CLOVIS PALEOECOLOGY AND LITHIC TECHNOLOGY IN THE CENTRAL RIO GRANDE RIFT REGION, NEW MEXICO

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Clovis sites occur throughout the southwestern United States and northwestern Mexico, but are poorly documented in the central Rio Grande rift region. Here, we present data from two relatively unknown Clovis projectile point assemblages from this region: the first is from the Mockingbird Gap Clovis site and the second is from a survey of the surrounding region. Our goals are to reconstruct general features of the paleoecological adaptation of Clovis populations in the region using raw material sourcing and then to compare the point technology in the region to other Clovis assemblages in the Southwest and across the continent. Our results show that both assemblages were manufactured from similar suites of raw materials that come almost exclusively from the central Rio Grande rift region and the adjacent mountains of New Mexico. Additionally, we show that Clovis projectile points in the study region are significantly smaller than the continental average. Our results suggest that Clovis populations in this region operated within a large, well-known, and relatively high-elevation territory encompassing much of northern and western New Mexico.

Sitios de la cultura Clovis ocurren por toda la región sudoeste de los Estados Unidos y el noroeste de México, pero no están bien documentados en la región del Rift de Río Grande. Presentamos datos de dos ensamblajes de puntas de proyectil relativamente desconocidos de esta región: el primero es del sito Mockingbird Gap y el segundo es de una inspección del área al rededor de este sito. Nuestras metas eran reconstruir las características generales de la adaptación paleoecológica de la población Clovis en la región usando la identificación de la proveniencia de materias primas, y luego comparar la tecnología de puntas en la región a otros ensamblajes de la cultura Clovis. Nuestros resultados demuestran que ambos ensamblajes fueron creados con juegos de materias primas que provienen casi exclusivamente de la región del Rift de Río Grande y las montañas colindantes de Nuevo Mexico. Adicionalmente, demostramos que las puntas de proyectil Clovis en la región de estudio son significativamente mas pequeñas que el promedio en el continente. Nuestros resultados sugieren que las poblaciones Clovis en esta región operaban dentro de un territorio grande, bien conocido, y de elevación relativamente alta que cubría una gran parte del norte y el oeste de Nuevo Mexico.

Clovis is the earliest well-documented technocomplex in the southwestern United States and northwestern Mexico and likely represents the archaeological record of the initial hunter-gatherer populations to colonize the region during the late Pleistocene. The greater Southwest region includes many well-known Clovis sites, including the famous cluster of Clovis sites in the San Pedro River valley, Arizona (Haury et al. 1953; Haury et al. 1959; Haynes and Huckell 2007; Hemmings and Haynes 1969), several sites in western Sonora (Gaines et al. 2009; Robles Ortiz 1974; Sánchez 2001, 2010), and numerous isolated finds throughout the region (Figure 1). Additionally, several Clovis sites occur on the neighboring Southern Plains, including the Clovis type site, Blackwater Draw Locality #1 (Boldurian and Cotter 1999; Hester 1972), Lubbock Lake (Holliday 1997; Holliday et al. 1994; Johnson 1987), Miami (Holliday et al. 1994; Sellards

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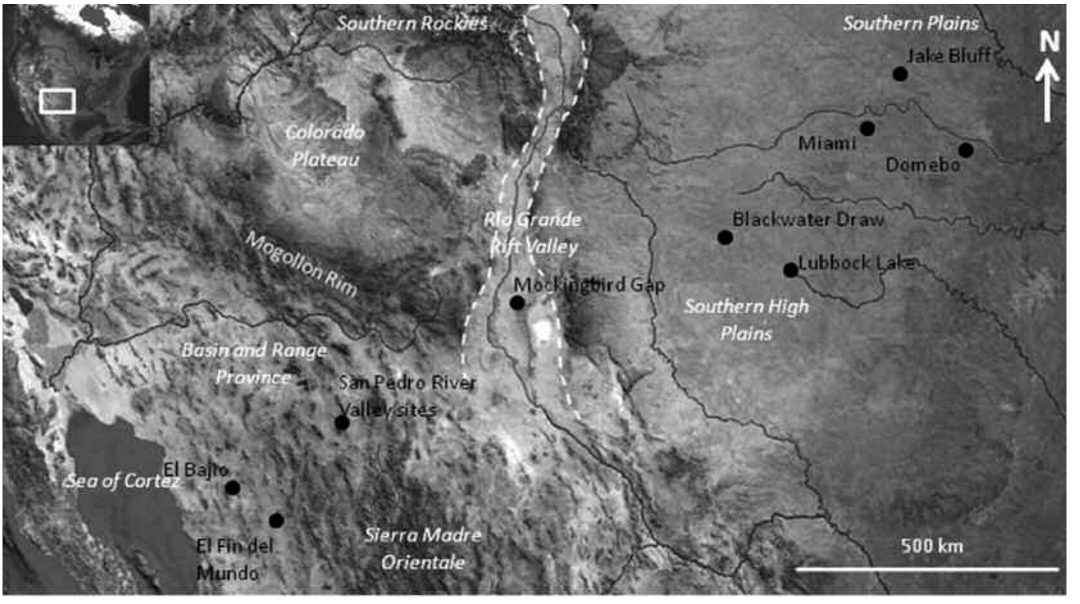

Figure 1. The greater southwest U.S./northern Mexico region.

1938), and Domebo (Leonhardy 1966). In contrast, relatively little is known about the Clovis occupation of the central Rio Grande rift region.

Here we describe and analyze two relatively unknown Clovis projectile point assemblages from the central Rio Grande rift region of New Mexico (Figure 2). The first assemblage includes 222 projectile points from the Mockingbird Gap site (Holliday et al. 2009; Huckell et al. 2006; Huckell et al. 2007; Huckell et al. 2008; Judge 1973; Weber and Agogino 1997), located southeast of Socorro, New Mexico, and the second assemblage includes 70 surface-collected projectile points from a survey of the greater central Rio Grande rift region (Figure 3). Both assemblages were collected, catalogued, and curated over a period of about 60 years by Robert H. Weber,[1] a geologist for the New Mexico Bureau of Geology and Mineral Resources and an avocational archaeologist. The artifacts are currently housed at the Museum of Indian Arts and Culture in Santa Fe, New Mexico.

Our analyses of the Clovis projectile point assemblages from the central Rio Grande rift region focus on two aspects of the data: (1) the location and distribution of known raw material sources for Clovis projectile points found in the region and (2) comparisons of the dimensions of Clovis points in the study region with Clovis assemblages in the greater Southwest and Southern Plains and from across the continent. We infer from these analyses that the central Rio Grande Clovis population had extensive knowledge of a broad and diverse geographic region extending from the Mogollon Mountains in the south to the Colorado Plateau in the north, and from the Rio Grande rift region in the east to the mountains of western New Mexico and eastern Arizona in the west. We also show that Clovis projectile point technology in the Rio Grande rift region shares broad similarities with other Clovis assemblages in the greater Southwest and across the continent in general.

Regional Setting, Geology, and Paleoecology of the Central Rio Grande Rift Region

The Mockingbird Gap site is situated about 60 km southeast of the town of Socorro, and about 30 km east of the Rio Grande at the northern end of the Jornada del Muerto (Figure 1). The site was first discovered in the late 1950s by Robert H. Weber. The Mockingbird Gap site covers an area of about 800 m by 150 m along a low-lying gravel ridge adjacent to Chupadera Wash (Holliday et al. 2009). The surface-collected artifacts come from two primary concentrations, a northern cluster and a southern cluster, both of which seem to have an internal substructure of artifacts suggesting spatially and/or temporally discrete occupation events (Hamilton 2008). Two limited excavation projects have been conducted at the site. The first project focused on a locality in the southern cluster and took place between 1966 and 1967 under the direction of George Agogino of Eastern New Mexico University (ENMU) (Weber and Agogino 1997). The second project was initiated in 2005 in the area of the ENMU excavations, but in 2007 was focused in the northern cluster at a locality referred to as Locus 1214 under the direction of Bruce Huckell and Vance Holliday (Holliday et al. 2009; Huckell et al. 2006; Huckell et al. 2007; Huckell et al. 2008). In this paper, we include projectile points recovered from these excavations.

