Artifact Distribution and Its Relationship to Microtopographic Geomorphic Features in an Eolian Environment, Chihuahuan Desert

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Two models have been developed to explain the relative roles of cultural and geomorphic processes on the distribution of artifacts in the arid southwestern United States. This study tested the Geological Disturbance Model at a microtopographic scale in an area of approximately 14 km² in the northeastern Hueco Basin, West Texas. Coppice dunes, interdunal deflational areas, and sandsheets have formed throughout the Hueco Basin within the last 100–150 years. The number of coppice dunes in 1,397 ha was counted, and 48 ha were mapped to determine the surface area of the coppice dunes and interdunal deflational areas. Artifact distribution was statistically compared to the coppice dunes in each hectare. No significant linear correlation was found. Cultural practices or other factors appear to have a greater influence on the distribution of artifacts than geomorphic processes at this scale. © 1999 John Wiley & Sons, Inc.

INTRODUCTION

Both behavioral and geomorphic processes control artifact distribution. Two models have been used to explain the distribution of artifacts in the arid climates of the southwestern United States: (1) the Holocene Litter Model and (2) the Geological Disturbance Model (Doleman, 1992). The Holocene Litter Model proposes that the archaeological record is “a product of highly dispersed foraging/extraction activities,” which results in an archaeological record that is primarily controlled by behavioral processes (Doleman, 1992:73). In contrast, the Geological Disturbance Model proposes that the geomorphic processes of erosion and deposition that formed the modern-day geomorphic features, such as coppice dunes, sandsheets,
and interdunal deflational areas, have formed “eolian windows, whose placement and size are more or less random” (Doleman, 1992:73). Deflation opens these windows through the eolian mantle, exposing and concentrating artifacts and other objects too heavy to be carried away by the wind. Because the windows control the exposure of archaeological materials, the Geological Disturbance Model proposes that geomorphic processes result in a “highly localized and biased” archaeological record (Doleman, 1992:73). In the Tularosa Basin, Doleman and Stauber (1992) found a high correlation between surface artifact densities and their presence on elevated landforms at a scale of tens to hundreds of meters. Their findings could prove very useful in management decisions of federal lands. This study compares the distribution of artifacts to recent geomorphic features in the northeastern Hueco Basin, West Texas, at a micropalaeogeographical scale (ones to tens of meters) to both test the Geological Disturbance Model at a different scale than Doleman and Stauber (1992), and to possibly provide information to assist in management decisions.

GEOMORPHIC HISTORY AND STRATIGRAPHY

The northern Hueco Basin has a rich cultural and geomorphic history (Ruhe, 1967; Basehart, 1974; Beckes et al., 1977; Whalen, 1977, 1978; Pigott, 1978; Carmichael, 1986; Seaman et al., 1988; Doleman, 1991, 1992, 1995; Doleman and Swift, 1991; Anschuetz et al., 1990; Camilli and Ebert, 1992; Doleman et al., 1992; Monger, 1995; Buck, 1996; Burgett et al., 1996a, 1996b; Buck and Monger, 1998; Buck et al., 1998; Monger et al., 1998). This basin forms one of the eastern-most extensions of the southern Rio Grande Rift and is bounded by the Hueco Mountains on the east and the Franklin Mountains on the west (Figure 1). A model based on soil-geomorphology, stratigraphy, and palynologic, isotopic, and radiometric analyses has been developed to explain late Quaternary stratigraphy in and around the Hueco and surrounding basins and ranges (Ruhe, 1967; Hawley, 1975; Gile et al., 1981; Monger, 1995; Buck, 1996; Buck et al., 1998; Monger et al., 1998; Buck and Monger, 1998). This model suggests that alluvial erosion and deposition along alluvial fans is primarily controlled by climatic fluctuations in which increased erosion and concurrent deposition and progradation of younger fan surfaces occurs during arid climates (Ruhe, 1962). These arid periods are followed by periods of increased precipitation in which vegetative cover increases, erosion decreases, and stable land surfaces with associated soil development occurs (Gile, 1975; Gile et al., 1981; Monger, 1995; Monger et al., 1998). These climatic fluctuations had similar effects within the Hueco basin floor; however, the major difference is that the primary controls on erosion and deposition in the basin floor are eolian processes (Buck, 1996; Buck and Monger, 1998; Buck et al., 1998). The morphologic characteristics, stratigraphic position, and radiocarbon ages within geomorphic surfaces in both adjacent alluvial fans and the basin floor, indicate that the late Quaternary eolian sediments within the Hueco Basin are time correlative to the alluvial sediments on adjacent alluvial fans (Buck, 1996; Buck and Monger, 1998). Five major strat-
Figure 1. Study area in Hueco Basin, Fort Bliss Military Base, West Texas.
graphic units are present within the Hueco Basin: La Mesa, (eolian) Jornada (I and II), (eolian) Isaacks’ Ranch, (eolian) Organ (I, II, and III), and Historic Blowsand (Table I) (Monger, 1995; Buck, 1996; Buck et al., 1998; Buck and Monger, 1998; Monger et al., 1998). However, these units are not distributed uniformly across the basin. Because of the nonlinear nature of the eolian processes responsible for their formation and preservation, many areas within the basin may lack one or more of these units either to nondeposition or erosion.

