

To the Graduate Council:

I am submitting herewith a dissertation written by Jodi A. Jacobson entitled "Determining Human Ecology on the Plains through the Identification of Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*Odocoileus virginianus*) Postcranial Material." I have examined the final electronic copy of this dissertation for form and content and recommend that it be accepted in partial fulfillment of the requirements for the degree of Doctor of Philosophy, with a major in Anthropology.

Walter E. Klippel  
Major Professor

We have read this dissertation  
and recommend its acceptance:

Charles H. Faulkner

Paul W. Parmalee

Hazel R. Delcourt

Accepted for the Council:

Anne Mayhew  
Vice Provost and Dean of  
Graduate Studies

(Original signatures are on file with official student records)

**DETERMINING HUMAN ECOLOGY ON THE PLAINS  
THROUGH THE IDENTIFICATION OF MULE DEER (*ODOCOILEUS  
HEMIONUS*) AND WHITE-TAILED DEER (*ODOCOILEUS VIRGINIANUS*)  
POSTCRANIAL MATERIAL**

**A Dissertation**

**Presented for the Degree of**

**Doctor of Philosophy**

**The University of Tennessee, Knoxville**

**Jodi A. Jacobson**

**May 2004**

## ACKNOWLEDGMENTS

This dissertation would not have been possible without the help of numerous individuals. First I would like to thank the members of my committee for all their help and support. My chair, Dr. Walter Klippel, has been a true mentor. He supported me throughout my entire graduate career and taught me so much in such little ways. His door was always open to me during my stay at UT and I will never forget it. Drs. Paul Parmalee and Charles Faulkner helped to encourage and correct me and were always available when I had a problem. Dr. Hazel Delcourt truly opened my eyes to the world of Quaternary ecology and has given me infinite knowledge of paleoenvironmental change and its use in interpreting past human lifeways. Without her and her husband Paul Delcourt, my knowledge of environmental reconstruction would be lacking.

Other people and institutions helped in various stages of this research. The Illinois State Museum allowed me access to their vertebrate comparative collection. Furthermore, Dr. James “Rick” Purdue helped me find my way around the collection and was also a wealth of information on deer osteology. In addition, he and his wife were kind enough to provide me with housing while I conducted my research in Springfield. I was also granted access to the Natural History Museum at the University of Kansas and Dr. Thorvald Holmes aided me while I was there. Jim Hefflefinger, of Arizona Game and Fish, is an old family friend who not only encouraged my research, but also collected the majority of the deer in my sample from Arizona. Barry Hale of New Mexico Game

and Fish and Dr. Walter E. Cook, a vet with the University of Wyoming, were also responsible for collecting modern deer legs.

There are many who helped me on the archaeological end of the research. Dr. Jack Hofman of the University of Kansas suggested the Scott County Pueblo Site as potential research material. Dr. Mary Adair and Jeannette Blackmar, also at the University of Kansas, and Mathew E. Hill at the University of Arizona shared old presented paper drafts and knowledge of the site with me. I definitely must thank the Kansas State Historical Society for allowing me to examine the fauna and Virginia Wulfkuhle for facilitating that loan. Lastly, I must thank the staff at the University of Tennessee's Statistical Consulting Center for aiding in my knowledge of the statistical methods utilized herein.

On a more personal level, I have many family and friends without whom this dissertation would not have been possible. Thank you to Kate Spradley, Dan Weinand, and Jeannine Windham for letting me discuss aspects of my dissertation with them or for just be a sounding board when not everything was going right. Thank you to my parents, Harry and Judy, and my brothers, Todd and Anjan, who have supported my every step in life. More specifically though I would like to thank my dad who has taught me more about wildlife biology than any class or book ever could by immersing me in it from the day I was born. I do appreciate now all those years of being dragged out to check stations, deer pens, and Southeast Deer Study group meetings.

The person, however, who has given me the most support throughout this endeavor (and done the most proofreading) is my best friend and husband, Paul Matchen.

I cannot imagine the patience and love that had to be involved for someone who prefers lithics to struggle through roughly 200 pages on fauna.

## ABSTRACT

Mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*) were widely utilized resources in North America during prehistoric and protohistoric times. The two species overlap in geographic space over a large portion of the Plains; yet mule deer and white-tailed deer utilize different habitats within that region. Identification of the two species from archaeological context could aid in interpreting human ecological use of an area by past cultures. Prior to this study, there have been no reliable means by which to differentiate between the two species through use of postcranial skeletal material.

Techniques for differentiating between mule deer and white-tailed deer based on morphological and metrical characteristics are presented. Deer remains from the Scott County Pueblo Site (14SC1) are re-analyzed using these techniques. The Scott County Pueblo Site is a mid 1600s to early 1700s protohistoric site in western Kansas. A shift in procurement from primarily mule deer to exclusively white-tailed deer is noted at the site. Differences in hunting strategies and/or the environment during Puebloan and post-Puebloan Dismal River occupations are possible explanations for this change.

## TABLE OF CONTENTS

| CHAPTER  | PAGE |
|--|------|
| 1. INTRODUCTION .....  | 1    |
| 2. IDENTIFICATION AND HISTORY OF ZOOARCHAEOLOGICAL STUDIES .....                   | 7    |
| Identification .....   | 7    |
| Identification of Ungulate Skeletal Material .....                                 | 8    |
| Previous Methods for Differentiating between Mule Deer and White-tailed Deer ..... | 10   |
| Identification for Archaeological Interpretation .....                             | 16   |
| Agriculture and Anthropogenic Disturbance of the Environment ..                    | 16   |
| Changing Environment .....   | 20   |
| Elevational Gradients .....  | 23   |
| Conclusion .....   | 26   |
| 3. EVOLUTION AND PREHISTORIC DISTRIBUTION OF <i>ODOCOILEUS</i> .....               | 28   |
| Evolutionary History of North American Cervids .....                               | 28   |
| Evolutionary History of Genus <i>Odocoileus</i> .....                              | 30   |
| Fossil Evidence .....  | 30   |
| MtDNA Evidence .....   | 31   |
| Modern Odocoileine Variability .....   | 34   |
| Hybridization within the Genus <i>Odocoileus</i> .....                             | 36   |
| Archaeological and Paleontological Evidence of Distributions .....                 | 41   |
| White-tailed Deer Presence outside Modern Distribution .....                       | 45   |
| Mule Deer Presence outside Modern Distribution .....                               | 46   |
| Summary .....  | 50   |
| 4. ECOLOGY OF THE GENUS <i>ODOCOILEUS</i> .....                                    | 52   |
| Introduction .....   | 52   |
| Habitat .....  | 52   |
| Differential Niche Utilization in Overlapping Geographical Territories .           | 54   |
| Case Studies .....   | 55   |
| Historic Evidence for Deer Population and Habitation Instability .....             | 64   |
| Diet .....   | 68   |
| Disease as a Vector for Separation .....   | 70   |

|    |  |     |
|----|--|-----|
|    | White-tailed Deer Non-clinical Parasites . . . . . | 70  |
|    | Mule Deer Non-clinical Parasites . . . . .         | 71  |
|    | Parturition . . . . .                              | 75  |
|    | Predation . . . . .                                | 75  |
|    | Modern to Past Application . . . . .               | 77  |
|    | Agriculture . . . . .                              | 77  |
|    | Environmental Change . . . . .                     | 78  |
|    | Elevation . . . . .                                | 78  |
|    | Locomotion . . . . .                               | 79  |
|    | Summary . . . . .                                  | 81  |
| 5. | METHODS AND MATERIALS FOR IDENTIFICATION . . . . . | 82  |
| 6. | RESULTS . . . . .                                  | 90  |
|    | Introduction . . . . .                             | 90  |
|    | Morphological Characteristics . . . . .            | 90  |
|    | Metrical Analysis . . . . .                        | 112 |
|    | Scapula . . . . .                                  | 114 |
|    | Pooled-age . . . . .                               | 114 |
|    | Adult . . . . .                                    | 118 |
|    | Humerus . . . . .                                  | 123 |
|    | Pooled-age . . . . .                               | 124 |
|    | Adult . . . . .                                    | 124 |
|    | Radius . . . . .                                   | 125 |
|    | Adult . . . . .                                    | 125 |
|    | Pelvis . . . . .                                   | 126 |
|    | Adult . . . . .                                    | 127 |
|    | Metatarsal . . . . .                               | 128 |
|    | Pooled-age . . . . .                               | 129 |
|    | Adult . . . . .                                    | 131 |
|    | 2 <sup>nd</sup> Front Phalanx . . . . .            | 135 |
|    | Pooled-age . . . . .                               | 136 |
|    | Adult . . . . .                                    | 137 |
|    | 2 <sup>nd</sup> Hind Phalanx . . . . .             | 139 |
|    | Pooled-age . . . . .                               | 139 |
|    | Adult . . . . .                                    | 140 |
|    | Pooled 2 <sup>nd</sup> Phalanx . . . . .           | 140 |
|    | Pooled-age . . . . .                               | 140 |
|    | Adult . . . . .                                    | 141 |
|    | Male versus Female Differences . . . . .           | 142 |
|    | Morphological Characteristics . . . . .            | 142 |
|    | Metrical Results . . . . .                         | 143 |

|    |  |     |
|----|--|-----|
|    | Summary .....  | 144 |
| 7. | RESEARCH HISTORY OF THE SCOTT COUNTY PUEBLO SITE<br>(14SC1), KANSAS .....                          | 149 |
|    | Protohistoric Central Plains .....   | 150 |
|    | Dismal River and Plains Apache .....   | 150 |
|    | 14SC1 Site Description .....   | 152 |
|    | Location .....   | 152 |
|    | History of Excavation and Study .....  | 152 |
|    | Kansas State Historical Society Investigations at 14SC1 .....                                      | 156 |
|    | 1970's Excavation at 14SC1 .....   | 156 |
|    | Research on KSHS 14SC1 Collections .....   | 158 |
|    | Summary .....  | 165 |
| 8. | SCOTT COUNTY PUEBLO SITE (14SC1), KANSAS: DISCUSSION<br>AND INTEGRATION OF DEER BONE ANALYSIS..... | 167 |
|    | Scott County Pueblo Analysis .....   | 167 |
|    | Unit 28 .....  | 170 |
|    | Unit 89 .....  | 172 |
|    | Feature 168 .....  | 172 |
|    | Feature 192 .....  | 173 |
|    | Feature 196 .....  | 175 |
|    | Feature 829 .....  | 176 |
|    | Discussion .....   | 177 |
|    | Summary .....  | 179 |
| 9. | CONCLUSION .....   | 181 |
|    | REFERENCES CITED .....   | 185 |
|    | APPENDICES .....   | 199 |
|    | Appendix A: Scott County Pueblo Data .....   | 200 |
|    | VITA .....   | 203 |

## LIST OF TABLES

| TABLE  | PAGE |
|--|------|
| 2.1 Characteristics for Differentiating between White-tailed and Mule Deer (Baker 1984) . . . . .  | 11   |
| 3.1 North American Land Mammal Ages (Webb 1998). . . . .   | 29   |
| 4.1 Habitat preferences of Mule Deer and White-tailed Deer . . . . .   | 53   |
| 4.2 Use of Spatial Zones in a Sympatric Elk, Mule Deer, and White-tailed Deer Study in a Winter Range in Western Montana . . . . .   | 57   |
| 4.3 Susceptibility of Various North American Ungulates to Parelaphostrongylosis. . . . .   | 72   |
| 5.1 Age and Sex Distribution of Mule Deer and White-tailed Deer Used in this Study . . . . .   | 85   |
| 5.2 Geographic Distribution of Mule Deer and White-tailed Deer Used in this Study . . . . .  | 86   |
| 6.1 Epiphyseal Fusion Ages for <i>Odocoileus</i> . . . . .   | 115  |
| 6.2 Number of Specimens Included in Models . . . . .   | 116  |
| 6.3 Summary Table for Predictor Formulas . . . . .   | 145  |
| 7.1 NISP Recovered by Wedel (1959) at the Scott County Pueblo Site . . . . .   | 155  |
| 7.2 Bison NISP by Feature for Provenienced Material Recovered by KSHS at the Scott County Pueblo Site (Hill and Blackmar 1996) . . . . .   | 161  |
| 7.3 Minimum Number of Elements (MNE) of Appendicular Bison Remains Recovered during the KSHS Excavations (Hill and Blackmar 1996) and Bison Carcass Utility Value Ranks (Emerson 1990) . . . . . | 161  |
| 7.4 MNI of Small Fauna from Scott County Pueblo (Blackmar 1996) . . . . .  | 164  |
| 8.1 Deer Bones Identifiable to Species from the Scott County Pueblo Site . . . . .   | 169  |
| 8.2 Distribution of Identifiable Deer Species from the Scott County Pueblo Site . . . . .  | 171  |

## LIST OF FIGURES

| FIGURE |   | PAGE |
|--------|---|------|
| 2.1    | Characteristics for Differentiating between Mule Deer and White-tailed Deer Astragali . . . . .   | 14   |
| 2.2    | Characteristics for Differentiating between Mule Deer and White-tailed Deer Central-Tarsals . . . . .                                   | 14   |
| 2.3    | Central Incisors of Mule Deer and White-tailed Deer . . . . .   | 15   |
| 2.4    | Atlas Vertebrae of Mule Deer and White-tailed Deer . . . . .  | 15   |
| 3.1    | Evolutionary Relationships of the Genus <i>Odocoileus</i> . . . . .   | 32   |
| 3.2    | Modern Distribution of White-tailed Deer . . . . .  | 35   |
| 3.3    | Modern Distribution of Mule Deer . . . . .  | 37   |
| 3.4    | Modern Geographic Overlap of Mule Deer ( <i>O. hemionus</i> ) and White-tailed Deer ( <i>O. virginianus</i> ) . . . . .                 | 42   |
| 3.5    | Prehistoric Occurrence of Mule Deer According to <i>Faunmap</i> Database . . . . .  | 43   |
| 3.6    | Prehistoric Occurrence of White-tailed Deer According to <i>Faunmap</i> Database . . . . .  | 44   |
| 4.1    | Distribution of Mule Deer on the National Bison Range . . . . .   | 58   |
| 4.2    | Distribution of White-tailed Deer on the National Bison Range . . . . .   | 59   |
| 4.3    | Habitat Characteristics Influencing Movement Patterns and Relative Distribution of Deer on the Cherry Creek Study Area . . . . .        | 61   |
| 4.4    | Geographical Distribution of the Meningeal Worm. . . . .  | 73   |
| 6.1    | Morphological Characteristics for the Identification of <i>O. hemionus</i> and <i>O. virginianus</i> . . . . .                          | 91   |
| 7.1    | Percent of MNI by Class for Small and Medium Sized Mammals, Reptiles, Aves, and Fish Recovered by KSHS at Scott County Pueblo . . . . . | 163  |

# CHAPTER 1

## Introduction

In the Plains region of North America the primary food staple throughout the prehistoric and historic periods was bison (*Bison bison*). There has been much research on this animal and the role that the environment played in affecting its native range, movement, and use by human populations. Bamforth (1988) examined in detail how human lifeways and organization on the Plains were affected by environmental impact on bison and their habitats. Most faunal research in the Plains today is conducted on bison remains. Throughout the Plains, however, deer (*Odocoileus*) have played an important role as a secondary food staple. In fact, during some periods of climatic change such as during the mid-Holocene, there are areas of the Plains where deer became the primary staple (Hofman 1989). Research is conducted here to aid in the understanding of prehistoric and historic human ecology in the Plains based on the identification and interpretation of deer remains found at archaeological sites.

There are two deer species which occur in the Plains, mule deer (*Odocoileus hemionus*) and white-tailed deer (*Odocoileus virginianus*). These two animals frequently overlap in geographic space but utilize different habitats within that space. Even though differential use of habitat by mule deer and white-tailed deer is well known, this information has not been used to form paleoecological reconstructions at archaeological sites. The main reason for this is that there are few means for discriminating between the

two species based on skeletal remains. Cranially the two animals differ both as whole live animals and in skeletal shape (Buie and Purdue 1986). The cranium of either species, however, is not likely to be transported to an archaeological site since it is of low utility and provides little nutritional return (Jacobson 2000). Even if transported, most cranial fragments needed for identification would be unlikely to survive taphonomic processes. Antlers, the most frequent means of identification, may not indicate animals used for subsistence as deer shed their antlers on a yearly basis. Antlers may also be modified for tool production and their identifying characteristics obscured.

Therefore, most analysis of deer remains in regions where the two species overlap is limited in taxonomic distinction to *Odocoileus* sp. or *Odocoileus* spp. (Graham and Semken 1987). The use of “sp.” occurs when archaeological specimens are identifiable only to genus, while “spp.” indicates that more than one species is possible (Reitz and Wing 1999:37). There are a few cases where detailed paleoecological reconstruction has been conducted, but by necessity analysis based on which species of deer is present must be omitted. Thus, identification of postcranial deer bones to species could provide vital new information for paleoecological inference.

Similar investigations have been carried out with a range of other ungulates. Chapter 2 examines studies differentiating between closely related ungulates that may be confused in archaeological context. Means of identification are explored as possible suggestions for areas of the bone where mule deer and white-tailed deer may be distinguished. In addition, past methods for differentiating between mule deer and white-tailed deer are presented. Prior use of ungulate species proportional presence as an

indicator of hunting strategies, the introduction and development of agriculture, environmental fluctuation, and movement in areas of elevational gradients are discussed.

In order to discern time frames and geographic regions where it would be necessary to distinguish whether mule deer or white-tailed deer were represented, deer evolutionary history and paleontological, archaeological, and modern distributions are investigated. Chapter 3 presents general background information on the evolution of North American cervids. Specific information on Odocoileines is further investigated by focusing on mtDNA and fossil evidence. Modern variability and potential for hybridization are examined. General knowledge regarding archaeological and paleontological distributions based on assumed and known identifications are presented.

Knowledge regarding habitat choices, behavior, and biology of deer are necessary for interpreting human ecology based on faunal material found at archaeological sites. Chapter 4 provides information on mule deer and white-tailed deer habitat, evidence for deer population and habitation instability, diet differences and similarities, disease, parturition, and locomotion. Both general information and specific case studies in regions of overlap are discussed. Further use of this information for interpreting past human ecology is presented. Knowledge of deer behavior and habitat suggests areas of the skeleton where morphology may differ.

Mule deer and white-tailed deer differ in their locomotive strategies and these differences have affected the physiology of the two species. Methods for differentiating between the two species based on skeletal morphology and biometrics of limb and foot

elements is examined and presented. These techniques can then be applied to archaeological material.

Chapter 5 discusses the methods and materials used for gathering a modern sample and investigating possible differences on each of the limb and foot elements. Procedures for morphological and metrical investigations are included.

The results of these investigations are presented in Chapter 6. Morphological characteristics are exhibited photographically and the accuracy of each characteristic used to segregate species is provided. The metrical results with the most statistical significance and those more applicable to archaeological situations are presented for each element.

These means of identification are applied to archaeological material to test their effectiveness. Chapter 7 presents background information on the site chosen for this study. Scott County Pueblo (14SC1) in western Kansas is a protohistoric (mid 1600s to early 1700s) site which has been linked with Taos pueblo refugees and Plains Apache Dismal River Aspect groups (Adair 1992; Gunnerson 1960). There has been much speculation as to whether the Scott County Pueblo site is actually El Quartejejo. Initial discovery and examination of the site occurred in 1898 (Williston and Martin 1900). Wedel (1959) excavated at the site in 1939 and 1940. More modern research was conducted at the site in the mid-1970s by the Kansas State Historical Society under the direction of Witty (1983). The material excavated by Witty, especially the fauna and botanicals, has been studied in detail yet not published. Information regarding environmental reconstruction, the presence and degree of agriculture, and bison hunting

strategies is available from a series of papers presented at Plains Conference meetings (Blackmar 1995, 1996; Adair 1992; Hill and Blackmar 1996). Other research involves an in-depth analysis of lithics from the site (Butler 1997). It appears that the site was utilized by two different cultures: Plains Apache Dismal River and Puebloan groups. There is also evidence at the site that the Puebloan groups were conducting full scale agriculture. This is demonstrated not only by the presence of corn both in storage pits and elsewhere, but also by the presence of bone hoes and evidence of irrigation canals (Wedel 1959; Witty 1983; Adair 1992). In addition, faunal analysis of bison suggests a mid-to-late winter stress where bone fracturing for marrow extraction increased (Blackmar 1995).

Due to the presence of the two cultures and the occurrence of agriculture, the Odocoileine fauna from the site will be analyzed to assess differences in hunting strategies between the two groups and what if any role agriculture played in the availability and/or selection of faunal resources. In addition, changes over time in the proportional presence of mule deer and white-tailed deer are examined. This information is presented in Chapter 8.

In conclusion, differences in habitat use by mule deer and white-tailed deer in the same region may be used to interpret human ecological use and subsistence strategies if the two species can be identified archaeologically. The identification techniques presented here can be useful in interpreting changing species proportions in areas under environmental change, human movements in environments with altitudinal gradients, and the impact of the introduction of agriculture on prehistoric deer use. The application of

these techniques to material from the Scott County Pueblo site is just a starting point.

The differences in use of the two deer species at the site demonstrate some of the proposed knowledge to be gained . This knowledge could be used to aid in the interpretation of past human lifeways.

## CHAPTER 2

### Identification and History of Zooarchaeological Studies

#### **Identification**

The primary goal of zooarchaeology is the identification of faunal remains to the most specific level possible. Without identification, there can be no further analysis or interpretation. Identification of animals and skeletal parts can be affected by any number of factors. Recovery and sampling procedures will affect what bone sample is retrieved. Whether archaeological recovery includes screening and what size of screening is used could affect what bone is present to be identified. Taphonomy is another factor; identification is often complicated due to fragmentation or degradation of bone. The cultural attributes and lifeways of the people who left the record could affect the ability to identify material. Standard butchering or cooking processes affect identifiability. Bone that is highly fragmented due to marrow or grease extraction is less likely to be identifiable. The largest factor, though, is which animals occur temporally and spatially in a particular geographic area. Similar-sized and closely related animals living in the same geographic region could cause confusion to the researcher. Most zooarchaeological studies concerning mammal identification have been centered on finding and refining techniques for differentiating between varying species of ungulates as they are the primary prey of most human populations.

### *Identification of Ungulate Skeletal Material*

A 1951 Peabody Museum Paper (Lawrence 1951) examined the differences between deer, pronghorn (*Antilocapra americana*) and sheep-goat (*Ovis/Capra*). These animals were widely utilized in the Southwest. As zooarchaeology was still in its infancy, much faunal analysis at the time was conducted by mammalogists and zoologists. The aforementioned article was produced as a guide to archaeologists who may want to answer questions such as when domestic animals began to be used by Native Americans. Characteristics are limited to postcranial elements and include features of the axial skeleton, such as the pelvis. Lawrence (1951) also includes some notes on *Bos/Bison* differentiation through the use of long bones, tarsals, and phalanges.

Olsen (1960) conducted a study with detailed descriptions and drawings of *Bos/Bison* differences comparing *Bison bison*, *Bos taurus*, and *Bos indicus* or Zebu. Zebu is an Asiatic humped cattle which was brought to South Carolina in 1849 for domestic purposes. Olsen examined individual cervical, thoracic, and lumbar vertebrae, as well as the sacrum, os coxae, front long bones, rear long bones, tarsals, and phalanges of all three species.

A more recent and in-depth study of *Bos taurus* and *Bison bison* was conducted by Balkwill and Cumbaa (1992). After attempting to use Olsen's (1960) work they discovered that the majority of bones recovered from their study site were ribs and vertebrae. These bones and others, such as the smaller carpals and tarsals, were not covered in Olsen's (1960) publication. Balkwill and Cumbaa (1992) pooled characters from both Olsen (1960) and Lawrence (1951), examined new characteristics on

previously unanalyzed bone, and then scored the percent accuracy of each characteristic so that researchers could discern the validity or likelihood of a correct species identification.

Other studies have followed these seminal works in parts of the world where sympatric, congeneric species of bovids live. Frey and Nilssen (2002) attempted to differentiate between the postcrania of Steenbok (*Raphicerus campestris*) and Cape Grysbok (*Raphicerus melanotis*) in South Africa through the use of biometrics.

Studies concerning paleontological specimens have also been of use to archaeologists. Gee (1993) examined the differences between postcranial bones of *Bos primigenius* and *Bison priscus* from British Pleistocene deposits in an attempt to re-examine the taxonomic status of *Bos* and *Bison*.

Probably the largest amount of literature for differentiating between closely related species occurs with sheep and goat. Boessneck (1969) was among the first to concentrate on identifying skeletal differences between sheep (*Ovis aries*) and goat (*Capra hircus*) and his study was so thorough it is still the most referenced work on the matter. He examined differences on the skull as well as postcranial elements such as the atlas and axis vertebrae, scapula, humerus, radius and ulna, metacarpal, pelvis, femur, tibia, astragalus, calcaneus, metatarsal, and phalanges. Others have followed with refinements and additions of morphological characteristics (Davis 1987) or the inclusion of biometric data for separating the two (Payne 1969; Noddle 1978; Rowley-Conwy 1998). There have also been more recent studies which have concentrated on segregating

sheep and goat teeth morphologically (Payne 1985; Halstead et al. 2002) and metrically (Grine et al. 1986).

Few, however, have attempted to differentiate between species of deer. Since deer were the most widely utilized resource prehistorically in many portions of the world, it is surprising that differentiation of various cervids has not been studied in greater detail. A few studies have addressed the issue in areas where multiple cervids overlap in time and geographic space. Lawrence (1951) briefly mentioned some mule deer and white-tailed deer differences in her study, but her focus with those species was more on the differentiation between the genus *Odocoileus* and pronghorn antelope (*Antilocapra americana*). Other studies on mule deer and white-tailed deer will be discussed below.

Lister (1996) conducted a thorough investigation on the distinctions between fallow deer (*Dama dama*) and red deer (*Cervus elaphus*). Lister was able to discern many morphological characteristics for distinguishing between the two species based on antlers, axis vertebrae, scapula, humerus, radius, metacarpal, tibia, astragalus, calcaneus, metatarsal, phalanges, and various teeth. The work was detailed and includes sample size and percent accuracy for each characteristic.

#### *Previous Methods for Differentiating between Mule Deer and White-tailed deer*

There has long been a need to differentiate between mule deer and white-tailed deer based on skeletal characteristics. Wildlife biologists have used several physical characteristics to distinguish between the two species (Table 2.1). Of these, the

**Table 2.1 - Characteristics for Differentiating between White-tailed and Mule Deer (Baker 1984).**

| <b>Characteristic</b>    | <b>White-tailed Deer</b>                  | <b>Mule Deer</b>                     |
|--------------------------|---|--------------------------------------|
| Major beam of antler     | Curving forward without dichotomous fork  | Growing upward with dichotomous fork |
| Sub-basal snag of antler | Long                                      | Short                                |
| Length of ear            | 1/2 length of head                        | 3/4 length of head                   |
| Metatarsal gland         | Less than 42 mm long                      | More than 70 mm long                 |
| Color of tail            | Brown above, laterally fringed with white | White or black above, tip black      |
| Lacrimal fossa           | Shallow                                   | Deep                                 |

morphology of the antlers and the depth of the lacrimal fossa are osteologically diagnostic and permit species-level identifications.

Other means of differentiating between species based on cranial characteristics include dental morphology. Rees (1971) was able to use measurements on several areas of the mandible to quantitatively differentiate between the two species. These areas included diastemal length, mandibular notch height, and mandibular length.

Unfortunately, all three measurements are rarely possible with archaeological material (Buie and Purdue 1986). Buie and Purdue (1986) examined a series of *Odocoileus* mandibles from both modern comparative collections and archaeological contexts. Measurements of mandibular depth and width were taken at nine points. Discriminant Function Analysis was used and differential grouping of the two species did occur. When variables that contributed to the reference groups were applied to archaeological material results were spurious. Two different sets of variables were applied to material from the same site. The analysis results suggested mule deer dominated the assemblage based on one set of variables; yet the second set of variables indicated white-tailed deer dominated the assemblage instead. Buie and Purdue (1986) determined that the conflicting results were due to interspecific variation. They further concluded that since Rees (1971) did not test the robustness of his statistical technique with archaeological data, there may be some doubt as to the validity of archaeological identifications made with it. They concluded that:

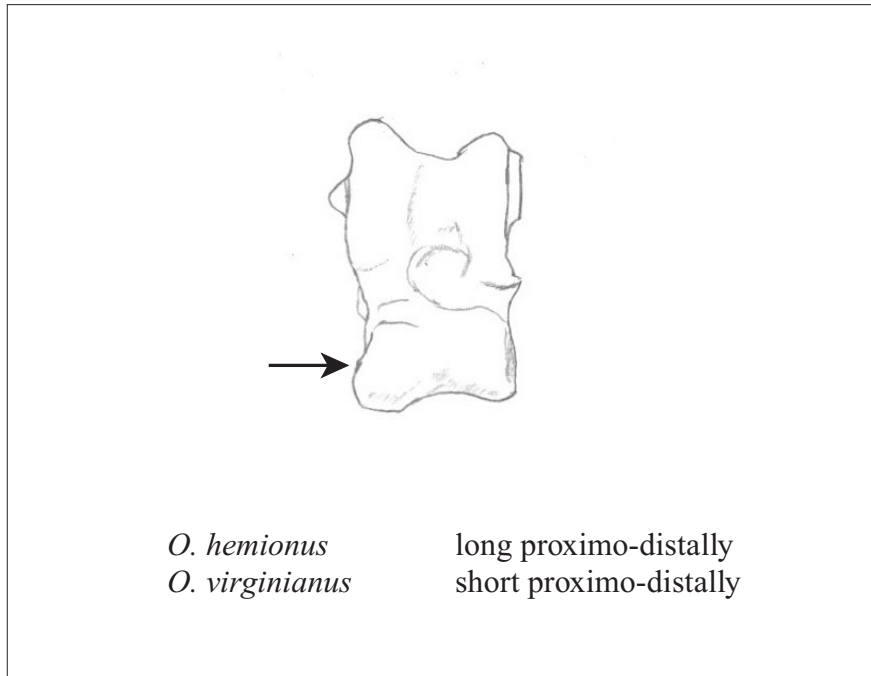
...under normal circumstances, archaeological samples of *O. virginianus* and *O. hemionus* cannot be segregated by characteristics of cheek-tooth row. Both species are too morphologically dynamic temporally and spatially to establish base

line data to which archaeological samples can be compared (Buie and Purdue 1986:69).

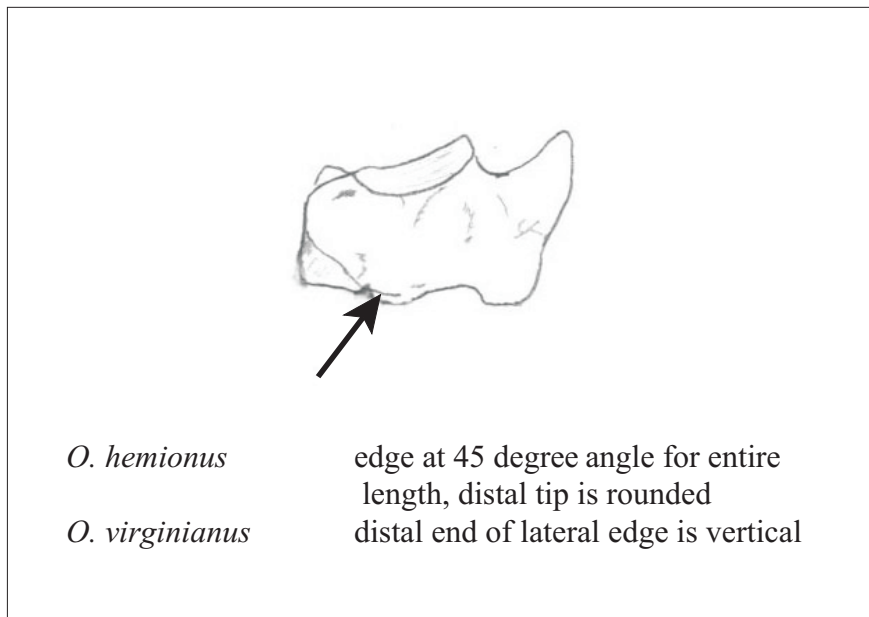
Other studies have attempted to assess postcranial differences between the two species. These studies have involved the astragalus and cuboid (Fisher 1980) and the atlas vertebra (Oates and Walker 1992). These previous attempts on postcranial material used a limited sample of specimens and other researchers (Buie and Purdue 1986:65; James R. Purdue, personal communication 2002) have had difficulty recognizing the defined characteristics in other samples of known species.

In his work Fisher (1980) used 14 mule deer and 5 white-tailed deer specimens. The characteristics he described for differentiating between the two species are presented in Figures 2.1 and 2.2. When examining skeletons for this research these characteristics were examined and were difficult to discern or contradictory in specimens in the Vertebrate Skeletal Comparative Collection at the Department of Anthropology, University of Tennessee.

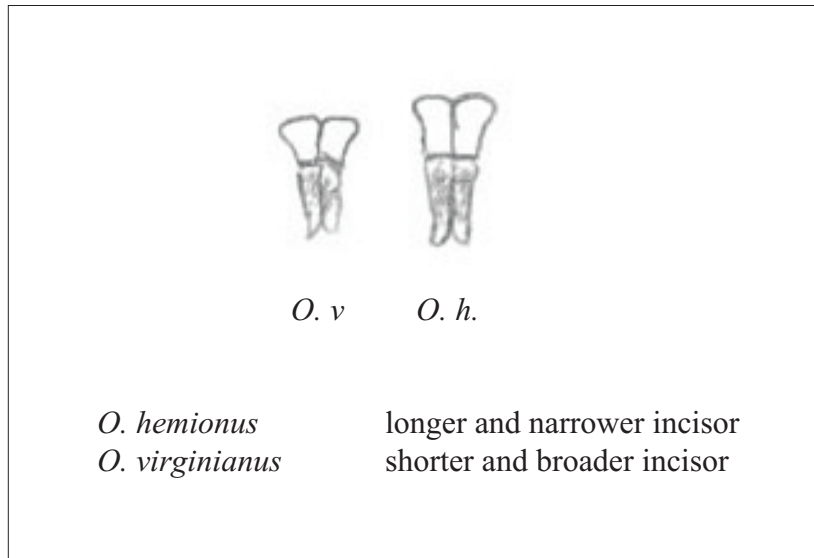
Oates and Walker (1992) have noted some cranial and postcranial characteristics for identifying mule deer and white-tailed deer. Cranially, in addition to characteristics already mentioned, they noted differences in the morphology of the two central incisors. The incisors are longer and narrower in mule deer than in white-tailed deer (Figure 2.3). Research by Miller et al.(1987) has found differences in the atlas vertebra of the two species (Figure 2.4). *O. hemionus* has more divergent anterior to posterior lateral margins of the vertebral wings. In *O. virginianus* the lateral margins of the wings are parallel (Oates and Walker 1992). This characteristic is also not consistent for specimens



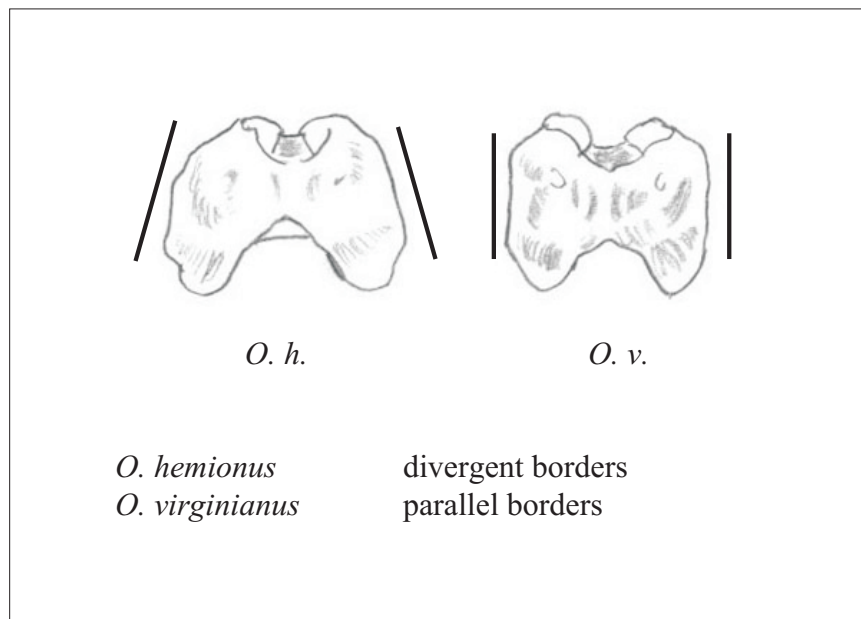
**Figure 2.1 - Characteristics for Differentiating between Mule Deer and White-tailed Deer Astragali. Redrawn from Fisher (1980:58:Figure 34).**



**Figure 2.2 - Characteristics for Differentiating between Mule Deer and White-tailed Deer Central-Tarsals. Redrawn from Fisher (1980:59:Figure 35).**



**Figure 2.3 - Central Incisors of Mule Deer and White-tailed Deer. Redrawn from Oates and Walker (1992:153:Figure 101).**



**Figure 2.4 - Atlas Vertebrae of Mule Deer and White-tailed Deer. Redrawn from Oates and Walker (1992:154:Figure 102).**

contained in Vertebrate Skeletal Comparative Collection at the Department of Anthropology, University of Tennessee.

### **Identification for Archaeological Interpretation**

Correct identifications of specimens can help fulfill the other goals of zooarchaeology – determining subsistence strategies, reconstructing past environments, and reconstructing human ecology and lifeways. With regard to ungulates, and specifically deer, it is necessary to examine what impact agriculture, environmental change, and elevational gradients may have on the availability of resources and therefore human strategies for acquiring them. These topics have all been examined to some degree with a variety of ungulate species.

### *Agriculture and Anthropogenic Disturbance of the Environment*

The impact of agriculture on the environment and other animals has been well-examined. Disturbance of natural habitats can lead to the increase in some species and to the detriment of others. For the most part, deer have benefitted from the food resources provided by agricultural fields or clearing. Humans in turn have benefitted from the predictability or ease of hunting animals that have frequented their crops.

Schibler and Steppan (1999) have examined human impact on the habitat of some large ungulates in eastern Switzerland and southwest Germany during the Neolithic. As lakeshore regions were increasingly occupied, human disturbance of the area involved the clearing of an originally dense forest. The resulting woodland was a more open mixed

deciduous forest. Ungulates and ruminants native to the area included aurochs (*Bos primigenius*), wild cattle (*Bison bonasus*), elk (*Alces alces*), red deer (*Cervus elaphus*), and horse (*Equus sp.*). The clearing should have had a positive effect on all species. Instead, wild grazers had to compete for food with increasing numbers of domestic cattle. The frequency of elk, aurochs, and other wild cattle bone decreases in relation to the previous millennium after 3300 B.C. Red deer presence, however, remained stable and red deer were the most important hunted species throughout the Neolithic. Due to the intensification of hunting, there were increasing numbers of younger deer represented archaeologically. The presence of horse in Germany remained constant. Wild horses also demonstrated an increase in body mass suggesting improved living conditions in this area. Therefore, the authors suggested red deer and horse appear to have benefitted from the human disturbance whereas elk and wild cattle species declined in numbers (Schibler and Steppan 1999).

Positive and negative effects of human disturbance may not be as pronounced as Schibbler and Steppan (1999) present. The increased representation of young animals, such as red deer, in archaeological context is usually the result of population stress due to over-predation. In addition, the apparent decrease of wild cattle presence at archaeological sites could be due to less human reliance on the species as domestic cattle provided a similar resource and were more easily attained.

