soffer and N. Praslov, pp. 293-310. Plenum Press. New York, New York.

1995 Modeling the Prehistoric Response to Altithermal Climates on the Southern High Plains. In *Ancient Peoples and Landscapes*, edited by E. Johnson, pp. 349-368. Texas Tech University Museum. Lubbock, Texas.

Meltzer, D. and B. Smith

1986 Paleoindian and Early Archaic Strategies in Eastern North America. In *Foraging, Collecting, and Harvesting: Archaic Period Subsistence and Settlement in the Eastern Woodlands*, edited by S. Neusius, pp. 3-31. Center for Archaeological Investigations, Occasional Paper No. 6. Carbondale, Illinois.

- Merriam, J. and C. Stock
 1932 *The Felidae of Rancho la Brea*. Carnegie Institute of Washington, Publication No. 422. Washington, District of Columbia.
- Messer, E.
 1988 Seasonal Hunger and Coping Strategies: An Anthropological Discussion. In *Coping with Seasonal Constraints*, edited by R. Huss-Ashmore, J. Curry, and R. Hitchcock, pp. 131-141. The University Museum, University of Pennsylvania. Philadelphia, Pennsylvania.
- Miller, D.
 1998 Why Some Things Matter. In *Material Cultures: Why Some Things Matter*, edited by D. Miller, pp. 3-21. University of Chicago Press. Chicago, Illinois.
- Miller, R. and W. Hartman
 1981 *The Grand Tour: A Traveler's Guide to the Solar System*. Workman Publishing. New York, New York.
- Mitchell, J., C. Chandler, and T. Kelley
 1984 The Rudy Haiduk Site (41KA23): A Late Archaic Burial in Karnes County, Texas. *La Tierra* 11:12-39.
- Mithen, S.
 1990 *Thoughtful Foragers: A Study in Prehistoric Decision Making*. Cambridge University Press. Cambridge, England.
- Mloszewski, M.
 1983 *The Behavior and Ecology of the African Buffalo*. Cambridge University Press. Cambridge, England.
- Mobley, C.
 1978 *Archaeological Research and Management at Los Esteros Reservoir, New Mexico*. Southern Methodist University, Archaeological Research Program. Dallas, Texas.
- 1979 *The Terminal Archaic at Los Esteros: A Late Hunter-Gatherer Community on the Joronada-Mogollon Frontier—Joronada Mogollon Archaeology*. New Mexico Historic Preservation Program, Historic Preservation Bureau. Santa Fe, New Mexico.
- Montgomery, J.
 1991 The Role of Seeds and Nuts in Prehistoric Adaptations of the Southern Plains. Paper presented at the Texas Tech University, Anthropology Department

Symposium, *Anthropology on the Southern Plains*, Arts and Sciences
Showcase Week. Lubbock, Texas.

Moore, M.

1984 A Reconnaissance Survey of Quartermaster Creek. In *Archaeology of the Mixed Grass Prairie, Phase I: Quartermaster Creek*, edited by T. Baugh, pp. 51-214. Oklahoma Archeological Survey, Archeological Resource Survey Report No. 20. Norman, Oklahoma.

1988a Fossiliferous Shale: A "New" Tempering Agent in Ceramics in Western Oklahoma. *Oklahoma Anthropological Society Newsletter* 36(1):2-3.

1988b *Archaeology of the Mixed Grass Prairie, Phase 2 and 3: Hay and Cyclone Creeks Surveys and Predictive Modeling in the Quartermaster Watershed*. Oklahoma Archeological Survey, Archeological Resource Survey Report No. 33. Norman, Oklahoma.

Moore, R.

1921 The Relation of Mountain Folding to the Oil and Gas Fields of Southern Oklahoma. *American Association of Petroleum Geologists Bulletin* 5(1). Tulsa, Oklahoma.

Morgan, D.

1996 1995 Oklahoma Anthropological Society Fall Survey. *Oklahoma Anthropological Society Newsletter* 44(1):1.

1999 A Survey of Archaeological Resources in the Packsaddle Wildlife Management Area, Ellis County, Oklahoma. *Oklahoma Anthropological Society Bulletin* 48:51-82.

Morgan, H. and A. Morgan

1984 *Oklahoma: A History*. W. W. Norton and Company. New York, New York.

Morlan, R.

1991 Bison Carpal and Tarsal Measurements: Bulls versus Cows and Calves. *Plains Anthropologist* 36:215-227.

Morris, J.

1977 Minerals, Mineral Industries, and Reclamation in Oklahoma. In *Geography of Oklahoma*, edited by J. Morris, pp. 93-111. Oklahoma Historical Society. Oklahoma City, Oklahoma.

1982 Non-Metallic Resources. In *Drill Bits, Picks, and Shovels: A History of Mineral Resources in Oklahoma*, edited by J. Morris, pp. 162-178. Oklahoma Historical

Society. Oklahoma City, Oklahoma.

Morris, J., C. Goins, and E. McReynolds

1986a Geographic Regions of Oklahoma. *Historical Atlas of Oklahoma*, p. 3. University of Oklahoma Press. Norman, Oklahoma.

1986b Temperature and Rainfall Maps of Oklahoma. *Historical Atlas of Oklahoma*, p. 7. University of Oklahoma Press. Norman, Oklahoma.

1986c Generalized Natural-Vegetation Map of Oklahoma. In *Historical Atlas of Oklahoma*, p. 9. University of Oklahoma Press. Norman, Oklahoma.

Morrow, T.

1996 Lithic Refitting and Archaeological Site Formation Processes: A Case Study from the Twin Ditch Site, Greene County, Illinois. In *Stone Tools: Theoretical Insights into Human Prehistory*, edited by G. Odell, pp. 345-373. Plenum Press. New York, New York.

Munsell Soil Color Charts

1974 *Munsell Color*. MacBeth Division of Kollmorgen Corporation. Baltimore, Maryland.

Murie, A.

1944 *The Wolves of Mount McKinley*. Faunas of the National Parks of the United States, Fauna Series No. 5. Washington, District of Columbia.

Murphy, B. and A. Nier

Variation in the Relative Abundance of the Carbon Isotopes. *Physics Review* 59:771-772.

Muto, G.

1971 A Stage Analysis of the Manufacture of Stone Tools. In *Great Basin Anthropological Conference: Selected Papers*, edited by M. Aiken, pp. 109-118. University of Oregon, Department of Anthropology. Eugene, Oregon.

Nance, C.

1972 Cultural Evidence for the Altithermal in Texas and Mexico. *Current Anthropology* 28:169-192.

National Oceanic and Atmospheric Administration

1974 *Climates of the States*, Volumes 1 and 2. Water Information Center. Port Washington, New York.

1977 Climate of Oklahoma. *Climatology of the United States* 60:18.

- Neal, L. and M. Duncan
1996 Mid-Holocene Radiocarbon Dates from the Kubik Site (34KA354). *Oklahoma Archeological Survey Newsletter* 16(2):3.
- Neck, R.
1987 Changing Holocene Snail Fauna and Environments along the Eastern Caprock Escarpment. *Quaternary Research* 27:312-322.
- Nelson, C.
1969 Salvage Archaeology on Van Bibber Creek, Site 5JF10. *Southwestern Lore* 34:85-106.
- Nelson, R.
1973 *Hunters of the Northern Forest*. University of Chicago Press. Chicago, Illinois.
- Neumann, T.
1991 High-Magnification Use-Wear Analysis of Projectile Points from Southeastern Minnesota. *Plains Anthropologist* 33:367-375.
- Newcomb, W.
1961 *The Indians of Texas: From Prehistoric to Modern Times*. University of Texas Press. Austin, Texas.
- Newcomer, M.
1971 Some Quantitative Experiments in Handaxe Manufacture. *World Archaeology* 3:85-93.
- Newcomer, M., R. Grace, and R. Unger-Hamilton
1988 Microwear Polishes, Blind Tests, and Texture Analysis. In *The Human Uses of Flint and Chert*, edited by G. Sieveking and M. Newcomer, pp. 253-263. Cambridge University Press. Cambridge, England.
- Newcomer, M. and L. Keeley
1978 Testing a Method of Microwear Analysis with Experimental Flint Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 195-205. Academic Press. New York, New York.
- Newman, B.
1976 *The Archaeological Project of the Youth Conservation Corps at the Lake Meredith Recreation Area during the Summer of 1976*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.
- Nichol, R. and G. Creak

- 1979 Matching Paired Elements among Archaeological Bone Remains. *Computer Archaeology Newsletter* 14:6-16.
- Nicholas, G.
1998 Wetlands and Hunter-Gatherers: A Global Perspective. *Current Anthropology* 39:720-731.
- Nicholson, J.
1960 *Geology of the Texas Panhandle*. Bureau of Economic Geology, Publication No. 6017. Austin, Texas.
- Nier, A. and E. Gulbransen
1939 Variation in the Relative Abundance of the Carbon Isotope. *American Chemistry Society Journal* 61:697-698.
- Noel, T., P. Mahoney, and R. Stevens
1994 *Historical Atlas of Colorado*. University of Oklahoma Press. Norman, Oklahoma.
- Northcutt, J.
1979 *An Archaeological Survey in the Gypsum Breaks of the Elm Fork of the Red River*. Museum of the Great Plains, Contributions No. 8. Lawton, Texas.
- Novakowski, N.
1964 Cemental Deposition as an Age Criterion in Bison, and the Relation of Incisor Wear, Eye Lens Weight, and Dressed Bison Carcass Weight to Age. *Canadian Journal of Zoology* 43:173-178.
- O'Brien, M. and R. Lyman (Editor)
2000 *Applying Evolutionary Archaeology: A Systematic Approach*. Kluwer Academic. New York, New York.
- O'Brien, P.
1984 *Archaeology in Kansas*. Museum of Natural History, Publication Series No. 9. Lawrence, Kansas.
- O'Connell, J. and K. Hawkes
1981 Alyawara Plant Use and Optimal Foraging Theory. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 99-125. University of Chicago Press. Chicago, Illinois.
- 1984 Food Choice and Foraging Sites among the Alyawara. *Journal of Anthropological Research* 40:504-535.

Odell, G.

1979 A New and Improved System for the Retrieval of Functional Information from Microscopic Observations of Chipped Stone Tools. In *Lithic Use-Wear Analysis*, edited by B. Hayden, pp. 329-344. Academic Press. New York, New York.

1981a The Morphological Express at Function Junction: Searching for Meaning in Lithic Tool Types. *Journal of Anthropological Research* 37:319-342.

1981b The Mechanics of Use-Breakage of Stone Tools: Some Testable Hypotheses. *Journal of Field Archaeology* 8:197-209.

1988 Addressing Prehistoric Hunting Practices through Stone Tool Analysis. *American Antiquity* 90:335-356.

Odell, G. and F. Odell-Vereeckan

1979 Verifying the Reliability of Lithic Use-Wear Assessments by 'Blind Tests': The Low Power Approach. *Journal of Field Archaeology* 7:87-120.

Odum, E.

1971 *Fundamentals of Ecology*. W. B. Saunders. Philadelphia, Pennsylvania.

Ohnuma, K. and C. Bergman

1981 Experimental Studies in the Determination of Flaking Mode. *Institute of Archaeology Bulletin* 19:161-179.

Oklahoma Archeological Survey

1988 Oklahoma Archeological Survey, Radiocarbon File. Beta Analytic, File No. 28121. Beta Analytic, Incorporated.

Oklahoma Department of Wildlife Conservation

n. d. a *Oklahoma Mammals*. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma.

n. d. b *Oklahoma Furbearers*. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma.

Oklahoma Geological Survey

1917 *Animal and Plant Life in Oklahoma*. Oklahoma Geological Survey, Circular No. 6. Norman, Oklahoma.

Oklahoma Planning and Resources Board

1934 Washita River, Hammon Flood, April 3-4, 1934. Oklahoma Planning and

Resources Board, Division of Water Resources. Oklahoma City, Oklahoma.

Oklahoma Water Resources Board

- 1967 *Appraisal of the Water and Related Land Resources of Oklahoma: Region 1.* Oklahoma Water Resources Board, Publication No. 17. Oklahoma City, Oklahoma.
- 1969 *Appraisal of the Water and Related Land Resources of Oklahoma: Region 4.* Oklahoma Water Resources Board, Publication No. 24. Oklahoma City, Oklahoma.
- 1980 *Synopsis of the Oklahoma Comprehensive Water Plan.* Oklahoma Water Resources Board, Publication No. 94-S. Oklahoma City, Oklahoma.
- 1984 *Oklahoma's Water Atlas.* Oklahoma Water Resources Board, Publication No. 120. Oklahoma City, Oklahoma.

Olausson, D.

- 1980 Starting from Scratch: The History of Edge-Wear Research from 1938-1978. *Lithic Technology* 9:48-60.

O'Leary, M.

- 1988 Carbon Isotopes in Photosynthesis: Fractionation Techniques May Reveal New Aspects of Carbon Dynamics in Plants. *BioScience* 38:328-336.

Owsley, D.

- 1989 The History of Bioarchaeological Research in the Southern Great Plains. In *From Clovis to Comanchero: Archeological Overview of the Southern Great Plains*, pp. 121-136, by J. Hofman, R. Brooks, J. Hays, D. Owsley, R. Jantz, M. Marks, and M. Manhein. Arkansas Archeological Survey, Research Series No. 35. Fayetteville, Arkansas.
- 1994a Warfare in Coalescent Tradition Populations of the Northern Plains. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D. Owsley and R. Jantz, pp. 333-343. Smithsonian Institution Press. Washington, District of Columbia.
- 1994b Osteological Examination of Burials from the Sullivan-Carpenter (*sic*) Site (34RM668) in Oklahoma. Report prepared for and on file at the Oklahoma Archeological Survey.

Palmer, A.

- 1983 The Decade of N. A. Geology: 1983 Geologic Time Scale. *Geology* 11:503-504.

