# CONTENTS

List of Figures ...................................................................................................................... v
List of Tables ......................................................................................................................... v
Abstract .................................................................................................................................. vii
Acknowledgments .................................................................................................................. ix

1. Introduction, by Bradley J. Vierra ....................................................................................... 1

2. Environmental Context, by Monica L. Murrell ................................................................. 5
   Environmental Setting ......................................................................................................... 5
       Physiography, Bedrock Geology, and Geomorphology ................................................. 5
       Quaternary Geomorphology and Surface Soils ............................................................ 10
       Climate, Flora, and Fauna ............................................................................................... 17

3. The Archaeology of the Southern Chuska Valley, by Bradley J. Vierra ......................... 27
   Early Foraging Societies (Paleoindian and Early–Middle Archaic Period) ..................... 27
   Early Maize Cultivation (Late Archaic/Basketmaker II Period) ........................................ 30
   Early Village Formation (Basketmaker III and Pueblo I Periods) .................................... 32
   Exchange and Social Inequity (Pueblo II Period) ............................................................ 34
   Social Restructuring (Pueblo III Period) ........................................................................... 35
   Agro-Pastoralists: The Navajo Occupation during the Historical Period ....................... 36

4. Research Design, by Christopher A. Turnbow, Bradley J. Vierra, and Phillip O. Leckman .... 39
   General Theoretical Orientation ....................................................................................... 39
       Introduction .................................................................................................................... 39
       Theoretical Perspectives .............................................................................................. 40
           Human-Behavioral Ecology ...................................................................................... 40
           Social Approaches to the Archaeological Record .................................................... 42
       The Archaeology of the Southern Chuska Valley ......................................................... 44
           Human-Behavioral Ecology and the Southern Chuska Valley .................................. 44
           Household, Place, and Landscape in the Southern Chuska Valley ......................... 47
   Research Questions and Issues ......................................................................................... 49
   General Research Domains ............................................................................................. 49
       Chronology .................................................................................................................. 50
       Paleoenvironmental Reconstruction .......................................................................... 50
       Subsistence .................................................................................................................. 51
       Land Use, Site Structure, and Social Organization ....................................................... 52
       Technology .................................................................................................................. 52
       Exchange and Regional Interaction ............................................................................. 53
   Historic Contexts and Research Questions ...................................................................... 54
       Changing Hunter-Gatherers ......................................................................................... 54
       Transition to Farming ................................................................................................... 56
       Foundations of Anasazi Culture .................................................................................. 57
       Chuska Communities and Their Role in the Chacoan System ..................................... 60
Post-Chacoan Occupations of the Chuska Valley ................................................................. 61
Early Navajo Occupation of the Chuska Valley ................................................................. 62

5. Methods, by Monica L. Murrell, Phillip O. Leckman, and Rebecca A. Kiracofe ........ 63
   The Provenience Designation Recording System .......................................................... 63
   Project Area .............................................................................................................. 64
   Mapping .................................................................................................................... 64
   Surface Collections ............................................................................................... 66
   In-Field Analysis .................................................................................................... 66
   Mechanical Excavation ......................................................................................... 66
   Hand Excavation ..................................................................................................... 67
   Artifact and Sample Collections ............................................................................ 67
   Provenience Recording, Material Treatment, and Collection ............................... 68
      Laboratory Processing ......................................................................................... 68

References Cited ...................................................................................................... 69
LIST OF FIGURES

Figure 1. U.S. 491 project corridor map ..........................................................2
Figure 2. Physiographic provinces of the greater San Juan Basin .................6
Figure 3. Structure of the San Juan Basin .........................................................7
Figure 4. Stratigraphic column of the San Juan Basin and Chuska Mountains (Warren 1967) ..............................................................8
Figure 5. Quaternary geology chronologies developed for the San Juan Basin and the desert Southwest (Smith and McFaul 1997) .........................11
Figure 6. NRCS surface soils mapped in Segment 4 of the U.S. 491 project corridor .................................................................13
Figure 7. NRCS surface soils mapped in Segment 3 of the U.S. 491 project corridor .................................................................14
Figure 8. NRCS surface soils mapped in Segment 2 of the U.S. 491 project corridor .................................................................15
Figure 9. NRCS surface soils mapped in Segment 1 of the U.S. 491 project corridor .................................................................16
Figure 10. Biotic communities within the U.S. 491 project corridor ...............18
Figure 11. Map of northern, central, and southern Chuska Valley ................28

LIST OF TABLES

Table 1. NRHP-Eligible Cultural Resources within the U.S. 491 South Corridor, by Segment .................4
Table 2. NRCS Surface Soil Descriptions for Units Mapped in the U.S. 491 Project Corridor ..................12
Table 3. Vegetation Species Documented during the Current Vegetation Survey and the Chuska Valley Biological Survey .................................................................20
Table 4. Faunal Species Documented in the Chuska Valley ...............................25
Table 5. Proposed Phase Sequence for the Southern Chuska Valley ..................29
Table 6. Post-Encounter Caloric-Return Rates for Wild Foods .........................40
Table 7. Project Sites and Project Corridor Construction Limits, by Segment .........65
Between 2011 and 2013, archaeologists from Statistical Research, Inc., investigated a total of 26 archaeological sites situated along a 30 mile stretch of the highway U.S. 491 southern corridor on Navajo Nation Trust lands, located between Sheep Springs and Twin Lakes, New Mexico. The U.S. 491 highway project corridor extends slightly within the southern margin of the central Chuska Valley and transects across a large portion of the southern Chuska Valley within Tohatchi Flats. A total of 20 sites (NM-H-62-112, NM-H-62-105, NM-H-62-101, NM-H-62-99, NM-Q-3-76, NM-Q-3-75, NM-Q-3-74, NM-Q-3-72, NM-Q-3-58, NM-Q-3-39, NM-Q-14-73, NM-Q-15-56, NM-Q-15-52, NM-Q-15-29, NM-Q-15-51, NM-Q-15-49, NM-Q-15-46, NM-Q-15-43, NM-Q-15-41, NM-Q-15-28) were mitigated owing to impacts from the proposed expansion of U.S. 491, and an additional 6 sites (NM-H-62-16, NM-Q-3-14, NM-Q-15-55, NM-Q-15-53, NM-Q-15-106, NM-Q-15-42) included surface manifestations located immediately outside of the construction zone and were tested for the potential of buried deposits within the area of potential effects (APE). Only one of the tested sites (NM-H-62-16) yielded intact subsurface remains within the construction zone, warranting full-scale data recovery activities. The remaining tested sites were all found to be contained outside of the APE. Portions of the 21 archaeological sites that extended into the proposed construction zone were subject to complete excavation. Results of the archaeological investigations revealed a total of 51 components ranging from the Early Archaic to the Historical period. The archaeological sites revealed a broad spectrum of human occupation in the Chuska Valley, ranging from ephemerally used logistical sites to densely aggregated village settings.
We would like to thank the Navajo Nation and New Mexico Department of Transportation (NMDOT) for providing this opportunity to work along the Chuska Slope. We also extend our deepest gratitude for the hospitality we experienced from the Naschitti and Tohatchi Chapters during our fieldwork efforts. Funding for this project was provided by the Federal Highway Administration and NMDOT. We would especially like to thank NMDOT Environmental Section Manager Blake Roxlau and Sharon Brown, who served as a NMDOT Environmental Scientist throughout the duration of our fieldwork, as well as Navajo Nation Historic Preservation Department (NNHPD) Tribal Historic Preservation Officer Ron Maldonado for all of their support. This fieldwork could not have been accomplished without the efforts of Statistical Research, Inc. (SRI), Vice President Terry Majewski, Director of Corporate Operations and Project Manager Robby Heckman, Lab Manager Rebecca Kiracofe, Cartography and Geospatial Technologies Department (CAGST) Director Phillip Leckman, and Administrative Research Assistant Lisa Atkinson, who accommodated all of our logistical and administrative needs. We would like to extend a special thanks to SRI Assistant Project Directors David Unruh and Meaghan Trowbridge, previous SRI Project Director Art MacWilliams, and SRI Geomorphologist Jeff Homburg, as well as our subcontractor David Greenwald from Four Corners Research for providing invaluable support in the field. We would like to thank all of the U.S. 491 field and laboratory staff for their tireless efforts and dedication. Adam McManus, Amanda Hernandez, Andy Wakefield, Ashley Manygoats, Brandon McIntosh, Brittany Jenkins, Cannon Daughtrey, Chris Bouchard, Christina Chavez, Dave Prucell, Dean Durysa, Donovan Quam, Dottie Ohman, Eric Schreiber, Heather Blanton, Heather Miljour, Henry Etsitty, Jennie Lee, Jeremy Davis, Jorge Provenzali, Justin Greenwald, Katherine Smyth, Kent Mead, Lawrence Francisco, Leah Westley, Logan Ralph, M. Lori Liburn, Michael Dilley, Mitchell Keur, Mychal Ludwig, Natalia Reeder, Olsen John, Paulina Przystupa, Rita Sulkowsky, Robert Rome, Sara Niedbalski, Shannon Acobtheley, Shaun Phillips, Ted Etsitty, Terry Etsitty, and Tevin Coleman, your hard work did not go unnoticed.

Last, but certainly not least, this report could not have been completed without the unending efforts of the SRI Editors and Graphics staff. Map figures for this publication were prepared by Luke Wisner, Christina Chavez, and Phillip Leckman from our graphics and CAGST departments. Andrew Saiz and Jacqueline Dominguez finalized all of the other imagery within the report body. SRI Director of Publications and Managing Editor Maria Molina and SRI Publications Assistant John Cafiero oversaw all of the technical editing for the report. Beth Bishop, Grant Klein, Jennifer Shopland, John Cafiero, Linda Wooden, KeAndra Begay, and Maria Molina meticulously edited and formatted the individual volumes; yours is often a thankless job, and we cannot express enough our appreciation of your efforts. Lastly, we would also like to thank Tim Kearns for his insightful comments while reviewing many of the chapters.
As part of its continuing effort to improve the New Mexico highway system, the New Mexico Department of Transportation (NMDOT), in cooperation with the Bureau of Indian Affairs, the Navajo Nation Department of Transportation (NNDOT), and the Federal Highway Administration (FHWA), is planning to reconstruct U.S. Highway 491 (U.S. 491) South Corridor. Two additional lanes will be added to U.S. 491 at approximately Milepost 46 within the community of Sheep Springs just south of the intersection of state highway NM 134 to the end of the 4-lane section near Navajo 9 at approximately Milepost 15.3 (Figure 1). The project corridor extends 49.4 km (30.7 miles) within Navajo Nation Trust Land in McKinley and San Juan Counties in unplatted areas shown on various U.S. Geological Survey (USGS) 7.5-minute quadrangle maps covering northwestern New Mexico. Funding for the project was provided by FHWA. This project was conducted under NMDOT Contract No. C05376 (incorporating three amendments), Control No. G5B16, and Project No. G5B16.

Cultural resource investigations were undertaken for the U.S. 491 South Corridor in compliance with federal legislation protecting cultural resources, including the National Historic Preservation Act of 1966 (NHPA), as amended (Public Law 89–665), and Navajo Nation legislation, regulations, and guidelines, including the Navajo Nation Cultural Resources Protection Act (Tribal Council Resolution CMY-19-88), the Navajo Nation Historic Preservation Department’s (NNHPD) *Interim Fieldwork and Report Standards and Guidelines* (NNHPD 1991), and the *Navajo Nation Policy for the Protection of Jischaa’: Gravesites, Human Remains, and Funerary Items* (NNHPD 2010a).

A Class I and III cultural resource survey of the project corridor was performed between August 2002 and July 2003 by archeologists from the NNDOT, Navajo Nation Division of Community Development, to evaluate the potential of the undertaking to affect significant cultural properties under the requirements of Section 106 of the NHPA (Walkenhorst and John 2003). That survey encompassed 111.7 km (69.4 miles) of road for the U.S. 491 North and South corridors at a survey corridor width of 121.9 m (400 feet) and additional areas along drainages and hillslopes. Those investigations were conducted on behalf of the NMDOT and NNDOT. NNDOT conducted a subsequent survey between October and November 2006 on those portions of the areas of potential effects (APEs) added since the original investigation.

The surveys identified 108 cultural resources in or near the U.S. 491 South Corridor. Of these, 81 were determined eligible for inclusion in the National Register of Historic Places (NRHP) by NNHPD. The remaining resources were determined not eligible, were previously excavated, and/or could not be relocated. Subsequent archeological test excavations were undertaken on 20 sites within the U.S. 491 South Corridor portion (Railey 2004). During those investigations, backhoe trenching and manually excavated test units were placed primarily on the east side of the existing U.S. 491. Ten sites were found to contain intact cultural deposits within the then-identified impact area.

Highway development plans along U.S. 491 South Corridor divide the corridor into four segments: Segment 1 from Mileposts 15.3 to 19.75, Segment 2 from Mileposts 19.75 to 31, Segment 3 from Mileposts 31 to 37, and Segment 4 from Mileposts 37 to 46. The APE includes all of the right-of-way (ROW) between the proposed fence lines. This typically expands the existing corridor width from 12.2 to 30.5 m (40 to 100 feet) on the side of the highway containing the new lanes.

Based on this construction strategy, 24 NRHP-eligible sites in U.S. 491 South Corridor were located at least partially within the proposed construction limits. Archaeological test excavations at four of those sites (NM-H-62-111, NM-Q-3-65, NM-Q-3-68, and NM-Q-15-109) found no evidence of intact cultural deposits or features within the APE. Therefore, no further work was recommended, as the portions of those sites that
Figure 1. U.S. 491 project corridor map.
contributed to NRHP eligibility would not be affected by the proposed project (Railey 2004). Initial stages of data recovery fieldwork were conducted by the Office of Contract Archaeology (OCA) in 2007, including surface collections at NM-H-62-112, NM-H-62-105, NM-H-62-101, NM-Q-3-76 (Locus 1), NM-Q-3-75, NM-Q-3-74, and NM-Q-3-72. Data recovery efforts were not completed, and additional fieldwork was scheduled to be conducted at these sites as part of the current project. The OCA also completed offsite testing in 2007 at NM-H-14-27/28, NM-H-62-16, NM-H-62-120, NM-Q-3-71, NM-Q-14-72, NM-Q-15-47, NM-Q-15-52, NM-Q-15-54, NM-Q-15-107, NM-Q-15-108, NM-Q-15-111, NM-Q-18-209, and NM-Q-18-210. These sites were located outside the APE, but testing was undertaken in order to ensure that no unseen subsurface deposits were located within the APE. Buried features were identified at only one of these sites, NM-Q-15-52. The site was added to the list of resources requiring data recovery. In addition, OCA determined that testing was not necessary at NM-H-62-16 because of previous soil disturbance. Finally, OCA was able to complete data recovery at a single site (NM-H-62-110) (Cribbin et al. 2010). The project was subsequently delayed, and OCA terminated fieldwork efforts.

Additional testing was still required at 6 sites (NM-H-62-16, NM-Q-3-14, NM-Q-15-55, NM-Q-15-53, NM-Q-15-106, and NM-Q-15-42) and data recovery at 20 sites. Testing and data recovery was conducted by Statistical Research, Inc. (SRI), from 2011 to 2013. Buried cultural deposits were identified at NM-H-62-16, with the site being added to the data recovery program. At the sites, we identified various cultural components, including Early Archaic through the Pueblo III period and Navajo sites dating to the historical period (Table 1). They range from isolated features or small, light-density artifact scatters to large habitations with multiple room blocks and pit structures. The components include 6 Archaic, 7 Basketmaker III or Pueblo I, 16 Pueblo I–III, and 4 components with ceramics suggestive of a Pueblo IV time frame. Three sites yielded evidence of relatively late Navajo components.

Over 1,000 features were documented during the project, with more than 16,000 lithic artifacts, 59,000 ceramic artifacts, and 16,000 animal bones having been recovered during the excavations. In addition, human remains were identified at four sites. The human remains and associated items were reburied per Navajo Nation Policy for the Protection of Jischaa’. The ultimate treatment and disposition of the remainder of the recovered artifacts complied with the guidelines and requirements presented in the 2010 NNHPD Permit Package (NNHPD 2010b).

The report consists of four volumes: Volume 1, Background; Volume 2, Site Descriptions; Volume 3, Analysis; and Volume 4, Synthesis. Because excavations proceeded from north to south (Segment 4 to Segment 1), the processing, analysis, and report production also occurred in this sequence. Therefore, the report discussions will be presented in this order, and each volume will be accompanied by the relevant appendixes on disk. The project background—the environmental context, the archaeology of the Southern Chuska Valley, the project research design, and project methods—is contained in this volume.
Table 1. NRHP-Eligible Cultural Resources within the U.S. 491 South Corridor, by Segment

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM-H-62-105</td>
<td>Late Archaic, Pueblo II–IV</td>
<td>Specialized-activity site.</td>
</tr>
</tbody>
</table>

**Segment 3**

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM-Q-3-76, Locus 2</td>
<td>Basketmaker III–Pueblo I</td>
<td>Habitation site with rubble concentration, pit-structure depression, and midden.</td>
</tr>
<tr>
<td>NM-Q-3-75</td>
<td>Basketmaker III–Pueblo I</td>
<td>Habitation site with rubble mounds, pit-structure depressions, rubble features, hearths, and middens.</td>
</tr>
<tr>
<td>NM-Q-3-74</td>
<td>Pueblo II</td>
<td>Habitation site with rubble mound.</td>
</tr>
<tr>
<td>NM-Q-3-72</td>
<td>Basketmaker III–Pueblo II, Navajo</td>
<td>Habitation site with rubble mound, possible kiva, and historical-period hogan.</td>
</tr>
</tbody>
</table>

**Segment 2**

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM-Q-3-58</td>
<td>Basketmaker III–Pueblo I</td>
<td>Habitation site with rubble mound and midden.</td>
</tr>
<tr>
<td>NM-Q-3-39</td>
<td>Pueblo II, modern</td>
<td>Artifact scatter, paleontological.</td>
</tr>
<tr>
<td>NM-Q-14-73</td>
<td>Late Archaic</td>
<td>Lithic scatter.</td>
</tr>
<tr>
<td>NM-Q-15-52</td>
<td>Basketmaker III–Pueblo II, Navajo</td>
<td>Habitation site with pit-structure, rubble mound, and historical-period features.</td>
</tr>
<tr>
<td>NM-Q-15-29</td>
<td>Basketmaker III–Pueblo IV</td>
<td>Habitation site with rubble mound.</td>
</tr>
<tr>
<td>NM-Q-15-51</td>
<td>Late Archaic, Basketmaker III–Pueblo II</td>
<td>Habitation site with buried Basketmaker III component.</td>
</tr>
<tr>
<td>NM-Q-15-49</td>
<td>Late Archaic, Pueblo II</td>
<td>Habitation site with rubble mound and sandstone concentration.</td>
</tr>
</tbody>
</table>

**Segment 1**

<table>
<thead>
<tr>
<th>Site No.</th>
<th>Age</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>NM-Q-15-46</td>
<td>Basketmaker III–Pueblo II</td>
<td>Habitation site with rubble mounds and middens.</td>
</tr>
<tr>
<td>NM-Q-15-43</td>
<td>Pueblo II, Navajo</td>
<td>Habitation site with rubble mound, cattle sale area, cement slab, and rubble mound.</td>
</tr>
<tr>
<td>NM-Q-15-28</td>
<td>Basketmaker III–Pueblo II, Navajo</td>
<td>Habitation site with great kiva, rubble mounds, sandstone concentrations, midden, hogan depression, and corral.</td>
</tr>
</tbody>
</table>

*Note: Segments and sites are arranged from north to south.*
CHAPTER 2

Environmental Context

Monica L. Murrell

Environmental Setting

This section presents an overview of the environmental context of the U.S. 491 project area, located within the San Juan Basin of northwestern New Mexico. The project corridor is situated on a coalescent fan-piedmont formed along the eastern and southern flanks of the Chuska Mountains, in an area commonly referred to as the Chuska Valley (Gregory 1916; Warren 1967). Marshall et al. (1979) redefined this area as the Chuska Slope, because it essentially consists of an alluvial outwash between the uplands and the central basin floor rather than a true valley. The historical development of the natural environment in the vicinity of the Chuska Valley is discussed below in detail. This environmental summary provides information regarding the overall structure of the San Juan Basin in regard to physiography, bedrock geology, geomorphology, climate, and plant and animal communities, all of which were contributing factors to land-use strategies and settlement location in this area.

Physiography, Bedrock Geology, and Geomorphology

The U.S. 491 project corridor is situated within the Navajo Section of the Colorado Plateau physiographic province (Fenneman and Johnson 1946; Hawley 1986). This province includes a substantial portion of northwestern New Mexico and extends into adjacent areas of Arizona, Utah, and Colorado (Figure 2). The Colorado Plateau is characterized as an erosional landscape formed on relatively undeformed sequences of sedimentary and volcanic rocks. The Navajo Section is dominated by two structural basins composed of thick sequences of gently dipping Mesozoic and Cenozoic rocks consisting of sandstone, mudstone, and shale (Hawley 1986). The San Juan Basin consists of the larger of these two basins, bounded by the Nacimiento uplift, the Archuleta anticlinorium, the Four Corners Platform, the Defiance uplift, and the Zuni uplift (Figure 3).

Precambrian basement formations composed of granite and metamorphic rocks reportedly have been encountered at depths exceeding 4,570 m (15,000 feet) within the San Juan Basin (Ayers and Kaiser 1994). Rock formations outcropping along the Defiance monocline on the eastern slopes of the Chuska Mountains consist of sedimentary strata (Figure 4) dating to the Paleozoic era (Wright 1956). Mesozoic rocks in the San Juan Basin are dominated by Upper Cretaceous formations; however, Jurassic and Triassic sedimentary rocks are present along the Defiance monocline and Defiance Plateau, in addition to extensive outcrops located on the Four Corners Platform (O‘Sullivan and Beikman 1963). Upper Cretaceous geologic formations consist of thick accumulations of sandstone, limestone, and shales corresponding to the fluctuating shoreline of the Western Interior Seaway, a vast shallow sea that covered much of New Mexico (Hawley 1986; Kues and Callender 1986). These Upper Cretaceous formations are found throughout the San Juan Basin (O‘Sullivan and Beikman 1963).

Cenozoic geologic formations in the basin are dominated by sedimentary strata and igneous formations associated with the desertification of the region and a sustained period of volcanism (Cather et al. 2008). These sedimentary strata consist of a thick sandstone formation capping the Chuska Mountains, which also is present as landslide debris along the eastern flanks of the range displaced during the Pleistocene (Gregory 1917; Wright 1956). Tertiary igneous rock formations consist of volcanic plugs, dike ridges, and minor lava flows that overlie and intertongue sedimentary deposits in the Chuska Mountains and Valley. These igneous formations also constitute the uplands that are located on the southeastern margin of the Colorado Plateau (Smith 2004).
Figure 2. Physiographic provinces of the greater San Juan Basin.
Figure 3. Structure of the San Juan Basin.
The San Juan Basin is an asymmetrical syncline initially formed during the Laramide orogeny, a profound tectonic event spanning from the Late Cretaceous through the early Tertiary periods. Prior to the Laramide event, the San Juan Basin was near sea level until the final marine transgression occurred around 74 million years ago (mya) (Cather 2004). Orogenic processes associated with the Laramide deformation marked the beginning of relative uplift, monocline formation, and basin subsidence on the Colorado Plateau. Recent studies of Cenozoic landscape evolution on the Colorado Plateau have revealed that epeirogenic uplift resulting from volcanic magmatism and/or post-Laramide removal of the Farallon plate was the cause of major rock uplift on the plateau rather than orogenic or rift-related processes (Cather et al. 2008; Roy et al. 2009).

During the early to middle Eocene culmination of the Laramide orogeny, fluvial systems developed across the southern and central portions of the Colorado Plateau originating from the highlands located to the south and west. This episode of fluvial activity resulted in a low-relief erosional surface across portions of the plateau (Cather et al. 2008). Major volcanic centers developed along the eastern and southeastern margin of the San Juan Basin.
of the Colorado Plateau during the late Eocene. This volcanic activity resulted in the formation of relatively continuous constructional highlands that effectively trapped the fluvial drainages that previously exited the plateau to the east (Cather 1992, 2004; Cather et al. 2008).

Aggradation ensued on the Colorado Plateau, driven by the restriction of fluvial drainages and piedmont deposits from southwestern Colorado that prograded southwestward across the San Juan Basin (Cather et al. 2003). These paleogeomorphic events are recorded in the Deza Member of the Chuska Sandstone formation consisting of a basal fluvial unit onlapped over portions of the low-relief paleoerosion surface (Tsaille surface) in response to the piedmont-drainage system that headed in the San Juan Mountains (Cather et al. 2003; Cooley 1958; Schmidt 1991).

The late Eocene was marked by a shift to widespread aeolian deposition from the prevailing southwest-erly paleowinds (Repenning et al. 1958; Wright 1956). This period of sustained aeolian activity corresponds to a global transition from greenhouse to icehouse conditions and the major glaciation of Antarctica (the Oi-1 event) (Barrett 2003; DeConto and Pollard 2003; Evanoff et al. 1992; Obradovich et al. 1995; Zachos et al. 2001). A transition from fluvial to aeolian (loessic) sedimentation across the Great Plains and, as suggested by paleontologic evidence, drying and minor cooling occurred during the Oi-1 event, which may have also been responsible for the aridification of this region (Zachos et al. 2001). During this time, a sandy aeolian environment enveloped the Colorado Plateau as widespread dune development resulted in the formation of a regional sand sea (Chuska erg) that occupied much of the central and southern portions of the plateau (Cather et al. 2008). Volcanism continued throughout erg development resulting in intertongued volcanic and sedimentary deposits formed around the developing volcanic aprons as aeolianites aggraded and lapped eastward (Cather et al. 2008). The Narbona Pass Member of the Chuska Sandstone formation records aeolian sediment transport along the regional paleoslope established during the Deza fluvial deposition consisting of thick sand accumulations (500 m) intercalated with arenaceous detritus (Cather et al. 2003; Gregory 1917; Lucas and Cather 2003; Wright 1956).

Aeolianite deposition associated with the Chuska erg ceased during the shift to a warmer and wetter climate and reduced Antarctic glaciation around the late Oligocene (Cather et al. 2008; Zachos et al. 2001). Major volcanism ended in the San Juan volcano field subsequent to voluminous eruptions of mafic lavas ca. 26–25 mya (Chapin et al. 2004). This time period also corresponds to the beginning of tectonic activity associated with the formation of the Rio Grande Rift, located along the eastern margin of the Colorado Plateau (Chapin and Cather 1994; Smith 2000). Several phreatomagmatic eruption centers (maars) caused by the interaction between shallow groundwater and ascending magmas in the Navajo volcano field occurred within the Chuska Mountains closely following the end of aeolian accumulation (Semken 2003). Miocene trachybasaltic lavas unconformably overlie the relict sand sea represented by the Narbona Pass Member capping the Chuska Mountains, in addition to the intrusive volcanic necks that form Roof Butte (Appledorn and Wright 1957; Semken 2003). A degradational regime ensued on the Colorado Plateau following the end of the Chuska erg deposition that has continued into the Holocene (Cather et al. 2008).

The landscape of the Navajo Section is characterized by broad rolling plains carved on loosely consolidated bedrock interspersed with cuestas and tablelands capped by gently dipping sandstone beds (Hawley 1986). Narrow hogback belts eroded on steeply dipping strata of monoclines flanking major structural anticlines are also present throughout the Navajo Section. Canyonlands and escarpments are confined to the eastern portion of the San Juan Basin, where relatively short canyon reaches intersect broad stream valleys (Hawley 1986). The central part of the San Juan Basin is characterized by a low relief consisting of wide valleys with sporadic cuestas or mesas; the relief increases toward the surrounding mountain ranges along the outer parts of the basin (Warren 1967). The Chuska Valley and Mountains include numerous volcanic rocks, necks, dikes, sills, a maar crater, and minor lava flows that form distinctive topographic features associated with the Navajo volcanic field (Appledorn and Wright 1957; Ehrenberg 1978). The most notable of these volcanic features is the Shiprock, which consists of a breccia neck and minette dikes rising 482 m (1,583 feet) above the Chuska Valley (Semken 2003).

Major perennial water sources in the San Juan Basin consist of the San Juan, Animas, and La Plata Rivers, which coalesce near Farmington (Hawley 1986). The east-west-trending San Juan River crosses the San Juan Basin along a wide valley flat bordered by Quaternary gravel terraces, rock scarps, and badland areas
The Chaco River and Canyon Largo serve as major tributaries to the San Juan River and are located in the southern drainage basin. Along most if its course, the Chaco River is characterized by a wide, flat sandy bed bordered by alluvial flats and terraces (Warren 1967). During adequate rainfall, the Chaco River flows northward into the San Juan River. Lower elevations of the Chuska Valley are separated from the Chaco River by a long, dissected ridge of mesas, buttes, and cuestas. Tributaries of the Chaco River, including Deadman’s, Pena Blanca, Captain Tom, Theodore, and Naschitti Washes, head in the Chuska Mountains and flow east and northeast across the Chuska Valley (Warren 1967).