The effect of agriculture on deer has been well-studied in Mayan archaeology. Some have even argued that the close relationship between the two was a step towards taming and the initial phase of domestication of the deer (White et al. 2001). To

investigate this claim, White et al. (2001) examined stable isotopic evidence for the consumption of maize by deer and dogs. They established levels for expected isotopic ratios based on whether species are wild, commensal, semi-domesticated, or domesticated. Wild animals would have diets with little to no reliance on human crops or garbage. Both commensal and semi-domesticated creatures, those animals scavenging on human garbage or crops, would have isotopic values representative of diets intermediate to those of humans and wild animals. The material examined was recovered from the lithic manufacturing community of Colha, an Early Middle Preclassic to Terminal Late Preclassic Mayan site in Belize. At this site dogs demonstrated a broad spectrum with some suggesting a strongly maize-supplemented diet. Deer, on the other hand, demonstrated isotopic signatures of forest feeders (White et al., 2000). White et al. (1993) did find evidence from deer remains at the later Classic period site of Pacbitun in Belize that indicated either grazing from maize fields or purposeful feeding.

Emery et al. (2000) have used deer isotope signatures as an indicator for Mayan land use and the extent of agriculture. They examined the availability of maize to browsing herbivores in the Petaxbatun region of Guatemala and stated that:

Any expansion of agricultural fields or intensive monocropping of maize should have increased the availability of this crop to field-raiding herbivores like the white-tailed deer. Since maize is the main C4 cultigen available to deer in this habitat, changes in its consumption should be indicated by carbon isotope ratios of bone. Indeed, deer consumption of maize has been shown to increase in proportion to its abundance within a foraging territory (Emery et al. 2000:539).

Isotopic levels do indicate use of maize by deer, yet levels do not fluctuate over time, thus suggesting stability within the area. They hypothesized that lower human population

numbers and advanced agricultural techniques led to little environmental disturbance over time (Emery et al., 2000).

Research on the possibility of garden hunting as a strategy by horticulturalists has been conducted in tropical areas and more recently in temperate environments as well. Neusius (1996) examined evidence for garden hunting amongst the Dolores Anasazi in Colorado. There are three assumptions inherent to garden hunting. First, the fields and gardens have a high density and diversity of animal species in comparison to the nearby undisturbed habitats. Cleared fields allow for growth of cultigens and weedy pioneer plants, which could increase the plant food available for herbivorous species. Second, the exploitation of animals which frequent horticultural areas provides high-quality protein to supplement the diet and at the same time may reduce competition by these species for crop yields. Third, garden hunting is embedded in other activities and, therefore, is a low cost and low risk means of meat procurement. Garden hunting can be recognized archaeologically by a higher proportion of animals known to frequent gardens, especially when compared with natural species distribution and diversity of fauna. Data from the sites in the Dolores study area found that garden species accounted for over 73% of the faunal assemblage from each site. In most cases high biomass animals available nearby, such as elk and antelope, were overlooked in favor of a variety of smaller mammals known to frequent gardens. Mule deer was the largest prey species present and is well-known for raiding horticultural fields (Neusius 1996).

All of these studies show that human procurement of meat could be greatly affected by large-scale clearing and/or horticultural and agricultural practices. These

effects can further be identified in the archaeological record by examining ratios of species presence.

### *Changing Environment*

Environmental change and its impact on animal species is well-documented (Graham and Semken 1987). Most studies, however, have focused on those most affected by smaller scale environmental shifts: micro-fauna. At archaeological sites, recovery strategies or taphonomic processes often compromise the presence of micro-faunal remains. Researchers are forced to rely on the material that is more likely present – the denser and larger bones of substantial-sized animals such as ungulates – in order to make environmental inferences.

Ferring (1986) documents changes in the environmental record at Delaware Canyon in Oklahoma. He noticed that both pelecypod and vertebrate presence at the canyon suggested more riparian and woodland fauna habitat at times and more prairie beneficial habitat at others. Bison, indicative of a prairie habitat, are represented by higher bone frequencies in the drier late Archaic and Plains Village components. While some bison bone is present, Plains Woodland deposits have much higher frequencies of small game and deer remains. The increase use of forest fauna, such as white-tailed deer, is linked with periods of moister conditions in the area. The use of bison, however, is more prevalent during drier, more prairie beneficial times.

Further use of shifting environments at a macro-level have been examined based on large ungulate presence in the Plains. During the Early Plains Archaic there is a

dispersal and drop in bison populations. The start of this period, around 8000 B.P. calendrical, coincides with the beginning of the warm dry interval of the mid-Holocene, often called the altithermal (Wedel 1986). Prior to this time most bison utilized in the Paleoamerican period were either *Bison occidentalis* or *Bison antiquus*. After this period, all bison utilized were *Bison bison*. It is proposed that the two earlier species either could not adapt to changing climatic conditions and became extinct, or that one or both (depending on differences in taxonomic classification) evolved into *Bison bison*. Some researchers (Dillehay 1974) have proposed that during the Early Archaic the Plains region suffered an “Absence Period” from bison. This is not to say that bison were truly absent, but that they ceased to utilize the Plains interior and moved to outer regions such as Canada or Texas where more favorable conditions existed. Other researchers (Baugh 1986) suggest that in the interior herds were smaller and more dispersed. Evidence shows that bison remains are present at archaeological sites throughout the region. In preceding periods all the parts of many individuals were represented at archaeological sites, but during this time there is a switch to all the parts of only one or a few individuals present. It has been suggested that groups would have been highly mobile at this time following the bison who were in search of better grasslands. Sites would therefore be surficial and ephemeral giving the impression of absence. Unfortunately, not enough paleontological work has been conducted examining bison distributions in the region to supplement the paucity of archaeological data (Hofman and Graham 1998).

Another case for fluctuating prey choice based on changing environmental conditions occurs in the Middle East. Bate (1937) analyzed faunal material from Mount

Carmel and noticed a fluctuation in the proportion of gazelle (*Gazella gazella*) use to Mesopotamian fallow deer (*Dama mesopotamiacus*) use. She proposed that the cause of these fluctuations was environmental change. Mount Carmel, though at a higher altitude, is presently situated very near more dry and desert-like conditions. It was proposed that as warming and drying conditions occurred, the forested areas would retreat and the desert grasslands would advance. As environmental conditions cooled, woodlands would once again increase and replace desert grasslands. Fallow deer with teeth more suited for deciduous browse and hooves efficient on soft ground would prefer the woodland environment. Gazelle, on the other hand, have molars better developed for scrubby brush and hooves and legs more suited to rapid progress on hard terrain. According to Bate (1937), fluctuations in ungulate presence at Mount Carmel were indicative of climatic changes and not cultural influences. Others (Davis 1982; Garrard 1982; Higgs 1967) have reanalyzed her data, some agreeing and some disagreeing with her conclusions. In general it appears that there were proportional changes in use. Newer, environmental data suggest that the differences in species frequencies were caused by fluctuations in the availability of the two artiodactyls due to climatic conditions, rather than random human changes in preferred prey. Davis (1982), however, has argued that while innovative, Bate (1937) did miss one significant detail. While the presence of fallow deer did fluctuate in the area, overall use of gazelle did not change as drastically. Instead, there were only minor changes in gazelle use, with other ungulates and prey species being utilized to fill in the gaps left by fluctuating fallow deer presence.

### *Elevational Gradients*

Areas of strong topographic variability are usually comprised of a multitude of ecosystems. These ecosystems are necessarily restrictive in what species they can support so resource variability is high in these zones. Much knowledge can be gained about human movements and subsistence strategies in regions of steep elevational gradients by investigating faunal remains at archaeological sites.

The classic example of elevation and human strategy is Julian Steward's work in the Great Basin. Steward (1938) described the historic Shoshone means of surviving in a harsh, unpredictable environment with an elevationally diverse availability of resources. He describes groups who adapted to this environment by exploiting the contiguous yet dissimilar environments through seasonal rounds. Groups centered around a semi-permanent winter residential base, usually at a higher elevation with accessibility to piñon nuts, seeds, and water. Resources were supplemented through cooperative hunts of jack rabbits (*Lepus*) and antelope from nearby areas. During the spring groups would disperse into the lower riverine zones where a diverse and diffuse strategy was utilized. Subsistence resources included a variety of plant resources again supplemented by hunting.

Thomas (1973) tested the veracity of applying these strategies to prehistoric groups in the Great Basin through widespread testing of archaeological sites in the Reese River Valley in Nevada. Thomas established parameters of how logical outcomes of Steward's model for the Shoshone would be reflected in the archaeological record if the same strategies were used by Desert Archaic populations. He concluded that "...it is

probable that the Shoshonean subsistence system operated in the prehistoric Reese River Valley” (Thomas 1973:172). Thomas defines the Reese River subsistence system as being characterized by two types of settlement – Shoreline settlement and Piñon Ecotone settlement:

The *Shoreline settlement* consists of a series of sites located on a permanent water source within the lower sagebrush-grass lifezone. The economic focus is upon summer ripening crops, primarily grasses and roots. . . . No consistent locus of habitation was reoccupied; apparently campsites were situated near scattered caches of seeds. . . . The vegetal diet was undoubtedly supplemented by rodents and rabbits, procured from the nearby flats (Thomas 1973:173).

The Piñon Ecotone settlement consists of winter habitations which were located in or near stands of piñon (*Pinus*) and juniper (*Juniperus*) trees. These settlements were usually located on long low ridges enabling exploitation of dual lifezones. The reliance on piñons was supplemented by the hunting of artiodactyls. Settlements were usually occupied by multiple families (Thomas 1973). These strategies demonstrate differential use of resources whose availability is partially limited by elevationally defined ecotones.

More recent work by Adams et al. (2002) has examined archaeological sites along the Continental Divide. The distribution of artifacts and types of raw material present suggests a migration corridor along the Divide between the Pacific and Atlantic drainages. More specifically they were able to infer “...two-way travel of prehistoric hunters and gatherers following game migrating between summer range in the Greater Yellowstone Ecosystem and winter range in the Green River Basin of southwest Wyoming” (Adams et al. 2002:abstract only:32)

Other studies have been conducted linking prehistoric human movement with animal migration in elevated regions. Woolfenden (1988) examined the relationship between prehistoric site distributions and the behavior of migratory mule deer in the Stanislaus National Forest in the Sierra Nevada mountain range. The basis of the project was to test the correlation of site distributions with deer migratory patterns to see whether the behavior of deer could partially explain the spatial archaeology by conferring a dynamic relationship to what is primarily a static array of prehistoric sites.

The antiquity of deer migration patterns in the central Sierra Nevadas is well-established from the time of the melting of the Sierran ice cap (Woolfenden 1988). Presently, the Stanislaus National Forest has four herds of mule deer occupying co-extensive ranges with drainage basins of the major rivers. There are three separate seasonal ranges. The winter range is located amongst the foothills in areas with chaparral and ponderosa pine forests. Migration out of this range parallels new spring plant growth and starts around mid-March to April. The second seasonal range is the intermediate range. This range is mostly low montane forest of ponderosa pine and mixed conifer. Groups or individuals may “delay” along the migration corridor for a few days to three or four weeks. The spring “delay” is usually associated with meadows. The fall “delay” is usually associated with ridgetops and southwest facing slopes among stands of mountain whitethorn or deerbrush with a mix of manzanita (*Arctostaphylos*) and black oak (*Quercus kelloggii*). Some deer may summer in the intermediate range, but most continue onward. The third seasonal range is the summer range. This range is located in upper montane and subalpine forest characterized by exposed granite bedrock and large

meadows. The meadows or shrub and herb vegetation communities are usually used for fawning units. Some deer may move into a higher range or even alpine habitat. Around mid-October the migration back to the lower holding begins (Woolfenden 1988).

The cultural resource inventory shows that prehistoric sites are distributed along the entire elevation gradient of the forest and are well correlated with deer migration corridors (Woolfenden 1988). This is suggestive of possible prehistoric economic behavior. Archaeological site densities were plotted against the seasonal ranges of the mule deer and the result was a bimodal distribution. It is expected that site density would decrease as elevation increased because of a decline in zonal productivity. However, the maximum site density in the summer range actually exceeds that of the density of the others. Woolfenden (1988) asserts that the large meadows may be the reason. There is no difference in the proportions of site types between the seasonal ranges which suggests comparable human activities in all ranges by families. The sites represent whole cultural units rather than small hunting bands pursuing deer (Woolfenden 1988).

These studies demonstrate that the availability of resources in areas of elevational gradient can affect human strategies, culture, and lifeways. These three things can be determined by examining the faunal resources present when placed in the context of site location, season, and environmental habitat.

## **Conclusion**

Human subsistence strategies, past environments, and human ecology and lifeways could be better explained by the identification of mule deer and white-tailed deer

remains at archaeological sites. In order to examine how, it is necessary to understand the evolution, ecology, and behavior of these two species.

## CHAPTER 3

### Evolution and Prehistoric Distribution of *Odocoileus*

#### **Evolutionary History of North American Cervids**

There are certain traits which set extant members of the family Cervidae apart from other members of the order Artiodactyla. There are some exceptions to these traits, but none occur within the genus *Odocoileus*. Members of the family Cervidae have no gallbladder. The cervids have dew hooves which show, and thus are considered four-toed. They have a lacrimal depression in front of each eye. They have 32 teeth with a dental formula of 0033/3133. Generally, only mature males of the family Cervidae develop antlers (Krausman 1994).

The first members of the family Cervidae appeared in North America during the late Hemphillian (NALMA; North American Land Mammal Age) in the early Pliocene Epoch of the Tertiary Period (Table 3.1). Two distinct cervid genera, *Bretzia* and *Odocoileus*, appeared in the Blancan just before the end of the Tertiary. Cervids seem to have been rare during the late Tertiary, yet drastically increase in numbers during the Quaternary. Most New World Cervidae appear to have been descended from the immigration of a single Odocoileine genus, which then spread widely in the neotropical regions of North and South America (Webb 1998). *Navahoceras* and *Sangamona* are both Pleistocene members of the subfamily Odocoileinae. *Navahoceras fricki* is between

**Table 3.1 - North American Land Mammal Ages (Webb 1998).**

| PERIOD     | EPOCH        | NALMA*        | TIME FRAME      |
|------------|--------------|---------------|-----------------|
| Quaternary | Holocene     |               | 10 ka - present |
|            | Pleistocene  | Rancholabrean | 1.4 ma - 10 ka  |
|            |              | Irvingtonian  | 2.0 ma - 1.4 ma |
| Tertiary   | Pliocene     | Blancan       | 4.5 ma - 2.0 ma |
|            |              | Hemphillian   | 8.9 ma - 4.5 ma |
|            | Late Miocene |               |                 |

\* North American Land Mammal Age

the size of a mule deer and an elk (*Cervus canadensis*) with a known range limited to the Rocky Mountains and nearby areas. *Sangamona fugitiva* is closer to the size of a modern elk than *Navahocerus fricki* with noted fossil locales in the east-central United States. Teeth and skeletal material suggest an adaptation to open grassland. Both *Navahocerus* and *Sangamona* became extinct during the Pleistocene/Holocene transition (Kurtén and Anderson 1980).

Of the eight Cervid genera present in the New World during the Quaternary, only three entered the New World during the cooler, more severe late Quaternary – *Cervus*, *Alces*, and the extinct *Cervalces*. The remaining five Quaternary genera – *Bretzia*, *Navahocerus*, *Sangamona*, *Blastocerus*, and *Odocoileus* – descended from the first Odocoileine immigrants (Webb 1998).

### **Evolutionary History of Genus *Odocoileus***

The genus *Odocoileus* belongs in the superfamily Odocoileinae. Characteristics used to separate *Odocoileus* from other New World cervids include the presence of nonpalmate antlers, a hairless muzzle, absence of the upper ends of the lateral metacarpals and the vomer dividing the posterior nasal cavities, presence of metatarsal, tarsal, and pedal glands, and an unfused naviculo-cuboid and cuneiform (Baker 1984).

#### *Fossil Evidence*

According to Kurtén and Anderson (1980), the first fossil evidence for the appearance of the genus *Odocoileus* occurs during the Blancan, 3.5 million years ago.

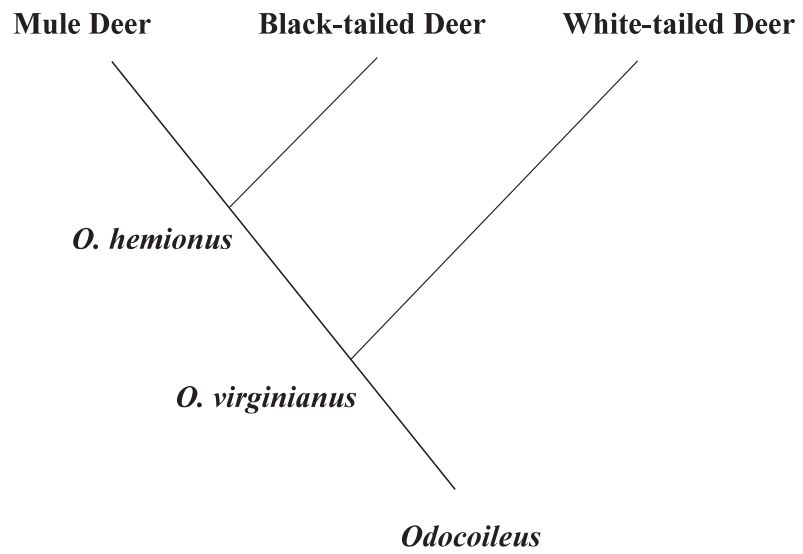
There is evidence for the presence of *Odocoileus virginianus* first appearing around 3.2 million years ago, which also presumably represents the ancestral stock to *O. hemionus* (Figure 3.1). Fossil remains identified as *Odocoileus hemionus* are first reported between 700,000 and 1.9 million years ago, but a more widespread geographic occurrence of mule deer is not evident until the Rancholabrean (Kurtén and Anderson 1980; Carr and Hughes 1993).

#### *MtDNA Evidence*

Recent studies of mtDNA have begun to question the viability of a split occurring so far in the past (Carr and Hughes 1993). Fossil evidence is mostly based on existent means of separating mule and white-tailed deer, namely the antlers. MtDNA evidence using the standard molecular divergence clock with a rate of

$$\frac{2\%}{1 \times 10^6 \text{ years}} \text{ per pair of lineages}$$

indicates a divergence time for the genus *Odocoileus* at around 3 million years ago (Carr and Hughes 1993). The fossil evidence and the genetic clock both argue for the appearance of the genus *Odocoileus* during the Blancan. Minimum sequence divergence observed between the two species of *Odocoileus*, however, implies that “speciation and separation of lineages between *O. hemionus* and *O. virginianus* were completed only within the past few hundred thousand years” (Carr and Hughes 1993:339). Since fossil evidence argues for a divergence of the two species of *Odocoileus* from 700,000 to as far back as 1.9 million years, there is an ongoing debate as to when the biological split



**Figure 3.1 - Evolutionary Relationships of the Genus *Odocoileus* (Carr and Hughes 1993; Webb 1998; Baker 1984).**

between the two species occurred. This disagreement between contemporary genetic and fossil evidence has been offered as a rationale for a reanalysis of the paleontological material. There is some possibility that a more recent (about one million years ago) hybridization between mule and white-tailed deer in Texas could have confused the mtDNA evidence as mule deer and the Texas white-tailed deer clade, *Odocoileus virginianus texanus*, genetic relationships show evidence of strong introgression of mule deer mtDNA. Other comparisons with other clades of white-tailed deer, however, make confusion of the mtDNA evidence unlikely (Carr and Hughes 1993). Regardless, divergent speciation between *O. virginianus* and *O. hemionus* likely occurred during the Pleistocene.

Geist (1987) states that the formation of new species of cervids and bovids are possible in multiple ways. If a species is formed due to segregation based on social differentiation resulting in allopatric populations, the two forms are not likely to hybridize. Species formed due to ecological differentiation or geographic separation resulting in sympatric populations are more likely to hybridize upon meeting (Geist 1987). Thus, since mule deer and white-tailed deer are sympatric species who can hybridize, the event responsible for the divergence of the two species was likely an ecological or geographic separation. As their evolutionary split occurred during the Pleistocene, it is possible that separation by glacial advance or glacial environments was the cause for their split.

### **Modern Odocoileine Variability**

The genus *Odocoileus* is very diverse. White-tailed deer range from near-treeline in Canada to sub-equatorial South America (Figure 3.2). Most researchers recognize 38 subspecies of white-tailed deer, but with intergradation the genetic boundaries are blurred and many specialists recognize only five or six genetically distinct subspecies (Baker 1984). Body size of white-tailed deer can be affected by its clinal location. Live weights range from less than 50 pounds (22.65 kg) in tropical insular habitats to more than 400 pounds (135.9 kg) in northern latitudes (Krausman 1994). In addition, the coat can vary from a more reddish or even blackish color in subtropical or tropical environments to a more grayish color in northern latitudes and higher altitudes (Baker 1984). The subspecies *Odocoileus virginianus texanus*, found in Texas, New Mexico, Oklahoma, Kansas, Nebraska, and Colorado – regions with sympatric habitation of mule deer – shows a more outward physical resemblance to desert mule deer, *Odocoileus hemionus crooki*, than to some other subspecies of white-tailed deer (Taylor 1956).

The species *Odocoileus hemionus* is not quite as variable as that of its sister species. *O. hemionus* has been divided into as many as 11 subspecies. Nine of these are considered mule deer. Two sub-species, *O. hemionus columbianus* and *O. hemionus sitkensis* are genetically distinct enough to be considered black-tailed deer (Taylor 1956; Carr and Hughes 1993). Populations of *Odocoileus hemionus* range as far north as the northern extremes of Alberta and British Columbia, even into coastal parts of southeastern Alaska, and as far south as the Baja Peninsula and northern Mexico. The



eastern distribution of *O. hemionus* is limited to Nebraska and Kansas and populations extend west to the Pacific Ocean (Wallmo 1981); however, scattered populations have been found as far east as Minnesota and Iowa (Figure 3.3). Wildlife records suggest that the mule deer in Minnesota migrated eastward through North and South Dakota. Occasional sightings of mule deer occurred in extreme northwest Minnesota prior to 1900. During the late 1940s and early 1950s the sightings of mule deer in Minnesota increased (Erickson and Bue 1954).

Weights for mule deer range between 125 and 250 pounds (57-115 kg) (Mackie 1994). Physically, mule deer have large ears like a mule (hence their name *hemi*=half *onus*=ass), a dark forehead, small white tail with a blacktip, grayish-white rump patch, reddish-brown back and sides in summer and grayish-brown back and sides in winter with a white underside (Jones et al. 1983). Black-tailed deer differ from this by smaller rump patches and tails that are black and brown above their black tips (Mackie 1994). Black-tailed deer tend to occur more along the northern coast of the Pacific and into the Sierra Nevada Mountains, while mule deer occur along the southern coast, into the Rocky Mountains, and down into the Southwestern deserts (Taylor 1956) (Figure 3.3).

#### *Hybridization within the Genus Odocoileus*

Considering the evolutionary closeness and the geographic overlap of the two species, hybridization is an issue that should be addressed. While rare, hybridization in the wild has been known to occur. Behaviorally, it is more likely for mule deer does to mate with white-tailed deer bucks due to differential breeding behavior (Wishart 1980).



**Figure 3.3 - Modern Distribution of Mule Deer. Redrawn from Mackie (1994:248).**

Part of the reasoning researchers have suggested for a greater likelihood of this particular cross is that “mule deer does are far less elusive than white-tailed does when approached by rutting bucks” (Wishart 1980:719; via V. Geist, personal communication). MtDNA also suggests that hybridization predominantly involves male white-tailed deer and female mule deer crosses; however, some evidence from west Texas has suggested hybridization between white-tailed deer does and mule deer bucks (Carr and Hughes 1993).

Hybrids have been more frequently known in captive situations where they were bred; yet, even in captivity the survivorship of hybrids beyond the first few months is low. Nine hybrids were produced in one study in Arizona in the 1930s (Nichols 1938). In the 1970s another study produced 10 hybrids in captivity (Day 1980). In both studies only four of the hybrids survived to six months of age. Even under well-fed, pampered, and predator free conditions hybrids have a low survival rate (Hefflefinger 1999). Those in the wild have further problems with predator avoidance due to confused escape mechanisms. Mule deer have a stotting escape mechanism while white-tailed deer have a long smooth running stride (Geist and Lingle 1994). Locomotion is discussed in greater detail in Chapter 4. White-tailed and mule deer hybrids tend to exhibit locomotor strategies of both, and when attempting to escape a “predator” will confuse the two mechanisms. Even a deer that is only 1/8th white-tailed is unable to stott and instead runs in a clumsy bound (Geist 1994).

A study involving captive deer in Tennessee (Whitehead 1972) produced hybrids between black-tailed deer (*Odocoileus hemionus columbianus*) and white-tailed deer of

varying subspecies (*O. v. borealis*, *O. v. texanus*, *O. v. osceola*, *O. v. virginianus*).

Physically, the hybrids produced appeared more like black-tailed deer than white-tailed.

Hybrid deer were placed in pens with fertile purebred white-tailed or black-tailed deer.

Though 50 percent of the hybrids produced offspring during their second year, 66 percent of those offspring were stillborn. Locomotively, the hybrids exhibited strategies of both deer.

Physiologically, the two species are evolutionarily separate enough that different combinations of matings could result in different possibilities of viable offspring. Studies both in the wild and captivity have shown that female offspring of mule deer does and white-tailed bucks are viable. Male hybrids are usually infertile. Histological exams have revealed that male hybrids have varying degrees of sperm degeneration leading to an inability to pass on genetic information. In Texas, however, normal spermiogenesis has been observed in a male hybrid (Hughes and Carr 1993). This suggests that at least some male hybrids, maybe those of mule deer with subspecies of white-tailed deer less divergent, would be viable. Texas has a much longer fossil history of geographic overlap between the two species than other regions where sperm degeneration is the rule. In addition, as noted above, evidence suggests that *O. virginianus texanus* has a greater degree of relatedness to *O. hemionus* than to some subspecies of white-tailed deer (Taylor 1956). Not surprisingly, it has recently been suggested that the type specimen for the subspecies *Odocoileus hemionus crooki* (desert mule deer), the subspecies that occurs in Texas, southern Arizona, southern New Mexico, extreme southeast California and northern Mexico, is actually a desert mule deer and Coues white-tailed deer (*O.*

*virginianus couesi*) hybrid (Hefflefinger 2000). This is not to suggest that the desert mule deer is not a mule deer subspecies, just that its nomenclature should be based on a type specimen (*O. hemionus eremicus*) found near the Gulf of California in an arid portion of Sonora, Mexico (Hefflefinger 2000). However, the frequency of *crooki* type traits amongst the desert mule deer suggests a strong hybridizing history between the Coues white-tailed deer and the desert mule deer.

Genetically, mtDNA analyses show that "...the extent and direction of hybridization vary over the species' ranges" (Hughes and Carr 1993:524), but that the most extensive hybridization has been reported from west Texas. In contrast, the lowest frequency of hybridization is reported from Montana.

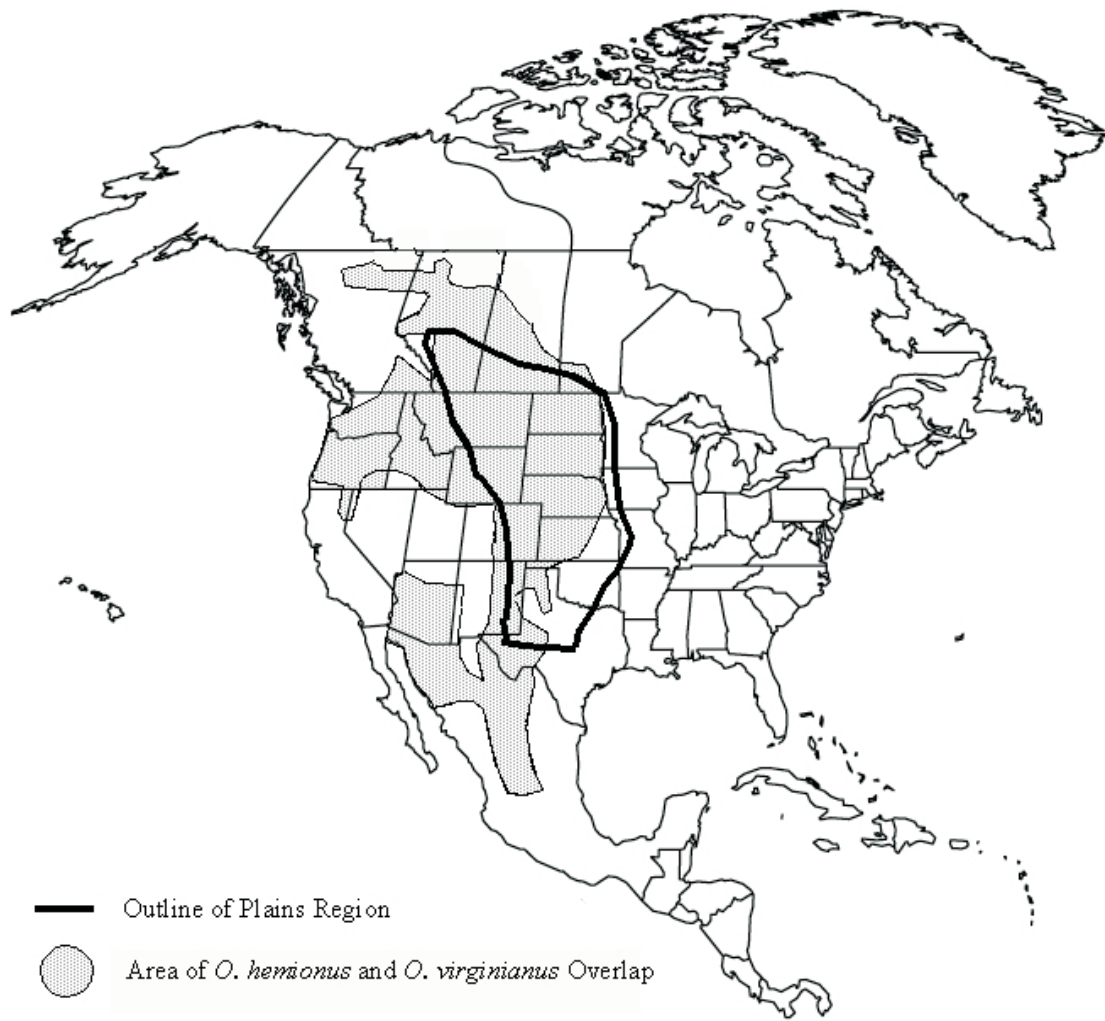
The question has arisen both with fossil and mtDNA evidence as to how much hybridization of the two species could affect identification of skeletal material. Modern hybrids often show either external physical characteristics of both parent species or characteristics partway between the two. The only good diagnostic character for determining a live hybrid is based on the length of the metatarsal gland (Wister 1980, Hefflefinger 2000). Skeletal material may also demonstrate a composite of parental characteristics or an indeterminate feature partway between the two. Unfortunately, no hybrid skeletal material was available for this study so it is unknown how the skeleton would be affected. As mentioned above, escape mechanisms of hybrids have been seen to be a confusion of the two means of locomotion. Since the limb bone differences between the two species are most likely due to their differing means of locomotion and hybrids exhibit a blending of locomotor strategies, hybrids would presumably exhibit

indistinct or contradictory morphological features. Hybrid frequencies are rare enough in modern populations to make archaeological identification problems insignificant. Care should be taken, however, in positively identifying faunal material from areas where there is a long history of overlap, such as Texas. Researchers should be willing to leave questionable material with a broader identification level of *Odocoileus* spp. if characteristics are indeterminate or conflicting.

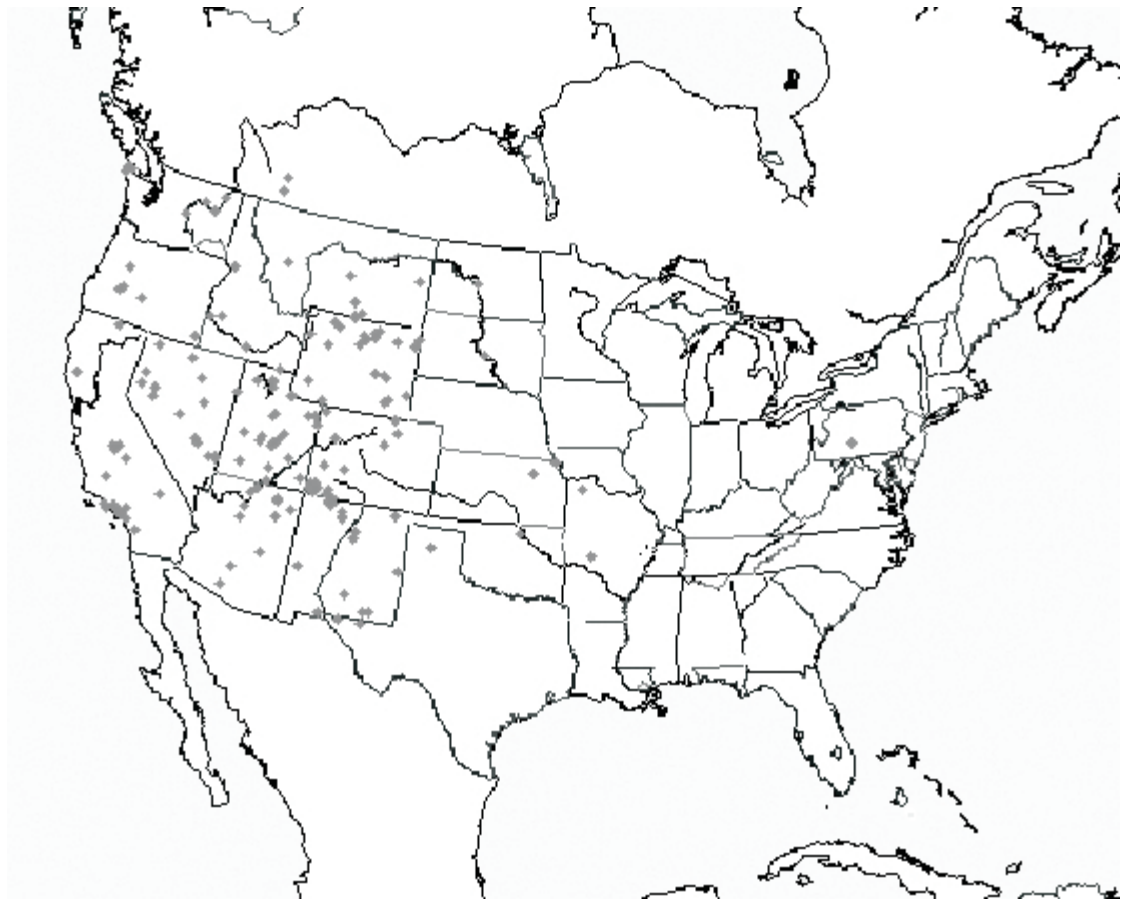
### **Archaeological and Paleontological Evidence of Distributions**

Due to the reliance on cranial material and range assumptions to accurately identify archaeological and fossil remains, past distributions of the two species of *Odocoileus* are only partly known. Modern areas of overlap of the two species are shown on Figure 3.4.

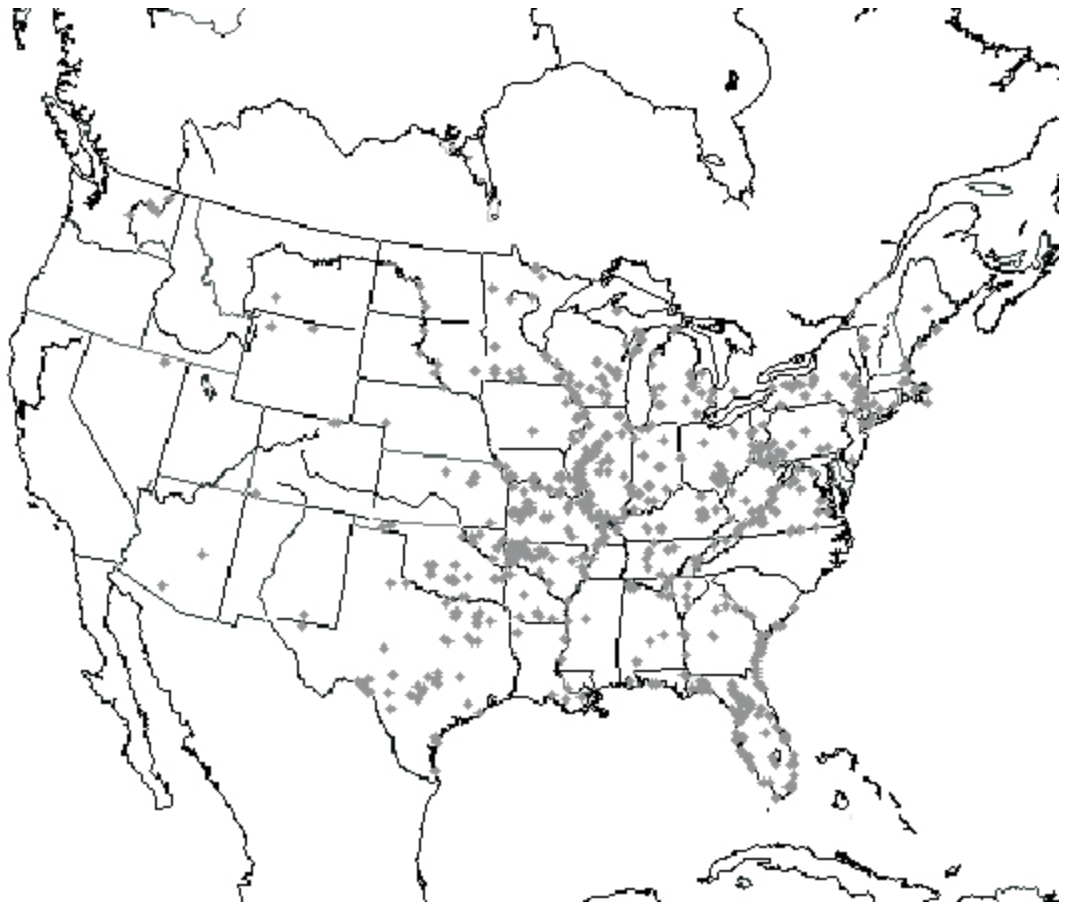
The best conglomeration of identified mule deer and white-tailed deer specimens found in mostly archaeological, though sometimes paleontological, context is that of *Faunmap: A Database Documenting Late Quaternary Distributions of Mammal Species in the United States*. The location data across all time periods for sites with mule deer and white-tailed deer remains are presented in Figures 3.5 and 3.6 respectively. The data presented are based on published reports and the veracity of those identifications may vary (Graham and Lundelius 1994). For the most part, the occurrences of each species fall within their current distributions. The map generated by *Faunmap*, however, notes deer identified in the archaeological and/or paleontological record outside the area of modern distribution according to its database. White-tailed deer are noted as occurring



**Figure 3.4 - Modern Geographic Overlap of Mule Deer (*O. hemionus*) and White-tailed Deer (*O. virginianus*). Adapted from Baker (1984:14:Figure 12), Wallmo (1981:3:Figure 1), Jones et al. (1983:321, 324: Figure 192, 195), and Fagan (2000:112).**



**Figure 3.5 - Prehistoric Occurrence of Mule Deer According to *Faunmap* Database. Adapted from Graham and Lundelius (1994).**



**Figure 3.6 - Prehistoric Occurrence of White-tailed Deer According to *Faunmap*. Adapted from Graham and Lundelius (1994).**

in Nevada and Colorado. The location of the Colorado site is within the distribution of white-tailed deer as presented by wildlife sources (Smith and Rhodes 1994, Baker 1984). Mule deer is noted as occurring in Kansas, Missouri, Oklahoma, Arkansas, and, remarkably, Pennsylvania.

#### *White-tailed Deer Presence outside Modern Distribution*

White-tailed deer are a very diverse species and as the progenitor of mule deer, it is not surprising to find evidence for them present in an assemblage outside their modern distribution. According to *Faunmap*, they have been identified from the Deer Creek Cave site in Nevada. Ziegler (1963) mentions that only an occipital fragment and intact piciform were found belonging to *Odocoileus*. He says that while mule deer occur in the area today, white-tailed deer are "...found in northwestern Nevada and also into southeastern Idaho and may have ranged into the Deer Creek area at some times in the past" (Ziegler 1963:18). Nowhere does he state that the bone was positively identified as either species of deer.