- Park, E.
1969 *The World of the Bison*. J. B. Lippincott. New York, New York.
- Park, R. and S. Epstein
1961 Metabolic Fraction of ^{13}C and ^{12}C in Plants. *Plant Physiology* 36:133-138.
- Parker, K., C. Robbins, and T. Hanley
1985 Energy Expenditures for Locomotion by Mule Deer and Elk. *Journal of Wildlife Management* 48:474-488.
- Parry, W. and J. Speth
1984 *The Garnsey Spring Campsite: Late Prehistoric Occupation in Southeastern New Mexico*. University of Michigan, Museum of Anthropology, Technical Reports No. 15. Ann Arbor, Michigan.
- Parsons, M., R. Hill, and W. Parker
1979 The Old Tom Burial, Dickens County, Texas. *Texas Archaeological Society Bulletin* 50:69-87.
- Patterson, L.
1982 Replication and Classification of Large Size Lithic Debitage. *Lithic Technology* 11:50-58.
- Patterson, L., S. Kindall, W. McClure, and E. Aucoin
2001 *Additional Investigations at 41GV53, Galveston County, Texas*. Houston Archaeological Society, Report No. 18. Houston, Texas.
- Patterson, L. and J. Sollberger
1978 Replication and Classification of Small Size Debitage. *Plains Anthropologist* 23:103-112.
- Patton, L.
1923 *The Geology of Potter County*. Texas Bureau of Economic Geology, Bulletin No. 2330. Austin, Texas.
- Pearson, E.
1974 Soil Characteristics of an Archaeological Deposit: Randall, County, Texas. *Texas Archaeological Society Bulletin* 45:151-189.
- Peden, D.
1972 The Trophic Relations of Bison bison to the Shortgrass Plains. Unpublished Ph.D. dissertation, Range Science Department, Colorado State University. Fort Collins, Colorado.

- 1976 Botanical Composition of Bison Diets on Shortgrass Plains. *American Midland Naturalist* 96:225-229.
- Peden, D., G. Van Dyne, R. Rice, and R. Hansen
 1974 The Trophic Ecology of Bison bison on Shortgrass Plains. *Journal of Applied Ecology* 11:489-498.
- Pelcin, A.
 1997 The Effect of Indentor Type on Flake Attributes: Evidence from a Controlled Experiment. *Journal of Archaeological Science* 24:1-9.
- Pendergast, D.
 2000 The Problems Raised by Small Charcoal Samples for Radiocarbon Analysis. *Journal of Field Archaeology* 27:237-239.
- Peregrine, P.
 1996 Introduction: World-Systems Theory in Archaeology. In *Pre-Columbian World Systems*, edited by P. Peregrine and G. Feinman, pp. 1-10. Monographs in World Archaeology No. 26. Madison, Wisconsin.
- Perkins, D. and P. Daly
 1968 The Potential of Faunal Analysis, An Investigation of the Faunal Remains from Suberde, Turkey. *Scientific America* 219:96-106.
- Perlman, S.
 1980 An Optimum Diet Model, Coastal Variability, and Hunter-Gatherer Behavior. In *Advances in Archaeological Method and Theory, Volume No. 3*, edited by M. Schiffer, pp. 257-310. Academic Press. New York, New York.
- Perttula, T.
 1992 *The Caddo Nation: Archaeological and Ethnohistorical Perspectives*. University of Texas Press. Austin, Texas.
- Peterson, J., D. Watson, and A. Goedert
 1993 *A Pawnee Bone Grease Processing Area: Site 25HW75, Howard County, Nebraska*. Nebraska Archaeological Survey, Technical Report 93-01. University of Nebraska State Museum. Lincoln, Nebraska.
- Peterson, L.
 1977 *A Field Guide to Edible Wild Plants: Eastern and Central North America*. Houghton Mifflin Company. Boston, Massachusetts.
- Peterson, R. and C. Boyd
 1998 *Ecology and Management of Sand Shinnery Communities: A Literature Review*.

United States Department of Agriculture, Forest Service, Rocky Mountain Research Station. General Technical Report RMRS-GTR-16. Fort Collins, Colorado.

Peterson, R. and S. Hughes

- 1980 Appendix 2: Continuing Research in Bison Morphology and Herd Composition Using Chronological Variation in Metapodials. In *The Vore Site, 48CK302, A Stratified Buffalo Jump in the Wyoming Black Hills*, edited by C. Reher and G. Frison, pp. 170-190. Memoir 16. Plains Anthropologist 25, Part 2.

Petrides, G.

- 1972 *A Field Guide to Trees and Shrubs: Field Marks of All Trees, Shrubs, and Woody Vines that Grow Wild in the Northeastern and North-Central United States and in Southeastern and South-Central Canada*. Houghton Mifflin. Boston, Massachusetts.

Pettit, R.

- 1986 *Sand Shinnery Oak: Control and Management*. Texas Tech University, Range and Wildlife Management Note No. 8. Lubbock Texas.

Phagan, C.

- 1980 Lithic Technology: Flake Analysis. In *Prehistory of the Ayacucho Basin, Peru, Volume 3*, by R. MacNeish, R. Vierra, A. Nelken-Terner, and C. Phagan, pp. 233-281. University of Michigan Press. Ann Arbor, Michigan.

Pianka, E.

- 1978 *Evolutionary Ecology*. Harper and Row. New York, New York.

Point, N.

- 1967 *Wilderness Kingdom, Indian Life in the Rocky Mountains: 1840-1847*. Holt, Rinehart, and Winston. New York, New York.

Pond, A.

- 1930 *Primitive Methods of Working Stone Based on Experiments of Halvor K. Skavlem*. Beloit College, Logan Museum Bulletin 2(1). Beloit, Wisconsin.

Prewitt, E.

- 1981 Cultural Chronology in Central Texas. *Texas Archaeological Society Bulletin* 52:65-89.

Purdy, B.

- 1974 Investigation Concerning the Thermal Alteration of Silica Minerals: An Archaeological Approach. *Tebiwa* 17:37-66.

Pyke, G., H. Pulliam, and E. Charnov

- 1977 Optimal Foraging: A Selective Review of Theory and Tests. *Quarterly Review of Biology* 52:137-154.

Quigg, J.

- 1997a *The Sanders Site (41HF128): A Single Event Late Archaic Camp/Bison Processing Site, Hansford County, Texas*. TRC Mariah Associates, Technical Report No. 19751. Austin, Texas.

- 1997b Excavation at the Sanders Site, Palo Duro Reservoir. *Cultural Resource Management News and Views* 9(2):19-21. Texas Historical Commission. Austin, Texas.

- 1997c Bison Processing at the Rush Site, 41TG346, and Evidence for Pemmican Production in the Southern Plains. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 145-161. Memoir 29. *Plains Anthropologist* 42, Part 1.

- 1998 A Late Archaic Bison Processing Event in the Texas Panhandle. *Plains Anthropologist* 43:367-383.

Quigg, J. and J. Peck

- 1995 *The Rush Site (41TG346): A Stratified Late Prehistoric Locale in Tom Green County, Texas*. TRC Mariah Associates, Technical Report No. 816C. Austin, Texas.

Quimby, D. and J. Gaab

- 1952 Preliminary Report on the Study of Elk Dentition as a Means of Determining Age Class. *Western Association of State Game and Fish Commission Proceedings* 32:225-227.

Raab, L. and A. Goodyear

- 1984 Middle-Range Theory in Archaeology: A Critical Review of Origins and Application. *American Antiquity* 49:225-268.

Radcliffe-Brown, A.

- 1922 *The Andaman Islanders*. Cambridge University Press. Cambridge, England.

Rafferty, J.

- 1986 The Archaeological Record on Sedentariness: Recognition, Development, and Implications. In *Advances in Archaeological Method and Theory, Volume 8*, edited by M. Schiffer, pp. 113-156. Academic Press. New York, New York.

Raisz, E.

- 1957 *Landforms of the United States*. Published by Raisz Landform Maps. Brookline, Massachusetts.
- Ramage, J. and J. Bean
 1992 *Writing Arguments: A Rhetoric with Arguments*. MacMillian Publishing. New York, New York.
- Ray, C.
 1941 The Various Types of Clear Fork Gouge. *Texas Archaeological and Paleontological Society Bulletin* 13:152-162.
- 1961 Deductions Concerning the Clear Fork Gouge. *Texas Archaeological Society Bulletin* 30:199-208.
- 1999 Some Unusual Cremated Burials Found near Colorado, Texas. *Texas Archaeological and Paleontological Society Bulletin* 8:9-16. (Texas Archaeological Society Reprint)
- Read, D. and G. Russell
 1996 A Method for Taxonomic Typology Construction and an Example: Utilized Flakes. *American Antiquity* 61:663-683.
- Rebnegger, K. and D. Green
 n. d. Lithic Technology and Geoarchaeology of a Late Archaic Camp Site: 34RM507. Unpublished manuscript on file at Sam Noble Oklahoma Museum of Natural History, Archaeology Division. Norman, Oklahoma.
- Redding, J. and W. Parker
 1991 Crosby County Lunate Stone Burial. *Texas Archaeological Society Bulletin* 60:217-239.
- Reeves, B.
 1983 Six Millenniums of Buffalo Kills. *Scientific America* 249:120-135.
- Reeves, C.
 1966 Pleistocene Climate of the Llano Estacado, II. *The Journal of Geology* 74:642-647.
- Reeves, C. and J. Reeves
 1996 *The Ogallala Aquifer of the Southern High Plains*. Estacado Books. Lubbock, Texas.
- Reher, C.

- Appendix II. The Wardell Bison bison: Population Dynamics and Archaeological Interpretations. In *The Wardell Buffalo Trap 48SU301: Communal Procurement in the Upper Green River Basin, Wyoming*, edited by G. Frison, pp. 89-104. Museum of Anthropology, Anthropological Papers No. 48. Ann Arbor, Michigan.
- 1973 Population Study of the Casper Site Bison. In *The Casper Site*, edited by G. Frison, pp. 113-124. Academic Press. New York, New York.
- 1977a Adaptive Process on the Shortgrass Plains. In *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, edited by L. Binford, pp. 13-40. Academic Press. New York, New York.
- 1977b Bison Populations and Other Deterministic Factors in a Model of Adaptive Process on the Short Grass Plains. In *Bison Procurement and Utilization: A Symposium*, edited by L. Davis and M. Wilson, pp.23-39. Memoir 14. Plains Anthropologist 23, Part 2.
- Reher, C. and G. Frison (editors)
- 1980a *The Vore Site, 48CK302, A Stratified Buffalo Jump in the Wyoming Black Hills*. Memoir 16. Plains Anthropologist 25, Part 2.
- Reher, C. and G. Frison
- 1980b Analysis of the Bison Mandibles. In *The Vore Site, 48CK302, A Stratified Buffalo Jump in the Wyoming Black Hills*, by C. Reher and G. Frison, pp. 59-94. Memoir 16. Plains Anthropologist 25, Part 2.
- Reitz, E. and N. Honerkamp
- 1983 British Colonial Subsistence Strategies on the Southeastern Coastal Plain. *Historical Archaeology* 17(1):4-26.
- Renaud, E.
- 1929a Basketmakers in Oklahoma. *El Palacio* 27:187-188.
- 1929b A Summer's Expedition to Northeast New Mexico and Western Oklahoma. *El Palacio* 27:247-248.
- 1929c Archaeological Research in Northeastern New Mexico and Western Oklahoma. *El Palacio* 27:276-279.
- 1930a Prehistoric Cultures of the Cimarron Valley, Northeast New Mexico and Western Oklahoma. *Colorado Scientific Society Proceedings* 12:113-150.

- 1930b A Summary of the Prehistoric Cultures of the Cimarron Valley. *El Palacio* 29:123-129.
- Reynolds, H., R. Glaholt, and A. Hawley
 1982 Bison: Bison bison. In *Wild Mammals of North America: Biology, Management, and Economics*, edited by J. Chapman and G. Feldhammer, pp. 972-1007. Johns Hopkins University Press. Baltimore, Maryland.
- Richter, B. and C. Kreitler
 1986 *Geochemistry of Salt-Spring and Shallow Subsurface Brines in the Rolling Plains of Texas and Southwestern Oklahoma*. Texas Bureau of Economic Geology, Report of Investigations No. 155. Austin, Texas.
- Ricklis, R. and K. Cox
 1993 Examining Lithic Technological Organization as a Dynamic Cultural Subsystem: The Advantages of an Explicitly Spatial Approach. *American Antiquity* 58:444-461.
- Robarchek, C.
 1994 Plains Warfare and the Anthropology of War. In *Skeletal Biology in the Great Plains: Migration, Warfare, Health, and Subsistence*, edited by D. Owsley and R. Jantz, pp. 307-316. Smithsonian Institution Press. Washington, District of Columbia.
- Robbins, C., B. Bruun, and H. Zim
 1966 *Birds of North America: A Guide to Field Identification*. Golden Press. New York, New York.
- Robinson, C.
 1982 Ground Stone. In *Harry S. Truman Dam and Reservoir, Missouri: Holocene Adaptations within the Lower Pomme de Terre River Valley, Missouri*, Volume II, edited by Marvin Kay, pp. 312-333. Illinois State Museum Society. Springfield, Illinois.
- Roberts, F.
 1942 *Archaeological and Geological Investigations in the San Jon District, Eastern New Mexico*. Smithsonian Miscellaneous Collections 103(4). Washington, District of Columbia.
- Roe, F.
 1970 *The North American Buffalo: A Critical Study of the Species in Its Wild State*. University of Toronto Press. Toronto, Ontario.
- Rogers, E.

- 1972 The Mistassini Cree. In *Hunters and Gatherers Today*, edited by M. Bicchieri, pp. 90-137. Holt, Reinhart, and Winston. New York, New York.
- Roosevelt, A.
1998 Clovis Clarification: A Follow-up. *Mammoth Trumpet* 13:1, 15-17.
- Roper, D.
1979 The Method and Theory of Site Catchment Analysis: A Review. In *Advances in Archaeological Method and Theory*, Volume 2, edited by M. Schiffer, pp. 119-140. Academic Press. New York, New York.