La Mesa

The La Mesa geomorphic surface in the Hueco Basin overlies the fluvial facies of the Camp Rice Formation, which contains well-rounded pebbles derived from the ancestral Rio Grande (Seager, 1981; Seager et al., 1987). The La Mesa geomorphic surface extends across the entire basin floor, except for areas in which normal faulting has resulted in uplift and erosion. In many instances it contains stage III, but more commonly contains stage IV or V carbonate morphology, which is characterized by a massive, plugged horizon of calcium carbonate, with or without a laminar cap or pisoliths (Gile et al., 1966; Machette, 1985). However, this massive, plugged horizon is not a planar, continuous unit across the entire basin. Instead, it is often characterized by dissolution pipes, in which large sections of the petrocalcic horizon are missing. In addition, because the depth to the top of the petrocalcic horizon has had localized differences through time, the petrocalcic horizon has precipitated and dissolved at different rates and depths. Therefore, both the degree of development and the character of the La Mesa petrocalcic horizon varies extensively across the entire basin.

(Eolian) Jornada I and II

Jornada I and II sediments within the Hueco Basin are very rare and difficult to identify. In most places within the basin, the Jornada-age deposits are either (1)
welded onto the La Mesa petrocalcic horizon, (2) have been eroded, or (3) were never deposited. This makes the interpretation of Jornada I or II classification within the basin floor very difficult (Buck et al., 1998).

**Eolian Isaacks’ Ranch**

Isaacks’ Ranch deposits within the basin are characterized by stage II nodules of calcium carbonate (Table I) and were deposited between 13,000 and 8,000 yr B.P. (Gile et al., 1981; Gile, 1995). These sediments usually contain slightly higher percentages of clay (sandy loam) as compared to the younger Organ and Historic Blowsand deposits (loamy sand) (Buck, 1996). However, in many areas within the Hueco Basin, the Isaacks’ Ranch deposit is missing entirely, and often only its stage II nodules remain. These nodules of carbonate are present either in a paleolag deposit, or as part of a modern deflational lag between coppice dunes (Buck, 1996; Buck and Monger, 1998; Buck et al., 1998).