White-tailed deer presence has also been noted for a very early site in Colorado, the Lindenmeier site (Haynes and Agogino 1960, Wilmsen and Roberts 1978, Graham 1987). The majority of the bones retained from the excavations have been clearly demonstrated to belong to the Folsom occupation. This includes the deer. In a species list from the site, *Odocoileus virginianus* is represented by 2 cranial bones, 1 phalanx, and 3 teeth. Wilmsen and Roberts state that "Assignment of deer to the faunal assemblage is tenuous" and based on field identifications because "positive identification

of deer is difficult due to the fragmentary condition of existing materials” (Wilmsen and Roberts 1978:47). There is no mention upon what the identification of white-tailed deer is based. Later Wilmsen and Roberts state:

Deer are not commonly found today in the immediate vicinity of Lindenmeier, but a few miles away, in valleys that still have adequate water and on the wooded slopes of the hogback ridges to the west, I have often seen a dozen or more mule deer in a single day. These animals, 11,000 years ago, should have found the Lindenmeier Valley an attractive habitat (1978:47-48).

This raises concerns on the identification of the deer present as white-tailed deer.

Pronghorn antelope were found in the same associated material as the deer and are also found in the vicinity of Lindenmeier today (Wilmsen and Roberts 1978). But, other non-mammalian vertebrate and invertebrate fauna present at the site indicate a riparian grassland habitat during occupation (Graham 1987), a habitat suited to white-tailed deer. Accuracy of identification cannot be gauged without re-analysis of the bone in question. Since the elements identified include cranial material and teeth, it is possible that the identification is accurate as incisors and sections of the skull would be identifiable through use of prior methods (Chapter 2).

#### *Mule Deer Presence outside Modern Distribution*

Mule deer tend to be more restricted in their habitat than white-tailed deer. Yet, there are isolated populations of mule deer currently in Minnesota and Iowa. At some time in the past, the distribution of mule deer may have extended in a continuous population further than it does today. Within more sloped areas of the eastern Plains and

Midwest there is likely archaeological evidence for the distribution of these animals that has yet to be identified further than *Odocoileus spp.*

There is evidence for the presence of mule deer at two sites in Kansas. The first is Blue Earth Village, a late 18<sup>th</sup> to early 19<sup>th</sup> century site (Molloy 1993). The site is located at the junction of the Missouri River and Independence Creek in Doniphan County. The site was first excavated by Frederick H. Sterns in 1914. Later excavations by Wedel (1959) identified the presence of 18 white-tailed deer bones. Molloy (1993) examined the fauna from the Sterns excavation which had never been analyzed and identified 38 mule deer bones and 22 white-tailed deer bones. She distinguished between the two species primarily by size comparison with specimens in the comparative osteological collections in the Museum of Comparative Zoology at Harvard University. Use of size as a distinguishing characteristic is fallible as both species vary greatly in size. Live weights of modern mule deer range from 125 to 250 pounds while weights of modern white-tailed deer range from 50 to 400 pounds (Baker 1984; Krausman 1994). Research by Purdue (1989) has shown that white-tailed deer size varied drastically during the Holocene in Illinois, so past populations of either deer species may have been smaller or larger than modern populations currently in an area. Observations made during this study have occasionally noted bones larger and more robust from white-tailed deer than from mule deer. For instance, specimens recovered from the same wildlife area in Arizona during the same hunting season produced one white-tailed buck with bones much larger and more robust than any of the mule deer recovered from the same area. Because of the overlap in body size of the two animals, size should not be considered a reliable

character, especially as applied to archaeological material. As the material was recovered from northeastern Kansas, it is entirely possible that the identifications are viable. Bison remains were also present and evidence for agriculture exists in ethnohistoric accounts and the archaeological record. This identification is further supported by material from another Kansas site.

Material from a second site in Doniphan County, Kansas has also been identified as mule deer (Heavin 1970). 14DP13 is associated with the Nebraska Culture. The site was excavated in 1959 and again in 1967. Heavin (1970) described material from two storage pits which were partially excavated in both 1959 and 1967. There is mention of worked antler tines and unworked mule deer and white-tailed deer remains in both pits. Again, there is no mention of how the identifications were determined, yet there is repeated mention of an abundance of antler recovered. Antler is one of the few reliable characteristics which allows identification to species.

Hawksley (1986) describes a series of sites with remains of Quaternary vertebrates in the Ozarks. He documents the presence of mule deer in Missouri at the Blackwater River site in Johnson County (Hawksley 1986). Gray wolf, peccary, bison, possible elk, a white-tailed deer metatarsal and possible mule deer remains were recovered from the site. Identification of mule deer was based on a left tibia lacking the proximal end. Hawksley (1986) also describes the presence of a mule deer radius from Crevice Cave in Perry County, Missouri. The shaft is described as being larger than *O. virginianus* with measurements within the general size range of *O. hemionus*.

Mule deer were documented at the Bowling Alley site in Kay County, Oklahoma (Sudbury 1968). The site is a late prehistoric site with cultural traits of the Optima and Smoky Hill aspects including bell-shaped and cylindrical trash pits. The Bowling Alley Site has a subsistence economy divided equally between maize agriculture and hunting. Sudbury (1968) states that two of the deer bones are identifiable as mule deer (*O. hemionus*) - a fragmentary metacarpal and a mandible fragment. It is possible that the mandible fragment could be positively identified based on prior techniques. As demonstrated in Chapter 6, there are means to differentiate between the metacarpals of these two species. While not previously described in the literature, it is possible that the analyst noticed these differences. Sudbury (1968) also mentions that there were other bones which could not be positively identified as mule deer or white-tailed deer.

There is one well researched site containing possible mule deer bones in Arkansas. Peccary Cave (Quinn 1972, Semken 1984, Graham 1987) is located in northwestern Arkansas with deposits dating between 16,700 and 2290 radiocarbon years B.P. The earlier material has no human association while the later material is associated with Archaic populations. The assemblage of deer bone mostly consists of mandible and teeth fragments. Positive identification of material belonging to white-tailed deer was made, while some of the teeth compared favorably with mule deer. The Pleistocene fills also contained bones of two now extinct deer taxa *Sangamona* and *Cervalces* (Quinn 1972).

The most notable mention of mule deer occurring outside its range is from Frankstown Cave in Blair County, Pennsylvania. This is well outside any documented

occurrence in prehistoric, historic, or modern distributions. The location is a paleontological site discovered during limestone quarrying (Holland 1907). Kurten and Anderson (1980) list the site as a Rancholabrean site containing Wisconsinan-age fauna. Many extinct species were uncovered including *Bison*, *Mastodon*, and *Cervalces*. A 1908 report of the cave by Holland mentions *Cervalces* and two smaller species of deer, one identified by antler as possibly *Cariacus virginianus* (Holland 1908). *Cariacus* is not a genus that has commonly been used for white-tailed deer. It has more frequently been used for denoting mule or black-tailed deer (Kurten and Anderson 1980; Cope 1889). In the Lewis and Clark journals from the winter of 1805-1806, however, the common red deer was referred to as *Cariacus virginianus macrurus*, today known as white-tailed deer (WSU Department of History 2004).

Peterson (1926) conducted a more thorough analysis of the fauna recovered from Frankstown Cave. Peterson identified mule deer (*Odocoileus hemionus*) and white-tailed deer (*O. virginianus*) from the cave. The mule deer identification was based on a molar inner basal cusp whose size was larger than that of a modern white-tailed deer. Limb and foot bones associated with the teeth were also larger than modern white-tailed deer. Peterson (1926) described other limb bones in the deposit which were identified as white-tailed deer.

## **Summary**

Present evidence for an archaeological occurrence of mule deer or white-tailed deer outside their present range is not well-supported. Application of the techniques

presented here may help resolve issues concerning known distribution of the two species. The mtDNA, fossil, and archaeological evidence suggests a split which occurred during the Pleistocene resulting in an eastern distribution of white-tailed deer and western distribution of mule deer. What role glaciation may have had in the separation of the two species is unknown. Modern knowledge of the ecology of the two species may aid in determining what effects past environment may have had on the deer and how archaeological samples where both species are possible should be interpreted.

## CHAPTER 4

### Ecology of the Genus *Odocoileus*

#### **Introduction**

Zooarchaeology can often benefit from knowledge and integration of literature from wildlife biology, zoology, and ecology. Now that zooarchaeology has progressed to a point where mere species lists are not enough, it is imperative to understand animal behavior and biology in our attempts to interpret past human lifeways. Topics such as habitat preferences, diet, disease, parturition, and behavioral strategies are important in zooarchaeological studies today.

#### **Habitat**

Central to the idea of understanding human use of ecological zones based on the identification of *Odocoileus* bones found at archaeological sites is the ecology of, and habitat use by those two congeneric deer species. Mule deer and white-tailed deer tend to utilize different habitats (Table 4.1), though both are crepuscular and therefore active at the same time. Mule deer prefer mountains, fringes of mountain meadows, and mixed forests of aspen (*Populus*) and evergreens. Mule deer are deer of open forests and brush land. They are also capable of living in fully desert environments occupying wholly open slopes and even the desert floor. In the past they have been incapable of colonizing level country (Dalrymple 1978). As this inability is likely due to an escape mechanism which

**Table 4.1 - Habitat preferences of Mule Deer and White-tailed Deer.**

|                   | <b>Mule Deer Habitat</b>  | <b>White-tailed Deer Habitat</b>  |
|-------------------|---|---|
| <b>Terrain</b>    | Slope<br>Rugged or open<br>Desert<br>Mountain and mountain fringe | Level<br>Riparian   |
| <b>Vegetation</b> | Open brush and grasslands<br>Mixed aspen and evergreen            | Dense forest thickets and edges<br>Marshy wetlands<br>Juniper/Cottonwood/Aspen<br>Open grasslands near riparian cover |
| <b>Elevation</b>  | No limit<br>Summer-use of full alpine                             | Limited   |

is less efficient on level ground, the waning presence of carnivores capable of killing a mule deer may affect their ability to utilize level habitats in the near future. Currently, mule deer can be seen crossing stretches of level land, but only in the process of moving from one slope to another (Dalyrimple 1978).

White-tailed deer tend to occupy a very different territory from mule deer (Table 4.1). They prefer the level country that mule deer are unable to occupy. The habitat they use is diverse in vegetation growth, climate, and aridity; however, they must have areas of dense thickets and edges to furnish food and provide cover (Dalyrimple 1978). While they inhabit a range of altitudes, they cannot occupy subalpine zones or areas of high elevation with deep snow. Paleoenvironmental reconstructions (Adams 2002) and geographic occurrence maps (Chapter 3) of the two deer demonstrate the climatological limitations of white-tailed deer. Climates where only mule deer are found are those that are tropical semi-desert, cool semi-desert, cool temperate coniferous forests, and alpine tundra. This is in keeping with the environments mule deer can utilize, but limits white-tailed deer use by a lack of dense thickets and edges.

### **Differential Niche Utilization in Overlapping Geographical Territories**

There have been many studies researching differential niche utilization in areas where mule deer and white-tailed deer range overlap. All of these studies agree that in areas where mule deer and white-tailed deer both occur they will occupy the same limited region and even overlap in their subsistence resources (see diet section below), but seldom will their ranges overlap. Several studies examining niche utilization in areas

where mule and white-tailed deer ranges overlap with each other and other ungulates are examined in this review.

### *Case Studies*

Baty (1995) conducted a study examining resource partitioning of sympatric elk, mule deer, and white-tailed deer on a winter range in western Montana. Baty found that mule deer tended to frequent sites with deeper and more crusted snow. Mule deer are adept at collapsing their phalanges in order to increase their foot area which reduces foot loading and facilitates locomotion in deep snow. Mule deer also tended to use douglas-fir (*Pseudotsuga*) habitats with sparse overstory canopy cover, but as snow increases they will shift to a more mature douglas-fir stand with more overstory canopy cover. Mule deer may use high elevation subalpine fir (*Abies lasiocarpa*) habitats as well. Though the snow is deep, mule deer prefer northerly exposed slopes and areas with dense overstory which can mitigate the adverse snow depth and crust conditions (Baty 1995).

Conversely, Baty (1995) found that white-tailed deer tended to use areas with shallower snow, less crusted snow, and areas with higher daily temperatures than those used by mule deer. Also, white-tailed deer would tend to use level habitats with abundant overstory canopy cover and variable shrub understories. Unlike mule deer, the white-tailed deer preferred to use areas with a southwesterly or westerly exposure (Baty 1995).

While fecal analysis and behavioral observation demonstrated both species had a diet more similar to one another than to any other ungulate in the study area (see diet section below), the two Odocoileines maintained a low spatial overlap (Baty 1995).

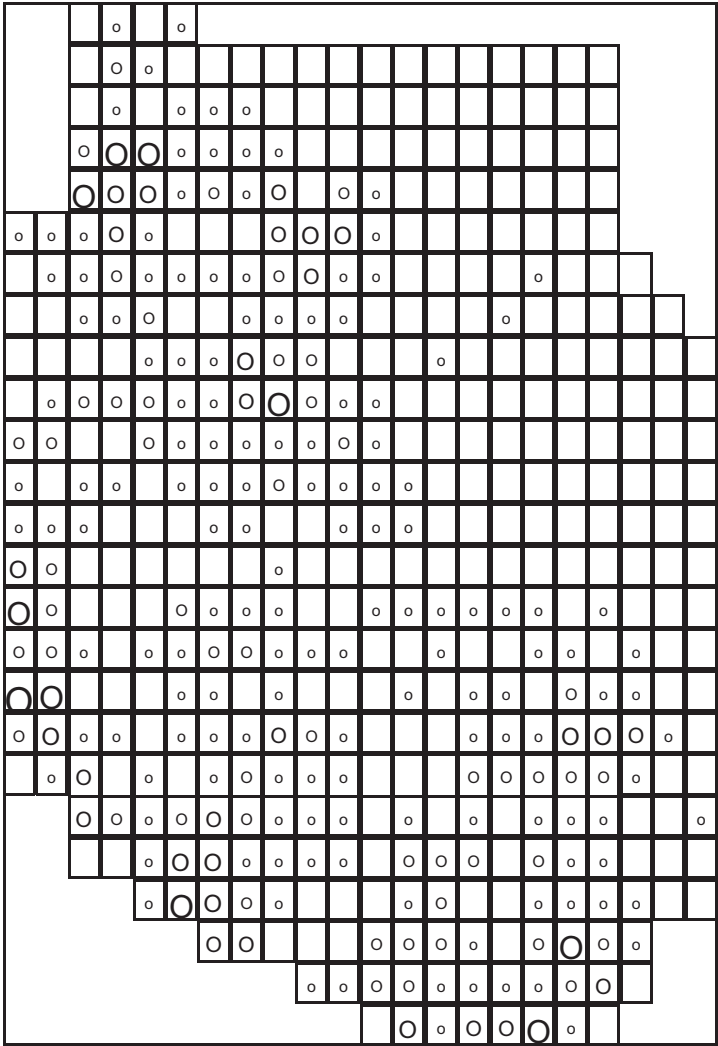
Table 4.2 shows the use difference of the four spatial units in the study area by the three cervid species during the winters of 1992 and 1993. As can be seen in the table, Zone 1 is highly utilized by white-tailed deer (71.5-82.9%) for both months in each year and rarely used by mule deer (1.0-7.2%). Meanwhile, Zone 3 is heavily utilized by mule deer (70.5-75.8%), and rarely utilized by white-tailed deer (0.9-8.4%). Zones 2 and 4 have fairly even use by the two species with rare occurrences of either species in Zone 2 and numerous occurrences of both in Zone 4.

McCullough (1980) examined niche separation of seven North American ungulates on the National Bison Range in Montana. This study, while focusing on many different ungulate species, supports what has been presented about mule deer and white-tailed deer distribution so far. Mule deer in the study were widely dispersed over the steep southern two-thirds of the refuge and were strongly associated with mountain sides. Figure 4.1 and 4.2 show the population distribution of mule deer and white-tailed deer within the study area. Mule deer in the region tended to use rocky areas, south facing slopes, open douglas-fir and ponderosa pine (*Pinus ponderosa*) stands, as well as weedy brushy patches near talus slope (McCullough 1980).

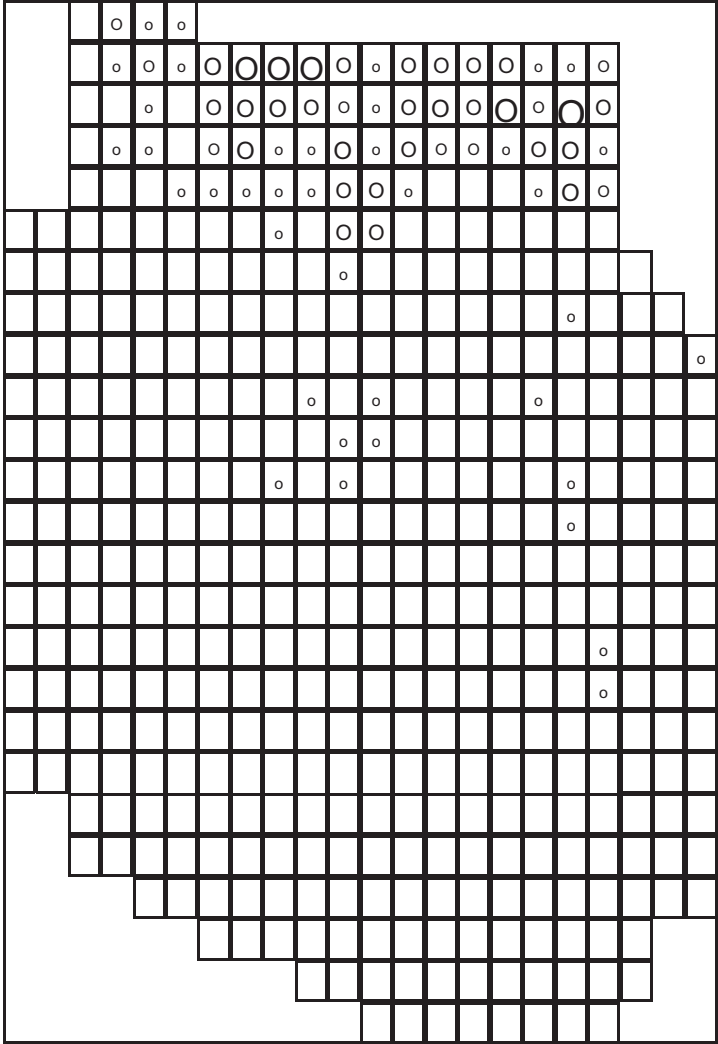
White-tailed deer in this study (McCullough 1980) preferred more riparian habitats with dense low shrubby vegetation, marshy wetlands, and juniper (*Juniperus*), cottonwood (*Populus*), and aspen tree stands. White-tailed deer could also be seen in open rolling grasslands near riparian cover, but they tended to use ravine bottoms as concealed routes to the grasslands (McCullough 1980). As can be seen by comparing

**Table 4.2 - Use of Spatial Zones in a Sympatric Elk, Mule Deer, and White-tailed Deer Study in a Winter Range in Western Montana. Adapted from Baty (1995:63:Table 10).**

| <b>Month/Year</b> | <b>Zone</b> | <b>% Use by Elk</b> | <b>% Use by Mule Deer</b> | <b>% Use by White-tailed Deer</b> |
|-------------------|-------------|---------------------|---------------------------|-----------------------------------|
| January 1992      | 1           | 20.0                | 1.0                       | 78.0                              |
|                   | 2           | 21.2                | 2.0                       | 1.8                               |
|                   | 3           | 42.6                | 75.1                      | 0.9                               |
|                   | 4           | 16.2                | 21.9                      | 19.0                              |
| February 1992     | 1           | 24.1                | 7.2                       | 82.9                              |
|                   | 2           | 24.8                | 3.6                       | 1.9                               |
|                   | 3           | 34.3                | 70.5                      | 3.4                               |
|                   | 4           | 16.8                | 18.8                      | 11.8                              |
| January 1993      | 1           | 11.3                | 2.0                       | 71.5                              |
|                   | 2           | 37.7                | 1.6                       | 0.9                               |
|                   | 3           | 38.9                | 75.8                      | 8.4                               |
|                   | 4           | 12.1                | 20.0                      | 19.2                              |
| February 1993     | 1           | 10.4                | 1.1                       | 78.0                              |
|                   | 2           | 42.9                | 0.7                       | 0.6                               |
|                   | 3           | 34.3                | 78.2                      | 1.1                               |
|                   | 4           | 12.4                | 20.1                      | 19.7                              |



**Figure 4.1 - Distribution of Mule Deer on the National Bison Range. Circles Represent the Proportion of Observations in each Cell. Adapted from McCullough (1980:40:Figure 8).**



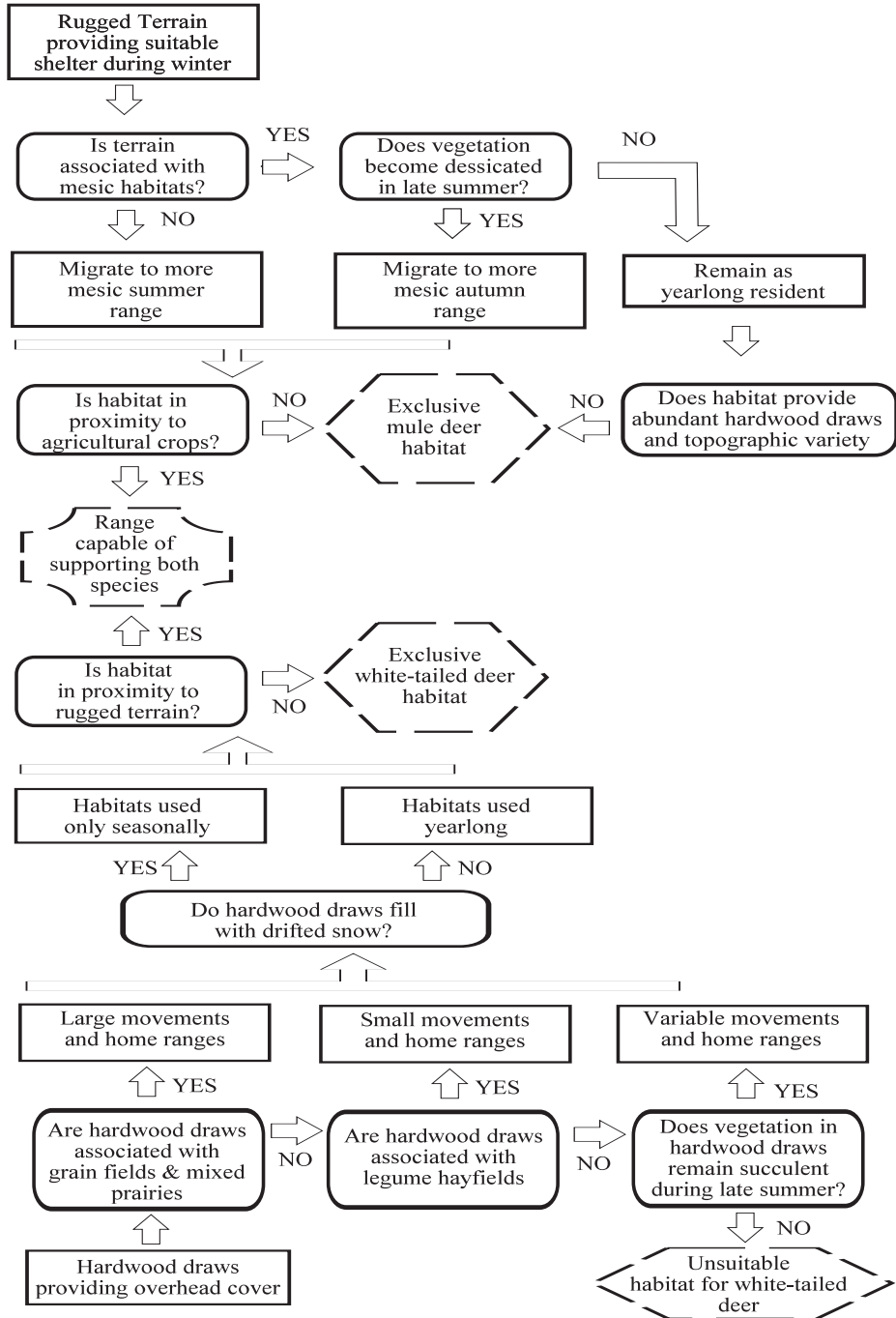
**Figure 4.2 - Distribution of White-tailed Deer on the National Bison Range. Circles Represent the Proportion of Observations in each Cell. Adapted from McCullough (1980:41:Figure 9).**

the two figures on population distribution, there is little to no overlap of the two deer species within the study area.

One additional factor separating the two cervids in the National Bison Range is elevation (McCullough 1980). White-tailed deer are most strongly associated with lower elevations with few white-tailed deer spotted above 910 meters. Ninety percent of the white-tailed deer in the area occur between 760 and 910 meters. In contrast, the mean elevation use of the area by mule deer is 1000 meters, with peak use occurring between 940 and 1060 meters. These numbers leave little possibility for overlap in use by the two species (McCullough 1980). The difference in elevational use could be related to snow depth and the ability of mule deer to use the deeper crusted snow that would occur at higher elevations.

Wood et al. (1989) studied white-tailed deer and mule deer movement and habitat use in the Cherry Creek Refuge area in eastern Montana. The Cherry Creek area, in contrast to the montane environments discussed previously, is a prairie environment. This study used research gathered over multiple years and multiple seasons. Wood et al. (1989) assert that patterns of distribution, movement, home range size, and habitat use were not based on direct relationships between deer and individual habitat components. Rather, they were responses of both species to overall habitat complexes that were seasonally important to each. They formulated a “decision tree” model to summarize the characteristics of prairie locations and whether those habitats could be utilized by mule deer, white-tailed deer, or both (Figure 4.3).

**KEY MULE DEER HABITAT NEEDS**



**KEY WHITE-TAILED DEER HABITAT NEEDS**

**Figure 4.3 - Habitat Characteristics Influencing Movement Patterns and Relative Distribution of Deer on the Cherry Creek Study Area. Adapted from Wood et al. (1989:67:Figure 13).**

For the most part mule deer/white-tailed deer interaction in the study area is consistent with the generalizations presented. Once again rough terrain is the key component of mule deer habitat in a prairie environment. Mule deer prefer badlands and bunch grass prairie habitats providing shelter and other resources necessary during the winter. Some of the mule deer also utilized hardwood draws and mesic habitats throughout the year. In these areas, there would be some overlap with white-tailed deer since these are regions they also occupy. In addition, white-tailed deer used hardwood draw-agricultural complexes not associated with topographic relief, though these areas were abandoned in winter when the fields filled with drifted snow (Wood et al., 1989). The prairie environment in this study appears to have the most spatial overlap of the studies examined here. This is likely due to the fact that it is an environment capable of supporting both species.

Wood et al. (1989) provide speculation as to why the general habitat choices of these two animals differ when an overlap in their use of food resources does occur. One of the possible factors mentioned includes their predator avoidance mechanism. This is discussed in detail later in this chapter. Another possible factor governing their spatial and habitat separation is competitive exclusion. Evidence of interspecific competition, however, was limited in both Cherry Creek and other study sites investigated. At Cherry Creek there was some sign of interspecific competition between 1976 and 1982 because both populations of deer increased and peaked. The duration of this competition was limited in the area because populations were reduced by increased harvest rates (Wood et al. 1989).

Kramer (1973) examined segregation of the two species in areas of overlap to investigate whether separation was caused by conflict aversion and competition or by actual differential habitat preferences. Since diet has been known to overlap, observance of behavior was necessary to satisfy the issue. Kramer's (1973) study was conducted in 40 square miles of the western portion of the Cypress Hills in southern Alberta and Saskatchewan. Cypress Hills is a low plateau stretching 1000 square miles and rising out of the plains of southern Canada. The specific study area had an elevational range of 3800 to 4700 feet (12464 to 15416 meters) above sea level. Ecozones included a rough fescue and lodgepole pine plateau; an eastward running valley; mixed-grass prairie, aspen, and mixed forests on south facing slopes; and a rolling mixed-grass prairie. On average, the ratio of mule deer to white-tailed deer in the study area was 1.5:1. The study showed that there seemed to be "no more avoidance between the two deer species than within either species" (Kramer 1973:293). In fact,

The absence of competitive interference is reminiscent of the relationship between roe deer (*Capreolus capreolus*), red deer (*Cervus elaphus*), and fallow deer (*Dama dama*) in Scotland, where shifts in species ratios can be explained by forest succession alone (Kramer 1973:297).

When the ranges of the two species were noted it was apparent that they did not completely overlap and it was possible to distinguish exclusive mule deer and exclusive white-tailed deer ranges. White-tailed deer exclusive ranges were found at lower elevations characterized by willow thickets while mule deer utilized higher elevation areas with few or no willows. Seasonally the degree of separation and range overlap

varied as well. The ranges overlapped to the greatest extent in spring and the least in winter (Kramer 1973).

Kufeld and Bowden (1995) examined mule deer and white-tailed deer inhabiting eastern Colorado in the Plains river bottoms. Their study focused less on specific habitat use and more on a general shift within the region. They noticed that agricultural changes in their study area were affecting the landscape and leading to changes in the deer populations in the region. In the 1800s land along the South Platte and Lower Arkansas rivers had been relatively treeless. In this type of habitat the dominant deer was mule deer. There has been a trend in this vicinity, however, toward increased agricultural development which has resulted in heavily wooded areas interspersed with agriculture. This is a habitat highly favorable to white-tailed deer. During 1991, winter deer counts along the Lower Arkansas River in Colorado recorded only eight mule deer, whereas the white-tailed deer population was estimated at 800 animals. It is apparent that the change in habitat has also produced a shift in the dominant deer species in this region.

Present and past encroachment of white-tailed deer into mule deer range when favorable habitat develops could in part be aided by disease and parturition. Both are discussed below.

### **Historic Evidence for Deer Population and Habitation Instability**

Historical populations and occurrences of both mule deer and white-tailed deer have fluctuated over time. Mule deer were nearly eliminated from the Plains during the last part of the 19<sup>th</sup> century because of their use as food by early Euro-American settlers,

along with other factors (Jones et al. 1983). It has been noted that “in 1900 there were fewer than 100 mule deer in Nebraska, and the species was uncommon throughout the state until 1950” (Kufeld and Bowden 1995:4). Cary (1911) conducted a biological survey of Colorado and concluded that no mule deer remained on the plains east of the mountains in 1911. Since that time, however, mule deer have managed to repopulate the Colorado plains, though their densities in the plains are still lower than those in the mountains (Kufeld and Bowden 1995).

Early reports from Euro-American settlers in the late 19<sup>th</sup> and early 20<sup>th</sup> centuries indicate that there were small populations of white-tailed deer present in Colorado in the vicinity of San Isabel National Forest south and west of Pueblo, in the Black Forest near Colorado Springs, and along the foothills north to Boulder and Fort Collins. A search for white-tailed deer conducted in 1941 by Hunter (1948) in the lower Arkansas River area was unsuccessful. No white-tailed deer were found and there were no reports of them living in the area, though sizeable numbers of mule deer were encountered during the search for white-tailed deer. After a more extensive survey of ranchers and game wardens in portions of Colorado where white-tailed deer had been reported in the late 19<sup>th</sup> and early 20<sup>th</sup> century, it was concluded that by 1948 no white-tailed deer resided year round in Colorado (Hunter 1948). Since that time, however, white-tailed deer have been successfully transplanted from Oklahoma into Colorado along the South Platte River four miles east of Weldona, and in Cherokee Park north of Fort Collins (Kufeld and Bowden 1995).

According to several sources, mule deer were common in the northern Plains during most of the 19<sup>th</sup> century (Burroughs 1961; Severson 1981; Wood et al. 1989). White-tailed deer were locally abundant in this region along major river drainages and tributaries. Both species declined in numbers with increasing human encroachment in eastern Montana from 1872 through 1922. Hunting seasons were strongly restricted due to this drop but, despite the protection, white-tailed deer had disappeared from most of the region prior to 1941 and mule deer numbers remained low through most of that period (Allen 1971, Wood et al. 1989). In the 1940s and 1950s the numbers started to climb and in 1943 the first observations of white-tailed deer in northeastern Montana were made (Cook 1945; Wood et al. 1989).

For instance, in Lewis and Clark's trip down the Yellowstone River in 1804-1806 (Koch 1946; Burroughs 1961; Dusek et al. 1989), white-tailed deer were not mentioned as occurring while there are numerous accounts of bison (*Bison bison*) and elk (*Cervus elaphus*). Later during the 1860s and 1870s settlement of the northern Plains increased. This "...indirectly led to the near extirpation of the big game populations by the 1880s as a result of subsistence and market hunting" (Dusek et al. 1989:17). Around 1880 there are occasional accounts of white-tailed deer on the main stem or tributaries of the lower Yellowstone River. Yet, there are many more reports of mule deer, suggesting that white-tailed deer were scarce at that time. Mule deer "were the only big game animals observed on riparian bottom lands of the Yellowstone above the mouth of the Bighorn during the late 1940's" (Dusek et al. 1989:17). It is indicated that in the extreme lower reaches of the Yellowstone River in eastern Montana there was a limited distribution of

white-tailed deer in 1941 (Dusek et al. 1989). In other words, white-tailed deer were scarce in eastern Montana while mule deer populations were high prior to 1940.

Harvest trends for the mid-to-late 20<sup>th</sup> century show a drastic increase in the white-tailed deer population. In the 1950s 1000-3000 white-tailed deer per year were harvested while in the mid-to-late 1980s 5000-21,000 were harvested per year (Dusek et al. 1989). This change is partially due to anthropogenic disturbance.

Dusek et al. state that 19<sup>th</sup> century descriptions and photographs of the lower Yellowstone River indicate “a sparsely wooded floodplain with little or no shrub understory” (1989:49). This habitat resulted from “heavy use by large numbers of bison and other native ungulates, highly variable subsurface waterflow, frequent fires, and natural succession toward climax grasslands” (Dusek et al. 1989:49). Not only would the varied availability of necessary forage limit use by white-tailed deer, but competitive resource partitioning by other species would have further restricted white-tailed deer use. The presence of predators such as wolves and a limit of suitable cover would be further detrimental to population numbers. Euro-American migration into the area led to the elimination of bison and decline in numbers of other wild ungulates and reduced competition. Widespread agriculture and irrigation systems resulted in shallower and more stable surface water and a broader ecological niche for white-tailed deer. Predator control and restricted hunting also allowed for the fluorescence of white-tailed deer (Dusek et al. 1989). All of this change, however, increased white-tailed deer habitat and numbers while resulting in a decline in the mule deer habitat and population.

Other studies have examined overall winter deer density in southern Montana in the late 1970s. During this three year study Swenson et al. (1983) observed 33,000 mule deer and 13,000 white-tailed deer. Obviously, despite changes in habitat, mule deer still dominate the region even if their numbers are somewhat proportionally lower than previously documented. In the study, while winter concentrations of white-tailed deer were greatest in riparian areas, distribution outside these areas was sparse. Winter concentrations of mule deer were greatest in rough topography – badlands, juniper breaks, and pine-dominated habitats (Swenson et al. 1983). These areas are lacking in resources useable by white-tailed deer. Therefore, until other alteration of the environment in these areas occurs, mule deer populations should remain dominant.

This historical evidence shows that deer numbers can fluctuate over time because of pressure by humans and other factors. In an area where the two species overlap, it has been demonstrated that one or both species of deer could be affected in its distribution or numbers.

## **Diet**

While diet of the two *Odocoileines* is more similar to one another than to any other ungulate in areas where the two species overlap, inter-specific competition is rare. Degrees of similarity in diet, however, vary depending on the study (Beasom and Krysl 1984). Beasom and Krysl (1984) enclosed animals of both species in a large fenced area of 230 hectares with an elevational gradient of 870 to 900 meters asl in northwest Texas to test whether expansion of white-tailed deer herds was due to habitat change or

competitive exclusion. The animals within the enclosure included 14 mule deer and 15 white-tailed deer. Data on dietary overlap and habitat use were acquired over a two year period. The fenced area was previously known to have supported one mule deer per 30 ha with recent sightings of white-tailed deer which normally occurred 40-60 km to the north, east, and south. The amount of overlap in habitat use between the two species did increase over the time of the study, but mule deer were observed more often in rolling juniper-mesquite upland and badlands habitat, while white-tailed deer were observed more in creek and slope and mesquite upland flat areas (Beasom and Krysl 1984). This is consistent with general known differences in habitat use by the two species. These choices in habitat are partly due to diet, though some overlap in diet and habitat did occur in the study.

During the summer mule deer diet was primarily comprised of browse whereas white-tailed deer relied on forbs. In the fall, winter, and spring both species consumed similar amounts of browse and forbs. Overlap between diets was lowest in the summer at 56%. Diets overlapped 67% in fall, 77% in winter and 80% in spring. White-tailed deer were more dynamic in their use of habitat and food sources and had the most changes over the length of the study. Mule deer were more consistent and were more constrained by useable environments. The two species had essentially segregated habitats when forbs and deciduous leaves were more readily available and this segregation declined as fall and winter approached, forb availability declined, and deciduous leaf drop had occurred (Beasom and Krysl 1984).

The need to diversify the diet based on the seasonal decline of preferred resources lessened the ability for specific segregation. Therefore, even though there are some differences in diet, overall the changes are not enough to keep the species apart and we must look to other reasons for continued mule deer and white-tailed deer separation.

### **Disease as a Vector for Separation**

Cervids are the host for many parasites, most of which affect all members of the cervid family to some degree. White-tailed deer are hosts for 112 species of internal and external parasites while mule deer are hosts to 79 species (Samuel 1994a). For the most part when these species invade one Odocoileine host there are equivalent effects in the other. There are some parasites, however, which may cause no clinical disease in one member of the genus *Odocoileus* but could have serious repercussions for the other.

#### *White-tailed Deer Non-clinical Parasites*

The most well-known and serious parasite which occurs non-lethally in white-tailed deer is the meningeal worm (*Parelaphostrongylus tenuis*). While the worm does not harm white-tailed deer who have developed an “immunity” to it, it usually produces a neurologic disease, parelaphostrongylosis, in most ungulates that share a range with infected white-tailed deer (Samuel 1994b). Spread of the larvae starts when

The adult parasite inhabits the cranial venous sinuses and the subdural space. Eggs are generally deposited into the venous blood and are carried to the lungs where they embryonate into first-stage larvae which pass up the respiratory tract, are swallowed, and are eliminated in the feces. Larvae occur only in the mucous coat of the fecal pellet and they are resistant to freezing temperatures and

desiccation. The larvae penetrate into the foot of terrestrial molluscs which generally abound on deer range, and reach the infective stage in 3-4 weeks at summer temperatures (Anderson, 1972:304).

Larvae can survive winter in gastropods though development may be retarded in estivating and hibernating species. Cold and dry conditions can slow or cease development, but the arrival of warm, wet weather expedites development. Deer become infected by ingesting gastropods containing infective larvae. Typically, low damp forests are more likely to have molluscs capable of transmitting the meningeal worm than a dry elevated forest (Anderson 1972). This may be partially responsible for the slow spread of the disease out onto the Plains; however, Anderson (1972) states that while grassy fields may have few carrier molluscs, the prevalence of larvae in the fields is high. Since deer feed a great deal in grassy fields it is a high area of transmission of the worm. Presently the disease has spread far enough west as to be threatening mule deer populations (Samuel 1994b). The susceptibility of various ungulates to the meningeal worm is presented in Table 4.3 and the range is presented in Figure 4.4.