1987 Plains Paleoindian Red Ochre Use and Its Possible Significance. *Current Research in the Pleistocene* 4:82-84.

1989 *Protohistoric Pawnee Hunting in the Nebraska Sand Hills: Archaeological Investigations at Two Sites in the Calmus Reservoir*. Commonwealth Cultural Resources Group. Jackson, Michigan.

1992 Documentary Evidence for Changes in Protohistoric and Early Historic Pawnee Hunting Practices. *Plains Anthropologist* 37:353-366.
- Rosenzweig, M.
1966 Community Structure in Sympatric Carnivoria. *Journal of Mammalogy* 47:601-612.
- Ruhe, R.
1983 Aspects of Holocene Pedology in the United States. In *Late-Quaternary Environments of the United States*, edited by H. Wright, pp. 12-25. University of Minnesota Press. Minneapolis, Minnesota.
- Rutberg, A.
1986 Lactation and Fetal Sex Ratios in American Bison. *American Naturalist* 127:89-94.
- Sahlins, M.
1965 On the Sociology of Primitive Exchange. In *The Relevance of Models for Social Anthropology*, edited by M. Banton, pp. 139-236. Tavistock Publishing. London, England.
- Salmon, M.
1975 Confirmation and Explanation in Archaeology. *American Antiquity* 40:459-464.
- Sample, M.

- 1987 *Bison: Symbol of the American West*. Falcon Press. Helena, Montana.
- Saunders, R.
- 1974 The Clay and Roberts Sites: Two Lithic Workshop Sites in Western Oklahoma. In *Report of the ARKLA Salvage Project*, pp. 73-112. Oklahoma Archeological Survey, Contract Archeology Series No. 1. Norman, Oklahoma.
- 1978 *Archaeological Resources of Black Mesa State Park, Cimarron County, Oklahoma*. Oklahoma Archeological Survey, Archaeological Resource Survey Report No. 7. Norman, Oklahoma.
- 1983 *The Carrizozo Creek Bridge Site: A Plains Woodland Site on the Oklahoma/New Mexico Border*. Oklahoma Department of Transportation, Papers in Highway Archaeology No. 7. Oklahoma City, Oklahoma.
- Saunders, R., J. Hofman, and D. Wyckoff
- 1972 *Synopsis of Survey and Recommendations Concerning Archaeological Resources along the Proposed Anadarko Pipeline Project of Arkansas Louisiana Pipeline Company*. University of Oklahoma Research Institute (Oklahoma Archeological Survey). Norman, Oklahoma.
- Savage, S.
- 1995 *Bison Procurement and Processing Strategies: Contrasts in Two Non-Kill Sites on the Southern Plains*. Unpublished Ph. D. dissertation, Department of Anthropology, University of Oklahoma. Norman, Oklahoma.
- Savin, S.
- 1977 The History of the Earth's Surface Temperature during the Past 100 Million Years. *Annual Review of Earth Planetary Sciences* 5:319-355.
- Schalk, R.
- 1977 The Structure of an Anadromous Fish Resource. In *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, edited by L. Binford, pp. 207-249. Academic Press. New York, New York.
- Scheffer, V.
- 1950 Growth Layers on the Teeth of Pinnipedia as an Indication of Age. *Science* 112:309-311.
- Scheffler, I.
- 1963 *The Anatomy of Inquiry: Philosophical Studies in the Theory of Science*. Alfred A. Knopf. New York, New York.

Schiffer, M.

- 1975 Archaeology as Behavioral Science. *American Anthropologist* 77:836-848.
- 1986 Radiocarbon Dates and the "Old Wood" Problem: The Case of Hohokam Chronology. *Journal of Archaeological Science* 13:13-30.
- 1987 *Formation Processes of the Archaeological Record*. University of New Mexico Press. Albuquerque, New Mexico.
- 1995 *A History of Archaeological Thought*. Cambridge University Press. Cambridge, England.

Schlanger, N.

- 1995 Mindful Technology: Unleashing the *Chaîne Opératoire* for an Archaeology of Mind. In *The Ancient Mind: Elements of Cognitive Archaeology*, edited by C. Renfrew and E. Zubrow, pp. 143-151. Cambridge University Press. Cambridge, England.

Schmits, L.

- 1978 The Coffey Site: Environmental and Cultural Adaptations at a Prairie-Plains Archaic Site. *Midcontinental Journal of Archaeology* 3:69-185.

Schoener, T.

- 1971 Theory of Feeding Strategies. *Annual Review of Ecology and Systematics* 2:369-404.

Schortman, E. and P. Urban

- 1987 Modeling Interregional Interaction in Prehistory. In *Advances in Archaeological Method and Theory, Volume 11*, edited by M. Schiffer, pp. 37-95. Academic Press. New York, New York.

Schroeder, A.

- 1960 *A Study of the Apache Indians, Part III, The Mescalero Apache*. United States Department of Interior, National Park Service, Southwest Region. Santa Fe, New Mexico.
- 1962 A Reanalysis of the Route of Coronado and Oñate into the Plains in 1541 and 1601. *Plains Anthropologist* 7:2-23.

Schultz, G.

- 1977 *Field Conference Guidebook on Late Cenezoic Biostratigraphy of the Texas Panhandle and Adjacent Oklahoma*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.

Schultz, G. and V. Rawn

- 1978 Faunal Remains from the Deadman's Shelter Site. In *Archaeology at MacKenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 191-197. Texas Historic Commission, Archaeological Survey Report No. 24. Austin, Texas.

Scott, L.

- 1982 Pollen and Fiber Analysis of the McEndree Ranch Site, 5BA30, Southeastern Colorado. *Southwestern Lore* 48:18-24.

Sellards, E.

- 1955 Fossil Bison and Associated Artifacts from Milnesand, New Mexico. *American Antiquity* 20:336-344.

Semenov, S.

- 1976 *Prehistoric Technology: An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. Barnes and Noble Books. Totowa, New Jersey. (Translated by M. Thompson)

Semken, H.

- 1983 Holocene Mammalian Biogeography and Climatic Change in the Eastern and Central United States. In *Late-Quaternary Environments of the United States*, edited by H. Wright, pp. 182-207. University of Minnesota Press. Minneapolis, Minnesota.

Seni, S.

- 1980 *Sand-Body Geometry and Depositional Systems, Ogallala Formation, Texas*. Texas Bureau of Economic Geology, Report of Investigations No. 105. Austin, Texas.

Shaak, G. and R. Franz

- 1978 Faunal Succession and Environments of Deposition of Pleistocene Lake Buffalo Northwestern Oklahoma. *Oklahoma Geology Notes* 38:175-189.

Shackleton, D., L. Hills, and D. Hutton

- 1975 Aspects of Variation in Cranial Characters of Plains Bison (Bison bison bison Linnaeus) from Elk Island National Park, Alberta. *Journal of Mammalogy* 56:871-887.

Shafer, H.

- 1973 Lithic Technology at the George C. Davis Site, Cherokee County, Texas. Unpublished Ph.D. dissertation, Department of Anthropology, University of Texas. Austin, Texas.

- 1974 Lithic Reduction Strategies at the George C. Davis Site. *Louisiana Archaeology*

1:66-74.

1977 Late Prehistory of Central Texas. *South Plains Archaeological Society Bulletin* 3:18-24.

Shaffer, B.

1992 Quarter-Inch Screening: Understanding Biases in Recovery of Vertebrate Faunal Remains. *American Antiquity* 57:129-136.

Shaeffer, C.

1962 The Bison Drive of the Blackfeet Indians. In *Buffalo Jumps Symposium*, pp. 28-34. Montana Archaeological Society, Memoir 1. Billings, Montana.

Shaeffer, J.

1966 The Lawton Aspect of the Southern Plains Archaic. *Oklahoma Anthropological Society Bulletin* 14:62-86.

Shanks, M. and C. Tilley

1987 *Social Theory and Archaeology*. University of New Mexico Press. Albuquerque, New Mexico.

Shaw, J. and T. Carter

1989 Calving Patterns among American Bison. *Journal of Wildlife Management* 53:896-898.

Shaw, J. and M. Lee

1997 Relative Abundance of Bison, Elk, and Pronghorn on the Southern Plains, 1806-1857. In *Southern Plains Bison Procurement and Utilization from Paleoindian to Historic*, edited by L. Bement and K. Buehler, pp. 163-172. Memoir 29. Plains Anthropologist 42, Part 1.

Shay, J.

1988 On Accuracy and Relevance in Lithic Use-Wear Analysis. *Lithic Technology* 16:44-50.

Shelley, P.

1990 Variation in Lithic Assemblages: An Experiment. *Journal of Field Archaeology* 17:187-193.

Sheridan, P.

1888 *Personal Memoirs of P. H. Sheridan, General, United States Army*, Volume II. Charles L. Webster. New York, New York.

Shields, W.

- 1980 Preliminary Investigations at the McEndree Ranch Site, 5BA30. *Southwestern Lore* 46:1-17.
- Shockey, D.
1994 Fluorescence and Heat Treatment of Three Lithic Materials Found in Oklahoma. *Oklahoma Anthropological Society Bulletin* 43:86-100.
- Shott, M.
1986 Technological Organization and Settlement Mobility: An Ethnographic Examination. *Journal of Anthropological Research* 42:15-51.

1989 Technological Organization in Great Lakes Paleoindian Assemblages. In *Eastern Paleoindian Lithic Resources Use*, edited by C. Ellis and J. Lothrop, pp. 221-237. Westview Press. Boulder, Colorado.
- Shott, M., A. Bradbury, P. Carr, and G. Odell
2000 Flake Size from Platform Attributes: Perspective and Empirical Approaches. *Journal of Archaeological Science* 27:877-894.
- Shotwell, J.
1955 An Approach to Paleoecology of Mammals. *Ecology* 36:327-337.

1958 Inter-Community Relationships in Hemphillian (Mid-Pliocene) Mammals. *Ecology* 39:271-282.
- Sievert, G. and L. Sievert
1993 *A Field Guide to Reptiles of Oklahoma*. Oklahoma Department of Wildlife Conservation. Oklahoma City, Oklahoma.
- Simpkins, W. and T. Gustavson
1987 *Erosion Rates and Processes in Subhumid and Semiarid Climates, Texas Panhandle: Statistical Evaluation of Field Data*. Bureau of Economic Geology, Report of Investigations No. 162. Austin, Texas.
- Simpkins, W., T. Gustavson, A. Alhades, and A. Hoadley
1981 *Impact of Evaporite Dissolution and Collapse on Highways and Other Cultural Features in the Texas Panhandle and Eastern New Mexico*. Texas Bureau of Economic Geology, Circular No. 81-4. Austin, Texas.
- Simpson, C.
1976 Trinchera Cave: A Rockshelter in Southeastern Colorado. Unpublished master's thesis, Department of Anthropology, University of Wyoming. Laramie, Wyoming.

- Sinclair, A.
1977 *The African Buffalo: A Study of Resource Limitation of Populations*. University of Chicago Press. Chicago, Illinois.
- Sission, S. and J. Grossman
1938 *The Anatomy of Domestic Animals*. W. B. Saunders. Philadelphia, Pennsylvania.
- Skinner, B. and S. Porter
1992 *The Dynamic Earth: An Introduction to Physical Geology*. John Wiley and Sons. New York, New York.
- Skinner, M. and O. Kaisen
1947 The Fossil Bison of Alaska and Preliminary Revision of the Genus. *American Museum of Natural History* 89:1-256.
- Smith, C.
1968 The Adaptive Nature of Social Organization in the Genus of Tree Squirrels Tamiasciurus. *Ecological Monographs* 38:31-63.
- Smith, C.
1985 To Save a Dune. *Southwest Heritage* 14:5-19.
- Smith, E.
1981 The Application of Optimal Foraging Theory to the Analysis of Hunter-Gatherer Group Size. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 36-65. University of Chicago Press. Chicago, Illinois.
- 1983 Anthropological Applications of Optimal Foraging Theory: A Critical Review. *Current Anthropology* 24:625-651.
- 1987 Optimization Theory in Anthropology: Applications and Critiques. In *The Latest on the Best: Essays on Evolution and Optimality*, edited by J. Dupre, pp. 201-249. Bradford Books. Cambridge, Massachusetts.
- Smith, E. and B. Winterhalder
1981 New Perspectives on Hunter-Gatherer Socioecology. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 1-12. University of Chicago Press. Chicago, Illinois.
- 1992 Natural Selection and Decision-Making: Some Fundamental Principles. In *Evolutionary Ecology and Human Behavior*, edited by E. Smith and B. Winterhalder, pp. 25-60. Aldine de Gruyter. New York, New York.

- Smith, M.
1978 Optimisation Theory in Evolution. *Annual Review of Ecology and Systematics* 9:31-56.
- Snider, L.
1917 *Geography of Oklahoma*. Oklahoma Geological Survey, Bulletin No. 27. Norman, Oklahoma.
- Socolofsky, H. and H. Self
1988 *Historical Atlas of Kansas*. University of Oklahoma Press. Norman, Oklahoma.
- Soper, J.
1941 History, Range, and Home Life of the Northern Bison. *Ecological Monographs* 11:349-412.
- Spaulding, A.
1960 The Dimensions of Archaeology. In *Essays in the Science of Culture in Honor of Leslie A. White*, edited by G. Dole and R. Carneiro, pp. 437-456. Crowell Publishers. New York, New York.
- Speer, R.
1979 Bison Remains from the Rex Rogers Site. In *Bison Procurement and Utilization: A Symposium*, edited by L. Davis and M. Wilson, pp. 113-127. Memoir 14. Plains Anthropologist 23, Part 2.
- Spence, M., J. Kimberlin, and G. Harbottle
1984 State-Controlled Procurement and the Obsidian Workshops of Teotihuacan, Mexico. In *Prehistoric Quarries and Lithic Production*, edited by J. Ericson and B. Purdy, pp. 97-106. Cambridge University Press. Cambridge, England.
- Speth, J.
1974 Experimental Investigations of Hard-Hammer Percussion Flaking. *Tebiwa* 17:7-36.