The Rio Grande rift valley stretches from the southern Rocky Mountains south into northern Mexico, where it merges with the Basin and Range province of the Mexican Cordillera, separating the Colorado Plateau and basin and range of the southwest U.S. in the west from the North American craton in the east (Figure 1). The Rio Grande rift is a broader structural complex that flanks and encompasses the valley (Hawley 2005). The topography of the study region is complex and diverse, ranging from relatively low-lying basins ~900 m asl to high-elevation ranges > 4,200 m asl. The Late Cretaceous Laramide orogeny (~80–50 mya) resulted in the uplift of intermontane western North America, creating much of the modern topography. The Rio Grande rift began forming ~35 million years ago during the Late Cenozoic due to widespread crustal extension and shearing throughout the region (Smith 2004). This crustal extension and shearing resulted in the formation of a series of north-south trending half-grabens along what is now the Rio Grande rift valley (Hawley 2005). This rifting led to the evolution of the northern Rio Grande and the subsequent deposition of intermontane alluvium along the river valley, known as the Santa Fe Group. The combination of the Laramide orogeny, the block-fault formations of the basins, the formation of the Rio Grande River valley, and the localized volcanism associated with the Late Cenozoic crustal extension created a landscape rich in primary and secondary deposits of high quality lithic raw materials, including cherts, chalcedonies, rhyolites, and obsidians. These lithic raw materials were used to make tools by Clovis populations of the region, as well as by subsequent cultures over the following 13,000 years.

The Rio Grande rift region lies at the far northern extent of the Chihuahuan Desert and currently is characterized primarily by desert grasslands at low elevations and mixed conifer forest at high elevations (Van Devender 1995). Packrat middens in the San Andres Mountains of New Mexico suggest that during the Late Pleistocene higher elevations were dominated by mixed conifer forests above ~1,700 m, grading into juniper woodlands and pinyon-juniper-oak woodlands on rocky slopes at lower elevations. These then graded into grassland-savannahs in the river basins, while riparian corridors likely maintained gallery forests (Van Devender 1990). The presence of C_4 grasses and shrubs in packrat middens from the Big Hatchet Mountains in the bootheel of New Mexico indicates an intact monsoonal regime southwest of the Jornada del Muerto (Holmgren et al. 2007). The lack of C_3 shrubs suggests cold winters (Van Devender 1990). Annual precipitation during the Late Pleistocene was bimodal and would have followed predictable elevational and latitudinal gradients (Holmgren et al. 2006; Holmgren et al. 2007). The hydrology of the region during the Late Pleistocene was composed of widespread lake systems throughout northern Mexico (Reeves 1969; Van Devender 1990) and the U.S. Southwest (Allen 2005; Allen and Anderson 2000; Anderson et al. 2002), some of which were interconnected. However, by the end of the Late Pleistocene these lakes had receded substantially from their recorded high stands (Holmgren et al. 2003; Van Devender 1990).

Paleoecological data are also available from the Mockingbird Gap site. Geoarchaeological coring of Chupadera Wash, currently a dry, shallow drainage with localized arroyo development located immediately to the west of the site, revealed that the wash was deeply incised (~10m below the site and the present floor) during the Clovis period and occupied by a stream or wetland or both, and possibly spring fed (Holliday et al. 2009; Huckell et al. 2008). This wetland environment likely would have attracted game along

Table 1. Absolute and Relative Frequencies of Projectile Points and Preforms from Mockingbird Gap and Survey Collection by Condition.

	Mockingbird Gap			Survey Collection		
	Frequency	% of total points	% of sub- category	Frequency	% of total points	% of sub-category
Total points	222	-	-	70	-	-
Complete points						
Preform	3	-	.11	3	-	.30
Finished	24	-	.89	7	-	.70
Total	27	.12	-	10	.14	
Fragmentary points						
Preform fragments						
base	41	-	.21	2	-	.03
base/midsection	4	-	.02	3	-	.05
midsection	-	-	-	-	-	-
tip	13	-	.07	-	-	-
fragment	8	-	.04	-	-	-
Subtotal	66	-	.34	5	-	.08
Finished fragments						
base	46	-	.24	49	-	.82
base/midsection	72	-	.37	4	-	.07
midsection	2	-	.01	-	-	-
tip	1	-	.01	2	-	.03
fragment	8	-	.04	-	-	-
Subtotal	129	-	.66	55	-	.92
Total	195	.88	-	60	.86	-

the arroyo, providing plentiful hunting and gathering opportunities for Clovis foragers. As such, the geoarchaeological and paleoecological setting of Mockingbird Gap is not unlike other early Paleoindian sites on the Southern High Plains, such as Lubbock Lake and Blackwater Draw (Holliday 1997; Holliday et al. 2009). In effect, the central Rio Grande Valley would have offered the benefits of a Plains-like foraging environment with the additional benefit of local access to high quality lithic raw materials and a wide diversity of ecosystems.

The Assemblages

The Mockingbird Gap Projectile Point Assemblage

The Mockingbird Gap Clovis assemblage contains a total of 222 points (Table 1). Twenty-seven of the projectile points from Mockingbird Gap are complete (12 percent), while the rest are basal, midsection, or tip fragments. During the excavation seasons in 2005 and 2007, four incomplete points were recovered, two on the surface and two in situ from excavations (Huckell et al. 2006; Huckell et al. 2008).

The complete points at Mockingbird Gap include diagnostic Clovis points as well as what appear to be miniature points manufactured on flakes. The normal-sized Clovis points exhibit the suite of diagnostic characteristics common to Clovis projectile points, including bifacial flaking, basal fluting, and ground margins. The miniature points exhibit several of the same attributes but are unusually small in comparison to typical Clovis points (Weber and Agogino 1997). Some of the miniature points appear simply to be heavily resharpened points, whereas others appear to have been manufactured from small preforms. There is also evidence of point reworking where large point fragments were being manufactured into new points. We return to this issue in greater detail below.

The Survey Collection Projectile Point Assemblage

The central Rio Grande rift region survey collection consists of 70 Clovis points, including complete points and fragments (Table 1). These arti-

