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Long-Term Interactions of People and Animals in the Mimbres Region, Southwest New Mexico AD 200–1450

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Understanding how people maintain long-term access to animals for food and other uses is important in the context of archaeology and may also have implications for contemporary societies' access to animal resources. This study gathers information from 70 sets derived from existing data and museum collections to examine the long-term record of human population and settlement patterns, land use, and animal remains at archaeological sites in the Mimbres area. In some periods, the increasing aggregation of the population and the increasing sedentism contributed to altered environments near the villages and for that reason, the access to certain resources became more difficult. The recovery of some animal populations is also evident during periods when many human residents left the area to live elsewhere. These long-term trends demonstrate the power of recovery of different animal species to human hunting and anthropogenic changes in the landscape.

Comprender cómo las personas mantienen acceso de largo plazo a los animales para la alimentación y otros usos es importante en el contexto de la arqueología y también puede tener implicaciones para el acceso de las sociedades contemporáneas a los recursos animales. Este estudio reúne información de 70 conjuntos derivados de datos existentes y colecciones de museos para examinar el registro a largo plazo de la población humana y los patrones de asentamiento, el uso de la tierra, y los restos de animales en sitios arqueológicos en el área Mimbres. En algunos períodos, la creciente agregación de la población y el sedentismo contribuyeron a ambientes alterados cerca de los pueblos y por eso, el acceso a ciertos recursos se hizo más difícil. La recuperación de algunas poblaciones animales también es evidente durante los periodos en que muchos residentes humanos abandonaron el área para vivir en otra parte. Estas tendencias a largo plazo demuestran el poder de recuperación de

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las diferentes especies animales a la caza humana y el cambio del paisaje antropogénico.

KEYWORDS Mimbres, Zooarchaeology, Animals, Hunting, Resilience, Ecology, Anthropogenic change, Southwest US

Sustainable hunting and the resilience of animal resources to human impacts are important issues in both archaeology and wildlife biology. In many critical modern habitats, wild game is a vital food resource for subsistence farmers. Some taxa become depleted or extirpated as the demands of human populations for food and agricultural land increase, but others do well under these conditions. Archaeological studies can provide long-term perspectives on the balance between human resource demands and the persistence of animal populations, including examples of more and less resilient patterns of animal use at a scale of centuries. The Mimbres region is an excellent place to examine long-term patterns in human aggregation and dispersal and accompanying changes in fauna over more than a thousand years, from AD 200 to 1450.

Two key questions are addressed in this study. First, how are changes in human settlement and population related to changes in key mammal taxa in the Mimbres region? To address this, I examine how theoretically less resilient and more resilient taxa respond as human settlements grow in some time periods, and as the intensity of human activity lessens with reduced human populations in other time periods. A secondary question concerns the challenges and benefits of combining multiple datasets in a large-scale project. After briefly summarizing some of the challenges encountered, I summarize chronology and settlement patterns in the area, including a brief summary of previous faunal studies. I then use a series of zooarchaeological analyses to examine temporal changes in the representation of key animal taxa in order to assess whether changes are potentially linked to those animals' responses to hunting and/or anthropogenic landscape change. These analyses show local depletion of some animal resources during times of high human population, and later recovery of resources when human populations fell in the region.

Challenges in Combining Multiple Preexisting Datasets

Methodological challenges arise when combining datasets from multiple archaeological sites, projects, and analysts. Differences in the excavation and screening practices used by archaeologists affect the assemblages themselves, and the analysis and recording techniques used by zooarchaeologists vary (Driver 1992). This analysis addresses some of these potential problems by including only screened assemblages (1/4″, 1/8″, 1/16″, and combinations of these screen sizes). Unscreened assemblages had a substantial effect on artiodactyl index values and were not used in this study. Screen size (1/4″ and below) for screened assemblages did not affect the indices used here (which concern taxa too large to be missed in 1/4″ screens), so assemblages with a range of different screen sizes are combined. I also group taxa to the genus level for calculating the various indices discussed in this paper; for example, specimens recorded by the original analysts as *Sylvilagus audobonii*, *S. floridanus*, and *Sylvilagus* sp. are all counted as *Sylvilagus*. This approach is obviously not suited to every analysis, but is one way to address a source of inter-analyst differences in identification. I also rely on Number of Identified Specimens (NISP) counts rather than Minimum Number of Individuals (MNI), as the former is more widely reported in these published and unpublished datasets and is less subject to interanalyst variability in the way it is calculated (Grayson 1984:28–40). Finally, this analysis examines robust general trends in taxon abundance across 70 faunal assemblages (Table 1). I assume that in general this large number of assemblages will cancel out particularistic biases from individual assemblages with unusual taphonomy, sampling, or analytical techniques such that the broader general trends identified here will not be affected. Performing the analyses described here with versus without including assemblages with mammal NISP counts under 100 did not affect the outcomes; hence, the discussion here includes all of the assemblages (Figure 1). A few apparent trends remain vulnerable to biases caused by individual assemblages due to sample size issues related to the number of assemblages from a given area and time period; these issues are noted where appropriate in the analysis and discussion sections.

Human Populations, Hunting, and Anthropogenic Habitat Change

A number of different factors influence the relative abundance of animal bones from different taxa in an archaeological assemblage, including taphonomic factors affecting preservation, environmental variation (either due to non-anthropogenic factors like elevation or anthropogenic influences on habitat), and variation in human social practices such as hunting methods or bone disposal (Lyman 2003; Schollmeyer and Driver 2013). This study investigates taxon relative abundance linked to anthropogenic influences. As with the interproject and interanalyst variability discussed above, I attempt to mitigate the effects of other factors by examining broad trends across a large number of assemblages to minimize the impact of taphonomic variability at individual sites (Lyman 2003). Environmental variation is controlled by considering three regions within the study area over time, as well as altitude differences within each region. Non-anthropogenic environmental variation from climatic variability over time has been well studied in the area (Dean 1996; Grissino-Mayer 1996; Minnis 1985b; Shaw 1993) and does not appear to be a substantial influence on the patterns discussed here. I compare the relative proportions of several orders and genera of animals in these archaeological assemblages using the NISP identified to the order, genus, or lower taxonomic level. Comparing proportions highlights changes in the relative abundance of different types of animals over time, and how those changes are related to shifts in the size and distribution of the local human population.

Numerous studies have demonstrated that the size and degree of sedentism of human populations are closely linked to anthropogenic habitat changes and reduction or recovery of the populations of animals that lived and were hunted in

TABLE 1.

ASSEMBLAGES USED IN THIS STUDY WITH VERTEBRATE NISP

Area	Site	Map no.	Early Pithouse	Late Pithouse	Classic Mimbres	Early Postclassic	Late Postclassic	Reference
Reserve	Ho-Bar (LA 68160)	1	190					Pool pers. comm.
	SU Tank (LA 39972)	2	13		65			Oakes (1999b)
	Mogollon Village (LA 11568)	3	229	98				Cannon (1999)
	Lazy Meadows (LA 39975)	4		100				Oakes (1999b)
	Luna Village (LA 45507)	5		2607				Oakes (1999b)
	Humming Wire (LA 45508)	6		13				Oakes (1999b)
	Fence Corner (LA 70196)	7		463				Oakes (1999b)
	Haury's Site (LA 39969)	8			167			Oakes (1999b)
	Hough (LA 3279)	9				5462		Oakes (1999b)
	Spurgeon Draw (LA 39968)	10				1377		Oakes (1999b)
	DZ Site (LA 70185)	11				49		Oakes (1999b)
Upper Gila	LA 83772	12	105					Wiseman (1998:55–56, 105)
	Duncan Site (AZ CC:8:4 [ASM])	13	222					Lightfoot (1984:134)
	Mesa Top	14	73					Berman (1978)
	Peterson Canyon (LA 121159)	15		23				Turnbow (2000:236)
	MC 110 (LA 88765?)	16		111				Fitting (1971:31)
	Wind Mountain (Y:7:1/Y:7:3)	17		3604	251			Olsen and Olsen (1996:394–397)
	Woodrow Ruin (LA 2454)	18		1316	150			Schollmeyer (2015)
	Heron Ruin (LA 34788)	19			25			Burns (1972:47)
	Saige-McFarland (LA 5421)	20			1142			Gillespie (1987)
	Riverside (LA 34789)	21			15		54	Baker (1971:41)
	Fornholt (LA 164471)	22				3005		Schollmeyer (2016)
	Gila Cliff Dwellings (LA 13658)	23				563		McKusick (1986)
	Villareal II (LA 34794)	24					132	Lekson (2002:54–55)
	3-Up (LA 150373)	25					958	Starkovich and Bork (in press)

Continued

TABLE 1.