1983 *Bison Kills and Bone Counts: Decision Making by Ancient Hunters*. University of Chicago Press. Chicago, Illinois.
- Speth, J. and W. Parry
1978 *Late Prehistoric Bison Procurement in Southeastern New Mexico: The 1977 Season at the Garnsey Site*. University of Michigan, Museum of Anthropology, Technical Report No. 8. Ann Arbor, Michigan.

1980 *Late Prehistoric Bison Procurement in Southeastern New Mexico: The 1978*

Season at the Garnsey Site (LA18399). University of Michigan, Museum of Anthropology, Technical Report No. 12. Ann Arbor, Michigan.

Speth, J. and K. Spielmann

1983 Energy Source, Protein Metabolism, and Hunter-Gatherer Subsistence Strategies. *Journal of Anthropological Archaeology* 2:1-31.

Spivey, T.

1979 Prehistoric Burial Found on Cache Creek. *Museum of the Great Plains Newsletter* 5:4-5.

Stangl, F., W. Dalquest, and R. Baker

1992 *Mammals of Southwestern Oklahoma*. Museum of Texas Tech University, Occasional Papers No. 151. Lubbock, Texas.

Stafford, T.

1981 Alluvial Geology and Archaeological Potential of the Texas Southern High Plains. *American Antiquity* 46:548-565.

Stafford, T., P. Hare, L. Currie, A. Jull, and D. Honahue

1991 Accelerator Radiocarbon Dating at the Molecular Level. *Journal of Archaeological Science* 18:35-72.

Steele, A.

1966 A History of the Sandstone Creek Area, Upstream Flood Prevention Project. *Chronicles of Oklahoma* 43:432-442.

Steele, D. and B. Baker

1993 Multiple Predation: A Definitive Human Hunting Strategy. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 9-37. Center for Archaeological Investigations, Occasional Paper No. 21. Carbondale, Illinois.

Steen, C.

1955 The Pigeon Cliffs Site: A Preliminary Report. *El Palacio* 62:174-180.

Steffian, A.

1991 Territorial Stability as a Factor in the Occurrence and Perpetuation of Inter-group Buffer Zones. In *Foragers in Context: Long-Term, Regional, and Historical Perspectives in Hunter-Gatherer Studies*, edited by P. Miracle, L. Fisher, and J. Brown, pp. 89-105. University of Michigan, Discussions in Anthropology No. 10. Ann Arbor, Michigan.

Stein, M.

- 1983 *A Cumulative Bibliography of Reports Received by the Kansas State Historic Preservation Office*. Kansas State Historical Society, Historic Preservation Division. Topeka, Kansas.
- Stephens, A. and W. Holmes
1989 *Historical Atlas of Texas*. University of Oklahoma Press. Norman, Oklahoma.
- Stephens, D. and J. Krebs
1986 Average-Rate Maximizing: The Prey and Patch Models. In *Foraging Theory*, edited by D. Stephens and J. Krebs, pp. 13-37. Princeton University Press. Princeton, New Jersey.
- Stevens, M. and C. Hoag
2000 *Narrowleaf Cattail (Typha angustifolia)*. United States Department of Agriculture, Natural Resources Conservation Service, National Plant Data Center. Baton Rouge, Louisiana.
- Steward, J.
1955 *Theory of Culture Change*. University of Illinois Press. Urbana, Illinois.
- Stini, W.
1969 Nutritional Stress and Growth: Sex Difference in Adaptive Response. *American Journal of Physical Anthropology* 31:417-426.
- 1971 Evolutionary Implications of Changing Nutritional Patterns in Human Populations. *American Anthropologist* 73:1019-1030.
- 1972 Reduced Sexual Dimorphism in Upper Arm Muscle Circumference Associated with Protein Deficient Diet in a South American Population. *American Journal of Physical Anthropology* 36:341-352.
- Stock, C.
1929 A Census of Pleistocene Mammals of Rancho la Brea Based on the Collections of the Los Angeles Museum. *Journal of Mammalogy* 10:281-289.
- Strahler, A.
1955 *Physical Geography*. John Wiley and Sons. New York, New York.
- Strahler, A. and A. Strahler
1994 *Introduction to Physical Geography*. John Wiley and Sons. New York, New York.
- Stuart, D.
1977 Seasonal Phases in Ona Subsistence Territorial Distribution and Organization:

- Implications for the Archaeological Record. In *For Theory Building in Archaeology: Essays on Faunal Remains, Aquatic Resources, Spatial Analysis, and Systemic Modeling*, edited by L. Binford, pp. 251-283. Academic Press. New York, New York.
- Stubbenieck, J., G. Friisoe, and M. Bolick
 1995 *Weeds of Nebraska and the Great Plains*. Nebraska Department of Agriculture, Bureau of Plant Industry. Lincoln, Nebraska.
- Stuiver, M.
 1993 Editorial Comment. *Radiocarbon* 35:iii.
- Stuiver, M. and F. Braziunas
 1989 Atmospheric ^{14}C and Century Scale Solar Oscillations. *Nature* 338:405-408.
 1993 Sun, Ocean, Climate, and Atmospheric ^{14}C : An Evaluation of Causal and Spectral Relationships. *The Holocene* 3:289-305.
- Stuiver, M. and G. Pearson
 1989 High-Precision Calibration of the Radiocarbon Time Scale, AD 1950-500 BC. *Radiocarbon* 28:805-838.
 1992 Calibration of the Radiocarbon Time Scale, 2500-5000 BC. In *Radiocarbon after Four Decades: An Interdisciplinary Perspective*, edited by R. Taylor, A. Long, and R. Kra, pp. 19-33. Springer-Verlag. New York, New York.
- Styles, B.
 1993 Discussion: Social Interaction. In *From Bones to Behavior: Ethnoarchaeological and Experimental Contributions to the Interpretation of Faunal Remains*, edited by J. Hudson, pp. 263-270. Center for Archaeological Investigations, Occasional Paper No. 21. Carbondale, Illinois.
- Suhm, D. and E. Jelks
 1962 *Handbook of Texas Archaeology: Type Descriptions*. Texas Memorial Museum, Bulletin No. 4. Austin, Texas.
- Sullivan, A.
 1978 Inference and Evidence in Archaeology: A Discussion of the Conceptual Problems. In *Advances in Archaeological Method and Theory*, Volume 1, edited by M. Schiffer, pp. 183-222. Academic Press. New York, New York.
- Sutherland, S.
 1977 Climate of Oklahoma. In *Geography of Oklahoma*, edited by J. Morris, pp. 40-53. Oklahoma Historical Society. Oklahoma City, Oklahoma.

- Sutton, G.
 1977 *Fifty Common Birds of Oklahoma and the Southern Great Plains*. University of Oklahoma Press. Norman, Oklahoma.
- Svoboda, M.
 1967 *Plants that the American Indians Used*. Field Museum of Natural History. Field Museum Press. Chicago, Illinois.
- Taber, R.
 1963 Criteria for Age and Sex. In *Wildlife Investigational Techniques*, pp. 325-401. The Wildlife Society. Bethesda, Maryland.
- Tainter, J.
 1979 A Functional Analysis of the Croton Creek Lithic Scatter, Roger Mills County, Oklahoma. *Oklahoma Anthropological Society Bulletin* 28:137-146.
- Taylor, A. and C. Highley
 1995 *Archeological Investigations at the Loma Sandia Site (41LK28): A Prehistoric Cemetery and Campsite in Live Oak County, Texas*. Texas Archeological Research Laboratory, Studies in Archeology No. 20. Austin, Texas.
- Taylor, W.
 1964 Tethered Nomadism and Water Territoriality: An Hypothesis. *Actas del XXXV Congreso Internacional de Americanistas*, pp. 197-203. Mexico, Distrito Federal.
 1983 *A Study of Archaeology*. Southern Illinois University Press. Carbondale, Illinois.
- Testart, A.
 1980 The Significance of Food Storage among Hunter-Gatherers: Residence Patterns, Population Densities, and Social Inequalities. *Current Anthropology* 23:523-537.
 1987 Game Sharing Systems and Kinship Systems among Hunter-Gatherers. *Man* 22:287-304.
- Thomas, D.
 1983 *The Archaeology of Monitor Valley: 2. Gatecliff Shelter*. American Museum of Natural History, Anthropological Papers 59(1). Washington, District of Columbia.
- Thomas, R., B. Winterhalder, and S. McRae

1979 An Anthropological Approach to Human Ecology and Adaptive Dynamics. *Yearbook of Physical Anthropology* 22:1-46.

Thurmond, A. and J. Thurmond

2000 The Rain on the Plains: Feast or Famine. *Oklahoma Anthropological Society Newsletter* 49(3):8-10.

Thurmond, J.

n. d. Thurmond Ranch Map—Springs, Flowing Streams, and Lake Levels as of January 1998 (plotted on USGS 7.5-minute topographic maps).

1983 State of Oklahoma Archaeological Site Form: 34RM337. Oklahoma Archeological Survey. Norman, Oklahoma.

1984a State of Oklahoma Archaeological Site Form: 34RM449. Oklahoma Archeological Survey. Norman, Oklahoma.

1984b State of Oklahoma Archaeological Site Form: 34RM451. Oklahoma Archeological Survey. Norman, Oklahoma.

1984c State of Oklahoma Archaeological Site Form: 34RM454. Oklahoma Archeological Survey. Norman, Oklahoma.

1988a The 1988 Oklahoma Anthropological Society Field School: The Beaver Dam Site, 34RM208, Roger Mills County, Oklahoma. *Oklahoma Anthropological Society Newsletter* 36(4):2-5.

1988b An Update on Investigations at the Beaver Dam Site, 34RM208, Roger Mills County, Oklahoma. *Oklahoma Anthropological Society Newsletter* 36(6):3-9.

1988c Proposal for Emergency Salvage Excavations by the Oklahoma Anthropological Society 1988 Spring Dig at 34RM208, the Beaver Dam Site, Thurmond Ranch, Roger Mills County Western Oklahoma. Manuscript on file at the Oklahoma Archeological Survey. Norman, Oklahoma.

1988d Update on the Fall 1988 Anthropological Society Dig at 34RM208. *Oklahoma Anthropological Society Newsletter* 36(8):3.

1989 An Accelerator Mass Spectrometer Date from a "Late Archaic" Component in Roger Mills County, Oklahoma. *Oklahoma Anthropological Society Newsletter* 37(9):3-4.

1990a *Late Paleoindian Utilization of the Dempsey Divide on the Southern Plains*. Memoir 25. *Plains Anthropologist* 35, Part 1.

- 1990b A Glow-in-the-Dark Radiocarbon Date from Roger Mills County. *Oklahoma Anthropological Society Newsletter* 38(7):5-6.
- 1991a Archeology of the Dempsey Divide, A Late Archaic/Woodland Hotspot on the Southern Plains. *Oklahoma Anthropological Society Bulletin* 39:103-157.
- 1991b A Late Archaic/Woodland Lunate Stone Burial in Far Western Oklahoma. *Texas Archaeological Society Bulletin* 60:241-255.
- 1993 Some Brief Reflections on Annual Precipitation in Roger Mills County Since 1950. *Oklahoma Anthropological Society Newsletter* 41(9):8-9.
- 1996 What the Devil is Going on with the Weather Out Here. *Oklahoma Anthropological Society Newsletter* 44(6):8-10.
- 1997a A Recently Recorded Late Woodland Campsite. *Oklahoma Anthropological Society Newsletter* 45(4):9-11.
- 1997b Archaeology of the Ogallala Boundary, Roger Mills County, Western Oklahoma. Paper presented at the Institute for Tertiary-Quaternary Studies (TER-QUA) Symposium. Alva, Oklahoma.
- Thurmond, J., C. Freeman, K. Kindscher, H. Loring, C. Morse, and B. Hoagland
2002 Preliminary Report of an Ethnobotanical Survey along the Ogallala Ecotone of the Dempsey Divide in Roger Mills County, Oklahoma. *Oklahoma Archaeology* 50(2):10-37. (Formerly *Oklahoma Anthropological Society Bulletin/Newsletter*)
- Thurmond, J., K. Kraft, and D. Wyckoff
2000 Calibration of Radiocarbon Dates from 34RM501, the Swift Horse Site. *Oklahoma Anthropological Society Newsletter* 48(1):12-13.
- Thurmond, J. and M. Moore
1985 A Preliminary Report of an Archaeological Inventory on the Thurmond Ranch, Roger Mills County, Oklahoma. *Oklahoma Anthropological Society Newsletter* 33(5):10-12.
- Thurmond, J. and D. Wyckoff
n. d. Radiocarbon Dates from Archaeological Site 34RM507.
- 1998 Late Pleistocene Dunes along the Dempsey Divide, Roger Mills County, Oklahoma. *Current Research in the Pleistocene* 15:139-143.
- 1999 The Calf Creek Horizon in Northwestern Oklahoma. *Plains Anthropologist*

44:231-250.

2000 Thirty-Thousand Years of Change on the Dempsey Divide: A Two Decade Study of the Archaeology, Paleoclimatology and Paleogeography of the Dempsey Divide, the Upland Ridge Separating the Valleys of the Washita River and the North Fork of the Red River in Southern Roger Mills County, Oklahoma. <http://www.geocities.com/dempseydiv/Text.htm>

2001 Delaware Canyon Radiocarbon Dates: Delaware Creek and Copan Paleosols. http://www.geocities.com/dempseydiv/delaware_canyon_radiocarbon_date.htm

Thurmond, J., D. Wyckoff, and C. Batchelor

1998 A Rapid Return to Woodland Period Conditions? or How Site 34RM451 Returned to Waterfront Property. *Oklahoma Anthropological Society Newsletter* 46:5-8.