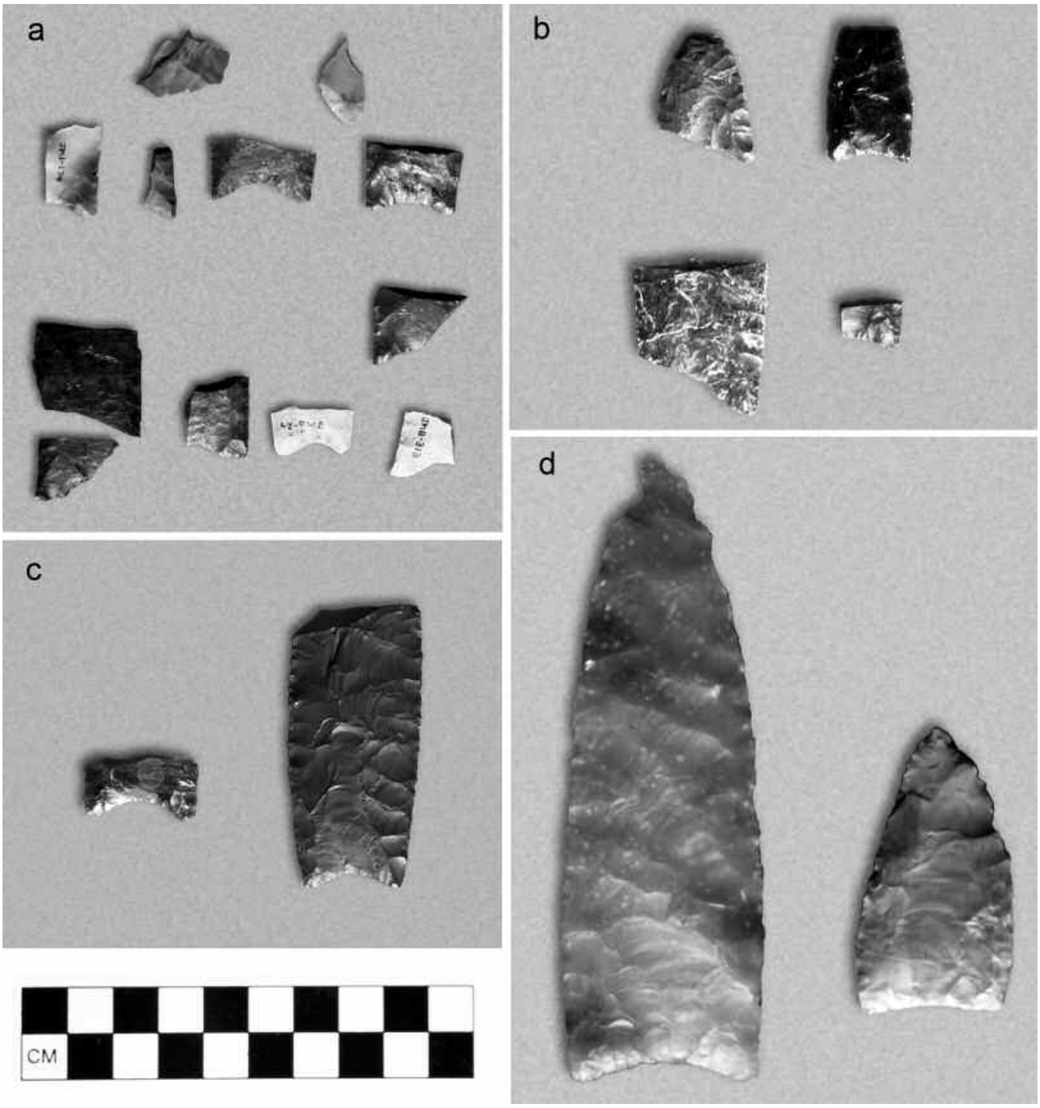

Figure 2. A representative sample of complete and fragmentary Clovis points from the Rio Grande rift region: (a) point fragments (and two gravers, top row) from the Jornada area; (b) and (c) point fragments from the plains of San Agustin; (d) large point and reworked point from near Socorro.

facts were also collected by Robert H. Weber during his regional surveys of Socorro and Catron counties in western New Mexico (Figure 2). This survey region encompasses several thousand square kilometers of the central Rio Grande rift region and western mountains of New Mexico. Several major river drainages were covered by the surveys, including parts of the Rio Grande, Rio Salado, and Rio Puerco, which flow through this region from high-elevation coniferous forests to the grasslands and Chihuahuan desert scrub of the Rio Grande rift region and the Jornada del Muerto.

The projectile points from the survey were recovered primarily from three areas of the study region (Figure 3): (1) the northern Jornada del Muerto (n = 54 points), from about 1,290–1,500 m asl, particularly in the Chupadera Arroyo drainage system and associated springs, both upstream from Mockingbird Gap toward Chupadera Mesa and downstream into the Jornada del Muerto basin; (2) the Plains of San Agustin (n =

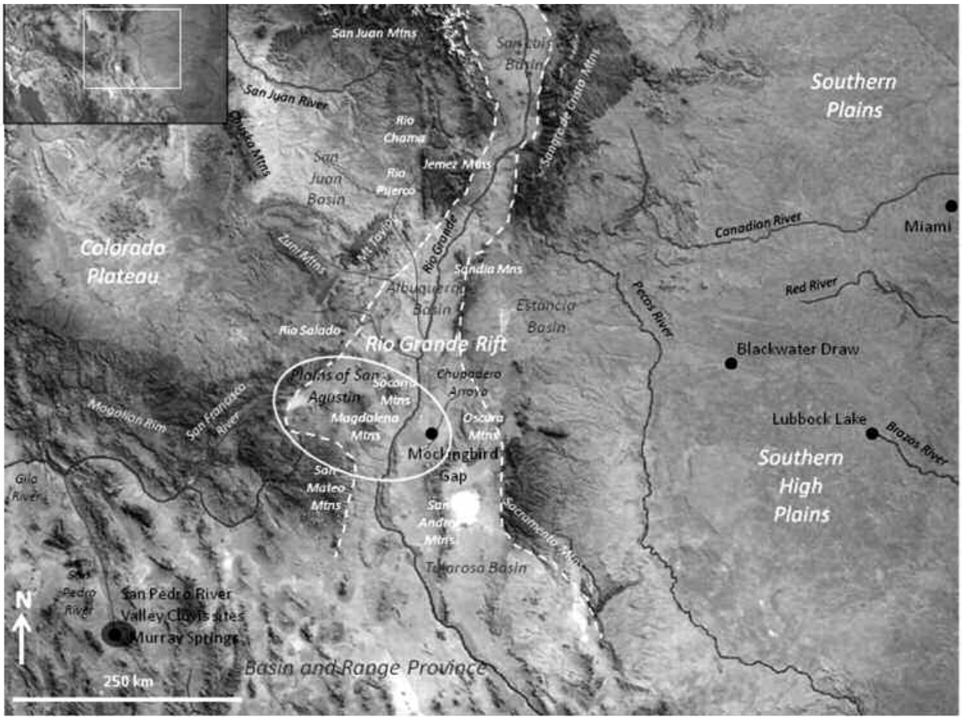

Figure 3. The Rio Grande rift region and surrounding area. The white oval delineates the approximate extent of the survey collection.

10 points), from above 2,100 m asl, as well as a cluster of finds at the northern end of the San Mateo Mountains in the pass leading into the Plains of San Agustin; and (3) the eastern edge of the Magdalena Mountains along the western side of the Rio Grande (n = 6 points), from about 1,800 m asl. Finds in this area are associated with two springs, Torreon and Molino in the foothills of the Magdalena Mountains. Finally, a cluster of four points was discovered on the eastern slope of Socorro Mountain near the town of Socorro. This is the same region as some of the known silicified-rhyolite raw material sources.