#### *Mule Deer Non-clinical Parasites*

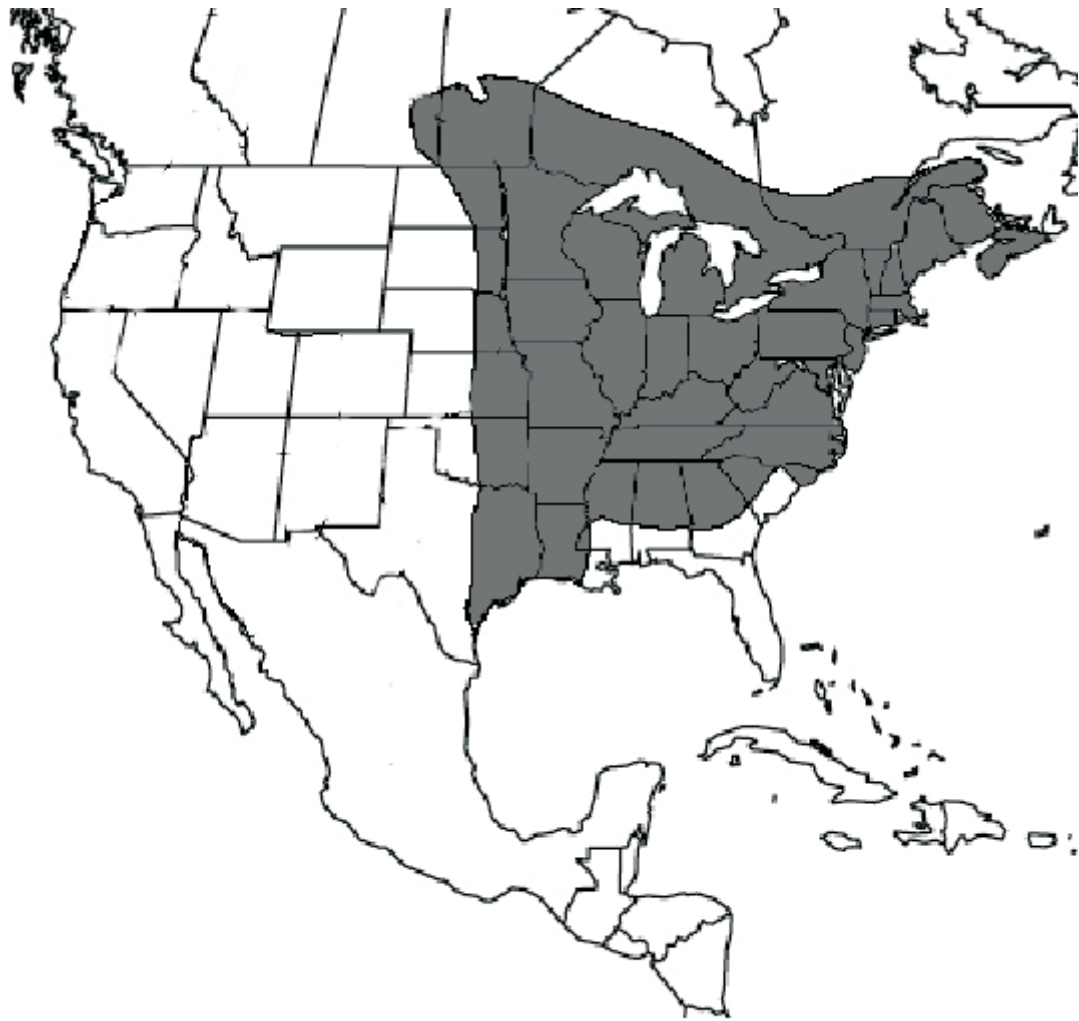
Mule deer also carry parasites which may have little to no effect on them, yet be potentially fatal to other cervids. *Elaeophora schneideri*, or the carotid artery worm, causes no clinical disease in mule deer. In other cervids, however, such as elk and moose it can cause muzzle and ear necrosis, malformed antlers, blindness, and death. Clinical signs in all adult white-tailed deer begin with an enlargement beneath the mandibular lower ramus, followed by debilitation, lack of coordination, and an absence of a fear of

**Table 4.3 - Susceptibility of Various North American Ungulates to Parelaphostrongylosis. Adapted from Samual (1994b:235)**

---

| <b>Infected Animals</b>      | <b>Apparent Susceptability to Fatal Disease</b> |
|------------------------------|---|
| White-tailed deer            | Resistant                                       |
| Mule deer, black-tailed deer | Very susceptible                                |
| Caribou                      | Very susceptible                                |
| Moose                        | Susceptible, many fatalities                    |
| Elk                          | Susceptible                                     |
| Pronghorn                    | Probably very susceptible                       |
| Domestic Goat                | Very susceptible, but few reports               |
| Domestic Sheep               | Resistant, but some fatalities reported         |
| Bighorn Sheep                | Susceptible                                     |
| Cattle                       | Resistant                                       |

---



**Figure 4.4 - Geographical Distribution of the Meningeal Worm. Adapted from Samuel (1994b:236).**

humans. Other signs have included thrombosis and parasitism of the coronary artery, shock followed by death, posterior weakness and trouble walking, cyanosis, dyspnea, and hyperexcitability. Dental lesions produced by the disease are also cause for other unrelated infections (Hibler and Prestwood 1981:352).

Movement of *E. schneideri* into abnormal locations may cause death of the host. For example, immature *E. schneideri* caused blockage of a major branch of the coronary artery which resulted in death of a fawn 4 weeks postinfection (Hibler and Prestwood 1981:354).

The parasite is spread by horseflies which “acquire microfilariae while feeding on the forehead and facial region of infected deer” (Hibler and Prestwood 1981:352). It takes two weeks for the microfilaria to develop to an infective larval stage. These larvae migrate to parts of the mouth of the horsefly and are then transmitted into the bloodstream of the cervid when the horsefly feeds.

The parasite is found commonly amongst mule deer in California, New Mexico, Arizona, Utah, Colorado, Wyoming, Montana, and British Columbia. In fact it has been found that nearly 100 percent of adult mule deer in the mountainous regions of New Mexico harbor *E. schneideri*. While the parasite occurs widely amongst mule deer, it has only a restricted occurrence amongst white-tailed deer. Reports of white-tailed deer infection have come from Arizona, Oklahoma, Texas and the Texas-Arkansas border, and in the Southeast along the lower Coastal Plain Physiographic Province.

It is suggested (Hibler and Prestwood 1981) that control of the arterial worm infections can best be controlled by preventing contact between the infected horsefly and deer. Since this is impossible:

In enzootic locales in the Southeast, mule deer or black-tailed deer should not be introduced since the addition of a preferred definitive host probably would break the delicate balance now held in these areas by white-tailed deer, horseflies, and the parasite (Hibler and Prestwood 1981:355).

This comment suggests possible reasons for the continued separation of the two species that has little to do with habitat.

### **Parturition**

Another factor influencing separation of mule deer and white-tailed deer involves differential survival of the two species in areas where they overlap. For a population to persist, recruitment and mortality must be roughly equal. The early survival of fawns in an area of heavy predation or disease may be affected by the date of parturition, especially in an area of sympatric species where the timing of birth may provide an advantage to one species over another (Whittaker and Lindzey 1999).

### *Predation*

Whittaker and Lindzey (1999) conducted a study determining the effects of coyote predation on mule deer and white-tailed deer fawn survival in Adams County, Colorado. The study area was confined to a military arsenal enclosed by a chain link fence. No hunting or livestock grazing occurred in the area but coyotes were present. Within the enclosure, mule deer outnumbered white-tailed deer 4:1 and 79 percent of fawn deaths were caused by coyote predation. Of the two species, mule deer fawns had a much greater chance of surviving the first month of their life than white-tailed deer. On average

white-tailed deer fawns in the area were born 8-10 days earlier than mule deer fawns. Since mule deer far outnumbered white-tailed deer, these earlier parturition dates would leave white-tailed deer more vulnerable to attack while mule deer are protected through predator swamping (Whittaker and Lindzey 1999). Other researchers have shown that “...synchrony of birth, or lack thereof, could affect survival of neonatal ungulates. Young born outside peak parturition, when density of newborns was low, had lower survival than those born during the peak” (Whittaker and Lindzey 1999:260). Whittaker and Lindzey noted that 49 mule deer and 11 white-tailed deer fawns survived greater than 30 days. Of those, 92 percent of mule deer and 55 percent of white-tailed deer fawns “...were born during or immediately after peak density of fawns” (Whittaker and Lindzey 1999:260). Other studies (Wood et al. 1989) observed similar summer fawn mortality rates for sympatric mule and white-tailed deer populations in Montana. Yet in that study, white-tailed deer fawns had greater winter survivorship rates than mule deer, thereby leading to no inter-specific differences in annual recruitment.

Diet and spatial overlap studies support the interpretation that mule deer and white-tailed deer overlap most during the winter months. Studies show that mule deer fawn overwinter survival is strongly affected by population density (more deer equal less survival). This may be linked with averaging of populations. Mule deer and white-tailed deer diet partially overlap, but white-tailed deer fawns may benefit in some areas from increased predation early on leaving fewer fawns and less food competition during winter months. Mule deer fawns, on the other hand, by having a higher early surviveability rate increase winter feed competition in areas of higher deer density, thereby leading to greater

winter mortality. Thus, in high density areas numbers and ratios of the sympatric species should remain stable. In areas of lower deer density, if predation alone is the factor, then the species with the most births in the peak density should have the highest recruitment and continue to increase.

### **Modern to Past Application**

All of this information concerning the ecology of the two species leads to a few hypotheses about how the introduction of agriculture, environmental change, and areas of elevational gradient may affect the proportional presence of each deer species in the archaeological record. Other data, such as botanical remains or microfauna, should be used to support explanations for a shift in deer species presence at archaeological sites when possible.

#### *Agriculture*

In areas where terrain less rugged or steep and initially dominated by mule deer, with the introduction of agriculture there should be an increased presence of white-tailed deer in the archaeological record. This may or may not be accompanied by a decline in representation of mule deer. Wildlife studies show mule deer and white-tailed deer have the largest habitat overlap in areas under agricultural cultivation. While parturition should favor mule deer fawn survivorship, competition for winter food would lead to an even recruitment between the two species. Historic examples suggest white-tailed deer would prevail in previous mule deer dominant zones due to the clearing necessary for

agriculture and the introduction of a stable food source as long as there is still limited cover nearby.

### *Environmental Change*

During times of drying conditions when forests are opening and fringes retreating, there may be a reduction in some areas of white-tailed deer at archaeological sites. Since bison populations would be expected to decrease as well at such times, there would be an expected increase in deer utilization resulting in an increase in deer bone of both species at archaeological sites. Human groups should be more reliant on mule deer in areas of sloped terrain and rough topography. Mule deer populations may also extend further eastward during drying conditions. On the other hand, in times of more moist conditions when forests are increasing and cover is more prevalent, there should be an increase in the use of white-tailed deer over mule deer at archaeological sites in the eastern portion of Plains.

### *Elevation*

At sites in mountainous terrain with elevational gradients, human movements and settlements can be reconstructed by examining the faunal record. Sites above the elevational limit of white-tailed deer that have white-tailed deer bone present would suggest forays below that point for hunting or other tasks. In general though, sites at higher elevations or in areas of deep-crusted snow should show an archaeological predominance of mule deer bones.

## **Locomotion**

Mule deer and white-tailed deer have many behavioral and physiological similarities. Physically, the live animals are alike with differences in antlers, coat colors, and tail colors used as the visual clues for a quick identification (Krausman 1994). Skeletally, the two have appeared so similar to zoologists, wildlife biologists, and archaeologists that there have been few means by which to tell the species apart when relying on skeletal material. Therefore, when examining the two species' behavioral background, it is necessary to look for cues which may suggest physiological differences that could result in skeletal indicators. The most obvious cue for this is their locomotor strategies.

Mule deer prefer more rugged terrain. Their predator escape mechanism includes a stotting, or vertical bounding, gait. For this gait the mule deer propels itself forward and up at a ten to fifteen degree angle and appears to remain suspended in the air. While airborne, however, it is slowly moving both pairs of legs forward so that it lands nearly simultaneously on all four feet. All four legs equally absorb the shock of the landing. Mule deer often move in a zig-zag pattern which can further confuse predators. The mule deer gait allows it to keep obstacles in the path of its predator, to ascend a hill straight on, or to dash off at unpredictable angles (Geist and Lingle 1994).

White-tailed deer, however, prefer more level and wooded terrain. Their escape mechanism is a galloping escape gait of several long strides and alternating high leaps moving straight ahead in an attempt to outrun danger. They use their hind legs to push off for a long low leap with great horizontal momentum and land on their front hooves,

which dig in helping to pull the body forward. This gait allows the white-tailed deer to attain speeds up to 40 miles per hour in the wild, contrasted with the mule deer stott which only enables the deer to reach speeds of 20-30 miles per hour (Geist and Lingle 1994).

These strategies suggest possible physiological and developmental differences which would result in skeletal distinction between the bones of the limbs and feet. Further support for possible differences in the limb bones is provided by Scott (1987). Scott examined adaptations in cervid postcranial skeletons related to habitat and animal size. She found that some differences in skeletal morphology of cervids are based on body weight. As cervids increase in size, limb bones become thicker relative to length, though not as drastically as in bovids. She states that some “limb modifications in cervids may be related to locomotor differences, especially the number and duration of the suspended phases in the gallop” (Scott 1987:68). Mule deer have one extended suspended phase during the gallop while white-tailed deer have a shortened gathered suspension. Scott also assumes that “differences in morphology may not depend simply on habitat but on strategies of predator escape, and on gait and locomotor behaviors” (1987:68). Unfortunately, the study’s scope is on general cervid trends and does not examine individual species. Data on transformed limb length differences between mule deer and white-tailed deer bones show that the most extreme differences occur on the humerus, metacarpal, and tibia (Scott 1987).

## Summary

Habitat, behavior, and general ecology of the genus *Odocoileus* supplies information that may be useful for interpreting the archaeological record. Knowledge of ecology can aid in the interpretation of mule deer and white-tailed deer remains found at archaeological sites. Further, differences in locomotive patterns of each species may provide a cause for possible skeletal differences which can be used for identifying postcranial bones found in archaeological context.

## CHAPTER 5

### Methods and Materials for Identification

Due to the differing gaits and locomotor strategies of the two deer species as well as their differing abilities with respect to collapsing their phalanges to mediate front-loading, it was decided to focus on bones associated with locomotion and the feet to attempt to discern morphological and biometrical differences. The bones used in analysis included the scapula through phalanges and pelvis through phalanges. Skeletons to be studied primarily consisted of those from subspecies of the two deer in zones of geographic overlap (Chapter 3). Skeletons from throughout the United States were included on a smaller scale to account for as much intra-specific variation as possible.

Modern specimens from comparative collections at various institutions were included in the study. Postcranial bones from 17 animals curated in the Vertebrate Comparative Collection in the Department of Anthropology at the University of Tennessee, 42 animals from both the Zoological and Archaeological Vertebrate Comparative Collections at the Illinois State Museum, and 14 animals from the Natural History Museum at the University of Kansas were analyzed. In order to further extend the geographic reach of this study, wildlife biologists and agents were contacted to aid in the collection of deer legs from Arizona, New Mexico, Wyoming, Colorado, and Texas. Limb bones from 28 deer were collected by agents in Arizona, 2 deer in New Mexico, 1 deer in Wyoming, 3 deer in Colorado and 5 deer in Texas. The acquisition of larger

numbers of specimens was not possible due to some state's restrictions and the outbreak of chronic wasting disease in most of the western states. Only disease free animals were allowed to be sent from New Mexico and Wyoming.

The bones present for analysis varied partly due to collection procedures. Comparative collection material was more likely to have complete specimens where all the limb bones, scapula, and pelvis were present, but many of the specimens were from road kill animals where only the heads and portions of the legs were collected. All available bones in these specimens were analyzed. Material gathered by the biologists and wildlife agents primarily came from hunted animals and therefore it was more difficult to acquire upper limb elements. Agents were instructed to saw through the front leg at the distal radius/ulna and through the hind leg at the distal tibia of hunted animals. This would allow for all carpals, tarsals, metapodials, and phalanges to be included in the study. In a few cases it was possible for the agents to collect more of the limb.

Species identifications from the comparative collections were determined by unknown individuals at the time of collection. Two of the animals in the study had been collected as early as the late 19<sup>th</sup> century. Deer collected by agents specifically for this study were identified by those agents. All research contained herein assumes that identifications are accurate. Also, as mentioned in Chapter 4, while hybridization is rare and survival of hybrids even more so, it does occur. First generation hybrids can usually be identified by biologists, but it is possible that road-kill hybrids would be harder to identify. Accurate identification of these individuals would depend on the knowledge of the collector and the decomposition level of the animal. Second or third generation

hybrids that have back-bred consistently with the same parent species would be even more difficult to identify. Therefore, it is possible that animals identified as white-tailed deer and used in this study may have contained some genetic material of mule deer and vice versa. The only way to rule out this possibility would be through mtDNA testing. Testing of that level is financially prohibitive. The size of the sample and low probability of actual hybrid occurrence, however, make it unlikely that the data represent any substantial errors.

The specimens collected by wildlife agents were frozen and shipped to the Department of Anthropology at the University of Tennessee. The legs were defrosted and processed in the Zooarchaeological Processing Facility. The defleshed bone was then analyzed and measured in the same manner as specimens from the comparative collections.

All available front (scapula, humerus, radius, ulna, metacarpal, carpals, and phalanges) and hind (pelvis, femur, patella, tibia, metatarsal, tarsals, and phalanges) limbs of 112 deer were examined morphologically and metrically. Sixty mule deer and 52 white-tailed deer of varying age, sex (Table 5.1), and location (Table 5.2) were included in the study. Initial characteristics were determined by examining four individuals of each species in detail to establish possible traits on an element-by-element basis. Some characteristics were established by using Balkwill and Cumbaa's (1992) distinctions between *Bos taurus* and *Bison bison* and Lister's (1996) distinctions between *Dama dama* and *Cervus elaphus* as a guide. Other characteristics were established through

**Table 5.1 - Age and Sex Distribution of Mule Deer and White-tailed Deer Used in this Study**

| Species               | Adult (>2 years) |        |         |       | Subadult/Juvenile |        |         |       | Total Number of Specimens |
|-----------------------|------------------|--------|---------|-------|-------------------|--------|---------|-------|---------------------------|
|                       | Male             | Female | Unknown | Total | Male              | Female | Unknown | Total |                           |
| <i>O. hemionus</i>    | 17               | 15     | 0       | 32    | 21                | 4      | 3       | 28    | 60                        |
| <i>O. virginianus</i> | 20               | 15     | 5       | 40    | 8                 | 3      | 1       | 12    | 52                        |

**Table 5.2 - Geographic Distribution of Mule Deer and White-tailed Deer Used in this Study**

| <b>Species</b>     | <b>Location</b>       | <b>Total</b> |
|--------------------|-----------------------|--------------|
| <i>O. hemionus</i> | Arizona               | 14           |
|                    | British Columbia      | 1            |
|                    | Colorado              | 5            |
|                    | Kansas                | 1            |
|                    | New Mexico            | 4            |
|                    | Utah                  | 1            |
|                    | Washington            | 2            |
|                    | Wyoming               | <u>32</u>    |
|                    | TOTAL                 | 60           |
|                    | <i>O. virginianus</i> | Arizona      |
| Florida            |                       | 1            |
| Illinois           |                       | 1            |
| Kansas             |                       | 5            |
| Missouri           |                       | 2            |
| Ohio               |                       | 1            |
| Tennessee          |                       | 6            |
| Texas              |                       | 9            |
| Washington         |                       | 1            |
| Wyoming            |                       | <u>12</u>    |
| TOTAL              | 52                    |              |

detailed and timely examination of each individual bone. All characteristics were then listed on a checklist.

Metrical analysis of the two deer species followed a similar protocol. Each limb element from the eight initial sample animals was measured using all the metrical delineations developed by Von Den Dreisch (1976). Some measurements not typically utilized on cervids, namely the medial depth of the astragalus and the smallest depth of the metapodial diaphyses, along with new measurements derived for this project, were also included in the analysis.

Once study protocol was established, the research was broadened. Each of the 112 animals in the study was examined to determine presence or absence of the characteristics when the corresponding elements were present, and all available measurements were taken on those elements. Using a modified version of Lister's (1996:121) scoring of the percent accuracy of characteristics, morphological characters were given a designation based on a three point scale to show the degree to which they expressed the presumed character state for that particular species. The three points include:

- W      trait initially observed in the white-tailed deer
- M      trait initially observed in the mule deer
- I      trait that is indeterminate, partway between, or unlike those seen in the two species

Percentages of the characteristics were then calculated for each of the two species using the formulas:

$$\begin{array}{l}
 \text{Mule Deer} \quad \frac{n^M(100\%) + n^I(50\%) + n^W(0\%)}{N} = \text{percent accuracy} \\
 \\
 \text{White-tailed Deer} \quad \frac{n^W(100\%) + n^I(50\%) + n^M(0\%)}{N} = \text{percent accuracy}
 \end{array}$$

where  $n^M$  equals the number with mule deer condition,  $n^W$  equals the number with white-tailed condition,  $n^I$  equals the number with an indeterminate condition and  $N$  equals the total number of individuals analyzed for the corresponding species. The percent accuracy result roughly represents the degree of expression of the characteristic in each of the two species.

Due to differences of traits which could develop as an individual ages and the long bones fuse, analysis was conducted both on a pooled basis including adults, juveniles, and subadults, and on an adult-only basis which included animals two years old and older. The adult-only group was further examined by sex to see if there were any significant differences. Data are examined for any variations based on sex.

As animals were examined it became apparent that some characteristics initially observed were due to individual or sub-specific variation. Thirty-five characteristics were originally established. Of those, only 28 had any level of accuracy for either species above 50 percent. Those characteristics with an accuracy level for both species at the fifty percent level are presented in Chapter 6. Any level of accuracy below 50 percent would still equate to little more than a guess and be useless in scientific terms.

Furthermore, researchers are cautioned that when conducting identification using characteristics herein they should pay special attention to the accuracy rate and adjust their identification confidence accordingly.

Model selection procedures including r-squared and backward elimination were conducted on the data on an element-by-element basis to determine which characteristics were highly influenced by species difference. Both simple linear regression and logistic regression analysis were conducted using apparent significant models. All statistical analyses were run using SAS version 8.2. Analysis was also performed on the data on a pooled age-level of all animals and on an adult-only level. Adult animals were also separated into male versus female categories and differences based on sex are examined.

Data are presented which had a limitation of  $r^2 > .5$  and  $p \leq .001$ . Again, researchers should realize that  $r^2$  in linear regression represents the percent of variation that can be explained by the dependent variable, species. So  $r^2 > .5$  suggests an accuracy limit similar to that presented for morphological characteristics of 50 percent. In other words for  $r^2 = .5$ , 50 percent of the variation found in the model is determined by the deer's species. In logistic regression  $r^2$  values are not quite comparable, but still give a fair assessment of how much of the model's variation is based on the dependent variable. The p-values represent the effect; thus, the lower the p-value the more support there is for the null hypothesis and the greater the likelihood that the identification is accurate. Identification confidence should be examined within these boundaries.

## CHAPTER 6

### Results

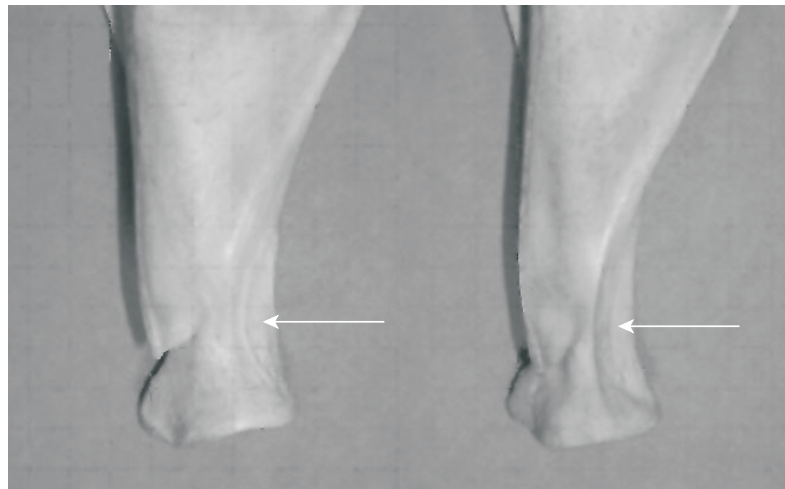
#### **Introduction**

The results obtained show significant differences both morphologically and metrically for many of the limb bones. All bones of the limbs including the scapula and pelvis were analyzed. The ulna, many of the carpals and tarsals, and the 1<sup>st</sup> and 3<sup>rd</sup> phalanx were analyzed but no characteristics fitting the significance and accuracy limitations of this particular study were identified. Bones with significant morphological characteristics for the two species include the scapula, humerus, 2<sup>nd</sup> and 3<sup>rd</sup> fused carpal, metacarpal, pelvis, femur, tibia, lateral malleolus, astragalus, and metatarsal. Bones with significant metrical means of separation include the scapula, humerus, radius, pelvis, metatarsal, and 2<sup>nd</sup> phalanx.

#### **Morphological Characteristics**

Characters for the separation of white-tailed deer and mule deer are shown in Figure 6.1. Photographs are of actual bones of known species designation from the University of Tennessee Department of Anthropology Vertebrate Skeletal Comparative Collection. All bones represented are from the left side of the animal. Those differences which are labeled should be considered significant while all other differences between specimens should be considered incidental or the result of individual specimen variation.

## SCAPULA



*O. hemionus*

*O. virginianus*

### *O. hemionus*

1. Lateral:

Groove for muscle articulation is shallow

Pooled-age 87.5% (n=36)

Adult-only 92.1% (n=19)

### *O. virginianus*

1. Lateral:

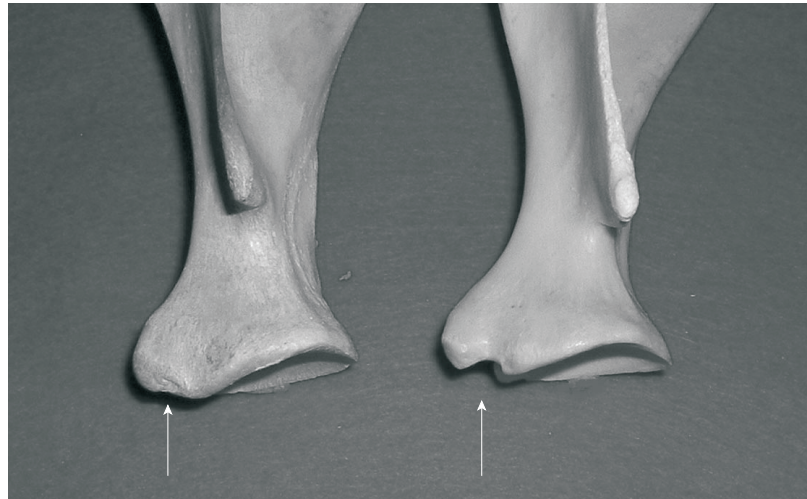
Groove for muscle articulation is deep and more pronounced

Pooled-age 93.6% (n=31)

Adult-only 97.8% (n=23)

**Figure 6.1 - Morphological Characteristics for the Identification of *O. hemionus* and *O. virginianus***

## SCAPULA



*O. hemionus*

*O. virginianus*

### *O. hemionus*

2. Lateral:

Supraglenoid tubercle is straight or curved and unbroken

Pooled-age 98.6% (n=36)

Adult-only 100% (n=18)

### *O. virginianus*

2. Lateral:

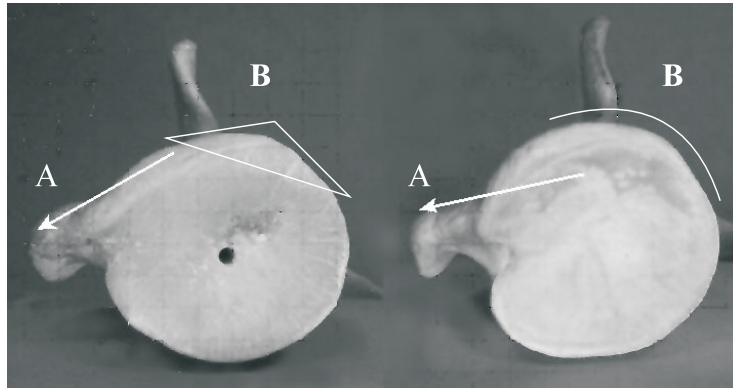
Supraglenoid tubercle is notched

Pooled-age 83.9% (n=31)

Adult-only 81.3% (n=23)

**Figure 6.1 continued.**

**SCAPULA**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

3. Distal:

3. Distal:

a. Supraglenoid tubercle connects to glenoid cavity at about a 30 degree angle

a. Supraglenoid tubercle connects to glenoid cavity at an almost perpendicular angle

Pooled-age 91.7% (n=36)  
Adult-only 92.1% (n=19)

Pooled-age 98.4% (n=31)  
Adult-only 100% (n=24)

b. Lateral caudal portion of the glenoid is mildly flat and square

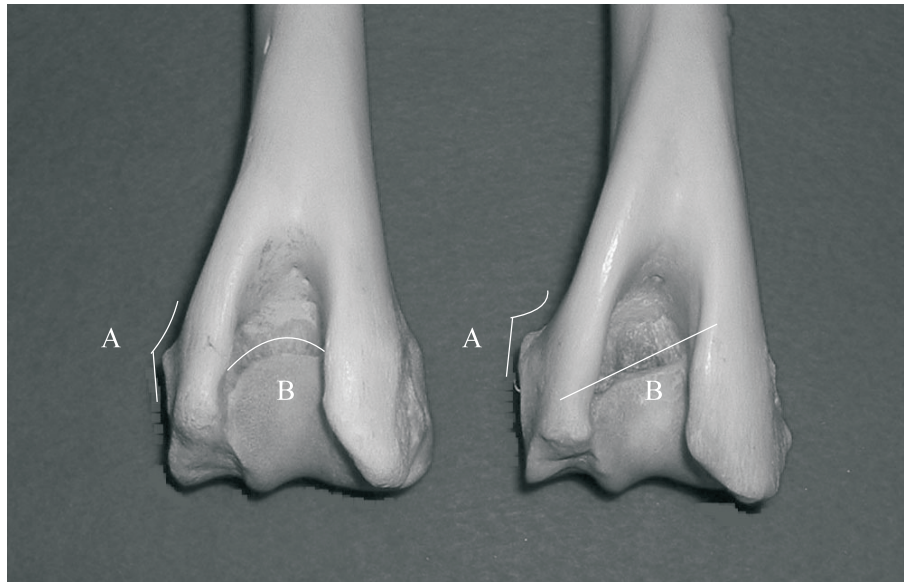
b. Lateral caudal portion of the glenoid is more rounded

Pooled-age 97.2% (n=36)  
Adult-only 97.4% (n=19)

Pooled-age 62.1% (n=29)  
Adult-only 69.6% (n=23)

**Figure 6.1 continued.**

## HUMERUS



*O. hemionus*

*O. virginianus*

### *O. hemionus*

### *O. virginianus*

#### 4. Anterior:

#### 4. Anterior:

a. Lateral distal protuberance less pronounced and angled

a. Lateral distal protuberance more pronounced and squared

Pooled-age 75.7% (n=37)  
Adult-only 75.0% (n=20)

Pooled-age 87.1% (n=31)  
Adult-only 87.5% (n=24)

b. Trochlea/olecranon fossa juncture more rounded

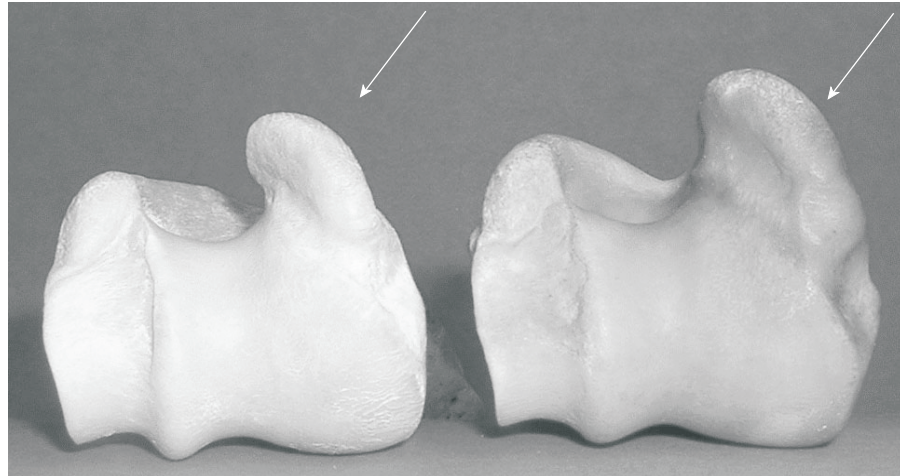
b. Trochlea/olecranon fossa juncture more flattened or angled

Pooled-age 85.1% (n=37)  
Adult-only 77.5% (n=20)

Pooled-age 93.6% (n=31)  
Adult-only 93.8% (n=24)

**Figure 6.1 continued.**

## HUMERUS



*O. hemionus*

*O. virginianus*

### *O. hemionus*

5. Distal:

Medial caudal protuberance is smaller and more confined

Pooled-age 100% (n=37)  
Adult-only 100% (n=20)

### *O. virginianus*

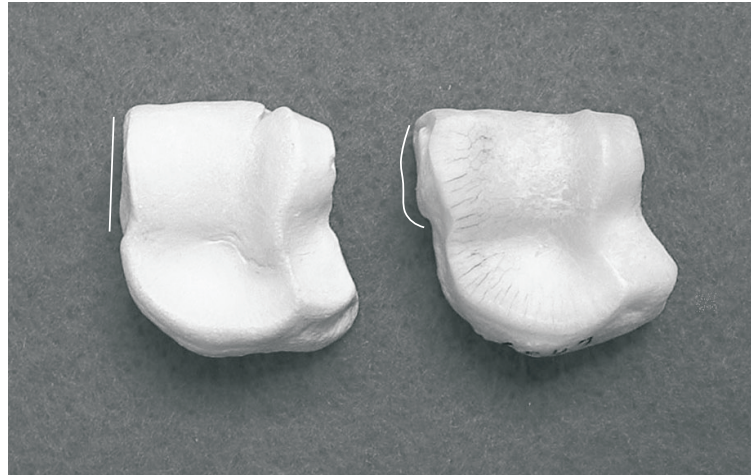
5. Distal:

Medial caudal protuberance is blockier and larger

Pooled-age 93.6% (n=31)  
Adult-only 91.8% (n=24)

**Figure 6.1 continued.**

**2<sup>ND</sup> AND 3<sup>RD</sup> FUSED CARPAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

6. Proximal:

6. Proximal:

Posterior portion of lateral surface is flat

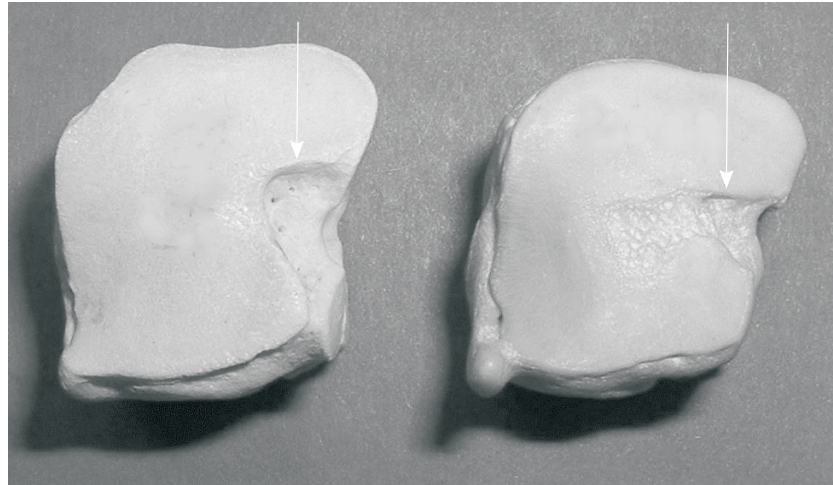
Posterior portion of lateral surface forms rounded tuberosity

Pooled-age 77.4% (n=53)  
Adult-only 78.3% (n=23)

Pooled-age 57.8% (n=45)  
Adult-only 59.3% (n=27)

**Figure 6.1 continued.**

**2<sup>ND</sup> AND 3<sup>RD</sup> FUSED CARPAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

7. Distal:

7. Distal:

Deep and pronounced groove

Shallow, almost flat, groove

Pooled-age 89.6% (n=53)

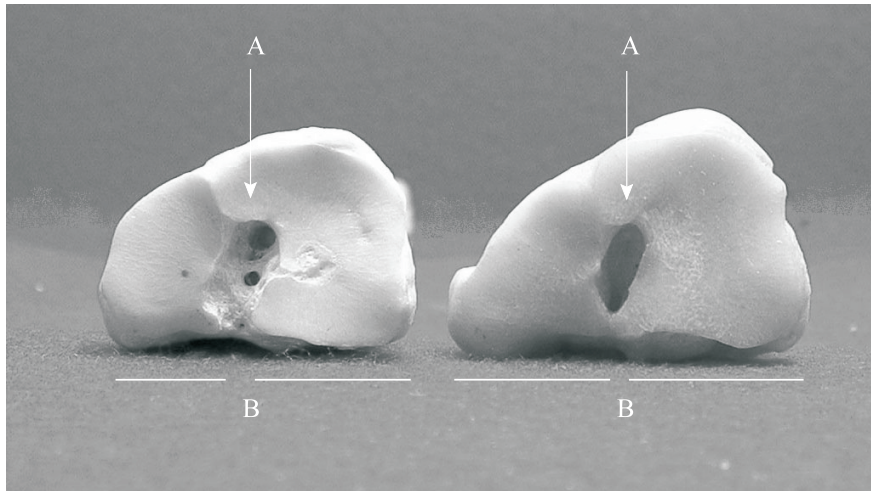
Pooled-age 94.4% (n=45)

Adult-only 89.1% (n=23)

Adult-only 90.7% (n=27)

**Figure 6.1 continued.**

## METACARPAL



*O. hemionus*

*O. virginianus*

### *O. hemionus*

### *O. virginianus*

8. Proximal:

8. Proximal:

a. Open, blocky space between facets

a. Long, linear space between facets

Pooled-age 92.7% (n=55)

Pooled-age 78.7% (n=47)

Adult-only 92.0% (n=25)

Adult-only 79.4% (n=34)

b. Lateral facet length is smaller than the medial facet length

b. Lateral and medial facet lengths are nearly equal

Pooled-age 84.6% (n=55)

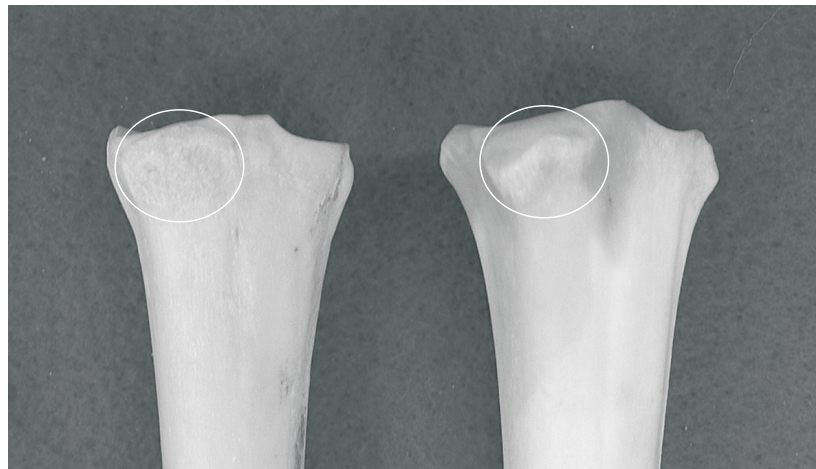
Pooled-age 88.5% (n=48)

Adult-only 88.0% (n=25)

Adult-only 87.1% (n=35)