CONTINUED

Area	Site	Map no.	Early Pithouse	Late Pithouse	Classic Mimbres	Early Postclassic	Late Postclassic	Reference
Mimbres Valley	McAnally (LA 12110)	26	76					Diehl and LeBlanc (2001:78)
	Tunis School (LA 54814)	27	541					Jones et al. (2012:1376)
	LA 129562	28	1027					Jones et al. (2012:1414)
	Beauregard (LA 18888/Z:1:27)	29		364				Powell (1977:46)
	Galaz (LA 635)	30		933				Powell (1977:46)
	Harris (LA 1867)	31		1978				Powell (2015)
	La Gila Encantada (LA 113467)	32		947				Schmidt (2010)
	Florida Mountain (LA 18839)	33		349				Schriever (2002:248)
	Montezuma (Z:1:30)	34		128	425			Powell (1977: 46)
	Mattocks (LA 676)	35		27	5372			Powell (1977: 46)
	Old Town (LA 1113)	36		2401	144			Sanchez (1992:61)
	NAN Ranch (LA 2465)	37		6121	9531			Sanchez (1992:51–52); Shaffer (1991:91–93)
	Mitchell (LA 12076)	38			293			Powell (1977: 46)
	Jackson Fraction (LA 111413)	39			402			Kearns et al. (1999)
	Badger Ruin (LA 111395)	40			26			Kearns et al. (1999)
	Cooney Ranch #1 (LA 5841)	41			148			Nisengard (2000)
	Columbus Pueblo (LA 85774)	42			952			Cannon (2010)
	Walsh (LA 15044/Z:5:80)	43				2715		Anyon pers. comm.
	Montoya (LA 15075/Z:5:112)	44				1177		Anyon pers. comm.
	Black Mountain (LA 49)	45				4774	553	Schollmeyer (2016)
	Disert (Z:5:10) (LA 15021)	46					3516	Nelson and LeBlanc (1986:302)
	Janss (LA 10277)	47					682	Nelson and LeBlanc (1986:303)
	Stailey (Z:1:78) (LA 18939)	48					207	Nelson and LeBlanc (1986:303)
	Kipp Ruin (LA 153465)	49					192	DeBry (2008)
	76 Draw (LA 156980)	50					10579	McCarthy (2013)

Continued

TABLE 1.

CONTINUED

Area	Site	Map no.	Early Pithouse	Late Pithouse	Classic Mimbres	Early Postclassic	Late Postclassic	Reference
Eastern Mimbres	Ocotillo (LA 75797)	51	1160					Daniel et al. (1994b)
	Cuchillo (LA 50548)	52		173	52			Munford et al. (1994)
	LA 50547	53		52				Kugler et al. (1994)
	Placitas Arroyo 2 (LA 13145)	54		19				Butler (1984)
	Placitas Arroyo 8 (LA 13151)	55		12				Butler (1984)
	Berrenda Creek (LA 12992)	56			339			Gomolak and Ford (1976:125)
	Nalda Mitchell (LA 53483)	57			41			Daniel et al. (1994a)
	Avilas Canyon (LA 44997/45000)	58			492			Schollmeyer (2009); Schollmeyer et al. (2011)
	Juniper Village (LA 37781)	59			413			Schollmeyer (2009); Schollmeyer et al. (2011)
	SJ Hamlet (LA 54028)	60			115			Schollmeyer (2009); Schollmeyer et al. (2011)
	Pague Well Village (LA 130191)	61			640			Schollmeyer (2009); Schollmeyer et al. (2011)
	Flying Fish Village (LA 37767)	62			4201			Schollmeyer (2009); Schollmeyer et al. (2011)
	Las Animas Village (LA 3949)	63			584			Schollmeyer (2009); Schollmeyer et al. (2011)
	Lizard Terrace (LA 37726/37727)	64			24	826		Schollmeyer (2009); Schollmeyer et al. (2011)
	Buckaroo (LA 70259)	65			998	1723		Schollmeyer (2009); Schollmeyer et al. (2011)
	Phelps (LA 37691)	66				545		Schollmeyer (2009); Schollmeyer et al. (2011)
	Mountain Lion (LA 37728)	67				185		Schollmeyer (2009); Schollmeyer et al. (2011)
	Ronnie (LA 45103)	68				561		Schollmeyer (2009); Schollmeyer et al. (2011)
	Lee (LA 68709)	69				233		Schollmeyer (2009); Schollmeyer et al. (2011)
	Pinnacle Ruin (LA 2292)	70					522	Lekson et al. (2002: 34)

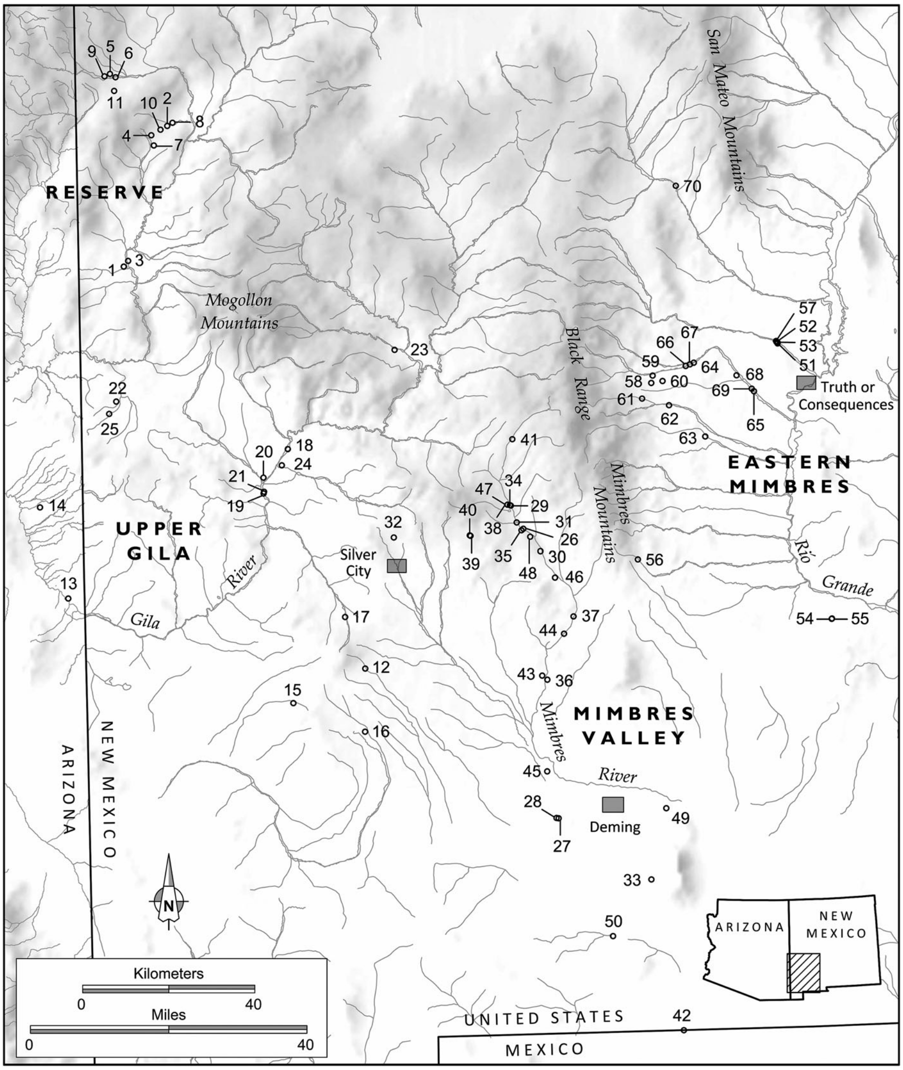

FIGURE 1. Sites with faunal assemblages in the Mimbres region of southwest New Mexico. Figure by Catherine Gilman.

these landscapes. Both factors are consistently identified as important influences on the populations of game species with social and economic importance to humans, particularly artiodactyls (Badenhorst and Driver 2009; Cannon 2000; Grayson 1991; Janetski 1997; Schollmeyer and Driver 2013; Szuter and Bayham 1989). Anthropogenic habitat changes also reduce the suitability of landscapes for some animals while enhancing the food sources and habitat (particularly disturbance-loving plants) required by other taxa, especially via activities like clearing land for fields and gardens, planting crops, and collecting wood for fuel (Cannon 2000; Driver 2002; Driver and Woiderski 2008; Neusius 2008; Schollmeyer 2005). Attributes of human populations that influence hunting pressure and habitat change include human population density and settlement dispersal and social practices including changes in hunting technologies, changes in the social rules governing the hunting of certain animals, and the scheduling demands of hunting alongside farming and other activities (Broughton 2002; Dean 2007; Schollmeyer and Driver 2013). No substantial changes in hunting technology or social practices governing hunting are known from the study area during the time periods examined here, although some changes in social practices are hard to detect archaeologically. Hunting technology in the Mimbres area included bows and arrows, snares, and nets, and has been studied based on a combination of hunting tools themselves (including projectile points and some perishable materials), depictions of hunting on Classic Mimbres Black-on-white bowls, and characteristics of faunal assemblages (Nelson 1986; Schmidt 1999; Shaffer and Gardner 1997; Shaffer et al. 1996). There is no evidence that the relative popularity of existing technologies changed over time (Cannon 2001:207–256).