Methods

Digitization of Points

The digitizing method we used to analyze the points was the same as the method employed by Buchanan (2005), Buchanan and Collard (2007), and Buchanan and Hamilton (2009). Digital images of artifacts were imported into the Thin Plate Spline Digitizing program (Version 2.02) (Rohlf 2004). Thirty-two landmarks were used to define the edges and base of each point, and the coordinate data were used to compute area and inter-landmark distances in Matlab 6.0. Here we focus on four characters: point area, basal width, midline length, and overall length. Point area is calculated as the area enclosed by the 32 landmarks outlining each specimen. The square root of the measure is then taken to make the units the same as basal width. Basal width is the width of the base between the two corners. Midline length is calculated as the distance from the tip landmark to the midpoint of the basal concavity. Overall length is calculated as the distance from the tip landmark to the midpoint of the segment between the basal landmarks. We use these measures for the following reasons. Point area is a robust measure of point size and shape, but by definition, is restricted solely to the analysis of complete points. In addition, point area can be affected by the use life of the point, where resharpening, for example, can change aspects of the original shape of the point. Although a much simpler measure, basal width allows us to increase the sample size of an-

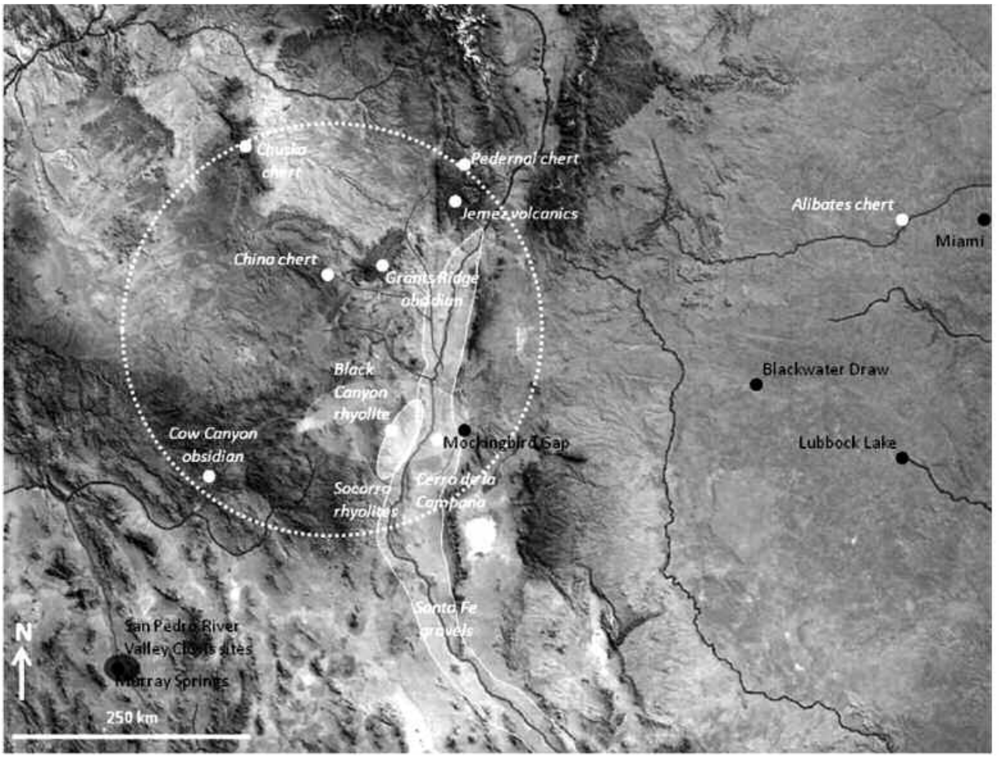

Figure 4. The distribution of known raw material sources (in white text) occurring in the Clovis projectile point collections. Other Clovis sites in the region are in black text. The dashed white circle is the minimum spanning circumference of Clovis raw material sources occurring in the Central Rio Grande rift.

alyzed points substantially and largely circumvents the issue of resharpening, as resharpening is most frequently concentrated on the retooling of the blade segment of the point and rarely impacts the hafting element (Judge 1973). An exception to this, however, may be in cases where large point blade fragments are reworked into new points. We used the difference between the overall and midline lengths as a measure of the depth of the basal concavity of points.

We estimated missing values for the nearly complete points. This was accomplished with the expectation-maximization missing-data replacement method, which uses information about covariation among variables to predict missing values (Strauss et al. 2003). Simulations have demonstrated that expectation-maximization estimation is more precise and reliable than principal-component estimation when using a moderate number of characters and large sample sizes (Strauss et al. 2003).

Statistical Methods

Statistical tests for the comparison of projectile point assemblages (*t* test) and the analysis of basal morphology and raw material type (ANOVA) were performed in Minitab v15. We conducted the Kolmogorov-Smirnov and *t* tests in PASW (SPSS) 18. All the other analyses were conducted in MATLAB 6.0 (release 12), using statistical functions written by R. E. Strauss (www.faculty.biol.ttu.edu/Strauss/Matlab/matlab.htm).

Results

Analysis 1: Lithic Raw Material Selection in the Central Rio Grande Rift Region

Lithic Raw Material Selection in the Mockingbird Gap Assemblage. The majority of projectile points at Mockingbird Gap were manufactured with raw materials from sources located within about 50 km from the site (Figure 4) (Weber and Agogino 1997); however, the less abundant raw materials indicate an almost exclusive use of lithic sources to the north and west of the site.

The most abundant raw material at Mockingbird Gap is "Socorro jasper" (Dello-Russo 2004) (Figure 5a, Table 2), a term used to describe a distinctive dark red to dull yellow jasper that outcrops at various places within the northeastern part of the Mogollon-Datil volcanic field (Chamberlin and Eggleston 1999; Osburn and Chapin 1983). One such outcrop is within Black Canyon in the northern Chupadera Mountains, some 11.5 km southwest of Socorro. It is likely the product of the alteration of intra-cauldron ash flow tuffs to jasperoids during the late Oligocene by silica- and ferromagnesian-rich hydrothermal fluids circulating within fracture zones in the earlier Oligocene Socorro Cauldron. At the Black Canyon quarry (Dello-Russo 2004), this high quality jasperoid appears as localized dikes, part of the Upper Jasperoidal Subzone of Chamberlin and Eggleston (1999:54–59).

The Black Canyon quarry is approximately 45 km west of the site (Figure 4); other outcrops are present farther to the west. The toolstone within these sources varies in quality from fine-grained rhyolites to an almost quartzite-like coarseness, and ranges in color from deep maroon to red and yellow. An XRF analysis conducted by Dello-Russo (2004) found a probable match between a single Clovis point from Mockingbird Gap and material from the Black Canyon quarry. Several site visits to the Black Canyon rhyolite quarry by the authors revealed abundant evidence of prehistoric quarrying, including evidence of the bifacial reduction of high quality rhyolite consistent with Clovis technology.

The second most abundant raw material represented in the Mockingbird Gap assemblage is a green-grey-black chert, which varies widely in quality (Figure 5a, Table 2). The source of this chert is unknown at present, but likely outcrops in Paleozoic limestones exposed in one of the many nearby mountain ranges or arroyos. This chert dominates the lithic raw material assemblage from the recent excavations of Locus 1214 at the Mockingbird Gap site (Huckell et al. 2006; Huckell et al. 2007; Huckell et al. 2008). The lithic assemblage from Locus 1214 consists of several hundred artifacts, including several biface fragments, informal tools, projectile point fragments, and considerable amounts of debitage.

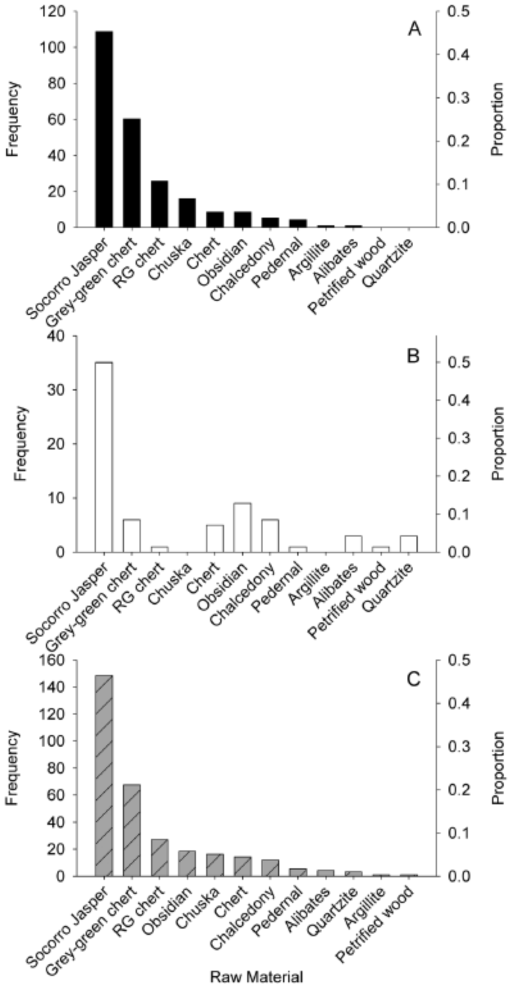

Figure 5. Histogram of raw material frequencies and proportions at Mockingbird Gap, in the survey collection, and in the central Rio Grande rift region as a whole: (a) Mockingbird Gap; (b) the survey collection; (c) Rio Grande rift region assemblage.