Todd, L.

1986 Determination of Sex of Bison Upper Forelimb Bones: The Humerus and Radius. *Wyoming Archaeologist* 29:109-123.

1987a Taphonomy of the Horner II Bone Bed. In *The Horner Site: The Type Site for the Cody Cultural Complex*, edited by G. Frison and L. Todd, pp. 107-198. Academic Press. New York, New York.

1987b Appendix 1. Bison Bone Measurements. In *The Horner Site: The Type Site for the Cody Cultural Complex*, edited by G. Frison and L. Todd, pp. 371-403. Academic Press. New York, New York.

1991 Seasonality Studies and Paleoindian Subsistence Strategies. In *Human Predators and Prey Mortality*, edited by M. Stiner, pp. 217-238. Westview Press. Boulder, Colorado.

Todd, L., M. Hill, D. Rapson, and G. Frison

1997 Cutmarks, Impacts, and Carnivores at the Casper Site Bison Bonebed. In *Proceedings of the 1993 Bone Modification Conference, Hot Springs, South Dakota*, edited by L. Hannus, L. Rossum, and R. Winham, pp. 136-157. Augustana College, Archaeology Laboratory, Occasional Publication No. 1. Sioux Falls, South Dakota.

Todd, L. and J. Hofman

1987 Appendix 8. Bison Mandibles from Horner and Finley Sites. In *The Horner Site: The Type Site of the Cody Cultural Complex*, edited by G. Frison and L. Todd, pp. 493-539. Academic Press. New York, New York.

- Todd, L., J. Hofman, and C. Schultz
1990 Seasonality of the Scottsbluff and Lipscomb Bonebeds: Implications for Modeling Paleoindian Subsistence. *American Antiquity* 55:813-827.
- Todd, L., D. Rapson, and J. Hofman
1996 Dentition Studies of the Mill Iron and Other Early Paleoindian Bison Bonebed Sites. In *The Mill Iron Site*, edited by G. Frison, pp. 145-175. University of New Mexico Press. Albuquerque, New Mexico.
- Tomka, S. and J. Quigg
1997 Lithic Debitage Concentrations. In *The Sanders Site (41HF128): A Single Event Late Archaic Camp/Bison Processing Site, Hansford County, Texas*, by J. Quigg, pp. 47-51. TRC Mariah Associates, Technical Report No. 19751. Austin, Texas.
- Toots, H.
1965 Sequence of Disarticulation in Mammalian Skeletons. *Contributions to Geology* 4:37-39.
- Torbit, S., L. Carpenter, D. Swift, and A. Alldredge
1985 Differential Loss of Fat and Protein by Mule Deer during Winter. *Journal of Wildlife Management* 49:80-85.
- Trigger, B.
1995 *A History of Archaeological Thought*. Cambridge University Press. Cambridge, England.
- Trimble, D.
1990 *The Geologic Story of the Great Plains: A Nontechnical Description of the Origin and Evolution of the Landscape of the Great Plains*. United States Geological Survey Bulletin No. 1493. Denver, Colorado.
- Tringham, R., G. Cooper, G. Odell, B. Voytek, and A. Whitman
1972 Experimentation in the Formation of Edge Damage: A New Approach to Lithic Analyses. *Journal of Field Archaeology* 1:171-196.
- Trivers, R. and D. Willard
1973 Natural Selection of Parental Ability to Vary the Sex Ratio of Offspring. *Science* 179:90-92.
- Trotter, M. and G. Gleser
1951 Estimation of Stature from Long Bones of American Whites and Negroes. *American Journal of Physical Anthropology* 10:463-514.

- 1957 A Re-Evaluation of Estimation Based on Measurements of Stature Taken during Life and of Long Bones after Death. *American Journal of Physical Anthropology* 16:79-123.
- Tunnel, C. and J. Hughes
1955 An Archaic Bison Kill in the Texas Panhandle. *Panhandle-Plains Historical Review* 28:63-70.
- Turner, C.
1992 New World Origins: New Research from the Americas and the Soviet Union. In *Ice Age Hunters of the Rockies*, edited by D. Stanford and J. Day, pp.7-50. Denver Museum of Natural History and University Press of Colorado. Niwot, Colorado.
- Turner, E.
1988 Exploring the Possibilities of Acorn Utilization in the Burned Rock Middens of Texas. *Texas Archaeological Society Bulletin* 59:177-191.
- Turner, E. and T. Hester
1985 *A Field Guide to Stone Artifacts of Texas Indians*. Texas Monthly Press. Austin, Texas.
- Turpin, S., L. Bement, and H. Eling
1992 Big Lake: A Playa Bison Kill Site in Western Texas. *Current Research in the Pleistocene* 9:45-46.
- Tylor, E.
1881 *Anthropology: An Introduction to the Study of Man and Civilization*. Macmillan Publishing. London, England.
- United States Army Corps of Engineers
1993 *Red River Chloride Control Project* (pamphlet). United States Army Corps of Engineers, Tulsa District. Tulsa, Oklahoma.
- United States Department of Agriculture
1954 Aerial Photograph—Washita River, North of Stafford, Oklahoma, taken at 5:15 PM. Soil Conservation Service, Negative No. 10-853. Photograph at USDA, Natural Resources Conservation Service, Cultural Resources Section, State Office. Stillwater, Oklahoma.
- 1958 *Work Plan for Runoff and Waterflow Retardation and Soil Erosion Prevention: Sandstone Creek Watershed of the Washita River Watershed, Oklahoma and Texas*. Soil Conservation Service. Fort Worth, Texas.

- 1964 *The Washita: Land Treatment and Flood Prevention*. Soil Conservation Service. Stillwater, Oklahoma.
- 1975 *Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys*. Soil Survey Staff, Agriculture Handbook No. 436. Washington, District of Columbia.
- 1976 *Bobwhite Management Guide*. Soil Conservation Service. Stillwater, Oklahoma.
- 1977 *Whitetail Deer Management Guide*. Soil Conservation Service. Stillwater, Oklahoma.
- 1978 *Wild Turkey Management Guide*. Soil Conservation Service. Stillwater, Oklahoma.
- 1979 *Prairie Chicken Management Guide*. Soil Conservation Service. Stillwater, Oklahoma.
- 1994 *Soil Erosion by Water*. Soil Conservation Service. Agricultural Information Bulletin No. 513. Stillwater, Oklahoma.
- 1997 *Manhattan Plant Materials Center, 1997 Annual Report*. Natural Resources Conservation Service. Manhattan, Kansas.
- 2004a *Annual Marshelder (Iva Annuua)*. Natural Resources Conservation Service, National Plant Data Center. Baton Rouge, Louisiana.
- 2004b *Spikerush (Eleocharis)*. Natural Resources Conservation Service, National Plant Data Center. Baton Rouge, Louisiana.
- United States Department of the Army
- 1970 *Survival. Field Manual 21-76*. Headquarters, Department of the Army. Washington, District of Columbia.
- United States Environmental Protection Agency
- 2000 Droughts, Floods, and Sprawl—They're All Connected. *Watershed Events Newsletter*, pp. 1-2. Summer 2000. Washington, District of Columbia.
- United States Geological Survey
- n. d. *Oklahoma: Floods and Droughts*. Water Supply Paper No. 2375. Oklahoma City, Oklahoma.
- 1989 *Baker Lake, Oklahoma, 7.5- Minute Series Topographic Map*. United States

Geological Survey. Denver, Colorado.

1996 *Flooding*. Fact Sheet FS-036-96. Oklahoma City, Oklahoma.

Vail, P., R. Mitchum, and S. Thompson

1977 Seismic Stratigraphy and Global Changes of Sea Level, Part 4. In *Global Cycles of Relative Changes of Sea Level*, pp 83-97. American Association of Petroleum Geologists, Memoir 26. Tulsa, Oklahoma.

Van Camp, J.

1973 *Snow Conditions and the Winter Feeding Behavior of Bison bison in Elk Island National Park*. Canadian Wildlife Services, Parks Advisory Report. Ottawa, Ontario.

Van Gerven, D.

1972 The Contribution of Size and Shape Variation to Patterns of Sexual Dimorphism of the Human Femur. *American Journal of Physical Anthropology* 37:49-60.

Van Royen, W.

1937 Prehistoric Droughts in the Central Great Plains. *Geographical Review* 27:637-650.

VanVoris, P., R. O'Neill, W. Emanuel, and H. Shugart

1980 Functional Complexity and Ecosystem Stability. *Ecology* 61:1352-1360.

Vehik, S.

1977 Bone Fragments and Bone Grease Manufacturing: A Review of Their Archaeological Use and Potential. *Plains Anthropologist* 22:169-182.

1982 A Model for Prehistoric Cultural Change in North-Central Oklahoma. In *Pathways to Plains Prehistory: Anthropological Perspectives of Plains Natives and Their Pasts*, edited by D. Wyckoff and J. Hofman, pp. 65-75. Oklahoma Anthropological Society, Memoir No. 3. Norman, Oklahoma.

1984 The Woodland Occupations. In *Prehistory of Oklahoma*, edited by R. Bell, pp. 175-197. Academic Press. New York, New York.

1986 Oñate's Expedition to the Southern Plains: Routes, Destinations, and Implications for Late Prehistoric Cultural Adaptations. *Plains Anthropologist* 31:13-33.

Vehik, S. and K. Kraft

1995 Historic Bison Distribution on the Southern Plains. Paper presented at the 17th Annual Flint Hills Conference. Norman, Oklahoma.

- Vita-Finzi, C. and E. Higgs
 1970 Prehistoric Economy in the Mt. Carmel Area of Palestine: Site Catchment Analysis. *Prehistoric Society Proceedings* 36:1-37.
- Von Den Driesch, A.
 1976 *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum, Bulletin No. 1. New Haven, Connecticut.
- Voorhies, M.
 1969 *Taphonomy and Population Dynamics of an Early Pliocene Vertebrate Fauna, Knox County, Nebraska*. University of Wyoming, Contributions to Geology, Special Paper No. 1. Laramie, Wyoming.
- Walker, P. and J. Long
 1977 An Experimental Study of the Morphological Characteristics of Tool Marks. *American Antiquity* 42:605-616.
- Wallace, A.
 1971 Administrative Forms of Social Organization. *Current Topics in Anthropology: Theory, Methods, and Content* 2:1-12.
- Waller, G., R. Morrison, and A. Nelson
 1972 *Chemical Composition of Native Grasses in Central Oklahoma from 1947 to 1962*. Oklahoma Agricultural Experiment Station, Bulletin B-697. Stillwater, Oklahoma.
- Wallis, C.
 2000 *Investigations (of) Upper Elk Creek Watershed, Washita County, Oklahoma: Sites 34WA157 and 34WA161, Impoundments 3A and 3B*. Oklahoma Conservation Commission, Miscellaneous Research Report No. 26. Oklahoma City, Oklahoma.
- Wandsnider, L.
 1997 The Roasted and the Boiled: Food Composition and Heat Treatment with Special Emphasis on Pit-Hearth Cooking. *Journal of Anthropological Archaeology* 16:1-48.
- Warburton, M. and P. Duke
 1995 Projectile Points as Cultural Symbols: Ethnography and Archaeology. In *Beyond Subsistence: Plains Archaeology and the Postprocessual Critique*, edited by P. Duke and C. Wilson, pp. 211-228. University of Alabama Press. Tuscaloosa, Alabama.

- Waselkov, G. and R. Paul
1981 *Frontiers and Archaeology. North American Archaeologist* 2:309-329.
- Watson, P., S. LeBlanc, and C. Redman
1971 *Explanation in Archaeology: An Explicitly Scientific Approach*. Columbia University Press. New York, New York.
- Weaver, J. and F. Albertson
1956 *Grasslands of the Great Plains: Their Nature and Use*. Johnsen Publishing Company. Lincoln, Nebraska.
- Wedel, W.
1940 *Culture Sequence in the Central Great Plains*. Smithsonian Institution, Miscellaneous Collections 100:291-352. Washington, District of Columbia.

1975 Chalk Hollow: Cultural Sequence and Chronology in the Texas Panhandle. *Actas del XLI Congreso Internacional de Americanistas* 1:271-278. Mexico, Distrito Federal.

1978 Plains Archeology in 1977. *Great Plains Journal* 17:25-39.

1983 The Prehistoric Plains. In *Ancient North Americans*, edited by J. Jennings, pp. 203-235. W. H. Freeman and Company. San Francisco, California.

1986 *Central Plains Prehistory: Holocene Environments and Culture Change in the Republican River Basin*. University of Nebraska Press. Lincoln, Nebraska.
- Weir, F.
1976 The Central Texas Archaic Reconsidered. In *The Texas Archaic: A Symposium*, edited by T. Hester, pp. 60-66. Center for Archaeological Research, Special Report No. 2. San Antonio, Texas.
- Weltfish, G.
1965 *The Lost Universe: Pawnee Life and Culture*. University of Nebraska Press. Lincoln, Nebraska.
- Wendland, W.
1978 Holocene Man in North America: The Ecological Setting and Climatic Background. *Plains Anthropologist* 23:273-287.
- Wendorf, F. and J. Miller
1959 Artifacts from High Mountain Sites in the Sangre de Cristo Range, New Mexico. *El Palacio* 66:37-52.

Wheat, J.

- 1972 *The Olsen-Chubbuck Site: A Paleo-Indian Bison Kill*. Memoir 26. *American Antiquity* 37, Part 2.

White, L.

- 1949 *The Science of Culture*. Grove Press. New York, New York.

- 1959 *The Evolution of Culture*. McGraw-Hill Publishing. New York, New York.

White, R.

- 1981 Clear Fork Gouges Found in the Oklahoma Panhandle. *Oklahoma Anthropological Society Bulletin* 30:19-25.
- 1987 The Muncy Site in the Oklahoma Panhandle: Indian Cultural Evidence over a Long Time Span. *Oklahoma Anthropological Society Bulletin* 36:39-103.