**Figure 6.1 continued.**

**METACARPAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

9. Anterior:

9. Anterior:

Tuberosity on proximal anterior is flatter and more blocky

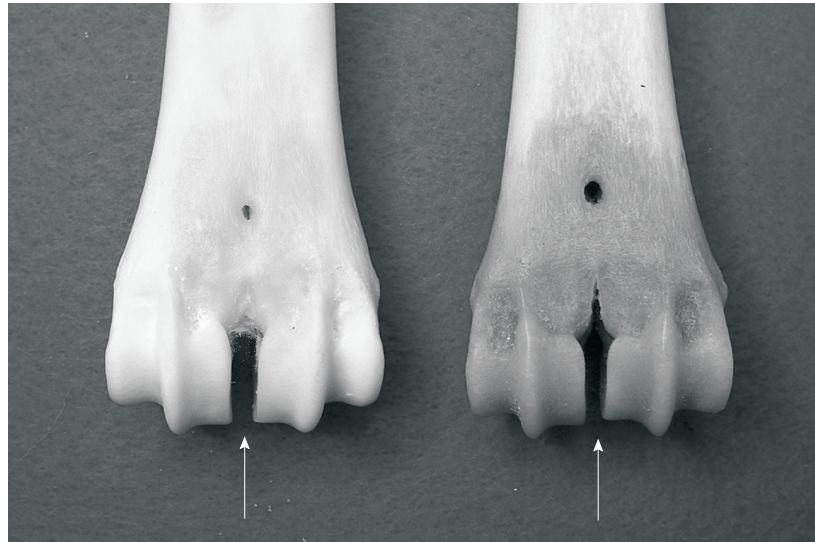
Tuberosity is more bulbous and well-defined

Pooled-age 81.5% (n=54)  
Adult-only 85.4% (n=24)

Pooled-age 73.9% (n=46)  
Adult-only 84.9% (n=33)

**Figure 6.1 continued.**

## METACARPAL



*O. hemionus*

*O. virginianus*

### *O. hemionus*

10. Posterior:

Inter-condylar space is more lance-shaped

Pooled-age 74.5% (n=55)  
Adult-only 78.0% (n=25)

### *O. virginianus*

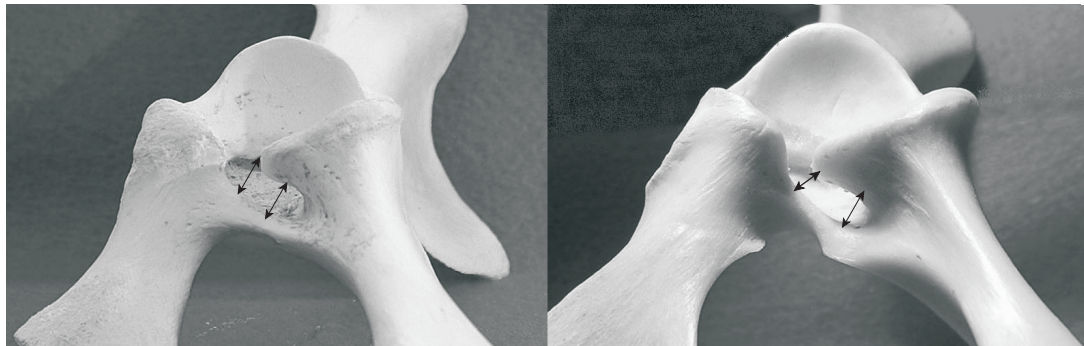
10. Posterior:

Inter-condylar space is more diamond shaped

Pooled-age 81.9% (n=47)  
Adult-only 77.9% (n=34)

**Figure 6.1 continued.**

## PELVIS



*O. hemionus*

*O. virginianus*

### *O. hemionus*

11. Ventral:

Acetabular notch is more open and evened distance

Pooled-age 76.9% (n=26)  
Adult-only 81.3% (n=16)

### *O. virginianus*

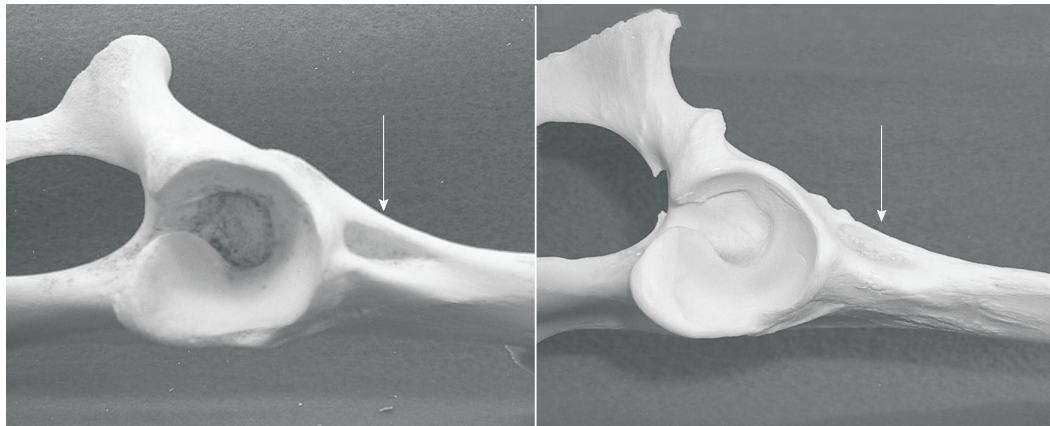
11. Ventral:

Acetabular notch constricts

Pooled-age 75.0% (n=26)  
Adult-only 69.1% (n=21)

**Figure 6.1 continued.**

## PELVIS



*O. hemionus*

*O. virginianus*

### *O. hemionus*

### *O. virginianus*

12. Lateral:

12. Lateral

Anterior rim of supra-acetabular fossa is broad but fossa is deep and narrow

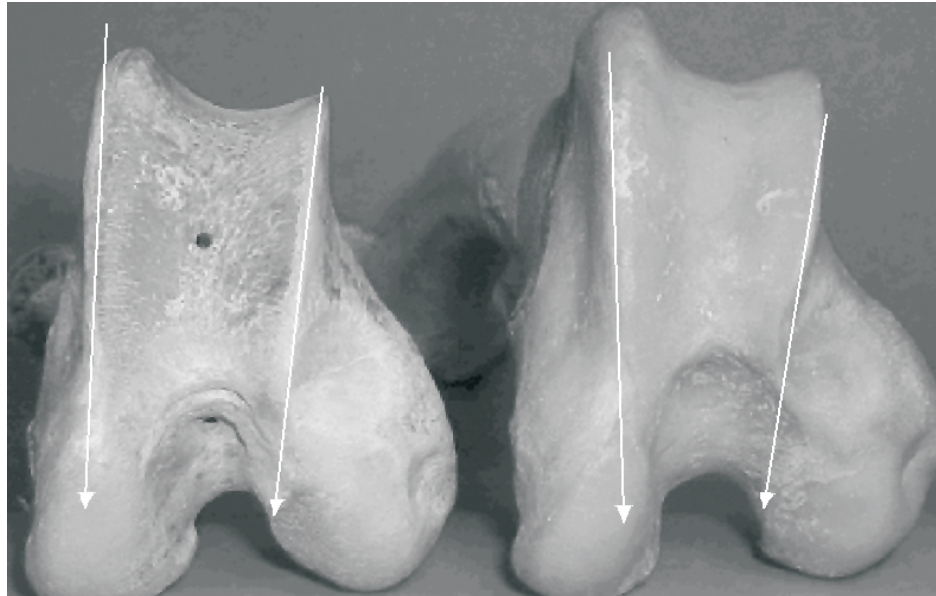
Anterior rim of supra-acetabular fossa is thin and ridgelike but fossa is shallow

Pooled-age 86.5% (n=26)  
Adult-only 96.9% (n=16)

Pooled-age 71.2% (n=26)  
Adult-only 64.3% (n=21)

**Figure 6.1 continued.**

## FEMUR



*O. hemionus*

*O. virginianus*

### *O. hemionus*

### *O. virginianus*

13. Distal:

13. Distal:

Medial and lateral ridges of trochlea progress posteriorly in a parallel manner

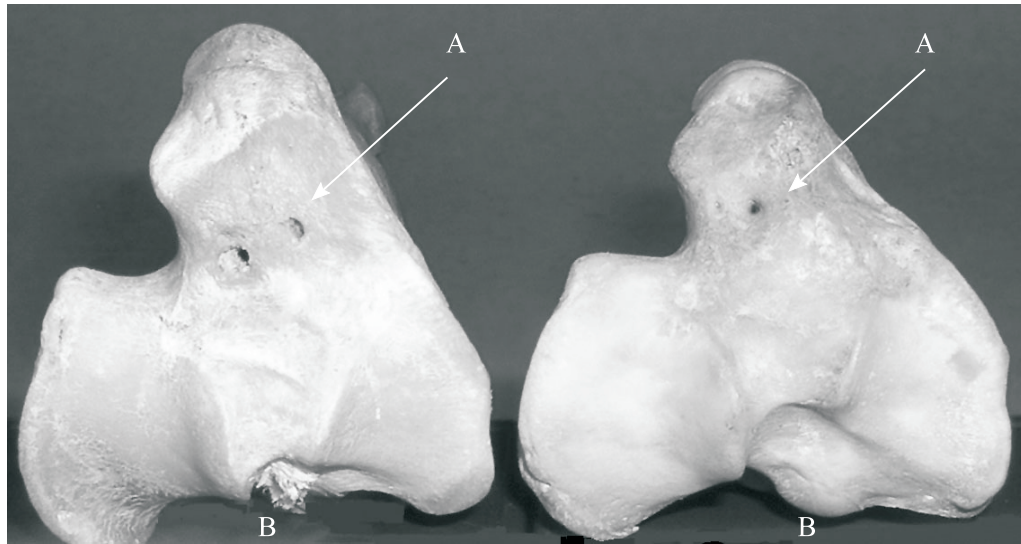
Medial and lateral ridges of trochlea progress posteriorly toward each other

Pooled-age 89.7% (n=39)  
Adult-only 100% (n=21)

Pooled-age 96.9% (n=32)  
Adult-only 96.0% (n=25)

**Figure 6.1 continued.**

**TIBIA**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

14. Proximal:

14. Proximal:

a. Two or more nutrient foramen

a. Only one nutrient foramen

Pooled-age 98.8% (n=40)

Pooled-age 93.8% (n=32)

Adult-only 97.6% (n=21)

Adult-only 92.0% (n=25)

b. Caudal tuberosity less pronounced and flattened

b. Caudal tuberosity bulbous shaped

Pooled-age 96.3% (n=41)

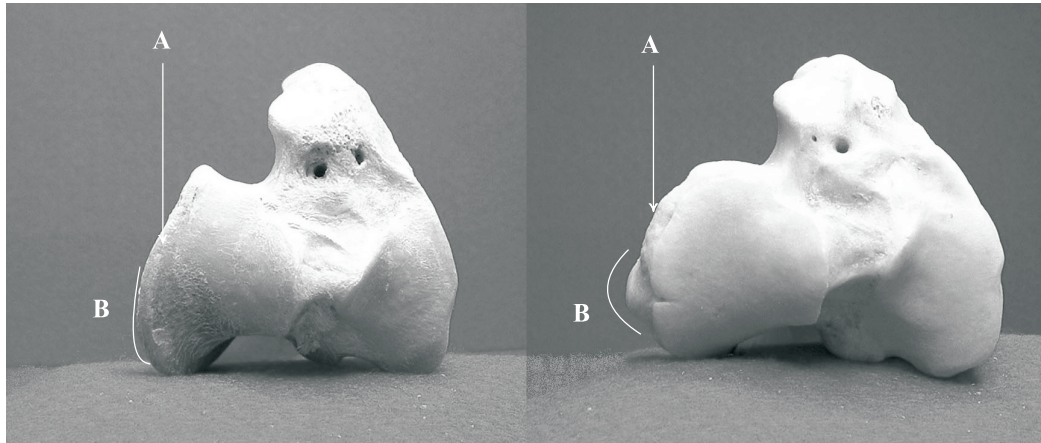
Pooled-age 96.9% (n=32)

Adult-only 95.5% (n=22)

Adult-only 98.0% (n=25)

**Figure 6.1 continued.**

**TIBIA**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

15. Proximal:

15. Proximal:

a. Smooth finish to edge of lateral articular surface

a. Rough surface at posterior lateral edge of articular facet

Pooled-age 82.9% (n=41)

Pooled-age 92.2% (n=32)

Adult-only 81.8% (n=22)

Adult-only 90.0% (n=25)

b. Flat or no lateral protuberance

b. Lateral protuberance present

Pooled-age 68.3% (n=41)

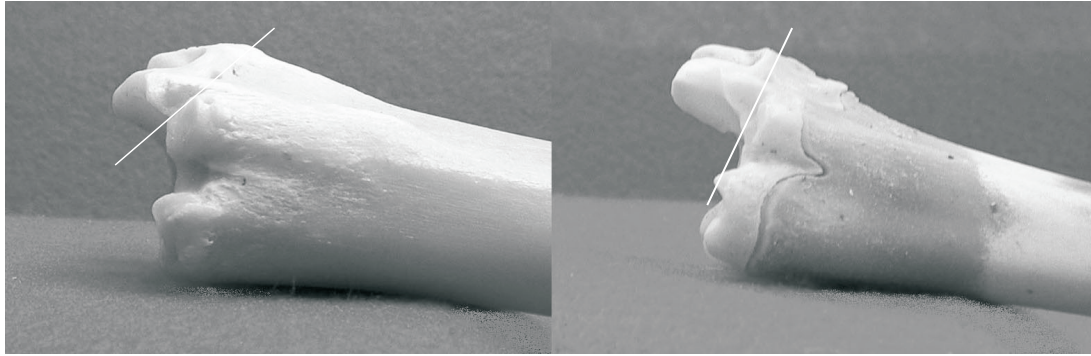
Pooled-age 75.0% (n=32)

Adult-only 56.8% (n=22)

Adult-only 84.0% (n=25)

**Figure 6.1 continued.**

## TIBIA



*O. hemionus*

*O. virginianus*

### *O. hemionus*

16. Lateral:

Proximal lateral facet slopes at about 45 to 60 degree angle.

Pooled-age 74.6% (n=55)  
Adult-only 84.6% (n=26)

### *O. virginianus*

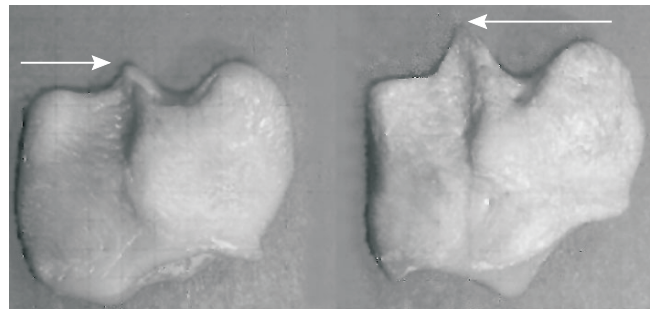
16. Lateral:

Proximal lateral facet faces ventrally at 60 to 90 degree angle.

Pooled-age 78.2% (n=39)  
Adult-only 79.3% (n=29)

**Figure 6.1 continued.**

**LATERAL MALLEOLUS**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

17. Lateral:

17. Lateral:

Central ridge on proximal surface equal to height of surrounding ridges

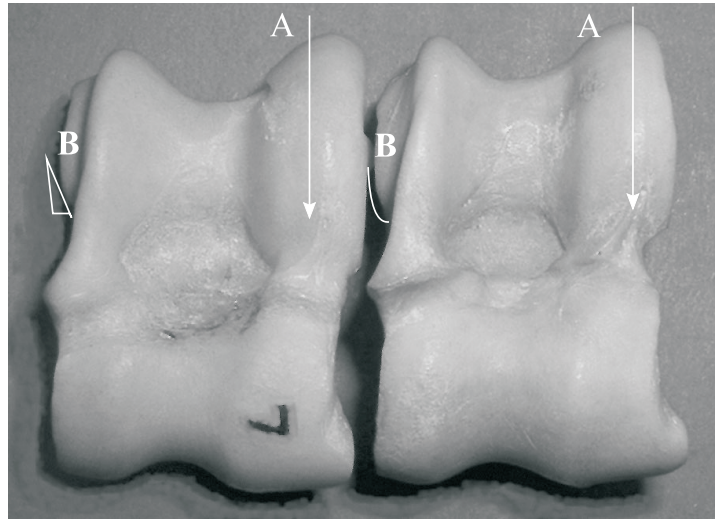
Central ridge on proximal surface extends beyond surrounding ridges, even up to twice the height

Pooled-age 99.1% (n=55)  
Adult-only 100% (n=25)

Pooled-age 89.2% (n=37)  
Adult-only 88.9% (n=27)

**Figure 6.1 continued.**

## ASTRAGALUS



*O. hemionus*

*O. virginianus*

### *O. hemionus*

### *O. virginianus*

18. Dorsal:

18. Dorsal:

a. No or slight ridge running at an angle medially to laterally

a. Well-defined ridge running at an angle medially to laterally

Pooled-age 85.9% (n=57)  
Adult-only 94.4% (n=27)

Pooled-age 90.8% (n=38)  
Adult-only 90.7% (n=27)

b. Extension of medial condyle cuts in at a more perpendicular/squared angle

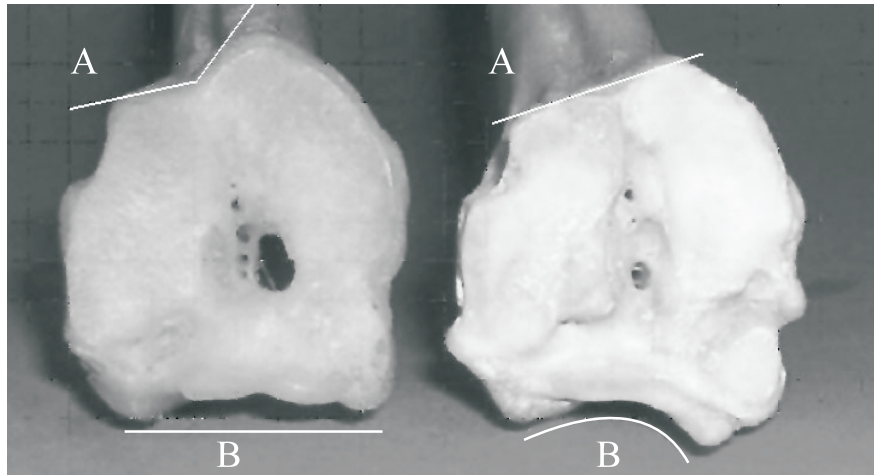
b. Extension of medial condyle slants in at a gentle angle

Pooled-age 71.9% (n=57)  
Adult-only 81.5% (n=27)

Pooled-age 67.1% (n=38)  
Adult-only 59.3% (n=27)

**Figure 6.1 continued.**

**METATARSAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

19. Proximal:

19. Proximal:

a. Junction of proximal articular facets is broken and step-like

a. Junction of proximal articular facets is smooth and linear or slightly curved

Pooled-age 84.9% (n=53)  
Adult-only 87.5% (n=24)

Pooled-age 98.9% (n=45)  
Adult-only 98.5% (n=33)

b. Posterior edge is more straight

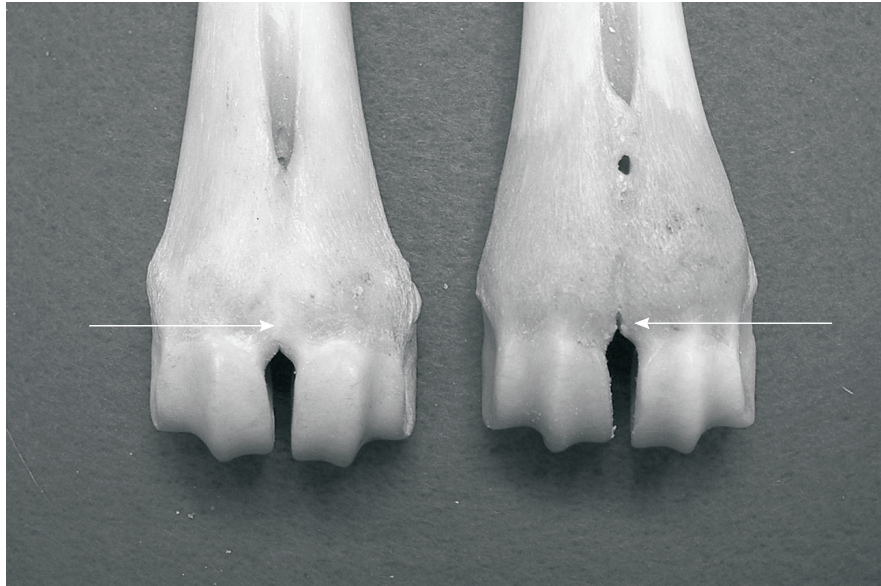
b. Lateral posterior edge protrudes

Pooled-age 69.8% (n=53)  
Adult-only 64.6% (n=24)

Pooled-age 80.0% (n=45)  
Adult-only 75.8% (n=33)

**Figure 6.1 continued.**

**METATARSAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

20. Anterior:

20. Anterior:

No or minor split visible between condyles at epiphyseal juncture

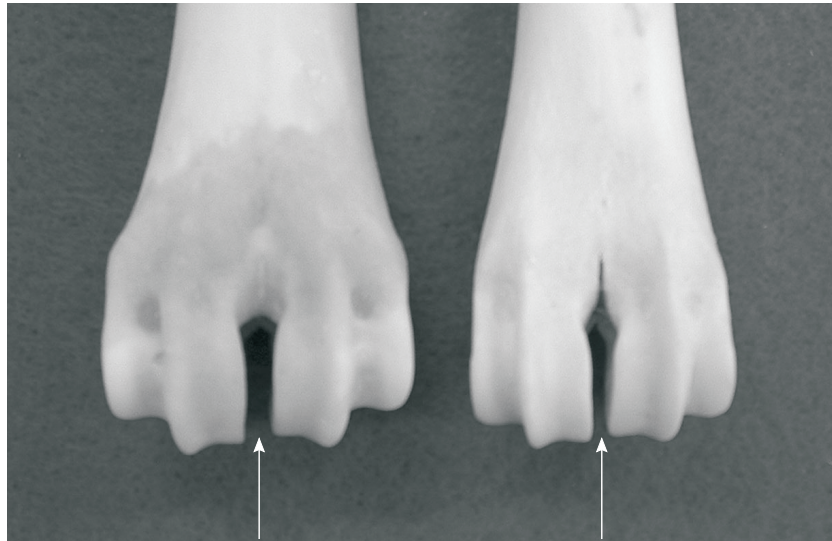
Distinct split visible between condyles at epiphyseal juncture

Pooled-age 82.9% (n=44)  
Adult-only 89.6% (n=24)

Pooled-age 85.9% (n=39)  
Adult-only 83.8% (n=34)

**Figure 6.1 continued**

**METATARSAL**



*O. hemionus*

*O. virginianus*

***O. hemionus***

***O. virginianus***

21. Posterior:

21. Posterior:

Inter-condylar space is more lance shaped

Inter-condylar space is more diamond shaped

Pooled-age 95.5% (n=56)  
Adult-only 98.1% (n=26)

Pooled-age 66.0% (n=47)  
Adult-only 55.8% (n=34)

**Figure 6.1 continued.**

The photos and descriptions of the various characters indicate the full characteristic condition of each of the individual species. No indeterminate expressions of characteristics are shown. In addition, percent accuracy of the various characteristics for both the pooled-age and adult-only levels of analysis is presented. This number is accompanied by sample sizes for each species ('n').

### **Metrical Analysis**

Measurements were regressed using simple linear regression and logistic regression techniques. While logistic regression is better for binary data, simple linear regression can still produce a general idea of the relationship between the independent variables and the dependent variable. F-statistic and Chi-square statistics were highly significant for the measurements used in these analyses for the bones presented.

As stated in Chapter 5, model selection procedures were initially conducted on all data recovered. The first cut-off for inclusion in later regression procedures was  $r^2 > 0.5$ . Following standard statistical methods, if the  $r^2$  leveled out with a lower variable model, such as two variables, further models containing more variables, such as three or more, are not presented in most cases. Since the object of this project was to include as many means to identify the deer to species as possible, however, some exceptions are made. For instance, if higher variable models contained measurement locales different from the lower variable model then they are presented. Also, since the object is to provide as much accuracy of identification as possible, all lower variable models with  $r^2 > 0.5$  whose accuracy increases by at least 0.1 when additional measurements are included are

presented as well. Therefore, researchers analyzing less complete specimens will still be able to identify the deer to species, while researchers with more complete specimens will be able to include more measurements and have a higher level of confidence in those identifications. In some cases, due to the nature of the SAS program, model procedures would produce a slightly different  $r^2$  from the simple linear regression procedure as it would only use specimens where all variables from the model were available. If the resulting  $r^2$  was lower in the simple linear regression than the 0.5 cut-off, a further decision had to be made whether to include the data in this study. In those cases, if the  $r^2 > .45$  and  $p \leq .001$ , then the model is included and logistic regression procedures were conducted. In addition, all models that were significant for the pooled-age group were also analyzed on an adult-only level for comparison. Adult-only analysis frequently generated additional significant models.

Logistic regression produces both odds ratios and generates a predictor formula for application to archaeological material. Odds ratios represent the ratio of the expected number of times that an event will occur to the expected number of times that it will not occur. Point estimates demonstrate these ratios by representing the likelihood that a measurement will be different for the species chosen as the default in relation to the control species, which acts as a constant. All point estimates were obtained with white-tailed deer set as the default. The predictor formulas generated represent:

$$\log(\psi) = \beta_0 + \beta_1x_1 + \beta_2x_2 + \dots + \beta_kx_k$$

The log represents the standard log [i.e.  $\log_{10}(\psi)$ ]. If  $\psi > 1$  then the bone more likely belongs to a white-tailed deer. If  $\psi < 1$  then the bone more likely belongs to a mule deer. However, since the  $\log(1) = 0$ , then more simply stated if  $\log(\psi) > 0$  then the bone is more likely that of a white-tailed deer, and if  $\log(\psi) < 0$  then the bone is more likely that of a mule deer.

The following sections present all relevant statistical information and the predictor formulas generated for each bone. Information is presented for both adult-only and pooled juvenile and adult data. For information on ageing and when to use the appropriate formula refer to Table 6.1. The number of specimens included in each model is arranged by element and is presented in Table 6.2.

### *Scapula*

Species identification of unknown Odocoileine scapulae is possible through the measurement of multiple variables. The length of glenoid (LG), breadth of glenoid (BG), greatest length of proximal (GLP), height along spine (HS), diagonal height (DHA), greatest dorsal length (LD), and the smallest length of the neck (SLC) all appear in useful models. Pooled-age statistics produced three and four variable models while adult-only statistics also produced significant two variable models.

### Pooled-age

There are one three-variable and two four-variable models fitting the requirements of this study. The three-variable model for the scapula uses the greatest

**Table 6.1 - Epiphyseal Fusion Ages for *Odocoileus*. Adapted From Purdue (1983:1210:Table 3).**

| <b>Fusion Date</b>                             | <b>Element and Portion</b>   |
|--|--|
| Completed by 2 years                           | Radius (proximal)<br>Humerus (distal)<br>Second Phalanx (proximal and distal)<br>First Phalanx (proximal and distal)<br>Tibia (distal)                                   |
| Begins 20-23 months, completed by 29-38 months | Calcaneum<br>Ulna (proximal)<br>Femur (proximal)<br>Metacarpal (distal)<br>Metatarsal (distal)<br>Radius (distal)<br>Femur (distal)<br>Tibia (proximal)<br>Ulna (distal) |
| Begins after 2 years                           | Humerus (proximal)<br>Pelvis (pubic symphysis)   |

**Table 6.2 - Number of Specimens Included in Models**

| Element            | Model*          | Pooled-age         |                       | Adult              |                       |
|--------------------|-----------------|--------------------|-----------------------|--------------------|-----------------------|
|                    |                 | <i>O. hemionus</i> | <i>O. virginianus</i> | <i>O. hemionus</i> | <i>O. virginianus</i> |
| Scapula            | LD, LG, BG      | 32                 | 26                    | 21                 | 23                    |
|                    | HS, LD, LG, BG  | 32                 | 24                    | 21                 | 21                    |
|                    | DHA, LD, LG, BG | 32                 | 25                    | 21                 | 22                    |
|                    | LG, BG          | NA                 | NA                    | 22                 | 25                    |
|                    | GLP, LG         | NA                 | NA                    | 21                 | 26                    |
|                    | GLP, LG, BG     | NA                 | NA                    | 21                 | 25                    |
|                    | LD, GLP, LG,    | NA                 | NA                    | 18                 | 24                    |
| Humerus            | Bd, BT          | 37                 | 30                    | 23                 | 25                    |
| Radius             | Bp, BFp         | NA                 | NA                    | 18                 | 19                    |
| Pelvis             | SB, SC          | NA                 | NA                    | 18                 | 23                    |
|                    | SH, SB          | NA                 | NA                    | 18                 | 23                    |
| Metatarsal         | DD, Dd          | 55                 | 47                    | 27                 | 36                    |
|                    | Dp, DD, Bd      | 53                 | 45                    | 26                 | 35                    |
|                    | Bp, Dp, DD      | 53                 | 45                    | 26                 | 35                    |
|                    | Dp, SD, DD      | 51                 | 45                    | 25                 | 35                    |
|                    | GL, Dp, DD, Bd  | 51                 | 44                    | 25                 | 34                    |
|                    | Dp, DD, Dd      | NA                 | NA                    | 25                 | 35                    |
| 2nd Front Phalanx  | GL, Bd          | 48                 | 46                    | 20                 | 35                    |
|                    | Bp, Bd          | 48                 | 46                    | 20                 | 35                    |
|                    | Bd,SD           | NA                 | NA                    | 20                 | 35                    |
| 2nd Hind Phalanx   | GL, Bd          | 48                 | 45                    | 20                 | 34                    |
| Pooled 2nd Phalanx | GL, Bd          | 96                 | 91                    | 40                 | 69                    |

\* measurements based on Von Den Dreisch (1976)

dorsal length (LD), the length of glenoid (LG), and breadth of glenoid (BG). Linear regression statistics yielded  $r^2 = .4867$ ,  $F=17.06$ ,  $p<.0001$ . Logistic regression statistics resulted in  $r^2=.4804$ , max-rescaled  $r^2=.6429$ ,  $\chi^2=37.9764$ ,  $p<.0001$ . Point estimates (LD=.958, LG=.257, BG=3.915) suggest that glenoid breadth is more likely to increase in relation to dorsal length and glenoid length for white-tailed deer while the relation of the two measurements remain constant in mule deer.

Species identification of unknown specimens is possible through the measurement of these three variables on archaeological specimens. These measurements can then be entered in the predictor formula:

$$\log(\psi) = 6.5959 - 0.0427(LD) - 1.3575(LG) + 1.3648(BG)$$

If  $\psi>1$  then the scapula is more likely that of a white-tailed deer. If  $\psi<1$  then the scapula is more likely that of a mule deer. The predictor formula is testing the likelihood that the scapula is that of white-tailed deer - the greater the odds ( $\psi$ ), the higher the likelihood.

The first four variable model for the scapula uses the height along spine (HS), greatest dorsal length (LD), the length of glenoid (LG), and breadth of glenoid (BG). Linear regression statistics yielded  $r^2 = .5110$ ,  $F=13.32$ ,  $p<.0001$ . Logistic regression statistics resulted in  $r^2=.4991$ , max-rescaled  $r^2=.6700$ ,  $\chi^2=38.7100$ ,  $p<.0001$ . Point estimates (HS=1.075, LD=.902, LG=.241, BG=3.060) demonstrate that the breadth of glenoid is increasing more in relation to the other three measurements in white-tailed deer than mule deer. The predictor formula generated is:

$$\log(\psi) = 9.1056 + 0.0721(\text{HS}) - 0.1031(\text{LD}) - 1.4224(\text{LG}) + 1.1185(\text{BG})$$

If  $\psi > 1$ , then the scapula is more likely that of a white-tailed deer. If  $\psi < 1$ , then the scapula is more likely that of a mule deer.

The second four-variable model for the scapula uses the diagonal height (DHA), greatest dorsal length (LD), the length of glenoid (LG), and breadth of glenoid (BG). Linear regression statistics yielded  $r^2 = .5120$ ,  $F=13.64$ ,  $p<.0001$ . Logistic regression statistics resulted in  $r^2=.5000$ , max-rescaled  $r^2=.6700$ ,  $\chi^2=39.5069$ ,  $p<.0001$ . Point estimates (DHA=1.089, LD=.908, LG=.226, BG=3.066) indicate the same trend with an increasing glenoid breadth. This measurement is likely connected to the two morphological characteristics presented earlier in Figure 6.1. The predictor formula generated for these measurement locales is:

$$\log(\psi) = 7.8279 + 0.0852(\text{DHA}) - 0.0963(\text{LD}) - 1.4874(\text{LG}) + 1.205(\text{BG})$$

where if  $\psi > 1$  then the scapula is more likely that of a white-tailed deer and if  $\psi < 1$  then the scapula is more likely that of a mule deer.

### Adult

In addition to models presented in the pooled-age data, there are four additional models possible with the adult-only data. There are two two-variable models, two three-variable models, and three four-variable models within the significance-level of this

study. The models that were significant with the pooled-age data are presented first for contrast.

The model which includes the greatest dorsal length (LD), the length of glenoid (LG), and breadth of glenoid (BG), has  $r^2 = .6208$ ,  $F=21.83$ ,  $p<.0001$  when run with only data from the adult animals two years old and older. These numbers have much greater significance than those for the pooled-age group. This suggests that information based on adults would be more accurate. Logistic regression statistics for this grouping resulted in  $r^2=.5934$ , max-rescaled  $r^2=.7918$ ,  $\chi^2=39.6005$ ,  $p<.0001$ . Again, this is more significant than for the pooled-age data. Point estimate information (LD=.918, LG=.119, BG=8.212) shows a greater increase in glenoid breadth relative to the other two measurements in white-tailed deer than in mule deer with respect to the adult data. The predictor formula for the adult data is slightly modified from that of the formula for pooled-age animals:

$$\log(\psi) = 14.2441 - 0.0861(LD) - 2.1281(LG) + 2.1056(BG)$$

where  $(\psi)>1$  is more likely a white-tailed deer scapula and  $(\psi)<1$  is more likely a mule deer scapula.

Other models which were significant for the pooled data set yet are more robust for the adult data include measurements on the height at spine (HS), dorsal length (LD), the length of glenoid (LG), and breadth of glenoid (BG) and a model with the measurements for the diagonal height of the scapula (DHA), dorsal length (LD), the

length of glenoid (LG), and breadth of glenoid (BG). For the first model (HS, LD, LG, BG) simple regression resulted in  $r^2 = .6255$ ,  $F=15.45$ ,  $p<.0001$ , while the second model (DHA, LD, LG, BG) yielded  $r^2 = .6136$ ,  $F=15.09$ ,  $p<.0001$ . These are fairly comparable to one another, as is to be expected as both share three variables, and the fourth is dependent upon some measurement of the height of the scapula. Logistic regression for the two models produced  $r^2=.6058$ , max-rescaled  $r^2=.8077$ ,  $\chi^2=39.0952$ ,  $p<.0001$  for the HS, LD, LG, and BG model and  $r^2=.5944$ , max-rescaled  $r^2=.7927$ ,  $\chi^2=38.8022$ ,  $p<.0001$  for the DHA, LD, LG, and BG model. Point estimates (HS=.917, LD=.985, LG=.089, BG=12.737 and DHA=.946, LD=.950, LG=.103, BG=11.462) suggest the same trends seen previously. The formulas generated through logistic regression are:

$$\log(\psi) = 18.7438 - 0.0872(\text{HS}) - 0.0155(\text{LD}) - 2.4126 (\text{LG}) + 2.5445(\text{BG})$$

$$\log(\psi) = 15.6558 - 0.0559(\text{DHA}) - 0.513(\text{LD}) - 2.2737(\text{LG}) + 2.4390 (\text{BG})$$

If  $\psi>1$ , then the scapula is more likely that of a white-tailed deer. If  $\psi<1$ , then the scapula is more likely that of a mule deer.

There are several models which were not statistically significant for the pooled-age data but are for the adult data. The length of glenoid (LG) and breadth of glenoid (BG) form a very useful model for application to less complete adult deer archaeological material. Linear regression of the two-variable model produced  $r^2 = .6122$ ,  $F=34.73$ ,  $p<.0001$ . Logistic regression statistics for this grouping resulted in  $r^2=.5889$ , max-

rescaled  $r^2=.7862$ ,  $\chi^2=41.7736$ ,  $p<.0001$ . Point estimates (LG=.093, BG=7.671 )

demonstrate the trend in increase of the breadth of the glenoid in relation to the length for white-tailed deer as the relationship remains constant in mule deer. The formula:

$$\log(\psi) = 14.0958 - 2.3794(LG) + 2.0375(BG)$$

where if  $\psi>1$ , the scapula is more likely that of a white-tailed deer and if  $\psi<1$ , the scapula is more likely that of a mule deer can be applied to unknown specimens.

A model using the greatest length of the glenoid process (GLP) and length of glenoid (LG) is not as significant as the two-variable model above ( $r^2 = .4759$ ,  $F=19.97$ ,  $p<.0001$ ), but is useful to archaeological material where the anterior and posterior ends of the process are intact and the lateral or medial side is fragmented. Logistic regression ( $r^2=.4756$ , max-rescaled  $r^2=.6365$ ,  $\chi^2=30.3382$ ,  $p<.0001$ ) produces the predictor formula:

$$\log(\psi) = 4.5258 + 1.4157(GLP) - 1.9833(LG)$$

If  $\psi>1$ , then the scapula is more likely that of a white-tailed deer. If  $\psi<1$ , then the scapula is more likely that of a mule deer. Point estimates, yet again, suggest that white-tailed deer have a broader glenoid cavity in relation to mule deer.

A model using the greatest length of the glenoid process (GLP), the length of glenoid (LG), and breadth of glenoid (BG) yielded  $r^2 = .6766$ ,  $F=29.29$ ,  $p<.0001$ .

Logistic regression returns  $r^2=.6607$ , max-rescaled  $r^2=.8832$ ,  $\chi^2=49.7233$ ,  $p<.0001$ . While

not much of an improvement over the model using LG and BG, the ability to record all three measurements on the glenoid process definitely provides better statistical accuracy for determining archaeological material than just the use of GLP and LG. It definitely appears, however, that the LG and BG two-variable model would be of the most use archaeologically. Point estimate analysis (GLP=5.919 , LG=.005 , BG=10.092 ) suggests that both the greatest length of the glenoid process and the breadth of the glenoid are more likely to increase on white-tailed deer than on mule deer relative to glenoid length. Glenoid breadth has already been addressed. When referring to the morphological characteristics (Figure 6.1), it is obvious that the increase in the total length of the glenoid process is connected with the perpendicular angle of the supraglenoid tubercle on the white-tailed deer scapula contrasted with the slanted angle of the supraglenoid tubercle on the mule deer scapula. The predictor formula generated through logistic regression is:

$$\log(\psi) = 23.2667 + 1.7781(\text{GLP}) - 5.2559(\text{LG}) + 2.3117(\text{BG})$$

where  $(\psi) > 1$  is more likely a white-tailed deer scapula and  $(\psi) < 1$  is more likely a mule deer scapula.

The last model selected for the adult scapula uses the variables of the dorsal length (LD), greatest length of glenoid process (GLP), length of glenoid (LG), and length of scapular neck (SLC). Simple linear regression ( $r^2 = .6379$ ,  $F=16.30$ ,  $p<.0001$ ) and logistic regression ( $r^2=.6164$ , max-rescaled  $r^2=.8276$ ,  $\chi^2=40.2447$ ,  $p<.0001$ ) demonstrate

that this is the most significant model for the scapula of the adult animals. Point estimates (LD=.826, GLP=15.046, LG=.066, SLC=.772 ) demonstrate again the greater increase in the greatest length of the glenoid process relative to the other measurements in white-tailed deer than in mule deer. Species identification of archaeological material can be determined through use of the formula:

$$\log(\psi) = 4.3841 - 0.1916(LD) + 2.7111(GLP) - 2.7218(LG) - 0.2587(SLC)$$

where  $(\psi) > 1$  is more likely a white-tailed deer scapula and  $(\psi) < 1$  is more likely a mule deer scapula.