Locally available tan-brown cherts are the third most abundant raw material represented in the Mockingbird Gap site assemblage (Figure 5a, Table 2). These cherts are widely available as secondary deposits in the Santa Fe formation gravels along the Rio Grande River channel and also occur in Eocene-age cobble gravels exposed at the Cerro de la Campana, some 15 km west of the Mockingbird Gap site. At the latter, yellow,

Table 2. Absolute and Relative Frequency of the Mockingbird Gap Projectile Points by Raw Material and Condition.

Mockingbird Gap	All points	%	Complete	%	Fragments	%
Socorro jasper	101	.45	17	.63	84	.43
Grey-green chert	56	.25	2	.07	54	.28
Tan chert	24	.11	3	.11	21	.11
Chuska	15	.07	-	-	15	.08
Obsidian	8	.04	2	.07	6	.03
Other chert	8	.04	2	.07	6	.03
Other Chalcedony	5	.02	-	-	5	.03
White chalcedony	4	.02	1	.04	3	.02
Argillite	1	.00	-	-	1	.01
Totals	222	-	27	-	195	-

red, and variegated yellow and gray high quality cherts are present.

Three other types of chert occur in lower frequencies in the Mockingbird Gap assemblage (Figure 5a, Table 2). Constituting about 7 percent of the assemblage, Chuska chert is a distinctive, lustrous, fine-grained orange-to-pink chert from the Chuska Mountains of northwestern New Mexico located over 300 km from the site. Pedernal chert, a fine-grained white chalcedony characterized by faint black bands and red inclusions, also occurs in the assemblage. Pedernal chert outcrops in the Jemez Mountains of northern New Mexico, ~250 km north of the site. Correo "China" chert was also used, accounting for 2.7 percent of the debitage from Locus 1214 (Huckell et al. 2008). It outcrops in the northeastern Zuni Mountains, ~200 km to the northwest of Mockingbird Gap. Alibates chert from Texas (~500 km from the site) is also represented in very low frequencies.

Obsidian from various sources occurs in the Mockingbird Gap assemblage (Hamilton et al. 2009) (Figure 5a). Analyses of 10 obsidian Clovis points using XRF indicate extensive use of sources in the mountains to the north and west of the site (Hamilton et al. 2009). Eight of the points were sourced to obsidian outcrops in the Jemez Mountains (six points from Cerro Toledo and two from Valles rhyolite sources). One point was sourced to Mount Taylor, New Mexico, and one to Cow Canyon, Arizona. The use of the Jemez and Mount Taylor sources is consistent with the northwestern origin of the Chuska, Correo China, and Pedernal cherts, suggesting that Clovis groups traveled across the northern mountains and San Juan Basin and may have utilized the major drainages of the region, including the northern Rio Grande, Chama, Puerco, and San Juan rivers. However, several of these raw materials are available from secondary deposits and so do not necessarily require direct procurement. For example, the Mount Taylor obsidians occur in the gravels of the Rio Puerco and Rio Grande, and the Cerro Toledo obsidians also occur in the Rio Grande, though nodules of the size needed to manufacture bifaces suitable for Clovis point preforms generally do not occur in the Rio Grande as far south as Socorro (Shackley 2005, 2010). Obsidian from the Valles rhyolite, however, has not eroded out of the Valles Caldera, and so this material must have been procured directly from the high elevations of the Jemez Mountains (Shackley 2005, 2010). Of course, whether the Clovis occupants at Mockingbird Gap visited the source directly or acquired the obsidian through trade is unknown.

The Cow Canyon obsidian projectile point is particularly interesting. Cow Canyon is the source for obsidian tools recovered at the Murray Springs Clovis site in the San Pedro River valley, Arizona (Hamilton et al. 2009; Shackley 2007). The Cow Canyon marekanite (eroded nodules of unhydrated obsidian (Shackley 2005)) source is located below the Mogollon Rim in eastern Arizona and would have required travel either through the Gila Mountain range (likely via the San Francisco river), or down the Rio Grande Valley and west across the Lordsburg Gap to the Gila River, a journey of several hundred kilometers either way. The shared use of Cow Canyon obsidian suggests a possible connection between the Clovis populations in the central Rio Grande rift region and the San Pedro River valley (Shackley 2010). Whether this connection indicates no more than a shared use of a high quality obsidian

Table 3. Absolute and Relative Frequency of the Survey Collection Projectile Points by Raw Material and Condition.

Survey Collection	All points	%	Complete	%	Fragments	%
Socorro jasper	36	.51	4	.4	32	.53
Grey-green chert	5	.07	-	-	5	.08
Tan chert	1	.01	-	-	1	.02
Chuska	-	-	-	-	-	-
Obsidian	9	.13	1	.1	8	.13
Other chert	3	.04	1	.1	2	.03
Other Chalcedony	7	.10	4	.4	3	.05
White chalcedony	5	.07	-	-	5	.08
Argilite	-	-	-	-	-	-
Quartzite	3	.04	-	-	3	.05
Petrified wood	1	.01	-	-	1	.02
Totals	70	-	10	-	60	-

source, or direct trading, is unknown. Interestingly, however, the utilization of the Cow Canyon source would have required detailed knowledge of the Mogollon Rim country and considerable time and effort to make the journey.

Lithic Raw Material Selection in the Central Rio Grande Rift Region Survey Assemblage. The central Rio Grande rift region survey assemblage is also dominated by Socorro jasper (Figure 5b, Table 3). Points made of green-grey-black chert, tan-brown Rio Grande chert, or Cerro de la Campana chert occur in less frequency in the survey assemblage than in the Mockingbird Gap assemblage, perhaps reflecting the restricted availability of these materials to particular localized areas. The other abundant raw materials in the survey assemblage include cherts, chalcedonies, and obsidians, all of which also occur at Mockingbird Gap. The cherts in the survey assemblage are from unknown sources, but some of the points made of chalcedony are likely Pedernal. Of the six obsidian points in the assemblage, five were XRF sourced to the Jemez Mountain sources (Valles Rhyolite, Cerro Toledo Rhyolite, and El Rechuelos), and one point from the Socorro Mountains was sourced to Cow Canyon, Arizona. This result indicates that Cow Canyon obsidian is present at Murray Springs, Mockingbird Gap, and in the mountains to the west of the Rio Grande Valley. There are no points made from Chuska chert in the survey assemblage, but there are points made from quartzite and petrified wood from unknown sources, neither of which have been found at Mockingbird Gap (Table 3). However, these raw materials occur at low frequencies and combined constitute less than 10 percent of the assemblage (Figure 5b).