**Eolian Organ**

On the piedmont slope of the adjacent alluvial fans, Organ deposits have been divided into three distinct units: Organ I, II, and III (Gile et al., 1981). Organ I deposits have been dated between 7,500 and 2,200 yr B.P., Organ II between 2,200 and 1,100 yr B.P., and Organ III between 1,100 yr B.P. and approximately 150 years ago (Table I) (Gile, 1975; Gile et al., 1981). Within the Hueco Basin, the three Organ units are distinguished by their carbonate morphology, texture, and relationship to the other stratigraphic units within a profile. Generally, Organ I sediments contain ready visible, strong stage I carbonate filaments. Organ II sediments contain weakly developed, faint stage I filaments and are not always present. In those cases, Organ III deposits overlie Organ I sediments (Figure 2). Organ III sediments are characterized by the absence of carbonate filaments and either no or very faint stratification. Organ I, II, and III deposits have a loamy sand texture, but generally vary in color from strong brown (7.5YR 5/6; 5/8), light brown (7.5YR 6/4), or reddish yellow (7.5YR 6/6) (Buck, 1996).

**Historic Blowsand**

The youngest deposit is the Historic Blowsand, which is characterized by coppice dunes and interdunal sandsheets composed of stratified loamy sand containing no carbonate filaments. This deposit has formed within approximately the last 150 years as a result of overgrazing and/or a possible recent increase in aridity (Buffington and Herbel, 1965; Gile, 1975; Blair et al., 1990). This resulted in decreased vegetative cover and erosion of underlying deposits. Interdunal deflational areas contain a modern surficial lag composed of Rio Grande pebbles, fragments of carbonate from the stage III, IV, and V petrocalcic horizon of the La Mesa surface and/or a Jornada I deposit, and stage II nodules from the Isaacks’ Ranch or possibly a Jornada II deposit. This lag also contains artifacts, which were uncovered and concentrated as the overlying fine-grain deposits were blown away.
Figure 2. Idealized figure of a typical interdunal deflation area in the Hueco Basin. Deflation within the last 100–150 years has opened eolian windows between coppice dunes, exposing and concentrating clasts including artifacts in a surficial lag.
LANDSCAPE EVOLUTION

Although the Hueco Basin today is dominated by coppice dunes, interdunal deflational areas and some sand sheets, geomorphic and isotopic evidence indicates that the formation of these existing geomorphic features is relatively recent—within approximately the last 100–150 years (Buffington and Herbal, 1965; Gile, 1966, 1975; Blair et al., 1990; Buck, 1996; Buck and Monger, 1998; Buck et al., 1998; Monger et al., 1998). Isotopic signatures of pedogenic carbonate suggest that the Hueco Basin contained a stable C₄ grassland during the late Pleistocene, and that this grassland was abruptly replaced by a C₃ desert scrub vegetation community between 9 and 7 ka (Buck, 1996; Buck and Monger, 1998). The isotopic data are supported by geomorphic evidence indicating that the stable late Pleistocene landscape was abruptly eroded between 9 and 7 ka, corresponding to increased C₃ desert scrub and an accompanying increase in bare surface area. This eolian erosion event exhumed underlying clasts, including the stage II nodules from the subsurface Bk horizon of the Isaacks’ Ranch and other late Pleistocene paleosols. These clasts accumulated on the surface and were subsequently buried by the Organ I deposit in many parts of the basin, forming a paleolag deposit (Blair et al., 1990; Monger, 1995; Buck, 1996; Buck and Monger, 1998; Buck et al., 1998). Regional palynological, isotopic, and geomorphic evidence from adjacent alluvial fans supports this scenario. A period of landscape stabilization after approximately 4 ka probably reflects increased moisture and a return of C₄ grasses indicated by pollen, stable isotopes, and geomorphic data from both alluvial fans and eolian basin-floor deposits. Another arid event occurred at approximately 2.2 ka and correlates to depleted δ¹³C values indicative of C₃ desert scrub (Buck, 1996; Buck and Monger, 1998), decreased Gramineae pollen from the alluvial fans (Freeman, 1972), and increased erosion and deposition of the Organ II deposit along adjacent alluvial fans and within localized areas of the basin (Gile, 1975; Buck, 1996; Buck et al., 1998; Buck and Monger, 1998). Because of the more localized nature of this erosional and depositional event, it was probably less severe than the one between 9 and 7 ka (Buck, 1996; Buck et al., 1998). The most recent erosional event occurred within the last century and has been attributed to overgrazing coincident with Euroamerican settlement throughout the region (Buffington and Herbel, 1965; Gile, 1966, 1975; Hennessy et al., 1983; Blair et al., 1990). Where preserved, buried Organ I and III soils throughout the basin contain planar A horizons, which suggests that the modern-day topography characterized by 0.5–3.5 m high coppice dunes with interdunal deflational areas is a relatively new phenomenon created within the last 100–150 years (Buck, 1996). This massive, basin-wide eolian erosional event created a surficial lag of subsurface clasts, which were too large to be carried away by the wind (Figure 2). The surficial lag is composed of Rio Grande pebbles, fragments of stage III–V petrocalcic horizon, stage II nodules, and artifacts. In addition, these cyclic erosional and depositional events during the late Pleistocene and Holocene have resulted in a discontinuous and complicated eolian stratigraphy, which may have a significant effect upon the archaeological record preserved within the basin.
To test the possible geomorphic effects, we compared the distribution of artifacts to geomorphic features at a microtopographic scale.