### *Humerus*

While many models appear useful for identification of the humerus to species, all of the models utilize the measurements of the greatest breadth of the distal end (Bd) and the greatest breadth of the trochlea (BT). All of the models above the two-variable model showed little or no increase in significance over that based on Bd and BT. Therefore, only the two-variable model for those measurement locales is presented. The distal end of the humerus is more dense than some other long bone epiphyses, such as the femur and radius (Lyman 1994) and is likely to survive taphonomic processes. In addition, the humerus of white-tailed deer is of middle utility and more likely to be transported to a habitation site than the cranium, radius, metapodials, or phalanges (Jacobson 2000). Therefore, this bone should be very useful for archaeological identification.

### Pooled-age

Simple linear regression on pooled-age data for the variables Bd and BT yielded  $r^2 = .5380$ ,  $F=37.27$ ,  $p<.0001$ . Logistic regression produced  $r^2=.5169$ , max-rescaled  $r^2=.6918$ ,  $\chi^2=48.7514$ ,  $p<.0001$ . Point estimates (Bd=8.100, BT=0.064) demonstrate that the total breadth of the distal end increases in relation to the breadth of the trochlea in white-tailed deer as compared to mule deer. In other words, the trochlea would constitute relatively more of the distal end in the mule deer than in the white-tailed deer. The predictor formula for the humerus is:

$$\log(\psi) = 16.1638 + 2.0918(\text{Bd}) - 2.7516(\text{BT})$$

where if  $(\psi)>1$  the humerus is more likely that of a white-tailed deer and if  $(\psi)<1$  the humerus is more likely that of a mule deer.

### Adult

Simple linear regression on adult data for the variables Bd and BT yielded  $r^2=.5330$ ,  $F=25.67$ ,  $p<.0001$ . The similarity to the data for pooled-age humeri is likely due to the early fusion date of the distal humerus in deer starting at just a few months and completing by around one year (Purdue 1983). Logistic regression analysis resulted in  $r^2=.5122$ , max-rescaled  $r^2=.6833$ ,  $\chi^2=34.4558$ ,  $p<.0001$ . Point estimate analysis (Bd=6.810, BT=.075) demonstrates the same trends as for the pooled-age data. The predictor formula generated by logistic regression is:

$$\log(\psi) = 17.3680 + 1.9184(\text{Bd}) - 2.5889(\text{BT})$$

where if  $(\psi) > 1$  the humerus is more likely that of a white-tailed deer and if  $(\psi) < 1$  the humerus is more likely that of a mule deer.

### *Radius*

No models matched the levels of statistical significance established in this study for the pooled-age data. Statistical procedures run with the adult data produced multiple models. All of these models included the variables for the greatest breadth of the proximal end (BP) and the greatest breadth of the proximal articular facet (BFp). There were no significant increases in statistical robustness with higher level models.

Therefore, only the two-variable model for these measurement locales is presented.

### Adult

Simple linear regression of the greatest breadth of the proximal end of the radius (BP) and the greatest breadth of the proximal articular facet (BFp) yielded  $r^2 = .5069$ ,  $F = 10.28$ ,  $p < .0001$ . Logistical regression resulted in  $r^2 = .5235$ , max-rescaled  $r^2 = .6986$ ,  $\chi^2 = 29.6524$ ,  $p < .0001$ . Point estimate analysis ( $Bp = 14.335$ ,  $BFp = 0.018$ ), not surprisingly, demonstrates a relationship between the distal humerus and proximal radius. In white-tailed deer as opposed to mule deer, the greatest breadth of the proximal radius will increase relative to the breadth of the proximal articular facet (i.e., the facet constitutes relatively more of the proximal end in mule deer than in white-tailed deer). A similar

incidence occurred with the breadth of the distal end and distal articular facet of the humerus. This makes sense as the two bones articulate with one another. The predictor formula generated by the logistic regression analysis is:

$$\log(\psi) = 42.8045 + 2.6627(\text{Bp}) - 4.0331(\text{BFp})$$

If  $\psi > 1$  then the humerus is more likely that of a white-tailed deer. If  $\psi < 1$  then the humerus is more likely that of a mule deer.

### *Pelvis*

Many models appeared promising during model selection. Later regressions, however, suggested that the data had been inflated due to the low number of models of full rank used during selection procedures. Many of the standard measurements on the innominate require not just a complete pelvis, but that both sides are present and starting to fuse. There were only 12 specimens where those measurements were possible. In addition, r-square of a perfect 1 was returned for the pooled data when at least 11 of the 12 possible measurements were included in the model. Unfortunately, the F-values were very low and p-values were well above the set limit for inclusion in this study for that data. There were no models that met the limits of this study for the pooled-age data. A variety of useful adult-only models, however, were still possible which fit the inclusion requirements and relied on fewer measurements, more useful for archaeological purposes. There was little increase in significance level between the two-variable and higher level

variable models which included the same measurement locales as the two-variable models. Therefore, only the two-variable models are presented below.

### Adult

The measurements which were most defining involved the locales on the ilium. The first model used the smallest breadth of ilium shaft (SB) and smallest circumference (SC) of ilium shaft. Simple linear regression yielded  $r^2=.4947$ ,  $F=18.60$ ,  $p<.0001$ . Logistic regression analysis succored  $r^2=.4667$ , max-rescaled  $r^2=.6253$ ,  $\chi^2=25.7717$ ,  $p<.0001$ . Point estimate analysis (SB=4.468, SC=.580) suggests that the breadth of the ilium in white-tailed deer is larger in relation to the circumference than in mule deer. The predictor formula generated is:

$$\log(\psi) = 17.0863 + 1.4970(\text{SB}) - .5454(\text{SC})$$

If  $\psi>1$  then the pelvis is more likely that of a white-tailed deer. If  $\psi<1$  then the pelvis is more likely that of a mule deer.

The more statistically sound model which uses measurements in the same locale involves the smallest breadth of ilium shaft (SB) and smallest height of ilium shaft (SH). Simple linear regression resulted in  $r^2=.5117$ ,  $F=19.91$ ,  $p<.0001$ , while logistic regression yielded  $r^2=.4725$ , max-rescaled  $r^2=.6332$ ,  $\chi^2=26.2275$ ,  $p<.0001$ . Point estimate analysis (SB=2.816, SH=.354) indicates a slightly greater breadth in relation to height on the

white-tailed deer iliac shaft when compared to the mule deer ilium. The determiner formula is:

$$\log(\psi) = 14.5405 - 1.0372(\text{SH}) + 1.0353(\text{SB})$$

where  $\psi > 1$  means that the pelvis is more likely that of a white-tailed deer and  $\psi < 1$  means that the pelvis is more likely that of a mule deer.

The measurement differences on the breadth of the ilium in relation to other iliac shaft measurements support the differences noted with morphological differences of the shaft around the supra-acetabular fossa (Figure 6.1). This characteristic is just ventral to the measurement of smallest height of the ilium (SH). Morphologically, there is indication of a thinner medial rim around the fossa in white-tailed deer and a more broad rim in mule deer.

### *Metatarsal*

There are a variety of models useful for differentiating between mule deer and white-tailed deer based on the metatarsal. Measurements included in these models are the greatest length of the metatarsal (GL), breadth of proximal end (Bp), depth of proximal end (Dp), smallest breadth of the diaphysis (SD), smallest depth of the diaphysis (DD), breadth of the distal end (Bd), and greatest depth of the distal end (Dd). The last measurement is one usually reserved for equids.

### Pooled-age

One two-variable model, three three-variable models and one four-variable model provide possible means for distinguishing between the two species. The first model relies on the measurements of smallest depth of the diaphysis (DD) and the greatest depth of the distal end (Dd). In cervids both these measurements occur on the distal portion of the metatarsal and would be useful archaeologically. Simple linear regression on these variables returned  $r^2=.5162$ ,  $F=52.82$ ,  $p<.0001$ . Logistic regression analysis yielded  $r^2=.5018$ , max-rescaled  $r^2=.6705$ ,  $\chi^2=71.0781$ ,  $p<.0001$ . Point estimate analysis (DD=3.888, Dd=.142) suggests that the depth of the diaphysis increases in relation to the depth of the distal end in white-tailed deer as compared with mule deer. In other words, the difference between distal diaphysis depth and distal epiphysis depth is less in white-tailed deer than mule deer. The predictor formula for this model is:

$$\log(\psi) = 21.7859 + 1.3579(DD) - 1.9526(Dd)$$

where  $\psi>1$  means that the metatarsal is more likely that of a white-tailed deer and  $\psi<1$  means that the metatarsal is more likely that of a mule deer.

The first of the three-variable models includes the measurements of the depth of the proximal end (Dp), smallest depth of the diaphysis (DD), and breadth of the distal end (Bd). Simple linear regression resulted in  $r^2=.5508$ ,  $F=38.42$ ,  $p<.0001$ , while logistic regression yielded  $r^2=.5137$ , max-rescaled  $r^2=.6865$ ,  $\chi^2=70.6518$ ,  $p<.0001$ . Point estimates (Dp=.462, DD=4.638, Bd=.533) demonstrate the same trend as above with a

greater diaphyseal depth in white-tailed deer relative to mule deer when contrasted with the other two variables. As the model calls for both proximal and distal measurements, the predictor formula:

$$\log(\psi) = 18.6067 - .7717(Dp) + 1.5343(DD) - .6289(Bd)$$

where  $\psi > 1$  is more likely a white-tailed deer metatarsal and  $\psi < 1$  is more like a mule deer metatarsal, would be less useful in archaeological context than some of the other models.

The next two models include the breadth of the proximal end (Bp), depth of the proximal end (Dp), and smallest depth of the diaphysis (DD) and the depth of the proximal end (Dp), smallest breadth of the diaphysis (SD), and smallest depth of the diaphysis (DD). Linear regression for the first model (Bp, Dp, DD) resulted in  $r^2=.4997$ ,  $F=31.29$ ,  $p<.0001$ , while the second model (Dp, SD, DD) yielded  $r^2=.4958$ ,  $F=30.15$ ,  $p<.0001$ . Logistic regression resulted in  $r^2=.4610$ , max-rescaled  $r^2=.6160$ ,  $\chi^2=60.5629$ , and  $p<.0001$  for the first model (Bp, Dp, DD) and  $r^2=.4617$ , max-rescaled  $r^2=.6164$ ,  $\chi^2=59.4503$ ,  $p<.0001$  for the second model (Dp, SD, DD). Statistical results for both models demonstrate the data are not as significant as model selection procedures indicated. Point estimates (Bp=.840, Dp=.377, DD=3.446; Dp=.326, SD=1.453, DD=2.682) with the default set to white-tailed deer establish only minor changes in diaphyseal depth when compared with the other measurements between the two species. The formulas for application to archaeological material is:

$$\log(\psi) = 13.2349 - .1740(Bp) + .9747(Dp) + 1.2372(DD)$$

$$\log(\psi) = 10.9025 - 1.1220(Dp) + .3737(SD) + .9867(DD)$$

If  $\psi > 1$  then the metatarsal is more likely that of a white-tailed deer. If  $\psi < 1$  then the metatarsal is more likely that of a mule deer.

The four-variable model presented is based on the greatest length of the metatarsal (GL), depth of the proximal end (Dp), depth of the diaphysis (DD), and breadth of the distal end (Bd). Linear regression analysis produced  $r^2=.5465$ ,  $F=27.12$ ,  $p<.0001$ . Logistic regression analysis produced  $r^2=.5160$ , max-rescaled  $r^2=.6893$ ,  $\chi^2=68.9435$ , and  $p<.0001$  and the predictor formula:

$$\log(\psi) = 18.5607 + .0351(GL) - .9302(Dp) + 1.3709(DD) - .6691(Bd)$$

where  $\psi > 1$  is more likely a white-tailed deer metatarsal and  $\psi < 1$  is more like a mule deer metatarsal. Point estimates (GL=1.036, Dp=.394, DD=3.939, Bd=.512) reveal trends previously stated.

### Adult

As with the other elements, those equations which were significant for the pooled data will be presented first. There are five models that were significant for the pooled data along with one new model suggested by the adult data. Simple linear regression

( $r^2=.4811$ ,  $F=27.81$ ,  $p<.0001$ ) and logistic regression ( $r^2=.4817$ , max-rescaled  $r^2=.6468$ ,  $\chi^2=41.4092$ ,  $p<.0001$ ) analysis on the smallest depth of the diaphysis (DD) and the greatest depth of the distal end (Dd) suggest that the adult data are not more robust than the pooled data. Point estimates (DD=4.935, Dd=.133) demonstrate the same trend of increasing distal diaphysis depth with regards to the other measurement in white-tailed deer, while the proportions remain constant in mule deer. The predictor formula generated is:

$$\log(\psi) = 19.8838 + 1.5963(DD) - 2.0193(Dd)$$

If  $\psi>1$ , then the metatarsal is more likely that of a white-tailed deer, and if  $\psi<1$ , then the metatarsal is more likely that of a mule deer.

Simple linear regression on pooled-age data for the variables Dp, DD, and Bd yielded  $r^2=.5060$ ,  $F=19.46$ ,  $p<.0001$ . Logistic regression produced  $r^2=.4786$ , max-rescaled  $r^2=.6428$ ,  $\chi^2=39.7212$ ,  $p<.0001$ . Point estimates (Dp=.492, DD=4.529, Bd=.601) indicate that in white-tailed deer relative to mule deer, the smallest depth of the diaphysis is likely to increase in depth in comparison to the depth of the proximal end and the breadth of the distal end. The formula:

$$\log(\psi) = 13.5777 - .7099(Dp) + 1.5105(DD) - .5094(Bd)$$

where  $\psi > 1$  is more likely a white-tailed deer metatarsal and  $\psi < 1$  is more like a mule deer metatarsal can be applied to archaeological samples.

The breadth of the proximal end (Bp), depth of the proximal end (Dp), and smallest depth of the diaphysis (DD) are not as significant a model as initial model selection procedures inferred ( $r^2 = .4838$ ,  $F = 17.80$ ,  $p < .0001$ ). Logistic regression ( $r^2 = .4508$ , max-rescaled  $r^2 = .6055$ ,  $\chi^2 = 36.5579$ ,  $p < .0001$ ) suggests this model is weaker than the other adult models on the metatarsal, yet it is still useful. The same trends as above are demonstrated with the point estimates (Bp=.672, Dp=.441, DD=3.887).

Logistic regression analysis generates the formula:

$$\log(\psi) = 13.2626 - .3975(Bp) - .8176(Dp) + 1.3576(DD)$$

If  $\psi > 1$ , then it is more likely a white-tailed deer metatarsal. If  $\psi < 1$ , then it is more likely a mule deer metatarsal.

Another model which was more robust with the pooled age data than with the adult data includes the depth of the proximal end (Dp), smallest breadth of the diaphysis (SD), and smallest depth of the diaphysis (DD). Simple linear regression ( $r^2 = .4571$ ,  $F = 15.71$ ,  $p < .0001$ ) and logistic regression ( $r^2 = .4293$ , max-rescaled  $r^2 = .5779$ ,  $\chi^2 = 33.6538$ ,  $p < .0001$ ) both suggest that this model is the least significant of any presented. This model is barely within acceptable bounds mentioned in this study and would not even be included except that r-square values for both adult and pooled data were initially above the .5 level during model selection. The point estimates for the logistic regression are

Dp=.413, SD=.707, and DD=3.589. The predictor formula below would likely be unnecessary as other, more significant, measurements would likely be possible if Dp, SD, and DD are present. Therefore, while the formula is included here, it is not included in the summary table at the end of the chapter:

$$\log(\psi) = 11.3471 - .8847(Dp) - .3462(SD) + 1.2778(DD)$$

where  $\psi > 1$  is more likely a white-tailed deer metatarsal and  $\psi < 1$  is more like a mule deer metatarsal.

The last model included in the adult analysis which was also included in the pooled grouping uses the variables of the greatest length of the metatarsal (GL), depth of the proximal end (Dp), depth of the diaphysis (DD), and breadth of the distal end (Bd). Simple linear regression ( $r^2=.4957$ ,  $F=13.27$ ,  $p<.0001$ ) and logistic regression ( $r^2=.4686$ , max-rescaled  $r^2=.6297$ ,  $\chi^2=37.2997$ ,  $p<.0001$ ) statistics are still relatively weak. Point estimates (GL=1.003, Dp=.496, DD=4.321, Bd=.597) show not only an increasing distal depth, but a slight relative increase in overall length for white-tailed deer relative to mule deer. The predictor formula is:

$$\log(\psi) = 13.4485 + .0035(GL) - .7021(Dp) + 1.4634(DD) - .5158(Bd)$$

where  $\psi > 1$  is more likely a white-tailed deer metatarsal and  $\psi < 1$  is more likely a mule deer metatarsal.

Since the two-variable model for the adult data has an r-square below .5, the best three-variable model which includes DD and Dd is presented for greater accuracy of identification. That model uses the variables of depth of proximal end, smallest depth of diaphysis, and depth of distal end. Simple linear regression yields  $r^2=.5412$ ,  $F=22.02$ ,  $p<.0001$ . Logistic regression returns  $r^2=.5082$ , max-rescaled  $r^2=.6840$ ,  $\chi^2=42.5774$ ,  $p<.0001$ . This model is the strongest of all the adult models. Point estimates are  $Dp=.566$ ,  $DD=5.986$ , and  $Dd=.280$ . For application to archaeological samples the determiner formula:

$$\log(\psi) = 16.9976 - .5695(Dp) + 1.7895(DD) - 1.2741(Dd)$$

where  $\psi>1$  is more likely a white-tailed deer metatarsal and  $\psi<1$  is more like a mule deer metatarsal can be applied.

Overall, the metatarsal is not as statistically sound as a determining agent as the other bones presented here. As noted by the last model, however, the relationship of the varying depth measurement points seems to give the best indication of species-level differences.

### *2<sup>ND</sup> Front Phalanx*

There are multiple models which are significant for the 2<sup>nd</sup> front phalanx. The variables included are the greatest length (GL), distal breadth (Bd), proximal breadth (Bp), and smallest diaphyseal breadth (SD).

### Pooled-age

Simple linear regression of the first model with the variables greatest length (GL) and distal breadth (Bd) yields  $r^2=.6156$ ,  $F=72.86$ ,  $p<.0001$ . Logistic regression returns  $r^2=.5795$ , max-rescaled  $r^2=.7728$ ,  $\chi^2=81.4290$ ,  $p<.0001$ . Analysis (point estimate  $GL=2.739$ ,  $Bd=.027$ ) shows that the breadth to length ratio is relatively smaller in white-tailed deer than it is in mule deer.. The white-tailed deer phalanx is longer and less broad relative to the same measurements in mule deer. Logistic regression generates the formula:

$$\log(\psi) = 8.4629 + 1.0074(GL) - 3.6227(Bd)$$

where  $(\psi)>1$  is more likely a white-tailed deer 2<sup>nd</sup> phalanx and  $(\psi)<1$  is more likely a mule deer 2<sup>nd</sup> phalanx.

The second model includes the variables breadth of proximal (Bp) and breadth of distal (Dd) ends. Simple linear regression ( $r^2=.5109$ ,  $F=47.52$ ,  $p<.0001$ ) and logistic regression ( $r^2=.4816$ , max-rescaled  $r^2=.6422$ ,  $\chi^2=61.7519$ ,  $p<.0001$ ) analysis are not as strong as for the model above, but they are significant. Point estimate analysis ( $Bp=11.895$ ,  $Bd=.022$ ) demonstrates a large proximal breadth to distal breadth ratio in white-tailed deer as compared with mule deer. These data suggest that mule deer would have a narrower proximal epiphysis and broader distal epiphysis relative to white-tailed

deer. This trait may be partially due to the mule deer ability to splay its hooves in a snow-shoe like effect for dispersed loading in snow. The formula is:

$$\log(\psi) = 8.7950 + 2.4762(Bp) - 3.8254(Bd)$$

If the result of the formula is  $\psi > 1$ , then the 2<sup>nd</sup> phalanx is more likely that of a white-tailed deer. If the result of the formula is  $\psi < 1$ , then the 2<sup>nd</sup> phalanx is more likely that of a mule deer.

### Adult

There are three two-variable models significant enough for inclusion with the adult data. The first two models are the same as those for the pooled data. The variables greatest length (GL) and distal breadth (Bd) return simple linear statistics of  $r^2 = .7518$ ,  $F = 78.75$ ,  $p < .0001$  and logistic regression statistics of  $r^2 = .7262$ , max-rescaled  $r^2 = .9942$ ,  $\chi^2 = 71.2428$ ,  $p < .0001$ . Point estimates ( $GL > 999.999$ ,  $BD < .001$ ) demonstrate previously mentioned trends, but much more emphatically. The white-tailed deer has a much greater length to width ratio than the mule deer. The determiner formula is:

$$\log(\psi) = 4.5814 - 1.0105(GL) + 3.6985(Bd)$$

where  $(\psi) > 1$  is more likely a white-tailed deer 2<sup>nd</sup> phalanx and  $(\psi) < 1$  is more likely a mule deer 2<sup>nd</sup> phalanx. This is the best model in the study and would return the most

accurate results if applied to archaeological material. It would not be likely, however, to separate a front from hind phalanx in archaeological context.

The second model includes the proximal breadth (Bp) and distal breadth (Bd). Simple linear regression produced  $r^2=.5906$ ,  $F=37.51$ ,  $p<.0001$ . Logistic regression yielded  $r^2=.5459$ , max-rescaled  $r^2=.7474$   $\chi^2=43.4227$ ,  $p<.0001$ . Point estimates (Bp=21.256, Bd=.009) suggest that the proximal to distal breadth ratio is higher in white-tailed deer than mule deer. The determiner formula is:

$$\log(\psi) = 12.4190 + 3.0567(\text{Bp}) - 4.7576(\text{Bd})$$

If  $\psi>1$ , then it is more likely a white-tailed deer second phalanx. If  $\psi<1$ , then it is more likely a mule deer second phalanx.

The third model only works for the adult data and includes the variables of distal breadth (Bd) and smallest breadth of the diaphysis (SD). Simple linear regression returns  $r^2=.5177$ ,  $F=27.91$ ,  $p<.0001$ . Logistic regression yields  $r^2=.4919$  max-rescaled  $r^2=.6734$   $\chi^2=37.2407$ ,  $p<.0001$ . and the formula:

$$\log(\psi) = 18.7965 - 3.7444(\text{Bd}) + 2.2900(\text{SD})$$

where  $(\psi)>1$  is more likely a white-tailed deer 2<sup>nd</sup> phalanx and  $(\psi)<1$  is more likely a mule deer 2<sup>nd</sup> phalanx. Analysis of point estimates (Bd=.024, SD=9.875) suggests that it

is more likely for the diaphysis to be broader in relation to the distal end in white-tailed deer as compared with mule deer.

### *2<sup>ND</sup> Hind Phalanx*

The measurements used in the models below include greatest length (GL) and distal breadth (Bd). While for other elements the ability to measure the greatest length in archaeological samples is rare, the phalanx is smaller and less likely to be butchered. It is more probable that the whole bone would survive when compared with other long bones.

#### Pooled-age

The pooled-age data returned one model including the variables of greatest length(GL) and distal breadth (Bd). Simple linear regression produced  $r^2=.5168$ ,  $F=48.13$ ,  $p<.0001$ . Logistic regression yielded  $r^2=.4804$ , max-rescaled  $r^2=.6407$ ,  $\chi^2=60.8842$ ,  $p<.0001$ . The formula generated is:

$$\log(\psi) = 12.1076 + .5793(GL) - 2.8288(BD)$$

where  $(\psi)>1$  is more likely a white-tailed deer 2<sup>nd</sup> phalanx and  $(\psi)<1$  is more likely a mule deer 2<sup>nd</sup> phalanx. Point estimates (GL=1.785 BD=.059) show a similar trend as the front 2<sup>nd</sup> phalanx.

## Adult

The greatest length (GL) and distal breadth (Bd) are also a useful model for the adult data. Simple linear regression ( $r^2=.6062$ ,  $F=39.25$ ,  $p<.0001$ ) and logistic regression ( $r^2=.5648$ , max-rescaled  $r^2=.7712$ ,  $\chi^2=44.9254$ ,  $p<.0001$ ) statistics are robust. Point estimates (GL=2.943, Bd=.028) demonstrate the same trend as the pooled data. The formula is:

$$\log(\psi) = 5.0920 + 1.0795(\text{GL}) - 3.5596(\text{Bd})$$

If  $\psi>1$ , then it is more likely a white-tailed deer 2<sup>nd</sup> phalanx. If  $\psi<1$ , then it is more likely a mule deer 2<sup>nd</sup> phalanx.

## *Pooled 2<sup>ND</sup> Phalanx*

As stated above, it is rarely possible to differentiate between front and hind phalanges in archaeological context. For that reason, the data for the front and hind 2<sup>nd</sup> phalanx were pooled and statistical regression applied. Results for the pooled data were similar to those for the individual bones as to which models were significant.

## Pooled-age

There was one model which was significant for the pooled-age data consisting of the measurements for the greatest length (GL) and breadth of the distal end (Bd). Simple linear regression resulted in  $r^2=.5390$ ,  $F=107.56$ ,  $p<.0001$ . Logistic regression returned

$r^2=.5122$  max-rescaled  $r^2=.6831$ ,  $\chi^2=134.2310$ ,  $p<.0001$ . Point estimates (GL=1.940, Bd=.049) less dramatically reiterate prior trends. The formula generated for application to archaeological material is:

$$\log(\psi) = 11.8449 + .6627(\text{GL}) - 3.0098(\text{Bd})$$

If  $\psi>1$ , then it is more likely a white-tailed deer second phalanx. If  $\psi<1$ , then it is more likely a mule deer second phalanx.

### Adult

There are two significant models for the adult data. The first again involves the variables for greatest length (GL) and distal breadth (Bd). Simple linear ( $r^2=.6457$ ,  $F=96.61$ ,  $p<.0001$ ) and logistic regression ( $r^2=.6061$  max-rescaled  $r^2=.8287$ ,  $\chi^2=101.5513$ ,  $p<.0001$ ) returned highly significant results. Prior trends (GL=3.316, Bd=.013) are again noted through analysis of the point estimates. For application to archaeological material the formula:

$$\log(\psi) = 10.8756 + 1.1987(\text{GL}) - 4.3312(\text{Bd})$$

is applied where  $(\psi)>1$  is more likely a white-tailed deer 2<sup>nd</sup> phalanx and  $(\psi)<1$  is more likely a mule deer 2<sup>nd</sup> phalanx.

The second model utilizes the measurements of the proximal breadth and distal breadth. Linear regression procures  $r^2=.5170$ ,  $F=56.73$ ,  $p<.0001$ . Logistic regression yields  $r^2=.4871$ , max-rescaled  $r^2=.6659$ ,  $\chi^2=72.7752$ ,  $p<.0001$ . Point estimates ( $B_p=8.840$ ,  $B_d=.021$ ) concur with earlier results on the front and hind 2<sup>nd</sup> phalanges. The predictor formula is:

$$\log(\psi) = 13.7847 + 2.1793(B_p) - 3.8483(B_d)$$

If  $\psi > 1$ , then it is more likely a white-tailed deer 2<sup>nd</sup> phalanx. If  $\psi < 1$ , then it is more likely a mule deer 2<sup>nd</sup> phalanx

### **Male versus Female Differences**

For the most part, the sex of the deer did not affect the accuracy of the results and differences between sexes were minor. There were a few instances, however, where results for males and females differed from the pooled adult data. Sample sizes are small once adult data are divided into sexes so results by sex are not as reliable as those for the pooled or adult-only data.

### *Morphological Characteristics*

For the most part, differences between the sexes were negligible. The innominate, however, did demonstrate differences based on sex. The morphological differences in the acetabular notch shape (Figure 6.1) showed marked differences in accuracy for the two

sexes. For adult mule deer individuals of known sex, all nine females demonstrated the full mule deer characteristic. Only four mule deer males demonstrated the mule deer characteristic, while three were more similar to the white-tailed deer trait. For adult white-tailed deer individuals of known sex, eight of the females had the full white-tailed deer characteristic while two were indeterminate and one had the mule deer trait. Four adult male white-tailed deer had the full white-tailed deer trait, while three had indeterminate characteristics and three demonstrated the mule deer trait. For both mule deer and white-tailed deer this demonstrates that the characteristic is much more reliable in females than in males, though more males carry the trait than do not.

#### *Metrical Results*

Differences in metrics again for the most part were also negligible. While some models presented show minor differences based on sex, the most drastic difference is a bone that is not included in this current study because it does not meet the specifications. The differences for models presented above were minor enough and often hard to access statistically. This was due to the small sample sizes for some of the models when divided into sex, especially the innominate. As a result, these differences are discounted.

An earlier form of this study involving a smaller sample of animals suggested that differentiation between the species was possible through the use of the astragalus (Jacobson 2003). This earlier study used 23 adult mule deer and 20 adult white-tailed deer. Included were 11 male and 12 female mule deer and 8 male and 12 female white-tailed deer. Since that study, the largest addition of animals to the sample has come from

those animals collected by wildlife agents - animals that were all male. The current sample consists of 29 adult mule deer (15 male, 14 female) and 38 adult white-tailed deer (19 male, 14 female, 2 unknown). While only two female deer of each species have been added to the sample of the earlier study, three male mule deer and 11 male white-tailed deer have been added. Jacobson (2003) presents the adult simple linear regression statistics for the greatest lengths of the lateral (GLl) and medial sides (GLm) and the depth of the lateral (Dl) and medial sides (Dm) of the astragalus as  $r^2=.604$ ,  $F=12.22$ ,  $p<.0001$ . Linear regression on the measurements for the complete sample of animals here is  $r^2=.3806$ ,  $F=8.14$ ,  $p<.0001$ . Linear regression on the adult male data, however, yields  $r^2=.3740$ ,  $F=3.73$ ,  $p=.0163$ , while linear regression on the adult female data produces  $r^2=.6132$ ,  $F=8.72$ ,  $p=.0002$ . This suggests that there are differences between the male and female characteristics, and that it may be possible to determine species for a female astragalus. Since it would be necessary to determine sex before determining species, however, this model is not useful.

## **Summary**

The results demonstrate that there are multiple means possible to identify the species of postcranial deer remains in the archaeological record. Both morphological and statistical results produce traits with enough accuracy to be confidently applied. Table 6.3 provides an additional listing of the predictor formulas presented in this chapter. The overall strength of the characteristic should be taken into account when interpreting the archaeological record. In addition, conflicting results of similar strength should be

**Table 6.3 - Summary Table for Predictor Formulas. If  $\psi > 1$  White-tailed Deer, if  $\psi < 1$  Mule Deer.**

| <b>ELEMENT</b> | <b>AGE GROUP</b> | <b>PREDICTOR FORMULA</b>  |
|----------------|------------------|---|
| <b>Scapula</b> | Pooled           | $\log(\psi) = 6.5959 - 0.0427(\text{LD}) - 1.3575(\text{LG}) + 1.3648(\text{BG})$                       |
|                |                  | $\log(\psi) = 9.1056 + 0.0721(\text{HS}) - 0.1031(\text{LD}) - 1.4224(\text{LG}) + 1.1185(\text{BG})$   |
|                |                  | $\log(\psi) = 7.8279 + 0.0852(\text{DHA}) - 0.0963(\text{LD}) - 1.4874(\text{LG}) + 1.205(\text{BG})$   |
|                | Adult            | $\log(\psi) = 14.0958 - 2.3794(\text{LG}) + 2.0375(\text{BG})$  |
|                |                  | $\log(\psi) = 4.5258 + 1.4157(\text{GLP}) - 1.9833(\text{LG})$  |
|                |                  | $\log(\psi) = 14.2441 - 0.0861(\text{LD}) - 2.1281(\text{LG}) + 2.1056(\text{BG})$                      |
|                |                  | $\log(\psi) = 23.2667 + 1.7781(\text{GLP}) - 5.2559(\text{LG}) + 2.3117(\text{BG})$                     |
|                |                  | $\log(\psi) = 18.7438 - 0.0872(\text{HS}) - 0.0155(\text{LD}) - 2.4126(\text{LG}) + 2.5445(\text{BG})$  |
|                |                  | $\log(\psi) = 15.6558 - 0.0559(\text{DHA}) - 0.513(\text{LD}) - 2.2737(\text{LG}) + 2.4390(\text{BG})$  |
|                |                  | $\log(\psi) = 4.3841 - 0.1916(\text{LD}) + 2.7111(\text{GLP}) - 2.7218(\text{LG}) - 0.2587(\text{SLC})$ |
| <b>Humerus</b> | Pooled           | $\log(\psi) = 16.1638 + 2.0918(\text{Bd}) - 2.7516(\text{BT})$  |
|                | Adult            | $\log(\psi) = 17.3680 + 1.9184(\text{Bd}) - 2.5889(\text{BT})$  |
| <b>Radius</b>  | Adult            | $\log(\psi) = 42.8045 + 2.6627(\text{Bp}) - 4.0331(\text{BFp})$   |

**Table 6.3 continued.**

| <b>ELEMENT</b>           | <b>AGE GROUP</b> | <b>PREDICTOR FORMULA</b>   |
|--------------------------|------------------|--|
| <b>Pelvis</b>            | Adult            | $\log(\psi) = 17.0863 + 1.4970(\text{SB}) - .5454(\text{SC})$<br>$\log(\psi) = 14.5405 - 1.0372(\text{SH}) + 1.0353(\text{SB})$  |
| <b>Metatarsal</b>        | Pooled           | $\log(\psi) = 21.7859 + 1.3579(\text{DD}) - 1.9526(\text{Dd})$<br>$\log(\psi) = 18.6067 - .7717(\text{Dp}) + 1.5343(\text{DD}) - .6289(\text{Bd})$<br>$\log(\psi) = 13.2349 - .1740(\text{Bp}) + .9747(\text{Dp}) + 1.2372(\text{DD})$<br>$\log(\psi) = 10.9025 - 1.1220(\text{Dp}) + .3737(\text{SD}) + .9867(\text{DD})$<br>$\log(\psi) = 18.5607 + .0351(\text{GL}) - .9302(\text{Dp}) + 1.3709(\text{DD}) - .6691(\text{Bd})$  |
|                          | Adult            | $\log(\psi) = 19.8838 + 1.5963(\text{DD}) - 2.0193(\text{Dd})$<br>$\log(\psi) = 16.9976 - .5695(\text{Dp}) + 1.7895(\text{DD}) - 1.2741(\text{Dd})$<br>$\log(\psi) = 13.5777 - .7099(\text{Dp}) + 1.5105(\text{DD}) - .5094(\text{Bd})$<br>$\log(\psi) = 13.2626 - .3975(\text{Bp}) - .8176(\text{Dp}) + 1.3576(\text{DD})$<br>$\log(\psi) = 13.4485 + .0035(\text{GL}) - .7021(\text{Dp}) + 1.4634(\text{DD}) - .5158(\text{Bd})$ |
| <b>2nd Front Phalanx</b> | Pooled           | $\log(\psi) = 8.4629 + 1.0074(\text{GL}) - 3.6227(\text{Bd})$<br>$\log(\psi) = 8.7950 + 2.4762(\text{Bp}) - 3.8254(\text{Bd})$   |

**Table 6.3 continued.**

| <b>ELEMENT</b>            | <b>AGE GROUP</b> | <b>PREDICTOR FORMULA</b>  |
|---------------------------|------------------|---|
|                           | Adult            | $\log(\psi) = 4.5814 - 1.0105(\text{GL}) + 3.6985(\text{Bd})$<br>$\log(\psi) = 12.4190 + 3.0567(\text{Bp}) - 4.7576(\text{Bd})$<br>$\log(\psi) = 18.7965 - 3.7444(\text{Bd}) + 2.2900(\text{SD})$ |
| <b>2nd Hind Phalanx</b>   | Pooled           | $\log(\psi) = 12.1076 + .5793(\text{GL}) - 2.8288(\text{Bd})$   |
|                           | Adult            | $\log(\psi) = 5.0920 + 1.0795(\text{GL}) - 3.5596(\text{Bd})$   |
| <b>Pooled 2nd Phalanx</b> | Pooled           | $\log(\psi) = 11.8449 + .6627(\text{GL}) - 3.0098(\text{Bd})$   |
|                           | Adult            | $\log(\psi) = 10.8756 + 1.1987(\text{GL}) - 4.3312(\text{Bd})$<br>$\log(\psi) = 13.7847 + 2.1793(\text{Bp}) - 3.8483(\text{Bd})$  |

considered as an indeterminate characteristic and the designation of species left as unknown.

## CHAPTER 7

### Research History of the Scott County Pueblo Site (14SC1), Kansas

These means of identification were applied to an archaeological sample from Scott County, Kansas, to test their effectiveness. The Scott County Pueblo Site occurs within an area of the Plains where there were both past and modern overlap of white-tailed and mule deer. Material from the site had been previously excavated and a substantial quantity of deer bone was recovered. Prior faunal and environmental analysis of the site had been conducted. This made it possible to integrate the analysis of the deer remains into an already existing framework.

Scott County Pueblo (14SC1) in western Kansas is a protohistoric (mid-1600s to early 1700s) site which has been linked with Taos Pueblo refugees and Plains Apache Dismal River aspect groups (Adair 1992; Gunnerson 1960). There has been much speculation as to whether the Scott County Pueblo site is actually El Quartejejo.

El Quartejejo was a refuge founded by Taos Pueblo Native Americans in the mid 1600s (Witty 1983; Gallegos 1999). The Taos were a group living in New Mexico under Spanish rule. Multiple revolt attempts were made by the Puebloan groups. Following one aborted plot some of the Taos voluntarily migrated to Kansas (Gallegos 1999). The Plains Apache had begun trade with the eastern Pueblos before 1540, and some Apache groups had moved into Pueblo country before 1583 (Gunnerson 1968). Thus, there was already a strong relationship between Plains Apache and Pueblo groups prior to the Taos

migration. Between 1675 and 1676 the governor of New Mexico, Juan Francisco de Trevino, ordered that the Taos who had left be returned to their native Pueblo. Juan de Archuleta, a troop of 20 soldiers, and Native American aids found the group in western Kansas and returned them to New Mexico without incident (Gallegos 1999). In 1680 there was another revolt against the Spanish in New Mexico which was successful. From 1692-1696 the Spanish recaptured the region. In 1696 a group of Picuris fled New Mexico though some were recaptured. The members of the puebloan group who escaped lived with the Apache at El Cuartelejo until 1706. At that time the Spanish governor ordered Juan de Ulibarri to return the Picuris to New Mexico. Ulibarri kept detailed records of his travel to “Santo Domingo of El Cuartelejo” and descriptions match well with the location of the Scott County Pueblo site (Witty 1983).

### **Protohistoric Central Plains**

In the central and southern Plains the Protohistoric period begins in 1541 with the Spanish entrada of Coronado and ends around 1750 - 1800 when historic documentation becomes more complete for the region. The Dismal River Aspect is the most well known Protohistoric archaeological complex in the western Plains region (Hofman 1989).

#### *Dismal River and Plains Apache*

The Dismal River Aspect was first described by William Duncan Strong from a series of sites in Nebraska (Wedel 1959). Dismal River sites occur in a variety of locations and do not have any fortifications, ditches, or burials associated with the them

(Wedel 1959). Gunnerson states that the distribution of Dismal River sites "...suggests that the Plains Apache...inhabited essentially the area between the 100<sup>th</sup> meridian and the Rocky Mountains, from the Black Hills south to at least northern New Mexico" (1968:169). He proposes that the environment and landscape of this region favored a subsistence economy based on hunting:

In keeping with such an environment, the Dismal River people lived mainly by hunting, with horticulture as a minor but valued means of supplementing the food supply. In that it had this dual base, their subsistence economy resembled that of the protohistoric and historic earth-lodge dwellers farther east, among whom, however, the relative emphasis on hunting and farming was reversed (Gunnerson 1968:170).

Frequently two to three feet deep bell-shaped or straight walled pits were dug and the interior fired, then filled with food for cooking. Many of the pits were later filled with refuse. In addition there are frequently irregular trash-filled pits associated with Dismal River sites which can be up to 15 feet wide and four feet deep. These were likely borrow pits excavated as a source of dirt for covering houses and later filled with detritus.