With the factors discussed above held constant, changes in human settlement and population over time in the study area are expected to be evident in faunal changes accompanying anthropogenic landscape change and shifts in human hunting intensity. I expect that increases in human population will be accompanied by increases in the relative abundance of species resilient to both these pressures. My approach to measuring these changes and results are discussed below. I also expect increases in human populations to affect the relative abundance of cottontails in comparison to jackrabbits (measured by the lagomorph index) and of artiodactyls in comparison to lagomorphs more generally.

Human Populations and Cultural Changes in the Mimbres Region, AD 200–1450

The study area has an interesting history of alternately dispersed and aggregated settlement with accompanying changes in human population levels. The sites examined in this study are classified into four geographic areas within the greater Mogollon region, and five time periods. During the Early Pithouse (AD 200–550) and Late Pithouse (AD 550–1000) periods, people increased their reliance on agricultural products and lived in increasingly larger and more permanent villages composed of semisubterranean pithouses. The Classic Mimbres period from AD 1000 to 1130 is characterized by large, aggregated above ground masonry villages, often of a hundred rooms or more, located along river valleys (Anyon and LeBlanc 1984; Blake et al. 1986; LeBlanc 1983; Nelson 1999:36–40). Subsistence focused primarily on crops grown on the river floodplains and on hunted and gathered resources from surrounding areas. This period is widely agreed to represent the peak of population growth and agricultural intensity in the region (Blake et al. 1986; Hegmon et al. 1999). Between AD 1130 and 1150, the large villages of the Classic Mimbres period were largely depopulated, marking the beginning of the Early Postclassic period (Hegmon et al. 1999; LeBlanc 1976). After a 50-year period during which most of the study area was very sparsely occupied, people once again began aggregating into large villages more similar in size (40–100 rooms) and subsistence practices to those of the Classic Mimbres period, and often immediately adjacent to these older sites (Creel 2000). Despite a similar overall village size during the 1200s, far fewer villages existed in the region than characterized the preceding period. The Late Postclassic period (AD 1300–1450) saw a population increase, with aggregated villages of 100 or more rooms participating in the Cliff phase Salado tradition in the western and central portions of the study area (Hegmon et al. 1999; Lekson 2002; Nelson and LeBlanc 1986), and aligning themselves with other local traditions in the eastern Mimbres area (Ferguson et al. 2016; Schollmeyer and Nelson 2011).

The Reserve area includes the Pine Lawn Valley and environs near the modern town of Reserve, New Mexico. This area is at the western edge of the Mimbres region and the highest elevation and most mesic of the four areas discussed here. Material culture is very similar to that of the Mimbres area during the Early and Late Pithouse periods (AD 200–1000), but during subsequent periods, it is considered part of the Mountain Mogollon rather than Mimbres Mogollon tradition. Archaeological evidence suggests human populations here decreased between the Early Pithouse period (locally called the Pinelawn phase) and the beginning of the Late Pithouse period around AD 550, then rose gradually over the AD 550–1000 period, followed by a more rapid increase between AD 1000–1100 to reach peak regional population levels between AD 1100–1300 (Accola 1981; Bluhm 1960; Oakes 1999a). In the Reserve area the AD 1000–1100 period is called the Reserve phase, but for brevity, the charts in this paper refer to this period by the Classic Mimbres period terminology used in the other three areas in the study region. The Early Postclassic (AD 1100–1300) is referred to by many different phase names in the region; it is called the Tularosa phase in the Reserve area, and was characterized by more aggregation into larger villages than previous periods, particularly during the century from AD 1200–1300 (Oakes 1999a). By AD 1350, the region was no longer used for residential purposes by Puebloans (Oakes 1999a).

The upper Gila area in this study consists of the Gila River drainage from its headwaters to the Arizona–New Mexico border. The Mule Creek sites (Fornholt and 3-Up) are also included in this area, as sites here are geographically closer to the Cliff Valley than to Reserve and more closely resemble it environmentally and culturally, containing deposits characteristic of the Classic Mimbres rather than Reserve culture areas (Dungan 2015; Huntley et al. in press). The population here is thought to have risen gradually through the Early and Late Pithouse periods, and peaked at the end of the Late Pithouse period and beginning of the Classic Mimbres period (Lekson 1990; Sedig 2015). After a period of a very low human population during the Early Postclassic (with few sites locally termed either Tularosa phase or Black Mountain phase), the area's population increased again during the Late Postclassic when people were concentrated in Cliff phase Salado villages (Lekson 2002).

The Mimbres Valley consists of the closed drainage basin of the Mimbres River. Like the upper Gila, populations rose through the Early and Late Pithouse periods and reached their highest levels during the Classic Mimbres period (Blake et al. 1986; Hegmon et al. 1999). After AD 1130 most people left the area, although smaller remnant populations persisted in some Classic Mimbres villages (Creel 2000). Within 50 years, population aggregation began again in villages termed

Black Mountain phase (Creel 2000; Putsavage 2015). During the Late Postclassic, the area's population increased somewhat with the establishment of Cliff phase Salado villages, but never again became densely populated by Puebloan people (Nelson and LeBlanc 1986; Putsavage 2015).

The eastern Mimbres area lies between the Black Range mountains and the Rio Grande. Due to rain shadow effects from the Black Range, it is the most xeric of the four areas discussed here. Settlement and population changes here resembled those of the Mimbres Valley through the Early and Late Pithouse periods and the Classic Mimbres period, although the eastern Mimbres area's population was never as high (Nelson 1993; Nelson et al. 2006). Around AD 1130, people dispersed out of the Classic Mimbres villages and into nearby hamlets, leading to a slight reduction in the area's overall population (Nelson and Hegmon 2001; Schollmeyer 2011). By 1200 population levels were lower, and farmers re-aggregated into a few adobe villages (Hegmon et al. 1999). The Late Postclassic in this area is characterized by large masonry and adobe pueblos with a variety of architectural and ceramic styles culturally linked to surrounding regions (Clark and Laumbach 2011; Ferguson et al. 2016; Laumbach and Laumbach 2006; Lekson et al. 2002; Schollmeyer and Nelson 2011; Schollmeyer et al. 2010).

Previous zooarchaeological studies in the region above the site level of analysis have largely focused on change over time from the Late Pithouse through Early Postclassic periods in the Mimbres Valley and eastern Mimbres areas. In the Mimbres Valley, artiodactyl availability decreased by the latter centuries of the Late Pithouse period and remained low in the Classic Mimbres period (Cannon 2000, 2001). Large mammals were also locally depleted by the Classic Mimbres period in the eastern Mimbres area, a situation the Postclassic period reorganization after AD 1130 did not measurably improve (Nelson and Schollmeyer 2003; Schollmeyer 2011; Schollmeyer and Coltrain 2010; Schollmeyer and Driver 2013). Land clearing for farming was also pervasive in both areas during the Classic Mimbres period (Minnis 1978, 1985a; Nelson and Diehl 1999; Nelson et al. 2006; Sanchez 1996), although some indications of recovery are apparent during the Early Postclassic (Schollmeyer 2005). This study expands on existing work by examining faunal data at a broader temporal and spatial scale to assess changes in the relative abundance of animal taxa and their implications for understanding how shifts in human population and settlement in the region over time affected animal resources.