**METHODS**  
**Archaeological Data**

The majority of the Hueco Basin is controlled by Fort Bliss Military Reservation, and this study was conducted under the direction of the Directorate of Environment, U.S. Army, to assist in management decisions of the area. A 14 km² area west of the Hueco Mountains was designated as the Hueco Mountain Archaeological Project (HMAP). Artifact counts for the 14 km² were derived from point-provenienced data collected during the surface collection phase of the HMAP project (Burgett, 1995). Systematic sweeps were made with an interval of 15 m between crew members. Proveniencing was accomplished largely by piece plotting artifact coordinates with an electronic distance measuring (EDM) instrument, although some optical transit observations were made in some areas. All visible artifacts were plotted, collected, and returned to the HMAP laboratory at Fort Bliss. These observations were then coded and entered into a database management system. Locations and boundaries of artifact distributions were then plotted on 1:3,000 scale aerial images throughout the project area.

**Geomorphic Data**

The 14 km² area of the HMAP was divided into grid areas of 1 ha each. The 14 km² of the HMAP area includes portions of the Hueco Mountains, alluvial fans radiating along the western edge of the Hueco Mountains, and the basin floor (Figure 3). The easternmost 4 km² (approximately) includes limestone bedrock outcrops, alluvial fan deposits, and a transition zone between the alluvial fan deposits and the eolian sandy deposits of the basin floor (Figure 3). The break between the silty alluvium of the transition zone and the eolian sandy deposits of the basin floor is not as abrupt as shown in Figure 3. However, to confine this study to only eolian geomorphic features, surface area measurements of the geomorphic features were restricted to the western 10 km². The only geomorphic correlation that involved the easternmost 4 km² was the number of coppice dunes vs. number of artifacts (per hectare). The number of coppice dunes was counted in 1,397 ha using a 1:3,000 scale blueprint of aerial photographs (aerial photographs were not available and/or the quality was too poor for the remaining 3 ha). Based on these counts, we defined seven classes or units of dune density. Forty-eight hectares in the western 10 km² were randomly chosen to be mapped by foot using the blueprints. Mapping units included coppice dunes, interdune deflational areas containing surficial lag, interdune sandsheet deposits, and man-made deflational areas (also containing surficial lag), including roads. The maps were then digitized using the AutoCad program. The surface area of each mapping unit was determined using a digitizer and the DesignCad program. The surface area of eolian windows included the interdune...
deflational areas containing surficial lag, and the man-made deflational areas including roads (which also contained surficial lag).