The Chuska Mountains, along with the Lukachukai and Tunitcha subranges, are situated between the Defiance Uplift and monocline, bordering the southwestern margin of the San Juan Basin. A thick succession of sandstone that dips gently to the west forms the tableland capping the range, with prominent bounding escarpments paralleling the Chuska Valley on the northeast (Hawley 1986). The eastern flank of the mountains from Toadlena to Tohatchi is covered by immense landslide debris (Wright 1956). Intrusive volcanic formations, including Roof Butte, Tsaile Buttes, Beautiful Mountain, Sonsela Buttes, the Palisades, and a minor lava flow at Narbona Pass are located throughout the range (Semken 2003; Wright 1956). The Chuska Mountains represents a topographic high on the Colorado Plateau, with elevations rising in excess of 2,700 m (9,000 feet) above mean sea level [AMSL]. Roof Butte is the highest point of the range, situated at 2,994 m (9,823 feet) AMSL.

Situated between the Chuska Mountains on the west and the Chaco River on the east is spacious, open lowland referred to as the Chuska Valley or Slope (Marshall et al. 1979; Warren 1967). Deep valleys and canyons are located along the eastern front of the Chuska Mountains that broaden into wide alluvial flats as elevations descend to the basin floor. The lowland area includes occasional discontinuous washes that diminish into sandy flats. Fan alluvium deposited across the Chuska Valley is not heavily dissected; however, recent downcutting has impacted stream courses primarily located to the north. For the most part, surface water along the Chuska Valley is in the form of springs and seeps, as well as intermittent streams. Numerous springs have formed at the base of the Chuska Sandstone unit and the Menefee Formation Shale along the eastern mountain front. Although a few of the washes located near Sanostee and Toadlena originate as perennial water sources, these channels become ephemeral or intermittent as they reach the lower elevations toward the basin floor (Warren 1967). The larger of these drainages within the southern and eastern portions of the valley include the Sheep Springs, Naschitti, Salt Springs, Tocito, Muddy Wash, Red Willow, and Figueredo Washes, which trend eastward toward the Chaco River.

Quaternary Geomorphology and Surface Soils

Quaternary landscape evolution in the San Juan Basin has been dominated by an erosional regime beginning in the late Oligocene and continuing into the Holocene epoch (Cather et al. 2008). Major Quaternary deposits in the basin consist of gravel terrace, landslide debris, dunes, alluvium, and pediment gravels (O’Sullivan and Beikman 1963). Modern stream courses in the San Juan Basin were established during the middle Tertiary (Hunt 1956). These drainage were subject to erosion and downcutting during the early Pleistocene, coinciding with the formation of pediment surfaces on the eastern slopes of the Chuska Mountains (Allen and Balk 1954). Landslide debris consisting of Chuska Sandstone and igneous rock were displaced on the eastern slopes of the Chuska Mountains during the late Pleistocene–Holocene. During this time, pediment surfaces expanded and gravel terraces also began to form along the San Juan River (Watson and Wright 1963). Broad sheets of Quaternary alluvium border fluvial drainages and ephemeral streams in the San Juan Basin and mantle the Chuska Valley (O’Sullivan and Beikman 1963). Sizable dune fields also formed primarily east of the Chaco River as well as within the Captain Tom locality.

Throughout the late Pleistocene–Holocene, the San Juan Basin has been witness to alternating periods of alluviation and erosion. Early reconstructions of Quaternary deposits in the basin suggest at least three widespread episodes of aeolian deposition accompanied by differential soil formation that were caused by dry climatic intervals during the late Pleistocene, middle Holocene, and late Holocene (Hall 1990; Wells et al. 1990). However, Wells et al. (1990) has suggested that dune formation in Chaco Canyon during the middle
Holocene may have been in response to relatively moist conditions. A recent study (Smith and McFaul 1997) of Quaternary stratigraphy and soil development in the western San Juan Basin has proposed additional depositional episodes that were followed by periods of landscape stability and soil formation (Figure 5).

Smith and McFaul’s (1997) framework for Quaternary landscape evolution designated six widespread episodes of regional land-surface stability, based on the succession of Pleistocene and Holocene soils (Tohatchi I–VI) documented across the basin. These paleosols are mantled with aeolian, alluvial, and playa sediment deposits indicating periods of landscape stability and soil formation that were sometimes followed by unfavorable conditions marked by erosion and concurrent depositional episodes, as well as wetter and cooler periods associated with playa formation. Natural Resources Conservation Service surface soils mapped within the U.S. 491 project corridor are presented in Table 2 and Figures 6–9.

Figure 5. Quaternary geology chronologies developed for the San Juan Basin and the desert Southwest (Smith and McFaul 1997).
<table>
<thead>
<tr>
<th>Soil Series</th>
<th>Taxonomic Class</th>
<th>Soil Profile</th>
<th>Textural Class</th>
<th>Landform Position</th>
<th>Parent Material</th>
<th>Slope (%)</th>
<th>Elevation (m AMSL)</th>
<th>Elevation (feet AMSL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hanksville clay loam</td>
<td>Typic Torriorthents</td>
<td>A-Cy-Cyk-Cr</td>
<td>clay loam, silty clay, shale</td>
<td>hillslopes, eroding shale hills, lower terraces, alluvial fans</td>
<td>residuum, colluvium, and alluvium, derived from shale</td>
<td>0–50</td>
<td>1,220–2,070</td>
<td>(4,000–6,800)</td>
</tr>
<tr>
<td>Jeddito loamy sand</td>
<td>Typic Torriorthents</td>
<td>A-C1-C2-C3-C4-C5</td>
<td>loamy sand, fine sandy loam, coarse sand</td>
<td>stream terraces</td>
<td>stream alluvium</td>
<td>0–5</td>
<td>1,430–1,860</td>
<td>(4,700–6,100)</td>
</tr>
<tr>
<td>Jocity sandy clay loam</td>
<td>Typic Torrifluvents</td>
<td>A-C1-C2</td>
<td>sandy clay loam, fine sandy loam</td>
<td>floodplains, alluvial fans</td>
<td>stream alluvium</td>
<td>0–4</td>
<td>1,340–1,890</td>
<td>(4,400–6,200)</td>
</tr>
<tr>
<td>Mesa loam</td>
<td>Typic Calciargids</td>
<td>A-Bt-Bk1-2Bk2-2Bk3</td>
<td>loam, clay loam, very gravelly loam</td>
<td>high terraces, fans, mesa tops, relict pediment surfaces</td>
<td>alluvium or pedisediments</td>
<td>0–12</td>
<td>1,280–1,830</td>
<td>(4,200–6,000)</td>
</tr>
<tr>
<td>Notal silty clay loam</td>
<td>Typic Torriorthents</td>
<td>A-By-BCy-Cy</td>
<td>silty clay loam, silty clay</td>
<td>low stream terraces on valley floors, small depressions of undulating plateaus</td>
<td>alluvium, stream alluvium, and fan alluvium derived from shale, siltstone, and sandstone</td>
<td>0–5</td>
<td>1,430–1,980</td>
<td>(4,700–6,500)</td>
</tr>
<tr>
<td>Razito loamy fine sand</td>
<td>Typic Torripsamments</td>
<td>A-C1-C2</td>
<td>loamy fine sand, fine sand</td>
<td>stable dunes of undulating plateaus, mesas, cuestas, valley margins, valley floors</td>
<td>aeolian material and alluvium derived from sandstone</td>
<td>1–8</td>
<td>960–2,070</td>
<td>(3,150–6,800)</td>
</tr>
<tr>
<td>Redlands loamy fine sand</td>
<td>Typic Haplargids</td>
<td>A-AB-BA-Bt1-Bt2-Bk</td>
<td>loamy fine sand, fine sandy loam, clay loam</td>
<td>fan remnants, mesas, structural benches</td>
<td>aeolian material and alluvium derived from sandstone and shale</td>
<td>1–8</td>
<td>1,460–1,890</td>
<td>(4,800–6,200)</td>
</tr>
<tr>
<td>Shiprock fine sandy loam</td>
<td>Typic Haplargids</td>
<td>A-Bt-Bk1-Bk2</td>
<td>fine sandy loam</td>
<td>mesa summits, plateaus, cuestas, fan remnants, fan terraces on valley sides and sideslopes of hills</td>
<td>aeolian material, fan alluvium, and slope alluvium derived from sandstone and shale</td>
<td>0–15</td>
<td>1,460–2,070</td>
<td>(4,800–6,800)</td>
</tr>
<tr>
<td>Werito loam</td>
<td>Sodic Haplocambids</td>
<td>A-Bwn1-Bwn2-2Bkn-3By-3C-3Cr</td>
<td>loam, clay loam, silty clay, shale</td>
<td>toeslopes below structural benches, mesas, cuestas</td>
<td>alluvium derived from sandstone and shale</td>
<td>1–3</td>
<td>1,650–1,770</td>
<td>(5,400–5,800)</td>
</tr>
</tbody>
</table>

Key: AMSL = above mean sea level
Figure 6. NRCS surface soils mapped in Segment 4 of the U.S. 491 project corridor.
Figure 7. NRCS surface soils mapped in Segment 3 of the U.S. 491 project corridor.
Figure 8. NRCS surface soils mapped in Segment 2 of the U.S. 491 project corridor.
Figure 9. NRCS surface soils mapped in Segment 1 of the U.S. 491 project corridor.
Climate, Flora, and Fauna

The San Juan Basin ecosystem is intrinsically linked to the regional climate, with the primary factor consisting of moisture availability. Precipitation has a major influence on the formation of plant communities, availability of wild-plant resources, and dynamics of wildlife populations (Scurlock 1998). The variability of temperatures over time has also influenced the distributions of specific vegetation types and surface water availability, which in turn has directly impacted human activities (Tuan et al. 1973).

New Mexico climate is generally characterized by light precipitation, a wide range of diurnal and seasonal temperature variations, abundant sunshine, low relative humidity, and high evaporation rates (Bennett 1986; Scurlock 1998). These climatic factors are influenced by the proximity of New Mexico to the Pacific Ocean and Gulf of Mexico, distance from the equator, topography, and varying ranges in elevation. Overall, temperatures in the state are highly variable, primarily resulting from different elevation ranges and latitude. Temperature fluctuations vary greatly for diurnal, seasonal, annual, and longer periods, with average maximum temperatures typically occurring in late June or early July, whereas January is generally considered the coldest month (Bennett 1986). The project corridor is generally located between 1,770 and 1,920 m (5,800 and 6,300 feet) AMSL within a semi-arid setting characterized by high average temperatures and evaporation rates. Average high and low temperatures for the area range between 32.7°C and −7.2°C (90.8°F and 19.1°F). Evaporation rates in the state are two to five times greater than the precipitation amounts, which also impacts native vegetation, crops, runoff, streamflows, lake levels, and ground water. These high evaporation rates are influenced by a number of environmental factors, including solar radiation, air temperature, relative humidity, wind, water turbidity, water temperature, soil texture, depth of water table, and vegetation (Bennett 1986:48–49; Tuan et al. 1973:112–115).

Precipitation across the majority of New Mexico predominately occurs during the summer months, with the bulk of the annual rainfall originating from localized thunderstorms of high intensity and short duration. This pattern emerges from the instable moist air moving inland from high pressure conditions in the Gulf of Mexico (Bennett 1986; Dick-Peddie 1993). Summer thunderstorms typically occur along the southern slopes of the Rocky Mountains in the late afternoon and result from the heating of the rocky terrain that, in turn, produces vigorous, rising air currents that intermixes with the moist Gulf air and develops into convectional storms (Bennett 1986; Dick-Peddie 1993). Cyclonic storms of moist Pacific air masses typically moving eastward across the landscape produce most of the winter snowfall precipitation (Scurlock 1998).

Seasonal, annual, and decadal precipitation in New Mexico varies greatly, resulting in dry or sustained drought periods that can persist a single season, a year, or longer (Scurlock 1998). The average annual rainfall in New Mexico is approximately 38 cm (15 inches); however, precipitation increases with elevation, especially along the montane regions (Dick-Peddie 1993). For instance, the higher elevations within the Chuska Mountains may receive an average 50+ cm (20+ inches) a year, in contrast to the lower elevations within the San Juan Basin, which may only receive 20–25 cm (8–10 inches) a year (Dick-Peddie 1993; Harris 1967). Average annual rainfall documented from the Tohatchi, New Mexico, weather station from 1914 to 1992 was 19.1 cm (7.5 inches), whereas the average from the Sheep Springs, New Mexico, weather station from 1948 to 1971 was 15 cm (6 inches). The growing season for the San Juan Basin typically averages 150 frost-free days.

The U.S. 491 project corridor is located within the transition between the Coniferous and Mixed Woodland, Great Basin Desertschrub, and Desert Grassland biotic communities (Figure 10). Woodland vegetation differs from forest vegetation in that the canopies of individual woodland trees rarely overlap and woodland tree species are commonly smaller in stature (Dick-Peddie 1993). The degree of openness within woodland areas also varies greatly, with the piñon-juniper woodland predominately characterized by widely spaced stands. The coniferous woodland biome covers extensive areas across the American Southwest and likely evolved in the Great Basin from the Madro-Tertiary geoflora (Brown 1982a). Coniferous woodland in New Mexico is typically characterized by piñon-juniper, along with mixed woodland typically consisting of broadleaf deciduous species, such as Gamble oak. Stand density of the piñon-juniper woodland generally increases with ascending elevation, in which the lower, drier boundary of this zone is often characterized by widely spaced individual trees and the upper, moist boundary may consist of an entirely closed canopy (Dick-Peddie 1993).
Figure 10. Biotic communities within the U.S. 491 project corridor.
This vegetation community is analogous to Brown’s (1994) Great Basin Conifer Woodland. Single-leaf piñon (Pinus edulis) is the most common piñon within this vegetation zone in New Mexico. This species is typically accompanied by one-seed juniper (Juniperus monosperma), along with big sagebrush (Artemisia tridentata) as the dominant shrub.

Scrubland vegetation is characteristically dominated by shrub species with low available-moisture requirements. Plants dominating the Great Basin desertscrub can survive in deep sands, whereas common shrub species have specifically adapted water-retention features (Dick-Peddie 1993). Environmental conditions such as low annual precipitation, short growing season, a hot dry atmosphere, desiccating winds, steep slopes, southwest-facing exposures, shallow rocky soils, and sandy gravelly and saline soils are contributing factors responsible for the formation of this type of vegetation community (Dick-Peddie 1993). The Great Basin desertscrub biome is presumed to have appeared within the last 5,000–12,000 years (Brown 1982b; Butler 1976; Stutz 1978). Major shrubs within this community include big sagebrush, shadscale (Atriplex confertifolia), greasewood (Sarcobatus vermiculatus), and fourwing saltbush (Atriplex canescens) (Dick-Peddie 1993).

Desert grassland vegetation has also been characterized as semidesert grassland (Brown 1982b), as well as desert shrubland, desert savanna, desert plains grassland, and desert-grassland transition. This ecotone is codominated by sagebrush (Artemisia) or saltbush (Atriplex) shrubs and grasses (Dick-Peddie 1993). Much of the desert grassland in New Mexico occupies areas that previously consisted of grassland. Overgrazing of grassland areas has resulted in the replacement of palatable grasses into various forbs and shrubs. Because of the transitional nature of the ecotone resulting from intensive grazing activities, the composition of plant species in desert grassland areas is highly variable. Some plant species can be considered diagnostic in understanding past vegetation patterns that had persisted prior to this transition. It has been proposed that desert grassland communities, including big sagebrush or shadscale shrub dominants, and cool-season grasses as grass dominants represent recently transitioned communities that consisted of plains-mesa grassland prior to this century (Dick-Peddie 1993:109). The dominant grass within this ecotone typically consists of black grama (Bouteloua eriopoda), whereas a variety of species constitute the shrub and forb components (Dick-Peddie 1993). An exhaustive list of vegetation species of the Chuska Valley was compiled as a result of an environmental survey conducted by the Museum of New Mexico in conjunction with the Navajo Indian Irrigation Project (Harris et al. 1967). The plant species documented as a result of this project are presented in Table 3.

Plant identifications and modern observations on surface vegetation patterns were made by Pamela McBride as a result of a vegetation survey conducted in the project corridor during the fieldwork investigations. The effects of overgrazing and the paucity of winter precipitation are visible in the scarcity of vegetation in the project area except along roadsides where runoff allows plants to survive. This picture of poor land health may be in some part due to the time of year when the area was surveyed. The spring of 2013 was relatively cold and rainfall has been scarce to absent. Roadside vegetation consists mostly of bunchgrasses, such as Sporobolus (either sand dropseed [Sporobolus cryptandrus] or alkali sacaton [Sporobolus airoides]), and possibly ring muhly (cf. Muhlenbergia torreyi) and rabbitbrush (cf. rubber rabbitbrush [Ericameria nauseosa]). One noticeable pattern is that the density of fourwing saltbush increases as one proceeds north from the junction of Route 9 with U.S. 491 to Sheep Springs.

Changes in vegetation patterns were documented at a sample of the U.S. 491 project sites. Fourwing saltbush, cf. galleta grass (Hilaria jamesii), and a member of the aster family (Asteraceae [Compositae]) grow along the road in proximity of NM-H-62-112. Broom snakeweed (Gutierrezia sarothrae), sand dropseed or alkali sacaton, and the same member of the aster family growing near the road are also found at the site itself. NM-H-62-105 is dominated by fourwing saltbush and sand dropseed or alkali sacaton, whereas rabbitbrush is especially lush near the roadside. At NM-H-62-99, broom snakeweed and stickleaf (Mentzelia sp.) grow alongside U.S. 491 and fourwing saltbush and sand dropseed or alkali sacaton are prolific. Indian ricegrass (Achnatherum hymenoides [Oryzopsis hymenoides]) and cf. galleta grass are also present in the vegetation community at the site. Dominant species at NM-Q-3-72 consist of Russian thistle (Salsola sp.), alkali sacaton or sand dropseed, mustard (Brassicaceae [Cruciferae]), scarlet globemallow (Sphaeralcea coccinea), and fourwing saltbush. Indian ricegrass and cf. galleta grass are also fairly widespread at the site.
### Table 3. Vegetation Species Documented during the Current Vegetation Survey and the Chuska Valley Biological Survey

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Agave family</strong></td>
<td>Agavaceae</td>
</tr>
<tr>
<td>Great Plains yucca</td>
<td>Yucca glauca</td>
</tr>
<tr>
<td><strong>Buckwheat family</strong></td>
<td>Polygonaceae</td>
</tr>
<tr>
<td>Buckwheat (probably perennial pink buckwheat)</td>
<td>Eriogonum sp. (probably <em>E. effusum</em>)</td>
</tr>
<tr>
<td><strong>Cactus family</strong></td>
<td>Cactaceae</td>
</tr>
<tr>
<td>Dagger cholla</td>
<td>Grusonia clavata</td>
</tr>
<tr>
<td>Prickly pear</td>
<td>Opuntia spp.</td>
</tr>
<tr>
<td><strong>Cypress family</strong></td>
<td>Cupressaceae</td>
</tr>
<tr>
<td>One-seed juniper</td>
<td>Juniperus monosperma</td>
</tr>
<tr>
<td><strong>Elm family</strong></td>
<td>Ulmaceae</td>
</tr>
<tr>
<td>Siberian elm</td>
<td>Ulmus pumila</td>
</tr>
<tr>
<td><strong>Goosefoot family</strong></td>
<td>Chenopodiaceae</td>
</tr>
<tr>
<td>Fourwing saltbush</td>
<td>Atriplex canescens</td>
</tr>
<tr>
<td>Goosefoot</td>
<td>Chenopodium sp.</td>
</tr>
<tr>
<td>Russian thistle (probably prickly Russian thistle)</td>
<td>Salsola sp. (probably <em>S. tragus</em>)</td>
</tr>
<tr>
<td>Shadscale</td>
<td>Atriplex confertifolia</td>
</tr>
<tr>
<td><strong>Grass family</strong></td>
<td>Poaceae [Gramineae]</td>
</tr>
<tr>
<td>Alkali sacaton</td>
<td>Sporobolus airoides</td>
</tr>
<tr>
<td>Blue grama</td>
<td>Bouteloua gracilis</td>
</tr>
<tr>
<td>Galleta grass</td>
<td><em>cf. Hilaria jamesii</em></td>
</tr>
<tr>
<td>Indian ricegrass</td>
<td><em>Achnatherum hymenoides</em> [<em>Oryzopsis hymenoides</em>]</td>
</tr>
<tr>
<td>Ring muhly</td>
<td><em>Muhlenbergia torreyi</em></td>
</tr>
<tr>
<td>Sand dropseed</td>
<td><em>Sporobolus cryptandrus</em></td>
</tr>
<tr>
<td>Sandhill muhly</td>
<td><em>Muhlenbergia pungens</em></td>
</tr>
<tr>
<td><strong>Joint-fir family</strong></td>
<td>Ephedraceae</td>
</tr>
<tr>
<td>Mormon tea</td>
<td>Ephedra sp.</td>
</tr>
<tr>
<td><strong>Loasa family</strong></td>
<td>Loasaceae</td>
</tr>
<tr>
<td>Stickleaf</td>
<td>Mentzelia sp.</td>
</tr>
<tr>
<td><strong>Mallow family</strong></td>
<td>Malvaceae</td>
</tr>
<tr>
<td>Scarlet globemallow</td>
<td><em>Sphaeralcea coccinea</em></td>
</tr>
<tr>
<td><strong>Mustard family</strong></td>
<td>Brassicaceae [Cruciferae]</td>
</tr>
<tr>
<td>Blunt tansy mustard</td>
<td>Descurainia obtusa</td>
</tr>
<tr>
<td>Spectacle pod</td>
<td><em>Dimorphocarpa wislizeni</em> [<em>Dithyrea wislizeni</em>]</td>
</tr>
<tr>
<td>Oleaster family</td>
<td>Elaeagnaceae</td>
</tr>
<tr>
<td>Russian olive</td>
<td><em>Elaeagnus angustifolia</em></td>
</tr>
<tr>
<td><strong>Parsley family</strong></td>
<td>Apiaceae</td>
</tr>
<tr>
<td>Chimajá</td>
<td><em>Cymopterus glomeratus</em></td>
</tr>
<tr>
<td><strong>Aster family</strong></td>
<td>Asteraceae [Compositae]</td>
</tr>
<tr>
<td>Big sagebrush</td>
<td><em>Artemisia tridentata</em></td>
</tr>
<tr>
<td>Broom snakeweed</td>
<td><em>Gutierrezia sarothrae</em></td>
</tr>
<tr>
<td>Cocklebur</td>
<td><em>Xanthium strumarium</em> [<em>Xanthium saccharatum</em>]</td>
</tr>
<tr>
<td>Rabbitbrush (probably rubber rabbitbrush)</td>
<td><em>Chrysothamnus/Ericameria</em> sp. (probably <em>E. nauseous</em>)</td>
</tr>
<tr>
<td>Sand sagebrush</td>
<td><em>Artemisia filifolia</em></td>
</tr>
</tbody>
</table>

20
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunflower (probably common sunflower)</td>
<td><em>Helianthus</em> (probably <em>H. annuus</em>)</td>
</tr>
<tr>
<td>Pea family</td>
<td>Fabaceae [Leguminosae]</td>
</tr>
<tr>
<td>Yellow sweet clover</td>
<td><em>Mellotus officinalis</em></td>
</tr>
<tr>
<td>Phlox family</td>
<td>Polemoniaceae</td>
</tr>
<tr>
<td>Long-flowered trumpet gilia</td>
<td><em>Ipomopsis longiflora</em></td>
</tr>
<tr>
<td>Plantain family</td>
<td>Plantaginaceae</td>
</tr>
<tr>
<td>Buckhorn plantain</td>
<td><em>Plantago lanceolata</em></td>
</tr>
<tr>
<td>Potato family</td>
<td>Solanaceae</td>
</tr>
<tr>
<td>Ivy-leaved groundcherry</td>
<td><em>Physalis hederfolia</em></td>
</tr>
<tr>
<td>Pale wolfberry</td>
<td><em>Lycium pallidum</em></td>
</tr>
<tr>
<td>Tamarix family</td>
<td>Tamaricaceae</td>
</tr>
<tr>
<td>Salt cedar</td>
<td><em>Tamarix ramosissima</em> [Tamarix pentandra]</td>
</tr>
</tbody>
</table>

**Additional Species Identified in the Chuska Valley (Harris 1967)**

| Amaranth family                  | Amaranthaceae                               |
| Small-flower sandpuffs           | *Tripterocalyx micranthus*                 |
| Wooton’s sandpuffs               | *Tripterocalyx wootonii*                   |
| Aster family                     | Asteraceae [Compositae]                    |
| Aster                            | *Chaetopappa ericoide [Aster arenosus]*    |
| Dandelion                        | *Taraxacum officinale*                     |
| Golden aster                     | *Heterotheca villosa var. foliosa* [Chrysopsis foliosa] |
| Mule-ears                        | *Scabrethia scabra ssp. scabra* [Wyethia scabra] |
| Orange sneeze-weed               | *Hymenoxys hoopesii* [Helenium hoopesii]   |
| Threadleaf groundsel             | *Senecio flaccidas var. flaccidus* [Senecio longilobus] |
| Beech family                     | Fagaceae                                    |
| Gambel oak                       | *Quercus gambeli*                          |
| Birch family                     | Betulaceae                                  |
| Alder                            | *Abus* sp.                                  |
| Borage family                    | Boraginaceae                                |
| Cryptantha                       | *Cryptantha flava*                         |
| Cactus family                    | Cactaceae                                   |
| Cholla                           | *Cylindropuntia* spp.                      |
| Caper family                     | Capparaceae [Capparidaceae]                |
| Yellow bee plant                 | *Peritoma lutea* [Cleome lutea]            |
| Cashew family                    | Anacardiaceae                              |
| Skunkbush                        | *Rhus aromatica* [R. trilobata]            |
| Cattail family                   | Typhaceae                                   |
| Arrow-head                       | *Sagittaria cuneata*                       |
| Cattail                          | *Typha angustifolia*                       |
| Water-plantain                   | *Alisma triviale*                          |
| Cypress family                   | Cupressaceae                                |
| Rocky mountain juniper           | *Juniperus scopulorum*                     |
| Evening primrose family          | Onagraceae                                  |
| Evening primrose                 | *Oenothera pallida* spp. *runcinata* [Oenothera runcinata] |
| Willow-weed                      | *Epilobium ciliatum* spp. *ciliatum* [Epilobium adenocaulon] |
| Figwort family                   | Scrophulariaceae                            |
| Beardlip penstemon               | *Penstemon barbatus*                       |

continued on next page
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Broadbeard beardtongue</td>
<td><em>Penstemon angustifolius</em></td>
</tr>
<tr>
<td>Creeping penstemon</td>
<td><em>Penstemon linarioides</em></td>
</tr>
<tr>
<td>Meadow beardtongue</td>
<td><em>Penstemon rydbergii</em></td>
</tr>
<tr>
<td>Monkey-flower</td>
<td><em>Mimulus glabratus</em></td>
</tr>
<tr>
<td>Flax family</td>
<td>Linaceae</td>
</tr>
<tr>
<td>Flax</td>
<td><em>Linum aristatum</em></td>
</tr>
<tr>
<td>Geranium family</td>
<td>Geraniaceae</td>
</tr>
<tr>
<td>Heron-bill</td>
<td><em>Erodium cicutarium</em></td>
</tr>
<tr>
<td>Richardson’s geranium</td>
<td><em>Geranium richardsonii</em></td>
</tr>
<tr>
<td>Tufted geranium</td>
<td><em>Geranium caespitosum</em> [G. eremophilum]</td>
</tr>
<tr>
<td>Goosefoot family</td>
<td>Chenopodiaceae</td>
</tr>
<tr>
<td>Greasewood</td>
<td><em>Sarcobatus vermiculatus</em></td>
</tr>
<tr>
<td>Grass family</td>
<td>Poaceae [Gramineae]</td>
</tr>
<tr>
<td>Bluestem</td>
<td><em>Andropogon gerardii</em> spp. hallii [A. hallii]</td>
</tr>
<tr>
<td>Cheatgrass</td>
<td><em>Bromus tectorum</em></td>
</tr>
<tr>
<td>Creeping bentgrass</td>
<td><em>Agrostis stolonifera</em> [A. palustris]</td>
</tr>
<tr>
<td>Fox-tail</td>
<td><em>Alopecurus aequalis</em></td>
</tr>
<tr>
<td>Interior bluegrass</td>
<td><em>Poa interior</em></td>
</tr>
<tr>
<td>Kentucky bluegrass</td>
<td><em>Poa pratensis</em></td>
</tr>
<tr>
<td>Needlegrass</td>
<td><em>Hesperostipa comata</em> [Stipa comata]</td>
</tr>
<tr>
<td>Nodding brome</td>
<td><em>Bromus anomalus</em></td>
</tr>
<tr>
<td>Pine dropseed</td>
<td><em>Muhlenbergia tricholepis</em> [Blepharoneuron tricholepis]</td>
</tr>
<tr>
<td>Pinon ricegrass</td>
<td><em>Piptochaetium fimbriatum</em></td>
</tr>
<tr>
<td>Rabbit-foot grass</td>
<td><em>Polygong monspeliensis</em></td>
</tr>
<tr>
<td>Red threeawn</td>
<td>*Aristida purpurea var. longiseta [A. longiseta]</td>
</tr>
<tr>
<td>Saltgrass</td>
<td><em>Distichlis spicata</em> spp. stricta [Distichlis stricta]</td>
</tr>
<tr>
<td>Slender wheatgrass</td>
<td><em>Elymus trachycaulus</em> [Agropyron trachycaulum]</td>
</tr>
<tr>
<td>Squirrel-tail</td>
<td><em>Elymus elymoides</em> [Sitanion hystrix]</td>
</tr>
<tr>
<td>Timothy</td>
<td><em>Phleum pratense</em></td>
</tr>
<tr>
<td>Tufted hairgrass</td>
<td><em>Deschampsia cespitosa</em></td>
</tr>
<tr>
<td>Wheatgrass</td>
<td><em>Pascopyrum smithii</em> [Agropyron smithii]</td>
</tr>
<tr>
<td>Joint-fir family</td>
<td>Ephedraceae</td>
</tr>
<tr>
<td>Green Mormon tea</td>
<td><em>Ephedra viridis</em></td>
</tr>
<tr>
<td>Torrey’s joint-fir</td>
<td><em>Ephedra torreyana</em></td>
</tr>
<tr>
<td>Lily family</td>
<td>Liliaceae</td>
</tr>
<tr>
<td>False-hellebore</td>
<td><em>Veratrum californicum</em></td>
</tr>
<tr>
<td>False Solomon’s-seal</td>
<td><em>Maianthemum racemosum</em> spp. racemosum [Smilacina racemosa]</td>
</tr>
<tr>
<td>Onion</td>
<td><em>Allium macropetalum</em></td>
</tr>
<tr>
<td>Mallow family</td>
<td>Malvaeeae</td>
</tr>
<tr>
<td>Gray globemallow</td>
<td><em>Sphaeralcea incana</em></td>
</tr>
<tr>
<td>Scaly globemallow</td>
<td><em>Sphaeralcea leptophylla</em></td>
</tr>
<tr>
<td>Maple family</td>
<td>Sapindaceae [Aceraceae]</td>
</tr>
<tr>
<td>Rocky mountain maple</td>
<td><em>Acer glabrum</em></td>
</tr>
<tr>
<td>Mustard family</td>
<td>Brassicaceae [Cruciferae]</td>
</tr>
<tr>
<td>Peppergrass</td>
<td><em>Lepidium montanum</em></td>
</tr>
<tr>
<td>Olive family</td>
<td>Oleaceae</td>
</tr>
<tr>
<td>Adelia</td>
<td><em>Forestiera pubescens var. pubescens</em> [Forestiera neomexicana]</td>
</tr>
</tbody>
</table>
NM-Q-3-58 is on a large dune and has the greatest diversity of plant taxa observed in the project corridor. This pattern was also observed by Harris in his 1967 survey of the Shiprock area in San Juan County. He stated that “in sandy areas, kinds and numbers of plants increase” (Harris 1967:22). Scattered one-seed juniper, rabbitbrush (Chrysothamnus/Ericameria spp.), broom snakeweed, fourwing saltbush, and Russian thistle are some of the plants that grow here that were also seen elsewhere. However, many Mormon tea (Ephedra sp.), sand sagebrush (Artemisia filifolia), sandhill muhly (Muhlenbergia pungens), and a subshrub form of buckwheat (probably perennial pink buckwheat [Eriogonum effusum]) grow here and nowhere else along U.S. 491. More rabbitbrush and Indian ricegrass grow along the roadside at the base of the dune. NM-Q-15-52 is located next to a gas station, and there seems to be a greater number of exotic or invasive species at the site. Buckhorn plantain (Plantago lanceolata), Siberian elm (Ulmus pumila), and yellow sweet clover (Melilotus officinalis) are among the plants in this category. Blunt tansy mustard (Descurainia obtusa) and scarlet