White, T.

- 1952 Observation on the Butchering Technique of Some Aboriginal Peoples: 1. *American Antiquity* 17:337-338.
- 1953 A Method of Calculating the Dietary Percentage of Various Food Animals Utilized by Aboriginal Peoples. *American Antiquity* 18:396-398.
- 1955 Observations on the Butchering Technics (*sic*) of Some Aboriginal Peoples, Numbers 7, 8, and 9. *American Antiquity* 21:170-178.

Whittaker, J.

- 1994 *Flintknapping: Making and Understanding Stone Tools*. University of Texas Press. Austin, Texas.

Wickstrom, M., C. Robbins, T. Hanley, D. Spalinger, and M. Parish

- 1984 Food Intake and Foraging Energetics of Elk and Mule Deer. *Journal of Wildlife Management* 48:1285-1301.

Wiessner, P.

- 1982 Beyond Willow Smoke and Dogs' Tails: A Comment on Binford's Analysis of Hunter-Gatherer Settlement Systems. *American Antiquity* 47:171-178.

Wilcox, D.

- 1981 The Entry of the Athapaskans into the American Southwest: The Problem Today. In *The Protohistoric Period in the North American Southwest, 1450-1700*, edited by D. Wilcox and W. Masse, pp. 213-239. Arizona State University. Tempe, Arizona.

Wilkins, D.

- 1997 Slip-Sliding Away—The McIntyre Bison Kill Site (41RB87). *The Steward* 4:31-37.

Willey, G.

- 1966 *An Introduction to American Archaeology, Volume One: North and Middle America*. Prentice-Hall. Englewood Cliffs, New Jersey.

Willey, G. and P. Philips

- 1958 *Method and Theory in American Archaeology*. University of Chicago Press. Chicago, Illinois.

Willey, P.

- 1978 Human Skeleton from the Deadman's Shelter Site. In *Archaeology at Mackenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 198-204. Office of the State Archaeologist, Survey Report No. 24. Texas Historical Commission. Austin, Texas.

Willey, P., B. Harrison, and J. Hughes

- 1978 The Blue Clay Site. In *Archaeology at Mackenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 138-140. Office of the State Archaeologist, Survey Report No. 24. Texas Historical Commission. Austin, Texas.

Willey, P. and J. Hughes

- 1975 *An Archaeological Survey of an Isolated Section in Lake Theo State Park, Briscoe County, Texas*. Kilgore Research Center, Archaeological Research Laboratory. Canyon, Texas.

- 1978a The Deadman's Shelter Site. In *Archaeology at Mackenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 149-190. Office of the State Archaeologist, Survey Report No. 24. Texas Historical Commission. Austin, Texas.

- 1978b The County Line Site. In *Archaeology at Mackenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 115-137. Office of the State Archaeologist, Survey Report No. 24. Texas Historical Commission. Austin, Texas.

- 1978c Summary and Recommendations. In *Archaeology at Mackenzie Reservoir*, edited by J. Hughes and P. Willey, pp. 279-282. Office of the State Archaeologist, Survey Report No. 24. Texas Historical Commission. Austin, Texas.

Willey, P. and D. Ubelaker

- 1976 Notched Teeth from the Texas Panhandle. *Washington Academy of Science Journal* 66:239-246.

Wilmsen, E.

- 1973 Interaction, Spacing Behavior, and the Organization of Hunting Bands. *Journal of Anthropological Research* 29:1-31.

Wilson, M.

- 1981 Population Dynamics of the Garnsey Site Bison. In *Late Prehistoric Bison Procurement in Southeastern New Mexico: The 1978 Season at the Garnsey Site (LA18399)*, edited by J. Speth and W. Parry, pp. 88-129. University of Michigan, Technical Reports No. 12. Ann Arbor, Michigan.

Winter, J.

- 1988 *Stone Circles, Ancient Forts, and Other Antiquities of the Dry Cimarron Valley: A Study of the Cimarron Seco Indians*. New Mexico Historic Preservation Program, Historic Preservation Division. Santa Fe, New Mexico.

Winterhalder, B.

- 1981a Optimal Foraging Strategies and Hunter-Gatherer Research in Anthropology: Theory and Models. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 13-35. University of Chicago Press. Chicago, Illinois.
- 1981b Foraging Strategies in the Boreal Forest: An Analysis of Cree Hunting and Gathering. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 66-98. University of Chicago Press. Chicago, Illinois.
- 1986 Diet Choice, Risk, and Food Sharing in a Stochastic Environment. *Journal of Anthropological Archaeology* 5:369-392.
- 1987 The Analysis of Hunter-Gatherer Diets: Stalking an Optimal Foraging Model. In *Food and Evolution: Toward a Theory of Human Food Habits*, edited by M. Harris and E. Ross, pp. 311-339. Temple University Press. Philadelphia, Pennsylvania.

Winterhalder, B. and E. Smith (Editors)

- 1981 *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*. University of Chicago Press. Chicago, Illinois.

Wolfshol, K.

- 2000 Take Land Back From Cedars. *Progressive Farmer* 115(2):54-55.

Wolpoff, M.

- 1971 A Functional Measure of Tooth Size. *Southwestern Journal of Anthropology*

27:279-286.

Wood, C.

1974 Excavations at Trinchera Cave, 1974. *Southwestern Lore* 40:53-56.

Wood, W. and D. Johnson

1978 A Survey of Disturbance Processes in Archaeological Site Formation. In *Advances in Archaeological Method and Theory*, Volume 1, edited by M. Schiffer, pp. 315-381. Academic Press. New York, New York.

Wormington, H.

1957 *Ancient Man in North America*. Denver Museum of Natural History. Denver, Colorado.

Wright, E. and T. Bretz

1949 Shade Trees for the Plains. In *Trees: The Yearbook of Agriculture*, pp. 65-72. United States Department of Agriculture. Washington, District of Columbia.

Wyckoff, D.

1963 *Mangum Reservoir Archaeological Survey, Greer and Harmon Counties, Oklahoma*. Oklahoma River Basin Survey, General Survey Report No. 2. Norman, Oklahoma.

1970 State of Oklahoma Archaeological Site Form: 34BK46. Oklahoma Archeological Survey. Norman, Oklahoma.

1989 An Introductory Study of Alibates Gravel Occurrences along Western Oklahoma's Canadian River. In *In Light of Past Experiences, Papers in Honor of Jack T. Hughes*, edited by B. Roper, pp. 405-452. Panhandle Archaeological Society, Publication No. 5. Clarendon, Texas.

1991 Refitting and Protohistoric Knapping Behavior: The Lowrance Example. In *Piecing Together the Past: Applications of Refitting Studies in Archaeology*, edited by J. Hofman and J. Enloe, pp. 83-127. British Archaeological Reports, International Series No. 578. Oxford, England.

1992a Archaic Cultural Manifestations on the Southern Plains. *Journal of American Archaeology* 5:168-199.

1992b Background to the Nature and Significance of the Certain Bison Kill Site, 34BK46, Beckham County, Oklahoma. Manuscript prepared for Bob Fleshman, Elk City, Oklahoma. On file at the Oklahoma Archeological Survey.

1993a Gravel Sources of Knappable Alibates Silicified Dolomite. *Geoarchaeology*

8:35-38.

1993b A Summary of the Calf Creek Horizon in Oklahoma. *Oklahoma Anthropological Society Bulletin* 42:179-210.

1993c Introduction to the 1991 Bulletin. *Oklahoma Anthropological Society Bulletin* 42:1-8.

1999 Southern Plains Folsom Lithic Technology: A View from the Edge. In *Folsom Lithic Technology: Explorations in Structure and Variation*, edited by D. Amick, pp. 39-64. International Monographs in Prehistory, Archaeological Series No. 12. Ann Arbor, Michigan.

Wyckoff, D., G. Brakenridge, K. Buehler, B. Carter, W. Dort, L. Martin, J. Theler, and L. Todd.

1991 *Interdisciplinary Research at the Burnham Site (34WO73), Woods County, Oklahoma*. A Prehistory of the Plains Border Region, Guidebook of the 9th Annual Meeting of the South-Central Friends of the Pleistocene, compiled by B. Carter and P. Ward, pp. 82-121. Department of Agronomy, Oklahoma State University. Stillwater, Oklahoma.

Wyckoff, D. and B. Carter

1994 *Geoarchaeology at the Burnham Site: 1992 Investigation at a "Pre-Clovis" Site in Northwestern Oklahoma*. National Science Foundation Grant DBS-9120314. Special Publication of the Oklahoma Archeological Survey.

Wyckoff, D., B. Carter, W. Dort, K. Buehler, L. Martin, J. Theler, and L. Todd

1990 Northwest Oklahoma's Burnham Site: Glimpses beyond Clovis? *Current Research in the Pleistocene* 7:60-63.

Wyckoff, D. and L. Neal

1994 Some Preliminary Conclusions about the Calf Creek Horizon in the Osage Savannah. *Oklahoma Anthropological Society Bulletin* 40:347-350.

Wyckoff, D. and D. Shockey (editors)

1994 (untitled). *Oklahoma Anthropological Society Bulletin* 40 (for 1991).

1995 (untitled). *Oklahoma Anthropological Society Bulletin* 42 (for 1993).

Wyckoff, D. and L. Taylor

1971 The Pumpkin Creek Site: An Early Archaic Site on the Southern Plains Border. *Plains Anthropologist* 16:20-51.

Wylie, H.

- 1974 Tool Microwear and Functional Types from Hogup Cave, Utah. *Tebiwa* 17(2):1-32.
- Yesner, D.
- 1981 Archaeological Applications of Optimal Foraging Theory: Harvest Strategies of Aleut Hunter-Gatherers. In *Hunter-Gatherer Foraging Strategies: Ethnographic and Archaeological Analyses*, edited by B. Winterhalder and E. Smith, pp. 148-170. University of Chicago Press. Chicago, Illinois.
- Young, D. and R. Bonnicksen
- 1984 *Understanding Stone Tools: A Cognitive Approach*. Center for the Study of Early Man, Peopling of the Americas Process Series No. 1. Orono, Maine.
- Zimmerman, L.
- 1985 *Peoples of Prehistoric South Dakota*. University of Nebraska Press. Lincoln, Nebraska.
- Zimmerman, L. and L. Bradley
- 1993 The Crow Creek Massacre: Initial Coalescent Warfare and Speculations about the Genesis of Extended Coalescents. In *Prehistory and Human Ecology of the Western Prairies and Northern Plains*, edited by J. Tiffany, pp. 215-226. Memoir 27. Plains Anthropologist 38, Part 1.

Appendix A Select Spring to Fall Bison Kills with Mandible Data						
	Garnsey	Scottsbluff	Mill Iron	Wardell	Lipscomb	Vore
0.0 - 0.4 years	Modern, SE New Mexico (0.0-0.1) Fetal & neonatal; no or slight dental wear on peak of deciduous premolars; M1 in bud stage & below alveolus	Extinct, W. Nebraska Not Available	Extinct, SE Montana (0.0-0.1) Neonatal; only 20-30 mm on the M1 crowns are formed at birth & roots of premolars are not completely formed (abv. based on comp. coll.)	Modern, W. Wyoming (0.4) Deciduous incisors & premolars erupted; dp2 & dp3 have moderate wear; dp4 minimal wear; M1 is erupted but unworn	Extinct; NE Texas Not Available	Modern; E. Wyoming (0.0-0.1) All deciduous teeth erupted; two & possibly four cusps exposed with variable wear on facets 1-4
1.0 - 1.4 years	(1.0) M1 erupted to level of dp4 which has all but exostylid in wear; facets 1-6 in wear on M1 & facets 7-8 are slightly worn; M2 erupted, in bud stage	(1.1-1.2) Deciduous premolars in wear; facets 1-8 are worn on M1; exostylid on M2 is 8-14 mm from wear	(1.1-1.2) M1 is in full wear, exostylid is 9-11 mm below the occlusal surface; M2 is erupting with the metaconid about 12 mm above alveolus; M3 not visible	(1.4) Roots on all dp's are exposed; dp2 & dp3 well worn; dp4 moderately to well worn; M1 slightly worn; M2 erupted with occasional wear on cusp 1	(1.2-1.4) M1 fully erupted & all facets in wear; M2 exhibits variable stages of eruption but not worn	(1.1-1.2) M2 begins erupting; M3 might be visible, but not worn
2.0 - 2.5 years	(2.0) dp4 starting to cup; M1 in full wear on all facets & exostylid has slight to no wear; M2 is in wear on all facets, with slight wear on facets 7-8; M2 exostylid not in wear & M3 unerupted	(2.1-2.2) Heavy wear on all deciduous premolars; M1 & M2 in full wear, but M2 facets 6-8 in light wear; M1 exostylid 4-5 mm from wear; M3 unerupted but visible	(2.0-2.2) M1 is in regular use with the exostylid just beginning to wear, or 3-5 mm from the occlusal surface; M2 is erupted with variable wear; facets 1-4 are always in wear & often wear progresses through facet 8; M3 beginning to erupt but hypo. is not exposed	(2.4) Extensive wear on dp2, dp3, & dp4 with roots exposed on dp2 & dp3; roots & permanent teeth sometimes visible below dp2 & dp3; M1 & M2 moderately to well worn; M3 erupted with first cusp occasionally in wear & second cusp visible; M3 hypoconulid never visible	(2.2-2.5) M1 is in full wear including exostylid on a few specimens; exostylids are both joined & separated while others are 3 mm from wear; wear on M2 varies from full to wear on facets 1-6; M3 never in wear & hypoconulid not visible	(2.1-2.5) First cusp of M3 starts erupting at 2.2 years & by 2.5 all cusps are erupted except hypoconulid; possible light wear on facets 1-2
3.0 - 3.6 years	(3.0) Wear on M3 occurs on facets 1-6; exostylid not yet visible; description based on one specimen	(3.1-3.3) M1 is in full wear with the exostylid joined on some specimens & separated on others; M2 in wear except for exostylid; M3 attrition is	(3.0-3.2) P2 & P3 is erupted & exhibits slight wear; M1 in full use with exostylid in wear; M2 exostylid is roughly 7-9 mm below the surface;	(3.4) P4 partially erupted but never worn; M1 & M2 in regular use while the hypoconulid of M3 is never worn; facets 1-8 are in wear on M3 but to a	(3.2-3.5) M1 & M2 in full wear; exostylid on M1 is worn but still isolated; M2 exostylid is 9-10 mm from wear; M3 hypoconulid erupted but is	(3.0-3.6) Wear on facets 1-4 on M3 & at 3.3 years the hypoconulid emerges; by 3.6 years the hypoconulid is fully erupted but not in wear;