Analysis

Changes in human populations and settlement patterns alter the abundances of different types of animals, particularly via hunting and habitat changes. Some species decline in abundance in response to these changes, while those termed "resilient species" are able to survive and reproduce successfully despite fluctuations in local conditions (Balmford 1996; Cowlishaw et al. 2005). In this section, I identify changes in fauna accompanying shifts in human populations using a resilience index as well as the more familiar lagomorph and artiodactyl indices.

Resilience

Animal taxa resilient to factors accompanying increased human populations are able to maintain abundance in the face of local fluctuations in conditions (Holling 1973; White and Harrod 1997), including increased hunting and habitat changes accompanying the expansion of agricultural landscapes. Resilient species persist through such changes, while less resilient ones experience population declines, extirpation, or extinction. Modern conservation biology studies of the effects of increased hunting and anthropogenic landscape change commonly document decreases in the populations of less resilient taxa (e.g., Cowlishaw et al. [2005]; Peres [2000]), and I expect similar patterns archaeologically. Small terrestrial mammals (less than 20 kg) with high reproductive rates and nonspecialized habitat and dietary requirements persisted as a resilient food resource for thousands of years in the US southwest and other regions (Schollmeyer and Driver 2012a). Their persistent abundance contrasts with well-documented fluctuations in larger-bodied mammals and suggests these small taxa were highly resilient to anthropogenic effects (Schollmeyer and Driver 2012a).

I identify shifts in more versus less resilient animals by ranking mammal taxa identified in archaeological assemblages in the study area in terms of their relative vulnerability or resilience based on characteristics associated with five major attributes identified as having the greatest influence on vulnerability to anthropogenic effects. I then combine the results of these separate rankings to create broader groupings of taxa categorized as least resilient, somewhat resilient, and most resilient to a combination of hunting and anthropogenic landscape change. For the most part, taxa are considered only at the genus level. Although some of the variables examined here show potentially important variation among species, the majority of Mimbres area archaeological faunal remains cannot be identified to the species level and a species focus would have reduced sample sizes to unacceptably low levels. This resilience grouping approach relies on methods created with Jonathan Driver for a study in the Mesa Verde area (Schollmeyer and Driver 2012b).

Attributes of resilient taxa are derived from conservation biology literature on characteristics associated with mammal extinction risks. Numerous studies have identified five major attributes with the greatest influence on extinction vulnerability for a very wide range of taxa: body size, life history, diet, population density, and geographic range (Cardillo et al. 2005; Isaac and Cowlishaw 2004; McKinney 1997; Purvis et al. 2000), the last of which is not relevant in the study area due to its limited size. Large body size is one of the traits most often associated with vulnerability to extinction. In part, this is because large size is often associated with other traits linked to vulnerability (such as lower reproductive rates or more specialized diet and habitat requirements) (Beissinger 2000; Caughley 1977; Caughley and Krebs 1983; Jerozolimski and Peres 2003; McKinney 1997; Milner-Gulland and Akçakaya 2001; Purvis et al. 2000). Large-bodied taxa also tend to be preferred items for hunters, for both economic and social reasons. This has been documented by both conservation biology studies (e.g., Cowlishaw et al. [2005]; Fa et al. [2005]; Isaac and Cowlishaw [2004]; Jerozolimski and Peres [2003]; Peres and Nascimento [2006]; Vickers [1991]) and anthropological ones (e.g., Brown and Emery [2008];

Driver [1997]; Grimstead [2010]; Kent [1989]; Potter [1997, 2000]; Schollmeyer [2009:93–96]), including studies of diet breadth and prey choice (e.g., Grayson and Cannon [1999]; Lupo [2007]; Winterhalder and Smith [2000]). There is strong evidence for this in the study area as well as the southwest more generally (Schollmeyer and Coltrain 2010). Cardillo and colleagues (2005) note that increased body mass appears to amplify other risk factors (such as low population density or slow reproductive rates), with an increase in this amplification factor at around 3 kg and another increase at around 20 kg of taxon body mass. Accordingly, I ranked Southwestern mammal taxa found in archaeological sites based on body size estimates as follows: 1 = most resilient (taxa weighing less than 3 kg); 2 = somewhat resilient (taxa 3–20 kg); and 3 = least resilient (taxa weighing more than 20 kg). Rank 1 taxa include most of the Southwestern rodents and lagomorphs, and a few of the smallest carnivores (Table 2). Rank 2 taxa include marmots, porcupines, and many carnivores. Rank 3 taxa consist of beaver, large carnivores, and all Southwestern ungulate taxa.

Life-history traits are widely recognized as a major contributor to taxon vulnerability to hunting and habitat change (e.g., Bodmer et al. [1997]; Cardillo et al. [2005]; Cowlishaw et al. [2005]; McKinney [1997]; Milner-Gulland and Akçakaya [2001]; Peres [2001]; Purvis et al. [2000]). Animals with "slow" life histories (small litters, slow growth rates, late onset of sexual maturity, long gestation periods, and long intervals between births) are relatively vulnerable to pressure from hunting and habitat change; they cannot compensate for increased mortality with increases in fecundity as readily as taxa with "fast" life histories can (Cowlishaw et al. 2005; Milner-Gulland and Akçakaya 2001; Purvis et al. 2000). In a study of biological correlates of extinction risk encompassing hundreds of species worldwide, Purvis et al. (2000) found that gestation length was a more important predictor of extinction vulnerability than other life-history variables. Gestation length is "the most reliable indicator of a species' position on the fast–slow continuum of life-history strategies," and is highly correlated with other aspects of life history (age to maturity, litter size, and birth intervals) independently of body size (Purvis et al. 2000:1950). I follow this study in using gestation length as a measure of life-history "speed" and ranked Southwestern taxa as follows: 1 = most resilient (taxa with gestation periods of less than 30 days); 2 = somewhat resilient (gestation periods of 31–49 days), 3 = somewhat vulnerable (gestation periods of 50–74 days), and 4 = least resilient (gestation periods of 75 days or longer). Rank 1 taxa consist of most of the Southwestern rodents, cottontails, and pika (Table 2). Rank 2 taxa include certain rodents (grasshopper mice, wood rats, and several sciurids), jackrabbits, and ferrets. Rank 3 taxa consist of smaller carnivores. Rank 4 taxa consist of the two largest rodent taxa (porcupine and beaver), larger carnivores, and all Southwestern ungulate taxa.

Diet affects vulnerability to hunting and habitat change in several ways. First, taxa at higher trophic levels are vulnerable to disturbances among the lower trophic level taxa on which they feed, and taxa on which their prey feed (Purvis et al. 2000). Second, species with highly specialized diets may be more vulnerable to anthropogenic changes in local landscapes that impact their narrow range of food resources (Daily et al. 2003; Isaac and Cowlishaw 2004; Peres 2001; Smith 2005). In the US

TABLE 2.

TAXON ATTRIBUTE RANKINGS AND CLUSTER GROUPS FOR RESILIENCE RANKINGS

Genus	Name	Body size rank	Gestation rank	Diet rank	Population density rank	Cluster group
Puma concolor	Mountain lion	3	4	4	3	3
Castor canadensis	Beaver	3	4	3	3	3
Canis lupus	Wolf	3	3	4	3	3
Antilocapra americana	Pronghorn	3	4	2	3	3
Cervus sp.	Elk	3	4	2	3	3
Odocoileus sp.	Deer	3	4	2	3	3
Ovis canadensis	Bighorn	3	4	2	3	3
Erethizon dorsatum	Porcupine	2	4	2	3	3
Lynx sp.	Bobcat or lynx	2	3	3	3	3
Ursus sp.	Bear	3	4	1	3	3
Canis latrans	Coyote	2	3	2	3	2
Procyon lotor	Raccoon	2	3	2	3	2
Taxidea taxus	Badger	2	4	1	3	2
Marmota flaviventris	Marmot	2	2	2	3	2
Urocyon cinereoargenteus	Gray fox	2	3	1	3	2
Vulpes sp.	Red fox or kit fox	2	3	1	3	2
Mustela frenata	Weasel	1	4	1	3	2
Mephitis sp.	Skunk	2	3	1	3	2
Bassariscus astutus	Ringtail	1	3	1	3	2
Sciurus sp.	Tree squirrel	1	2	3	2	1
Tamiasciurus sp.	Red squirrel	1	2	3	2	1
Lepus sp.	Jackrabbit	1	2	2	2	1
Tamias sp.	Chipmunk	1	2	3	1	1
Neotoma sp.	Wood rat	1	2	2	1	1
Ammospermophilus sp.	Antelope squirrel	1	2	1	2	1
Sylvilagus sp.	Cottontail	1	1	2	1	1
Thomomys sp.	Pocket gopher	1	1	2	1	1
Geomys sp.	Pocket gopher	1	1	2	1	1
Cratogeomys castanops	Yellow-faced pocket gopher	1	1	2	1	1
Dipodomys sp.	Kangaroo rat	1	1	1	2	1
Onychomys sp.	Grasshopper mouse	1	2	1	1	1
Sigmodon sp.	Cotton rat	1	1	2	1	1
Ondatra zibethicus	Muskrat	1	1	2	1	1
Cynomys sp.	Prairie dog	1	1	2	1	1

Continued

TABLE 2.