Interassemblage Comparison of Raw Material Selection. The majority of projectile points from both Mockingbird Gap and the survey assemblage are manufactured from the same five raw material sources: Socorro jasper, green-grey-black chert, Rio Grande chert, obsidian, and Pedernal chert (Figure 5c, Tables 2 and 3). These raw materials constitute ~75 percent of the survey assemblage and ~85 percent of the Mockingbird Gap assemblage. Both assemblages are dominated by the local Socorro jasper, which constitutes about 50 percent of the survey assemblage and 45 percent of the Mockingbird Gap assemblage (Figure 5a–c). Both assemblages include obsidian from the Jemez Mountains and Cow Canyon sources. However, there are differences in the use of particular Jemez Mountain sources. Both assemblages include obsidian procured from the Valles Rhyolite source, but only Mockingbird Gap includes Cerro Toledo obsidian, and the survey assemblage includes El Ruechelos obsidian. Additionally, Mount Taylor obsidian does not occur in the survey assemblage, but is found at Mockingbird Gap. However, it is important to note that, given the small number of obsidian artifacts analyzed, these differences may well be influenced by sampling. The overall similarities in the use of raw material sources suggest a behavioral link between the assemblages and suggest that they are two archaeological components of the same regional Clovis population using the central Rio Grande rift region over a number of years or generations.

Point Morphology of the Central Rio Grande Rift Region Clovis Projectile Points. Basal point fragments make up the majority of the Mockingbird Gap assemblage (Table 1), consistent with campsite retooling activities such as the discard, manufacture, and replacement of broken points. The shape of the basal concavities in the Mockingbird Gap assemblage varies widely, ranging from flat to varying degrees of concavity to triangular. Analysis of variance shows that shape of the base is not related to raw material type, as neither basal width, measured by the distance between the two basal ears ($F = 1.47$, $df = 9, 92$, $p = .17$), nor the depth of basal concavity, measured by the difference between overall and midline lengths ($F = .90$, $df = 8, 80$, $p = .52$), varies consistently with raw material type. This suggests that much of the variation in basal form likely results from manufacturing decisions or cultural traditions, rather than mechanical constraints imposed by the properties of the individual raw materials. Fluting characteristics vary in the collection from single to multiple flutes.

Projectile points in the survey assemblage are of the same general morphology as the standard-sized Clovis points from Mockingbird Gap, and although they display a high degree of variation in form, in general, points are parallel-sided with a similar range of variation in basal concavities as those found at Mockingbird Gap. There are no miniature points in the survey assemblage, though this might be due to size-based identification and collection bias. Similar to the Mockingbird Gap points, neither basal width ($F = 2.59$, $df = 5, 24$, $p = .05$) nor depth of basal concavity ($F = 2.24$, $df = 7, 33$, $p > .05$) varies with raw material type in the survey sample. The two largest Clovis points from the survey assemblage were recovered immediately to the west of Socorro (Figure 2d). One is a heavily reworked point and the other is a complete point, both manufactured of chert or agate from unknown sources. The agate point in particular is consistent with the size and craftsmanship of some of the larger points found in Clovis caches throughout the western United States (Kilby 2008). Unfortunately, this specimen was recovered in a secondary alluvial deposit of Holocene age, and no other Clovis artifacts were recovered from the immediate area (R. H. Weber, personal communication, 2007).

Analysis 2: Point Size Distributions

For the quantitative comparison of the assemblages, we now turn to the statistical analysis of point size distributions.

Mockingbird Gap Point Character Distributions. Figure 6a shows the point area distribution for all 25 complete points from Mockingbird Gap. The distribution is unimodal and lognormal, as would be expected for culturally transmitted technologies (Hamilton and Buchanan 2009). However, the same data plotted by basal width, rather than overall size, reveal a different pattern. Figure 6b shows that the distribution of basal widths of complete points is truncated at about 2 cm, with the body of the distribution resembling the lower tail of a normal distribution. A plot of all basal widths from Mockingbird Gap shows a more standard unimodal distribution, though slightly left skewed (Figure 6b). The peak in the distribution of all basal widths matches the truncation of the complete points, suggesting that while the total assemblage of points used, manufactured, and discarded at Mockingbird Gap is normally distributed, the sample of complete points is heavily biased toward small points. We suggest that this may reflect the reuse and reworking of heavily used and broken points at Mockingbird Gap, consistent with the impression that the site was repeatedly occupied over a substantial length of time. In general, the distributions in Figure 6b suggest that all broken points with a basal width greater than ~2 cm were systematically collected and reworked into new points and tools, whereas all broken points below that threshold were discarded and left at the site, presumably because they were regarded as too small to be reused.

Central Rio Grande Rift Region Survey Point Character Distributions. Figure 6c shows the basal width distributions for the complete points from the survey assemblage ($n = 8$) and all complete bases ($n = 32$). Although the sample size of complete points is very small, the distribution of complete points and all bases is similar in shape, and both are skewed to the right. Note also that there is only one complete point and two complete bases less than 2 cm wide, suggesting that, on average, the points from the survey collection are larger than at Mockingbird Gap. However, plotting both distributions on the same figure (Figure 6d) is revealing. These distributions suggest that

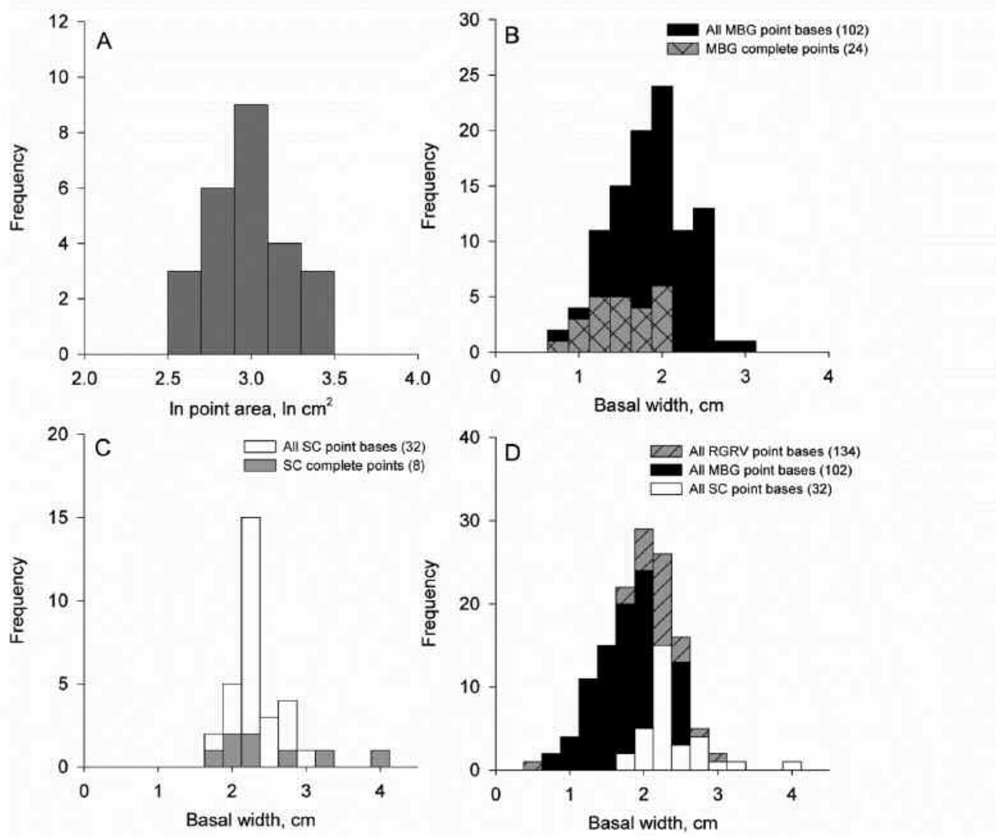

Figure 6. Point size distributions for the Mockingbird Gap (MBG) and the survey collection (SC): (a) frequency distribution of point areas of complete points from Mockingbird Gap; (b) frequency distributions of basal widths of both complete points and all complete bases (including complete points) from Mockingbird Gap; (c) frequency distributions of basal widths of complete points and all complete bases from the survey collection; (d) frequency distributions of all complete bases from Mockingbird Gap, the survey collection, and a combined distribution of all complete point bases representing the distribution of Clovis point basal widths from the Rio Grande rift region in general.

the points from the survey assemblage form the upper tail of the overall central Rio Grande rift region Clovis point distribution, while the Mockingbird Gap assemblage forms the lower tail and main body. Indeed, the overall distribution of all 132 complete Clovis bases from the central Rio Grande rift region forms a normal distribution.