**Statistical Methods**

To test the Geological Disturbance Model, we used Pearson's product moment correlation coefficient, $r$, to measure the strength of the linear relationship between variables. We compared the total number of artifacts (per hectare) to: (1) the number of coppice dunes (per hectare) in the western 10 km², (2) the number of coppice dunes (per hectare) in the original 14 km², (3) the surface area of dunes (per hectare) in the western 10 km², and (4) the surface area of the eolian windows (per hectare) in the western 10 km². In addition, we analyzed the frequency of dunes (per hectare), and compared maps of the frequency of artifacts (per hectare) to the frequency of dunes (per hectare). Lastly, a logistic regression of the presence...
of artifacts (per hectare) as a function of the number of dunes (per hectare) was performed to predict the presence or absence of artifacts.

RESULTS

Frequency of Dunes (per Hectare)

The frequency of the number of dunes per hectare shows a high degree of symmetry around 30 dunes per hectare if the hectares containing zero dunes are omitted (Figure 4).

Maps of the Frequency of Number of Dunes and Number of Artifacts (per Hectare)

Maps were produced showing the frequency of the number of dunes per hectare (Figure 5) and the frequency of the number of artifacts per hectare (Figure 6). When these maps are compared, no correlation is observed. There are regions containing high numbers of artifacts and no dunes, and, in contrast, there are areas containing high concentrations of artifacts as well as dunes.

Number of Artifacts vs. Number of Dunes (Original 14 km²)

The number of dunes per hectare was counted for 1,397 ha. This data set was correlated to the number of artifacts in those 1,397 ha, for a total of $n = 1,397$ pairs.
Figure 5. Frequency map of number of dunes as a function of UTM location. Categories are midpoints: 0 represents the hectares with 0–10 coppice dunes, 20 represents 11–30 coppice dunes, 40 represents 31–50 dunes, and 60 represents hectares with greater than 51 dunes.

(Figure 7) (Table II). The results, $r = -0.0069$, $p$ value = 0.7973, indicate that there is no linear relationship between the number of artifacts and the number of dunes per hectare.

**Number of Artifacts vs. Number of Dunes (Western 10 km²)**

The number of dunes per hectare was counted for the westernmost 997 ha (3 ha could not be counted because of poor quality and/or lack of blueprint aerial photos). The number of artifacts in these 997 ha were correlated to the number of dunes per hectare for a total of $n = 997$ pairs (Table II). The results, $r = 0.0453$ and $p$ value $= 0.1529$, indicate that there is no linear correlation between the number of artifacts per hectare and the number of dunes per hectare along the basin floor (Figure 8).

**Number of Artifacts vs. Surface Area of Dunes (m²/ha) (Western 10 km²)**

The surface area of dunes per hectare was mapped and measured in 48 ha and correlated to the number of artifacts in those ha (Figure 9). The average surface area of dunes per hectare is $1,124 ± 464$ m². The results, $r = 0.35$ and $p$ value $= 0.0147$. The small $p$ value indicates that the coefficient $r = 0.35$ is detectably different from zero. Therefore, there is a positive linear correlation, but of weak strength between the two variables.
Figure 6. Frequency map of artifacts as a function of UTM location. Categories are midpoints: 0 represents the hectares with 0–25 artifacts, 50 represents 26–75 artifacts, 100 represents 76–125 artifacts, 150 represents 126–175 artifacts, and 200 represents hectares with greater than 176 artifacts.

Figure 7. Plot of the number of artifacts (per hectare) versus the number of dunes (per hectare) for 1,397 hectares.
Table II. Summary of the correlations on the number of artifacts (per square hectometer) to geomorphic features (per square hectometer).

<table>
<thead>
<tr>
<th>Artifacts vs.</th>
<th>Pearson’s Coefficient (r)</th>
<th>p-Value</th>
<th>Number of Pairs (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. of dunes</td>
<td>-0.0096</td>
<td>0.7973</td>
<td>1397</td>
</tr>
<tr>
<td>No. of dunes*</td>
<td>0.0453</td>
<td>0.1329</td>
<td>997</td>
</tr>
<tr>
<td>Eolian windows (m²/ha)</td>
<td>-0.0313</td>
<td>0.8318</td>
<td>48</td>
</tr>
<tr>
<td>Area of dunes (m²/ha)</td>
<td>0.350</td>
<td>0.0347</td>
<td>48</td>
</tr>
</tbody>
</table>

* 997 square hectares in western 10 km².