CONTINUED

Genus	Name	Body size rank	Gestation rank	Diet rank	Population density rank	Cluster group
Perognathus sp.	Pocket mouse	1	1	1	1	1
Reithrodontomys megalotis	Harvest mouse	1	1	1	1	1
Peromyscus sp.	Deer mouse	1	1	1	1	1
Microtus sp.	Vole	1	1	1	1	1
Zapus hudsonius	Jumping mouse	1	1	1	1	1
Otospermophilus sp.	Ground squirrel	1	1	1	1	1
Xerospermophilus sp.	Ground squirrel	1	1	1	1	1

Note: Cluster group 1 is most resilient to anthropogenic effects, and 3 is least resilient.

Southwest, taxa with highly specialized diets are rare in comparison to the tropical environments in which much modern research on extinction risks has been focused. Many of the taxa with relatively specialized diets (e.g., seeds) might benefit from anthropogenic activities (like the planting of fields and gardens). Similarly, some taxa at higher tropic levels (such as rodent-eating carnivores) might benefit from landscape changes that, for example, attracted rodents to a village and its associated fields and grain storage facilities. Thus, applying rankings to dietary categories was less straightforward than ranking other attributes.

I ranked Southwestern taxa according to diet as follows: 1 = least vulnerable (taxa whose food supply is expected to benefit from human activities); 2 = less vulnerable (taxa whose food supply may benefit from some human activities, or will be unaffected); 3 = somewhat vulnerable (taxa for whom losses slightly outweigh any potential benefits); and 4 = most vulnerable (taxa whose food supply will experience more negative than positive effects from human activities). Rank 1 taxa include generally graminivorous rodents (attracted to garden and field crops), insectivores and insectivorous rodents (attracted to insects in gardens and fields), and small omnivorous carnivores preying largely on rodents (attracted to the rodents drawn to gardens and fields) who also consume insects and fruit. Garden-hunting humans would probably have exploited these taxa, but their small size would have given them an advantage in raiding fields. Rank 2 taxa consist primarily of browsing, grazing, and mixed-feeder taxa. Some of these animals would have been drawn to crops in gardens and fields, but are large enough to have been actively discouraged by humans (including by garden hunting); these include ungulates, lagomorphs, and the largest rodents (porcupine, packrat, and prairie dog), as well as larger species of omnivorous carnivores preying largely on rodents and lagomorphs (coyote, lynx, and raccoon). Others have diets unlikely to have been affected by humans (muskrat, pocket gopher, non-browsing rodent grazers). Taxa limited to environments unlikely to have been altered by farmers to any great extent (marmot, pika) are also assigned to this relatively neutral category. The food supplies of rank 3 taxa are more likely to have been negatively impacted by humans. These taxa include several sciurids consuming seeds of trees likely to have been cleared by humans; semi-aquatic animals whose food sources would have been disturbed by human activities (beaver, otter); and ferrets, because of the highly specialized nature of their diet. Rank 4 consists of only two taxa, wolves and mountain lions; these are the two top predators in the Southwest, and prefer large ungulates to other prey. Although fields and gardens would have been attractive to ungulates, the effects of human hunters on ungulate population densities would have outweighed those attractors.

Population density plays an important role in vulnerability by influencing a taxon's ability to recover from population crashes, whether natural or anthropogenic in origin (Purvis et al. 2000). Population density is a factor of both geographic range and abundance within that range; rare taxa and taxa with very limited geographic ranges are particularly vulnerable to extinction (McKinney 1997). Such species may have fewer opportunities to meet and reproduce within a given area, and fewer and smaller source populations from which to draw new members to replenish population sinks (McKinney 1997; Peres 2001). Population density is highly variable for mammal species in the US Southwest. Distinct parts of the region have different topography, precipitation, average temperature, and vegetation, all of which have profound effects on mammal population density. Density also varies seasonally in many areas. Estimates of Southwestern mule deer population density, for example, range from 1.8 to 69.4 individuals per square mile (Heffelfinger 2006: Table 10). I approach this complex issue by ranking taxa relative to each other based on average reported population densities in Nowak and Paradiso (1983). These data do not reflect actual density values for the US Southwest, but are sufficient for a relative ranking of different groups of taxa. Southwestern taxa are ranked as follows: 1 = least vulnerable (densities of 1,000 or more individuals per sq km reported for areas where the taxon occurs); 2 = somewhat vulnerable (densities of 10–1,000 per sq km reported); and 3 = most vulnerable (densities of 10 or fewer individuals per sq km for areas where the taxon occurs). Rank 1 taxa include many of the smaller Southwestern rodents. Rank 2 taxa consist primarily of larger rodents (squirrels, wood rats, muskrats) and lagomorphs. All Southwestern carnivores, ungulates, and the two largest rodent taxa (beaver and porcupine) are assigned to Rank 3.

These four variables have been identified as being of primary importance in predicting extinction risk across a broad variety of taxa worldwide. A number of more minor variables appear to be quite important in some environments, often working in concert with the major variables. These additional variables include social group size, tolerance of human presence, home range size, activity time, habitat, and locomotion. Adding these secondary variables to the cluster analysis described here did not prove useful, making the groups of taxa less distinct.

After ranking Southwestern taxa relative to one another in terms of resilience to extinction factors as described above, I used a combination of correspondence analysis and K-means to identify groups of taxa sharing similar relative resilience rankings along these four major dimensions. Using the program PAST (Hammer et al. 2001), I used correspondence analysis to determine how many groups to create, then used K-means to group the taxa into the suggested number of clusters.

The best fit for this dataset was achieved with three groups (Table 2). One group consists of the large carnivores, ungulates, and large-bodied, slow-reproducing rodents (mountain lion, wolf, bear, bobcat, pronghorn, elk, deer, bighorn, bison, beaver, and porcupine; wolverine and otter would also be in this group, but were not found in any of the study assemblages). These animals share characteristics that are likely to make them relatively vulnerable to human hunting and anthropogenic landscape change. A second group consists of the remaining carnivores and one large-bodied rodent (coyote, raccoon, badger, fox, weasel, skunk, ringtail, and marmot). These animals share characteristics making them somewhat vulnerable. The third group includes all the remaining rodents along with all lagomorphs. These small, fast-reproducing taxa with relatively high population densities would have been the most resilient to human hunting and anthropogenic landscape change.

This approach differs in several respects from simply using body size as the primary ranking factor, an approach commonly used by archaeologists working in a behavioral ecology framework. Weighting body size equally with life history and diet moves several taxa (porcupine, bobcat, and beaver) into the "least resilient" category that would typically not be grouped with large carnivores and artiodactyls. It also adds more specific consideration of the effects of anthropogenic landscape change by including taxon diet and population density as separate factors in the rankings. Importantly, this approach offers potential opportunities for comparison with other environments and regions, where the taxa included in each category would be quite different but the response of taxa in the "least resilient" category under changing conditions could still potentially be compared.

Temporal Changes in Taxon Resilience

In order to assess whether temporal changes occurred in the relative proportions of taxa classified in my rankings as more versus less resilient, I calculated the NISP of mammalian taxa within each of the three categories discussed above. Assemblages were grouped by the time period in order to assess whether the relative abundance of theoretically more and less resilient taxa changed over time (Figure 2). I expected the least resilient taxa to be least common in periods of the greatest human population, and relatively more common during intervals when human populations were lower. Temporal changes were initially identified based on visual inspection of graphs, and χ^2 analysis used to determine whether patterns were statistically significant (particularly given the effects of sample size) (Table 3).