The Central Rio Grande Rift Region Clovis Points in Comparison to Southwest-Southern Plains Clovis Assemblages. We conducted the same analysis at a coarser-grained spatial scale, using a sample of Clovis assemblages from the Southwest and Southern Plains (including Blackwater Draw, Domebo, Miami, Lehner, Naco, and Murray Springs; see Table 4), with a sample size of 55 points. Figure 7a shows that for all central Rio Grande rift region bases ($t = 2.93$, $df = 127$, $p = .004$) and complete points ($t = 3.63$, $df = 42$, $p = .001$), average point size is smaller than other Clovis points in the general region (Table 5). The distributions in Figure 7a show that as the upper tails of the central Rio Grande rift region bases and the wider sample are very similar, the difference is driven by the abundance of small points at the Mockingbird Gap site. To check for the effects of sample size, we then ran regressions of assemblage size on assemblage mean ($F = .79$, $df = 25$, $p = .38$) and variance ($F = .49$, $df = 25$, $p = .49$), but in both cases there was no significant trend, indicating that the sample size does not unduly influence the assemblage statistics.

The Central Rio Grande Rift Region Clovis Points in Comparison to Other Clovis Point Assemblages. Next, we compared the distribution of

Table 4. Absolute Frequency of Clovis Points by Site in the Continent-wide Assemblage.

Site	Count
Anzick	6
Blackwater Draw*	24
Bull Brook I	39
Bull Brook II	2
Butler	4
Cactus Hill	6
Colby	4
Debert	6
Dent	2
Domebo*	4
Drake	13
East Wenatchee	11
Fenn	16
Gainey	11
Gault	2
Kimmswick	3
Lamb	5
Lehner*	10
Miami*	3
Murray Springs*	6
Naco*	8
Rummells-Maske	10
Shoop	14
Simon	5
Vail	16
Whipple	2
Total	232

* Denotes inclusion in the Southwest-Southern Plains Clovis t test.

Clovis points in the central Rio Grande rift region with other assemblages from across the continent (Table 4). Figure 7b shows that Clovis points from the central Rio Grande rift region are significantly smaller, on average, than a continent-wide sample of Clovis points ($t = 8.03$, df = 248, $p < .001$). Because the central Rio Grande rift region distribution is composed of both complete and fragmentary points, whereas the continent-wide sample is composed of only complete points, we ran the same test only on complete points from the Rio Grande rift region and found similar results ($t = 5.80$, $df = 33$, $p < .001$).

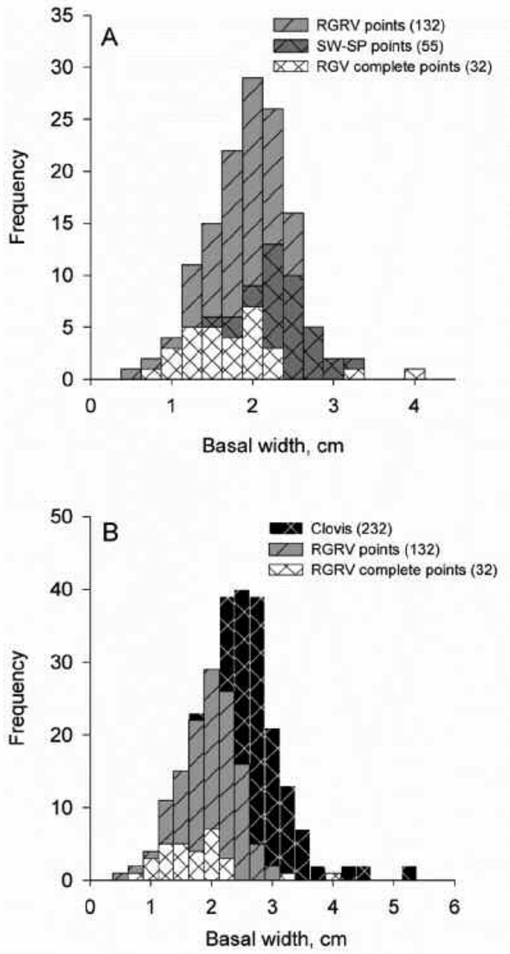

Figure 7. Frequency distributions comparing the Rio Grande rift region assemblage to other Clovis assemblages continent-wide and to regional Clovis assemblages from the Southwest and Southern Plains: (a) Rio Grande rift region points are significantly smaller on average than the greater sample of all Clovis points continent-wide both for both all complete bases ($t = 8.03$, $df = 248$, $p < .001$) and complete points ($t = 5.80$, $df = 33$, $p < .001$); (b) Rio Grande rift region points are equivalent in size to a distribution of combined Clovis assemblages from the Southwest and Southern Plains for both complete bases ($t = -.82$, $df = 148$, $p = 0.41$), and complete points ($t = 1.30$, $df = 50$, $p = 0.17$).

Discussion

The two assemblages presented here demonstrate a widespread Clovis occupation of the central Rio Grande rift region. The use of the same suite of raw materials used to make the points in both assemblages, as well as the similarities in manufacturing design, suggest that they are most parsimoniously explained as multiple components of a region-wide occupation. The timing and duration of this occupation currently is unknown because there are no radiocarbon dates from any Clovis sites in the study region. The Mockingbird Gap Clovis site is a large campsite, likely representing numerous reoccupation events, perhaps on a sea-

Table 5. Summary Statistics on Basal Width (cm) of Projectile Points from the Different Assemblages.

Collection	Sample	Average	St. Dev.	Count
	Fragment	1.85	.42	78
Mockingbird Gap	Complete	1.42	.36	24
	Combined	1.75	.45	102
	Fragment	2.18	.27	25
Survey Collection	Complete	2.51	.79	7
	Combined	2.26	.44	32
	Fragment	1.93	.42	103
Rio Grande Rift	Complete	1.67	.66	31
	Combined	1.87	.49	134
Southwest/Southern Plains	Complete	2.49	.56	55
Continental Clovis	Complete	2.83	.84	232

Note: Fragment refers to fragmentary points with intact bases; complete refers to the width of complete points; and combined refers to all basal widths in that assemblage.

sonal or annual basis. The survey assemblage is the archeological residue of a more diffuse occupation of the region, including temporary camps and isolated finds, again probably indicating seasonal mobility and access to a variety of high quality raw material sources for stone tool manufacture over a wide region of the southeast Colorado Plateau and southernmost Southern Rockies.

Camp activities at Mockingbird Gap are suggested by the overwhelming dominance of projectile point bases, manufactured primarily from locally available raw materials, but also by the many preform fragments in the assemblage, which are consistent with weaponry manufacture and retooling tasks. In addition, the Locus 1214 excavated assemblage includes many lithic artifacts indicative of projectile point manufacture, including biface fragments, biface reduction flakes, and the termination of a large overshot flake, in addition to two Clovis projectile point bases (Huckell et al. 2006; Huckell et al. 2007; Huckell et al. 2008).