Pottery associated with the Dismal River Aspect is usually sand or grit tempered. Mica-tempered ware is represented, however, at a variety of Dismal River sites and there is strong "evidence that micaceous pottery was made on the Plains" (Gunnerson 1968:178). The temper is likely due to clay with natural micaceous deposits found locally, though there is some relationship in design to pottery made by the Taos, Picuris, and Jicarilla Apache (Gunnerson 1968).

As can be seen in the discussion below and in the next chapter, all of these Dismal River traits are associated with the Scott County Pueblo Site in western Kansas.

## **14SC1 Site Description**

### *Location*

The present day area surrounding the High Plains site of Scott County Pueblo is short grass prairie. The site, itself, is located in the Ladder Creek Valley, a tributary of the Smoky Hill River. In the region of the site, Ladder Creek has cut deeply through the Ogallala geologic formation resulting in 200 feet of relief. The geological history of the site suggests that there should have been an abundance of freshwater springs in the area which could have supported large populations even during droughts. Modern irrigation practices have impacted the area resulting in a lowered water table. Presently, only one significant spring flows in this segment of the valley (Witty 1983).

In 1928 the site was donated by the landowner to the Daughter's of the American Revolution. The D. A. R. erected a monument over the southwest corner of the pueblo structure. In 1965 the site was designated a National Historic Landmark and a bronze plaque was added to the D. A. R. monument (Witty 1983).

Today the site is located within Lake Scott State Park. This park was created due to the inundation of the valley for the construction of the Scott County State Lake in the early 1930's. The Pueblo is located on terraces above the valley floor and is now near the edge of the modern lake (Witty 1983).

### *History of Excavation and Study*

The site was initially described by S. W. Williston in 1899 (Williston 1899). It was later excavated by Williston and H. T. Martin (Williston and Martin 1900), who

uncovered what they thought to be a seven room structure. They were able to outline four north rooms and three south rooms fully enclosed with no evidence of doors. Five of the seven rooms had small postholes spaced 12-18 inches apart in one corner which Martin (1909) interpreted as evidence for ladders. This would indicate an entry way through the roof, suggesting multiple stories. There was also evidence of burnt adobe, scorched artifacts, charcoal, and masses of carbonized corn indicating that the building had been destroyed by fire (Wedel 1959). Three or four small circular structures were also located by Williston and Martin (Martin 1909) about 25 yards to the north of the seven room adobe building.

The most well-known excavation of the site was carried out by Waldo Wedel (1959) in 1939 and 1940. He wrote extensively about the site in his *An Introduction to Kansas Archaeology*. While locating the corners of the seven room stone-walled structure as a reference, Wedel did not examine the main structure. Instead, he excavated previously untested refuse pits and nearby features not mentioned by Williston and Martin. He also tried to relocate the circular structures to the north but was unsuccessful and suspected that they had been obliterated during farming of the terrace before it was set aside as parkland (Wedel 1959).

Wedel (1959) excavated in three main areas, though his party also sank exploratory pits around the ruins. The first test area consisted of small exploratory pits on the main terrace and nearby flats. In this area Wedel found evidence of possible seasonal structures and a borrow or trash pit. One feature of particular note that he describes is “a circular bell-shaped pit 39 inches across the top, 53 inches across the bottom, and 39

inches deep” (Wedel 1959:428). While the well-defined walls were not burned or lined (Wedel 1959), the bell-shaped pit is like those described elsewhere (Gunnerson 1968) as being associated with the Dismal River Aspect.

The second test area encompassed the principal midden area immediately to the north of the pueblo ruin. The material in this area shows some European influence as there is a scarce amount of iron and glass beads inches above undisturbed subsoil in the midden fill. In addition, the area, though adjacent to the pueblo, had few artifacts of distinctively Puebloan origin. Most of the material was typical of that elsewhere in the Plains (Wedel 1959).

The third test area encompassed a midden area roughly 20 yards south of the historic “El Quartejejo” monument erected on the site by the D. A. R. (Wedel 1959). Excavated were a refuse basin containing scattered ash, charcoal, seams of burnt grass, corn cobs, other vegetal material, animal bones, bone tools, pot sherds, worked flint, and two pits interpreted as roasting or baking pits due to heavily burned walls and large amounts of ash, charcoal, and calcined rocks contained within.

The number of identifiable bones per species that Wedel (1959) recovered from Scott County Pueblo are listed in Table 7.1. Deer bones are second only to bison in number. Wedel (1959:441) states that deer “may have inhabited the brushy side canyon, as well as the Smoky Hill valley not far to the north.” Surprisingly, Wedel found no antelope remains at the site and mentions that the absence is strange as the terrain is prime antelope range. He suggests possible cultural and palatary reasons for the use of deer over antelope; however, later excavations revealed numerous antelope remains. The

**Table 7.1 - NISP recovered by Wedel (1959) at the Scott County Pueblo Site**

| Taxonomic Classification                             | NISP |
|--|------|
| Mammals  | 106  |
| <i>Bison</i> (Bison)                                 | 51   |
| <i>Odocoileus</i> (Deer)                             | 33   |
| <i>Canis</i> (Dog)                                   | 17   |
| <i>Cynomys</i> (Prairie Dog)                         | 2    |
| <i>Taxidea taxus</i> (Badger)                        | 2    |
| <i>Geomys</i> (Pocket Gopher)                        | 1    |
| Aves   | 12   |
| <i>Buteo regalis</i> (Ferruginous Rough-legged Hawk) | NR*  |
| <i>Falco mexicanus</i> (Prairie Falcon)              | NR   |
| <i>Bubo virginianus</i> (Great Horned Owl)           | NR   |
| <i>Fulica americana</i> (American Coot)              | NR   |
| <i>Anas</i> spp. (Teal)                              | NR   |
| Anatidae (Duck)                                      | NR   |
| <i>Grus americana</i> (Whooping Crane)               | NR   |
| Reptiles   | NR   |
| <i>Pseudemys</i> (Cooter)                            | NR   |
| <i>Chelydra serpentina</i> (Common Snapper)          | NR   |
| <i>Terrapene</i> (Box Turtle)                        | NR   |
| <i>Chrysemys</i> (Painted Turtle)                    | NR   |

---

\* NR = Not Recorded

absence of antelope from the 1939 and 1940 excavations may be due to sampling strategy, more broken and less identifiable remains, or possible misidentification of the material as deer. Later evidence definitely demonstrates that the inhabitants were indeed hunting antelope.

Subsequent investigations were carried out by James Gunnerson (1968) while investigating the Plains Apache occupation of western Kansas. In 1965 Gunnerson tested in the immediate vicinity of 14SC1 searching for remains of Apache houses. While he did not find evidence of these structures at the site, he located two structures one half-mile from the ruin. One of the structures exhibited a classic five base post Dismal River Pattern and the other had four posts (Gunnerson 1968).

### **Kansas State Historical Society Investigations at 14SC1**

#### *1970s Excavation at 14SC1*

The most recent work at the site was carried out by Thomas A. Witty, Jr. (1983) as part of a Kansas State Historical Society investigation under the possibility of erecting an interpretive center at the site. Excavations were carried out at the site during 1970, 1975, and 1976. Since the reason for the 1970 excavation was the possible construction of an interpretive center, investigations initially centered around identifying the pueblo location so that the ruins found by Williston and Martin could be reconstructed (Witty 1983). The first excavation concentrated in area 701 immediately adjacent to the Pueblo. There are no published accounts of these excavations. Excavation notes provide fairly

detailed descriptions of the site. Three features classified as borrow pits were the largest discoveries in this area.

During later investigations of the site, Witty (1975) conducted excavations in two different areas of the Scott County Pueblo site (14SC1). Area 751 was 100 yards south of the pueblo ruins near where other investigators had reported evidence of other smaller structures. In this area there was a low linear mound in which artifacts associated with Apache culture had been recovered:

The excavations began on the west side of this mound with 22 two meter square excavation units being eventually dug to a depth of 30 centimeters. All of the removed fill from the . . . dig areas was screened through 1/4 inch mesh which meant good recovery of anything larger than a 1/4 inch. Selected soil samples were also taken for later laboratory processing and washing (Witty 1975:3).

While no definite evidence of a structure outline could be determined through excavation, multiple areas of cultural activity were discovered. Area 752, the second excavation area, was located southwest of the reconstructed ruins. Three units from this area were excavated before the end of the 1975 field season (Witty 1975).

In 1976 KSHS extended the excavations to the north and east with 22 units. This area (761) contained a large trash filled pit, at least three other intruding pits, and concentrations of adobe and rubble. The material recovered all appeared to be characteristic of Plains Apache or Dismal River (Butler 1997).

Initial analysis of the material was limited. More recent research, however, has been conducted on lithic, botanical, and faunal material recovered during the Kansas State Historical Society excavations.

*Research Studies on KSHS 14SCI Collections*

Butler (1997) researched the lithics from the Scott County Pueblo site for an unpublished Master's thesis. The focus of the research was on raw material use for tool manufacture. Butler determined that a greater percentage of local material was employed in tool manufacture and that the rate of non-local material utilized decreased with source distance from the site. He also noted that the "specific lithic material qualities are partially determining their use as specific tool types" (Butler 1997:63). Tool types prevalent at the site suggest manufacture mostly for hunting and hide processing activities. Dominance of these tool types would normally suggest seasonal occupation, whereas the raw material use suggests lower mobility (Butler 1997). Butler did not look at differences across the site as he states that the close contacts of Pueblo and Dismal River cultures would make separation of the artifactual remains, specifically the lithic material, difficult. Unfortunately, due to the nature of his project, Butler did not list tool categories and their numbers or frequencies across the site to allow later perusal of his research and any link with possible cultural designations or change through time from more hunting dominant to more agriculturally dominant inhabitants at the site

Adair (1992) examined botanical remains from the KSHS 1970s excavations and the 1898 Williston and Martin excavations. Botanical materials recovered from the site include maize cobs, cob fragments and kernels, as well as desiccated watermelon and melon seeds. Some of the melon seeds compare favorably with cantaloupe, though exact generic determination could not be made. Watermelon had been introduced to the Southwest and central Plains by the late 1500s or early 1600s. Other melons were

introduced by the Spanish and also spread rapidly throughout North America. The presence of the melon remains at the Scott County Pueblo site supports a mid to late 17<sup>th</sup> century Pueblo influence. Historical accounts from 1706 state that individuals at El Quarteletejo were growing the melons rather than acquiring them through trade (Adair 1992).

The maize remains from Scott County Pueblo are consistent with other remains found throughout the central Plains. The maize does not demonstrate any morphological differences from other varieties found nearby and is quite similar to maize found at other Dismal River sites. The irrigation canals may be an attempt to increase the yield of the plants through technology (Adair 1992), but the presence of irrigation canals is rare in the Plains while a fairly standard practice in the Southwest. Whether this presence is due to migration of groups from the Southwest or merely an exchange of ideas over long distance is unknown. Since the historic documentation and archaeological evidence supports Scott County Pueblo as the location for El Quarteletejo, those canals are likely due to the influx of a migrating group.

Adair (personal communication) was able to obtain two carbon 14 dates on material from 14SC1. A melon seed was dated to  $350 \pm 35$  years ago ( $1600 \pm 35$ ) and watermelon dated to  $200 \pm 40$  years ago ( $1750 \pm 40$ ). These dates suggest melon could have been present at the site prior to the Taos Pueblo movement into the area.

While Butler (1997) suggested that tool production was centered on a hunting economy, those who have conducted research on the faunal material at the site (Hill and Blackmar 1996; Blackmar 1995) have proposed that the economy was equally dependent

on farming as they were on the hunting of bison and small game throughout the year. Hunting was supplemental to the agricultural diet of Scott County Pueblo occupants (Hill and Blackmar 1996). Adair's (1992) research presented here would seem to support that premise. Presence of irrigation canals and retrieval of substantial maize kernels and cobs from all the excavations suggest that agriculture was important for at least one of the cultural groups.

A series of papers presented at the *Plains Anthropological Conference* and one paper prepared for a graduate class at the University of Kansas have addressed the faunal material recovered during the KSHS excavations.

Hill and Blackmar (1996) investigated the use of large bodied animals, primarily bison, at the Scott County Pueblo Site. They were most interested in investigating the bison-maize interaction at the site. Of the material they analyzed from the 1970, 1975, and 1976 KSHS field seasons, the number of individual bison bones identified was 870 with an MNI of 24 bison. Table 7.2 lists the features and NISP and percent of NISP of bison found at the site according to Hill and Blackmar's (1996) research. Animals hunted appear to be primarily mature animals. Mortality profiles and seasonality studies of bison recovered from the site suggest that:

At the Scott County Pueblo, bison hunting was not a single annual event in which a large number of bison were killed. Instead, individual or small numbers of bison were preyed upon throughout the year, but especially during the spring and winter (Hill and Blackmar 1996:10).

This supports a year long occupation of the site. Also, the elements represented at the site are dominated by high utility parts (Table 7.3). Transport costs with large-bodied

**Table 7.2 - Bison NISP by Feature for Provenienced Material Recovered by KSHS at the Scott County Pueblo Site (Hill and Blackmar 1996).**

| <b>Feature*</b> | <b>NISP</b> | <b>% Total NISP</b> |
|-----------------|-------------|---------------------|
| 168             | 188         | 31.33               |
| 184             | 14          | 2.33                |
| 192             | 30          | 5.00                |
| 196             | 93          | 15.50               |
| 221             | 40          | 6.67                |
| 829             | 82          | 13.67               |

\* includes features with NISP > 10

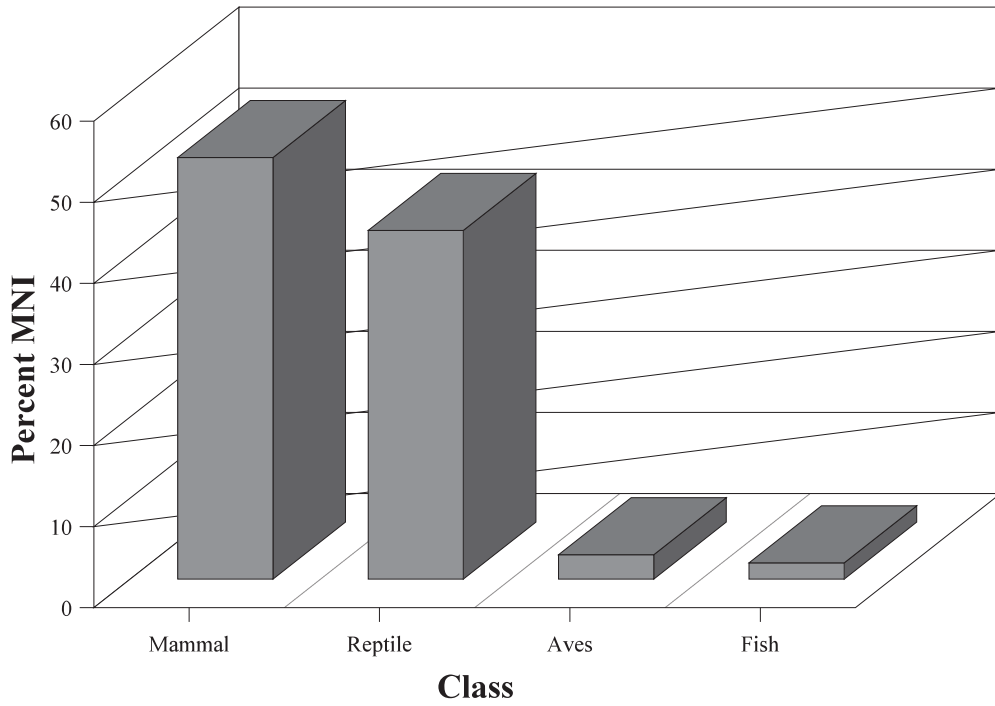
**Table 7.3 - Minimum Number of Elements (MNE) of Appendicular Bison Remains Recovered during the KSHS Excavations (Hill and Blackmar 1996) and Bison Carcass Utility Value Ranks (Emerson 1990).**

| <b>Element</b> | <b>MNE</b> | <b>Rank</b> |
|----------------|------------|-------------|
| Scapula        | 26         | 10          |
| Humerus        | 36         | 7           |
| Radius         | 24         | 8           |
| Ulna           | 20         | 8           |
| Metacarpal     | 1          | 11          |
| Innominate     | 28         | 6           |
| Femur          | 47         | 5           |
| Tibia          | 34         | 9           |
| Astragalus     | 7          |             |
| Calcaneus      | 7          |             |
| Metatarsal     | 4          | 12          |

animals such as bison would make this predictable (Emerson 1990). The presence of some low utility parts (metacarpal, metatarsal, astragalus, calcaneus, mandible, and teeth), however, suggests that the site occupants were procuring the animals rather than trading with nearby groups for meat resources.

Blackmar (1995) had further examined seasonality and stress as evidenced by bison mandibular teeth from the Scott County Pueblo site. Of the 14 mandibular tooth rows and 27 single mandibular teeth present at the site (totaling 59 teeth), three fragmented tooth rows and two single third molars belonged to animals under the age of four. The rest of the teeth all belonged to animals between six and 13 years of age. Breakage of some mandibular bones further suggested intentional fracturing for extraction of marrow (Blackmar 1995). While marrow use may indicate seasonal stress, the selection of only prime-aged individuals belies this. More likely, the overall high fat content of mandibular marrow and the ability to store it for later use, may have made it an excellent supplement to the low fat carbohydrate diet of corn during late winter and early spring when climatic conditions would make hunting less desirable (Blackmar 1995; Speth 1983).

Blackmar (1996) examined the selection and use of a variety of smaller animals from 14SC1. Since recovery at the pueblo site was limited to 1/4" mesh, some bias of remains may exist. There were 1918 bone fragments analyzed for this project, roughly 74% of the total assemblage. The size range of animal analyzed included deer and antelope size and smaller. Of the bones, 463 were identifiable to a species level. Figure 7.1 gives the percent of MNI accountable to each class. Mammal bone dominates, but



**Figure 7.1 - Percent of MNI by Class for Small and Medium Sized Mammals, Reptiles, Aves, and Fish Recovered by KSHS at Scott County Pueblo (Blackmar 1996). (See Table 7.4)**

**Table 7.4 - MNI of Small Fauna from Scott County Pueblo (Blackmar 1996).**

| <b>Taxonomic Classification</b>                | <b>MNI</b> |
|--|------------|
| Mammals  |            |
| <i>Odocoileus</i> (Deer)                       | 6          |
| <i>Antilocapra americana</i> (Antelope)        | 2          |
| <i>Canis</i> (Dog)                             | 5          |
| <i>Lutra canadensis</i> (River Otter)          | 1          |
| <i>Taxidea taxus</i> (Badger)                  | 1          |
| <i>Neotoma</i> (Wood Rat)                      | 4          |
| <i>Microtus ochrogaster</i> (Prairie Vole)     | 1          |
| <i>Dipodomys</i> (Kangaroo Rat)                | 1          |
| <i>Geomys bursarius</i> (Plains Pocket Gopher) | 1          |
| Aves   |            |
| Phasianidae (Quail)                            | 1          |
| <i>Aquila chrysaetos</i> (Golden Eagle)        | 1          |
| Reptiles                                       |            |
| <i>Chelydra serpentina</i> (Common Snapper)    | 1          |
| <i>Terrapene ornata</i> (Ornate Box Turtle)    | 17         |
| <i>Chrysemys</i> (Eastern Painted Turtle)      | 1          |
| <i>Apalone spinifera</i> (Spiny Softshell)     | 1          |
| <i>Graptemys</i> (Map Turtle)                  | 1          |
| Colubridae (non-venomous snake)                | 1          |
| Fish   |            |
| <i>Lepisosteus</i> (Gar)                       | 1          |

reptile bone accounts for the second highest percent of MNI. Each animal identified and its species is presented in Table 7.4. Some of these animals are similar to those discussed by Wedel (Table 7.1). Blackmar notes:

Deer would have also provided a source of fat and marrow. The highly fragmented nature of the deer mandibular fragments in combination with the evidence of cutmarks and burning indicate that the fractures were made intentionally in order to break the bone and access marrow (1996:5).

The deer long bones also display a series of green bone breaks which suggests extraction of marrow as well. The most notable presence at the site, however, is that of aquatic turtles. The presence of the site along a river tributary and the abundance of snapping, false map, spiny softshell, and painted turtles suggests frequent river exploitation (Blackmar 1996).

Fish and birds are only slightly represented at the site, but this may be due to sampling strategy (Blackmar 1996). Many fish and bird bones, such as the coot and teal mentioned in Wedel's (1959) inventory, could be lost through 1/4 inch mesh screen. Blackmar's (1996) inventory shows a paucity of rodents, which should be in abundance considering the evidence of crop storage.

## **Summary**

While there has never been a detailed report assembled on the KSHS excavations of the site, with the aid of original excavation records, catalog inventories, and prior research, much information is known about the inhabitants of the Scott County Pueblo Site. Prior research has provided evidence on group mobility, cultural interaction

between the central Plains and Southwest, agricultural practices, hunting strategies, and general geology and environment of the area. Since the presence of both species of deer at the site could be suggestive of garden-hunting, this would supplement research already conducted by Blackmar (1996). Without a finer-scale recovery method and the presence of smaller fauna, the analysis of the deer remains from the site is likely the only way to support this as a possible strategy. Furthermore, the presence of both species could lead to a larger MNI and a better idea of the true relationship of bison versus deer in the local diet. Also, changes and developments in agriculture along with better environmental information may be discerned by the ability to identify deer remains at the Scott County Pueblo site to species. New information presented in Chapter 8 is gained by applying the identification techniques presented in Chapter 6 to the deer remains at this site. Through the integration of this new information and prior research, a more complete picture of the lifeways of the individuals at 14SC1 can be presented.

## CHAPTER 8

### Scott County Pueblo Site (14SC1), Kansas: Discussion and Integration of Deer Bone Analysis

#### **Scott County Pueblo Analysis**

The NISP for the genus *Odocoileus* recovered during the KSHS excavations at Scott County Pueblo, 14SC1, was 103. Due to the overlap in size and close phylogenetic relationship of *Odocoileus* to *Antilocapra*, many bones could not be given a further designation than deer/antelope-sized artiodactyl. Of the 103 deer remains, 21 bones had sections present that were identifiable to species by morphological and/or metrical analysis. Eight of the bones had multiple morphological indicators present. Six of the bones were determinable to species by both morphological and metrical means. One bone exhibited a morphological characteristic indeterminate to either species. One metatarsal fragment compared favorably with mule deer, yet had metrical results suggesting a small likelihood that it belonged to a white-tailed deer. One pelvis fragment had a weak favorable comparison to mule deer morphologically, but had a strong metric designation of white-tailed deer based on two separate models. Therefore, the species of 19 Odocoileine bones could be identified with varying degrees of confidence. There were 12 white-tailed deer bones and seven mule deer bones recovered from the site. The element, portion present, side, degree of epiphyseal union, and means by which identifications

were made for each bone are included in Table 8.1. The minimum number of white-tailed deer recovered is three based on three distal left humeri. The minimum number of mule deer recovered is two based on two right distal scapula with overlapping glenoid cavities and scapular grooves. Prior research at the site suggested a total MNI for the genus *Odocoileus* of six based on mandibular fragments (Blackmar 1996), but current research disagrees. MNI for *Odocoileus* based on teeth is three. There are three left mandibular fourth premolars, three left mandibular third molars, three right maxillary first molars, three right mandibular and maxillary second molars and three right mandibular third molars. By combining the MNI for mule deer and white-tailed deer the total MNI for the genus *Odocoileus* is five.

Once analysis was conducted, the data were further examined to determine the spatial distribution of the bones at the site and the cultural material with which they were associated. There are three main cultural features from which most of the fauna from the site was recovered: Feature 168, Feature 192, and Feature 196. Feature 192 was initially listed as Features 116, 127, 150, 174, 178, 184, 187, 188, and 193 but later research determined that all were part of one larger midden area. The three main features from the site have been interpreted by Witty (1983) as “borrow pits.” The majority of the deer remains came from these features though the two identifiable pelvic fragments were recovered from Feature 829 and Feature 221. The fragment recovered from Feature 221 was that of a white-tailed deer. Feature 221 was discovered to be a discard pile from Wedel’s 1939 excavation; therefore, the bone will not be further discussed here except as representing the site-wide proportional presence of white-tailed deer to mule deer. Two

**Table 8.1 - Deer Bones Identifiable to Species from the Scott County Pueblo Site**

| Species               | Element     | Portion         | Side  | Epiphyseal Fusion* | Morphological Characteristic (Figure 6.1) | Measurement | Adult        | Adult Value of $\psi$ | Pooled       | Pooled          |
|-----------------------|-------------|-----------------|-------|--------------------|---|-------------|--------------|-----------------------|--------------|-----------------|
|                       |             |                 |       |                    |   | Locales     | $\log(\psi)$ |                       | $\log(\psi)$ | Value of $\psi$ |
| <i>O. hemionus</i>    | scapula     | distal          | right | ff                 | 1, 3b                                     |             |              |                       |              |                 |
|                       | scapula     | distal          | right | ff                 | 1   |             |              |                       |              |                 |
|                       | humerus     | distal          | right | ff                 | 4a, 4b, 5                                 | Bd, BT      | -3.08199     | 0.0008                | -3.4315      | 0.0003          |
|                       | radius      | proximal        | right | mf                 |   | Bp, BFp     | -2.2989      | 0.0050                |              |                 |
|                       | radius      | proximal        | left  | ff                 |   | Bp, BFp     | -10.9754     | 0.00000000001         |              |                 |
|                       | metacarpal  | proximal        | right | ff                 | 8a, 8b, 9                                 |             |              |                       |              |                 |
|                       | 2nd phalanx | complete        | NA    | ff                 |   | GL, Bd      | -2.2619      | 0.0055                | -0.5695      | 0.2695          |
| <i>O. virginianus</i> | scapula     | distal          | right | unknown            | 1   |             |              |                       |              |                 |
|                       | humerus     | distal          | left  | ff                 | 4a, 4b, 5                                 | Bd, BT      | 2.754        | 567.54                | 2.952        | 895.36          |
|                       | humerus     | distal          | left  | ff                 | 4a, 4b, 5                                 | Bd, BT      | 1.7956       | 62.459                | 1.7437       | 55.424          |
|                       | humerus     | distal          | left  | ff                 | 4b  | Bd, BT      | 3.1779       | 1506.26               | 3.1896       | 1547.39         |
|                       | metacarpal  | proximal        | left  | ff                 | 8a, 8b, 9                                 |             |              |                       |              |                 |
|                       | pelvis      | acetabulum      | left  | ff                 | 11, 12                                    |             |              |                       |              |                 |
|                       | pelvis      | ilium           | left  | ff                 | 12 (cf2 mule deer)                        | SB, SC      | 2.0633       | 115.69                |              |                 |
|                       |             |                 |       |                    |   | SH, SB      | 3.6281       | 4247.17               |              |                 |
|                       | tibia       | distal          | left  | ff                 | 16  |             |              |                       |              |                 |
|                       | 2nd phalanx | complete        | NA    | ff                 |   | GL, Bd      | 5.1052       | 127408                | 1.788        | 61.376          |
|                       | 2nd phalanx | complete        | NA    | ff                 |   | GL, Bd      | 5.66095      | 45809                 | 2.1691       | 147.61          |
|                       | 2nd phalanx | complete        | NA    | ff                 |   | GL, Bd      | 14.17399     | 149,276,003,711,318   | 8.5430       | 349,108,159     |
|                       | 2nd phalanx | nearly complete | NA    | ff                 |   | GL, Bd      | 9.9798       | 9,545,528,969         | 5.7135       | 517,011         |

\* ff=fully fused, mf=mostly fused

white-tailed deer 2<sup>nd</sup> phalanges were also found in non-feature associated excavation units. The material from these units and Feature 829 along with the three borrow pits will be discussed in-depth. Distribution of the two species at the site is also listed in Table 8.2. Data from prior faunal studies of the site material are examined for the features and units discussed. Also, material from excavation notes and the catalog inventory, which lists the artifacts recovered from the site, are included. While this information is somewhat useful, the inventory is fallible as some of the bones analyzed for this study were listed as chert flakes in the inventory. General knowledge concerning the across-site differences and possible cultural affiliations of these features (Dismal River versus Puebloan) can be gleaned, though only broad generalizations are possible. Nevertheless, distinct trends are noticed when examining the presence of the two deer species across the site.

#### *Unit 28*

One white-tailed deer 2<sup>nd</sup> phalanx was recovered from Unit 28. The number of identified specimens (NISP) for *Odocoileus* spp. was four. A series of artifacts were uncovered from Unit 28 in Area 701. A side-notched point with expanding stem and concave base, two plano convex scrapers, a Southwestern rim sherd of the black on red and buff type, a brown jasper side-notched triangular projectile point with a concave base, and a brown jasper long narrow plano convex scraper are mentioned on the excavation forms for this unit. There is no record of bison bone recovered from this unit and the artifact inventory merely lists bone, lithics, and turtle. There is only mention

**Table 8.2 - Distribution of Identifiable Deer Species from the Scott County Pueblo Site**

| <b>Feature</b> | <b>Species</b>        | <b>Element</b> |
|----------------|-----------------------|----------------|
| 168            | <i>O. hemionus</i>    | scapula        |
|                | <i>O. hemionus</i>    | humerus        |
|                | <i>O. hemionus</i>    | metacarpal     |
|                | <i>O. virginianus</i> | humerus        |
| 192            | <i>O. hemionus</i>    | scapula        |
|                | <i>O. hemionus</i>    | radius         |
|                | <i>O. hemionus</i>    | radius         |
|                | <i>O. hemionus</i>    | 2nd phalanx    |
|                | <i>O. virginianus</i> | humerus        |
| 196            | <i>O. virginianus</i> | scapula        |
|                | <i>O. virginianus</i> | humerus        |
|                | <i>O. virginianus</i> | metacarpal     |
|                | <i>O. virginianus</i> | tibia          |
|                | <i>O. virginianus</i> | 2nd phalanx    |
|                | <i>O. virginianus</i> | 2nd phalanx    |
| 829            | <i>O. virginianus</i> | pelvis         |

of deer and an antelope tibia and tooth row from Unit 28 in raw data recorded by Blackmar. Other faunal evidence from this unit is unknown.

#### *Unit 89*

There was also just one white-tailed deer 2<sup>nd</sup> phalanx recovered from Unit 89. NISP for *Odocoileus spp.* is three. There is no description of the unit, but excavation notes describe a yellow grey quartzite bifacially chipped blade tip and a rectangular slab of yellow brown sandstone with a lengthwise groove on one face. The catalog inventory for this unit lists lithics, potsherds, glass, metal, wire, mica-tempered pottery, a pipe-bowl fragment, and turtle shell. Prior faunal analysis does not mention bison (Hill and Blackmar 1996) or list other fauna from this unit.

#### *Feature 168*

Feature 168 had evidence of both mule deer and white-tailed deer remains. While more mule deer remains (a humerus, metacarpal, and scapula) were recovered from this feature, one white-tailed deer distal humerus was also retrieved. In addition 16 fragments assigned to *Odocoileus spp.* were recovered. Hill and Blackmar (1996) show Feature 168 occurring to the west of the Pueblo ruins. Excavation records describe the feature as basin-shaped with fill of mixed earth, burned earth, charcoal, bone, and artifacts. The feature description notes describe a possible bone flesher, Cowley Plain shell-tempered sherds, and worked and unworked stone. Artifacts listed in the inventory for Feature 168 include miscellaneous bone, bison bone, turtle remains, bone beads, bone awls, a drilled

ornament, scrapers, worked lithics, flakes, obsidian, wood, adobe, miscellaneous potsherds, shell-tempered potsherds, mica-tempered potsherds, and a grinding stone. One “worked scapula” was also recorded but there is no mention as to whether it was a possible bone hoe or other artifact. In addition, there is no mention of any botanical remains aside from the one piece of wood. Southwest style pottery is mentioned in the description of other features, but not Feature 168. While cultural affiliation cannot be definitely determined without further study of the artifacts, the absence of agriculture and the lack of Southwest sherds suggests the association may not be Puebloan. Furthermore, the presence of shell-tempered and mica-tempered pottery is fairly diagnostic of the Dismal River culture in the area (Hofman 1989). The bones could be the specific remains of butchering episodes or the refuse of a more hunting dependent group, such as Dismal River. Prior faunal analysis lists 188 bison (*Bison bison*) bones recovered from this feature (Hill and Blackmar 1996). Raw data collected by Blackmar list the presence of antelope (*Antilocapra americanus*), badger (*Taxidea taxus*), ornate box turtle (*Terrapene ornata*), map turtle (*Graptemys* sp.), and butchered dog (*Canis*) remains as well.

#### *Feature 192*

Feature 192 contained four mule deer bones and one white-tailed deer bone. The mule deer bones included a 2<sup>nd</sup> phalanx, two proximal radii, and one scapular glenoid fragment. The white-tailed deer bone was a distal humerus. At least 26 bone fragments belonging to *Odocoileus* spp. were also recovered. Feature 192 occurs to the southeast of the Pueblo ruins (Hill and Blackmar 1996; Witty 1983). The excavation notes suggest

the feature was originally a borrow pit that was later filled and used as a trash dump. It is a large midden area that was initially divided into a series of features and excavation units including Features 116, 127, 150, 174, 178, 184, 188, and 193 and Units 9, 10, 11, 509, 510, 511, 529, and 530. Artifacts mentioned in the descriptions with these features and units include bone, flakes, scrapers, blades, bone tools, awl, projectile points, core sections, brown jasper, sand-tempered sherds, mica-tempered sherds, Southwestern sherds, glass, adobe fragments, scapula bone hoe sections, and burnt corn. There are far more notations of Southwestern sherds than any other pottery. Southwestern sherds are barely mentioned with the other features discussed here. The addition of burned corn and scapula hoes found in this feature suggest agriculture. Whether the other features are associated with the Pueblo is questionable, but Feature 192 has a strong Southwestern association and is likely associated with the Puebloan occupation. Also, this is the only feature discussed here which mentions the presence of brown jasper. This jasper is most likely the locally available Smoky Hill jasper described by Butler (1997); who notes that this is the predominant lithic material recovered from the site.

Other fauna mentioned include 30 bison bone fragments (Hill and Blackmar 1996), antelope (*Antilocapra americana*), prairie dog (*Cynomys* spp.), wood rat (*Neotoma* spp.), river otter (*Lutra canadensis*), a member of the Accipitridae family, and one gar (*Lepisosteus* spp.) scale. Since bones were recovered through 1/4" mesh, the presence of small mammals is likely under-represented across the site. Overall, the total number of bone fragments is less in this feature than the other two similar borrow pits. Due to the greater presence of corn, it is likely that agriculture was more predominant and there was

less reliance on hunting. The greater diversity and higher proportion of small animals to large may suggest a different procurement strategy than that represented in the other two borrow pit features.

### *Feature 196*

All the deer bones recovered from Feature 196 were remains of white-tailed deer. In fact, six of the total 11 white-tailed deer bones recovered from the site were found in Feature 196. These bones included two 2<sup>nd</sup> phalanges, one distal tibia, one distal humerus, one proximal metacarpal, and one caudal glenoid portion of the scapula. NISP of *Odocoileus* spp. was 17. Hill and Blackmar (1996) and Witty (1983) show Feature 196 occurring just 10 feet south of the Pueblo ruins. Bone wedged postholes associated with a portalis for the Pueblo were found in this area. Excavation notes mention that three of these postholes were found beneath Feature 196. These notes mention that Feature 196 possibly post-dates these postholes. Since the portalis is associated with the Pueblo, it is likely that Feature 196 post-dates the Southwestern occupation of the site. Notes describe Feature 196 as an oval-shaped basin with an undulating floor. Ash, bison bones, pottery, worked stone, and bone tools are reported in descriptions. The feature is interpreted in the notes as a borrow pit filled with fireplace dumpings and refuse. Again there is no mention of any object associated with agriculture (botanical remains, bone hoes, etc...). Material listed in the catalog inventory for the site includes bone, turtle shell, carnivore teeth, worked-bone awls, a worked-bone cleaver, shell, a pipe-section, ochre, scrapers, projectile points, quartz, obsidian, adobe, a sandstone grinding stone,

charcoal, potsherds, mica-tempered pottery, two small Southwest potsherds, and unidentified organic matter.

Since the borrow pit intrudes into postholes associated with the pueblo ruins some cultural mixing can be assumed. Even if mixing was not assumed, the minor presence of Southwest sherds and the presence of one “unidentified organic matter” would not be enough evidence to associate the feature with the Puebloan occupation. There is evidence that the unidentified organic material mentioned in the catalog inventory is corn. Mary Adair (personal communication, 2003) analyzed corn from Feature 196. Adair attempted to carbon date the corn through an NSF grant to date cultigens from sites in the central Plains, but no date was possible.

Prior faunal analysis is also useful in interpreting Feature 196. Hill and Blackmar (1996) report 93 bison bones recovered from this feature. Raw data provided by Blackmar on smaller animals associated with this feature include: pronghorn antelope (*Antilocapra americanus*), prairie dog (*Cynomys* sp.), pocket gopher (*Geomys* sp.), wood rat (*Neotoma* sp.), painted turtle (*Chrysemys picta*) and ornate box turtle (*Terrapene ornata*). The small mammals were all identified based on mandibular fragments.

#### *Feature 829*

Only one identifiable deer bone was recovered from Feature 829: a white-tailed deer pelvis fragment. There were two additional bone fragments attributable to *Odocoileus* spp. identified. The feature is described as a stone and adobe concentration area. The notes suggest that it may represent a structure. There are bone-wedged

postholes similar to those mentioned as part of the main pueblo ruins portalis in nearby association to the feature. There were multiple corn cobs and watermelon seeds recovered from this feature. The seeds were AMS dated by Mary Adair (personal communication) to  $200\pm 40$  years B.P. ( $1750\pm 40$ ). The 1706 removal of the Picuris Pueblo group from El Quartejejo (Witty 1983) is just outside the range of these dates. Artifacts listed in the catalog inventory include turtle, bison bone, antelope mandible, daub, chert, side-notched arrow point, triangular arrow point, carnivore tooth, bone, sand-tempered pottery sherds, and vegetal samples. Fauna recovered include at least 82 bison bone fragments (Hill and Blackmar 1996). Raw data by Blackmar list deer/antelope and deer. Though the culture affiliation is unknown, the C14 date suggests a post-Puebloan occupation.

## **Discussion**

Little discussion is possible of the isolated excavation units due to the minimal presence of identifiable deer bone. The features, on the other hand, have enough information to allow some interpretation.

More bison were recovered from Feature 168 than any other feature at the site. The presence of antelope and the other small fauna also indicates open grassland or arid terrain. These indicators and the fact that 75 percent of the deer present were mule deer suggest that the occupants were procuring food in an open less-wooded landscape. The map turtle and one white-tailed deer bone in Feature 168 suggest minor opportunistic procurement along the nearby river. When combining mule deer, white-tailed deer, and

*Odocoileus* spp. bones, there was a total of 20 deer bones recovered. This contrasts with 188 bison bones in Feature 168. Apparently, hunting was centered more on procurement of bison than deer.

Feature 192 is notable as containing the only solid association of agriculture and deer identifiable to species in the borrow pit features. The high presence of Southwest sherds in the feature also suggests a connection with the Puebloan occupation. Blackmar (1996) discussed the possibility of “garden-hunting” at the Scott County Pueblo site based on the smaller fauna species present. Garden-hunting is a strategy well-supported amongst prehistoric Southwest groups such as the Anasazi (Neusius 1996). The higher frequency of mammals likely to use garden resources (deer, prairie dogs, and wood rats) or prey on animals who do (Accipitridae) over other larger-bodied animals (bison) may be an indication of this strategy. There is plenty of rough terrain nearby along with a water source and agricultural fields. Mule deer would thrive in this environment. Overall, when combining mule deer, white-tailed deer, and *Odocoileus* spp. bone, there is a total of 31 deer bones from this feature contrasted with only 30 bison bones. The relationship of bison to deer is basically equal in Feature 192; yet there is a 9:1 ratio of bison to deer in Feature 168 and a 4:1 ratio of bison to deer in Feature 196. Deer are usually a secondary staple so the higher presence of the genus *Odocoileus* in relation to bison in Feature 192 is not typical of other Plains sites. The higher frequency of deer in this feature supports the hypothesis for an agricultural group supplementing its diet through garden hunting.