Taxa in the "least resilient" category were relatively uncommon in nearly all the assemblages. In the Mimbres Valley, the percent of each assemblage composed of taxa in this category is consistently very low until the Late Postclassic, when it rises significantly to 28% ($\chi^2 = 180.69$, $p = 0.000$) (Figure 2, Table 3). In the Upper Gila area, the percent of the assemblage composed of the least resilient taxa is low in the Early Pithouse and Classic Mimbres periods, significantly higher in the Late Pithouse and Early Postclassic, with a large and statistically significant rise to 85% in the Late Postclassic (Table 3). The eastern Mimbres assemblages show a similar pattern, except that the late, statistically significant increase in the least resilient group's dominance does not occur until the Late Postclassic

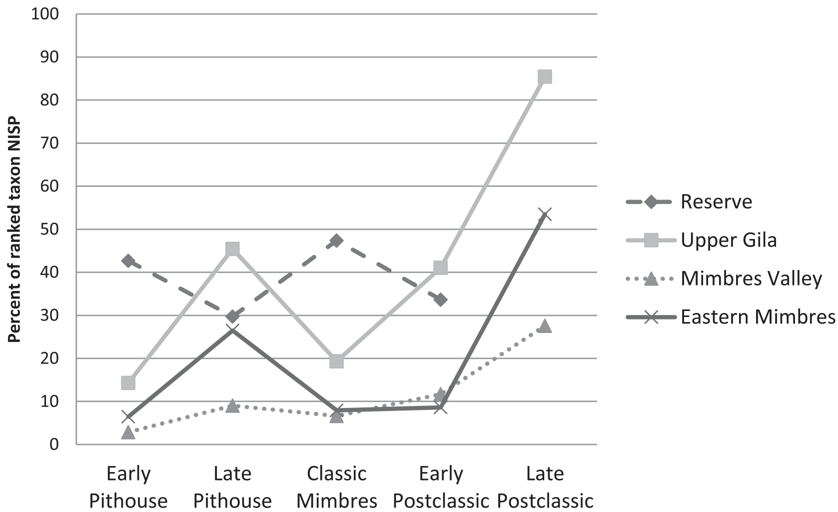

FIGURE 2. Relative abundance of taxa in the "least resilient" category.

(Table 3). All three suggest possible recovery of animals in the "least resilient" category during the latest time period, after a period of a relatively low human population. The Reserve area is somewhat different, with "least resilient" taxa somewhat more dominant in the Early Pithouse and Classic Mimbres periods, and less extreme (though still statistically significant, Table 3) changes overall, a pattern that likely reflects that area's somewhat different human population history.

The patterns shown here are due to changes in the relative abundance of artiodactyls, lagomorphs, carnivores, and rodents, but do not track exactly with any of those groups. Artiodactyls are the most common taxa in the "least resilient" category; large carnivores, beaver, and porcupine (the other "least resilient" taxa) are so rare in each individual assemblage that intra-assemblage differences in those taxa do not drive this pattern. This index does not solely reflect changes in the common artiodactyls and lagomorphs, as the patterns shown in Figure 2 are not identical to the artiodactyl index (Figure 5). Instead, it shows the interplay between changes in the abundance of many taxa. In the following sections, I examine three groups of mammals (carnivores, artiodactyls, and lagomorphs) more closely in order to assess how changes in their abundance affect this overall pattern of shifts in the relative abundance of more and less resilient taxa.

Carnivores

Unlike the other taxa discussed here, carnivores never comprised a large proportion of site faunal assemblages, and were probably never a substantial dietary resource. Instead, they may provide information about the availability of less resilient resources and/or of human use of less anthropogenic environments. In the Four Corners area, Driver (2002) suggests that declines in carnivore representation over time, especially in the Pueblo III period, indicate decreasing human use of distant, less heavily hunted areas and heavy reliance on the highly anthropogenic landscapes immediately around

TABLE 3.

NISP VALUES AND RESULTS OF x^2 ANALYSIS OF CHANGES BETWEEN TIME PERIODS IN EACH AREA

Area	Time period	Least resilient (NISP)	χ^2 results	Carnivores (NISP)	χ^2 results	Lepus (NISP)	Sylvilagus (NISP)	χ^2 results	Artiodactyls (NISP)	χ^2 results
Reserve	Early Pithouse	38		2		15	19		38	
	Late Pithouse	193	6.112 ($p = 0.013$)	11	0.350 ($p = 0.554$)	60	97	0.408 ($p = 0.523$)	193	2.487 ($p = 0.115$)
	Classic Mimbres	36	9.786 ($p = 0.002$)	1	0.246 ($p = 0.620$)	9	16	0.045 ($p = 0.832$)	36	0.485 ($p = 0.486$)
	Early Postclassic	627	6.102 ($p = 0.013$)	38	0.017 ($p = 0.895$)	262	531	0.096 ($p = 0.757$)	607	6.697 ($p = 0.010$)
Upper Gila	Early Pithouse	15		0		37	37		15	
	Late Pithouse	715	38.841 ($p = 0.000$)	14	1.359 ($p = 0.244$)	410	343	0.537 ($p = 0.464$)	707	33.072 ($p = 0.000$)
	Classic Mimbres	138	143.537 ($p = 0.000$)	7	0.033 ($p = 0.857$)	227	177	0.321 ($p = 0.571$)	129	97.188 ($p = 0.000$)
	Early Postclassic	369	87.403 ($p = 0.000$)	22	8.418 ($p = 0.004$)	81	275	87.774 ($p = 0.000$)	362	79.979 ($p = 0.000$)
	Late Postclassic	651	342.884 ($p = 0.000$)	3	7.782 ($p = 0.005$)	57	59	29.440 ($p = 0.000$)	651	96.046 ($p = 0.000$)
Mimbres Valley	Early Pithouse	10		11		108	41		10	
	Late Pithouse	395	15.534 ($p = 0.000$)	28	24.973 ($p = 0.000$)	2148	954	0.702 ($p = 0.402$)	374	11.511 ($p = 0.001$)
	Classic Mimbres	452	21.690 ($p = 0.000$)	18	8.995 ($p = 0.003$)	3435	1277	12.239 ($p = 0.000$)	444	13.219 ($p = 0.000$)
	Early Postclassic	252	58.513 ($p = 0.000$)	8	0.311 ($p = 0.577$)	1118	609	40.655 ($p = 0.000$)	251	33.179 ($p = 0.000$)
	Late Postclassic	697	180.692 ($p = 0.000$)	21	10.918 ($p = 0.001$)	776	525	8.207 ($p = 0.004$)	689	284.973 ($p = 0.000$)
Eastern Mimbres	Early Pithouse	8		0		18	89		7	
	Late Pithouse	27	17.136 ($p = 0.000$)	2	3.185 ($p = 0.074$)	29	28	21.095 ($p = 0.000$)	25	17.684 ($p = 0.000$)
	Classic Mimbres	199	42.578 ($p = 0.000$)	8	9.458 ($p = 0.002$)	309	622	7.466 ($p = 0.006$)	198	37.424 ($p = 0.000$)
	Early Postclassic	204	0.713 ($p = 0.398$)	1	5.047 ($p = 0.025$)	500	1395	14.149 ($p = 0.000$)	203	0.617 ($p = 0.432$)
	Late Postclassic	260	597.885 ($p = 0.000$)	2	12.194 ($p = 0.000$)	16	188	34.154 ($p = 0.000$)	260	619.005 ($p = 0.000$)

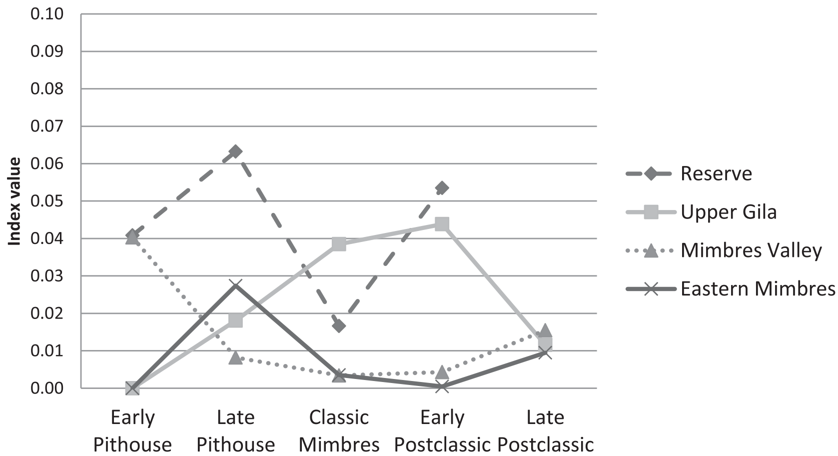

FIGURE 3. Carnivore index values over time and space.

villages. I assess changes in the relative abundance of carnivores over time using a carnivore index (carnivores/[carnivores + lagomorphs]) (Driver 2002).