4.0-4.5 years	(4.0) M2 & M3 strongly bilophodont while the M2 exostylid is isolated or worn to a small circle; M3 exostylid just visible below the surface; M3 hypoconulid facet is worn except the most posterior facet on the lingual surface Not Available	variable with wear always on facets 1-2 & often facet 3; light wear also noted on facets 4-8 occasionally; hypoconulid almost always unerupted (4.1-4.2) M1 is in full use, but the exostylid is separated; M2 is in full wear, but exostylid is not; M3 is fully erupted with wear on all facets, but to a lesser extent on facet 9	M3 is erupted with wear varying from facets 1-2 to 1-6 (always on facets 1-2); M3 hypoconulid is never worn	(4.0-4.2) All M3 facets except the hypoconulid is in wear; in some cases the hypoconulid has light polish	(4.4) Facets 1-4 of M3 are well worn & facets 5-8 moderately to well worn; hypoconulid on M3 is fully erupted & in wear with enamel bordering a slightly exposed layer of dentine	Not Available	never worn; M3 facet wear varies but rarely is there wear on facets 7-9	cusps 6-7 in wear & rarely is cusp 8
5.0-5.6 years	Not Available	Not Available	(4.9-5.2) P2-P4 all in wear with P4 at, or slightly below, the level of M1; M1 is in full wear & the exostylid is joined; M2 is in full use except for the exostylid which is 1-4 mm from wear; all M3 facets are in wear with varying degrees of connection to the occlusal surface; hypoconulid wear varies, also, from use to non-use	(5.4) Average enamel height of M1: 31.0 mm	Not Available	Not Available	(5.6) Average enamel height of M1: Level 1, 33.0 mm Level 2, 28.3 mm Level 3, 28.0 mm Level 4, not available Level 5, 31.0 mm	(4.0-4.5) All facets on M3 in use including the hypoconulid; hypoconulid wear continues through the fall; Average enamel height of M1: Level 1, 33.7 mm Level 2, 32.8 mm Level 3, 33.3 mm Level 4, not available Level 5, 34.5 mm
6.0-6.6 years	(6.0) All molars in full wear; M1 is weakly bilophodont; M2 is strongly bilophodont;	Not Available	(6.0-6.2) M2 is in full wear with the exostylid slightly worn, but not connected to the occlusal surface;	(6.4) Average enamel height of M1: 27.6 mm	Not Available	Not Available	(6.6) Average enamel height of M1: Level 1, 27.5 mm Level 2, 23.3 mm	

	M3 exostylid ranges from unworn but close to the crown, polished, to lightly worn with a small ring		M3 is in full use with the hypoconulid connected, with an occasional ring of enamel; M3 exostylid is not in wear & still 5-10 mm below the grinding (occlusal) surface			Level 3, 22.9 mm Level 4, not available Level 5, 28.0 mm
7.0-7.6 years	(7.0) M1 is beginning to cup in front; M2 varies from weakly to strongly bilophodont; M2 exostylid has joined the occlusal surface; M3 exostylid separated by a ring	Not Available	(7.0-7.2) M1 is in full wear & the prefosset is reduced in some cases; M1 exostylid is joined; M2 exostylid is joined; M3 in full wear but exostylid is separated by a ring of enamel	(7.4) Average enamel height of M1: 25.2 mm	Not Available	(7.6) Average enamel height of M1: Level 1, 23.8 mm Level 2, 20.9 mm Level 3, 18.1 mm Level 4, not available Level 5, 25.6 mm
8.0-8.6 years	(8.0) Anterior portion of M1 beginning to flatten out & cup; M2 occlusal surface nearly flat; M3 exostylid worn to an oval & almost joining the occlusal surface	Not Available	(8.0-8.2) No M1 data are available; P2-P4, M1-M3 are all in full use; exostylid on M1 & M2 have joined the occlusal surface; M3 exostylid is in wear but still isolated; M2 & M3 metaconid heights also used to rank age	(8.4) Average enamel height of M1: 22.3 mm	Not Available	(8.6) Average enamel height of M1: Level 1, 18.0 mm Level 2, 18.8 mm Level 3, 14.7 mm Level 4, not available Level 5, 22.0 mm
9.0-9.6 years	(9.0) Very similar to the above group & based mostly on metric traits; M1 varies from heavy wear to cupped; M2 is worn flat; M3 exostylid joining the occlusal surface	Not Available	(9.0-9.2) M1 prefosset is entirely gone or reduced to a small oval; M3 exostylid is still not joined to the primary occlusal surface	(9.4) Average enamel height of M1: 18.7 mm	Not Available	(9.6) Average enamel height of M1: Level 1, 15.8 mm Level 2, 16.4 mm Level 3, 10.6 mm Level 4, not available Level 5, 18.6 mm

10.0-10.6 years	(10.0) M1 & M2 cupped; M3 slightly bilophodont; M3 exostylid is oblong & has joined the occlusal surface	Not Available	(10.0-10.2) Not Available	(10.4) Average enamel height of M1: 14.8 mm	Not Available	(10.6) Average enamel height of M1: Level 1, 13.2 mm Level 2, 13.3 mm Level 3, 8.3 mm Level 4, not available Level 5, 15.3 mm
11.0-11.6 years	(11.0) M1 is shed or is reduced to root stubs; M2 enamel nearly gone & possible into root stubs; M3 is worn flat	Not Available	(11.0-11.2) Not Available	(11.4) Average enamel height of M1: 9.9	Not Available	(11.6) Average enamel height of M1: Level 1, 9.3 mm Level 2, 8.4 mm Level 3, not available Level 4, not available Level 5, 11.3 mm
12.0-12.6 years	(12.0) M1 is shed or is reduced to root stubs; M2 enamel nearly gone & possible into root stubs; M3 cupped	Not Available	(12.0-12.1) M1 is heavily worn with the prefosset obliterated, the post fosset greatly reduced, & the base of the exostylid is nearly removed; M2 fossets are reduced to ovals in the middle & rear; small part of exostylid is visible; M3 is in full use & the exostylid has joined the entire occlusal surface	(12.4) Average enamel height of M1: 5.5 mm	Not Available	(12.6) Average enamel height of M1: Level 1, not available Level 2, 4.5 mm Level 3, 2.0 mm Level 4, not available Level 5, 7.4 mm
13.0-13.6 years	Not Available	Not Available	(13.0-13.1) M1 & M2 are nearly gone & the enamel on the metaconids is almost gone; M3 exostylid is connected to the main occlusal surface; data are from a single specimen	(13.4) Average enamel height of M1: 4.0 mm	Not Available	(13.6) Average enamel height of M1: Level 1, 0.0 mm Level 2, 0.0 mm Level 3, 0.0 mm Level 4, not available Level 5, 4.5 mm

Appendix B Select Fall to Winter Bison Kills with Mandible Data						
	Glenrock Modern, Crtl. Wyoming (0.5) All deciduous incisors & premolars in place; dp2-4 worn; M1 erupted but unworn, there may be polish; M2 sometimes visible Average enamel height of M1, 54.1 mm	Casper Extinct, E. Wyoming (0.6) dp2-4 worn on all cusps; M1 erupted with wear on facets 1-4 & light wear on facets 5-6 some- times; M2 can be seen, 1-2 mm above surface, but not in wear	Horner II & Finley* Extinct, W. Wyoming (0.6) All deciduous premolars in place with slight wear on dp2, but dp3-4 are in full use; M1 erupted with no wear to light; M2 not erupted but visible being M1	Ayers-Frazier** Modern, Montana (0.6) dp3-4 in full wear; M1 lightly worn on facets 1-4 & 1-6 in some cases; M1 facets 3-4 not joined; facets 5-6 have a thin denture band; exostylid not yet visible, M2 is unerupted but visible behind M1; Average enamel height of M1, 49.5 mm	Hawken Extinct, E. Wyoming (0.7) All deciduous premolars in wear; M1 erupted with wear on facets 1-6, but wear is light on facets 5-6; M2 not erupted but visible in opening behind M1	Agate Basin---AB Comp. Extinct, E. Wyoming (0.8-0.9) All deciduous premolars in wear; M1 has wear on facets 1-8; M2 unerupted but visible below the alveolus
0.5 - 0.9 years						Agate Basin---HG Comp. Extinct, E. Wyoming (0.6-0.7) dp3-4 in wear; M1 demonstrates wear on facets 1-4 with light wear on facets 5-6; Average enamel height of M1, 55.0 mm
1.5 - 1.9 years	(1.5) dp2-4 well worn with roots visible & permanent premolars visible underneath. M1 moderately worn; M2 not fully erupted but may show wear; M3 visible & unworn; Average enamel height of M1, 46.3 mm	Not Available	(1.6) dp2-4 well worn with roots partially exposed; M1 in full use with wear occurring on facets 1-2 & occasionally on facets 1-4; M1 exostylid never in wear; M2 exostylid never exposed, but cusps 1-4 shown use; M3 unerupted	(1.6) All deciduous premolars in use with dp4 flattening out; M1 fully in wear; M1 exostylid visible but 12mm from occlusal surface; wear on M2 facets 1-3; M2 facets 7-8 still partially concealed at alveolar surface; Average enamel height of M1, 48.6 mm	(1.7) All deciduous premolars in use; M1 fully erupted & in use; M2 is erupted & shows variable use from facets; M2 wear on facets 1-2 with light wear on facets 3-4; M3 visible but not erupted	(1.6-1.7) P4 has not broken the alveolar plane; M1 is full use & reduced in length; M2 is erupted & wear varies; M2 facets 1-6 can be in use with wear being light on facets 5-6; M3 has not erupted but is visible below the alveolus
2.5 - 2.7 years	(2.5) P2 & P3 pushing up into dp2-3 which are barely rooted; dp4 worn but not dislodged; M1 & M2 moderately to well worn; M3 partially erupted, except for hypoconulid; never wear on M3; Average enamel height of M1, 38.2 mm	(2.6) Varies between P2 & P3 in place to dp2-3 still in place; dp4 well worn if still present; M1 & M2 in regular use; M3 cusps 1-2 exposed but no wear	(2.6) dp2-3 are pushed out or have roots exposed with P2 & P3 visible; P4 also visible below the alveolus; none of the permanent premolars are in use; all cusps of M1 & M2 is use; M1 exostylid beginning to wear or 1 mm from wear; M2 exostylid erupted but never in use;	(2.6) dp3 is shed & there is light wear on P3; dp4 worn flat. M1 is in full use & exostylid is connected with main occlusal plane; M2 in complete wear but exostylid is just reaching the alveolus, 7 mm from use; M3 partially erupted with polish or wear on	(2.6-2.9) P2 & P3 in place & might be in wear; dp4 being pushed out by P4; M1 & M2 in full use; exostylid of M1 in wear or beginning; M3 is erupted with wear on facets 1-2 & possibly on facet 3; hypoconulid is below the alveolus, but might be seen visible	(2.6-2.7) dp4 is above the alveolus; M1 exostylid just beginning to wear; light wear on cusps 1-2; Average enamel height of M1, 45.0 mm