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parsley family</td>
<td>Apiaceae [Umbelliferae]</td>
</tr>
<tr>
<td>Water-parsnip</td>
<td>Berula erecta</td>
</tr>
<tr>
<td>Pea family</td>
<td>Fabaceae [Leguminosae]</td>
</tr>
<tr>
<td>Licorice</td>
<td>Glycyrrhiza lepidota</td>
</tr>
<tr>
<td>Rusty lupine</td>
<td>Lupinus pusillus</td>
</tr>
<tr>
<td>Silvery lupine</td>
<td>Lupinus argenteus var. argenteus [Lupinus sitgreavesii]</td>
</tr>
<tr>
<td>Smallflowered milk-vetch</td>
<td>Astragalus nuttallianus</td>
</tr>
<tr>
<td>Stinking milk-vetch</td>
<td>Astragalus praelongus</td>
</tr>
<tr>
<td>Phlox family</td>
<td>Polemoniaceae</td>
</tr>
<tr>
<td>Gilia</td>
<td>Aliciella subnuda [Gilia subnuda]</td>
</tr>
<tr>
<td>Pine family</td>
<td>Pinaceae</td>
</tr>
<tr>
<td>Blue spruce</td>
<td>Picea pungens</td>
</tr>
<tr>
<td>Single-leaf piñon</td>
<td>Pinus edulis</td>
</tr>
<tr>
<td>Douglas fir</td>
<td>Pseudotsuga menziesii var. menziesii [P. taxifolia]</td>
</tr>
<tr>
<td>Ponderosa pine</td>
<td>Pinus ponderosa</td>
</tr>
<tr>
<td>Potato family</td>
<td>Solanaceae</td>
</tr>
<tr>
<td>Datura</td>
<td>Datura spp.</td>
</tr>
<tr>
<td>Fendler’s groundcherry</td>
<td>Physalis hederifolia var. fendleri [Physalis fendleri]</td>
</tr>
<tr>
<td>Longleaf groundcherry</td>
<td>Physalis longifolia</td>
</tr>
<tr>
<td>Nightshade</td>
<td>Solanum triflorum</td>
</tr>
<tr>
<td>White horse-nettle</td>
<td>Solanum elaeagnifolium</td>
</tr>
<tr>
<td>Rose family</td>
<td>Rosaceae</td>
</tr>
<tr>
<td>Alder-leaf mountain mahogany</td>
<td>Cercocarpus montanus</td>
</tr>
<tr>
<td>Antelope-brush</td>
<td>Purshia tridentata</td>
</tr>
<tr>
<td>Bush cinquefoil</td>
<td>Dasiphora fruticosa [Potentilla fruticosa]</td>
</tr>
<tr>
<td>Serviceberry</td>
<td>Amelanchier utahensis</td>
</tr>
<tr>
<td>Silverweed</td>
<td>Potentilla anserina</td>
</tr>
<tr>
<td>Saxifrage family</td>
<td>Saxifragaceae</td>
</tr>
<tr>
<td>Mockorange</td>
<td>Philadelphus microphyllus</td>
</tr>
<tr>
<td>Saxifrage</td>
<td>Micranthes rhomboidea [Saxifraga rhomboidea]</td>
</tr>
<tr>
<td>Wax currant</td>
<td>Ribes cereum</td>
</tr>
<tr>
<td>Willow family</td>
<td>Salicaceae</td>
</tr>
<tr>
<td>Valley cottonwood</td>
<td>Populus deltoides spp. wislizeni [Populus wislizenii]</td>
</tr>
<tr>
<td>Willow</td>
<td>Salix irrorata</td>
</tr>
</tbody>
</table>
globe to two common weedy species that grow next to the site. Indian ricegrass was particularly prolific, and either sand dropseed or alkali sacaton is also present in this area.

The most-common shrub species at NM-Q-15-29 are rabbitbrush, broom snakeweed, and saltbush. Many immature Russian thistle plants are also present. One chimajá (Cymopterus glomeratus) and a goosefoot (Chenopodium sp.) were observed, along with a few low-growing aster family plants with white flowers. One-seed junipers grow on the ridge above the Pueblo III room block along the flats below overlooking Red Willow Wash. Scattered blue grama (Bouteloua gracilis), big sagebrush, cf. galleta grass, prickly pear (Opuntia spp.), and dagger cholla (Grusonia clavata) are present on the flats. Among the rocks that border the base of the ridge, ivy-leaved groundcherry (Physalis hederifolia) can be found. Indian ricegrass appears in the arroyo cuts on the way down to the wash. Single specimens of spectacle pod (Dimorphocarpa wislizeni [Dithyrea wislizeni]), long-flowered trumpet gilia (Ipomopsis longiflora), and shadscale grow on the banks of the wash. Russian olive (Elaeagnus angustifolia), salt cedar (Tamarix ramosissima [Tamarix pentandra]), cocklebur (Xanthium strumarium [Xanthium saccharatum]), and Great Plains yucca (Yucca glauca) grow in the wash.

Broom snakeweed, big sagebrush, stunted fourwing saltbush, and wolfberry grow on the slope just west of NM-Q-15-46. More saltbush grows near U.S. 491, along with cf. galleta grass. NM-Q-15-28 vegetation consists primarily of pale wolfberry (Lycium pallidum) shrubs averaging about 50–60 cm in height. Small patches of blue grama, scattered fourwing saltbush, and cocklebur are also present, along with many immature Russian thistles (probably prickly Russian thistle [Salsola tragus]). The playa to the west of the site is filled with last year’s dried sunflowers, likely common sunflower (Helianthus annuus).

The Great Basin conifer woodland and desertscrub biotic communities support a diverse array of animal species. A few mammal species are closely tied to the Great Basin conifer woodland, such as the piñon mouse (Peromyscus truei) and the bushy-tailed woodrat (Neotoma albigula). A few mammal species are closely tied to the Great Basin conifer woodland, such as the piñon mouse (Peromyscus truei) and the bushy-tailed woodrat (Neotoma cinerea), whereas a larger number of more-adaptable species are widely distributed are found in this habitat (Brown 1994). This biome also provides a seasonal habitat for a number of montane and subalpine animals, such as Rocky Mountain elk (Cervus elaphus) and mule deer (Odocoileus hemionus) (Brown 1994).

Dominant mammal species that are present within the Great Basin desertscrub community include Townsend’s ground squirrel (Spermophilus townsendii), dark kangaroo mouse (Microdipodops megacephalus), and sagebrush vole (Lemmiscus curta). The former mammals favor the sagebrush community within this biome, in contrast to species commonly distributed in the Atriplex and other desertscrub series, including the pallid kangaroo mouse (Microdipodops pallidus) and the chisel-toothed kangaroo rat (Dipodomys microps). Mammal species best represented at higher altitudes include the Merriam’s shrew (Sorex merriami), Great Basin pocket mouse (Perognathus parvus), Ord’s kangaroo rat (Dipodomys ordii), and the montane vole (Microtus montanus). A number of mammals such as the coyote (Canis latrans) and black-tailed jackrabbit (Lepus californicus) are typically found throughout the Great Basin desertscrub, as well as other western biomes including the semidesert grassland. Pronghorn (Antilocapra americana) are found largely as an incursionary species from the adjacent or former grasslands, and the desert bighorn (Ovis canadensis nelsoni) is commonly lacking from this biome, likely because of transmittable diseases introduced into the area by domestic sheep grazing (Brown 1994). Mammals distributed in the semidesert grassland also include a number of species listed above in addition to spotted ground squirrel (Spermophilus spilosoma), hispid pocket mouse (Chaetodipus hispidus [Perognathus hispidus]), banner-tailed and Merriam’s kangaroo rats (Dipodomys spectabilis and D. merriami, respectively), white-footed mouse (Peromyscus leucopus), hispid and tawny-bellied cotton rats (Sigmodon hispidus and S. fulviventer, respectively), and the white-throated woodrat (Neotoma albigula). Badger (Taxidea taxus) is also typically well represented in semidesert-grassland locales. Fauna species occurring within the Chuska Valley were also documented during the biological component of the environmental survey conducted by the Museum of New Mexico (Harris 1967). An exhaustive list of fauna encountered during the biological survey is presented in Table 4.
## Table 4. Faunal Species Documented in the Chuska Valley

<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Amphibians</strong></td>
<td></td>
</tr>
<tr>
<td>Bullfrog</td>
<td>Lithobates catesbeianus [Rana catesbeiana]</td>
</tr>
<tr>
<td>Central Plains spadefoot</td>
<td>Spea bombifrons [Scaphiopus bombifrons]</td>
</tr>
<tr>
<td>Leopard frog</td>
<td>Lithobates pipiens [Rana pipiens]</td>
</tr>
<tr>
<td>Red-spotted toad</td>
<td>Anaxyrus punctatus [Bufo punctatus]</td>
</tr>
<tr>
<td>Tiger salamander</td>
<td>Ambystoma tigrinum</td>
</tr>
<tr>
<td>Woodhouse’s toad</td>
<td>Anaxyrus woodhousii [Bufo woodhousei]</td>
</tr>
<tr>
<td><strong>Reptiles</strong></td>
<td></td>
</tr>
<tr>
<td>New Mexico garter snake</td>
<td>Thamnophis sirtalis dorsalis [T. dorsalis]</td>
</tr>
<tr>
<td>Collard lizard</td>
<td>Crotaphytus collaris</td>
</tr>
<tr>
<td>Eastern fence lizard</td>
<td>Sceloporus undulatus</td>
</tr>
<tr>
<td>Glossy snake</td>
<td>Arizona elegans</td>
</tr>
<tr>
<td>Gopher snake</td>
<td>Pituophis catenifer</td>
</tr>
<tr>
<td>Lesser earless lizard</td>
<td>Holbrookia maculata</td>
</tr>
<tr>
<td>Little striped whiptail</td>
<td>Cnemidophorus inornatus</td>
</tr>
<tr>
<td>Plateau whiptail</td>
<td>Cnemidophorus velox</td>
</tr>
<tr>
<td>Sagebrush lizard</td>
<td>Sceloporus graciosus</td>
</tr>
<tr>
<td>Short horned lizard</td>
<td>Phrynosoma douglasii</td>
</tr>
<tr>
<td>Side-blotched lizard</td>
<td>Uta stansburiana</td>
</tr>
<tr>
<td>Striped whipsnake</td>
<td>Masticophis taeniatus</td>
</tr>
<tr>
<td>Tree lizard</td>
<td>Urosaurus ornatus</td>
</tr>
<tr>
<td>Western garter snake</td>
<td>Thamnophis elegans</td>
</tr>
<tr>
<td>Western rattlesnake</td>
<td>Crotalus viridis</td>
</tr>
<tr>
<td>Western whiptail</td>
<td>Cnemidophorus tigris</td>
</tr>
<tr>
<td><strong>Mammals</strong></td>
<td></td>
</tr>
<tr>
<td>Albert’s squirrel</td>
<td>Sciurus aberti</td>
</tr>
<tr>
<td>Apache pocket mouse</td>
<td>Perognathus flavescens melanotis [Perognathus apache]</td>
</tr>
<tr>
<td>Badger</td>
<td>Taxidea taxus</td>
</tr>
<tr>
<td>Banner-tailed kangaroo rat</td>
<td>Dipodomys spectabilis</td>
</tr>
<tr>
<td>Black-tailed jackrabbit</td>
<td>Lepus californicus</td>
</tr>
<tr>
<td>Bobcat</td>
<td>Lynx rufus</td>
</tr>
<tr>
<td>Brazilian free-tailed bat</td>
<td>Tadarida brasiliensis</td>
</tr>
<tr>
<td>Bushy-tailed woodrat</td>
<td>Neotoma cinerea</td>
</tr>
<tr>
<td>California myotis</td>
<td>Myotis californicus</td>
</tr>
<tr>
<td>Canyon mouse</td>
<td>Peromyscus crinitus</td>
</tr>
<tr>
<td>Cliff chipmunk</td>
<td>Tamias dorsalis [Eutamias dorsalis]</td>
</tr>
<tr>
<td>Colorado chipmunk</td>
<td>Tamias quadriovittatus [Eutamias quadriovittatus]</td>
</tr>
<tr>
<td>Coyote</td>
<td>Canis latrans</td>
</tr>
<tr>
<td>Deer mouse</td>
<td>Peromyscus maniculatus</td>
</tr>
<tr>
<td>Desert cottontail</td>
<td>Sylvilagus audubonii</td>
</tr>
<tr>
<td>Fringed myotis</td>
<td>Myotis thysanodes</td>
</tr>
<tr>
<td>Golden-mantled ground squirrel</td>
<td>Spermophilus lateralis [Citellus lateralis]</td>
</tr>
<tr>
<td>Gray fox</td>
<td>Urocyon cinereonargenteus</td>
</tr>
<tr>
<td>Gray wolf</td>
<td>Canis lupus</td>
</tr>
</tbody>
</table>

*continued on next page*
<table>
<thead>
<tr>
<th>Common Name</th>
<th>Scientific Name</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gunnison’s prairie dog</td>
<td>Cynomys gunnisoni</td>
</tr>
<tr>
<td>House mouse</td>
<td>Mus musculus</td>
</tr>
<tr>
<td>Kit fox</td>
<td>Vulpes macrotis</td>
</tr>
<tr>
<td>Least chipmunk</td>
<td>Tamias minimus [Eutamias minimus]</td>
</tr>
<tr>
<td>Long-eared myotis</td>
<td>Myotis evotis</td>
</tr>
<tr>
<td>Long-tailed vole</td>
<td>Microtus longicaudus</td>
</tr>
<tr>
<td>Long-tailed weasel</td>
<td>Mustela frenata</td>
</tr>
<tr>
<td>Meadow vole</td>
<td>Microtus pennsylvanicus</td>
</tr>
<tr>
<td>Mexican woodrat</td>
<td>Neotoma mexicana</td>
</tr>
<tr>
<td>Mink</td>
<td>Neovison vison [Mustela vison]</td>
</tr>
<tr>
<td>Mule deer</td>
<td>Odocoileus hemionus</td>
</tr>
<tr>
<td>Muskrat</td>
<td>Ondatra zibethicus</td>
</tr>
<tr>
<td>Northern grasshopper mouse</td>
<td>Onychomys leucogaster</td>
</tr>
<tr>
<td>Northern pocket gopher</td>
<td>Thomomys talpoides</td>
</tr>
<tr>
<td>Nuttall’s cottontail</td>
<td>Sylvilagus nuttallii</td>
</tr>
<tr>
<td>Ord’s kangaroo rat</td>
<td>Dipodomys ordii</td>
</tr>
<tr>
<td>Pallid bat</td>
<td>Antrozous pallidus</td>
</tr>
<tr>
<td>Piñon mouse</td>
<td>Peromyscus truei</td>
</tr>
<tr>
<td>Porcupine</td>
<td>Erethizon dorsatus [E. dorsatus]</td>
</tr>
<tr>
<td>Pronghorn</td>
<td>Antilocapra americana</td>
</tr>
<tr>
<td>Red fox</td>
<td>Vulpes vulpes fulvus [Vulpes fulva]</td>
</tr>
<tr>
<td>Red squirrel</td>
<td>Tamiasciurus hudsonicus</td>
</tr>
<tr>
<td>Rock squirrel</td>
<td>Spermophilus variegatus [Citellus variegatus]</td>
</tr>
<tr>
<td>Silky pocket mouse</td>
<td>Perognathus flavus</td>
</tr>
<tr>
<td>Silver-haired bat</td>
<td>Lasionycteris noctivagans</td>
</tr>
<tr>
<td>Small-footed myotis</td>
<td>Myotis leibii [M. subulatus]</td>
</tr>
<tr>
<td>Southern pocket gopher</td>
<td>Thomomys bottae</td>
</tr>
<tr>
<td>Spotted ground squirrel</td>
<td>Spermophilus spilosoma [Citellus spilosoma]</td>
</tr>
<tr>
<td>Stephen’s woodrat</td>
<td>Neotoma stephensi</td>
</tr>
<tr>
<td>Striped skunk</td>
<td>Mephitis mephitis</td>
</tr>
<tr>
<td>Vagrant shrew</td>
<td>Sorex vagrans</td>
</tr>
<tr>
<td>Western harvest mouse</td>
<td>Reithrodontomys megalotis</td>
</tr>
<tr>
<td>White-tailed antelope squirrel</td>
<td>Ammospermophilus leucurus [Citellus leucurus]</td>
</tr>
<tr>
<td>White-throated woodrat</td>
<td>Neotoma albigula</td>
</tr>
<tr>
<td>Yuma myotis</td>
<td>Myotis yumanensis</td>
</tr>
</tbody>
</table>

*Note: Scientific names derived from Harris (1967).*
The Archaeology of the Southern Chuska Valley

Bradley J. Vierra

The San Juan Basin is situated in northwestern New Mexico and covers an area of approximately 19,400 km$^2$ (7,500 square miles). It primarily consists of a central basin that is bounded by the Hogback Monocline on the northwest, north, and east, and the Chuska Slope to the southwest and south. The Chuska Slope lies below the Four Corners Platform, Chuska Mountains, and Zuni Mountains (Fassett and Hinds 1971); however, the area can also be divided into the Chuska Valley, which is situated to the east of the Carrizo and Lukachukai Mountains (Four Corners Platform) and the Chuska Mountains, vs. the Chaco Slope, which lies below the Zuni Mountains. The Chuska Valley is actually a broad slope rather than a valley and is bounded by the San Juan River to the north, the Chaco River to the east, and Lobo Mesa to the south. A series of tributaries crosscut the area and drain towards the Chaco River. The Chuska Mountains rise to a height over 2,740 m (9,000 feet) AMSL; however, the average elevation of the Chuska Valley is about 1,680 m (5,500 feet) AMSL. This topographic relief supports a variety of vegetation communities, including ponderosa pine–Douglas fir, piñon-juniper, big sagebrush, grassland, and riparian zones. These plant communities, in turn, support a variety of animal species (Harris 1967; Loose 1978; Warren 1967). The region can be subdivided into three archaeological districts consisting of the northern section from Beautiful Mountain to the San Juan River; the central section, which is the core of Chuskan archaeology; and the southern section in the area of Tohatchi Flats (Figure 11). The southern section is similar to the core area but exhibits a mixture of Chuskan and Cibola ceramic wares (Dykeman 2003). Our discussion will focus on the southern Chuska Valley and will simply refer to the central and northern sections as the northern Chuska Valley.

Numerous highway and pipeline projects have been conducted along U.S. 491 (NM 666) and adjacent areas of the basin, thereby providing information on Archaic, Basketmaker, and Pueblo I–IV period sites, as well as the Navajo occupation during the historical period (e.g., see Damp 1999; Gilpin 2007; Gilpin et al. 2000; Kearns and McVickar 2007; Peckham 1963; Railey 2004, 2008; Reed 2000; Walkenhorst and John 2003). Kearns (2007a) has provided a detailed synthesis and proposed chronology for the southern Chuska Valley which will be used for our discussion (Table 5). This chronology is based on the excavation of sites during the El Paso Pipeline Project.

**Early Foraging Societies (Paleoindian and Early–Middle Archaic Period)**

The Paleoindian period can be divided into three periods: Clovis (9500–9000 b.c.), Folsom (9000–8000 b.c.), and Late Paleoindian (8000–6000 b.c.). There is very little evidence for the Paleoindian period occupation of the southern Chuska Valley (Kearns 2007b). The Peach Springs site is the one exception, where Folsom and Cody components have been identified (Stuart and Gauthier 1981:28), with a possible Eden point from LA 80432 and radiocarbon dates of ca. 6500–6000 b.c. from LA 80434 (Kearns 2007a:3-21). Otherwise, most of the evidence of Paleoindian period use of the area has been derived from large surveys conducted in the northern San Juan Basin (Huse et al. 1978; Reher 1977; Vogler et al. 1993; Wait and Nelson 1983). Overall, the evidence for Paleoindian period use is minimal; however, it is unclear how much of this is actually due to past land-use practices or geomorphic processes. That is, many of the sites dating to this period may be buried or have been disturbed by erosion or deflation. Nonetheless, the majority of the points
Figure 11. Map of northern, central, and southern Chuska Valley.
recovered date to the Late Paleoindian period and may represent two distinct groups, including Cody and Rocky Mountains foragers. The former are characterized by the use of Eden points and Cody knives, both of which are broadly distributed across the Southwest and Great Plains and have been associated with bison hunting. By contrast, the latter are characterized by the use of lanceolate-shaped points with convex sides and concave bases. Several different point types have been attributed to this form; however, they probably represent resident populations in the southern Rocky Mountains of Colorado who hunted a range of game animals (Pitblado 2003; Stanford 1999; Vierra et al. 2013). Nonetheless, Pitblado’s (2003) study of Late Paleoindian period projectile points in the southern Rocky Mountains failed to identify any of these as being made of Chuska chert, although Amick (1999) did identify Folsom period points from the Rio Grande Valley that were made of this material.

The Archaic period can be separated into the Early (6000–3500 b.c.), Middle (3500–2000 b.c.) and Late Archaic/Basketmaker II (1300 b.c.–a.d. 500) periods. Kearns (2007a:3-22) noted that there is no current evidence of an Archaic period occupation of the southern Chuska Valley during ca. 6000–3500 b.c.; however, radiocarbon dates do indicate the presence of Middle–Late Archaic period groups from ca. 3500 to 1300 b.c. (Tocito phase). These sites appear to represent short-term campsites with brush shelters, interior hearths, and exterior features, including hearths, pits, and bell-shaped storage cists. Milling stones, wild seeds, and small game found at the sites appear to reflect a generalized foraging strategy. A single side-notched dart point was recovered from LA 80397, which yielded a range of Middle Archaic period dates from ca. 2800 to 2000 b.c.; however, San Jose and side-notched (Northern and Sudden style) points were also recovered

### Table 5. Proposed Phase Sequence for the Southern Chuska Valley

<table>
<thead>
<tr>
<th>Period</th>
<th>Phase</th>
<th>Approximate Time Frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recent historical period</td>
<td>none</td>
<td>a.d. 1930–present</td>
</tr>
<tr>
<td>Reservation</td>
<td>none</td>
<td>a.d. 1868–1930</td>
</tr>
<tr>
<td>Early historical period</td>
<td>none</td>
<td>a.d. 1700–1868</td>
</tr>
<tr>
<td>Protohistoric</td>
<td>none</td>
<td>a.d. 1450–1700</td>
</tr>
<tr>
<td>Pueblo IV</td>
<td>none (abandonment)</td>
<td>a.d. 1300–1450</td>
</tr>
<tr>
<td>Pueblo III</td>
<td>Twin Lakes</td>
<td>a.d. 1125/1140–1300</td>
</tr>
<tr>
<td>Pueblo II</td>
<td>Whirlwind (Late)</td>
<td>a.d. 1050–1125/1140</td>
</tr>
<tr>
<td></td>
<td>Whirlwind (Early)</td>
<td>a.d. 1025–1050</td>
</tr>
<tr>
<td></td>
<td>Coyote Canyon (Late)</td>
<td>a.d. 975/1000–1025</td>
</tr>
<tr>
<td></td>
<td>Coyote Canyon (Early)</td>
<td>a.d. 900/920–975/1000</td>
</tr>
<tr>
<td>Pueblo I</td>
<td>Flowing Well</td>
<td>a.d. 850–900/920</td>
</tr>
<tr>
<td></td>
<td>Red Willow</td>
<td>a.d. 775–850</td>
</tr>
<tr>
<td></td>
<td>Mexican Springs</td>
<td>a.d. 725–775</td>
</tr>
<tr>
<td>Basketmaker III</td>
<td>Tohatchi</td>
<td>a.d. 600–725</td>
</tr>
<tr>
<td></td>
<td>Muddy Wash</td>
<td>a.d. 500–600</td>
</tr>
<tr>
<td>Basketmaker II</td>
<td>hiatus</td>
<td>a.d. 150–500</td>
</tr>
<tr>
<td></td>
<td>Figueredo</td>
<td>500 b.c.–a.d. 150</td>
</tr>
<tr>
<td>Late Archaic/Basketmaker II</td>
<td>Ear Rock</td>
<td>1300–500 b.c.</td>
</tr>
<tr>
<td>Middle–Late Archaic</td>
<td>Tocito</td>
<td>3500–1300 b.c.</td>
</tr>
<tr>
<td>Early Archaic</td>
<td>none (data gap)</td>
<td>6000–3500 b.c.</td>
</tr>
<tr>
<td>Late Paleoindian</td>
<td>Dye Brush</td>
<td>7000–6000 b.c.</td>
</tr>
<tr>
<td></td>
<td>none (data gap)</td>
<td>8000–6000 b.c.</td>
</tr>
<tr>
<td>Folsom</td>
<td>Peach Springs</td>
<td>9000–8000 b.c.</td>
</tr>
<tr>
<td>Clovis</td>
<td>none (data gap)</td>
<td>9500–9000 b.c.</td>
</tr>
</tbody>
</table>

*Note: Table adapted from Kearns (2007a:3-2).*
during the testing phase of the project. Elyea and Hogan (1983) and Del Bene and Branchard (1994) observed a prevalence of side-notched dart points on Gallegos Mesa south of Farmington. Indeed, Elyea and Hogan (1983) suggested that these points may represent separate foraging groups, including San Jose groups to the south and Rocky Mountains groups to the north. The two point types do involve differences in technology that, at the very least, reflect differences in hunting tactics (Vierra 2012).

Del Bene and Branchard’s (1994) study of the Chuska Mountains and Defiance Plateau indicated that these uplands were being seasonally occupied by Archaic period groups (see also Vierra 1994). Early and Middle Archaic period use of the region seems similar, with obsidian associated with both periods being derived from sources in the Jemez Mountains. By contrast, obsidian from Late Archaic period sites located to the north on the Defiance Plateau were primarily derived from Arizona sources, and Late Archaic period sites located to the south in the Chuska Mountains included obsidian derived from New Mexico sources. Therefore, it appears that the region was being divided into separate procurement ranges by this later time period.