Number of Artifacts vs. Surface Area of Eolian Windows (m²/ha) (Western 10 km²)

The surface area of eolian windows per hectare was mapped and measured in 48 ha and correlated to the number of artifacts in those ha (Figure 10). The mean area of eolian windows per hectare is 5,310 ± 3,031 m². The results, $r = -0.032$, p value = 0.8318. There is no linear correlation between the number of artifacts and the surface area of eolian windows per hectare.

Logistic Regression of the Presence of Artifacts with the Number of Dunes

A logistic regression analysis was performed to predict the presence or absence of artifacts in a hectare based upon the number of dunes in that hectare (Figure 8).
Figure 9. Plot of the number of artifacts (per hectare) versus the surface area of dunes (m²/ha) (per hectare).

Figure 10. Plot of the number of artifacts (per hectare) versus the surface area of eolian windows (m²/ha) (per hectare).
Figure 11. Plot of the proportion of hectares that contain at least one artifact.

11). The response variable equals 1 when artifacts are present and 0 when absent. All hectares with equal number of dunes were counted and the proportion of hectares with artifacts by the number of hectares. For example, 5 ha had only one dune. Two of these five contained artifacts; therefore, the proportion is 0.4. The regression coefficients were statistically significant from zero; however, the coefficients were so small that the prediction function is essentially constant. Thus, varying the number of dunes produces no marked trend in the probability of finding an artifact in the hectare.

DISCUSSION
Numerous studies have been undertaken to understand and quantify the relative roles of behavior and geomorphic processes influencing the archaeological record (Wandsnider, 1989; Camilli and Ebert, 1992; Doleman, 1992; Doleman and Stauber, 1992; Ebert, 1992; Linse, 1993). To explain the distribution of artifacts in the arid climates of the North American Southwest, Doleman (1992) proposed two models to explain behavioral vs. geomorphic controls: (1) the Holocene Litter Model and (2) the Geological Disturbance Model. The purpose of this study was to test the Geological Disturbance Model by comparing the distribution of artifacts to geomorphic features at a microtopographic scale. Our results indicate that there is no correlation between the number of artifacts (per hectare) to: (1) the surface area of eolian windows (per hectare), (2) the number of dunes (per hectare) along the basin floor (western 10 km²), and (3) the number of dunes (per hectare) when the
alluvial fan and transition zones are included (original 14 km²) (Table II). However, in the last correlation (original 14 km²), many hectares contain no dunes, but do contain numerous artifacts (Figures 5 and 6). Additionally, many areas contain numerous artifacts as well as dunes (Figures 5 and 6). The majority of the areas contain no dunes, but numerous artifacts lie along the alluvial fans where the geomorphic surfaces are older than human occupation of North America. Thus, burial of artifacts on these surfaces since the beginning of human occupation has not happened. In addition, the processes of desert pavement formation also work to keep clasts, including artifacts, at the surface (McFadden et al., 1987). Although the number of dunes (per hectare) does not correlate to the number of artifacts (per hectare), the frequency of dunes across the study area does show a high degree of symmetry around 30 dunes per hectare if the areas containing no dunes are omitted (Figure 4). This may reflect a level of dynamic equilibrium within the eolian system.