The miniature points from Mockingbird Gap are morphologically and technologically distinct from the standard-sized Clovis points at the site and vary widely in manufacturing quality, ranging from flakes that have been crudely shaped to mimic the shape of Clovis points to others that were clearly manufactured by accomplished flintknappers. While flake-based miniature points are not abundant in Clovis assemblages, they do occur with some frequency in Folsom contexts, where they are generally termed "pseudo-fluted points" (Wilmsen and Roberts 1978). How these miniature points functioned is unknown. While several of the miniature points are crudely worked flakes that were shaped into the approximate form of Clovis points, perhaps indicating manufacture by children, others were apparently manufactured by skilled flintknappers, perhaps indicating that they were manufactured by parents for their offspring. The fact that miniature points occur with such high relative frequency at the Mockingbird Gap site is a function both of the large sample size of projectile points from the site and of the intensive survey and monitoring of the site by R. H. Weber.

Despite the large sample size and diversity of projectile point sizes at Mockingbird Gap, the suite of raw materials evidenced in the projectile point collection indicates a relatively focused use of source locations in the mountains to the north and west of the site. Indeed, there is a conspicuous paucity of known high quality raw materials from the east, particularly Edwards chert and Alibates agate. Other high quality raw material sources in the Jornada del Muerto, such as Rancheria chert (Amick 1996), are also absent from the Mockingbird Gap assemblage, despite its relative proximity. There are Clovis artifacts made from Rancheria chert in the region (Daniel Amick, personal communication, 2007), and so presumably the chert could have been obtained through either direct acquisition or trade. Of course, whether the Clovis occupation of the southern Jornada Basin was contemporary with the occupation in the northern Basin is unknown. Similarly, despite the significant presence of obsidian from sources throughout western New Mexico, there are no artifacts sourced to known obsidian outcrops to the south of the site (Hamilton et al. 2009). The overall impression is that Mockingbird Gap was likely a seasonally reoccupied campsite located at the extreme southeast corner of a well-established home range, which included a large geographic area encompassing the central Rio Grande rift valley and the adjacent mountains of western and northwestern New Mexico.

While Mockingbird Gap seems to be a primary focus of Clovis camping activity in the northern Jornada basin, there is evidence of additional Clovis activity along the Chupadera Arroyo drainage, both to the north and south of the site, evidenced by isolated finds and smaller sites. This pattern likely reflects Clovis groups using the resource-rich Chupadera Arroyo. The concentration of Clovis activity along Chupadera Arroyo must partly be a function of survey sampling, as Clovis hunters undoubtedly operated throughout the extensive savannah grasslands of this part of the northern Jornada Basin. However, the Clovis presence along the arroyo suggests that foraging and camping activities were focused along drainage systems, and perhaps Chupadera Arroyo provided a useful corridor for movement across an otherwise broad, arid valley.

On a regional scale, the Mockingbird Gap and survey assemblages suggest that Clovis land use in this part of the Southwest focused on the central Rio Grande rift region and adjacent mountains. Interestingly, however, the Clovis record of the Albuquerque Basin farther north in the Rio Grande rift region is sparse (Kilby et al. 2005), despite a considerable history of archaeological research in the area by universities, contract companies, and avocational archaeologists. While it is unclear why Clovis visited but seemed not to occupy the Albuquerque Basin, the overall picture created is of a relatively high-country adaptation, where Clovis groups in the region would have utilized the major drainages and mountain ranges at elevations well above 1,400 m asl. During the Late Pleistocene, the majority of this region would have been heavily forested, with wet, warm summers, and wet, cold winters, likely with heavy winter snows (Betancourt et al. 1990). As such, seasonal movements likely focused on the high country during the warmer spring and summer months, with fall/winter mobility focused primarily in the river valleys.

The similar suites of raw materials in both assemblages suggest not only that both assemblages were a part of a regional occupation, but that this Clovis population had access to resources across a vast geographic area. While the actual size of the territory these populations may have used is impossible to know with any certainty, if we delineate a minimum circumference that encompasses the primary raw material sources from these assemblages, then this would imply a lithic resource catchment area of over 100,000 km^2. Although this is a vast area, it is well within the range of territory sizes recorded among ethnographic hunter-gatherers (Binford 2001).

However, the direct acquisition of all raw materials cannot simply be assumed. Because the most dominant raw materials are relatively local, it is likely they were accessed directly either during the course of seasonal movements or during logistical forays. Other less abundant high quality raw materials likely moved long distances via trade networks (Hamilton and Buchanan 2007; MacDonald and Hewlett 1999). Arguably, this is likely the case for Alibates agate, a geographic outlier in the study region as it is the only known raw material from the Southern High Plains. The Cow Canyon obsidian points and the single petrified wood point may indicate similar potential trading connections with Clovis groups farther to the west in eastern Arizona.

The multiple reoccupations at Mockingbird Gap, and the consistent, almost exclusive, use of raw material sources from the extreme southern extent of the Southern Rockies north of the Mogollon Rim suggest a redundant use of the landscape over some unknown period of time. The diversity of known raw material sources indicates detailed working knowledge of a vast and complex landscape, suggesting the long-term use of an established territory (Hamilton and Buchanan 2007; Huckell and Haynes 2007; Meltzer 2004). The distribution of points on the landscape and the location of raw material sources suggest movement along the central Rio Grande rift region and to the west via the Rio Salado and/or Rio Puerco drainages, and perhaps farther north along the Rio Chama and San Juan. Access to the Cow Canyon obsidian source, either through trade or direct acquisition, would have involved crossing the Plains of San Agustin and perhaps traveling along the San Francisco River toward the Mogollon Rim, a route likely viable during only the summer.

The wider regional pattern of land-use across the greater Southwest and northern Mexico that seems to be emerging is one of relatively localized hotspots of activity connected by the shared use of raw materials, separated by regions of low density Clovis occupation. Such hotspots in the southwest region would include the central Rio Grande rift region, the San Pedro River valley, and western Sonora. This pattern of land use would be more consistent with models that suggest that Clovis populations established territories in favorable ecological contexts across the continent, bypassing less favorable regions (i.e. Anderson and Gillam 2000; Hamilton and Buchanan 2007; Meltzer 2004), rather than models that suggest a more ephemeral, non-redundant, sweeping use of the landscape (i.e. Kelly and Todd 1988; Martin 1967). Of course, the visibility of such hotspots is partly the result of survey and research sampling bias, as well as issues of preservation and deposition (Buchanan 2003; Prasciunas 2011). However, the primary centers of Clovis activity in the southwestern U.S. and northern Mexico are not directly associated with major population centers or areas of agriculture, unlike other regions across the continent (Buchanan 2003), which suggests that we may be starting to see the true spatial signal of the Clovis settlement pattern in this region.

Conclusion

The Clovis archaeological record of the central Rio Grande rift region suggests that Clovis populations utilized a large and well-known territory covering much of northern and western New Mexico. The archaeological record at Mockingbird Gap indicates extensive and, most likely, repeated occupations over an unknown period of time, and the consistent use of the same suite of high quality lithic raw materials from sources dispersed across this vast region suggests an intimate familiarity with this varied landscape. As such, the Clovis archaeology of this region indicates a high-elevation adaptation, between ~1500 m asl and ~4,000 m asl, which included both the savannah grasslands of the central Rio Grande rift valley and the woodlands and forests of the adjacent mountains.

The ecological setting of the Mockingbird Gap site is similar to other Clovis sites in the greater Southwest, such as Lubbock Lake and Blackwater Draw. Similarly, the lithic technology utilized by Clovis peoples in the region is consistent with other Clovis assemblages across the greater Southwest and across North America in general.

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Note

1. Dr. Robert H. Weber died in 2008.

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