Material recovered from Feature 196 seems consistent with a Dismal River occupation intruding into Pueblo posts. Though some evidence for agriculture is present,

it is minimal and possibly due to mixing with earlier deposits. Even smaller scale agriculture or trade for agricultural goods would be consistent with a Dismal River occupation. Artifacts and fauna suggest a heavier reliance on hunting. Butler (1997), while describing the site as a whole, mentions that a preponderance of the tools were used for hunting and butchering. The complete dominance of white-tailed deer in this feature contrasted with the dominance of mule deer in the other two features may suggest a post-pueblo environment that made the area more suitable for white-tailed deer. The combined total number of bones for all of the genus *Odocoileus* is 23 with an NISP for bison of 93. Bison still dominates, but not to the same extreme as in Feature 168. With no known date for this feature and no finer-scale recovery of micro-fauna or other environmental indicators, further association with a specific environmental change is not possible.

It is difficult to give any interpretation of Feature 829 as only one bone identifiable to species was present. There is strong support for both agriculture and use of bison in this feature. Material from Feature 829 produced an AMS date consistent with a post-Pueblo occupation. The presence of only white-tailed deer remains in this feature and Feature 196 strengthens the argument for a possible environmental change favoring white-tailed deer over mule deer.

## **Summary**

The proportional presence of mule deer and white-tailed deer vary in the three main features discussed here. Feature 168 and 192 have similar ratios of mule deer and

white-tailed deer bones. There is strong evidence connecting Feature 192 to the Puebloan habitation. The dominance of mule deer in the feature could be due to possible garden-hunting strategies or to environmental conditions. Feature 196 differs from Features 168 and 192. There is strong evidence that Feature 196 is intrusive to the Pueblo occupation and is likely a later Dismal River presence. The inclusion of only white-tailed deer bone in this feature suggests that there has been a change in environment, natural or anthropogenic, since the Puebloan occupation; or that different hunting strategies are being utilized. Most likely there has been a shift through time in the habitat which favored mule deer during the Puebloan occupation and favored white-tailed deer during a later period. This hypothesis is further supported by the presence of white-tailed deer in Feature 829 which also post-dates Puebloan occupation.

## CHAPTER 9

### Conclusion

The results presented demonstrate that it is possible to differentiate between white-tailed deer (*Odocoileus virginianus*) and mule deer (*Odocoileus hemionus*) postcranial material from both modern and archaeological contexts. While difficult to assign the inconsistencies in the presence of the two species to a specific factor, there was a change over time in the proportion of each deer species represented in the archaeological sample from the Kansas State Historical Society excavations at the Scott County Pueblo Site (14SC1). Further data and analysis of the artifacts recovered from this site could aid in interpreting the cause for the change through time in the two deer species proportions at the site.

Both morphological and metrical means of differentiating between the two species of deer have been successfully developed. Morphological characteristics for the scapula, humerus, 2<sup>nd</sup> and 3<sup>rd</sup> fused carpal, metacarpal, innominate, femur, tibia, lateral malleolus, astragalus, and metatarsal are presented. Metrical means of differentiation for the scapula, humerus, radius, innominate, metacarpal, and front and hind 2<sup>nd</sup> phalanx were possible. Most of the means used relied on only small portions of the bone making them useful for archaeological applications. Accuracy of adult and pooled-age group specimens differed in most instances. Overall, adult samples are more reliable for identification. Differences between adult males and females were negligible in most

cases. Morphologically, only the pelvis demonstrated any substantial difference in accuracy between the sexes. Interestingly, the astragalus which was metrically significant in a previous study (Jacobson 2003), was no longer significant once the sample size increased. Statistical analysis suggests that this is due to differences based on sex and the addition of more males than females to the current sample.

The potential to differentiate between mule deer and white-tailed deer remains from archaeological sites is beneficial for many reasons. Knowledge about environmental change and its impact on changing deer species proportions could aid in interpretation of prehistoric human ecology and lifeways. Human movements in areas of elevational gradient may be better understood. The impact of agriculture on prehistoric deer presence and human procurement strategies in agricultural zones could be better interpreted. Lastly, the distribution and potential availability of the two species over time could be known.

The across-site distribution of the mule deer (*O. hemionus*) and white-tailed deer (*O. virginianus*) at the Scott County Pueblo site in western Kansas allowed for some interpretation of the site during Pueblo occupation and later time periods. The recovery of deer remains, along with those of other taxa, and evidence for agriculture from a feature with strong Puebloan association, supports the hypothesis for garden hunting at 14SC1 during pueblo occupation. This idea was proposed for the site by Blackmar (1996) and is well-substantiated amongst Southwestern Puebloan groups. Another feature at the site that appears to post-date the pueblo occupation suggests a shift in species proportion or hunting strategies. Material associated with the pueblo ruins has a

4:1 ratio of mule deer to white-tailed deer. Material from the feature post-dating the pueblo occupation and associated with Dismal River artifacts has a 100 percent presence of white-tailed deer. Artifacts and fauna both suggest a return to a primarily hunting dependent economy.

There is also a substantial decrease in bison bone presence between two Dismal River features at the site. As mentioned in Chapter 4, the reduction in use of the lower Yellowstone River by large numbers of bison, along with other factors, led to a change in habitat that was less restrictive to white-tailed deer use (Dusek et al. 1989). Plant succession in the absence of heavy bison use resulted in the development of a sparsely wooded floodplain which provided cover and food resources necessary for white-tailed deer expansion (Dusek et al. 1989). A decrease in bison populations around the Scott County Pueblo Site could have indirectly produced habitat more beneficial to white-tailed deer.

There is evidence for environmental change at the Scott County Pueblo Site. This alteration resulted in a proportional decrease of mule deer and increase of white-tailed deer in the area. This shift is reflected by human selection of resources. Knowledge of environmental change based on analysis of microfauna is limited due to probable loss of small animal remains through 1/4 inch screens. Without the ability to identify members of the genus *Odocoileus* to species, information about environmental stability and human prey selection at the Scott County Pueblo Site (14SC1) in western Kansas would be unknown.

The need to identify archaeological specimens to the most accurate taxonomic level possible is the primary goal of archaeologists. Other interpretation is possible once this is achieved. The methods presented here should aid in the identification and interpretation of deer remains found throughout west-central North America.

## REFERENCES CITED

## REFERENCES CITED

Adair, Mary J.

1992 Plant Remains from El Quartejejo: Subsistence Change or Continuity during the Protohistoric Period. Paper presented at the 50<sup>th</sup> Plains Conference, Lincoln, Nebraska.

Adams, Jonathan

2002 *North America during the last 150,000 years*. Retrieved May 20, 2003 from <http://www.intp.us/quaternary/nercNORTHAMERICA.html>

Adams, Richard, Alison Hofbauer, Chris Cooper, and Tori N. Taylor

2002 Across the Great Divide: High Altitude Archaeology in the Northern Wind River Mountains, Wyoming. Paper presented at the 60<sup>th</sup> Plains Conference, Oklahoma City, Oklahoma.

Allen, E. O.

1971 White-tailed Deer. In *Game Management in Montana*, edited by T. W. Muessehl and F. W. Howell, pp 69-79. Montana Department of Fish and Game Federal Aid Project W-3-C.

Anderson, Roy C.

1972 The Ecological Relationships of Meningeal Worm and Native Cervids in North America. *Journal of Wildlife Diseases* 8:304-310.

Baker, Rollin H.

1984 Origin, Classification, and Distribution. In *White-tailed Deer: Ecology and Management*, edited by Lowell K. Hall, pp 1-18. Stackpole, Harrisburg, Pennsylvania.

Balkwell, Darlene M. and Stephan L. Cumbaa

1992 *A Guide to the Identification of Postcranial Bones of Bos taurus and Bison bison*. Canadian Museum of Nature Syllogeus No. 71.

Bamforth, Douglas B.

1988 *Ecology and Human Organization on the Great Plains*. Plenum Press, New York.

Bate, D. M. A.

1937 Palaeontology: The Fossil Fauna of the Wady El-Mughara Caves. In *The Stone*

*Age of Mount Carmel Part 2*, edited by D. A. E. Garrod and D. M. A. Bate, pp. 137-240, Clarendon Press, Oxford.

Baty, G. Ross

- 1995 Resource Partitioning and Browse Use by Sympatric Elk, Mule Deer and White-tailed Deer on a Winter Range in Western Montana. Unpublished M. S. thesis, University of Montana, Missoula.

Baugh, T.

- 1986 Late Prehistoric Bison Distributions in Oklahoma. *Plains Anthropologist* 31(114) part 2 Memoir 21: Current Trends in Southern Plains Archaeology.

Beasom, Samuel L. and Leslie J. Krysl

- 1984 Dietary Overlap and Habitat Use of a Confined Herd of Mule and White-tailed Deer. In *Deer in the Southwest: A Workshop*, edited by Paul R. Krausman and Norman S. Smith, pp 47-51. Arizona Chapter of the Wildlife Society, Tucson, Arizona.

Blackmar, Jeannette

- 1993 Analysis of the Bison Mandibles from Scott County Pueblo. Report on Class Research, from Department of Anthropology, University of Kansas, Topeka.
- 1995 Seasonality and Nutritional Stress: Evidence from Bison Mandibular Teeth at Scott County Pueblo, Kansas. Paper presented at the 53<sup>rd</sup> Plains Conference, Laramie, Wyoming.
- 1996 Small Faunal Remains from Scott County Pueblo: an Examination of Selection and Use. Paper presented at the 54<sup>th</sup> Plains Conference, Iowa City, Iowa.

Boessneck, J.

- 1969 Osteological Differences between Sheep (*Ovis aries Linné*) and Goat (*Capra hircus Linné*). In *Science in Archaeology: A Survey of Progress and Research*, edited by E. Brothwell and E. Higgs, pp 331-358. Praeger Publishing, New York.

Buie, E. Lin, and James R. Purdue

- 1986 On the Similarity of *Odocoileus hemionus* and *O. virginianus* Mandibles. *Plains Anthropologist* 31:65-71.

Butler, Todd L.

- 1997 Lithic Material Availability, Quality and Selection in the Protohistoric High Plains as Seen from the Scott County Pueblo. Unpublished M. A. thesis, University of Kansas, Topeka.

- Burroughs, R. D.  
1961 *The Natural History of the Lewis and Clark Expedition*. Michigan State University Press, East Lansing, Michigan.
- Carr, Steven M. and Glenys A. Hughes  
1993 Direction of Introgressive Hybridization Between Species of North American Deer (*Odocoileus*) as Inferred from Mitochondrial-Cytochrome-*b* Sequences. *Journal of Mammology* 74:331-342.
- Cary, M.  
1911 A Biological Survey of Colorado. *North American Fauna* 33:1-256.
- Cook, F. W.  
1945 White-tailed Deer in the Great Plains Region. *Journal of Wildlife Management* 9:237-242.
- Cope, E. D.  
1889 The Vertebrate Fauna of the *Equus* Beds. *American Naturalist* 14(12):833-858.
- Dalrymple, Byron W.  
1978 *North American Game Animals*. Crown, New York.
- Davis, Simon J. M.  
1982 Climatic Change and the Advent of Domestication: The Succession of Ruminant Artiodactyls in the Late Pleistocene-Holocene in the Isreal Region. *Paleorient* 8:5-15.  
  
1987 *The Archaeology of Animals*. Yale University Press, New Haven.
- Day, G. I.  
1980 Characteristics and Measurements of Captive Hybrid Deer in Arizona. *Southwest Naturalist* 25:434-438.
- Dillehay, T.  
1974 Late Quaternary Bison Population Changes on the Southern Plains. *Plains Anthropologist* 19:180-196.
- Dusek, Gary L., Richard J. Mackie, James D. Herriges, Jr., and Bradley B. Compton  
1989 Population Ecology of White-tailed Deer along the Lower Yellowstone River. *Wildlife Monographs* 104:1-68.
- Emerson, Alice M.  
1990 *Archaeological Implications of Variability in the Economic Anatomy of Bison*

bison. Ph.D. dissertation. Washington State University. University Microfilms, Ann Arbor, Michigan.

Emery, K. F., L. E. Wright, and H. Schwarcz

2000 Isotopic Analysis of Ancient Deer Bone: Biotic Stability in Collapse Period Maya Land-use. *Journal of Archaeological Science* 27(6):537-550.

Erickson, Arnold B. and Gerald T. Bue

1954 Additional Mule Deer Records for Minnesota. *Journal of Mammology* 35(3):457-458.

Fagan, Brian M.

2000 *Ancient North America*. Thames and Hudson Ltd, New York.

Ferring, C.

1986 Late Holocene Cultural Ecology in the Southern High Plains: Perspectives from Delaware Canyon, Oklahoma. *Plain's Anthropologist* 31 part 2 Memoir 21: Current Trends in Southern Plains Archaeology.

Fisher, John W., Jr.

1980 Guide to the Astragalus and Naviculo-cuboid. In *Mammalian Osteology*, edited by B. Miles Gilbert, pp 56-62 . Privately published by B. Miles Gilbert, Laramie, Wyoming.

Frey, C. J. and P. Nilssen

2002 Zooarchaeology and Wildlife: Metric Discrimination of Two Morphologically Similar South African Bovids. Paper presented at the 9<sup>th</sup> Conference of the International Council of Archaeozoology, Durham, United Kingdom.

Gallegos, Eloy J.

1999 *Spanish Pioneers in United States History: El Cuartelejo Home-Far-from-Home: History of the Spanish Presence in the High Plains and Missouri River Country before Lewis and Clark 1650 thru 1804*. Villagra Press, Knoxville, Tennessee.

Garrard, A. N.

1982 The Environmental Implications of a Re-analysis of the Large Mammal Fauna from the Wadi El-Mughara Caves, Palestine. In *Paleoclimates, Paleoenvironments and Human Communities in the Eastern Mediterranean Region in Later Prehistory*, edited by J. N. Blintliff and W. Van Zeist, pp 165-187. BAR International Series 133, Oxford.

Gee, Henry

1993 The Distinction between Postcranial Bones of *Bos primigenius* Bojanus, 1827 and

*Bison priscus* Bojanus, 1827 from the British Pleistocene and the Taxonomic Status of *Bos* and *Bison*. *Journal of Quaternary Science* 8(1):79-92.

Geist, Valerius

1987 On Speciation in Ice Age Mammals, with Special Reference to Cervids and Caprids. *Canadian Journal of Zoology* 65:1067-1084.

1994 Origin of the Species. In *Deer*, edited by Duane Gerlach, Sally Atwater, and Judith Schnell, pp 2-16. Stackpole Books, Mechanicsburg, Pennsylvania.

Geist, Valerius and Susan Lingle

1994 Taking Their World in Stride. In *Deer*, edited by Duane Gerlach, Sally Atwater, and Judith Schnell, pp 76-83. Stackpole Books, Mechanicsburg, Pennsylvania.

Graham, Russell W.

1987 Late Quaternary Mammalian Faunas and Paleoenvironments of the Southwestern Plains of the United States. In *Late Quaternary Mammalian Biogeography and Environments of the Great Plains and Prairies*, edited by Russell W. Graham, Holmes A. Semken, Jr., and Mary Ann Graham, pp 24-87. Illinois State Museum, Springfield, Illinois.

Graham, Russell W. and Ernest L. Lundelius, Jr.

1994 *Faunmap: A Database Documenting Late Quaternary Distributions of Mammal Species in the United States*. Illinois State Museum, Springfield, Illinois.  
<http://www.museum.state.il.us/research/faunmap>

Graham, Russell W. and Holmes A. Semken, Jr.

1987 Philosophy and Procedures for Paleoenvironmental Studies of Quaternary Mammalian Faunas. In *Late Quaternary Mammalian Biogeography and Environments of the Great Plains and Prairies*, edited by Russell W. Graham, Holmes A. Semken, Jr., and Mary Ann Graham, pp 1-17. Illinois State Museum, Springfield, Illinois.

Grine, Frederick E., Gisle Fosse, David W. Krause, and William L. Jungers

1986 Analysis of Enamel Ultrastructure in Archaeology: The Identification of *Ovis aries* and *Capra hircus* Dental Remains. *Journal of Archaeological Science* 13:579-595.

Gunnerson, James H.

1960 An Introduction to Plains Apache Archaeology: The Dismal River Aspect. *Smithsonian Institution Anthropological Papers Bulletin* 173:131-260.

1968 Plains Apache Archaeology: A Review. *Plains Anthropologist* 13(41):167-189.

- Halstead, P., P. Collins, V. Isaakidou  
 2002 Sorting the Sheep from the Goats: Morphological Distinctions between Mandibles and Mandibular Teeth of Adult *Ovis* and *Capra*. *Journal of Archaeological Science* 29:545-553.
- Hawksley, Oscar  
 1986 Remains of Quaternary Vertebrates from Ozark Caves and Other Miscellaneous Sites. *Missouri Speleology* 26:1-67.
- Haynes, C. V. and G. Agogino  
 1960 Geological Significance of a New Radiocarbon Date from the Lindenmeier Site. *Denver Museum of Natural History Proceedings*, 9.
- Heavin, Candice G.  
 1970 Two Nebraska Culture Storage Pits from Doniphan County, Kansas. *Plains Anthropologist* 15(47):54-62.
- Hefflefinger, Jim  
 1999 Tails with a Darkside. *The Journal of the Texas Trophy Hunters* May/June:100-107.
- 2000 Status of the Name *Odocoileus hemionus crooki* (Mammalia: Cervidae). *Proceedings of the Biological Society of Washington* 113(1):319-333.
- Hibler, C. P. and A. K. Prestwood  
 1981 Filarial Nematodes of White-tailed Deer. In *Diseases and Parasites of White-tailed Deer*, edited by William R. Davidson, pp 351-362. Miscellaneous Publication No. 7 of Tall Timbers Research Station, Tallahassee, Florida.
- Higgs, E. S.  
 1967 Environment and Chronology: The Evidence from Mammalian Fauna. In *The Haua Fteah (Cyrenaica) and the Stone Age of the South-east Mediterranean*, edited by C. B. M. McBurney, pp 16-44. Cambridge University Press, Cambridge.
- Hill, Matthew E. and Jeannette Blackmar  
 1996 Protohistoric Procurement and Processing of Large-Bodied Mammals at the Scott County Pueblo. Paper presented at the 54<sup>th</sup> Plains Conference, Iowa City, Iowa.
- Hofman, Jack L.  
 1989 Protohistoric Culture History on the Southern Great Plains. In *From Clovis to Comanchero: Archaeological Overview of the Southern Great Plain*, contributions by Jack L. Hofman, Robert L. Brooks, Joe S. Hays, Douglas W.

Ousley, Richard L. Jantz, Murray K. Marks, and Mary H. Manheim, pp. 91-100. Arkansas Archaeological Research Series No. 35, Fayetteville, Arkansas.

Hofman, Jack L. and Russell W. Graham

1998 The Paleo-Indian Cultures of the Great Plains. In *Archaeology on the Great Plains*, edited by E. Stanley Wood, pp 87-139. University Press of Kansas, Topeka, Kansas.

Holland, W. J.

1907 A Preliminary Account of the Pleistocene Fauna Discovered in a Cave Opened at Frankstown, Pennsylvania, in April and May, 1907. *Annals of the Carnegie Museum of Natural History* 4:228-233.

Hughes, Glenys A. and Steven M. Carr

1993 Reciprocal Hybridization between White-tailed Deer (*Odocoileus virginianus*) and Mule Deer (*O. hemionus*) in Western Canada: Evidence from Serum Albumin and MtDNA Sequences. *Canadian Journal of Zoology* 71(3):524-530.

Hunter, G.N.

1948 *History of White-tailed Deer in Colorado*. Colorado Game and Fish Department, Denver, Colorado.

Jacobson, Jodi A.

2000 White-tailed Deer Utility Indices: Development and Application of an Analytical Method. Unpublished M. A. thesis, University of Tennessee, Knoxville.

2003 Identification of Mule Deer (*Odocoileus hemionus*) and White-tailed Deer (*Odocoileus virginianus*) Postcranial Remains as a Means of Determining Human Subsistence Strategies. *Plains Anthropologist* 48(187):287-297.

Jones, J. Knox, Jr., David. M. Armstrong, Robert S. Hoffman, and Clyde Jones

1983 *Mammals of the Northern Great Plains*. University of Nebraska Press, Lincoln, Nebraska.

Koch, E.

1946 Big Game in Montana from Early Historical Records. *Journal of Wildlife Management* 5:357-370.

Kramer, August

1973 Interspecific Behavior and Dispersion of Two Sympatric Deer Species. *Journal of Wildlife Management* 48:1317-1325.

- Krausman, Paul R.  
1994 Taxonomy of White-tailed Deer and Mule Deer. In *Deer*, edited by Duane Gurlach, Sally Atwater, Judith Schnell, pp 17-20. Stackpole Books, Mechanicsburg, Pennsylvania.
- Kufeld, Roland C. and David C. Bowden  
1995 *Mule Deer and White-tailed Deer Inhabiting Eastern Colorado Plains River Bottoms*. Technical Publication No. 41. Colorado Division of Wildlife, Fort Collins.
- Kurten, Bjorn and Elaine Anderson  
1980 *Pleistocene Mammals of North America*. Columbia University Press, New York.
- Lawrence, Barbara  
1951 Post-cranial Skeletal Characteristics of Deer, Pronghorn, and Sheep-Goat with Notes on *Bos* and *Bison*. *Papers of the Peabody Museum of Archaeology and Ethnology* 35(3):12-42.
- Lister, Adrian M.  
1996 The Morphological Distinction Between Bones and Teeth of Fallow Deer (*Dama dama*) and Red Deer (*Cervus elaphus*). *International Journal of Osteoarchaeology* 6:119-143.
- Lyman, R. Lee  
1994 *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.
- Mackie, Richard J.  
1994 The Subspecies of Mule Deer. In *Deer*, edited by Duane Gurlach, Sally Atwater, Judith Schnell, pp 246-250. Stackpole Books, Mechanicsburg, Pennsylvania.
- Martin, H. T.  
1909 Further Notes on the Pueblo Ruins of Scott County. *The Kansas University Science Bulletin* 5(2):11-22.
- McCullough, Yvette Blazzard  
1980 Niche Separation of Seven North American Ungulates on the National Bison Range, Montana. Unpublished Ph.D. dissertation, University of Michigan, Ann Arbor.
- Miller, K. G., D. F. McKee, and D. N. Walker  
1987 Final Report: Analysis of Selected Post-cranial Skeletal Elements for *Odocoileus hemionus* and *Odocoileus virginianus*. On file, Wyoming Game and Fish Research Laboratory, University of Wyoming, Laramie.

- Molloy, Paula  
 1993 Hunting Practices at an Historic Plains Indian Village: Kansa Ethnoarchaeology and Faunal Analysis. *Plains Anthropologist* 38(143):187-197.
- Neusius, Sarah W.  
 1996 Game Procurement among Temperate Horticulturists: The Case for Garden Hunting by the Dolores Anasazi. In *Case Studies in Environmental Archaeology*, edited by Elizabeth J. Reitz, Lee A. Newsom, and Sylvia J. Scudder, pp.273-288 Plenum Press, New York.
- Nichols, A. A.  
 1938 Experimental Feeding of Deer. *Agricultural Bulletin, University of Arizona Experiment Station* 75:1-39.
- Nodde, Barbara  
 1978 Some Minor Skeletal Differences in Sheep. *Occasional Publication of the Institute of Archaeology* 3:133-139.
- Oates, David and Danny N. Walker  
 1992 Mule Deer vs White-tailed Deer. In *Wildlife Forensic Manual*, edited by William J. Adrian, pp 152-154. Association of Midwest Fish and Game Law Enforcement Officers, Colorado.
- Olsen, Stanley J.  
 1960 Post-cranial Skeletal Characters of *Bison* and *Bos*. *Papers of the Peabody Museum of Archaeology and Ethnology* 35(4).
- Payne, Sebastian  
 1969 A Metrical Distinction between Sheep and Goat Metacarpals. In *The Domestication and Exploitation of Plants and Animals*, edited by P. J. Ucko and G. W. Dimbleby, pp 295-305. Duckworth, London.
- 1985 Morphological Distinctions between the Mandibular Teeth of Young Sheep, *Ovis*, and Goats, *Capra*. *Journal of Archaeological Science* 12(2):139-147.
- Peterson, O. A.  
 1926 The Fossils of the Frankstown Cave, Blair County, Pennsylvania. *Annals of the Carnegie Museum* 16(2):249-314.
- Purdue, James R.  
 1983 Epiphyseal Closure in White-tailed Deer. *Journal of Wildlife Management* 47(4):1207-1212.

- 1989 Changes during the Holocene in the Size of White-tailed Deer (*Odocoileus virginianus*) from Central Illinois. *Quaternary Research* 32(3):307-316.
- Quinn, James H.  
 1972 Extinct Mammals in Arkansas and Related C<sup>14</sup> Dates Circa 3000 Years Ago. *Quaternary Ecology: 24<sup>th</sup> International Geological Congress*, Section 12:89-96.
- Rees, John W.  
 1971 Discriminatory Analysis of Divergence in Mandibular Morphology of *Odocoileus*. *Journal of Mammology* 52(4):724-731.
- Reitz, Elizabeth J. and Elizabeth S. Wing  
 1999 *Zooarchaeology*. Cambridge University Press, Cambridge.
- Rowley-Conwy, Peter  
 1998 Improved Separation of Neolithic Metapodials of Sheep (*Ovis*) and Goats (*Capra*) from Arene Candide Cave, Liguria, Italy. *Journal of Archaeological Science* 25:251-258.
- Samuel, William M.  
 1994a The Parasites and Diseases of Mule Deer. In *Deer*, edited by Duane Gurlach, Sally Atwater, Judith Schnell, pp 334-336. Stackpole Books, Mechanicsburg, Pennsylvania.  
 1994b The Parasites and Diseases of Whitetails. In *Deer*, edited by Duane Gurlach, Sally Atwater, Judith Schnell, pp 233-236. Stackpole Books, Mechanicsburg, Pennsylvania.
- Schibler, Jörg and Karlheinz Steppan  
 1999 Human Impact on the Habitat of Large Herbivores in Eastern Switzerland and Southwest Germany in the Neolithic. *Archaeofauna* 8:87-99.
- Scott, Kathleen M.  
 1987 Allometry and Habitat-Related Adaptations in the Postcranial Skeleton of Cervidae. In *Biology and Management of the Cervidae*, edited by Christen M. Wemmer, pp 65-79. Smithsonian Institution Press, Washington D.C.
- Semken, Holmes A., Jr.  
 1984 Paleoecology of a Late Wisconsin/Holocene Micromammal Sequence in Peccary Cave, Northwestern Arkansas. In *Contributions to Vertebrate Paleontology: A Volume in Memorial to John E. Guilday*, edited by H. H. Genoways and M. R. Dawson, pp 405-431. Carnegie Museum of Natural History Special Publication No. 8.

- Severson, Kieth E.  
 1981 Plains Habitat. In *Mule and Black-tailed Deer of North America*, edited by Olof C. Wallmo, pp 459-486. University of Nebraska Press, Lincoln, Nebraska.
- Smith, Michael H. and Olin E. Rhodes, Jr.  
 1994 The Subspecies. In *Deer*, edited by Duane Gurlach, Sally Atwater, Judith Schnell, pp 90-91. Stackpole Books, Mechanicsburg, Pennsylvania.
- Speth, John D.  
 1983 Some Unexplored Aspects of Mutualistic Plains-Pueblo Food Exchange. In *Farmers, Hunter, and Colonists: Interaction between the Southwest and the Southern Plains*, edited by Katherine A. Spielmann, pp 18-35. University of Arizona Press, Tucson, Arizona.
- Steward, Julian H.  
 1938 Basin-Plateau Aboriginal Sociopolitical Groups. *Bureau of American Ethnology Bulletin* 120.
- Sudbury, Byron  
 1968 Ka-131, The Bowling Alley Site: A Late Prehistoric Site in Kay County, Oklahoma. *Bulletin of the Oklahoma Anthropological Society* 17:87-135.
- Swenson, Jon E., Stephen J. Knapp, and Harold J. Wentland  
 1983 Winter Distribution and Habitat Use by Mule Deer and White-tailed Deer in Southeastern Montana. *The Prairie Naturalist* 15(3):97-112.
- Taylor, W. P.  
 1956 *The Deer of North America: The White-tailed, Mule and Black-tailed Deer, Genus Odocoileus, and their History and Management*. Stackpole Books, Harrisburg, Pennsylvania.
- Thomas, David Hurst  
 1973 An Empirical Test for Steward's Model of Great Basin Settlement Patterns. *American Antiquity* 38(2):155-176.
- Von den Dreisch, Angela  
 1976 *A Guide to the Measurement of Animal Bones from Archaeological Sites*. Peabody Museum Bulletin 1. Peabody Museum of Archaeology and Ethnology, Harvard University, Cambridge, Massachusetts.
- Wallmo, Olof C.  
 1981 *Mule and Black-tailed Deer of North America*. University of Nebraska Press, Lincoln, Nebraska.

- Webb, S. David  
 1998 Cervidae and Bovidae. In *Evolution of Tertiary Mammals of North America: Volume 1, Terrestrial Carnivores, Ungulates and Ungulate like Mammals*, edited by Christine M. Janis, Kathleen M. Scott, and Louis L. Jacobs, pp 508-510. Cambridge University Press, Cambridge, Massachusetts.
- Wedel, Waldo R.  
 1959 An Introduction to Kansas Archaeology. *Bureau of American Ethnology Bulletin* 174.
- 1986 *Central Plains Prehistory: Holocene Environments and Culture Change in the Republican River Basin*. University of Nebraska Press, Lincoln, Nebraska.
- Whitaker, Donald G., and Frederick G. Lindzey  
 1999 Effect of Coyote Predation on Early Fawn Survival in Sympatric Deer Species. *Wildlife Society Bulletin* 27(2):256-262.
- White, C. D., P. F. Healy, and H. P. Schwarcz  
 1993 Intensive Agriculture, Social Status and Maya Diet at Pacbitun, Belize. *Journal of Anthropological Research* 49:347-375.
- White, C. D., M. E. D. Pohl, H. P. Schwarcz, and F. J. Longstaffe  
 2001 Isotopic Evidence for Maya Patterns of Deer and Dog Use at Preclassic Colha. *Journal of Archeological Science* 28(1):89-107.
- Whitehead, Clifton J., Jr.  
 1972 A Preliminary Report on White-tailed and Black-tailed Deer Crossbreeding Studies in Tennessee. *Proceedings of the Annual Conference of the Southeast Association of Game and Fish Commission* 25:65-69.
- Williston, S. W.  
 1899 Some Prehistoric Ruins in Scott County, Kansas. *Kansas University Quarterly, Series B* 7(4):109-114.
- Williston, S. W. and H. T. Martin  
 1900 Some Pueblo Ruins in Scott County, Kansas. *Kansas University Quarterly, Series B* 6:124-130
- Wilmsen, Edwin N. and Frank H. H. Roberts, Jr.  
 1978 Lindenmeier, 1934-1974: Concluding Report on Investigations. *Smithsonian Contributions to Anthropology*, 24. Smithsonian Institution Press, Washington D.C.

Wishart, William D.

1980 Hybrids of White-tailed and Mule Deer in Alberta. *Journal of Mammology* 61(4):716-720.

Witty, Thomas A., Jr.

1983 An Archaeological Review of the Scott County Pueblo. *Bulletin of the Oklahoma Anthropological Society* 32:99-106.

Wood, Alan K., Richard J. Mackie, and Kenneth L. Hamlin

1989 *Ecology of Sympatric Populations of Mule Deer and White-tailed Deer in a Prairie Environment*. Color World Printers, Bozeman, Montana.

Woolfenden, Wallace B.

1988 Human Ecological Implications of Migratory Deer Behavior in Sierran Prehistory. *Proceedings of the Society for California Archaeology* 1:225-245. San Diego.

WSU Department of History

2004 Excerpts from the Journals of Lewis and Clark: Flora and Fauna (Recorded at Fort Clatsop, Winter, 1905-6). *Lewis and Clark Among the Indians of the Pacific Northwest*. A Curriculum Project for Pacific Northwest History in Washington State Schools. Retrieved February 15, 2003 from [http://www.libarts.wsu.edu/history/Lewis\\_Clark/LCEXP\\_Flora.html](http://www.libarts.wsu.edu/history/Lewis_Clark/LCEXP_Flora.html)

Ziegler, Alan C.

1963 Unmodified Mammal and Bird Remains from Deer Creek Cave, Elko County, Nevada. In *Deer Creek Cave, Elko County, Nevada*, edited by M. E. Shutler and R. Shutler, Jr., pp. 15-24. Nevada State Museum Anthropological Papers, No. 11.

## APPENDICES

**Appendix A - *Odocoileus* spp. Remains Recovered from KSHS Excavation at Scott County Pueblo**

| <b>Catalog Number</b> | <b>Feature</b> | <b>Side</b> | <b>Element</b>               | <b>Portion</b>           |
|-----------------------|----------------|-------------|------------------------------|--------------------------|
| 11397                 | 168            |             | atlas vertebra               | nearly complete          |
| 11413                 | 168            | r           | metatarsal                   | anterior dist diaphysis  |
| 14504 x350            | 168            |             | thoracic vertebra            | n. complete              |
| 11391                 | 168            |             | thoracic vertebra            | n. complete              |
| 13145 x61             | 168            |             | lumbar vertebra              | n. complete              |
| 13144 x61             | 168            |             | lumbar vertebra              | n. complete              |
| 14500 x350            | 168            | l           | femur                        | prox diaphysis           |
| 13137                 | 168            | l           | mandible                     | ramus, M2, M3            |
| 14521 x350            | 168            | r           | mandible                     | ramus, M2, M3            |
| 27396 x81             | 168            | r           | maxilla                      | P3, P4                   |
| 5586                  | 168            | l           | maxillary tooth              | M1                       |
| 27357                 | 168            |             | antler (worked)              | tine                     |
| 4952                  | 168            |             | antler (worked)              | tine                     |
| 14517 x350            | 168            |             | antler                       | tine                     |
| 5551                  | 168            |             | antler                       | tine                     |
| 27348 x81             | 168            |             | antler                       | tine                     |
| 4689 x10              | 192            |             | 1st phalanx                  | complete                 |
| 16566                 | 192            |             | 1st phalanx                  | complete                 |
| 12340x9               | 192            |             | 1st phalanx                  | complete                 |
| 12335 x9              | 192            |             | 1st phalanx                  | diaphysis and prox epiph |
| 16565                 | 192            | u           | metapodial                   | distal epiph - condyle   |
| 10814 x10             | 192            | r           | metacarpal (c.f. odocoileus) | prox epiph and diaph     |
| 10648 x9              | 192            |             | lumbar vertebra              | n. complete              |
| 5613 x10              | 192            | l           | radius                       | posterior diaphysis      |
| 26117 x10             | 192            | r           | mandible                     | ramus, M3                |
| 26118 x10             | 192            | r           | mandible                     | P2, P3, P4, M1, M2       |
| 10730 x10             | 192            | l           | mandible                     | P3, dP4                  |
| 12346 x9              | 192            | l           | mandible                     | P2, P3, P4               |
| 4696 x10              | 192            | l           | maxilla                      | M1, M2                   |
| 5402 x10              | 192            | l           | ulna                         | prox-semilunar notch     |
| 4695 x10              | 192            | l           | maxilla                      | P3 and P2 + sockets      |
| 26116 x10             | 192            | l           | maxilla                      | P2                       |

**Appendix A continued.**

| <b>Catalog Number</b> | <b>Feature</b> | <b>Side</b> | <b>Element</b>   | <b>Portion</b>        |
|-----------------------|----------------|-------------|------------------|-----------------------|
| 10180 x10             | 192            | r           | maxillary tooth  | M1                    |
| 12548 x510            | 192            |             | tooth            | M2                    |
| 1343 x529             | 192            | l           | mandibular tooth | M3                    |
| 12356 x510            | 192            | r           | maxillary tooth  | M2                    |
| 26119 x10             | 192            | r           | maxillary tooth  | P2, M1                |
| 10448                 | 192            |             | antler (worked)  | tine                  |
| 10447                 | 192            |             | antler (worked)  | tine                  |
| 6887 x9               | 192            |             | antler           | tine                  |
| 14546 x510            | 192            |             | antler           | tine                  |
| 9800                  | 192            |             | antler           | tine                  |
| 18356                 | 196            | r           | radius           | medial prox epiphysis |
| 19299                 | 196            | l           | calcaneus        | n. complete           |
| 18740 x504            | 196            |             | 1st phalanx      | complete              |
| 19158 x504            | 196            |             | 3rd phalanx      | complete              |
| 18347                 | 196            | r           | ulna             | prox - olecranon      |
| 25299 x504            | 196            | u           | scapula          | prox - blade          |
| 5814                  | 196            | r           | pelvis           | acetabular fragment   |
| 18355                 | 196            | u           | metapodial       | posterior - diaphysis |
| 18738 x504            | 196            | u           | metapodial       | posterior - diaphysis |
| 26432 x524            | 196            |             | lumbar vertebra  | n. complete           |
| 26421 x524            | 196            |             | lumbar vertebra  | n. complete           |
| 8002                  | 196            |             | antler (worked)  | tine                  |
| 7003                  | 196            |             | antler (worked)  | tine                  |
| 19559 x524            | 196            |             | antler (worked)  | tine                  |
| 11454 x524            | 196            |             | antler           | tine                  |
| 5202                  | 196            |             | antler           | tine                  |
| 19157                 | 196            |             | antler           | pedicle               |
| 26562 x562            | 221            |             | antler           | pedicle               |
| 39917 x920            | 829            | l           | mandibular tooth | P4                    |
| 40270 x925            | 829            |             | antler (velvet)  | tine                  |
| 1155 x28              |                | r           | mandible         | M1, dP4, P3           |
| 25785 x28             |                | l           | maxillary tooth  | M2                    |
| 25782 x28             |                | r           | maxillary tooth  | M2                    |

**Appendix A continued.**

|           |  |   |                  |                      |
|-----------|--|---|------------------|----------------------|
| 1149 x28  |  | u | humerus          | dist diaphysis       |
| 4458 x29  |  | r | femur            | diaphysis            |
| 22468 x49 |  | r | mandibular tooth | M2                   |
| 5281 x49  |  | r | mandibular tooth | M3                   |
| 529 x86   |  |   | 3rd phalanx      | complete             |
| 3541 x89  |  | r | maxillary tooth  | M1, M2               |
| 13161 x89 |  | l | humerus          | dist diaphysis       |
| 13174 x89 |  | u | metapodial       | dist epiph - condyle |
| 6148 x101 |  | l | humerus          | prox diaphysis       |
| 6655      |  |   | metatarsal       | anterior diaphysis   |
| none      |  |   | 1st phalanx      | dist epiphysis       |
| none      |  | l | maxillary tooth  | P3                   |
| none      |  | l | mandibular tooth | M3                   |

## VITA

Jodi Arlene Jacobson was born in Blacksburg, Virginia on June 25, 1974. At the age of two, her family moved to Starkville, Mississippi. Aside from one year spent overseas in Kathmandu, Nepal when she was 11, Jodi grew up in Starkville. After graduating from Starkville High School in 1992, she enrolled at Mississippi State University as an anthropology major. While at Mississippi State she participated in a variety of archaeological projects throughout the state of Mississippi. She earned her Bachelor's degree from Mississippi State University in 1996 and moved to Tennessee.

Jodi received an M.A. in anthropology with a concentration in zooarchaeology from the University of Tennessee, Knoxville in December, 2000. At that time she entered the Ph.D. program in the same field. While in graduate school, Jodi held a variety of assistantships and taught evening and summer school classes at UTK, in addition to working on a variety of archaeological projects and faunal contracts. On April 19, 2003 she was wed to fellow archaeologist and UTK employee Paul Matchen. Upon completion of her Ph.D. she hopes to teach at the University level.