**Early Maize Cultivation (Late Archaic/Basketmaker II Period)**

The earliest dates associated with the presence of maize (*Zea mays*) have in the Southwest have been pushed back to ca. 4300–3620 b.p., based on data from the McEuen and Old Corn sites in southern Arizona and west-central New Mexico; maize subsequently spread across the region by ca. 3000 b.p. (Huckell 2006; Miljour and Huber 2005). The current evidence suggests that when maize entered the Southwest its use spread quite rapidly. It is, however, still debatable as to whether its spread was due to the northern movement of farmers (Berry 1982; Berry and Berry 1986; Coltrain et al. 2007; Huckell 1990, 1995), the integration of this cultigen into hunting-and-gathering economies (Hard et al. 1996; Minnis 1992; Vierra 2004, 2008; Vierra and Ford 2006, 2007; Wills 1995), or a mixture of the two (Mabry 2005; Matson 2005). However, as Kohler et al. (2008) has pointed out, the current evidence indicates that population growth rates did not significantly increase until long after the initial arrival of maize to the Southwest and may be associated with the initial use of ceramic containers, the bow-and-arrow, and the use of more-productive varieties of maize rather than immigrant farmers.

Doolittle and Mabry (2006) (see also Mabry and Doolittle 2008) have described a range of agricultural tactics that could have been used for prehistoric maize cultivation throughout the Southwest. These include dry-land, high-water-table, rainfed, runoff, floodwater, and irrigation farming. Dry-land farming refers to fields that are situated in soils that retain moisture or have been enhanced with mulch (e.g., gravel); high-water-table farming is conducted in settings with high water tables. Rainfed farming relies on natural rainfall, and runoff farming involves controlling or diverting runoff into fields. Floodwater farming involves fields that are located in natural flooding areas, and irrigation farming consists of diverting water from springs or streams. Together, these tactics provide a range of options for subsistence farmers; however, Mabry and Doolittle (2008) have suggested that high-water-table farming, irrigation farming (at lower elevations), runoff and *ak chin* farming, dry-land farming, floodwater farming, and rainfed farming are ranked from the lowest to the highest degree of risk, respectively. In addition to farming techniques, it has also been shown that several varieties of maize were grown that exhibit varying degrees of agricultural productivity and are suited for cultivation across a variety of environmental settings (Adams 1994; Huckell 2006; Vierra and Ford 2007).

As Vierra (2008, 2010) has pointed out, the timing, nature and context for the initial use of maize cultivation is quite variable across the Southwest. The current evidence from flotation samples indicates that maize becomes the dominant plant species by ca. a.d. 150 in the Tucson Basin, a.d. 400 along the Chuska Valley, a.d. 600 in the northern Rio Grande Valley, and a.d. 1200 in the Jornada region of southeastern New Mexico. High-water-table farming adjacent to playas was important in the Jornada region and may have also been an important factor in the initial process of maize cultivation in the Chuska Valley. Certainly, these eastern slopes would have provided excellent opportunities for a variety of cultivation techniques, including runoff and high-water-table farming. For example, runoff farming might have been most productive at higher
elevations during periods of below average rainfall, along alluvial fans during periods of average rainfall, and adjacent to playas during periods of above average rainfall.

Pipeline excavations in the western San Juan Basin have provided some of the earliest evidence of agriculture (Vierra 2008). For example, LA 6444 contains maize that was dated to 788 cal b.c. Both flotation samples from this structure contained maize (Freuden 1998). Three sites dating to ca. 500–1 cal b.c. appear to represent a complementary settlement system for the area. These are Site 423-158, a possible winter habitation site; LA 6444, which contains a series of structures presumably situated near agricultural fields; and LA 6448, a field cache site with numerous large storage pits (Freuden 1998; Hammett and McBride 1994; Kearns et al. 1998; Redd et al. 1994). Vierra’s (2008:73) review of flotation samples from these sites (n = 69) revealed that 90 percent contained cheno-am (Chenopodium-Amaranthus), 78 percent contained maize, 30 percent contained Indian ricegrass (Achnatherum hymenoides), 10 percent contained squash family (Cucurbitaceae), and none contained any dropseed (Sporobolus spp.) (see also Gilpin 2007). Indian ricegrass is a cool-season grass that probably was enhanced by winter melt from the Chuska Mountains. In contrast, dropseed is a warm-season grass that depends on summer rainfall and presumably would have been more productive in adjacent areas of the San Juan Basin. Faunal remains from Basketmaker II period sites in the area primarily consist of jackrabbit (Lepus spp.), cottontail (Sylvilagus spp.), and prairie dog (Cynomys spp.), with very few deer (Odocoileus spp.) and pronghorn (Antilocapra americana) (Kearns 2007b; Redd et al. 1994). Lastly, 12 individuals were exhumed at a Basketmaker III period cache site that contained about 40 large storage pits (Kearns et al. 1998). Eight of the 12 burials contained funeral items, which primarily consisted of jewelry and minerals. The jewelry was associated with both adults and children and was made from abalone (Halioptis), Olivella, and possibly clam shell that reflect long-distance trade networks.

A recent highway construction project involved the excavation of the Sandy Rise site that contained seven Basketmaker II period structures and numerous exterior features (Railey 2007). The site appears to date to ca. 400–200 b.c. Flotation analysis revealed that 61 percent of the samples contained cheno-ams, 38 percent contained maize, with Indian ricegrass and dropseed only being identified in 15–20 percent of the samples, respectively. The abundance of maize is somewhat lower and dropseed much higher than the other previously discussed sites. The increase in the amount of dropseed could be due to the site’s location along the northern vs. southern Chuska Valley. That is, in an area where summer rain fall could be more prevalent than winter snowmelt.

Although runoff or high-water-table farming were probably important for cultivation along the Chuska slopes, possible early irrigation channels have been identified in the Zuni area (Damp et al. 2000; Damp et al. 2002). A single radiocarbon date of ca. 1000 b.c. was obtained from charcoal in the basal sediments of a ditch. Nearby Basketmaker II period sites date from approximately 400 b.c. to a.d. 425, which is much later than the irrigation feature. In addition, pollen samples collected from a series of ditches dating from ca. 1000 b.c. to a.d. 1000 did not yield any evidence of maize pollen but did yield local riparian and tree pollen. Nonetheless, it seems likely that this irrigation channel dates to the latter part of the first millennium b.c. and is associated with a period of alluvial-soil aggradation in the Zuni Valley. If so, it would also date to the same time period as the previously discussed sites.

This period has been defined as the Figueredo phase (500 b.c. to a.d. 150), which reflects the early Basketmaker II period occupation of the southern Chuska Valley (Kearns 2007b). On the other hand, Kearns (2007b) was unable to identify any occupations dating to the late Basketmaker II period (ca. a.d. 150–500). He therefore suggested that “the Basketmaker III and Pueblo I periods represent the initial colonization and development of sedentary, village dwelling, Anasazi agriculturalists” in the southern Chuska Valley (Kearns 2007c:5-1); however, this period is associated with a series of droughts and could simply reflect the upslope movement of late Basketmaker II groups. For example, Dello-Russo (2003:25) also noted a similar hiatus from ca. a.d. 200–500 for the middle Rio Grande Valley; however, Schmader (2001) suggested that this pattern closely corresponds to an increase in occupational intensity documented in the northern Rio Grande Valley. Occupations dating to this period have been identified to the north at Black Mesa, Cedar Mesa, and the Rainbow Plateau, indicating that much of the Basketmaker II period population may have resided in the Four Corners region during this time period (Dohm 1994; Geib and Spurr 2000; Matson 1991; Smiley 1985).
Early Village Formation (Basketmaker III and Pueblo I Periods)

Kearns (2007c) (see also Kearns et al. 2000) segregated the Basketmaker III period into early and late phases for the southern Chuska Valley: Muddy Wash (A.D. 500–600) and Tohatchi (A.D. 600–725). The Muddy Wash phase sites identified during the El Paso Pipeline Project were characterized as residential sites that contained several households with pit structures. Exterior storage features, hearths, and middens were often present. These sites tended to be situated on elevated positions overlooking nearby farmland and often represented palimpsests. Kearns (2007c:5-21) associated the initial ceramic production with the arrival of migrants into the area, including the use of plain utility wares. Ninety-five percent of the flotation samples from these sites contained maize, along with an abundance of cheno-ams, dropseed, and Indian ricegrass, but little squash family and no beans (Phaseolus spp.). The faunal remains primarily consisted of small game, with some deer, pronghorn, and bighorn sheep (Ovis canadensis). Burials contained few grave items, reflecting little social differentiation. Nonlocal obsidian, spotted yellow chert from Grants area, and Mogollon brownware ceramics reflect exchange networks with groups to the south and southeast.

The Tohatchi phase sites identified during the El Paso Pipeline Project were characterized by residential compounds with pit structures, surface jacal structures, pit rooms, and exterior storage pits (e.g., large slab-lined pits) (see also McVickar and Wails 1998; Peckham 1963). Pit structures were more formal, with antechambers and an increasing number of internal features. Household groups were loosely organized into villages, with the presence of possible communal structures. Residential sites were also situated in elevated positions but with the addition of seasonally occupied locales in the valley and nearby uplands (field houses?); however, there also appears to have been a repositioning of the population toward the western edge of the valley near the foothills. Maize and cheno-ams still dominated the Pueblo I period flotation samples, which also included dropseed, Indian ricegrass, and some squash family and beans (see also Damp and Kotyk 2000:104). Faunal remains were the same as those from the earlier phase but with some elk (Cervus elaphus), bison (Bison bison), and wild turkey (Meleagris gallopavo) remains (Kearns 2007a). The same nonlocal lithic materials were represented but with an increase in imported ceramics from the north and a decrease in ceramics from the south. Burials contain relatively more items, but there still is little evidence for social differentiation (Kearns 2007c).

The situation in adjacent regions of northwest New Mexico and northeast Arizona is similar to the southern Chuska Valley, being characterized by residential stability, an increasing dependence on maize cultivation, and early village formation; however, researchers consider that the Basketmaker III period occupation (ca. A.D. 400/450–700/750) reflects continuity from the Basketmaker II period (Reed, ed. 2000). There appears to be a significant increase in the number of Basketmaker III period sites along the Chuska Valley, with some containing large pit structures surrounded by stockades, which is suggestive of regional conflict (Reed, ed. 2000). Reed summarized the current perspective on this period by noting the expansion of farming into new areas and that “Basketmaker III agriculture was a relatively simple and straightforward process and that, given the right conditions, was extremely successful with a minimum amount of labor” (Reed 2000:9). He argued that there was evidence for an economy dependent on maize agriculture, year-round occupation, and planned village communities with communal structures, residential compounds, storage facilities, and local group leadership; however he did not dismiss the potential for regional variability and seasonal occupations in other areas (e.g., see Vogler et al. 1993:342–353).

This is, of course, what Wills and Windes (1989) argued for Shabik’eschee Village, which has been dated to ca. A.D. 500–700. This site represents a large palimpsest that was characterized by periods of seasonal aggregation associated with large piñon (Pinus spp.) crops and good crop harvests. Although there were residential compounds consisting of pit structures and external storage features, it is possible that a few individuals could have continued to reside at the site, in order to protect cached food stores while the larger group continued on their seasonal rounds. Such caches would be represented by internal antechambers or large, external slab-lined storage pits. Nonetheless, the use of both internal and external storage facilities implies a shifting strategy from communal to household levels of food production and sharing (Wills 1991). Another example of possible short-term occupation at a Basketmaker III period site is 29SJ628 in Chaco Canyon (McKenna 1986). In this case, a total of six pit structures and six exterior storage pits were excavated;
however, the authors suggested a “short, consecutive construction sequence” for this series of structures (McKenna 1986:52). More recently, Wills et al. (2012:345–346) have suggested that “the economic potential for small-scale farming in Chaco was perhaps attractive to segments of the regional Basketmaker population which were excluded from access to prime natural resources . . . but was well-suited to floodplain agriculture.” Those groups residing in the area of Tohatchi Flats would have had access to wild resources in both upland and lowland settings, in addition to the potential for floodwater, runoff or high-water-table farming. We can only speculate as to how the Basketmaker III period site of Tohatchi Village might compare with the sites from these other studies.

Kearns (2007c) stated that the Pueblo I period (a.d. 725–900/920) is poorly represented in the southern Chuska Valley (see also Damp and Kotyk 2000); however, as pointed out by Dykeman (2003), the density of sites actually increases during the Pueblo I period but is largely obscured by overlying Pueblo II period occupations. For example, Marshall and Bradley (1994:367) reported that the Standing Rock community was established during the Pueblo I period with a “substantial increase in Anasazi population and site density.” This community was situated east of the Tohatchi Flats area. Lastly, Wilshusen and Van Dyke (2006) suggested that Pueblo I period populations were primarily concentrated in the Four Corners (Mesa Verde) region, with large villages containing 15–40 households; by contrast, there appears to be fewer and smaller sites representing hamlets with only 2–3 households in the area of the San Juan Basin ca. a.d. 800–875. Subsequently, there was a movement of people out of the Four Corners region into the area of the San Juan Basin by the end of the Pueblo I period (ca. a.d. 900–925), which had a significant effect on community and regional social organization. For example, great kivas may have been used to integrate these diverse communities such as the one at Tohatchi Village. This perspective also has received support from Windes and Van Dyke’s (2012) recent study, where they suggested that the presence of great houses vs. great kivas may represent two contemporaneous models of community organization by the late a.d. 800s in the San Juan Basin.

A single Pueblo I site was excavated during the El Paso Pipeline Project in the vicinity of the Red Willow great house, which is situated between the Standing Rock community and Tohatchi Flats. LA 80410 consisted of a linear room block with 13 rooms, 2 pit structures, and numerous exterior pit features. The room block contained 5 front rooms and 8 rear rooms. The front rooms tended to be larger and the back rooms were smaller, presumably reflecting domestic vs. storage functions. The two pit structures were situated directly in front of the room block. Each one was deep, with a ventilator, wing walls, hearths and sipapus. A similar site was excavated in Chaco Canyon (29SJ724). This site also consisted of a linear row of 7 small back rooms, with 2 large front rooms and 2 ramadas, as well as 1 pit structure (McKenna 1986). A more complex constructional history was evident at 29SJ627. Initial construction of this site also consisted of a single row of 7 rooms with attached ramadas and 3 nearby pit structures (ca. a.d. 780–910); however, construction continued during the Pueblo II period, including the addition of front rooms and kivas (ca. a.d. 950–1050). Truell (1986) suggested that these architectural changes reflect a shift from the use of single-family dwellings during the Basketmaker III period to multifamily dwellings during the Pueblo I period. In addition, the continued occupation at 29SJ627 presumably reflects the long-term occupation of the site by the same lineage. Construction techniques used in the area are quite variable, including jacal, puddled adobe, cimiento (upright slab foundation), turtleback foundations, adobe/rock architecture, and masonry. Further, some large Basketmaker III period sites may also include surface architecture associated with a later Pueblo I period occupation (e.g., Tohatchi Village; see also Damp 2003; Damp and Kotyk 2000; McKenna 1986).

Kearns (2007c) reported that the Pueblo I flotation samples primarily contained maize (93 percent), along with cheno-am and dropseed but little Indian ricegrass. Squash family and beans were also represented. The faunal remains were similar to that of the earlier time periods, with mostly small mammals supplemented with deer and pronghorn; however, there was a marked increase in wild turkey remains. There was an increase in nonlocal spotted yellow chert and Mogollon brownwares, which appears to indicate strengthened ties to the south; however, the initial presence of some Chuska and Mesa Verde wares also reflects ties to the north (see also Vierra 1993, 1997; Windes and Van Dyke 2012).
Exchange and Social Inequity (Pueblo II Period)

During the Pueblo II period, the southern Chuska Valley became part of a “super-community” that Stein and Fowler (1996:122) referred to as Tohatchi Flats. Tohatchi Flats covered an area from the slopes of the Chuska Mountains to Coyote Canyon and from Tohatchi to the great house at Toh Lo Kai. Indeed, there are about 10 great houses or great-kiva sites in the area; these form the largest concentration of Pueblo II period communities along the Chuska Valley (Gilpin et al. 1996).

As Wilshusen and Van Dyke (2006) have pointed out, the origins of great house communities during the early A.D. 900s can be found within both Chaco Canyon and the surrounding area, with great houses dominant in the Chaco Canyon area and great kivas prevalent in areas to the south (Windes and Van Dyke 2012). Some of these great kivas may have been used as integrative structures by immigrants from the north who previously resided in large villages but subsequently reorganized into more-dispersed settlements. Some of the locations of these great kivas continued to be used as great house communities that were linked to Chaco Canyon by the A.D. 1000s.

Kearns (2007d) segregated the Pueblo II period into two phases: Coyote Canyon (A.D. 900/920–1025) and Whirlwind phase (A.D. 1025–1125/1140). These two phases correspond to the Early and Late Bonito phases defined for Chaco Canyon. It is during the Early Bonito phase that Chacoan outlier communities were initially constructed (Vivian 1990); however, as Kearns (2007d) pointed out, Coyote Canyon phase habitation sites consisted of small room blocks that were scattered across the landscape. Typically, these consisted of linear masonry room blocks with 10–15 rooms that were 2 rooms deep. Pit structures were constructed in front of the room block, and middens were situated on the outside periphery. These pit structures (kivas) were sometimes masonry lined and built with ventilator shafts. Although the Whirlwind phase habitation sites were similar to their earlier counterparts, they tended to be clustered around Late Bonito phase great houses. The Whirlwind phase is also characterized by a shift from the predominate use of Red Mesa Black-on-white to Gallup Black-on-white ceramics. Vivian (1990:227) included the southern Chuska Valley within a central core area that also included Chaco Canyon and the northern Chuska Valley but was separate from the Red Mesa regional variant to the south. That is, regional social ties shifted away from the south toward the north, becoming part of the Chacoan interaction sphere.

Red Willow, Figueredo, Dye Wash, Twin Lakes, Black Creek, Deer Springs, Bowman East, and Toh Lo Kai are great houses located in the southern Chuska Valley. Great kivas are present at Tohatchi Village, NM-Q-15-28, Beth’s Great Kiva, Mexican Springs, and Los Rayos near the Red Willow great house. (Dykeman 2003; Gilpin et al. 1996; Kearns 2007d; Marshall et al. 1979; Peckham 1969; Powers et al. 1983; Stuart and Gauthier 1981:91; Walkenhorst and John 2003). The Tohatchi Flats great houses have been described by Gilpin et al. (1996). Most of these sites consisted of large L-shaped room blocks with a great kiva; however, the Deer Springs site consists of a six-room structure with a tower kiva.

The Tohatchi Flats area was connected to Chaco Canyon via the southwest road segment that passed through Standing Rock, Peach Springs, and Gray Ridge and the parallel western road segment to the north. This latter road segment appears to have passed through the area of the Red Willow community, the Los Rayos great kiva, and possibly on to the isolated great kiva at Tohatchi Village. At any rate, two Chaco roads extend out from Chaco Canyon toward the southern Chuska Valley (Gilpin et al. 1996; Nials et al. 1987; Powers et al. 1983). It is unclear what the exact relationship was between the great houses in the Tohatchi Flats area and Chaco Canyon, but maize and timber may have been two important local resources (Benson et al. 2003; Durand and Shelley 1999; English et al. 2001; Toll 2006:133). In fact, it has been suggested that some families may have seasonally resided in both the Chuska Valley and Chaco Canyon (Toll 2006:134).

The Whirlwind community was situated north of Tohatchi Flats and includes a great house that also consisted of Bonito-style architecture but with only 12 rooms and an enclosed plaza with a great kiva. The great house was surrounded by approximately 30 smaller sites that ranged from 2 to 20 rooms in size (Kearns 2007d; Marshall et al. 1979:87–89). One of these small room-block sites (LA 80377) was excavated by Walkenhorst et al. (1996). It contained 17 rooms, 3 kivas, and 1 midden. The site exhibited several construction and remodeling episodes but was primarily occupied during the eleventh century. The Standing Rock
and Peach Springs communities were situated to the east of Tohatchi Flats. The great houses were constructed of Bonito-style masonry with U- and rectangular-shaped floor plans. Both sites contained about 40 first- and secondary-story rooms with an adjacent great kiva. The two communities each consist of about 50 Pueblo II period sites (Marshall and Bradley 1994; Marshall et al. 1979:231–233; Powers et al. 1983:55–94, 212–214). A single small site (Site 423-108) was excavated in the Standing Rock community that exhibited a continuous occupation during the eleventh through twelfth centuries. It contained a room block with at least 6 rooms, 2 pit structures, and 3 kivas. Several construction episodes were represented, including the sequential use of the kivas (Sullivan 1994).

Flotation samples excavated from Pueblo II period (Coyote Canyon and Whirlwind phases) sites primarily contained maize and cheno-ams, along with some squash family, Indian ricegrass, dropseed, piñon nuts, and beans, which represent a range of lowland and upland resources. Most of the identifiable faunal remains consist of small mammals (e.g., cottontail, jackrabbit, and prairie dogs), along with a few deer and pronghorn. On the other hand, there is a noticeable increase in the relative number of bird bones, with wild turkey contributing the same proportion as cottontails and jackrabbits (Kearns 2007c). The effect of the Chacoan network is exemplified in the presence of more Chuska wares, Jemez obsidian, and Chuska chert, although there is an increased presence of spotted yellow chert, which reflects at least some continued ties to the south. There is evidence of craft specialization (e.g., jewelry). Lastly, burials contained grave items, but there was no obvious indication of differential status (Flores and Kearns 1996; Kearns 2007d). It is noteworthy that Site 423-108 also exhibited many of the characteristics that Kearns described for the Pueblo II period in the southern Chuska Valley. That is, a similar range in fauna, including wild turkey, which was used for food and ritual activities. Both Cibola and Chuska wares were represented, as were spotted yellow chert, Chuska chert, and Jemez obsidian. In addition, a single flake of Government Mountain obsidian from northern Arizona was also identified (Sullivan 1994).

### Social Restructuring (Pueblo III Period)

The southern Chuska Valley witnessed a general decrease in site density, with remaining sites often being located in defensive settings during the Pueblo III period, or Twin Lakes phase dating from A.D. 1125/1140 to 1300 (Dykeman 2003; Kearns 2007d). Very few sites dating to the Twin Lakes phase were excavated during the El Paso Pipeline Project; however, the limited data revealed reductions in the ubiquity of maize (60 percent) and cheno-ams (40 percent), with some squash family, Indian ricegrass, dropseed, and piñon nuts. Faunal remains primarily consisted of small mammals (cottontail, jackrabbit, and prairie dog), with some birds and wild turkeys, along with a few deer, pronghorn, and bighorn sheep (Kearns 2007c). Ceramics included Chaco/McElmo Black-on-white, along with some Chuska wares, St. Johns Polychrome, and Mesa Verde wares. Spotted yellow chert and Chuska chert continued to be brought into the area, although spotted yellow chert was more common (Kearns 2007d).

As previously noted, at least one excavated small site in the Standing Rock community (Site 423-108) exhibited a continuous occupation from the late Pueblo II to early Pueblo III period. Other sites in this community also reflect early Pueblo III period occupations (Marshall and Bradley 1994). In fact, most of the Pueblo II period communities in the region continued to be occupied during the Pueblo III period, including Peach Springs, Grey Ridge, Red Willow, Figueredo, Twin Lakes, and Toh La Kai (Dykeman 2003; Gilpin et al. 1996; Marshall et al. 1979; Marshall and Bradley 1994; Nials et al. 1987; Powers et al. 1983; Stein and Fowler 1996). The Red Willow biwall site (not to be confused with the Red Willow community) is located near Tohatchi Flats (Peckham 1963). LA 4470 consisted of a masonry pueblo that contained approximately 20 rooms, 1 possible kiva, and 1 biwalled structure. Only the biwalled structure was excavated and reported by Peckham. The structure consisted of a central surface kiva with ventilator, deflector, lined hearth, and sipapu. It was surrounded by 7 rooms that were walled with either masonry and/or jacal construction. Very few artifacts were recovered from the kiva, with most of the collections being derived from
the adjacent rooms. Most of the ceramics were McElmo Black-on-white, Mesa Verde Black-on-white, and Coolidge corrugated that suggest a Pueblo III period occupation. It could be that the biwalled structure replaced the isolated Pueblo II period great kiva at Tohatchi Village and therefore represents an attempt to maintain social ties to this region; however, a field inspection of Tohatchi Village by Paul Reed failed to identify any Pueblo II period ceramics (Paul Reed, personal communication 2012; see also Stuart and Gauthier 1981:90). Therefore, it seems more likely that the great kiva actually dates to the Pueblo I period. A small Pueblo III period site with 2 pit structures was excavated near Figueredo Wash. This architecture was quite unusual for the period, and their function remains unclear. The structures could have been used as a seasonal residence (with central hearth) or as a large storage facility (without internal hearth) (Keams 2007d:6-59). Nonetheless, these structures could reflect a previously undefined strategy of breaking into small family groups during the Pueblo III period.

Vivian (1990:335) has suggested that the southern Chuska Valley became a void situated between the Chaco Canyon/northern Chuska Valley and the Houck regional variant to the south; however, it appears that there was a continued presence in the southern Chuska Valley during the Pueblo III period. Nonetheless, the Fenced-Up Horse Canyon community located east of Gallup also witnessed continued use during this time period. Indeed, local settlement patterns reflect a shift toward the occupation of aggregated communities at higher-elevation settings that appears to be associated with an influx in population. This area was an important center for the procurement and exchange of spotted yellow chert that linked communities in the region. The exchange of this distinctive colored rock reached its peak in the southern San Juan Basin during the Pueblo III period after the restructuring of the Chacoan social network (Marshall et al. 1979; Schutt 1997; Vierra 1997).

Agro-Pastoralists: The Navajo Occupation during the Historical Period

Ward et al. (1977) provided an excellent review of the local history of Navajo land use along the northern Chuska Valley (see also Bailey and Bailey 1983; Brugge 1986; Towner 1996; Winter 1993). The earliest site in their study area was CGP-605, which was a seventeenth-century fortified (Pueblo) site, with an additional four sites containing early ceramics. The area witnessed seasonal sporadic use until ca. 1875–1900, when a small residential population moved in. This group primarily consisted of single-hogan complexes until ca. 1902, when there was a small influx of people, as indicated by an increase in the number of multi-hogan complexes. This population remained stable until ca. 1917, when the number of permanent habitation sites doubled, including multihogan complexes. It is uncertain why this increase occurred, but Ward et al. (1977:241) suggested that it might be related to World War I and the movement of non–Native Americans out of the northern San Juan Basin. The Navajo met its maximum population size between 1928 and 1935. This period preceded the government stock reduction program, when numerous large herds were grazing in the basin. Overgrazing became a problem, and by 1933, the government required a reduction in stock size. After 1940, the local Navajo population declined to its fewest number, with only 17 permanent residences being present during the late 1970s, along with an additional 16 temporary sites dating to this post-1940 era. Some of the residents continued herding with farming, whereas others left for wage-earning jobs.

Residents of the area during the 1980s held grazing permits and were mostly related to each other. York (1983) provided a detailed review of the family genealogies, which included up to four generations dating back to the late nineteenth century. Informants provided data regarding subsistence activities that indicated a mix of grazing and farming, with cultivation occurring near washes. Wheat, corn, squash family, and melons were some of the crops reported to have been cultivated. One field was located in a meander, where both rainfall and flooding provided seasonal water. Another field was situated to take advantage of seasonal flooding from several small washes. Lastly, ditches might also have been dug to divert runoff into nearby fields. Winter (1993) provided an example of farming along Captain Tom’s Wash. The size of the cultivated area was determined by the amount of spring snowmelt. Individuals monitored the Chuska Mountains in
the late winter, in order to evaluate the potential runoff. Fields were planted in May, periodic visits were then made to maintain them, and then they were harvested in August. The size of the crop depended on the amount of summer rainfall. York (1983) also noted one example of a family residing in the Chuska Valley during the summer and then moving to the San Juan Basin in the fall after harvesting their crops. By contrast, other residences were only occupied during the winter for herding. Rugs and jewelry were made by some residents and traded for subsistence goods at the Fruitland Trading Company.
CHAPTER 4

Research Design

Christopher A. Turnbow, Bradley J. Vierra, and Phillip O. Leckman

General Theoretical Orientation

Introduction

The San Juan Basin and surrounding areas have a long and rich history of anthropological research. Much of the early work focused on Chaco Canyon, including the initial work of Wetherill and Pepper and subsequent excavations by Hewett, Judd, Vivian, and Hawley-Ellis. These studies focused on culture history and on understanding the interrelationships and occupational sequences of the sites (Vivian 1990:37–69). The arrival of the New Archaeology and cultural resource management (CRM) studies in the 1960s had a profound effect on the research being conducted in the region. These theoretical perspectives are best represented in the research designs and sample surveys that were implemented in Chaco Canyon and the San Juan Basin (Hayes et al. 1981; Reher 1977).

Varieties of new theoretical approaches have been proposed for understanding the variability observed in the archaeological record. Evolutionary ecology and the use of optimal-foraging theory have developed out of the earlier cultural ecology. In many respects, evolutionary ecology represents an outgrowth of the explicitly “scientific” focus of both cultural ecology and processual archaeology, with an emphasis on quantitative data, testable hypotheses, and broad, generalizing conclusions. In contrast, most current social-theory perspectives are informed by the postprocessual critiques directed at the self-consciously scientific and reductionist paradigm of processualism during the 1980s and early 1990s. Part of the broader postmodern critique within the humanities and social sciences (Johnson 2010:204), these approaches to the archaeological record typically emphasized the subjectivity of archaeological interpretation while stressing the importance of historical context and individual agency in the past (Johnson 2010:110). Writers labeled “postprocessual” were typically skeptical of scientific positivism and the separation between theory and data (Johnson 2010:103–105).