The most striking feature of the carnivore index is that it is so low in every assemblage (Figure 3). No single assemblage in the study area has more than 17 carnivore bones from taxa in the resilience ranking (although some do have additional unidentified carnivore-sized bone fragments and elements identified as either *Canis* sp. or domesticated dog which are not included here). Carnivores are most common (though still rare) in the Reserve and upper Gila areas, where the most common taxa are bobcat, coyote, bear, fox, and raccoon. These numbers are too low to derive meaningful temporal patterns, as the very small overall counts greatly amplify the effects of variation among individual site assemblages.

Lagomorphs

The lagomorph index (*Sylvilagus*/[*Sylvilagus* + *Lepus*]) has commonly been used to examine habitat changes in the study area and throughout the southwest. The response of these two genera to anthropogenic landscape change shows some environmental variability, but in the absence of other influences the ratio of jackrabbits to cottontails has been shown to shift with changes in human population size, aggregation, and the conversion of naturally occurring vegetation to farmland (Szuter 1991; Szuter and Bayham 1989). Below the Colorado Plateau, increases in human population size, settlement aggregation, and intensification of farming activities are correlated with increases in the proportion of jackrabbits relative to cottontails (Driver and Woiderski 2008). Although the habitat and diet preferences of these two genera overlap considerably, jackrabbits eat more grasses relative to forbs and shrubs than cottontails consume and escape predators by running rather than hiding, so more open conditions tend to favor jackrabbits over cottontails (Chapman et al. 1982; Driver and Woiderski 2008). In the study area, increased farming with expanding human populations is linked to a lower lagomorph index; on the Colorado Plateau, this pattern is reversed due to more shrubby

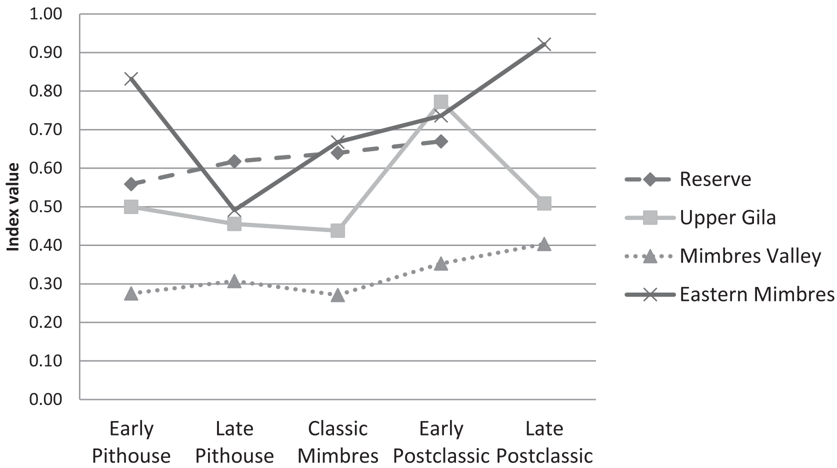

FIGURE 4. Lagomorph index values over time and space.

species of disturbance-loving vegetation common in that environmental zone (Driver and Woiderski 2008). The effects of elevation and precipitation are more likely to affect the lagomorph index than other indices used in this study as the vegetation in higher and moister habitats favors cottontails (Driver and Woiderski 2008; Sanchez 1996; Shaffer and Schick 1995), and these potential effects are considered in detail below.

I expected to see higher lagomorph index values during periods of the lowest human population. In general, the lagomorph index conforms with my expectations in most areas and time periods (Figure 4). Index values are lowest in the Mimbres Valley in comparison to the other three areas. A general increase in lagomorph index values in the Mimbres Valley and eastern Mimbres area after the Classic Mimbres period is consistent with vegetation recovery accompanying reduced human populations in the 1200s. Chi-square tests comparing *Lepus* and *Sylvilagus* NISP between pairs of consecutive periods show a significant decrease in *Sylvilagus* relative to *Lepus* in the Mimbres Valley between the Late Pithouse and Classic Mimbres periods and a significant increase in *Sylvilagus* relative to *Lepus* between the Classic Mimbres, Early Postclassic, and Late Postclassic periods in the Mimbres Valley and in the eastern Mimbres area (values shown in Table 3). This increase in *Sylvilagus* is particularly noteworthy in the eastern Mimbres area, where settlements shift downstream to lower elevations between the Classic and Early Postclassic periods. This downstream movement means the increase in cottontails is quite unlikely to be a factor of elevation differences between sites (which would favor jackrabbits). The substantial increase in the Late Postclassic may be exaggerated as the single eastern Mimbres area site from this time period (Pinnacle Ruin) is in a relatively mesic upstream location, but the trend remains in the direction I expected. In the Mimbres Valley, the lagomorph index increases across the Early Postclassic and Late Postclassic assemblages at the Black Mountain site (Schollmeyer 2016), providing additional confirmation that the increase in cottontails is likely due to habitat change rather than an artifact of elevation. In comparison to the Mimbres Valley and eastern Mimbres area, the Reserve area shows a similar but weak trend of increasing lagomorph index values over time, with no statistically significant differences between time periods.

In the upper Gila area, I expected the index to track human population changes by decreasing in the Classic and increasing in the Early and Late Postclassic. Instead, there are no statistically significant changes between the Classic Mimbres and earlier time periods, and the index increases significantly between the Classic and Early Postclassic and decreases in the Late Postclassic (Table 3). This deviation from my expectations is probably due to elevation. Sites with assemblages from both the Late Pithouse and Classic Mimbres periods (Woodrow Ruin and Wind Mountain) show the expected decrease in the lagomorph index between the two time periods (Olsen and Olsen 1996; Schollmeyer 2015). The Fornholt and Gila Cliff Dwellings assemblages are from higher altitudes than the upper Gila sites from earlier time periods, which likely accounts for the high index value in the Early Postclassic. These shifts in lagomorph ratios over time and space raise interesting possibilities regarding vegetation changes to examine with the paleoethnobotanical data currently being compiled by Michael Diehl for the larger study of which this project is a part.

Artiodactyls

The artiodactyl index is a commonly used measure for comparing artiodactyl relative abundance among assemblages. This index is the ratio of artiodactyls relative to the total NISP of artiodactyls plus lagomorphs (artiodactyls/[artiodactyls + lagomorphs]), calculated as the artiodactyl NISP divided by the sum of the artiodactyl and lagomorph NISPs (Broughton 1994; Cannon 2000; Spielmann and Angstadt-Leto 1996; Szuter and Bayham 1989). Specimens were included in the artiodactyl count if they were identified to the order Artiodactyla or any family, genus, or species within that order (in this region, native species of *Cervus*, *Odocoileus*, *Antilocapra*, and *Ovis*). The lagomorph count similarly included specimens identified to the order or any family, genus, or species within it (here, *Lepus* and *Sylvilagus*).

Deer (*Odocoileus* sp.) are the most common artiodactyls represented in nearly every area and time period. Pronghorn (*A. americana*) were also quite common in three assemblages: the Classic period upper Gila, and the Early Postclassic period in the Mimbres Valley and the eastern Mimbres area. Examination of the site-level data indicates this is caused by large assemblages from a few sites (Saige-McFarland, Walsh, and Phelps) located near especially rich areas of pronghorn habitat that heavily influenced the overall counts for these time periods, rather than widespread temporal shifts in pronghorn use.