When the number of artifacts (per hectare) is compared to the surface area of the dunes (per hectare), a weak positive correlation is found (Figure 9). This possibly suggests that the larger the coppice dunes, the greater the potential for artifacts to be present (per hectare). Because artifacts need to be exposed on the surface to be included in the database for this study, this suggests that the larger the surface area of the dunes, the larger the interdunal deflational area to create those dunes. Thus, there is the greater potential to expose and concentrate artifacts at the surface. In order to test this hypothesis, we compared the surface area of eolian windows containing surficial lag (per hectare) to the surface area of dunes (per hectare) and also found a weak correlation ($r = 0.320$, $p = 0.0391$, $n = 48$ pairs). This and other geomorphic data (Gile, 1975; Monger, 1995; Buck, 1996; Buck et al., 1998) indicate that the sediment forming the modern dunes is derived from older deposits within the basin, and therefore increased dune size and number indicates increased eolian erosion within the basin (but not necessarily within the boundaries of this study area). However, since both of these correlations are extremely weak, and because the surface area of eolian windows (per hectare) does not correlate to the number of artifacts (per hectare), neither of these correlations are useful for management decisions or other applications regarding artifact distribution in the field.

The final analysis performed in this study was a logistic regression analysis used to predict the presence or absence of artifacts (per hectare) based upon the number of dunes (per hectare). This analysis shows that varying the number of dunes produces no marked trend in the probability of finding an artifact in a hectare. Therefore, at a microtopographic scale, modern geomorphic features appear to have no marked effect upon the distribution of artifacts.

Factors that may have affected our study include the possibility that some deflational areas may not contain a surficial lag. Thus, these areas would not have been included in our correlations. However, this possibility is probably quite small because any area that showed evidence for deflation was included, and usually did have some sort of lag present, even if only one or two small clasts were present.
MICROTOPOGRAPHIC GEOMORPHIC FEATURES AND ARTIFACT DISTRIBUTION

A second factor is the amount of deflation, which varies from site to site throughout the basin. In some instances, Organ III deposits are deflated, while in others Organ I, II, and III and even older units such as Isaacks’ Ranch are deflated. Therefore, the magnitude of deflation and the availability of clasts (including artifacts from different stratigraphic horizons) to form a surficial lag could have affected the correlations involving eolian windows.

CONCLUSIONS

This study compared the distribution of artifacts to microtopographic geomorphic features in the northeastern Hueco Basin. No useful correlations were found, indicating that modern geomorphic features appear to have no marked effect upon the distribution of artifacts at a microtopographic scale. Within the study area, artifacts seem to be concentrated along approximately five to six specific locations (Figure 6). Because these concentrations of artifacts do not correlate to the modern geomorphic features, it suggests that behavioral processes may have played a dominant role in the distribution of these artifacts in those locations. However, other factors, such as the scale at which both behavioral and geomorphic patterns are observed, is extremely important in how the archaeological record is interpreted (Wandsnider, 1989; Ebert, 1992). Support for this was presented by Doleman and Stauber (1992), who found a high correlation between surface artifact densities and their presence on elevated landforms at a scale of tens to hundreds of meters (macrotopographic) in the Tularosa Basin, just north of our study area. This suggests that geomorphic features do influence behavior processes as well as possibly artifact preservation and exposure. However, the exact scale(s) at which this occurs and the degree to which geomorphic processes affect artifact distribution is still poorly understood. Future studies should address the importance of recognizing scale as a major factor in both the geomorphic influence and expression of the archaeological record in arid environments. These studies would be useful in making better interpretations of that record, as well as assisting managers in making policy decisions regarding the use of federal lands and the preservation of as-yet-unknown archaeological sites.

Thanks to Jeff Leach and Ray Mauldin for supplying the archaeological data, setting up the research design, and help in setting up the hectare sampling. This study was funded by the Fort Bliss Directorate of the Environment in contract with the University of Texas El Paso and New Mexico State University, and a Commission on Higher Education Graduate Student Research Grant. The writers would like to thank Frederico Almarez, Karen Faunce, Kelly Poche, Paul Lukowski, and Glen DeGarmo for assistance with the archaeological data and admittance on Fort Bliss. Thanks to William Doleman and two anonymous reviewers for reviewing an earlier version of this manuscript.

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Received April 3, 1998
Accepted for publication April 16, 1999