Over time, perspectives informed by these critiques have contributed to a wide body of new research questions and orientations representing a diversity of fruitful approaches to understanding the past (Johnson 2010). These include the investigation of gender and identity (e.g., Brumfiel 1991; Crown 2000; Joyce 2000, 2005); power, social cohesion, and social inequality (e.g., Canuto and Yaeger 2000; Jones 1997; Liebmann 2006; Mills 2000, 2008; Munson 2002; Preucel 2002); ideology and meaning (e.g., Capone and Preucel 2002; Graves and Van Keuren 2003; Liebmann 2002; Mills 2002); the significance of space and place (e.g., Barrett 1994; Moore 1996, 2005; Munson 2002; Snead 2002, 2008; Snead and Preucel 1999; Thomas 2001; Tilley 1994; Van Dyke 2008); and the historical, political, and social significance of archaeological sites and materials to contemporary indigenous communities (e.g., Colwell-Chanthaphonh et al. 2010; Ortiz 1994; Swentzell 1990; Wilcox 2002, 2008; Williams et al. 2006).

Evolutionary ecology and the range of research foci and perspectives here referred to as “social theory” are often viewed as conflicting or even diametrically opposed approaches to understanding the archaeological record. Although we concede the significant differences in terms of methods and theoretical perspectives that exist between these approaches, we agree with the suggestion made by VanPool and VanPool (2003) that the current diversity of theoretical perspectives can provide complementary approaches to answering different archaeological questions. In fact, this diversity of perspectives can provide greater insight than advocating a single approach. Therefore, we offer evolutionary ecology and several aspects of social theory as broad theoretical perspectives from which to understand the archaeology of the southern Chuska Valley.
Theoretical Perspectives

Human-Behavioral Ecology

Recent literature on early agriculture in the Southwest is full of articles involving the use of optimal-foraging theory (e.g., the diet-breadth model) to explain the inclusion of maize (*Zea mays*) cultivation in the subsistence economy (Barlow 2002, 2006; Dering 2005; Diehl and Waters 2006; Hard and Roney 2005; Hudspeth 2000; Mabry 2005; Simms 1987). In addition, central-place-foraging and gender-based models have been used to understand foraging behavior (Elston and Zeanah 2002; McGuire and Hildebrant 2005; Zeanah 2000, 2004).

The diet-breadth model uses a cost-benefit analysis to rank species with respect to their energetic costs of search, pursuit, and handling times vs. their energetic content (Bettinger 1991:83–112; Kelly 1995:78–90; MacArthur and Pianka 1966; Stephens and Krebs 1986:17–24). That is, it ranks available foods according to the amount of investment vs. the amount of benefit gained for each specific item, based on the costs of procuring and processing these foods for consumption. An important question is the following: Which foods provide the greatest return for the investment? Most studies use post-encounter rates to determine the caloric value of a particular species. However, there are several other aspects of the diet-breadth model, beyond package size, that can affect the ranking of a specific resource. For example, search costs can increase as a function of game depletion, and obviously there are no additional pursuit costs when collecting wild plants. On the other hand, handling (i.e., collection and processing) time would be more critical for plants or in response to the bulk acquisition of resources (Hudspeth 2000; Vierra 1995, 2004).

The various classes of food can be divided into three groups: high-, medium-, and low-ranking foods (Table 6). High-ranking foods include game animals, such as elk (*Cervus elaphus*), deer (*Odocoileus* spp.), pronghorn (*Antilocapra americana*), jackrabbits (*Lepus* spp.), and cottontails (*Sylvilagus* spp.). Although return rates were not available for bison (*Bison bison*), they would rank at the top of the list, whereas wild turkeys (*Meleagris gallopavo*) presumably would rank with small mammals and large birds. The medium-ranking

<table>
<thead>
<tr>
<th>Wild Food</th>
<th>Caloric-Return Rates (kcal/hour)</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk</td>
<td>&gt;20,000</td>
<td>1 (high)</td>
</tr>
<tr>
<td>Deer and bighorn sheep</td>
<td>18,000–31,000</td>
<td>2 (high)</td>
</tr>
<tr>
<td>Pronghorn and jackrabbit</td>
<td>13,000–15,000</td>
<td>3 (high)</td>
</tr>
<tr>
<td>Gopher and cottontail</td>
<td>9,000–11,000</td>
<td>4 (high)</td>
</tr>
<tr>
<td>Cattail pollen, ground squirrel, large bird,</td>
<td>3,000–6,000</td>
<td>5 (high)</td>
</tr>
<tr>
<td>and cattail roots</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Piñon nuts and bulrush</td>
<td>1,200–1,700</td>
<td>6 (medium)</td>
</tr>
<tr>
<td>Maize (plant and harvest)</td>
<td>1,300–1,700</td>
<td>7 (medium)</td>
</tr>
<tr>
<td>Prickly pear, yucca, and hedgehog cactus</td>
<td>1,000–2,000</td>
<td>8 (medium)</td>
</tr>
<tr>
<td>Acorns, saltbush, wildrye, and tansy mustards</td>
<td>800–1,300</td>
<td>9 (medium)</td>
</tr>
<tr>
<td>Lecheguilla</td>
<td>650–800</td>
<td>10 (low)</td>
</tr>
<tr>
<td>Sotol, aster family, goosefoot, and pigweed</td>
<td>400–500/600</td>
<td>11 (low)</td>
</tr>
<tr>
<td>Indian ricegrass</td>
<td>300–400</td>
<td>12 (low)</td>
</tr>
<tr>
<td>Typical agriculture</td>
<td>100–1,100</td>
<td>13 (low)</td>
</tr>
<tr>
<td>Dropseed and purslane</td>
<td>100–300</td>
<td>14 (low)</td>
</tr>
<tr>
<td>Intensive agriculture</td>
<td>50–350</td>
<td>15 (low)</td>
</tr>
</tbody>
</table>

Note: Scientific names of food taxa not mentioned in text are as follows: bulrush (*Scirpus* spp.), cattail (*Typha* spp.), gopher family (*Geomyidae*), goosefoot (*Chenopodium* spp.), ground squirrel (*Spermophilus* spp.), hedgehog cactus (*Echinocereus* spp.), pigweed (*Amaranthus* spp.), prickly pear (*Opuntia* spp.), purslane (*Portulaca* spp.), aster family (*Asteraceae*), tansy mustards (*Descurainia* spp.), and wildrye (*Elymus* spp.).

foods include trees and shrubs that contain nuts and seeds, such as piñon nuts (Pinus edulis), acorns (Quercus spp.), and saltbush (Atriplex spp.) seeds, as well as cactus family (Cactaceae) and yucca (Yucca spp.). The lowest-ranking food group primarily includes wild seeds from smaller plants, such as cheno-am (Chenopodium-Amaranthus), Indian ricegrass (Achnatherum hymenoides), and dropseed (Sporobolus spp.), although lecheguilla (Agave lecheguilla) and sotol (Dasylirion spp.) probably rank above these small plants but below the plants with larger seeds.

When a forager is faced with the decision of what to eat, high-ranking foods will always be selected over medium-ranking foods, and medium-ranking foods will be selected over low-ranking foods. Optimization models assume that natural selection favors individuals who make the most cost-effective decisions and that these individuals will have higher rates of reproductive success than individuals who make less-cost-effective decisions.

Given these assumptions, how does the cultivation of maize fit into the ranking scheme? The answer depends on the amount of energy invested in the cultivation of these plants. If the seeds are planted in a location conducive to germination and growth and if the only investment is returning to harvest the crop, maize would fall into the medium-ranking food group. On the other hand, if cultivation involves increased investment in labor and production, the crop would probably rank at the bottom of the low-ranking food group. Therefore, when cultivating maize, it is better to plant more areas and to leave the plants to fend for themselves than to plant fewer areas and spend more time tending the fields. In addition, Mabry and Doolittle (2008:61) suggested that return rates for maize would be higher with little milling and an emphasis on roasting green ears and popping and parching mature kernels. In contrast, the rank would decrease with an increasing emphasis on the milling of maize for flour. The return rates provided for maize cultivation in Table 6 are simple averages for differing levels of intensification. Obviously, several factors can affect the return rates for farming, including precipitation, the variety of maize, the area planted, the investment in production, the distance to fields, and the resultant crop yields (Hudspeth 2000).

Although the region is rich in resources, it is a risky place to live. Annual resource productivity can vary greatly across the landscape and is often tied to seasonal variations in the amount and distribution of rainfall (see Dello-Russo 1999, 2003; Hudspeth 2000). The question then becomes the following: How does an individual reduce the risk of living in a relatively stochastic environment? Risk-minimization models involve understanding the degrees of risk and uncertainty in the decision-making process. As Smith (1988:231) pointed out,

problems of risk concern the effects of stochastic variation in the outcome associated with some decision, while uncertainty refers to the lack of perfect information that afflicts decision-makers. . . . [R]isk then refers to the degree of stochastic variation in decision outcomes, while uncertainty refers to the stock of information that an actor has.

In contrast to optimization models, risk minimization involves trade-offs in the attempt to manage the mean value and variation associated with the expected outcome. Researchers have suggested a variety of techniques that can be used to manage risk, including diversity of tactics, resource diversity, storage, sharing (or pooling), exchange, scattered fields, and irrigation (Hegmon 1989, 1996; Huckell et al. 2002; Mabry 2002; Smith 1988; Smith and Boyd 1990; Wills 1992; Winterhalder 1990). Uncertainty can be reduced by gathering information during forays into the field and by exchanging information with other groups in the region (Binford 1980, 1983; Moore 1981; Smith 1988). As Winterhalder (1990) pointed out, sharing is an important tactic for reducing risk by attempting to average out annual fluctuations in natural-resource productivity. It is a tactic that works well among foraging groups who procure subsistence resources on a daily basis and can monitor whether other members of the group are participating in communal reciprocity. On the other hand, individuals may not always want to reduce risk but may be risk prone (vs. risk averse) when making decisions. This is true for some farming groups. That is, farmers attempt to increase variance in resource productivity by cultivating multiple isolated fields in differing ecological settings. This tactic increases the odds that at least some of the fields will yield crops. However, the extended period of cultivation and collection, in conjunction with the ability of individual households to control production, leads to hoarding.
Wills (1992) provided a southwestern archaeological example of these two strategies in discussing communal vs. household modes of production. For example, the Basketmaker III period village sites with exterior storage that he studied reflected communal sharing and pooling of resources, whereas sites with storage features situated inside residential structures represented an attempt to control foods for household consumption. He continued this avenue of research by suggesting that Basketmaker III period populations generally employed a risk-averse strategy characterized by extensive farming practices, but with regional variability. This contrasts with the approach applied by later aggregated-village communities that employed intensive farming strategies involving the use of a variety of agricultural technologies. Nonetheless, employment of both extensive and intensive systems probably occurred, as a means of reducing risk by using both risk-prone and risk-averse strategies (Wills et al. 1994; see also Vivian 1990:309–313).

The question, then, becomes the following: Is there an increase in diet breadth in conjunction with an increase in the investment in farming tactics? Leonard (1989) has argued that the botanical evidence for increasing diet breadth (i.e., species richness) is simply the result of sampling bias (but see McBride 1993). Instead, species evenness (i.e., the relative proportion of individual species) is a more appropriate measure. In this case, increases in agricultural production are characterized by an increasing emphasis on maize cultivation and a specialist economic strategy. As Leonard (1989) noted, generalist strategies are stable but less productive (e.g., foragers), whereas specialist strategies are unstable but more productive (e.g., agriculturalists). Therefore, minimizing risk becomes more important with subsistence intensification and a growing reliance on fewer subsistence resources.

Social Approaches to the Archaeological Record

As employed by some authors, “social theory” is an all-encompassing label referring to “bodies of general knowledge about sociocultural phenomena” (Schiffer 2000:1). Preucel and Hodder (1996) and Shanks and Tilley (1988) employed more-critical uses of the term. As discussed above, the initial use of the term by Shanks and Tilley was rooted in the postprocessual critique they pioneered and was typically positioned in opposition to more-positivist approaches to the archaeological record. Over time, however, the concerns and emphases highlighted by the original postprocessualists have filtered into the mainstream of archaeological thought in the Southwest and elsewhere. In particular, much current archaeology of all stripes is informed by a focus on individual agency and meaning, a concern for social and historical context, and a recognition of the potential for multiple valid interpretations of the past. The list of authors and research topics presented at the beginning of this chapter incorporates a wide variety of research approaches, analytical techniques, and theoretical orientations, suggesting that the “social theory” label is now broad enough to accommodate much of the breadth envisioned by Schiffer.

Although a considerable variety of theoretical subjects and research foci can conceivably be subsumed under the broader label of “social theory,” as indicated above, our research focus follows SRI’s recent proposal for work on the Navajo Nation (Statistical Research 2008) in emphasizing a nested series of scalar research foci, beginning with archaeological investigations of the household and continuing to investigations of architecture, site structure, and landscape at the multihousehold, site, and regional scales. At each scale, our proposed research foci are envisioned as broad fields of action upon which other dimensions of human social life, including those related to questions of power, gender, identity, and ideology, are enacted.

As the primary setting and point of intersection for many aspects of daily life and activity (Statistical Research 2008:2), the household has the potential to inform archaeological investigations of many aspects of past human lives. The archaeological signature of a household—here defined as “a basic unit of social and economic organization that consists of members who reside and produce together” (Statistical Research 2008:2)—is produced by the actions of its members, the autonomous individuals who, over time, make up the household group. The archaeological traces of a household can be interpreted in terms of these individuals and their practices, or the “culturally structured and routine activities of a particular people” as they are shaped, taught, and transformed over time (Statistical Research 2008:2). The archaeological record may thus preserve
traces of the ways in which the individual actors constituting a household “actually practiced living in, reproducing, and transforming the culture around them” (Johnson 2010:108).

Many dimensions of daily practice are therefore potentially accessible through the investigation of household assemblages. Evidence of craft production and household activities preserved in domestic assemblages, for instance, may give insight into craft specialization, household production, and the gendered division of labor (e.g., Brumfiel 1991; Mills 2000). The archaeology of domestic assemblages may also preserve traces of bodily practices, such as patterns of consumption, hinting at the physical experiences of a household’s members (e.g., Joyce 2005). Compositional analyses of ceramics or other products of the household may hint at patterns of population movement and ethogenesis, and examination of the decorative or stylistic dimensions of these artifacts may signal the efforts of individuals to negotiate changing social identities and convey social information (e.g., Capone and Preucel 2002; Clark 2001; Duff 2002; Mills 2002, 2008; Mobley-Tanaka 2002).

At the extrahousehold or multihousehold scale, investigations of the functions and meanings of architecture and site organization have afforded recent researchers the opportunity to explore many dimensions of past human interactions on a variety of scales. At temporary forager villages and other small, informally organized sites, researchers have combined insights drawn from classic hunter-gatherer ethnography and ethnoarchaeology (e.g., Bartram et al. 1991; O’Connell 1987; Yellen 1977) and observations regarding the acoustical properties of human voices to interpret the layout of dwellings and domestic features in terms of their implications for group dynamics, conflict, and social cohesion (Moore 2005). Attention to sounds, images, and other sensual phenomena has informed interpretations of more-formal architecture, as well (e.g., Hodder 2006; Houston 2006; Metcalf 1997; Moore 2005, 2006; Tilley 1994; Tringham 1994).

Elsewhere, analytical methods drawn from space-syntax studies (e.g., Hillier and Hanson 1984; Moore 1996) have been used to investigate access, connectivity, and exclusion within Pueblo room blocks and other, more-formal structures (Bustard 1996; Clark 2001; Cooper 1995; Ferguson 1996, 2002; Potter 1998; Shapiro 2005). Changes in such access patterns over time have been interpreted in terms of changing social organization, new social ideologies, or changes in household or village composition (Ferguson 1996, 2002; Liebmann 2006; Liebmann et al. 2005).

Other authors, drawing on the theoretical works of Michel Foucault (1977), Benedict Anderson (1983), and others, have emphasized the role of public architecture in social life, exploring the ways in which public spaces can help to enact and maintain a sense of community through shared rituals or other events or, conversely, how the exclusive privileges of ritual or political leaders can be legitimated and reified by restricting access to ritually significant spaces to a small elect (e.g., Barrett 1994; Canuto and Yaeger 2000; Graves and Van Keuren 2003; Inomata 2006; Inomata and Coben 2006; Moore 1996, 2005, 2006; Preucel 2000; Stein and Lekson 1992; Triadan 2006; Van Dyke 2000, 2004, 2008). Finally, several authors have turned to ethnographic sources, interpreting architecture and site structure in terms of cosmological principles held by related peoples (e.g., Ashmore 2007; Lekson 1999; Marshall 1997; Snead and Preucel 1999; Sofaer 1997, 2007; Williams et al. 2006).

Extending beyond the level of individual sites to the consideration of entire regions, the concept of “landscape” as an encompassing term for the web of interactions between humans and their natural environment has a long history in geography and related disciplines (e.g., Sauer 1925). Only in the last several decades, however, has the concept of landscape been embraced by archaeologists as a framework for considering such interactions (e.g., Anschuetz et al. 2001; Ashmore and Knapp 1999; Rossignol and Wandsnider 1992). In recent years, archaeologists have used landscape as an organizing principle for the consideration of many different dimensions of interactions between people and place, from the quantitative analysis of site locations relative to resource availability (e.g., Schlanger 1992) to the examination of perception and sensual experience as they relate to place (e.g., Tilley 1994). This capacity to accommodate disparate theoretical orientations and research interests—to serve as a “coherent organizational framework for presenting vastly different and occasionally competing conceptions of . . . land-use practices” (Whittlesey 1997:28)—is one of the chief advantages of a landscape-based perspective. It also makes this a research framework well suited to the current project.
Several researchers have offered suggestions for ordering the quantitative, experiential, and ideational dimensions of human relationships to space. Anschuetz et al. (2001:177–181) suggested a tripartite organizing principle for landscape studies that considers human-environment interactions in terms of settlement ecology and other economic and ecological variables, investigations of ritual landscapes based on cosmologically or spatially driven interpretations of ritual patterns, and ethnic landscapes derived from culturally specific patterns of land use and landscape knowledge. A similar division was presented by Snead (2008), who considered landscapes of provision, related to agriculture, land tenure, or other dimensions of subsistence; landscapes of identity, concerning cultural and natural landscape features linked to ideology and meaning within a society; landscapes of movement, related to mobility and travel between sites and other landscape features; and landscapes of competition, or the direct or indirect evidence on the landscape of contention, violent or otherwise, between and among human communities. Finally, Adam Smith (2003:73–75) and Ruth Van Dyke (2008:6–7) drew on the work of French theorist Henri Lefebvre (1991), who divided human spatial thinking into thinking about the material world itself, spatial representations of the material world, and spatial perceptions of the material world. As operationalized archaeologically by both Smith and Van Dyke, the material world consists of the physical landscape, including the distribution of sites or other human traces in relation to physical resources. Spatial representations refers to human depictions or conceptions of landscape in the form of art, texts, maps, or stories. Spatial perceptions refers to the sensual or emotional experience of landscape, which can be approached archaeologically through the consideration of visibility or “iconic symbolism” (Van Dyke 2008:7).

Archaeologically, investigations of landscape in the U.S. Southwest have touched on all the dimensions of landscape discussed above. On the more quantitative, materialist end of the spectrum, Schlanger (1992) approached the question of the recurrent use of certain locations on the landscape, interpreting those locations in terms of settlement strategies and subsistence technologies, which were, in turn, viewed as adaptations to environmental challenges (Schlanger 1992:98–99). Van West and Kohler (1996) took a historical-landscape approach to the topic of agricultural production at Mesa Verde, using a variety of agricultural, environmental, and site-location data to model patterns of complexity and cooperation during periods of ecological instability. In an effort to reconstruct some elements of the sensual experience of past landscapes, other authors have studied intervisibility between natural landmarks and elements of the built environment, using observations based on either Geographic Information Systems (GIS) modeling or personal experience to suggest relationships between sites and topographic features, with possible implications for the ideology and cosmology of past peoples (e.g., Snead 2008; Sofaer 2007; Van Dyke 2000, 2008). Physical interconnections between sites such as trails or roads have also been examined for insights into social organization, cultural boundaries, or the meanings invested in particular landscape features (e.g., Becker and Altschul 2008; Darling 2006; Darling and Eiselt 2003; Lekson 1992; Marshall 1997; Snead 2002, 2008; Stein and Lekson 1992; Van Dyke 2008). Other authors have explored intervisibility between sites in terms of systems of communication or mutual defense (e.g., Haas and Creamer 1993; Snead 2008; Swanson 2003). Finally, ethnographic research into the meanings invested in places by present human societies (e.g., Basso 1996; Feld and Basso 1996; Kelley and Francis 1994) has inspired several investigations of the significance of sites and other elements of past landscapes to contemporary southwestern indigenous groups (e.g., Anschuetz 2007; Duff et al. 2008).

The Archaeology of the Southern Chuska Valley

Human-Behavioral Ecology and the Southern Chuska Valley

The history of the southern Chuska Valley reflects the ebbs and flows that are common for Anasazi life in the northern Southwest. Long-term trends appear to indicate a growing pattern of agricultural intensification; however, changes in climate and rainfall over the centuries have had dramatic effects on Anasazi subsistence economies. As previously noted, annual resource productivity can vary greatly across the landscape and can be tied to seasonal variations in the amount and distribution of rainfall. For example, Dello-Russo’s (1999, 2003) studies identified an increase in diet breadth during periods of low rainfall and low
plant productivity. In addition, Bohrer’s (2007) study identified an increase in the cultivation of maize associated with increasing diet breadth. However, both studies were concerned with early agriculture. On the other hand, residential stability is associated with increases in maize production, population growth, regional packing, and competition over resources (Gumerman 1994; Gumerman and Dean 1989; Kakos 2003; Kohler et al. 2008). This would include the potential loss of traditional hunting areas and the depletion of local game animals (Speth and Scott 1989; Szuter and Bayham 1989). All of these factors affect decisions concerning which wild plants and animals to eat, how much to invest in cultivation, and what measures to employ as means of reducing subsistence risk. Reducing subsistence risk appears to have been particularly important with increasing specialization and the intensification of maize farming; however, the shifting importance of foraging would presumably be best predicted by the diet-breadth model. Therefore, measures of species evenness should be good indicators of specialization and intensification vs. species richness for variations in diet breadth (Leonard 1989).

Two primary perspectives have been used to explain the relationship between foraging and farming. These consist of the resource-abundance model (Binford 1983; Hunter-Anderson 1986) and the diet-breadth model (Barlow 2002, 2006). The former model assumes that subsistence resources are primarily exploited in the proportions in which they are present in the environment. Subsistence diversification and intensification are viewed as products of regional packing. That is, as the size of annual foraging ranges began to shrink, the number and type of resources available to those hunter-gatherers began to diminish. Maize was added to the diet in order to offset seasonal shortfalls in natural-resource productivity (e.g., piñon nuts). In contrast, the diet-breadth model predicts that resources are not added to the diet on the basis of their own availability but in relation to higher-ranked foods. The predictions of each model are fairly straightforward. The resource-abundance model predicts a broader diet breadth during periods of greater rainfall and, therefore, greater resource productivity. In contrast, the diet-breadth model predicts a narrow diet breadth during periods of greater rainfall and resource productivity. On the other hand, increasing attempts to minimize risk would be expected to correlate to increasing maize production (e.g., storage, technology, and exchange). The question is the following: How do resource-abundance, diet-breadth, and risk-minimization models explain the long-term variability in subsistence economies in the southern Chuska Valley?

Some available data indicate long-term variations in food selection in which a variety of plant and animal species from both lowland and upland settings is exploited. For example, Vierra’s (2008:73) review of Basketmaker II period flotation samples (n = 69) revealed that 90 percent contained cheno-am (Chenopodium-Amaranthus), 78 percent contained maize, 30 percent contained Indian ricegrass (Achnatherum hymenoides), 10 percent contained squash family (Cucurbitaceae), and none contained any dropseed (Sporobolus spp.) (see also Gilpin 2007). Indian ricegrass is a cool-season grass that probably was enhanced by winter melt from the Chuska Mountains. In contrast, dropseed is a warm-season grass that depends on summer rainfall and presumably would have been more productive in adjacent areas of the San Juan Basin. Faunal remains from Basketmaker II period sites in the area primarily consist of jackrabbit (Lepus spp.), cottontail (Sylvilagus spp.), and prairie dog (Cynomys spp.), with very few deer (Odocoileus spp.) and pronghorn (Antilocapra americana) (Kearns 2007a; Redd et al. 1994).

El Paso Pipeline Project excavations revealed that 95 percent of the Basketmaker III period flotation samples contained maize, along with an abundance of cheno-ams, dropseed, and Indian ricegrass, but little squash family and no beans (Phaseolus spp.). The faunal remains primarily consisted of small game, with some deer, pronghorn, and bighorn sheep (Ovis canadensis). Maize and cheno-ams still dominated the Pueblo I period flotation samples, which also included dropseed, Indian ricegrass, and some squash family and beans (see also Damp and Kotyk 2000:104). Faunal remains were the same as those from the earlier phase but with some elk, bison, and wild turkey remains (Kearns 2007b).

The Pueblo II period flotation samples primarily contained maize and cheno-ams, along with some squash family, Indian ricegrass, dropseed, piñon nuts, and beans, which represent a range of lowland and upland resources. Most of the identifiable faunal remains consist of small mammals (e.g., cottontail, jackrabbit, and prairie dogs), along with a few deer and pronghorn. On the other hand, there is a noticeable increase in the relative number of bird bones, with wild turkey contributing the same proportion as cottontails and jackrabbits (Kearns 2007c).
The limited data available for the Pueblo III period revealed reductions in the ubiquity of maize (60 percent) and cheno-ams (40 percent), with some squash family, Indian ricegrass, dropseed, and piñon nuts. Faunal remains primarily consisted of small mammals (cottontail, jackrabbit, and prairie dog), with some wild turkeys and other birds and a few deer, pronghorn, and bighorn sheep (Kearns 2007c).

Some suggestive patterns are represented in these data. For example, Basketmaker III period faunal assemblages contained both small and large game, and elk and bison were added during Pueblo I period times. This pattern may be associated with a wet period, increased grassland production, and the availability of bison and elk (McVickar 2007). On the other hand, there is a general shift to lower-ranking game, with more wild turkey and other birds, during the Pueblo II period. The Pueblo III period is characterized by the hunting of small game with an attempt to increase protein consumption by exploiting upland piñon nuts and bighorn sheep. Overall, there appears to have been a decrease in the hunting of artiodactyls and an increase in the hunting of smaller animals, wild turkeys, and other birds over time, although this might also have included increased use of logistical hunting in upland locales (see also Akins 1985; Dean 2003; Szuter and Bayham 1989). Cheno-ams and maize were always important in the diet, and the inclusion of squash family and beans came later. Otherwise, there were fluctuations in the harvesting of Indian ricegrass and dropseed over time (see also Toll 1985).

Doolittle and Mabry (2006) and Mabry and Doolittle (2008) described a variety of agricultural tactics that could have been used for prehistoric maize cultivation throughout the Southwest. These include dryland, rain-fed, runoff, high-water-table, floodwater, and irrigation farming. Dryland farming uses fields situated in soils that retain moisture or that have been enhanced with mulch (e.g., gravel); high-water-table farming is conducted in settings with high water tables. Rain-fed farming relies on natural rainfall, and runoff farming involves controlling or diverting runoff into fields. Floodwater farming involves fields located in natural flooding areas, and irrigation farming consists of diverting water from springs or streams. Together, these tactics provide a range of options for subsistence farmers; however, Mabry and Doolittle (2008) suggested that high-water-table farming, irrigation farming (at lower elevations), runoff and ak chin farming, dryland farming, floodwater farming, and rain-fed farming would be ranked from the lowest to highest degree of risk, respectively. (Ak chin is a type of runoff farming in which plots are located at the mouths of small drainages [Hack 1942:26–28].) It has also been shown that several of the varieties of maize that were grown exhibit varying degrees of agricultural productivity and are suited for cultivation across a variety of environmental settings (Adams 1994; Huckell 2006; Iltis 2006; Mangelsdorf 1974). High-water-table farming adjacent to playas was probably an important factor in the initial process of maize cultivation in the Chuska Valley. Certainly, these eastern slopes would have provided excellent opportunities for a variety of cultivation techniques, including runoff and high-water-table farming. For example, runoff farming might have been most productive at higher elevations during periods of below-average rainfall, along alluvial fans during periods of average rainfall, and adjacent to playas during periods of above-average rainfall.

Basketmaker II period irrigation channels have been identified in the Zuni area (Damp et al. 2000; Damp et al. 2002). But certainly, the greatest diversity of agricultural features has been recorded in Chaco Canyon (Vivian 1990:309–313). Nonetheless, it is currently unclear how much energy was invested in the construction and maintenance of agricultural features in the southern Chuska Valley. Was a mix of extensive and intensive strategies employed by these groups? It seems likely that the abundance of runoff could have negated the degree of investment in agricultural technology required by the residents of Chaco Canyon (but see Wiseman 1980).