3.5 - 3.9 years	(3.5) P2 & P3 moderately to well worn; P4 partially erupted with light wear possible; M1 & M2 in full use; M3 cusp 3 (hypoconulid) visible but never worn; Average enamel height of M1, 34.7 mm	(3.6) P2 & P3 erupted & in wear; dP4 may still be in place; M1 & M2 in regular wear; M3 is erupted with wear on cusps 1-2 (facets 1-8); hypoconulid is never worn	M3 partially erupted, but hypoconulid is still not exposed;	(3.6) P2 & P3 in place & in use; P4 is never in wear & dP4 may still be present; M1 & M2 have wear on all cusps; M1 exostylid is always in use but it may be light; M2 exostylid is never in wear; all cusps on M3 are in use except the hypoconulid	Not Available Average enamel height of M1, 39.0 mm	(3.7) All premolars have erupted & P4 is coming into wear; M1 & M2 are in full wear; M3 facets 1-8 are in wear, but amount of wear may be light on facets 7-8 hypoconulid is above the alveolus but not yet worn	(3.6-3.9) P2 & P3 are in wear; dP4 may still be in place but rarely; P4 has light wear; M2 exostylid in not in wear; M3 use varies but wear is generally on facets 1-8 with none on the hypoconulid; wear on M3 facets 7-8 might be slight	(3.6-3.7) M2 has a metaconid height of 58 mm; M2 exostylid is still below the occlusal surface; Average enamel height of M1, 34.7 mm
4.5 - 4.9 years	(4.5) P2-P4 are moderately to well worn; M1 & M2 are in regular use; M3 cusp 3 is lightly worn with just a little enamel showing; area between cusp 2-3 not worn; Average enamel height of M1, 28.8 mm	(4.6) P2-P4 are fully erupted with moderate use; M3 cusps 1-2 are in regular wear; M3 cusp 3 is only worn in the front; M3 cusp 3 will soon be worn to a large ring & soon join the occlusal surface	(4.6) P2-3 are erupted & in wear; P4 wear can be variable & may not be in wear; M1 & M2 are in full use; M1 & M2 exostylids are above the alveolus; M1 exostylid has joined; M2 exostylid is never worn; M3 has wear on all cusps, but hypoconulid is usually separated from occlusal surface by a ring of enamel	(4.6) All teeth (P2-M3) are in use; M1 exostylid is worn to a loop & enamel base is at or below the alveolus; M2 exostylid is unworn or lightly to a tiny ring; M3 exostylid is visible above the alveolus but 10 mm below the occlusal surface Average enamel height of M1, 26.0-30.5 mm	(4.6) All teeth are worn; M2 exostylid is usually in wear; M3 hypoconulid is in use, but isolated from the rest of the tooth; essentially the animal has a mature dentition at this stage in the lifecycle	(4.6-4.9) All teeth are in use; M3 hypoconulid is in wear, but the enamel still may form a ring isolating it from the remainder of the tooth's grinding surface	(4.6-4.7) All teeth are in wear; M2 exostylid is usually in wear or near wear; M3 hypoconulid has light wear; nearly mature animals at this age; Average enamel height of M1, 16.5 mm	(4.6-4.7) M2 has a metaconid height of 58 mm; M2 exostylid is usually in wear or near wear; M3 hypoconulid has light wear; nearly mature animals at this age; Average enamel height of M1, 16.5 mm
5.5 - 5.9 years	(5.5) All permanent teeth are fully erupted & in wear; hypoconulid in full wear; enamel is continuous around the teeth; fossi are still visible; dentally mature Average enamel height of M1, 25.4 mm	(5.6) Average enamel height of M1: 32.2 mm	(5.6) M1 enamel-root line is slightly below the alveolus; M2 exostylid is either in slight wear with an enamel ring visible, or not worn at all	(5.6) Enamel base of M1 is at the alveolus; M2 exostylid is worn to a loop, but is still separate from the main occlusal surface; M3 exostylid is worn but has is distinct from the wear plane	(5.7) Enamel line at the base of the M1 metaconid is close to the alveolus	(5.6-5.9) M1 wear continues but deterioration of M1 is not readily evident from the previous year; the enamel line at the base of M1 metaconid is nearly at the level of the alveolar surface; M2 exostylid is in use; fully mature dentition	(5.6-5.7) M2 exostylid is in full use, but a ring of enamel separates the stylid from the rest of the tooth's surface; Average enamel height of M1, 16.5 mm	(5.6-5.7) M2 exostylid is in full use, but a ring of enamel separates the stylid from the rest of the tooth's surface; Average enamel height of M1, 16.5 mm

6.5 - 6.9 years	(6.5) All permanent teeth are fully erupted & in wear; hypoconulid in full wear; enamel is continuous around the teeth; fossi are still visible; dentally mature; progression in wear from previous year; Average enamel height of M1, 22.5 mm	(6.6) Average enamel height of M1: 29.8 mm	(6.6) M1 enamel-root line is above the alveolus; M2 exostylid is always in wear but an enamel ring still isolates the stylid from the remainder of the tooth	(6.6) M1 enamel base is above the alveolus; M1 exostylid is worn to a loop which has joined the crown; M2 enamel base is below the alveolus; M2 exostylid has formed a loop & is just beginning to join the alveolar surface or is not joined just yet; M3 exostylid is not worn, or worn to a tiny ring, distinct from the crown; Average enamel height of M1, 16.5-15.3 mm	(6.7) M1 enamel base is above the alveolus; M2 enamel base is below the alveolus; some breakdown of M1 may be occurring; M3 exostylid begins to wear	(6.6-6.9) M1 enamel line is above the alveolus; M1 is reduced & cupping begins to occur, or breakdown of enamel; M2 enamel line is at or near the alveolar surface; M3 exostylid is in wear or is beginning to wear	(6.6-6.7) Enamel base of M1 is above the alveolus; M2 enamel line is below the alveolus; M1 is cupped in the front & as expected the rear of P4 is equally cupped; M3 exostylid is coming into wear; Average enamel height of M1, 19.0 mm
7.5 - 7.9 years	(7.5) All permanent teeth are fully erupted & in wear; hypoconulid in full wear; enamel is continuous around the teeth; fossi are still visible; dentally mature; progression in wear from previous year; Average enamel height of M1, 20.4 mm	(7.6) Average enamel height of M1: 26.1 mm	(7.6) M2 enamel-root line is near the alveolus or below; M2 exostylid is worn such that the stylid joins the rest of the occlusal plane; M3 exostylid may be in use, but it is separated from the rest of the tooth by an enamel ring	(7.6) M1 enamel base is above the alveolus; M1 exostylid has joined the rest of the tooth; M2 enamel base is below the alveolus; M2 exostylid is a loop & barely joining the crown; M3 enamel base is below the alveolus; M3 exostylid is worn to a circle expanding toward the crown; Average enamel height of M1, 16.5-15.3 mm	(7.7) Deterioration of M1 is evident; M1 cupping is occurring; M2 is still in good shape; M2 metaconid enamel base is close to the level of the alveolus	(7.6-7.9) M1 may be worn away; M2 metaconid enamel base is at the level of the alveolus; M3 metaconid height is used to identify the age group; M1 wear varies making it useless as a reliable age indicator	(7.6-7.7) Enamel level of M2 is at the alveolus; M3 exostylid is in wear; Average enamel height of M1, 17.0 mm
8.5 - 8.9 years	(8.5) All permanent teeth are fully erupted & in wear; hypoconulid in full wear; enamel is continuous around the teeth; fossi are still visible; dentally mature; progression in wear from previous year; Average enamel height of M1, 17.0 mm	(8.6) Average enamel height of M1, 20.5 mm	(8.6) M1 preforesette is heavily worn; M2 enamel-root line is at the same level as the alveolus; M2 exostylid has joined; M3 exostylid is always in wear, often with a ring left	Not Available	(8.7) M1 is deeply cupped; M1 enamel may only remain as small projections; M2 is deteriorating & cupping; enamel base of M2 is above the alveolus; M3 metaconid height is used to identify the age	(8.6-8.9) M1 enamel ranges from being absent at the metaconid to being flat; M2 is well worn; M2 metaconid level is above the alveolus; M3 metaconid height is used to identify the age group	Not Available

9.5 - 9.9 years	(9.5) All permanent teeth are fully erupted & in wear; hypoconulid in full wear; enamel is continuous around the teeth; fossi are still visible; dentally mature; progression in wear from previous year; Average enamel height of M1, 13.2 mm	(9.6) Average enamel height of M1, 15.4 mm	(9.6) M1 exostylid is usually gone; M1 fossettes may be worn away; M2 enamel-root line is above the alveolus; M2 exostylid is joined to the remainder of the tooth; M1 & M2 are unreliable in older individuals; M3 enamel-root line is at the level of the alveolus; M3 exostylid has joined the tooth to form a continuous ring of enamel	Not Available	(9.7) M1 & M2 are unreliable in older individuals; M2 & M3 are further reduced; M3 metaconid height is used to identify the age	(9.6-9.9) Condition of M1 & M2 varies greatly; enamel base of M3 is at the level of the alveolus	Not Available
10.5 - 10.9 years	(10.5) All permanent teeth are extensively worn; hypoconulid in full wear; in some case teeth are completely gone or all that is left is root stubs Average enamel height of M1, 9.3 mm	(10.6) Average enamel height of M1, 11.2 mm	(10.6) M1 fossettes & exostylid are gone; M2 fossettes are present, but heavily worn; M3 enamel-root line is above the alveolus	Not Available	(10.7) Enamel base of M3 metaconid is above the alveolus; M3 is greatly reduced; crown bases are quite obvious	(10.6-10.9) M3 enamel level is above the alveolus; M3 height is greatly reduced	Not Available
11.5 - 11.9	(11.5) All permanent teeth are extensively worn; hypoconulid in full wear; in some case teeth are completely gone or all that is left is root stubs Average enamel height of M1, 5.6 mm	(11.6) Average enamel height of M1, 5.0 mm	(11.6) Extreme degree of attrition on all molars; all M1 & M2 fossettes are gone; M3 pre-fosslette is worn away; exostylids on M1-M3 are gone; M3 enamel-root line is well above the alveolus	Not Available	(11.7) M3 is greatly reduced in height & fossettes are deteriorating	(11.6-11.9) M1 is worn below the level of the alveolus & only root stubs remain; M2 is nearly gone; M3 is greatly reduced	Not Available
	(12.5) All permanent teeth are extensively worn; hypoconulid in full wear; in some case teeth are completely gone or all that is left is root stubs	Not Available	Not Available	Not Available	Not Available	Not Available	Not Available

Appendix C Trench C Mandibles					Comments
Cat. #	Side	Age*	Sex** (mm)		
1065	Right	0.6-1.0	Unknown		Extensively damaged; M2 & M3 available only---M2 not in wear, exostylid on M1 not in wear
1105	Left	1.1	Unknown		M3 only---Facets 1-3 exhibit polish
1257	Right	1.6	Unknown		Extensively damaged; M2 facets 7 & 8 not in wear
2152	R & L	2.4-2.6	Unavailable		Compressed mandibles--- no sex id.; includes a few maxillary teeth and skull
1187	Left	2.6-2.8	Unknown		Still retains deciduous premolars, but well-worn
1131	Right	3.0-3.5	Unknown		M3 & dP3 only; dP3 cupped; exostylid 12.2 mm from occlusal surf.; cusps 5 & 6 new wear
1174	L & R	3.1-3.3	Unknown		Extensively damaged; M2 & M3 only both L & R; wear on facets 1 & 3 of M3
1007	Right	3.6-3.9 (4.0)	Cow (70.7)		Damaged below M3 (measurement estimated); associated with hyoid, atlas, & left maxilla
1027	Right	3.6-4.0	Unknown		M2 only; some of horizontal ramus is attached; exostylid is 5.4 mm from occlusal surface
1036 A	Left	4.0-4.4	Bull (75.5)		Apparently associated with 1036 B
1036 B	Right	4.0-4.4	Cow (69.8)		Damaged below M3 (measurement estimated)
2342	Left	4.0-4.6	Cow (68.3)		M1 exostylid is joined; M2 is near alveolus; M3 hypoconulid has wear on bucal
2232	R & L	~4.6	Cow (62.8)		M1 exostylid joined; M2 exostylid is a small ring; M3 exostylid is at alveolar plane
1212	Right	4.6+	Bull (76.7)		Juvenile bull still attached to cow-calf herd
13	Right	4.9-6.0	Unknown		M3 fragment but missing the hypoconulid; exostylid is 5.8 mm from occlusal surface
78	Right	~4.6	Unknown		P3 worn flat; posterior enamel ring is absent
84	Left	~4.6	Unknown		M3 only; all surfaces of hypoconulid are worn; exostylid is 11.8 mm from occlusal surface
1222	L & R	5.6	Cow (68.0)		Observations based on left mandible; damaged below M3 (measurement estimated)
2516	Right	5.6	Cow (70.6)		P2-4 level; M1 exostylid is joined; M2 exostylid is large ring; M3 exostylid not worn
2092	R & L	5.6	Bull (78.6)		Measurement taken on left mandible; includes a few maxillary teeth and skull frags.
1166	L & R	5.6 (<6.6)	Cow (70.5)		Observations based on left mandible; associated with hyoid, C1-3, & right maxilla
1167	L & R	5.6 (<6.6)	Bull (74.3)		Observations based on right mandible; still articulated with cranium---frontal obliterated
1100	L & R	5.6 (<6.6)	Bull (74.8)		Observations based on left mandible; associated with calcaneus-under mandible
1175	Left	5.6 (<6.6)	Cow (68.1)		Damage below M3 (measurement estimated)
2154	Left	5.6 (<6.6)	Bull (75.5)		Large specimen; exostylid on M3 not in wear
2177	Left	5.6 (<6.6)	Bull (85.6)		Large specimen; exostylid on M2 is in wear; some damage to the mandible under M3
2121	R & L	6.0+	Cow (70.1)		Includes a few maxillary teeth; some damage to the mandible under M3 (sex id.)
1034	Right	<6.6	Unknown		M2 & M3 only; maybe 4.2-4.7 or 5.6 depending on reference
2335	Left	6.6	Cow (68.1)		Exostylid on M2 in wear; hypoconulid of M3 beginning to wear
2828	R & L	6.6	Bull (79.7)		M1 is joined; M2 is a large ring; M3 hypoconulid is well worn, exostylid not in use
2190	R & L	6.6-7.0+	Cow (72.1)		Skull and mandible; occlusal surface is flattened; exostylid on M3 not visible

1161	Right	7.0-7.6	Bull (77.1)	Associated with hyoid & maxilla fragment
1052	Right	7.2-7.6	Unknown	Extensively damaged; age based on M3 only
2226	Left	7.6-8.6+	Bull (81.7)	M1 prefossette and postfossette are gone; M3 exostylid is still isolated; see 2333
1179	Right	8.0-8.6	Unknown	Age based on M2 & M3
1172	Left	8.2-8.6	Unknown	Damaged; exostylid on M2 has joined & on M3 it is isolated, but occlusal surface is wide
1194	Right	8.6-9.6	Cow (60.6)	Extensively damaged (measurement estimated)
2333	Right	8.6-9.0	Bull (81.3)	Most likely a match with mandible 2226---similar metric/non-metric characteristics
2509	Left	9.2-9.6	Unavailable	Fragmented specimen, ascending ramus; teeth included
2557	Right	9.0-12.0	Unavailable	P4 & M1 are cupped; M2 anterior crown gone; M3 exostylid is joined-large loop
1178	Left	(10.6+) 12	Cow (70.6)	Observations based on left mandible; some damage below M3; mature, robust cow
1181	L & R	11.6+	Bull (86.3)	Observations based on left mandible; geriatric male attached to cow-calf herd
2150	Right	12+	Cow (69.2)	Irregular occlusal surface; necrosis; bone is receding below M1 & M2 roots
2626	Left	13+	Bull (81.7)	Minimal enamel; old individuals may indicate optimal environmental conditions
1721	Left	N/A	N/A	Ramus fragment only; green bone fracture---possible cultural modification
* Based on multiple sources				
** Reher 1974				