The artiodactyl index shows several interesting patterns (Figure 5). In general, the Mimbres Valley and eastern Mimbres area have lower index values than the upper Gila and Reserve areas. This conforms to my expectations given the generally more mesic conditions and higher altitude of the latter two areas, the higher human population of the Mimbres Valley, and the relatively xeric conditions of the eastern Mimbres area. Temporal patterns are also interesting. The Mimbres Valley assemblages have a generally low artiodactyl index until about 1300, when there is a

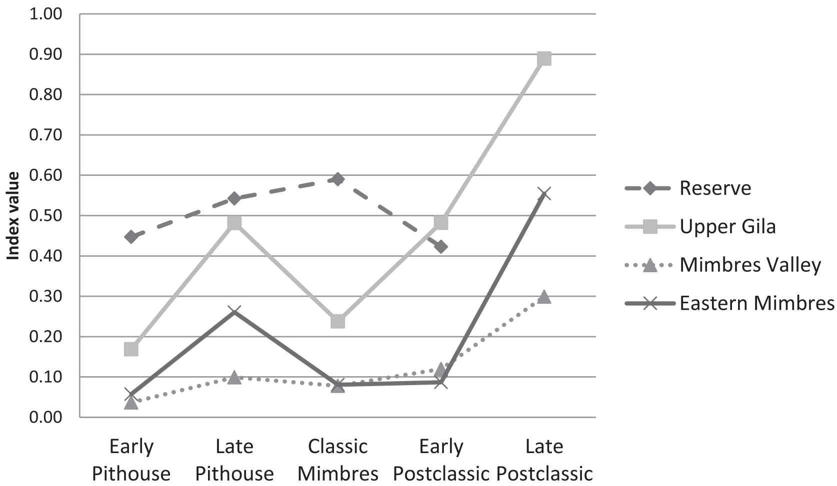

FIGURE 5. Artiodactyl index values over time and space.

statistically significant increase in the Late Postclassic period (Table 3). The eastern Mimbres and upper Gila show broadly similar patterns, but also experience statistically significant increases to their highest levels in the Late Pithouse period. In the Upper Gila area, sites with assemblages from both the Late Pithouse and Classic Mimbres periods (Woodrow Ruin and Wind Mountain) show a decrease in the artiodactyl index between the two time periods (Olsen and Olsen 1996; Schollmeyer 2015). This intrasite pattern confirms that the difference between time periods is not a factor of elevation there. Also in the upper Gila, part of the increase in the index from the Classic to Early Postclassic period is likely because the Fornholt and Gila Cliff Dwellings assemblages are from higher altitudes than the upper Gila sites from earlier time periods. However, two of the Late Postclassic sites here are from the same area in the Cliff Valley well represented in earlier time period assemblages, suggesting the continued increase in the artiodactyl index is not attributable to elevation differences alone. This is also confirmed in the Mimbres Valley at the Black Mountain site, where the artiodactyl index increases across the Early Postclassic and Late Postclassic assemblages (Schollmeyer 2016). The Reserve area shows a somewhat different pattern, with a significant increase from the Early to Late Pithouse periods, a slight but not statistically significant increase in the artiodactyl index from the Late Pithouse through Classic Mimbres period, and a statistically significant decrease in the Early Postclassic period (Table 3).

The relatively low artiodactyl index values in the Early Pithouse period are surprising, as human populations are thought to have been relatively low in the study area at that time in comparison to the later time periods; this result echoes that of the resilience index discussed above. Unfortunately, only the Mogollon Village site has assemblages from both the Early and Late Pithouse periods; this site does follow the general trend in having a lower artiodactyl index in the Early Pithouse period. Otherwise, the artiodactyl index in the Upper Gila, Mimbres Valley, and Eastern Mimbres assemblages follows my expectations based on human population changes, with the highest values in the Late Postclassic when these animals had probably recovered from hunting pressures during the 1200s. In the Reserve area, the index value is lowest during the Early Postclassic, when human populations were at their highest.

Discussion

The analyses presented here show several interesting patterns with implications for understanding the relationship between human population and settlement patterns and changes in archaeological faunal representation linked to taxon resilience to human hunting and anthropogenic landscape change. One surprising pattern concerns the unexpectedly low relative abundance of the least resilient mammal category characterizing Early Pithouse period assemblages. Resilience patterns largely conformed to my expectations during other time periods, but the Early Pithouse period in the upper Gila, Mimbres Valley, and eastern Mimbres areas show low relative abundances of the least resilient taxa, despite being characterized by much lower human population densities than subsequent periods in most archaeological estimates. Artiodactyl index values were also lower than expected in the Early Pithouse period in all four areas.

It is possible that our estimates for this period's population are somewhat too low, or that different social practices related to hunting or disposal of certain mammal remains in the Early Pithouse period are affecting this measure. Differences in the activities taking place in the sampled sites during this time period in comparison to subsequent periods may also be an important factor. Early Pithouse period structures are thought to have been seasonally occupied for shorter periods per year in comparison to nearly year-round occupations during the Late Pithouse period and year-round occupations of later period structures (Diehl 2001). Early Pithouse period structures were also used for fewer years in comparison to later structures (Diehl 2001). Early Pithouse sites tend to contain less trash than later sites in the same areas, suggesting differences in the relative intensity of trash disposal and residential abandonment processes affecting the accumulation of animal bone and other artifact assemblages (Diehl 1998). Perhaps hunters in this period used logistical hunting camps more often, processed carcasses to remove bone more thoroughly before transporting meat to villages, or engaged in other activities that led to underrepresentation of large and less resilient taxa compared to my expectations. Additional testing of Early Pithouse period archaeological sites would go a long way toward addressing this and a host of other questions about this relatively understudied time period in the region.

In the Reserve area, the "least resilient" taxon category is somewhat more dominant and the lagomorph and artiodactyl indices are generally higher than elsewhere in the study area over time. This is likely due in part to the area's higher elevation and more mesic conditions. It may also point to a lower regional population creating less substantial anthropogenic landscape changes, although additional research on population changes there over time is needed. The lagomorph index in the Reserve area is particularly interesting; contrary to my expectations it increases in the Early Postclassic, a time when human populations increase, the artiodactyl index falls (as expected), and the dominance of "most resilient" taxa increases (also as expected). The Reserve area lies at the transition between the Colorado Plateau and Basin and Range environmental zones (Martin et al. 1949), and it seems likely that the "contrary" behavior of the lagomorph index here is due to this factor. The Reserve area appears to mark one of the boundaries between the Colorado Plateau expectations for the lagomorph index (increased index values with more anthropogenic landscape change) and the expectations for the southern Southwest.

The upper Gila, Mimbres Valley, and eastern Mimbres areas largely conform to my expectations for the Late Pithouse and later time periods. When elevation differences are taken into account, the dominance of "most resilient" taxa and the lagomorph and artiodactyl indices generally support a pattern of high human hunting demands and intensive anthropogenic landscape change in the Classic Mimbres period, and recovery of artiodactyls (and less resilient taxa in general) accompanying the lower human populations in later time periods. Increasing lagomorph index values after the Classic Mimbres period also support this scenario.

Another interesting pattern is the contrast between the Late Pithouse to Classic Mimbres transition in the Mimbres Valley in comparison to elsewhere. In the Mimbres Valley, there is very little change in the relative abundance of "most resilient" taxa, the artiodactyl index, or the lagomorph index. Sites with assemblages spanning this transition (Montezuma, Old Town, and NAN Ranch) show very little change in lagomorph and artiodactyl indices, further supporting this pattern. This is consistent with Michael Cannon's (2001) suggestion that the main impacts on Mimbres Valley resources predate the Late Pithouse period. In the upper Gila and eastern Mimbres areas, human impacts as measured by these indices were somewhat lighter in the Late Pithouse period and greater in the Classic Mimbres period. It is possible that human populations grew more between the Late Pithouse and Classic Mimbres periods in the upper Gila and eastern Mimbres, and were more stable across this transition in the Mimbres Valley; investigating this issue is another interesting area for future research.

Studies in other regions of the western United States indicate that shifts to more intensive processing sometimes indicate artiodactyl resource depression even in the absence of significant changes in artiodactyl relative abundance in archaeological assemblages (Wolverton et al. 2008). To date, studies of this effect in the Mimbres region have not shown such a change in processing intensity through either bone fragmentation or disposal of certain bone elements before carcass transport (Schollmeyer 2011), although not all of the assemblages examined here have undergone such analyses. Changes in animal population age structures and the size of animals also indicate artiodactyl resource depression in some cases when artiodactyl relative abundance remains stable (Wolverton et al. 2008). The necessary data for such intensive investigations are not currently available from assemblages in the study area, but such a study would be an excellent avenue for future work.

In addition to Southwest archaeology, the data presented here also have implications for a modern problem in conservation biology: how long-term human activities on the landscape affect the availability of wild game. The results document reductions in the availability of socially and economically valued artiodactyls when the human use of the landscape was most intense, but also show recovery of these animals after a period of lower human population. This resource recovery is a benefit of the mobile residential strategy employed by farmers in the ancient Southwest, and also a traditional strategy of farmers in areas where wild game remains an important food source today.

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