Wills et al. (1994:311) suggested that Basketmaker III period groups could have implemented an extensive strategy similar to that used by historical-period Navajo groups: the seasonal relocation of residences in differing environmental settings. For example, Winter (1993) provided an example of farming along Captain Tom’s Wash; the size of the cultivated area was determined by the amount of spring snowmelt. Individuals monitored the Chuska Mountains in the late winter in order to evaluate the potential runoff. Fields were planted in May, and periodic visits were made to maintain the fields and to harvest in August. The size of the crop depended on the amount of summer rainfall. A variety of farming tactics was used by Navajo families residing in the region, including hand-watered kitchen gardens, rainfall, and spring-fed and diversion ditches that were constructed along seasonal drainages. Ditches diverted water into nearby fields, thereby
mimicking the tactic of situating fields at the mouths of ephemeral drainages. Fields could be located near residences, whereas others’ field locations were seasonally occupied. In some cases, local residents monitored fields planted by others. Therefore, both extensive and intensive strategies might have been implemented, although the latter primarily consisted of the diversion of seasonal runoff into nearby fields. This provides a historical-period example of the possible range of risk-reduction tactics used by the Navajo residents of the area. These tactics could be similar to those employed by ancient Anasazi groups.

**Household, Place, and Landscape in the Southern Chuska Valley**

In addition to the rich record of human subsistence discussed above, the archaeology of the southern Chuska Valley has preserved many traces of past social lives, from clues about household organization afforded by house-floor assemblages and domestic architecture to evidence of large-scale public ritual, political organization, and prehistoric ideology and cosmology potentially manifested in the arrangement of great houses and other public structures on the landscape. As discussed in detail elsewhere in this document, previous archaeological research in the area has provided a detailed record of the region’s long history that suggests great potential for the research approach driven by social theory outlined above.

Beginning at least as early as the Basketmaker II period, sites from the southern Chuska Valley include structures, storage pits, extramural activity areas, and other domestic contexts with the potential to contain deposits relevant to the investigation of households (see Damp et al. 2000; Damp et al. 2002; Kearns 2007a); similar deposits are present for all later periods, as well (see Damp and Kotyk 2000; Dykeman 2003; McKenna 1986). Careful attention to the context and disposition of in situ domestic artifacts in such settings may provide insights into domestic organization, gender, and identity within households, beginning from this early period. Published archaeological reports from Basketmaker III period sites (e.g., Kearns 2007b; Kearns et al. 1998) have also indicated the presence of nonlocal artifacts, ritual items, adornments, and other “special” items in domestic assemblages. The archaeological contexts for such materials may be of particular importance for understanding ideology and identity at the household scale or for unraveling the dimensions of local lineage systems and nascent political leaders. Additionally, nonlocal artifacts, including ceramics and other materials potentially associated with migration into the area (Kearns 2007b), may reveal additional details about social interaction and organization in the region. Household assemblages and meaning-laden artifacts from later periods, as the southern Chuska region became more integrated into the Chaco core (see Vivian 1990), may also provide insights into the relationships between local religious and political leaders and the larger, panregional ritual and/or political system centered on Chaco Canyon.

Basketmaker III period pit-structure architecture grew more formal, with more external features, formal antechambers, and possible communal structures, as outlined above (Kearns 2007b; McVickar and Wails 1998). Point-pattern analysis or other methods of spatial analysis may offer insight into the social dynamics of this increased formality as well as the dynamics of the increasing emphasis on aboveground room blocks and multifamily dwellings seen during the subsequent Pueblo I period (Damp and Kotyk 2000; Kearns 2007b). Although a comprehensive understanding of the spatial dynamics of Basketmaker III and Pueblo I period site structure will be complicated by the presence of overlying Pueblo II period occupations on many sites, comparisons of social organization between sites representing short-term occupations (e.g., McKenna 1986) and sites with long occupational histories stretching into the Pueblo I or II period (e.g., Dykeman 2003; Truell 1986) may suggest potential differences in social organization or group dynamics between sites with long occupational histories and those occupied for briefer spans. Spatial differences between sites with short- and long-term occupations may also have ramifications for understanding differences in social organization and group structure between sites representing year-round occupations (e.g., Reed 2000) and sites, like Shabik’eschee Village, that are argued to represent patterns of periodic seasonal occupation (e.g., Wills and Windes 1989).

As mentioned, public architecture was present in the southern Chuska Valley area by at least A.D. 600–720 (Dykeman 2003; Gilpin et al. 1996; Kearns 2007b). Early communal structures consist of large pit structures; great kivas appeared at village sites in the area by the end of the Basketmaker III period (Gilpin
et al. 1996; Marshall et al. 1979; Peckham 1969). Although the architectural data available for many early sites are somewhat limited, understanding the capacity and accessibility of such early public architecture is important, because it potentially reveals the scale of public ritual in early communities in the region. If access to probable ritual structures appears limited relative to potential community size, this may point toward the development of ritual hierarchies or restricted ritual knowledge, as seen in ethnographic Anasazi communities (Triadan 2006).

During the early Pueblo II period (A.D. 900/920–1020), habitation sites in the southern Chuska Valley were typically scattered across the landscape (Kearns 2007c). These sites are typically small, consisting of linear room blocks and associated pit structures usually interpreted as kivas. By the following late Pueblo II period (A.D. 1020–1140), small habitation sites similar to those of the Coyote Canyon phase increasingly clustered around Chacoan-style great houses, with as many as 10 great-house or great-kiva sites present in the area, forming the largest concentration of Pueblo II period communities along the Chuska Valley (Gilpin et al. 1996; Kearns 2007c; Vivian 1990). As mentioned, great houses with Bonito-style architecture in the area are often located in communities with occupation histories beginning in the Basketmaker III or Pueblo I period. Investigations of access, social integration, and other spatially visible dimensions of community organization may suggest details of the social organizations of these sites that may help to explain both their occupational persistence and their advantage as locations for Chacoan-style great houses or great kivas.

The spatial relationships between great houses and the habitation sites that surround them are also important to understanding the role that great houses played in their local settings (see Kantner and Mahoney 2000). This understanding might benefit from the kinds of space-syntax-based analysis employed effectively by several researchers within Chaco Canyon itself (e.g., Bustard 1996; Cooper 1995). Examinations of the accessibility of great houses relative to other local architecture, for instance, might have implications for understanding the degree to which great houses in the Tohatchi Flats area were integrated into their surrounding communities and, therefore, for understanding the relationship between the southern Chuska Valley area and the central Chaco core (Vivian 1990). More-experiential or more-phenomenological approaches to great-house architecture might also be informed by such accessibility analysis, perhaps indicating the degree to which rituals conducted in or around great houses could be accessed or perceived by residents of surrounding sites. Finally, the long occupations indicated at many great-house sites suggest the importance of detailed occupational histories for sites in the region. In addition to enhancing the understanding of the relationship between great houses and other sites within the Tohatchi Flats community, occupational histories might provide insights into possible cosmological or astronomical principles at play in site planning and layout, as seen in several structures within the Chaco core (Ashmore 2007; Preucel 2000; Snead and Preucel 1999).

Methods of spatial analysis may also help to unravel the changes that ensued between the Pueblo II and Pueblo III periods, because aggregation and increased site size in the northern Chuska Valley and the southern San Juan Basin were paralleled by an apparent decline in site density in the southern valley and in local production and status for some sites in the southern area. Spatial analyses of sites that persisted into the Pueblo III period may reveal differences from other sites, in terms of integration or other dimensions of social organization, and might help explain why these sites persisted. Similarly, examinations of kivas, biwalls, or other ritual spaces at the Pueblo III period sites may provide clues to dimensions of Pueblo III period ritual that suggest how remnant populations were integrated into more-aggregated Pueblo III period communities. Conversely, Pueblo III period pit structures, like the one excavated near Figueredo Wash (Kearns 2007c), may indicate a new, much-less-integrated settlement structure based on small family groups. A comparison of the spatial dynamics of this site and similar sites to other Pueblo III period sites and earlier, presumably family-group-based, small sites of the Basketmaker III or Pueblo I period could shed additional light on this hypothesis.

Great houses and other public architecture in the southern Chuska Valley region can also be profitably considered from a landscape perspective. Although their settings are not well synthesized (see Gilpin et al. 1996), the locations of great houses, great kivas, and other public architecture may be meaningful in terms of locally available resources, specialized procurement sites, or prominent topography or other landscape features. Attention should also be paid to the interrelationships between sites, particularly as suggested and emphasized by Chacoan roads and other potential corridors of prehistoric movement. At least two roads extend between Chaco Canyon
and the southern Chuska Valley, passing through the Red Willow great-house community, the Los Rayos great kiva, and possibly the great kiva at Tohatchi Village, which may, as indicated, date to the Basketmaker III period (Gilpin et al. 1996; Nials et al. 1987; Powers et al. 1983). The presence of these roads suggests interconnections between these great houses and the other sites and structures along their routes, including not only other great houses like Peach Springs, Standing Rock, and Gray Ridge but also smaller habitation sites and hamlets along the road corridors (Kantner 1997). Roadways probably have cosmological or ideological significance, as well (see Fowler and Stein 1992; Lekson 1999; Van Dyke 2000, 2004, 2008), linking sites with ritually significant peaks and other landmarks, shrines, or locations of ancestral importance. In this light, the possible association between one of the road segments and the Basketmaker III period occupation at Tohatchi Village is intriguing.

The resonance of this location may have occurred during the Pueblo III period, with the biwall structure at the Red Willow Site serving as a potential “replacement” for the Tohatchi Village great kiva and perhaps reflecting continued attempts by groups in the northern valley and the San Juan Basin to maintain social and ideological ties to that location (Peckham 1963).

Finally, the distribution of archaeological sites of all periods on the landscape is also significant in terms of the meaning that the area’s archaeological resources continue to hold for local indigenous peoples. Sites in the region continue to resonate for many of the area’s indigenous groups (see Duff et al. 2008; Ortiz 1994; Swentzell 1990; Williams et al. 2006), and perspectives on the past gleaned from collaboration between archaeologists and descendant communities can provide new insights into the dynamics of motion, procurement, production, and belief on and around the region’s cultural landscapes and can demonstrate the persistent importance of those landscapes as repositories of meaning, insight, and wisdom.

### Research Questions and Issues

Discovery, investigation, and interpretation of archeological resources in the San Juan Basin have expanded our understanding of the region’s cultural history and the dynamic processes that profoundly affect human beings. However, many questions remain unanswered. Archeological sites located within the U.S. 491 construction area have the potential to address major research questions involving cultural-history issues as well as other issues that deal with general cultural processes and environmental change.

Research will focus on Early Archaic period to historical-period Navajo occupations identified during previous investigations along the U.S. 491 corridors. General research domains involving cultural processes and environmental changes that crosscut cultural-historical periods include the following: (1) chronology; (2) paleoenvironmental reconstruction; (3) subsistence; (4) prehistoric land use, site structure, and social organization; (5) technology; and (6) exchange and regional interaction. Historic contexts and research questions pertaining to the southern Chuska Valley include (1) the nature of the early hunter-gatherers; (2) the transition to farming; (3) the foundations of Anasazi culture; (4) the development of Chuskan communities and their participation in the Chacoan system; (5) the character of post-Chacoan occupations; and (6) the nature of the early Navajo occupations of the area from the sixteenth to mid-nineteenth century.

The following sections summarize the major research issues and questions that will act as a research design for the mitigation of archeological sites along the U.S. 491 corridors.

### General Research Domains

In addition to the cultural-historical issues presented above, other research domains are important to organize and focus archeological research. To further address the complexity of cultural systems, five crosscutting research domains are offered below. One research domain, paleoenvironmental reconstruction, deals with natural contexts. The four cultural-context domains are (1) chronology; (2) subsistence; (3) land use, site structure, and social organization; and (4) regional interaction.
Chronology

To fully examine the evidence for land-use patterns represented by each period of occupation, each site component should be accurately dated and placed within the temporal framework for the region. A basic objective of the project will be to gather chronological data to establish during what temporal periods occupation occurred at the sites. Dating will rely on a combination of chronometric methods and relative-dating techniques based on artifact typologies and stratigraphic positioning.

Of particular importance will be the collection of tightly provenienced radiocarbon, archaeomagnetic, and dendrochronological samples. Dendrochronological samples will be collected wherever found, for processing at the Laboratory of Tree-Ring Research at the University of Arizona, and may provide the best results. Archaeomagnetic samples are the second most desirable and may occur in well-burned, clay-lined thermal features and floors; however, the archaeomagnetic calibrations do not extend much before A.D. 600, reducing their usefulness at Archaic and Basketmaker II period sites. Samples for radiocarbon dating, though less accurate, are likely to be more ubiquitous in well-preserved cultural contexts and have the advantage of being able to date Paleoindian and Archaic period components. For radiocarbon dating, efforts will be made to use annual seeds to avoid the “old wood” effect.

In addition to absolute techniques, diagnostic artifacts and their contextual distributions will be carefully and systematically analyzed for the purpose of extracting precise chronological data. All the sites have produced diagnostic artifacts. Projectile points have been recorded at some of the sites, particularly several identified as Archaic period occupations. Ceramics will be especially useful for this analysis. Ceramic cross-dating is a relative technique that applies chronologies established for a particular ceramic type in a region to ceramic artifacts at sites for which chronometric data are not available (Rice 1987:436–438; Shepard 1985:341–348). Relative dates for the sites will be established through the identification of ceramic types, which will be based on the accepted typologies developed for the region (Chapin 2005; Hogan 1996).

Although ceramic and projectile point typologies allow for relative dating of sites, the date ranges of these cultural materials often span several hundred years each. This problem is particularly acute for the Archaic period tradition, because none of the relevant projectile point typologies is well dated in the regions for which the typologies were originally formulated (Chapin 2005). There is a critical need to obtain chronometric dates from contexts associated with ceramics, to clarify the production-date ranges for the indigenous wares, and from contexts associated with projectile points, to refine and clarify the date ranges of projectile point types, particularly during the Archaic period.

Chronological control also is essential for establishing which features found at multi-occupational sites are contemporaneous within each occupational phase. Establishing the contemporaneity of features is critical to determining the nature of settlement patterns and occupational intensity. For example, do sites containing multiple structures represent occupation by several family groups, or do they represent successive occupations by a single residential group? If the latter, was the later site occupation continuous, or was the occupation episodic and characterized by successive abandonment and reoccupation? Therefore, recovery of datable materials for chronological placement of sites and a refinement of regional chronologies is a primary objective of this project.

Paleoenvironmental Reconstruction

Collecting data on past environmental conditions is crucial to understanding prehistoric developments in the project area. Because the Southwest is a marginal, semiarid environment, even minor fluctuations in precipitation levels and other climatic conditions have potentially profound effects on resource availability and farming systems. Moreover, human impact from farming and exploitation of critical resources (such as firewood) can have notable effects on local environments that can, in turn, affect the local residents. Data on past environments may be obtained from various sources, including macrobotanical remains obtained through flotation, pollen, and phytolith samples; faunal remains; and tree-ring sequences as well as hydrologic and geomorphic studies.
In an attempt to understand regional dynamics of the environment and its relationship to human behavior, McVickar (2007) has synthesized a paleoenvironmental reconstruction for the southern Chuska Valley using previous studies from dendroclimatology, hydrology, geomorphology, pollen research, and packrat-midden analyses as well as data collected from the El Paso Pipeline Project and other archeological investigations in the region. This research presents a thorough environmental reconstruction that can be used for the U.S. 491 project as a base from which to test and refine the sequence. This would include understanding the local geomorphic processes and their implications and describing the dynamic nature of the landscape, site-formation processes, site integrity, and the potential for buried deposits. The presence of intact middens and features at the U.S. 491 sites presents an excellent opportunity for recovering environmental data. Biological remains will be carefully analyzed to look for environmental indicators, and that information will be integrated into an analysis and interpretation of subsistence, settlement, and social-organizational patterns.

Key questions in this domain concern environmental conditions during the Archaic period, particularly the Late Archaic period. Studies of the Late Archaic period involve issues related to understanding the context for early maize cultivation and the potential occupational hiatus during the first centuries A.D. The role of climatic shifts associated with the rise and reorganization of the Chacoan system and the eventual abandonment of the San Juan Basin are other issues that may be addressed in this project. The presence of many Pueblo II and a few Pueblo III period components presents a good opportunity for exploring this question. Biological information from the sites should also help to address questions concerning local ecological conditions, which could aid in understanding past land use and the selection of particular site locations.

**Subsistence**

The most-direct evidence for variations in subsistence economy is derived from the waste products of food preparation—both plant and animal remains (or residues) and coprolites. Studies of these remains may also provide information on processing, storage, and season of occupation. What biotic communities were exploited? What wild foods were exploited, and how did these relate to the cultivation of domesticated plants? During which season or seasons were the sites occupied? Subsistence strategies can also be explored using ethnographic and environmental data; cultural, animal, and plant ecology; and optimal-foraging models. Macrobotanical and faunal remains recovered from sites provide first-line evidence for reconstructing subsistence strategies. Faunal remains, pollen, and charred botanical remains aid in the identification of the species present and the biotic zones exploited. Floral and faunal data also have the potential to provide information helpful to determining the season(s) during which a site was occupied. Research in this domain calls for an emphasis on the excavation of features, because organic materials are most likely to be preserved in such facilities and because charring is the best indicator that macrofossils were associated with cultural activities. Combined with chronological information, such data can be used to define changes in resource exploitation through time.

Manos and metates provide the means of milling various plant seeds into flour. One-handed cobble manos and milling stones or basin metates are the hallmarks of the Archaic period, associated with generalized grinding activities. In contrast, agriculturally dependent communities required two-handed manos and specialized slab or trough metates for processing maize (see Bartlett 1933; Haury 1950; Woodbury 1954). Researchers have begun to understand the data potential represented by this history and have used the information to help clarify the forager-to-farmer transition. For example, overall sizes of mano and metate grinding surfaces have been used to indicate degrees of grinding efficiency (e.g., the amount of time spent milling) and grinding intensity and as proxy measures for the importance of maize to the diet (Adams 1993; Diehl 1996; Hard 1986, 1990; Hard et al. 1996; Horsfall 1987; Mauldin 1993; Morris 1990; Lancaster 1986). Other studies have involved understanding the effect of the variety of maize, the crop yield, or the tool design on grinding efficiency (Adams 1999; Murrell 2007).

At sites lacking faunal remains, the analysis of the flaked stone assemblage to identify hunting tool kits probably will provide the major evidence for faunal procurement. The problem faced during analysis of lithic artifacts, however, is distinguishing materials related to hunting from debris associated with other activities.
The least-ambiguous indicator of hunting is the presence of projectile points, although other tool types (i.e., scrapers and bifaces) also are indicative of game procurement and processing. The latter tool types, though, are morphologically similar to those used for different purposes; so, the analyst will have to rely on variables such as wear or breakage patterns and edge angles to formulate arguments concerning tool function.

**Land Use, Site Structure, and Social Organization**

Occupations of the southern Chuska Valley changed through time from series of small, short-term camps oriented to exploit the local natural resources to permanent, residential sites focused at least in part on agriculture. The activities at these sites may be distinguished by the patterns of artifacts and food remains within discrete occupational areas. In order to successfully interpret such patterns of activity, discrete residential units at the sites must be confirmed through exposure of large areas, spatial analysis of site structure, and tight dating of the features to confirm contemporaneity. Through analysis of the distribution of habitations, activity areas, refuse areas, and other features, it is possible to make inferences about group size, group structure, length of occupation(s), and the task(s) undertaken (Kent 1987, 1991; Kroll and Price 1991).

Clearly, all features and artifacts play important roles in determining the function and activities of a site. They will be recorded and mapped. Features discovered during excavation will be fully investigated to determine type, orientation, and size. Particular care will be given to mapping the occupational surfaces of features and structures and the relationships of structures to other extramural features. Artifacts will be collected and analyzed for functional attributes and design elements. Spatial relationships of features to each other and relationships of artifact types to related features will be identified.

Archaeological sites can have complex occupational histories. Specific locations on the landscape may have unique characteristics or economic value in addition to lengths of occupation and potential for reoccupation with increasing residential stability (Binford 1982; Schlanger 1992). Therefore, site histories can be characterized by distinct and overlapping occupational episodes of varying duration and intensity (Bailey 2007; Schlanger 1991, 1992).

Defining the structural framework of a residential site can be important to identifying social units and the differential use of space. Intrisite spatial analyses can aid in distinguishing single occupations, palimpsests, and aggregation sites among hunter-gatherers. Architectural studies can segregate construction and remodeling episodes, and village layouts can provide information on the organization of domestic and ritual space as well as social integration. Studies of artifact density, artifact diversity, tool use life, recycling, and site furniture can provide information about the duration, intensity, and continuity of site occupation and abandonment (Adams 2002, 2005; Binford 1979; Gilpin et al. 1996; Kent 1987; Lekson 2007; Lipe and Hegmon 1989; Schlanger 1991; Vierra 1985; Vierra et al. 2003).

**Technology**

*Technology* refers not only to tools and facilities but also to the labor needed to reduce subsistence risk and to cope with the uncertainties of living in an arid environment. Changes in ceramic and stone-tool technology have often been linked to residential stability, storage, and agricultural intensification. For example, with the shift to agricultural-based economies, the conflicting demands of subsistence pursuits, labor, technology, and social activities need to be balanced, and there needs to be an increasing emphasis on corporate labor-group structure and the aspects of technology associated with agricultural intensification. Variability in domestic architecture is correlated to the amount of energy invested, relative to the expected length of occupation(s). That is, brush huts and pit structures reflect seasonal occupations, and room blocks reflect year-round occupations. Storage features vary from simple slab-lined pits that were used for seasonal food storage to surface rooms with greater storage capacity. In addition, corporate labor groups could have been involved in the construction, maintenance, and use of water-control features to intensify agricultural production (Kearns 2007a; Vivian 1990).
In many areas of the U.S. Southwest, ceramic-container technologies developed in the context of mixed-subsistence economies based on a combination of foraging and low-level horticulture (Crown and Wills 1995a, 1995b; Diehl and Waters 2006; Skibo and Blinman 1999; Whittlesey and Ciolek-Torrello 1996). Adoption of these technologies within a mixed economy and in a context of reduced mobility was likely attributable to changes in diet and food preparation, storage requirements, and task scheduling. Analyses of ceramic forms and attributes contribute to a better understanding of the processes of sedentism and agricultural dependence. The relationship between sedentism and vessel-form variability is highly complex, however, and requires careful assessment of vessel function and vessel-formation processes. Changes in vessel sizes, forms, functions, and diversity tend to correlate to increasing residential stability and household and specialized ceramic production (Arnold 1999; Braun 1980; Hagstrum 2001; King 2003; Reed et al. 2000; Skibo 1992; Toll 2001).

Stone-tool technology involves several organizational aspects that include tool design, the selection of raw materials, tool production and maintenance, tool use, and the eventual discard of worn-out tools (Binford 1973, 1977, 1979; Nelson 1991; Torrence 1989). Stone-tool technologies include a mix of both core-reduction and bifacial-tool production as a means of coping with the uncertainties of food procurement and processing. Simple flakes could be used for a variety of tasks, whereas bifacial tools were most often used for hunting and butchering. Several perspectives have been offered to explain variations in these technologies, including mobility, portability, raw-material availability, time stress, and labor organization (Andrefsky 1994; Bamforth 1986; Ebert 1979; Kelly 1988; Nelson 1996; Parry and Kelly 1987; Torrence 1983; Vierra 1993, 2005). Long-term changes in lithic technology have been discussed by Torres (2000) for the Basketmaker II through Pueblo III periods in regard to shifts in mobility, sizes of procurement ranges, and effects on procurement tactics, including embedded, direct, and indirect tactics (see Binford 1977, 1983; Ericson and Earle 1982).

Exchange and Regional Interaction

The redistribution of goods and services across space is represented by regional social and exchange networks (Braun and Plog 1982:511). Maintenance of economic and political associations and transmission of information are important aspects of trade, particularly that of ceramic and lithic artifacts. Issues pertinent to trade and exchange systems include the types and intensity of interactions of groups in different areas. For example, what types of relationships did groups in the Zuni and Acoma regions (Duff and Lekson 2006) and the northern Colorado Plateau (Lipe 2006) have with groups in the southern Chuska Valley? Key kinds of data that can be used to provide information about trade and exchange include manufactured items, such as ceramic vessels and stone artifacts; agricultural foodstuffs; and other procured resources, such as fauna, shell, feathers, or minerals (Neff 1992, 2000).

One issue that has particular relevance to the question of land-use patterns, community development, and trade has to do with the movement and regional interaction of populations. Research into the mobility of prehistoric groups and exchange among them will focus on the analysis of nonlocal lithic and ceramic materials at the sites. For example, lithic materials can be obtained using an embedded, direct, or indirect procurement tactic, whereas pottery can be produced for local consumption (i.e., household use) or mass produced for distribution (e.g., by craft specialists). Chuska wares, Narbona Pass chert, and spotted yellow chert are some of the best-known examples of items that were exchanged across the region (Cameron 1984, 2001; Hagstrum 2001; Jacobson 1984; King 2003; Mathien 1997; Stoltman 1999; Toll 1991, 2001, 2006; Vierra 1993, 1997).

Ceramic analysis offers one specific avenue whereby questions of regional interaction can be addressed. Mineralogical and chemical characterizations of ceramics are accepted methods for sourcing ceramics and thereby establishing the movement of people and pots across a prehistoric landscape. This is a multi-step process involving the collection of clay and temper samples and the use of reference groups of ceramics and clays from excavated sites in the area. To determine whether there are locally produced ceramics in the assemblages, viable potting-clay and temper samples can be collected within a 7-km radius of the sites under study. This distance correlates with ethnoarchaeological research (Arnold 1988:35–52; Garrett 1998) on the average distance that traditional potters traveled on foot to mine clay and temper. The collection of both clay and temper is necessary,
because potters often have recipes that involve mixing different clays and tempers for vessels requiring different performance characteristics (e.g., cooking, storage, and serving) (Arnold 1988:23–28, 61, 97–99; Bronitsky and Hammer 1986; Neff and Glascock 2000; Rice 1987:74, 226–232, 406–413). A comparative petrographic analysis can also be conducted on ceramics, local clays, and possible tempering agents to determine whether pottery was produced using local materials or imported as finished products.

Identification of lithic-material types provides another line of investigation of patterns of regional interaction. Using existing geological and archeological literature augmented by field survey, an attempt will be made to identify specific source materials represented in the lithic assemblages. Fieldwork will focus on the resources within a 7-km radius of the sites, using the cost-site-catchment approach outlined by Varien (1999:150–152), and samples will be collected for comparative use during the lithic analysis. Employing these data, quantitative analyses of material-type frequencies and their relationships to lithic-tool and -debitage categories can provide productive insights into determining local- vs. nonlocal-stone procurement; the results will be compared to results from similar studies in the general area. Obsidian artifacts, particularly any diagnostic specimens or those from well-dated contexts, are the best items to submit for X-Ray Fluorescence (XRF) analysis and can be linked to existing chemical-characterization databases for the region (Shackley 1995, 2005). Assuming that sufficient amounts of data will be generated from this type of analysis, the results can be interpreted in terms of general and regional models of obsidian procurement and exchange (Baugh and Nelson 1987; Brown 1990; Cameron and Sappington 1984; Findlow and Bolognese 1982a and 1982b; Shackley 1990, 2005; Toll 1991; Vierra 1993, 1994).

**Historic Contexts and Research Questions**

**Changing Hunter-Gatherers**

Spanning almost 6,000 years, the Archaic period tradition is defined as a preceramic adaptation to a broad-spectrum hunting-and-gathering economy dating from the end of the Paleoindian tradition to the beginning of intensive settlements associated with farming. These hunting-and-gathering populations developed residually mobile foraging strategies that followed seasonal patterns of efficient exploitation of plant and animal species within a number of different environmental settings.

Based on patterning of available floral resources, models of land-use patterning have been proposed for the annual cycle and range of Archaic period populations in the San Juan Basin (Hogan 1994; Toll and Cully 1994; Vierra 1985, 1994). Knowledge of the landscape and the climatic variation that affects the distribution and timing of resources would have allowed hunter-gatherer groups to evaluate their options. In the broadest sense, groups are believed to have traveled within the lowland grasslands from spring to late summer, taking advantage of an abundance of grass and other plant resources. In the fall, they would move to upland piñon-juniper woodland areas to forage piñon seeds, other seeds, and cactus fruits; to hunt a variety of faunal species; and to gather wood for fuel and shelter. Surviving the winter in these settings, they would start the cycle over in the spring. During these annual settlement cycles, groups used differential forms of residential and logistical mobility to efficiently exploit the resources (Vierra 1994).

Archaic period components in the San Juan Basin clearly reflect change from highly mobile hunting-and-gathering populations early in the sequence to semisedentary groups of at least part-time farmers by the outset of the Late Archaic/Basketmaker II period. Yet few of these sites have been excavated, particularly for the Early and Middle Archaic periods.

What evidence there is from the southern Chuska Valley is severely limited. Other than isolated or scavenged projectile points, no Early Archaic period components were documented until the U.S. 491 test excavations revealed a thermal feature with a date of 4490–4350 b.c. at NM-Q-62-112 (Kearns 2007a; Railey 2004). Evidence of the subsequent Middle Archaic period occupation of the southern Chuska Valley is better known, though not common. Four sites along the El Paso Pipeline Project project area that dated to 3645/3499–2204/1880 b.c. were excavated. Sites of the final Late Archaic/Basketmaker II period are more frequent but have not received extensive excavations and probably do not accurately reflect the settlement pattern of the period.
Based on these data, understanding of Archaic period land-use patterns in the southern Chuska Valley has been hampered by the difficulty of recognizing Archaic period sites. As has been witnessed during the El Paso Pipeline Project and U.S. 491 testing, identification of Archaic period components is dependent on postoccupational geomorphic processes through which unknown percentages of sites are exposed on the surface, whereas many others are buried by up to several meters of alluvial or aeolian deposits. As a case in point, archeological testing along the U.S. 491 South Corridor yielded nine Archaic period components, with only seven recognized by radiocarbon determinations. Given the results of the test excavations, it is anticipated that many other Archaic period components will be exposed by data recovery investigations along U.S. 491 South Corridor.

Archaic period resources currently known from the U.S. 491 South Corridor APE include one Early Archaic period component, one Middle Archaic period component, two Late Archaic period components predating 800 B.C., and four Late Archaic/Basketmaker II period components. These components have the potential to significantly advance our understanding of prehistoric land-use patterns.

1. How were these Archaic period components integrated into the population’s larger land-use patterns?

To successfully address this research question requires adequate chronological control, an understanding of the site structure and demography, an assessment of subsistence economy, significant evidence of what activities occurred there, and the means to examine each population’s larger pattern of territorial movement and interaction.

Although survey and excavations along the El Paso Pipeline Project project area and U.S. 491 have dramatically increased the number of sites and our knowledge of Archaic period land-use patterns, many data gaps remain. Of critical concern are questions about the ages, origins, and nature of Early and Middle Archaic period cultures prior to the arrival of agriculture. Other questions include the following:

2. Are projectile point typologies reliable dating techniques?

3. What were the changes in land-use patterns during the Archaic period, and why did they occur?

4. Are the seasonal models proposed for the San Juan Basin Archaic period supported by the southern Chuska Valley data?

5. Was there an Early Archaic period hiatus in the southern Chuska Valley?

6. What variations in technology are evidenced between differing environmental situations?

7. What are the sizes and composition of the groups represented by the components?

Knowledge of Archaic period subsistence strategies is critical to understanding Archaic period land-use patterns and the eventual transition to agriculture. This leads to questions of which plant and animal resources were being exploited in the southern Chuska Valley through the Archaic period tradition. More importantly, the earliest Archaic period populations appear to have been less dependent on wild-plant resources, judging from the low frequency of grinding implements and the few preserved floral remains.

8. Were Early Archaic period populations actually less dependent on plant foods than later Archaic period groups?

The southern Chuska Valley is beginning to produce evidence of early maize in Archaic period contexts. The El Paso Pipeline Project revealed maize pollen in Middle Archaic period deposits, although no macrobotanical indications of maize were found. A site along the U.S. 491 South Corridor (NM-Q-15-49) slated for data recovery investigations has also yielded charred squash family and maize in association with a calibrated 2Φ accelerator mass spectrometry (AMS) date of 1000–820 B.C. If the date accurately brackets the dates of use of the feature, then it could be one of the earliest direct indications of maize in the San Juan Basin.
9. Did the early introduction of maize into the diet increase the efficiency of hunting and gathering strategies, as proposed by Wills (1988a) and Hogan (1994), rather than replace or supplement non-domesticated subsistence resources?

Another research issue related to land-use patterns involves the size and changing character of group territory. Estimates for the scale at which an annual round might extend have varied among researchers. Older models assumed that the rounds were related to geographically bounded areas, such as basins or mountain ranges, and some researchers have used the distribution of nonlocal lithic materials to develop models of Archaic period territoriality in the San Juan Basin. Vierra (1994:393) and Chapin (2005) have concluded that hunter-gatherer mobility in the San Juan Basin involved large territories that changed through time. Data from the U.S. 491 data recovery may provide new information to test earlier territorial models and address questions like the following:

10. What were the spatial and temporal variations in lithic-raw-material patterns?

11. What implications do these patterns suggest for the size of hunter-gatherer annual ranges or social territories?

12. What evidence is present for exchange between territories?

**Transition to Farming**

The temporal span between 1800 B.C. and A.D. 500 is sometimes assigned to the Late Archaic period; however, the introduction of Mesoamerican cultigens into the American Southwest as early as 2100 B.C. may have caused rapid changes in the material and organizational aspects of the cultural systems in the region (Huckell et al. 1999; Mabry 2005:53). This transition from hunting and gathering to mixed farming-foraging has been the subject of ongoing research and debate (Berry 1982, 1985; Ford 1981, 1984; Hogan 1994; Huckell 1990, 1995, 1996; Matson 1991; Minnis 1985; Smiley 1994; Vierra 1994, 2008; Wills 1988a, 1988b, 1991, 1992; Wills and Huckell 1994). To separate these preceramic, mixed-farming-foraging populations from hunting-gathering groups, Huckell (1996:343) proposed the Early Agricultural period, which he marked as one of “decrease in residential mobility, commitment of labor and facilities to the farming of maize and other crop plants, and increased reliance on the storage of maize and other foodstuffs [that] signal the termination of the purely hunting-gathering, Archaic lifeway.”

Maize may have first arrived in the northern Southwest as early as 2000 B.C. (Huber and Miljour 2004). How it was incorporated into the subsistence and settlement systems of the local Archaic period populations remains poorly understood (Hogan 1994; Kearns 2007a; Vierra 2008). Gilpin (1994) reported direct dates on maize of between 1485 and 1109 B.C. from a site with numerous maize remains and pit-structure architecture in Lukachukai. Thus far, no similar evidence of maize agriculture has been recovered from Late Archaic/Basketmaker II period transition sites dating from 1300 to 500 B.C. in the southern Chuska Valley (Kearns 2007a), although a site east of Chaco Canyon did yield an early uncalibrated date of 2720 B.P. on maize (Simmons 1986).

In the San Juan Basin, more substantial evidence for farming has been found at sites assigned to the Basketmaker II period, the final preceramic cultures of the Colorado Plateau. This stage of Anasazi development is characterized by cultigens as a significant part of the diet, combined with reduced residential mobility and an absence of ceramics. Researchers have dated the period variously from 1000 B.C. to A.D. 500, and most have placed the beginning at around 600 B.C. (Reed 2000:6). Basketmaker II period habitations include small pit structures and large storage cists. Models of Anasazi development are based on the time when full dependence on maize agriculture was achieved. Research at Basketmaker II period sites at Cedar Mesa (Chisholm and Matson 1994; Matson 1991) and at Marsh Pass in Arizona (Smiley 1994) indicated a rapid transition to intensive agriculture, with full dependence on maize by A.D. 200 (Reed 2000:9).
Irrigation and water-control features have been recognized at Basketmaker II period sites in the Southwest. In southeastern Arizona, canals constructed between 1250 and 600 B.C. diverted water at least 2 km to irrigate fields (Mabry 2005:55). On the Zuni Indian Reservation, excavations revealed an agricultural system of fields and irrigation canals that appeared to date to as early as 1000 B.C. (Damp et al. 2002).

Excavations in the southern Chuska Valley have indicated significant early Basketmaker II period occupations (Judge 1982:37; Kearns 2007a:4-17–4-46; Vivian 1990:92). The El Paso Pipeline Project identified nine sites in the southern Chuska Valley that yielded components assigned to the Basketmaker II period (Kearns 2007a:4-17). A series of 41 radiocarbon determinations dated this period between 1000 B.C. and A.D. 150, but Kearns (2007b:3-23) suggested a more conservative estimate for the beginning of the period: 550 B.C. Kearns (2007a:4-32) considered the Basketmaker II period in the southern Chuska Valley to be characterized by “committed agriculturalists,” with maize ubiquity at 89 percent. Squash family were also conspicuous, and tobacco (Nicotiana spp.), the earliest known in the southern Chuska Valley, was also present.

Data from archeological testing of the U.S. 491 South Corridor found two components dating to the temporal span of 1000–550 B.C. and five dating to between 550 B.C. and A.D. 250. This contrasts with data from the El Paso Pipeline Project, from which no strong evidence of a late Basketmaker II period occupation was documented between A.D. 150 and 400. These and other, as-yet-undiscovered Basketmaker II period sites offer the potential to contribute significantly to research questions regarding agricultural origins and culture change in the region.

1. When was maize introduced into the southern Chuska Valley?
2. What was the nature of pre–Basketmaker II period use of cultigens in the region?
3. What portions of the diets of early farmer-foragers were provided by cultigens?
4. What motivated the change in labor investment associated with agriculture?
5. How did farmers and hunter-gatherers interact on the agricultural frontier?
6. What demographic changes occurred in settlements through the Basketmaker II period?
7. Did maize first arrive in the Colorado Plateau region as part of an early crop complex that included other cultigens?
8. Did cultigens arrive in the region through diffusion or through migration?
9. What early changes in Late Archaic period lifeways occurred after the introduction of maize?
10. Did irrigation systems appear in the region during the Basketmaker II period?
11. Was there an occupational hiatus between A.D. 150 and 500, as proposed by Kearns (2007b)?

**Foundations of Anasazi Culture**

One of the most important research issues in the San Juan Basin concerns the development of the Anasazi culture. Beginning by the fifth century A.D., a series of sociocultural developments took hold as early farming populations increasingly adapted to a more sedentary lifeway in the San Juan Basin. According to Rice’s (1975:97) definition, sedentary settlements are “those in which at least part of the population remains at the same location throughout the entire year.” These permanent settlements reflect a shift from residential mobility to logistical mobility wherein specialized task groups moved out from the residential base for the purpose of conducting specific activities.
Debate continues in regard to when and where the earliest sedentary villages were first established in the Anasazi country. Basketmaker II period villages had formed by 1500 B.C. in southeastern Arizona (Geib and Spurr 2000; Mabry 2005). It was sometime later that sedentary settlements appeared in the Anasazi region. Work by Wills and Windes (1989) questioned the long-held opinion that Basketmaker III period settlements had permanent populations. However, investigations from the Rainbow Plateau have indicated that the processes for sedentism were already underway in the Basketmaker II period (Damp 1999; Damp and Kotyk 2000; Kearns et al. 2000). Basketmaker III period settlements in the Chuska Valley and other regions have exhibited botanical remains, large storage facilities, settlement placement near good farming land, and large, communal pit structures that suggest year-round occupation (Kearns 2007c).

The development of sedentary villages in the southern Chuska Valley probably has its origins during the Basketmaker II period. Early Basketmaker II period settlements were likely not permanent but show evidence of shallow pit structures, brush shelters, and, sometimes, numerous large, bell-shaped storage pits that indicate surpluses (Kearns et al. 2000; Reed and Wilcox 2000). By A.D. 600–725, pit structures with antechambers became associated with arcs of surface storage facilities and bell-shaped pits. Large, communal pit structures were sometimes present. Pueblo I period habitations, dating to around A.D. 850 in the San Juan Basin, exhibit a residential site organization consisting of a unit-pueblo design with an arced room block facing a work area or small plaza containing pit structures and discreet middens.

Although these changes are recognized in the San Juan Basin, many basic questions remain:

1. Did the developmental changes witnessed elsewhere in the San Juan Basin also occur in the southern Chuska Valley?
2. What seasons are represented at Basketmaker III period residential and temporary sites?
3. Did Basketmaker III period settlements house permanent populations?
4. Can regional variability be identified among Basketmaker III and Pueblo I period communities?
5. What changes occurred in households from the Basketmaker III period to the Pueblo I period?
6. What demographic changes occurred from the Basketmaker II period to the Pueblo III period?
7. Considering Toll’s conclusions, do Basketmaker III to Pueblo II period sites in the southern Chuska Valley reflect a similar trend in maize ubiquity?
8. What changes occurred in storage facilities and storage capacity from the Basketmaker II period to the Pueblo II period?
9. As proposed by Wills and Windes (1989), was Basketmaker III period subsistence oriented to a dispersed settlement strategy that still relied on hunting and gathering?

Sedentism is closely correlated to the formation of formal communal structures and plazas. Very large pit structures begin to appear in the Basketmaker III period. Although some archeologists refer to them as great kivas, others avoid the terminology, so as not to confuse them with the great kivas of the Pueblo II and III periods. Although these structures integrated the population along social, political, ritual, and economic lines, questions arise as to how these structures functioned within the communities over time.
Strongly associated with increasing sedentism is greater social complexity. Examining Basketmaker III period settlements in the Mexican Springs area, Damp and Kotyk (2000) proposed that the variability in Basketmaker period material culture may represent social differentiation. They suggested that social inequality is reflected in disparities in pit-structure sizes, the placement of some sites within fenced enclosures, the distance to communal structures, and accumulations of material goods in the larger pit structures. In contrast, other researchers in the region have suggested that social status and rank were no more than what would be expected with age grading or achieved status (Kearns et al. 2000; Reed and Wilcox 2000). Sites along the U.S. 491 South Corridor may be able to address the question of whether Basketmaker III and Pueblo I period populations were developing social inequality, as proposed by Damp and Kotyk (2000). Questions about group leadership in the Basketmaker III and Pueblo I periods may also be addressed by the U.S. 491 sites.

10. Did these populations see a rise of powerful leadership and prestige within the region from the Basketmaker III period to the Pueblo I period?

Speaking of Mogollon village leadership, Lightfoot and Feinman (1982:80) suggested that “social differentiation and specialized decision making were present in parts of the prehistoric Southwest by at least A.D. 600.” They provided lines of evidence that might support their “big man” leadership model. Most important, larger pit structures assumed to be leaders’ homes had more internal space, were associated with communal structures, had more storage capacity, and had greater access to nonlocal goods. Wills and Windes (1989) considered Lightfoot and Feinman’s model for Basketmaker III period settlements, particularly Shabik’eschee, but found no evidence of individual leadership as proposed in the model. Instead, they viewed the communal structure as a place where solutions could be achieved by household heads. Thus far, no large Basketmaker III or Pueblo I period settlements have been identified in the U.S. 491 corridor that would be expected to represent a community center; however, the smaller settlements may offer comparative data for this question.

Increases in population size, social complexity, and political control may correspond to heightened threats of conflict. Basketmaker III period settlements in the Mexican Springs and Tohatchi Flats areas have exhibited post enclosures and burned pit structures that might suggest a period of brief but intense conflict. Settlement structure in the Mexican Springs area consists of one to six pit structures that often are surrounded by post enclosures. Damp and Kotyk (2000) noted that 80 percent of these pit structures were burned, and Damp et al. (2000) recorded that the number of burned pit structures rose to around 50 percent by the late Basketmaker III period. Of course, the burning of pit structures may have been part of a ritual closure (Wilshusen 1986)—for instance, after the death of the owner. It is likely that Basketmaker and Pueblo I period structures will be excavated during the U.S. 491 project. A search will be made for evidence of burned structures, fenced enclosures, and the de facto floor assemblages left when structures have been rapidly abandoned or destroyed. These data will be used to address issues concerning conflicts in Basketmaker III and Pueblo I period settlements.

11. Is there evidence for conflict during the Basketmaker III and Pueblo I periods?

Technological changes also accompanied the transition to sedentary villages. Key questions include:

12. When were ceramics introduced?

13. Reed et al. (2000) proposed a transition from indigenous brown ware to gray ware ceramics around A.D. 600. Do the U.S. 491 sites reflect this chronological shift?

14. Did reduction in mobility associated with the introduction of maize in the Basketmaker II period lead to radical changes in Anasazi lithic technology, as proposed by Torres (2000)?

15. How did grinding technology and processing facilities change, and why?

16. How did the forms of pottery vessels change, and what were their functions?
Chuska Communities and Their Role in the Chacoan System

Beginning at least by the Basketmaker III period, small habitation sites appear to have clustered into distinct communities that were often oriented around larger structures or great kivas (Kantner 2004; Kantner and Kintigh 2006; Wilshusen and Van Dyke 2006). These structures probably served ritual and sociopolitical functions that helped to integrate populations. Communities continued to flourish in the area until the Pueblo III period, when the region was depopulated.

Within this temporal span, a unique regional center developed in Chaco Canyon. People living in the canyon started construction of large buildings, called great houses, by the late A.D. 800s. These monumental structures are planned buildings of core-and-veneer construction with distinct masonry styles. Most exhibit multiple stories, large rooms with high ceilings, great kivas, and enclosed kivas. Earthworks and road segments are also associated with many of the great houses. Through time, the great-house form of architecture spread out over the San Juan Basin and beyond. These sites, sometimes called “outliers,” are often, but not always, associated with clusters of small sites, called Chacoan communities.

Communities that exhibit Chacoan architecture are often viewed as having participated in some form of regional Chacoan system. However, Kantner (2004:218) concluded that whatever Chaco was, it was not a unified system of regularly interacting groups. Instead, he contended that some forms of interaction promoted the shared patterning that emerged during the A.D. 900s and 1000s. Clearly, Chacoan architecture represented an ideological icon that was closely tied to sociopolitical differentiation in the canyon.

Whatever the underlying values that went into its construction, the Chacoan style of great house appeared in the southern Chuska Valley during the Pueblo II period (Gilpin 2003; Gilpin et al. 1996; Marshall et al. 1979). Communities of small habitation sites around these structures are known at Tohatchi Flats, Deer Springs, Twin Lakes, Figueredo, Naschitti, and Gray Ridge.

The U.S. 491 South Corridor project runs through the communities of Figueredo, Tohatchi Flats, and Naschitti. Although the project will not directly affect any great houses or great kivas, the project APE includes 27 sites dating to the Pueblo II period. Most are smaller habitations, but 2 have multiple large room blocks with at least 100 rooms each, including 1 with a great kiva outside the APE. Collectively, these sites offer an excellent opportunity to address questions of community formation and function.

1. How did the communities develop, and what constitutes a functional community?
2. How were the communities organized?
3. How did the communities relate to Chaco Canyon, and were the smaller sites occupied seasonally or year-round?
4. What were the population sizes of the small habitation sites?
5. What are the population estimates for the southern Chuska Valley communities at specific points in time?
6. Was there a settlement hierarchy (special-use site, farmstead, hamlet, and village), and how did it change through time?
7. What forms of interaction occurred between sites within communities and sites between communities?
8. What happened to the communities after the construction ceased in Chaco Canyon in about A.D. 1130?

Other questions are probably beyond the data potential of this project; however, information gleaned from the community habitation sites may help future researchers examine such questions as the following: (1) What degree of symbolic and sociopolitical unity existed across the Chaco world? (2) What was the
function of the great houses? and (3) What was the relationship between these structures and the surrounding community of small sites?

The Chuska Mountains and the settlements along their eastern slopes provided large quantities of goods to the regional center at Chaco Canyon, including maize, construction timbers, trachyte-tempered pottery, and Narbona Pass or Chuska chert (Cameron 2001; Toll 1985, 1991, 2006). A large labor force was also needed to transport these goods and to help construct the great houses in the canyon. Research is needed to address the following questions:

9. When did the Chuska populations become major suppliers for Chaco Canyon?

10. What goods were provided by the southern Chuska communities?

11. What was the nature of the relationship between Chaco Canyon and the Chuska slope (i.e., trade, tribute, pilgrimage offerings, or dual residence)?

12. What level of interaction occurred among these communities and between Chaco Canyon and these communities?

Maize, locally produced pottery, and Chuska chert will be recovered from the U.S. 491 sites. Past research has confirmed that maize grown along the slopes of the Chuska Mountains was supplied to Pueblo Bonito in Chaco Canyon by A.D. 850 (Benson et al. 2003; Cordell 2004). Specifically, the area of Captain Tom’s Wash was identified as the source of its production. Two kinds of analyses of excavated maize cobs, the ratio of strontium 86 to strontium 87 and the ratio of trace elements, allow researchers to match maize with where it was grown. Data from maize cobs found at the U.S. 491 sites and soil and water samples collected from drainages crossing the corridor could be compared to analyzed cobs from Chaco Canyon sites to determine whether the southern Chuska Valley also was a major supplier of food to the center.

Other major questions concern the Chacoan economies, social organization, ideology, and exchange. Questions about the subsistence economy include the following:

13. What was the ratio of hunted food to vegetable food?

14. Did hunting strategies change through time in the communities?

15. How did storage facilities and capacity change?

16. What was the ratio of cultigens to gathered food?

17. Did pottery-vessel forms change through time, and if so, why?

18. Did the people residing in the southern Chuska Valley provide food to the occupants of Chaco Canyon, or did they participate in periodic feasting ceremonies at Chaco Canyon great houses?

Post-Chacoan Occupations of the Chuska Valley

During the mid- to late A.D. 1110s, Chaco Canyon experienced another burst of great-house construction. Judge and Cordell (2006:205–206) contended that supporting the large labor force and visitors who came to Chaco Canyon during that time strained the carrying capacity of the canyon, leading to reestablishment of the center near the Animas and San Juan Rivers to the north (Lekson 1999:159). Once referred to as the collapse of the Chacoan system, this is now viewed as a “reorganization” in the early A.D. 1100s.
Sites dating after the Pueblo II period or the Chacoan era are relatively common in the southwestern San Juan Basin. Gilpin’s (2003:182) study of recorded Pueblo III period sites in the southwestern San Juan Basin noted only a slight decline in the number of Pueblo II period (188 to ca. 157) sites. Moreover, he identified site clusters at Tohatchi Flats, Twin Lakes, Tohlakai, and upper Dye Brush Wash and community structures at Grey Ridge Compound, The Twins, Red Willow, Figueredo, Deer Springs, Black Creek Flats, Twin Lakes, and Tohlakai. Dating to A.D. 1130–1300, sites of the Pueblo III period offer important information about the final years of Anasazi occupations in the southern Chuska Valley and changes in social organization, settlement, economy, technology, and exchange in the post-Chacoan era. Among the U.S. 491 sites to undergo data recovery, only one site, NM-Q-62-16, has been identified as a possible Pueblo III period occupation. In addition, the corridor runs through the Tohatchi Flats site cluster and immediately west of the Figueredo Great House, which may have continued to be occupied during the Pueblo III period (Gilpin et al. 1996).

A number of research questions focus on the post-Chacoan occupations of the region and include the following:

1. What social changes accompanied the slow reduction in population during the Pueblo III period?
2. Given the defensive locations of some Pueblo III period habitations along the slopes of the Chuska Mountains, is there evidence of conflict during the Pueblo III period in the southern Chuska Valley?
3. McKenna (1991) suggested that Mesa Verde ceramics include subregional types. Can these regional variants be distinguished in the project area?
4. McKenna (1991) thought that changes in subsistence in Chaco Canyon included shifts toward more reliance on small mammals and wild turkeys and from flint to flour corn. Is there evidence of such changes in subsistence in the southern Chuska Valley?
5. What changes in architectural style are represented in Pueblo III period habitations?

**Early Navajo Occupation of the Chuska Valley**

Survey of the U.S. 491 South Corridor has identified no NRHP-eligible Navajo sites within the project APE. One site, NM-H-62-111, has a stone foundation that has been interpreted as either a prehistoric field house dating to A.D. 885–985 or an atypically shaped Navajo hogan (Railey 2004:11.4). Historical-period artifacts on site, however, dated to post-1960 and did not appear to be associated with the structure. If the structure is Navajo, it probably dates to the early Navajo occupations of the Chuska Valley from the sixteenth to the nineteenth century, prior to the Carson campaign of 1863–1864. Sites from that period have been recorded in the Prayer Rock District and in the Burnham and Tohatchi Flats areas. These sites could offer significant information about the dates of Navajo presence in the region, Navajo social and political organization, and Navajo subsistence and economic pursuits. Specific questions could include the following:

1. What was the nature of the occupations at these early sites?
2. What changes in economic strategies occurred between the sixteenth century and the mid-nineteenth century?
3. Did site structure change through time?
4. Are there indications in the material culture of transitions in family size or structure?
Fieldwork conducted in the U.S. 491 project corridor was accomplished during three separate field seasons spanning from 2011 to 2013. This chapter outlines the field methods used during the data recovery efforts at the project sites. Generally, the fieldwork consisted of mapping, surface and subsurface collections, mechanical excavation, and hand excavation. The protocol regarding the collection and laboratory treatment of artifacts and samples will also be discussed. A brief summary of the recording system used by SRI is presented prior to details regarding the excavation methods used at the sites. Site-specific treatment plans were tailored to cultural resources previously documented during the Phase I and Phase II investigations conducted in the project corridor and were carried out according to the recommendations detailed in the plan of work (Turnbow et al. 2011). Relevant laws and regulations governing the excavation and treatment of cultural properties include, but are not limited to, the following:

- NHPA (as amended) and 36 Code of Federal Regulations (CFR) 60.4
- Archaeological Resources Protection Act
- American Indian Religious Freedom Act
- Native America Graves Protection and Repatriation Act and 43 CFR 10
- Navajo Nation Cultural Resources Protection Act (NNHPD 2010c)
- Navajo Nation Policy to Protect Traditional Cultural Properties (NNHPD 2010d)
- Navajo Nation Policy for the Protection of Jishcha’a: Cemeteries, Gravesites & Human Remains (NNHPD 2010a)
- Navajo Nation Guidelines for Treatment of Historic, Modern, and Contemporary Abandoned Sites (NNHPD 2010e)
- Navajo Nation Policy for the Disposition of Cultural Resource Collections, April 29, 2008
- New Mexico Administrative Code (NMAC), Title 4, Chapter 10, Cultural Properties and Historic Preservation

The Provenience Designation Recording System

Field recording conducted throughout the excavation process at each of the sites was accomplished using the PD (provenience designation) system developed by SRI. This recording system synthesizes the complexity of recording all of the many activities that may arise during data recovery projects into a single numerical sequence. The PD system is designed to integrate most of the components of field recording and assigns a unique identifier to each excavation unit and recovery activity space. Activities and units incorporated into this system include datums, backhoe trenches (TRs), mechanical-stripping units (MSUs), hand trenches (HTs), hand-stripping units (HSUs), profiles (PROFs), excavation units (e.g., test pits [TPs] and sections [SECs]), cultural and natural features, subfeatures, mapping nails (MNs), and point-plotted artifacts. Since a single consecutive series of numbers is used throughout the data recovery activities conducted at each individual site, PD numbers do not run sequentially by particular categories, such as features or units. Consequently, excavation units such as the backhoe trenches excavated at a given site have nonconsecutive numbers.
A unique PD of TR 39 should not be interpreted as indicating there were 39 individual trenches excavated at the site. Similarly, a PD of Feature 133 does not imply that 133 features were recorded at the site. During the course of the excavation project, previously identified and newly discovered features were assigned PD numbers as they were encountered.

Project Area

Fieldwork in the project corridor included data recovery and site-recording activities conducted inside and outside the U.S. 491 ROW, respectively. The highway expansion project involves extending the current ROW to accommodate the construction of additional lanes. The U.S. 491 south corridor is partitioned into four segments, based on construction development plans. Table 7 lists each of the archaeological sites located within project corridor and proposed construction limits (APE). Work activities carried out beyond the proposed construction zone consisted of site mapping and in-field analysis, whereas data recovery activities were limited to the construction zone. In total, 26 archaeological sites were investigated during the Phase III data recovery project. Of these, 20 sites were slated for data recovery, and testing activities were conducted at 6 sites. Subsequent to discovery of buried intact remains within the ROW of NM-H-62-16, full-scale data recovery activities commenced at the site.

Mapping

Site mapping and horizontal and vertical spatial control for the project were achieved using a combination of total station and mapping-grade Global Positioning System (GPS) technologies. At each site, SRI mapping personnel established two primary mapping control points to serve as the site’s main mapping datum and backsight, respectively. A mapping-grade GPS unit was then used to establish Universal Transverse Mercator (UTM) North American Datum 1983 (NAD 83), Zone 12, coordinates for both control points. Once established, a total station at each datum location was used for subsequent field mapping, recording the locations of all backhoe trenches, hand-stripping units, excavation units, surface-collection units, features, subfeatures, mapping nails, important modern or natural features, and point-plotted artifacts encountered during fieldwork. At most sites, a single location was used for all total station mapping, but several larger sites, such as NM-Q-15-46, required multiple mapping locations. At these sites, total station shots were taken between locations and cross checked, if possible. However, each set of mapping control points was separately recorded with the GPS unit. All data recorded with the total station were subjected to immediate quality-assurance review and imported into a master projectwide ArcGIS 10.0 geodatabase.

A traditional grid system was not used during data recovery. Instead, a set of mapping nails were placed at locations adjacent to features, artifact collection units, and other locales at locations deemed appropriate to facilitate field surface collections and excavations. Once set and numbered, mapping-nail locations were recorded with the total station, allowing each mapping nail to be subsequently used as a vertical and horizontal control point in terms of the site’s overall horizontal and vertical coordinates. Mapping nails were also placed at the corners of all feature or arbitrary excavations and indicated on hand-drawn field sketch maps, allowing field maps to be accurately registered for postfield georeferencing and digitization. After the conclusion of fieldwork, total station–derived mapping data and georeferenced field maps were systematically cross checked and reviewed. Additional details not recorded during total station mapping, such as aspects of wall morphology or construction, were digitized into the project geodatabase from field maps at this time.

To the greatest extent possible, a total station was also used to conduct detailed mapping at each site of previously recorded and newly documented features located beyond the project ROW. In some cases, however,
Table 7. Project Sites and Project Corridor Construction Limits, by Segment

<table>
<thead>
<tr>
<th>Navajo Site No.</th>
<th>LA Site No.</th>
<th>Milepost</th>
<th>Scope</th>
<th>Construction Limits</th>
</tr>
</thead>
<tbody>
<tr>
<td>Segment 4 (MPs 37.00–46.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NM-H-62-112</td>
<td>32920</td>
<td>45.55</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-H-62-105</td>
<td></td>
<td>41.20</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-H-62-101</td>
<td>32935</td>
<td>38.83</td>
<td>data recovery</td>
<td>50 feet west of existing ROW/ corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-H-62-99</td>
<td></td>
<td>37.44</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>Segment 3 (MPs 30.90–37.00)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NM-H-62-16</td>
<td>74493</td>
<td>36.80</td>
<td>testing/data recovery</td>
<td>35 feet west of existing ROW</td>
</tr>
<tr>
<td>NM-Q-3-76</td>
<td></td>
<td>36.00</td>
<td>data recovery</td>
<td>60 feet west of existing ROW/ corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-3-75</td>
<td></td>
<td>35.15</td>
<td>data recovery</td>
<td>60 feet west of existing ROW</td>
</tr>
<tr>
<td>NM-Q-3-74</td>
<td>32940</td>
<td>34.64</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-3-72</td>
<td>32943</td>
<td>33.95</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>Segment 2 (MPs 19.60–30.90)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NM-Q-3-14</td>
<td>74509</td>
<td>28.80</td>
<td>testing</td>
<td>100 feet west of existing ROW</td>
</tr>
<tr>
<td>NM-Q-3-58</td>
<td></td>
<td>28.27</td>
<td>data recovery</td>
<td>100 feet north of existing ROW</td>
</tr>
<tr>
<td>NM-Q-3-39</td>
<td>133020</td>
<td>27.75</td>
<td>data recovery</td>
<td>corresponds to existing south ROW</td>
</tr>
<tr>
<td>NM-Q-14-73</td>
<td></td>
<td>25.84</td>
<td>data recovery</td>
<td>70 feet north of existing ROW</td>
</tr>
<tr>
<td>NM-Q-15-56</td>
<td>103468</td>
<td>23.18</td>
<td>data recovery</td>
<td>corresponds to existing west ROW</td>
</tr>
<tr>
<td>NM-Q-15-55</td>
<td>103467</td>
<td>23.15</td>
<td>testing</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-15-53</td>
<td>103465</td>
<td>22.90</td>
<td>testing</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-15-52</td>
<td>103464</td>
<td>22.82</td>
<td>data recovery</td>
<td>corresponds to existing west ROW</td>
</tr>
<tr>
<td>NM-Q-15-29</td>
<td>79903</td>
<td>22.60</td>
<td>data recovery</td>
<td>65 feet east of existing ROW</td>
</tr>
<tr>
<td>NM-Q-15-51</td>
<td>103463</td>
<td>22.43</td>
<td>data recovery</td>
<td>65 feet east of existing ROW/ corresponds to existing west ROW</td>
</tr>
<tr>
<td>NM-Q-15-49</td>
<td>103461</td>
<td>22.10</td>
<td>data recovery</td>
<td>45 feet west of existing ROW</td>
</tr>
<tr>
<td>Segment 1 (MPs 15.60–19.60)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NM-Q-15-46</td>
<td>103458</td>
<td>18.85</td>
<td>data recovery</td>
<td>70 feet west of existing ROW</td>
</tr>
<tr>
<td>NM-Q-15-106</td>
<td></td>
<td>17.75</td>
<td>testing</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-15-43</td>
<td>103455</td>
<td>17.28</td>
<td>data recovery</td>
<td>50 feet west of existing ROW</td>
</tr>
<tr>
<td>NM-Q-15-42</td>
<td>103454</td>
<td>17.13</td>
<td>testing</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-15-41</td>
<td>32962</td>
<td>16.93</td>
<td>data recovery</td>
<td>corresponds to existing east ROW</td>
</tr>
<tr>
<td>NM-Q-15-28</td>
<td>83871</td>
<td>16.65</td>
<td>data recovery</td>
<td>50 feet west of existing ROW</td>
</tr>
</tbody>
</table>

Note: Segments and sites are arranged from north to south.
Key: LA = Laboratory of Anthropology; MP = milepost; ROW = right-of-way.
obstructions, steep slopes, or other obstacles prevented effective total-station mapping. In these instances, features located outside the project ROW were recorded with a mapping-grade GPS unit set to record and average 60 GPS positions for each feature vertex, in order to ensure positional accuracy.

**Surface Collections**

Prior to excavations, a systematic surface collection of all observed artifacts within the construction zone was conducted at the project sites. During the initial testing project, surface collections were conducted within the existing highway ROW at a number of the sites. Consequently, additional surface collections were not recommended for these areas. Collection methods were directly based on the surface-assemblage density observed across each individual site surface. Sites that included surface assemblages with fewer than 300 artifacts were collected using a point-provenience strategy: each individual artifact was marked with a pin flag, assigned a unique PD number, point-plotted using a mapping grade GPS unit, and collected. Sites with surface densities exceeding this threshold were collected using a predefined 5-by-5-m grid loaded onto a mapping-grade GPS unit. The extent of each collection unit (i.e., the southwest, northwest, northeast, and southeast corners) was pin-flagged and assigned an individual PD number. All artifacts observed within each unit were sorted by individual material types (e.g., flaked stone, battered stone, ceramics, or ground stone), tallied, and collected.

**In-Field Analysis**

Site-recording activities conducted outside of the construction zone included both detailed mapping and in-field artifact analysis. In-field analysis was recommended at a number of the sites investigated in the project corridor. Data recovery activities were only conducted within portions of the sites located within the APE. Thus, a characterization of the overall site assemblage was deemed necessary, so that materials collected during the excavations may be placed within an appropriate context. In-field analysis was carried out during the final days of the fieldwork phase, so that a familiarity of the excavated materials was taken into account when examining the larger site assemblages. The lead project lithic and ceramic analysts conducted the in-field analysis, in order to provide a comparable data set of the uncollected and excavated materials. Sample units (1 m in diameter) were situated in areas deemed to contain high artifact densities (e.g., middens).

**Mechanical Excavation**

Mechanical excavations were used to accomplish four main objectives during the data recovery process. Trenching was used to reopen the previously excavated backhoe trenches around the vicinity of the deeply buried features, in addition to allowing for a determination of the geomorphic context of the sites. Further, backhoe trenching was also used for exploratory excavations to determine the spatial extent of deeply buried components concealed below the ground surface. Mechanical stripping was used to remove overburden from deeply buried features, as well as for exploratory purposes.

Trench walls were faced to aid the project geomorphologist in the determination of the site stratigraphy and also to aid in the identification of archaeological features. At least one or more trenches at each of the investigated sites were examined by the project geomorphologist and sampled for sedimentological or pedologic analysis. Scaled stratigraphic profiles were drafted and photographed within each of the
investigated trenches. Sediment samples collected for optically stimulated luminescence dating were also collected from trench profiles at selected sites.

Mechanical scraping was conducted in areas of previously identified and newly discovered features located as a result of backhoe trenching. The primary object of scraping was to expedite excavations by removing the more-recent overburden covering archaeological features. Mechanical stripping was also necessary to expose additional buried features associated with prehistoric occupation surfaces. Subsequent to sampling midden deposits at a few of the sites, the plan of work also specified the use of mechanical stripping to identify any potentially concealed features underlying the middens.

Hand Excavation

Hand excavations were used in a number of contexts at the project sites. Arbitrary excavation units were primarily used to aid in defining the extent and nature of features. Hand stripping was used to expose previously identified features buried by shallow surface deposits. Hand-stripping units were preferred over mechanical-stripping units to define features not clearly visible but close to the ground surface, because mechanical stripping could possibly result in extensive disturbance. These units were also used to further expose prehistoric surfaces immediately surrounding features, in order to reveal any additional associated features.

Hand trenches were primarily excavated to determine the nature and extent of large, amorphous stains in profile, as well as to initially define preserved wall alignments within rubble mounds. Hand trenches were also excavated to sample spatially extensive midden deposits. Test pits were often used as control units to define the stratigraphy within a defined feature, such as rooms within a room block, as well as to sample middens. These units were also used to test for additional buried cultural deposits on sites with archaeological manifestations located near the modern ground surface. Test pits were extensively used in the excavations of NM-Q-14-73, in order to provide for more-spatially-controlled excavations of the lithic assemblage surrounding an ephemeral Archaic period habitation. This site was not deeply buried, and mechanical scraping would have removed all spatial integrity of the artifact assemblage associated with the structural remains.

The features were section-excavated into either halves, thirds, or quarters, based on the size and complexity of the feature. This excavation technique allows for profile exposures of the feature fill to be documented and photographed and for a determination of the stratigraphy within the feature. Each section was assigned a PD number for collections of associated artifacts, samples, and paperwork. Excavations were conducted using a combination of natural and arbitrary levels. Feature excavations were screened using \( \frac{1}{8} \)-inch mesh. Large structural features exceeding 1.5 m in depth were judgmentally screened, based on the nature of the fill. Natural sediments within the uppermost fill, as well as wall-fall and roof-fall deposits, were partially screened and grab-sampled. All floor fill within these large structures was completely screened. For smaller features, most a halved section was collected as flotation and pollen samples. Mapping nails were placed and assigned unique PD numbers to accommodate mapping and vertical control during the excavations. Scaled maps, including plan views, profiles, and cross sections, were generated for each feature in addition to photographic documentation.

Artifact and Sample Collections

All artifacts, ecofacts, and samples collected during the data recovery activities were sorted in the field according to specific material categories, placed in paper bags, and labeled with provenience information. Collections from each site were initially inventoried in the field in preparation for transport to SRI’s laboratory facilities in Albuquerque, New Mexico.
Special samples collected during the excavations included five categories of materials. Flotation samples, pollen samples, mineral samples, dating samples, and soil/sediment samples were all collected during the course of the excavations. Specialized dating samples collected from the project corridor included burned adobe and sediments for archaeomagnetic and optically stimulated luminescence analysis. Sediment/soil samples were also collected for a variety of sedimentological, pedological, and chemical characterizations related to the various geoarchaeological analyses. Flotation and botanical samples were collected both for the purposes of macrobotanical analysis, as well as radiocarbon and dendrochronological dating. Preference was given to annuals for radiocarbon analysis, which provide a secure dating context. The bulk flotation samples consisted of at least 2 liters, if sufficient fill was available from the features. Individual samples collected specifically for radiocarbon were recovered during the excavations, as well as from the light fractions recovered from the bulk flotation samples. Mineral samples consisted of unmodified mineral specimens recovered during the excavations.

**Provenience Recording, Material Treatment, and Collection**

**Laboratory Processing**

Each artifact or sample collected was assigned a PD number that, along with the minimal provenience information, was recorded on a collection bag label. These bags were then submitted to the laboratory for processing and subsequent analysis. Comparison of provenience information in the SRI relational database (SRID) with the bag labels provided inventory control for the artifacts and samples, as well as a first quality-control check of the provenience data. Additional queries assured that artifacts and samples were being consistently entered and assigned the correct physical location within the laboratory as personnel proceeded with artifact processing and analyses.

During preliminary processing, the artifacts were sorted into major categories (e.g., flaked stone, ground stone, ceramics, faunal remains, or botanical remains) and cleaned and organized for analysis. Washing with a brush and water was the default method of cleaning ceramics and lithics. Dry brushing was the preferred method of cleaning for all bone and in other cases when cleaning with water would destroy the artifact. All artifact and sample bags were barcoded and tracked through the analysis process. Bar-code readers were used for ceramic, lithic, and faunal analyses to reduce data entry errors. The unique barcode linked the artifacts to the related features and excavation units, analytical data, geospatial information, field site forms, and photographs within the database. Photographs were taken of lithic, ceramic, bone, and shell artifacts (especially ornaments, tools, vessels and a representative sample of diagnostic items). These photographs were then linked to the inventory’s barcode within the database, and some were then chosen as illustrations for the final report.

Flotation of bulk soil samples to recover macrofossils was performed in the SRI laboratory using a standard decant method flotation system, as described by Hammett and McBride (1993). Each flotation sample was poured into a bucket of water, agitated gently until the botanical remains floated to the surface, and then decanted onto a clean piece of chiffon material to dry. The residue at the bottom of the bucket (referred to as the heavy fraction) was rinsed to eliminate soil matrix, dried, and examined, in order to recover lithic, ceramic, and bone artifacts. Botanical remains were identified by an archaeobotanist prior to submitting for radiocarbon dating.

Soil samples were collected from the modern surface and archaeological contexts in order to extract the plant pollen. Samples were submitted to Texas A&M University for processing and then to the analyst. In addition, pollen washes were conducted of ceramic and ground stone artifacts. Any artifact with potential residual evidence on the surface was not cleaned prior to conducting a pollen wash. Sediments were also collected from within ceramic vessels prior to laboratory washing. Pollen washes used either distilled water or a weak hydrochloric acid solution to lift possible pollen from the use surfaces of the ceramic and ground stone artifacts. See Geib and Smith (2008) for the specific methods used.
Adams, Jenny L.


Adams, Karen R.

Akins, Nancy J.

Allen, John Eliot, and Robert Balk

Amick, Daniel S. (editor)

Anderson, Benedict

Andrefsky, William, Jr.
Anschuetz, Kurt F.

Anschuetz, Kurt F., Richard H. Wilshusen, and Cherie Schick

Appledorn, Conrad R., and H. E. Wright, Jr.

Arnold, Dean E.

Arnold, Philip J., III

Ashmore, Wendy

Ashmore, Wendy, and A. Bernard Knapp (editors)

Ayers, W. B., Jr., and W. R. Kaiser (editors)

Bailey, Garrick A., and Roberta G. Bailey

Bailey, Geoff

Bamforth, Douglas B.
Barlow, K. Renee  


Barrett, John C.  

Barrett, Peter  

Bartlett, Katherine  

Bartram, Lawrence E., Ellen M. Kroll, and Henry T. Bunn  

Basso, Keith H.  

Baugh, Timothy G., and Fred W. Nelson, Jr.  

Becker, Kenneth M., and Jeffrey H. Altschul  

Bennett, Iven  

Benson, Larry, Linda Cordell, Kirk Vincent, Howard Taylor, John Stein, G. Lang Farmer, and Kiyoto Futa  

Berry, Claudia F., and Michael S. Berry  
Berry, Michael S.  

Bettinger, Robert L.  

Binford, Lewis R.  


Bohrer, Vorsila L.  
2007 *Preceramic Subsistence in Two Rock Shelters in Fresnal Canyon, South Central New Mexico*. Archaeological Series No. 199. Arizona State Museum, University of Arizona, Tucson.

Braun, David P.  

Braun, David P., and Stephen Plog  

Bronitsky, Gordon, and Robert Hammer  
Brown, David E.


Brown, David E. (editor)

Brown, Gary M.

Brugge, David M.

Brumfiel, Elizabeth M.

Bustard, Wendy J.

Butler, Robert B.

Cameron, Catherine M.


Cameron, Catherine M., and Robert Lee Sappington
Canuto, Marcello A., and Jason Yaeger (editors)

Capone, Patricia W., and Robert W. Preucel

Cather, Steven M.


Cather, Steven M., Sean D. Connell, Richard M. Chamberlin, William C. McIntosh, Glen E. Jones, Andre R. Potochnik, Spencer G. Lucas, and Peggy S. Johnson

Cather, Steven M., Lisa Peters, Nelia W. Dunbar, and William C. McIntosh

Chapin, Charles E., and Steven M. Cather

Chapin, Charles E., Maureen Wilks, and William C. McIntosh

Chapin, Nicholas Merrill

Chisholm, Brian, and Richard G. Matson

Clark, Jeffery J.
Coltrain, Joan Brenner, Joel C. Janetski, and Shawn W. Carlyle

Colwell-Chanthaphonh, Chip, T. J. Ferguson, Dorothy Lippert, Randall H. McGuire, George P. Nicholas, Joe E. Watkins, and Larry J. Zimmerman

Cooley, Maurice E.

Cooper, Laurel M.

Cordell, Linda S.

Cribbin, Brian, Christopher A. Turnbow, and Patrick F. Hogan (editors)
2010  *Preliminary Investigations at 22 Archaeological Sites along US 491, McKinley and San Juan Counties, New Mexico*. NMDOT Project No. TPA-7500(52), CN CA 612. Office of Contract Archaeology, University of New Mexico, Albuquerque. Prepared for the New Mexico Department of Transportation.

Crown, Patricia L. (editor)

Crown, Patricia L., and Wirt H. Wills


Damp, Jonathan E.

Damp, Jonathan E., Stephen A. Hall, and Susan J. Smith

Damp, Jonathan E., and James W. Kendrick

Damp, Jonathan E., James W. Kendrick, Donovan Quam, Jeffery Waseta, and Jerome Zunie

Damp, Jonathan E., and Edward M. Kotyk

Darling, J. Andrew

Darling, J. Andrew, and B. Sunday Eiselt

Dean, Rebecca Marie

DeConto, Robert M., and David Pollard

Del Bene, Terry A., and William R. Branchard
Dello-Russo, Robert D.


Dering, J. Phil

Dick-Peddie, William A.

Diehl, Michael W.

Diehl, Michael W., and Jamie Anderson Waters

Dohm, Karen M.

Doolittle, William E., and Jonathan B. Mabry

Duff, Andrew I.

Duff, Andrew I., Thomas J. Ferguson, Susan Bruning, and Peter Whiteley

Duff, Andrew I., and Stephen H. Lekson
Durand, Stephen R., and Phillip H. Shelley  

Dykeman, Douglas D.  

Ebert, James I.  

Ehrenberg, Stephen N.  

Elston, Robert G., and David W. Zeanah  

Elyea, Janette M., and Patrick Hogan  

English, Nathan B., Julio L. Betancourt, Jeffrey S. Dean, and Jay Quade  

Ericson, Jonathon E., and Timothy K. Earle (editors)  

Evanoff, Emmett, Donald R. Prothro, and R. H. Lander  

Fassett, James E., and Jim S. Hinds  

Feld, Steven, and Keith H. Basso (editors)  
1996 *Senses of Place*. School of American Research Press, Santa Fe, New Mexico.
Fenneman, N. M., and D. W. Johnson

Ferguson, Thomas J.


Findlow, Frank J., and Marisa Bolognese


Flores, Pilar, and Timothy M. Kearns

Ford, Richard I.


Foucault, Michel

Fowler, Andrew P., and John R. Stein

Freuden, Carl
Garrett, Elizabeth M.  

Geib, Phil R., and Susan J. Smith  

Geib, Phil R., and Kimberly Spurr  

Gilpin, Dennis  
2007    *Social Transformation and Community Organization in the Southwest San Juan Basin, New Mexico: Archaeological Investigations along Navajo Route 9, Twin Lakes to Standing Rock*. Cultural Resources Report No. 00-49. SWCA, Phoenix.

Gilpin, Dennis, Douglas D. Dykeman, and Paul F. Reed  

Gilpin, Dennis, R. R. Fox, and N. L. Kilburn  
2000    *Archaeological Investigations in the Southwest San Juan Basin: Data Recovery along Navajo Route 9, Segment 2-1, Tohatchi Flats to Coyote Canyon, New Mexico*. Cultural Resources Report No. 00-49. SWCA, Flagstaff, Arizona.

Graves, William M., and Scott Van Keuren  

Gregory, Herbert E.  

Gumerman, George J. (editor)  
Gumerman, George J., and Jeffrey S. Dean

Haas, Jonathan, and Winifred Creamer

Hack, John T.

Hagstrum, Melissa B.

Hall, Stephen A.

Hammett, Julia E., and Pamela J. McBride


Hard, Robert J.


Hard, Robert J., Raymond P. Mauldin, and Gerry R. Raymond
Hard, Robert J., and John R. Roney

Harris, Arthur H.

Harris, Arthur H., James Schoenwetter, and A. Helene Warren (editors)

Haury, Emil W.

Hawley, John W.

Hayes, Alden C., David M. Brugge, and James W. Judge

Hegmon, Michelle


Hillier, Bill, and Julienne Hanson

Hodder, Ian R.

Hogan, Patrick

Horsfall, Gayel A.

Houston, Stephen D.

Huber, Edgar K., and Heather J. Miljour

Huckell, Bruce B.


Huckell, Bruce B., Lisa W. Huckell, and Karl K. Benedict

Huckell, Bruce B., Lisa W. Huckell, and M. Steven Shackley

Huckell, Lisa W.

Hudspeth, William B.
Hunt, Charles B.

Hunter-Anderson, Rosalind L.

Huse, Hannah, Bradley Noisat, and Judith Halasi

Iltis, Hugh H.

Inomata, Takeshi

Inomata, Takeshi, and Lawrence S. Coben (editors)

Jacobson, Louann

Johnson, Matthew

Jones, Siân

Joyce, Rosemary A.


Judge, W. James
Judge, W. James, and Linda S. Cordell

Kakos, Peter J.

Kantner, John

Kantner, John W., and Keith W. Kintigh

Kantner, John, and Nancy M. Mahoney (editors)
2000  *Great House Communities across the Chacoan Landscape*. Anthropological Papers of the University of Arizona No. 64. University of Arizona Press, Tucson.

Kearns, Timothy M.
Kearns, Timothy M., Chris A. Kugler, and Paul Stirniman

Kearns, Timothy M., and Janet L. McVickar (editors)

Kearns, Timothy M., Janet L. McVickar, and Lori Stephens Reed

Kelley, Klara B., and Harris Francis

Kelly, Robert L.


Kent, Susan


King, Valerie Claire
2003 The Organization of Production of Chuska Gray Ware Ceramics for Distribution and Consumption in Chaco Canyon, New Mexico. Unpublished Ph.D. dissertation, Department of Anthropology, University of New Mexico, Albuquerque.

Kohler, Timothy A., Matt Pier Glaude, Jean-Pierre Bocquet-Appel, and Brian M. Kemp

Kroll, Ellen M., and T. Douglas Price (editors)

Kues, Barry S., and Jonathan F. Callender
Lancaster, James W.

Lefebvre, Henri

Lekson, Stephen H.
1999 Chaco Meridian: Centers of Political Power in the Ancient Southwest. AltaMira Press, Walnut Creek, California.

Lekson, Stephen H. (editor)

Leonard, Robert D.

Liebmann, Matthew J.

Liebmann, Matthew J., Thomas J. Ferguson, and Robert W. Preucel

Lightfoot, Kent G., and Gary M. Feinman

Lipe, William D.

Lipe, William D., and Michelle Hegmon (editors)
Loose, Richard W.
1978 Physiography/Geology. In Western Area Survey, edited by Public Service Company of New Mexico, pp. 17–33. Public Service Company of New Mexico, Santa Fe.

 Lucas, Spencer G., and Steven M. Cather

 Mabry, Jonathan B.


 Mabry, Jonathan B., and William E. Doolittle

 MacArthur, Robert H., and Eric R. Pianka

 Mangelsdorf, Paul C.

 Marshall, Michael P.

 Marshall, Michael P., and Ronna J. Bradley

 Marshall, Michael P., John R. Stein, Richard W. Loose, and Judith E. Novotny
1979 Anasazi Communities of the San Juan Basin. Albuquerque Photo Lab, Albuquerque, New Mexico.

 Mathien, Frances Joan (editor)
Matson, Richard G.  


Mauldin, Raymond P.  

McBride, Pamela J.  

McGuire, Kelly R., and William R. Hildebrandt  

McKenna, Peter J.  

McKenna, Peter J.  

McVickar, Janet L.  

McVickar, Janet L., and Scott Wails  

Metcalf, Mary P.  
Miljour, Heather J., and Edgar K. Huber

Mills, Barbara J.


Mills, Barbara J. (editor)

Minnis, Paul E.


Mobley-Tanaka, Jeannette L.

Moore, James A.

Moore, Jerry D.


2006 “The Indians were Much Given to Their Taquis”: Drumming and Generative Categories in Ancient Andean Funerary Processions. In *Archaeology of Performance: Theaters of Power, Community,

Morris, Donald H.

Munson, Marit K.

Murrell, Jesse B.

Navajo Nation Historic Preservation Department (NNHPD)


2010b *Permit Package*. Navajo Nation Historic Preservation Department, Window Rock, Arizona.


Neff, Hector

Neff, Hector (editor)

Neff, Hector, and Michael D. Glascock
2000 *Instrumental Neutron Activation of Ceramics from New Mexico Highway 90 Project*. Research Reactor Center, University of Missouri, Columbia.
Nelson, Margaret C.

Nials, Fred L., John R. Stein, and John R. Roney

Obradovich, J. D., E. Evanoff, and E. E. Larson

O’Connell, James F.

Ortiz, Simon J.

O’Sullivan, Robert B., and Helen M. Beikman

Parry, William J., and Robert L. Kelly

Peckham, Stewart L.
1969  *An Archaeological Site Inventory of New Mexico*, pt. I. Laboratory of Anthropology, Museum of New Mexico, Santa Fe.

Peckham, Stewart L. (editor)
1963  *Highway Salvage Archaeology*, vol. 4. New Mexico State Highway Department and the Museum of New Mexico, Santa Fe.

Pitblado, Bonnie L.
Potter, James M.  


Preucel, Robert W.  

Preucel, Robert W. (editor)  

Preucel, Robert W., and Ian R. Hodder  

Railey, Jim A. (editor)  

2007 A Possible Dugout Structure at a Coronado Entrada Campsite: Data Recovery Excavation of an Exposed Feature at LA 54147 along NM 528 near the Intersection with Idalia Road, San Matilde, Sandoval County, New Mexico. NMDOT Control No. 3994. NMDOT Contract No. C04592, Consultant Task No. 4. NMCRIS Activity No. 94609. SWCA Project No. 7571-0004. SWCA Report No. 2006-36. SWCA Environmental Consultants, Albuquerque, New Mexico. Prepared for Blake Roxlau, New Mexico Department of Transportation, Santa Fe.


Redd, Ingrid L., Kevin D. Wellman, and Galen R. Burgett  
Reed, Lori Stephens, C. Dean Wilson, and Kelley Ann Hays-Gilpin

Reed, Paul F.

Reed, Paul F. (editor)

Reed, Paul F., and Scott Wilcox

Reher, Charles A. (editor)

Repenning, Charles A., John F. Lance, and James H. Irwin

Rice, Glen Eugene

Rice, Prudence M.

Rossignol, Jacqueline, and LuAnn Wandsnider (editors)

Roy, Mousumi, Thomas H. Jordan, and Joel Pederson

Sauer, Carl O.

Schiffer, Michael Brian
Schlanger, Sarah H.


Schmader, Matthew F.

Schmidt, Karl-Heinz

Schutt, Jeanne A.

Scurlock, Dan

Sebastian, Lynne


Semken, Steven C.

Shackley, M. Steven


Shanks, Michael, and Christopher Tilley. 1988 *Social Theory and Archaeology*. University of New Mexico Press, Albuquerque.


Smith, G. A.  


Smith, Grant D., and Michael McFaul  

Snead, James E.  


Snead, James E., and Robert W. Preucel  

Sofaer, Anna  


Speth, John D., and Susan L. Scott  

Stanford, Dennis J.  

Statistical Research (SRI)  
Stein, John R., and Andrew P. Fowler  

Stein, John R., and Stephen H. Lekson  

Stephens, David W., and John R. Krebs  

Stoltman, James B.  

Stuart, David E., and Rory P. Gauthier  
1981 *Prehistoric New Mexico: Background for Survey*. Department of Finance and Administration, State Planning Office, Historic Preservation Bureau, Santa Fe, New Mexico.

Stutz, H. C.  

Sullivan, Richard B.  

Swanson, Steve  

Swentzell, Rina  

Szuter, Christine R., and Frank E. Bayham  
Thomas, Julian

Tilley, Christopher

Toll, H. Wolcott


Toll, Mollie S.
1985 Flotation at a Spanish Colonial Farm (LA 16769) along the Santa Fe River, New Mexico. Technical Series. Castetter Laboratory for Ethnobotanical Studies, University of New Mexico, Albuquerque.

1993 Botanical Indicators of Early Life in Chaco Canyon: Flotation Samples and Other Plant Materials from Basketmaker and Early Pueblo Occupations. Manuscript on file, Chaco Cultural NHP Museum Archives, University of New Mexico, Albuquerque.

Toll, Mollie S., and Anne C. Cully

Torrence, Robin

Torrence, Robin (editor)

Torres, John A.

Towner, Ronald H. (editor)
Triadan, Daniela

Tringham, Ruth E.

Truell, Marcia L.

Tuan, Yi-Fu, Cyril E. Everard, Jerold G. Widdison, and Iven Bennett
1973 *The Climate of New Mexico*. New Mexico State Planning Office, Santa Fe.

Turnbow, Christopher A., Patrick F. Hogan, Bradley J. Vierra, and Phillip O. Leckman

Van Dyke, Ruth M.
2008 *The Chaco Experience: Landscape and Ideology at the Center Place*. School for Advanced Research Press, Santa Fe, New Mexico.

VanPool, Christine S., and Todd L. VanPool

Van West, Carla R., and Timothy A. Kohler

Varien, Mark D.
Vierra, Bradley J.


1988b *Early Prehistoric Agriculture in the American Southwest.* School of American Research Press, Santa Fe, New Mexico.


Wills, W. H., Patricia L. Crown, Jeffrey S. Dean, and Christopher G. Langton

Wills, W. H., and Bruce B. Huckell

Wills, W. H., and Thomas C. Windes

Wills, W. H., F. Scott Worman, Wetherbee Dorshow, and Heather Richards-Rissetto

Wilshusen, Richard H.

Wilshusen, Richard H., and Ruth M. Van Dyke

Windes, Thomas C., and Ruth M. Van Dyke
Winter, Joseph C.

Winterhalder, Bruce

Wiseman, Regge N.
1980 The Naschitti-North Project: The Excavation of Two Small Pueblo II Sites near Sheep Springs, San Juan County, New Mexico. Laboratory of Anthropology Note No. 143. Museum of New Mexico, Santa Fe.

Woodbury, Richard B.

Wright, H. E., Jr.

Yellen, John E.

York, Frederick F.

Zachos, James M., Mark Pagani, Lisa Sloan, Ellen Thomas, and Katharina Billups

Zeanah, David W.
